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CORPORATE REPORT

NO: R032 COUNCIL DATE: **February 6, 2017**

REGULAR COUNCIL

TO: **Mayor & Council** DATE: **February 2, 2017**

FROM: **General Manager, Planning & Development**
General Manager, Engineering FILE: **6520-20 (Abbey Ridge)**

SUBJECT: **Abbey Ridge Stage 2 Local Area Plan**

RECOMMENDATION

The Planning and Development Department and the Engineering Department recommend that Council:

1. Receive this report as information;
2. Approve the final and complete Abbey Ridge Local Area Plan (the "LAP") as documented in this report and attached in Appendix "I", as a means of managing development applications and the provision of engineering services for development in the LAP;
3. Authorize the City Clerk to introduce the necessary by-law to amend Surrey Zoning By-law, 1993, No. 12000 (the "Zoning By-law"), as documented in Appendix "II", to include amenity contributions for the Abbey Ridge based upon the density bonus concept; and
4. Authorize staff to incorporate the Development Cost Charge (DCC)-eligible infrastructure related to water, stormwater, sanitary sewer, and transportation for the LAP in the next edition of the City's 10-Year Servicing Plan.

INTENT

The purpose of this report is to seek Council approval for:

- The final and complete Abbey Ridge Stage 2 Local Area Plan documented in Appendix "I", including the Land Use Concept, Land Use Designation descriptions, Development Guidelines, Park Concept, Road and Transportation Network Concept, and associated amenity contributions.
- The Engineering Servicing Strategy to support the realization of the Land Use Concept Plan.
- The financing strategy to ensure the delivery of the necessary engineering infrastructure in the next edition of the City's 10-Year Servicing Plan.
- The funding mechanisms for plan amenities proposed for the Abbey Ridge area and the associated Fees and Zoning By-law amendments.

POLICY CONSIDERATIONS

The creation of a Land Use Concept and Local Area Plan (LAP) for the Abbey Ridge area is intended to guide the future land uses and infrastructure delivery in the plan area, including potential Official Community Plan ("OCP") and zoning amendments. The Abbey Ridge area has not been the subject of a secondary plan such as a General Land Use Plan or NCP to date, and is the only area within Fraser Heights to be part of a secondary plan process.

If an LAP is approved by Council for the area, the plan area may be designated as Secondary Plan Area in the Zoning By-law, with an attached schedule of Amenity Contributions to support park development, library materials, and police and fire service capital needs in exchange for bonus density, consistent with other LAP, NCP, and Infill Areas. The proposed amendments to Schedule G of the Zoning By-law, to incorporate the amenity fees that are discussed in further detail in this report, are documented in Appendix “II”.

BACKGROUND

The Abbey Ridge LAP is located in North Surrey and is approximately 184 hectares (455 acres) in size. The area is generally bounded by Highway No. 1 to the south; 172 Street to the west; Highway 17, Daly Road, and the CN Railway to the north; and Golden Ears Way to the east, as illustrated in Appendix “III”.

The LAP is bisected north to south by Highway 17 (176 Street), which also divides the area into two major drainage catchment areas. Several creeks, including Leoran Brook, flow north to the lowlands along the Fraser River, dividing the area into several sub-catchments. The area slopes generally to the north towards the Fraser River, and offers views over the river to Pitt Meadows and the Coast Mountains beyond. The planning area contains a mix of developed and undeveloped lands, with small remnant areas of limited infill potential, enclaves of suburban estates, and more recent urban subdivisions, as well as some areas where additional infill growth may be accommodated in the future.

The LAP planning process was completed in two stages, including:

- Stage 1: A land use concept and supporting transportation and drainage plan, along with a general servicing strategy.

- Stage 2: Engineering servicing strategies, design guidelines, and a financial strategy, including infrastructure financing and Community Amenity Contributions.

The Stage 2 Process is now complete and the purpose of this report is to seek Council’s endorsement of the Stage 2 Plan.

Stage 1 Plan History

On March 23, 2015, Council adopted the recommendations of Corporate Report No. R048; 2015 authorizing staff to initiate a land use planning and community consultation process for the Abbey Ridge area (formally East Fraser Heights). The Land Use Plan was to be prepared in response to increased development interest in the area.

The purpose of the planning process was to develop a coordinated land use concept and servicing strategy.

On June 25, 2015, a kick-off public meeting was held with property owners and the general public living within and around the Abbey Ridge area to provide an update on the intentions and status of the plan.

On September 23, 2015, staff attended a meeting with the Fraser Heights Community Association (FHCA) members and presented two draft land use concept options to provide the association members with an opportunity to comment on draft plans for the area. A preferred draft plan was prepared based on the public response received at the FHCA meeting.

On October 1, 2015, a public meeting was held with property owners and residents living within and around the Abbey Ridge area to provide residents, owners, and other interested parties with an opportunity to comment on the development of a preferred draft land use concept plan for the neighbourhood. A total of 256 persons attended this public open house, and 92 feedback forms were returned to the City, including a mix of responses balanced between those opposed and those in favour of aspects of the plan, as documented in Corporate Report R243; 2015 considered by Council on December 14, 2015. Based on feedback received, amendments were made to the preferred land use concept that was then brought to Council for approval.

On December 14, 2015, Council approved a Stage 1 Preferred Land Use Concept for the Abbey Ridge Area, as described in Corporate Report R243; 2015.

Stage 2 Plan History

On October 18, 2016, a public meeting was held with property owners and residents living within and around the Abbey Ridge area to provide residents, owners, and other interested parties with an opportunity to comment on a proposed engineering servicing and financial strategy to implement the approved Stage 1 plan.

Public and Stakeholder Engagement and Consultation

As mentioned above, two well-attended public meetings where held as part of Stage 1 of the LAP process, and a final public meeting was held for Stage 2 on October 18, 2016. This meeting served to provide an opportunity for public comment on the proposed engineering servicing and financial strategy, and minor refinements made to the land use concept in the Stage 2 planning review.

Approximately 56 people attended the Stage 2 Abbey Ridge LAP Public Open House held on October 18, 2016 at Fraser Heights Secondary School. The Planning and Development Department received nine completed feedback forms, representing comments from six properties within the Abbey Ridge LAP boundary, one property within 100 m of the boundary, and two properties outside these areas. A summary of the comment sheet information submitted to the City at the Stage 2 public open house is provided in Appendix “IV”.

In addition, since the public open house, staff has received letters and emails expressing both support and concern with the land use plan.

One of the letters was from the executive of the FHCA, expressing reservations with the planning process and, in particular, with residential densities in the plan. This letter expressed opposition to the inclusion of townhouse and "RF-13" single family designations in the plan, in relation to traffic congestion and neighbourhood character concerns.

On January 25, 2017, staff met with representatives of the FHCA and approximately 25 residents of Abbey Ridge to discuss their concerns with the Local Area Plan and the planning process.

During the preparation of the Stage 2 land use plan, staff received correspondence from the Katzie First Nation, indicating that on-going negotiations with the Provincial Government may result in the acquisition of lands within the Abbey Ridge plan area. Staff understands that these negotiations are not finalized. Depending on the outcome of these negotiations, land uses may be adjusted in the future on certain parcels.

Staff will engage with Katzie First Nation staff to ensure that the land use plans take into consideration the results of these negotiations.

Based on discussion at this meeting, staff made several minor adjustments to the land use plan, reducing residential densities along the east side of 179 Street between the Kinder Morgan pipeline right of way and Barnston Drive, and along the south side of 98 Avenue west of 181 Street. These adjustments were intended to establish a more compatible interface with established residential areas.

DISCUSSION

The goals of the Abbey Ridge Local Area Plan are to:

- Provide a level of certainty for residents, land owners and developers regarding the future character of the area;
- Assist the City in responding to development applications and inquiries in the Abbey Ridge neighbourhood;
- Ensure a comprehensive and coordinated land use, transportation, environmental, servicing, and financial strategy;
- Ensure adequate infrastructure such as, parks, roads, and utilities to support the land uses anticipated in the neighbourhood; and
- Ensure broad neighbourhood consultation on the future of the area.

The plan presented in this report is a result of nearly two years of planning and engineering work intended to help resolve the above issues, and outlines the main components of the Abbey Ridge Local Area Plan and servicing strategy.

Planning Context Vision

The majority of the LAP is designated for residential uses, along with a small band of existing industrial use fronting Daly Road in the north east section of the plan. The residential neighbourhoods within the study area are proposed as a mix of existing suburban properties; transitional density areas; pockets of higher-density urban subdivisions and developments; and parks and conservation areas.

In order to guide the comprehensive plan for this neighbourhood, a vision for the Abbey Ridge Neighbourhood was developed in consultation with community residents, which envisions:

> "An attractive and beautiful neighbourhood whose growth is planned to respect and complement the character of existing residential areas and the unique location of Abbey Ridge within the City of Surrey."

To implement this vision, several planning objectives were established, as discussed below.

Planning Objectives

The Abbey Ridge Local Area Plan includes specific provisions for:

- the retention of existing established and stable suburban/urban neighbourhood nodes;
- appropriate interfaces between developing and established areas;
- protection of riparian areas and wildlife corridors and retention of significant tree stands;
- additional housing choice through strategic areas of medium density townhouse and urban single family areas along the Highway 1 corridor and Highway 17 (South Fraser Perimeter Road);
- a more cohesive local road network, providing enhanced connections within the plan area and connections to the surrounding areas;
- a network of pedestrian and cycling routes and greenways, including future connections to the rest of Fraser Heights and regional parks; and
- identification of new neighbourhood parks in each sub-area to serve local recreation needs.

Land Use Plan Modifications from Stage 1 to Stage 2

While the approved Stage 1 Land Use Plan shown in Appendix "V" is similar to the proposed Stage 2 Land Use Concept Plan shown in Appendix "VI", several minor adjustments are proposed since the Stage 1 Plan was approved by Council in December 2015, as shown in Appendix "VII".

Overview of Land Use Designations

The following section describes the land uses proposed for the Abbey Ridge plan area.

The proposed Abbey Ridge Stage 2 Land Use Plan identifies 11 residential land use designations allowing for primarily residential uses, three of which allow single family or two family dwellings; four of which allow ground oriented multiple family dwellings such townhouses and rowhouses; and two of which allow higher density multifamily development such as stacked townhouses and low-rise apartment developments.

These residential land use designation areas are shown in the table below, with base density ranges and typical building forms:

Land Use Designation	Density Range	Typical Building Form(s)
Acreage Residential	1-2 UPA	Detached Single Family
Suburban Residential	2-4UPA	Detached Single Family
Urban Transition	4-5 UPA	Detached Single Family
Low Density Cluster	4-6 UPA	Detached Single Family
Single Family Residential	4-6 UPA	Detached Single Family, Semi-Detached
Urban Residential	8-10 UPA	Small Lot Detached Single Family
Urban Residential Transition	8-10 UPA	Single Family Wide Lots
Medium Density Cluster	10-12 UPA	Single Family , Semi-Detached, Multi-
Low Density Townhouse	12-15 UPA	2-3 Story Townhouse,
Low Density Townhouse Transition	12-15 UPA	2 Story Duplex, Semi-Detached
High Density Multiple Residential	30-45 UPA	3 Story Townhouse, Low Rise 4 Storey Apartments
Commercial	0.5 FAR	1 to 2 Storey Commercial Buildings
Institutional	0.3 FAR	Public Institutional Buildings
Industrial	0.5 FAR	Light Industrial Buildings

More detailed description of each of the land uses in the LAP is provided in the Land Use Designation section of the LAP document attached as Appendix “I”.

Summary of Residential Designations Uses

Appendix “VIII” summarizes the amount of land allocated within the plan for the different land uses, and the estimated number of dwelling units, population, and potential floor area at full build-out of the plan. A summary of the existing population, units, and the land use projections are generally described below, with details for each land use designation provided in the Local Area Plan document provided in Appendix “I”.

Current Population and Residential Units

There are approximately 747 residential dwelling units existing in the Abbey Ridge LAP area, with a population of approximately 2,242 people. It is also estimated that in addition there are 134 secondary suites in the existing residential areas with an estimated suite population of 258.
In total, the existing population for the area is estimated to be approximately 2,500, as of December, 2016.

Projected Population and Residential Units for LAP

Based on the proposed Stage 2 Land Use Concept, approximately 1,065 additional residential dwelling units with a population increase of approximately 3,321 people is expected, based on average projections at full build out of the LAP. Of these, 217 new residential units housing some 591 people are expected within the previously approved townhouse/apartment site located east of 176 Street and south of Barnston Drive.

At full-build out (approximately 15 to 20 years from today), Abbey Ridge is projected to have a total of 1,812 dwelling units and an estimated 472 secondary suites. The estimate of secondary suites is a based on the average across the City, which is significantly higher than that in the existing Fraser Heights neighbourhoods. These estimates would yield an estimated ultimate population, including suites, of 6,500 in the Abbey Ridge area, over the next 20 years. This population growth would represent 1.6% of the expected growth in the City over the next 20 years.

Commercial Uses

There are 3.6 acres of land designated for future commercial uses in the Plan area. It is projected that at full buildout this may include up to 7,500 square feet of commercial space, and 10 full time employment positions.

Industrial Uses

There are 16.1 acres of land designated for industrial uses in the Plan area. It is projected that at full buildout this may include over 350,000 square feet of industrial space, and 382 full time employment positions.

Institutional Uses

There are currently two Institutional designated areas within the LAP, accounting for 2.0 hectares (5.0 acres) of land to accommodate existing institutional uses, including: a Korean Central Presbyterian Church, located at 10117 – 176 Street, planned to be maintained and expanded for church uses; and City Fire Hall #5, located on Barnston Drive, immediately east of 176 Street along Barnston Drive East, which will also remain. Institutional uses are expected to provide for over 60 full time employment spaces.

Parks and Open Spaces

A map of the existing and proposed Parks and Open Space Areas is illustrated in Appendix "IX", and future Neighbourhood Parks and Natural area parks are generally described below.

Neighbourhood Parks

A total of 3.1 hectares (7.8 acres) of neighbourhood parks are proposed within the LAP. Neighbourhood parks provide local park amenities to serve residents and are located to be within walking distance of most residences. Neighbourhood park amenities may include:

- Playgrounds.
- Passive lawn/open space.
- Sports courts (ball hockey/basketball).
- Pathways/trails.
- Benches/picnic tables.

Natural Area Parks

A total of 8.8 hectares (21.7 acres) of additional natural area parkland is proposed within the LAP.

Natural area parkland accommodates natural amenities such as mature vegetation, watercourses, ravines, and other landscape features worthy of preservation, and it contributes to the open space and green infrastructure of the area.

These natural areas are made up of the following:

- Riparian areas located along Class A, Class AO, and Class B fisheries watercourses that provide for limited or no public access, as their function is to protect sensitive habitat areas, including the land around all significant creeks; and
- Biodiversity Corridors, including linear parks that provide natural areas and support wildlife movement to and through the plan area. Where these corridors include lands outside of riparian setbacks they may contain limited active park amenities such as:

    - natural areas, reforestation, and re-naturalization;
    - pathways/trails; and
    - benches/rest areas and viewpoints along pathways and trails.

For all new neighbourhood parks there will be a public engagement process to determine what amenities will be provided in each park.

Land Consolidation Strategy

In several areas of the LAP, land consolidation areas have been identified to inform developers of the consolidation requirement, to ensure compatibility and feasible development areas, and to achieve an equitable distribution of road dedication and construction costs across properties.

If land consolidation is proven not to be possible during the development process, a developer in these areas must:

- Demonstrate to the satisfaction of the City that the development potential of the excluded property is not compromised; and
- Share any required road construction costs or land dedications equitably amongst properties shown in the Abbey Ridge LAP land consolidation area plan.

Amenity Contribution Requirements

In accordance with City policy, to address the amenity needs of residents in Secondary Plan areas, all future development proposals that propose higher densities will be required to make a monetary contribution toward the provision of new police, fire protection, and library services, as well as toward the development of the parks, open spaces, and pathways at the time of rezoning.

The monetary contributions toward police, fire, and library materials will partially offset the capital costs of providing these services to the new development, and are applied on a standardized basis in all of Surrey's Secondary Plan areas. The monetary contributions toward parks, open spaces and pathway development are based on an estimate of the capital costs of these improvements for the particular LAP area. The total estimated cost is divided by the average anticipated number of new dwelling units (and acreages in the case of non-residential development) to ensure an equitable contribution arrangement.

The amenity contributions will be payable upon subdivision for single-family subdivisions or upon issuance of building permits for multiple development and other uses. Amenity Contribution Rates have been projected based on the average projected amount of new residential development, as illustrated in the table below.

ABBEY RIDGE LAP PROPOSED COMMUNITY AMENITY CONTRIBUTIONS			
	Per Unit Contribution All Residential (Approx. 1,090 new dwelling units @ mid-range density)	**Per Acre Contribution All Non-Residential Uses**	**Anticipated Total Revenue at Build Out**
Police Protection	$65.16 per dwelling unit	$260.65 per acre	$71,024.40 Residential $5,429.34 Non-Residential
Fire Protection	$281.46 per dwelling unit	$1,125.83 per acre	$306,791.40 Residential $23,451.04 Non-Residential
Development of Parks	$1,480.00 per dwelling unit	n/a	$1,613,200.00 Residential
Library Materials	$146.58 per dwelling unit	n/a	$159,772.20 Residential
Total Contribution (per unit or per acre)	$1,993.20 per dwelling unit	$1,386.48 per acre	$2,201468.38
Anticipated Total Revenue			**$2,201,468.38**

Overview of Engineering Servicing

Transportation, water distribution, sanitary sewer, and stormwater system servicing strategies have been developed to support the implementation of the land use plan. The following is a brief description of the final servicing strategy in relation to each service.

Transportation

The transportation network for the Plan Area is based on the guiding principles contained in the City's Transportation Strategic Plan as listed below:

- Effective and efficient management of the road network.
- Travel choices.
- Protection of the built and natural environments.
- Safe, healthy communities.

The existing Abbey Ridge road network has been developed over several years and is impacted by a number of factors:

1. Previous development in the area has not taken place comprehensively, with discreet pockets being established resulting in reduced connections.
2. The Plan area is bounded and bisected by a number of Provincial Highways (Highway 1, Highway 15, and Highway 17) that significantly limit opportunities for additional road connections, both within the neighbourhood and the neighbouring communities.
3. The Plan area has several creeks and riparian areas which prevent the opportunity to establish a fully connected road network.

The proposed transportation network for the Plan area is influenced by these factors and establishes some new road connections between existing local roads, updates some existing roads to current local road standards, and creates new local road networks within those areas of the plan designated for new development

The proposed road network to service build out of the Plan Area is attached to this report as Appendix "X".

Walking and Cycling

The proposed road network provides for walking and cycling throughout the LAP Area by designing all collector and arterial roads with sidewalks and cycling infrastructure within the LAP area. All sidewalks will be separated from traffic with boulevards that will accommodate street trees and street lighting. The walking and cycling network in the Plan area will be further enhanced by the introduction of the Abbey Ridge Greenway, which connects to the existing Fraser Heights Greenway to the west. The Riverside Greenway is also planned along the future Golden Ears Connector along the northern boundary of the Abbey Ridge LAP.

The network of pathways will provide good routes for walking and cycling within the Plan Area and connect to the adjacent communities of Fraser Heights and Port Kells.

Transit

While at this time there are no existing transit services within the LAP, 104 Avenue, 100 Avenue, and Barnston Drive will be designed to accommodate bus stops in anticipation of future bus services along these main corridors.

General Purpose Traffic

The road network is designed to provide route options and circulation for all modes to access in and out of the Abbey Ridge LAP. Although internal local road options are limited due to creeks and riparian areas , it is anticipated that future traffic will distribute onto the main collectors and arterial roads within the neighbourhood. New traffic signals are identified to ensure safe and efficient access to and from the arterial and Provincial Highway networks.

The Plan Area is currently well served in terms of access and connectivity with the neighbouring communities of Fraser Heights and Port Kells. It is also bordered by three Provincial Highways (Highway 1, Highway 15, and Highway 17) with interchanges in close proximity.

Transportation Improvements

A Traffic Impact Analysis was completed to determine the impact to the road network both within the LAP and on roadways outside. Based on the build out scenario, the study identified infrastructure improvements that are triggered by the development of the Plan Area. These improvements are provided in the Abbey Ridge LAP document. The majority of the improvements are at intersections to improve operational efficiencies, and no major road widening is required as a result of the Plan. The results of the analysis were sent to the Ministry of Transportation and Infrastructure (MoTI) for review, and MoTI staff had no comments or concerns regarding the need for any improvements to their infrastructure.

Utilities

<u>Stormwater</u>

The two major watersheds within the Abbey Ridge LAP area are Big Bend and Port Kells, each containing various sub-catchments. The piped system of the Big Bend watershed discharges to multiple tributaries along the Surrey escarpment that discharge to the lowlands and drain into Surrey Bend Regional Park. The Port Kells watershed is made up two distinctive halves with only the western half from Golden Ears Way within the Abbey Ridge LAP area. Runoff from this area drains north to the Fraser River within three major watercourses: Lyncean Creek West, Lyncean Creek East, and Leoran Brook. The drainage infrastructure within the Abbey Ridge LAP area is predominantly open channels, storm sewers, and culverts.

There are three existing detention facilities plus additional ponds in the area constructed as fish habitat compensation sites. Lyncean Creek (West and East) and Leoran Brook are natural streams that flow through the area, plus a number of unnamed creeks also run downslope towards the Fraser River. Due to the connections with the Fraser River, several watercourses including roadside ditches within the study area are also identified as fish bearing or provide overwintering habitat for fish.

The future development of the Abbey Ridge LAP area will change the existing land use, increase the amount of impervious areas, reduce infiltration, and increase surface runoff. Analysis of the existing drainage system revealed that many of the storm sewers do not have capacity to accommodate increased flows. In order to attenuate flows, future discharges to Leoran Brook and Lyncean Creek East should be limited through the use of Low Impact Development (LID) techniques in future roads and developments to reduce volume rates and as the primary erosion mitigation measure in sensitive areas.

The following on-lot measures and LIDs to retain rainwater at the source along with water quality enhancements are recommended:

- All new industrial, institutional, commercial, and multi-family residential development will provide on-site detention storage to limit off-site runoff discharge to 15 l/s/ha for the 5-year storm and 25 l/s/ha for the 100-year storm.
- All land uses to provide 450mm of enhanced topsoil on all pervious areas.
- LID measures are required for road runoff. Road LIDs recommended are 450mm of topsoil for boulevard areas, grading sidewalks towards the boulevard, and infiltration galleries or rain gardens that occupy 5% of the road or lane area.

- Water quality treatment for multi-family sites.
- Oil-grit traps on roadway catchbasins.
- Where applicable, establish riparian setbacks to comply with the Riparian Area Bylaw.

While some stretches of Lyncean Creek West, Lyncean Creek East, and Leoran Brook flow through lots owned by the City, other stretches flow through private property. These watercourses on private property need a Statutory Right of Way (SRW) to allow reliable conveyance of stormwater.

The stormwater infrastructure needed to support the development of the LAP area is illustrated in the map attached as Appendix "XI".

Sanitary Sewer

The Abbey Ridge LAP area is currently serviced by the Big Bend Trunk Sewer and the Big Bend Pump Station. The trunk sewer runs from east to west through Abbey Ridge to the pump station, which in turn pumps flows to Metro Vancouver's North Surrey Interceptor (NSI). Due to topography, areas south (uphill) of the trunk sewer are serviced by gravity sewers, whereas areas north (downhill) are serviced by low pressure sewers. Several properties in the area are currently using private septic field systems for wastewater treatment and disposal. In addition to servicing Abbey Ridge, the Big Bend Trunk Sewer currently conveys wastewater flows from the Port Kells industrial area via the Port Kells Pump Station and forcemain.

The Big Bend Trunk Sewer has capacity constraints in numerous locations, which will worsen as future development proceeds. Several constrained sections are located in side and rear yard easements, making it challenging and costly to upgrade along its current alignment. Topographical constraints also make it difficult to consider an alternate alignment for the trunk sewer without significant impacts to existing development.

The Big Bend Pump Station is situated within the 200-year floodplain of the Fraser River and is at risk of flooding. The design to relocate this pump station to a higher elevation is underway. The relocation of the pump station will impact the current servicing arrangement for a small pocket of existing development on 177A Street and an alternate servicing method will be needed for this area.

Regional Servicing Review

The Big Bend Trunk Sewer currently services existing development within the Abbey Ridge LAP area and the Port Kells industrial area. In exploring opportunities to service the LAP area, staff identified that it was technically feasible for the Big Bend Trunk Sewer to also service a portion of the Anniedale Tynehead NCP area if flows from Port Kells were diverted. As such, staff reviewed the merits of a broader sanitary servicing strategy for the Abbey Ridge LAP area that included the Port Kells and Anniedale-Tynehead NCP areas. Unfortunately this review identified that a portion of the Anniedale-Tynehead NCP area would be in a worse financial position than they are with the current servicing strategy for this area; as such, this approach is not recommended.

Servicing Strategy

Future developable areas east of 179 Street will be serviced by a new local pump station located at 182A Street and the Golden Ears connector. This pump station will pump flows around most of the constrained sections in the Big Bend Trunk Sewer and will connect to the trunk sewer near 179 Street and 99A Avenue. With the local pump station in place, only two segments of the Big Bend Trunk Sewer west of 179 Street will require upgrading.

The remaining developable areas south of the Big Bend Trunk Sewer will be serviced by extending the existing gravity sewer network, whereas remaining developable areas north of the trunk sewer will be serviced by low pressure sewer systems. A small community pump station will be required on 177A Street to service the existing development impacted by the relocation of the Big Bend Pump Station.

The sanitary sewer infrastructure needed to support the development of the LAP area is illustrated in the map attached as Appendix "XII".

Infrastructure Phasing

Future development upstream (east) of the two required Big Bend Trunk Sewer upgrades will need to complete these improvements. The City will monitor flows in the Big Bend Trunk Sewer to determine when the 182A Street pump station and forcemain will need to be implemented. The City will construct the community pump station at 177A Street in conjunction with the Big Bend Pump Station relocation to ensure continued sanitary service to this existing development

Water

The Abbey Ridge LAP area is currently partially serviced by the municipal water system, with the remaining areas serviced by private groundwater wells. In order to accommodate the proposed higher density development in the study area, the municipal water system needs to be expanded and enhanced.

Water supply to the area is currently provided by a 525mm diameter feeder main on 96 Avenue, which is supplied by a direct connection to Metro Vancouver's transmission main on 164 Street at 95 Avenue. This feeder main does not have the capacity to support future development conditions in the study area.

The topography of the area requires that two separate pressure zones be established in the study area. The majority of the proposed LAP area is located in the lower pressure zone (90m). A 400mm feeder main, which is already included in the current 10-Year Servicing Plan, is partially complete and is connected to the existing pressure reducing station at Cherryhill Court, would be extended to supply the 90m zone. This water supply is provided by the Whalley Reservoir and Pump Station at 14619 – 104A Avenue and its associated feeder main network to Cherryhill Court. A network of distribution mains would then be required to service the study area and improve the network connectivity.

Due to higher elevations, the south-western part of the study area is located in the higher pressure zone (135m). Currently, there are no City water networks in this area. The proposed feeder main identified in the Anniedale-Tynehead NCP area could be used to provide water supply to this portion of the study area. A network of distribution mains would also be required.

The water infrastructure needed to support the development of the LAP area is illustrated in the map attached as Appendix "XIII".

Infrastructure Phasing

Most of the feeder mains required for the 90m pressure zone are already complete and the remaining feeder mains and distribution network would be development driven. The first multi-family or commercial development within the 135m pressure zone will be required to install the 450mm main on Barnston Drive West between 170A Street and 172 Street.

Financial Analysis for Engineering Infrastructure

The water, sanitary sewer, stormwater and transportation infrastructure required to support development in the LAP area is modest. The following table summarizes the projected DCC revenues and construction costs for each of the major infrastructure systems that will be needed to support build-out of the LAP area.

Service	Estimated DCC Revenues	DCC Eligible Costs in LAP Area	DCC Revenues available for projects outside of LAP Area
Stormwater	$ 3,797,000.00	$ 578,000.00	$ 3,219,000.00
Sanitary Sewer	$ 2,488,000.00	$ 2,340,000.00	$ 148,000.00
Water	$ 1,924,000.00	$ 942,000.00	$ 982,000.00
Arterial Roads	$ 11,277,000.00	$ 6,600,000.00	$ 4,677,000.00
Collector Roads	$ 2,961,000.00	$ 2,900,000.00	$ 61,000.00

The revenues are based on the current DCC rates that came into effect on May 16, 2016, and include the DCC municipal assist factor for all DCC-Eligible Costs attributable to the LAP area for each utility as follows.

Service	Municipal Assist Factor	Cost of the Municipal Assist Factor
Drainage	10%	$ 345,000.00
Sanitary Sewer	10%	$ 226,000.00
Water	10%	$ 175,000.00
Arterial Roads	5%	$ 537,000.00
Collector Roads	5%	$ 141,000.00

As summarized above, the costs to provide the necessary water, sanitary sewer, stormwater and transportation infrastructure to support development in the LAP area can be afforded based on the projected DCC revenues from development in the area.

Implementation of the Recommended Servicing Strategies

The 10-Year Servicing Plan itemizes the City's capital expenditure plan for engineering infrastructure to service existing development and support new growth. In February 2016, Council endorsed an updated 10-Year (2016-2025) Servicing Plan. The Servicing Plan has been reviewed annually since 2006 and updates have occurred every two years since 2010. Staff are currently reviewing the 10-Year Servicing Plan and intend to bring forward an updated 10-Year (2017-2026) Servicing Plan and related DCC By-law to Council for their consideration in February 2017. It is recommended that the next edition of the 10-Year Servicing Plan include the DCC eligible infrastructure identified to support the development of the Abbey Ridge LAP area. Should Council not support the recommendations of this report, the 10-Year Plan/DCC Bylaw Corporate Report should be referred back to staff, as the 10-Year Plan includes some DCC eligible infrastructure to support the development of the Abbey Ridge area.

Operational and Maintenance Responsibilities

Infrastructure Type	Existing Inventory	Increase to Inventory	Increase to Inventory (%)
Sanitary mains	1,578 km	7.7 km	0.5 %
Water mains	1,851 km	9.6 km	0.5 %
Drainage mains	1,928 km	3.8 km	0.2 %
Local, Collector and Arterial Roads (centreline length)	1,745 km	2.5 km	0.1 %

The development of the Abbey Ridge LAP area will result in increases to the City's major infrastructure categories as follows.

The midline build-out population increase estimate of approximately 4,000 persons in the LAP area represents a 0.7% increase in the City's population. The infrastructure needed to support this increase in population results in the City's infrastructure inventory increasing by 0.1 to 0.5%; therefore, the added infrastructure to support the development of the LAP area is positively balanced when compared against the increase in population.

Implementation of the LAP

Future OCP Amendments

The current OCP suburban designation and the existing zoning in some portions of the LAP would require amendment to allow for the development envisioned in the Abbey Ridge Land Use Concept plan. These amendments would occur through Council consideration of individual land development applications brought forward by owners and/or developers.

Amenity Contributions

To activate the process by which amenity contributions are collected to support development within the LAP as discussed above, the Zoning By-law will need to be amended to add Abbey Ridge to the list of secondary plan areas within which monetary contributions are required in exchange for bonus density.

Design and Development Guidelines

In the case of single-family residential development in new subdivisions, approved building schemes will be required to control housing designs. Where single family developments are located in designated Development Permit Areas (Steep Slopes, Floodplain, or Environmental Protection), as well as for any multiple unit residential development, design guidelines will be implemented through the review and approval of a Development Permit.

SUSTAINABILITY CONSIDERATIONS

The Abbey Ridge LAP outlines a vision for the area that aligns with Surrey's Sustainability Charter 2.0 vision for a thriving, green, inclusive city, as well as numerous Desired Outcomes (DO) and Strategic Directions (SD).

Built Environment and Neighbourhoods

DO 1 Surrey is comprised of distinct, diverse and compact neighbourhoods and Town Centres, with an engaging public realm.
DO 2 Surrey is well-connected within the City and to the rest of the region by fast and efficient public transit and active all-ages-and-abilities transportation infrastructure.
DO 4 Surrey's neighbourhoods are safe, accessible, well-connected, walkable and bike friendly.
DO 5 Trees, green spaces and natural areas are integrated into all neighbourhoods.
DO 6 Land is used efficiently and sensitively, and development minimizes the impacts on the natural environment, viewscapes, agricultural land and urban wildlife.
DO 8 The built environment enhances quality of life, happiness and well-being.

SD 3 Integrate natural areas, ecosystems, and green areas in all neighbourhoods.
SD 4 Continue to plan and develop a transportation and mobility network (including active transportation) that supports safety, placemaking and integration of neighbourhoods.
SD 5 Leverage, incentivize and enhance community benefits through the planning and construction of new development.
SD 9 Design public spaces to enable flexible uses.

CONCLUSION

A City project team prepared a Stage 1 land use and transportation plan and a Stage 2 engineering servicing and financial strategy for the Abbey Ridge Local Area Plan, as authorized by Council. The plan was prepared in consultation with property owners, and Fraser Heights Community Association, City committees and advisory bodies, government agencies, utility companies, representatives of the land development industry, and the general public.

The final proposed and preferred Land Use Concept for the Abbey Ridge area was presented at a public open house on October 18, 2016, and has been further reviewed and refined as documented in this report, along with a preferred engineering servicing and financial strategy to be included in the 10 year servicing strategy. This is now brought forward for Council's consideration and final approval of the Stage 2 Plan. If approved, the plan will guide the review of future land development applications, set out the provision of infrastructure to support development, and will determine the community amenity contributions collected through development.

Based on the above discussion it is recommended that Council:

- Approve the final and complete Abbey Ridge Local Area Plan, as documented in this report and attached in Appendix "I", as a means of managing development applications and the provision of engineering services for development in the LAP;

- Authorize the City Clerk to introduce the necessary by-law to amend Surrey Zoning By-law, 1993, No. 12000, as documented in Appendix "II", to include amenity contributions for the Abbey Ridge based upon the density bonus concept; and

- Authorize staff to incorporate the Development Cost Charge (DCC)-eligible infrastructure related to water, stormwater, sanitary sewer, and transportation for the LAP in the next edition of the City's 10-Year Servicing Plan.

Original signed by
Jean Lamontagne
General Manager,
Planning and Development

Original signed by
Fraser Smith, P.Eng., MBA
General Manager,
Engineering

SW/MK/JP/DL/ss

<u>Appendices:</u>

Appendix "I"	- Proposed Stage 2 Abbey Ridge Local Area Plan Document
Appendix "II"	- Proposed Amendment to Schedule F and G of the Zoning By-law
Appendix "III"	- Map of Abbey Ridge LAP Boundaries
Appendix "IV"	- Summary of Public Comments from Stage 2 Public Information Meeting
Appendix "V"	- Stage 1 Land Use Concept Plan
Appendix "VI"	- Stage 2 Proposed Land Use Concept Plan
Appendix "VII"	- Summary of Modifications to Land Use Concept from Stage 1 to Stage 2
Appendix "VIIII"	- Stage 2 Abbey Ridge Land Use Statistics and Population/Unit Estimates
Appendix "IX"	- Parks and Opens Space Network Map
Appendix "X"	- Proposed Abbey Ridge Road & Greenway Network Plan
Appendix "XI"	- Proposed Abbey Ridge Drainage System Servicing Plan
Appendix "XII"	- Proposed Abbey Ridge Sanitary Sewer System Servicing Plan
Appendix "XIII"	- Proposed Abbey Ridge Water System Servicing Plan

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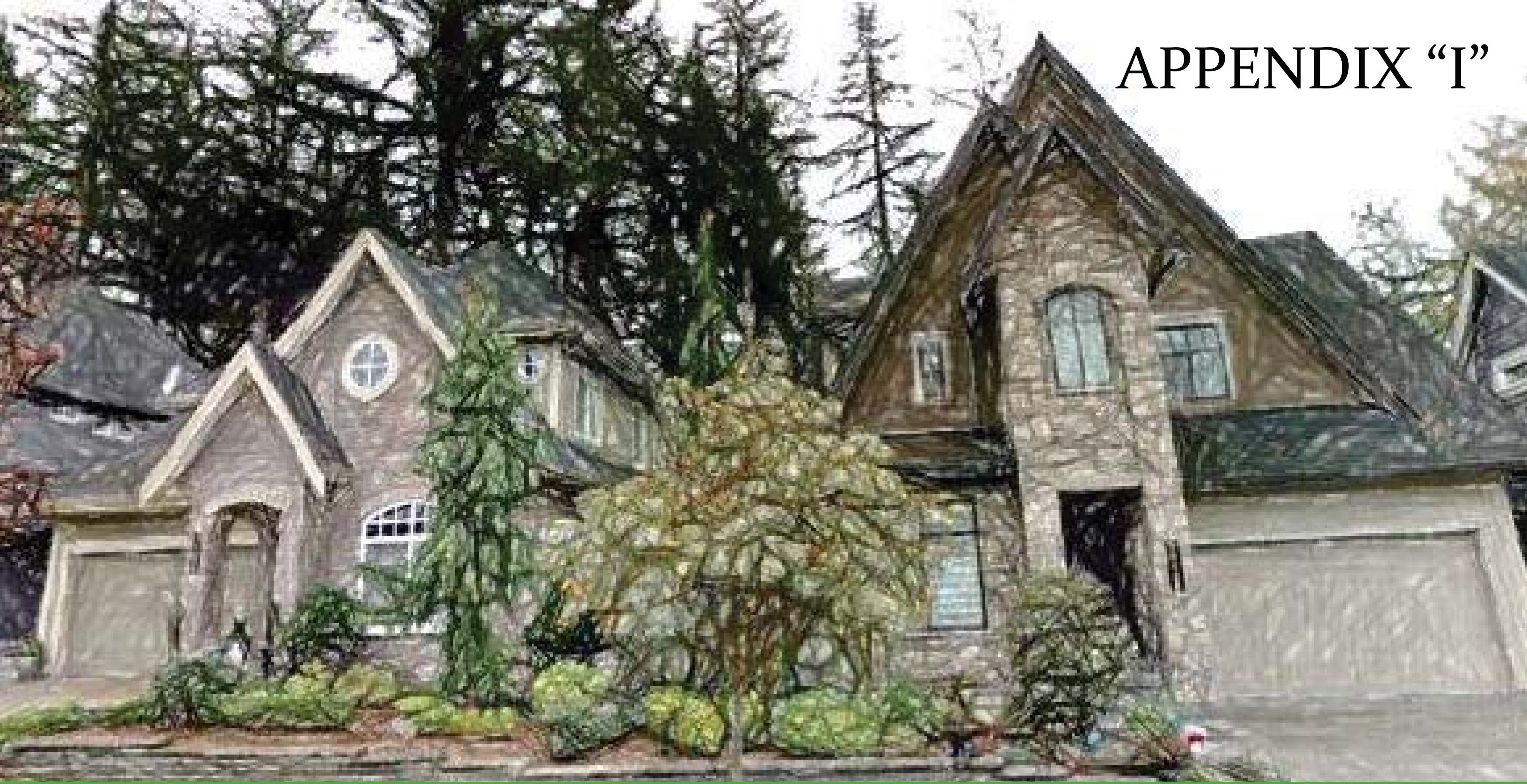
APPENDIX "I"



ABBEY RIDGE

LOCAL AREA PLAN LAP

CITY OF SURREY

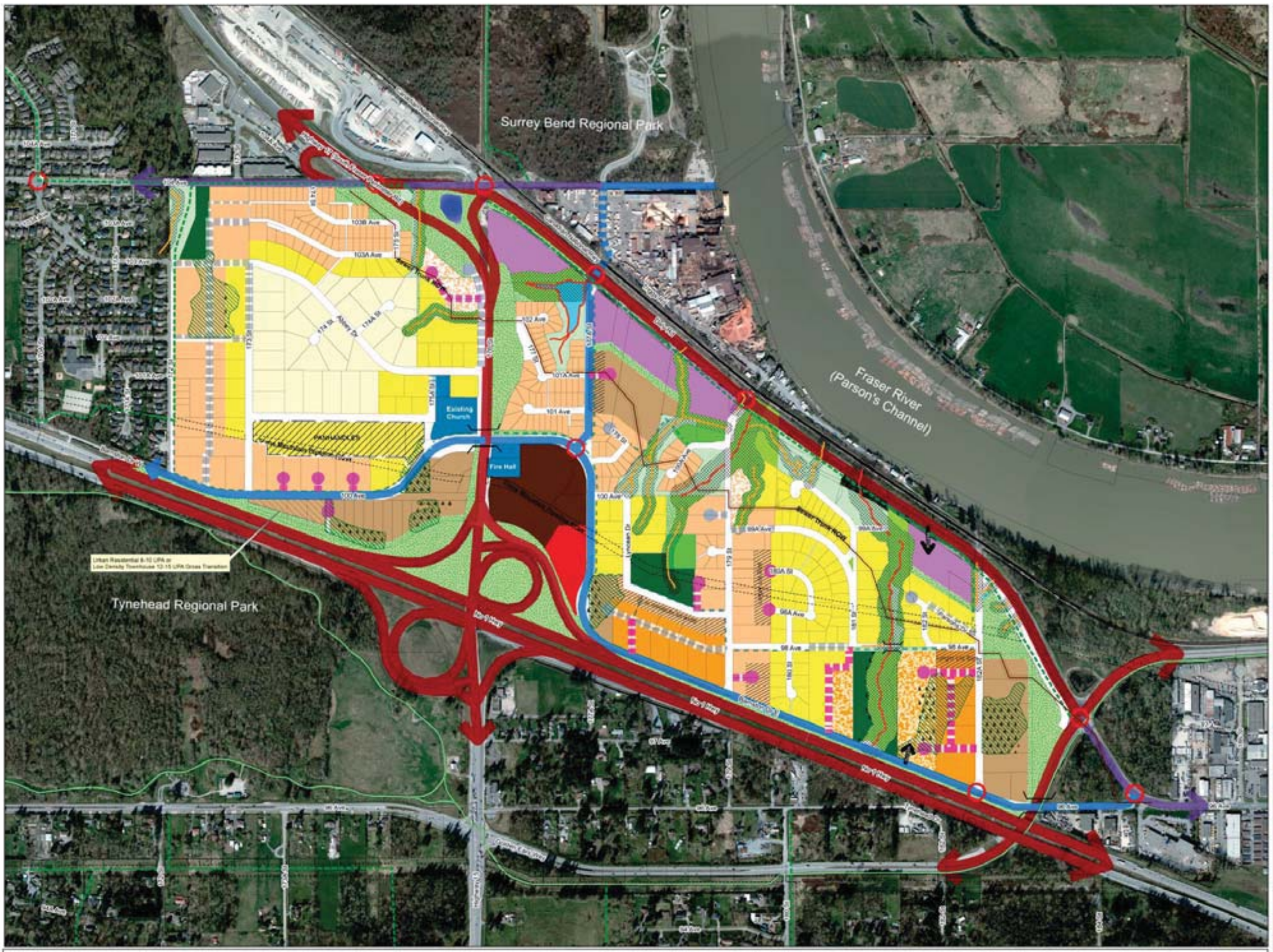
Abbey Ridge
Local Area Plan

Planning and Development &
Engineering Departments

City of Surrey
13450 104 Avenue
Surrey, British Columbia V3T 1V8

APPROVED BY COUNCIL FEBRUARY 6, 2017

CITY OF SURREY



LEGEND

Land Use Designations

- Acreage Residential 1-2 UPA
- Suburban Residential 2-4 UPA Gross
- Urban Transition 4-5 UPA
- Low Density Cluster 4-6 UPA Gross
- Single Family Residential 4-6 UPA
- Medium Density Cluster 10-12 UPA Gross
- Urban Residential 8-10 UPA Transition
- Urban Residential 8-10 UPA
- Low Density Townhouse 12-15 UPA Gross Transition
- Low Density Townhouse 12-15 UPA Gross
- High Density Multiple Residential 30-45 UPA
- Neighbourhood Commercial
- Industrial
- Institutional
- Existing Natural Area
- Future Natural Area
- Existing Neighbourhood Park
- Future Neighbourhood Park
- Landscape Buffer
- Storm Water Pond
- Wet Land
- Tree Retention Area

Transportation Network

- Proposed City Greenway
- Railway
- Signalized Intersection
- Cul De Sac
- Flex Cul De Sac
- Provincial Highway
- Arterial 30m
- Collector 24m
- Future Collector 24m
- Proposed Local 20m
- Proposed Flex Local Road
- Proposed Local Lane 6m
- Proposed Greenways 4m
- In Service Greenways 4m

Utilites & Other

- SanitaryTrunkSewer_ROW_10m_AbbyRidge
- SanitaryTrunkSewer_AbbyRidge
- Significant Tree Stand
- Trans Mountain Pipeline ROW (18.6m)
- Stream Class A
- Stream Class B
- Buffer of Fishclass A and AO 30m
- Buffer of Fishclass B 15m

Abbey Ridge
Stage 2 - Land Use Concept Plan

Approved by Council at it's Regular Council Meeting of February 6, 2017 - Resolution RES R___

City of Surrey Planning and Development Department

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CONTENTS

MAPS AND TABLES

MAPS

TABLES

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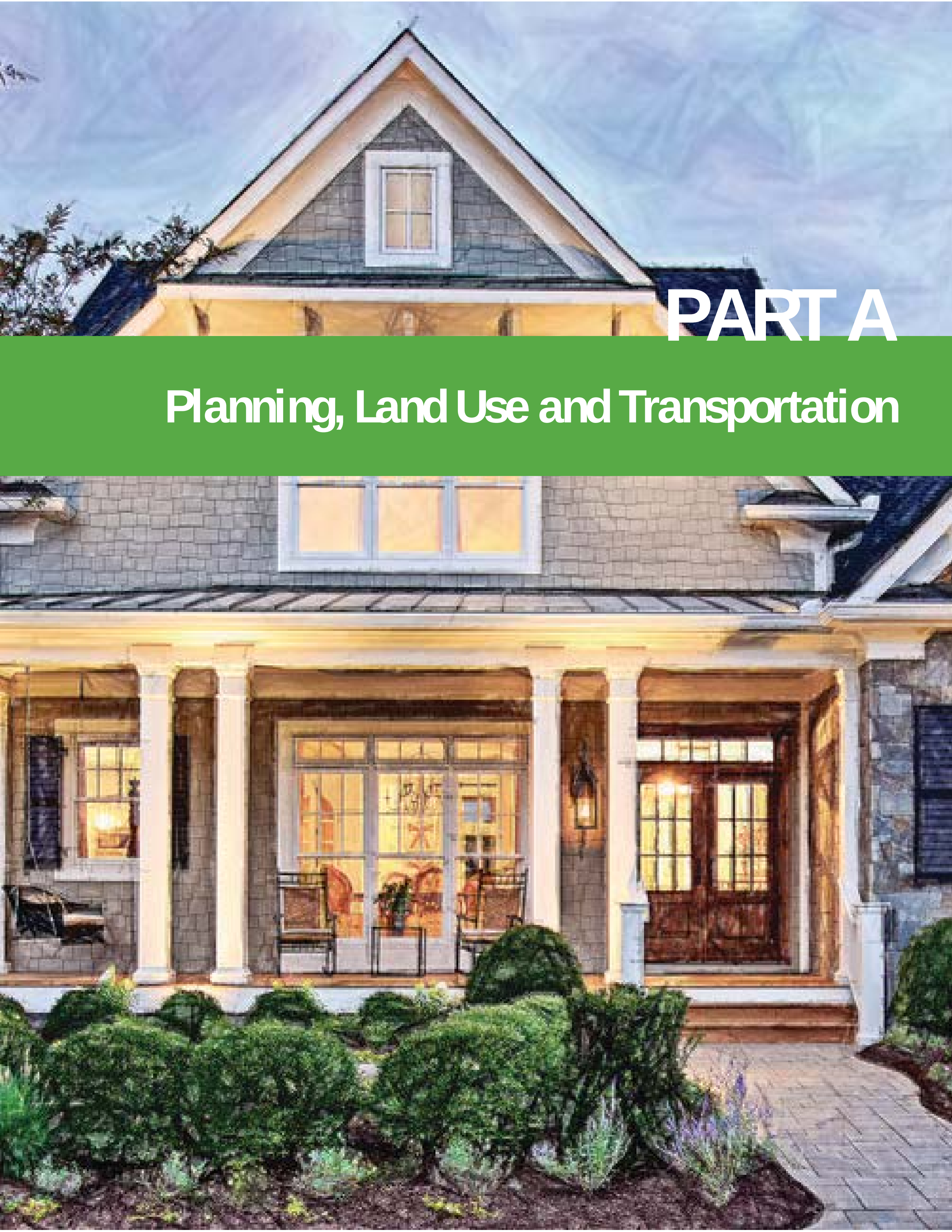
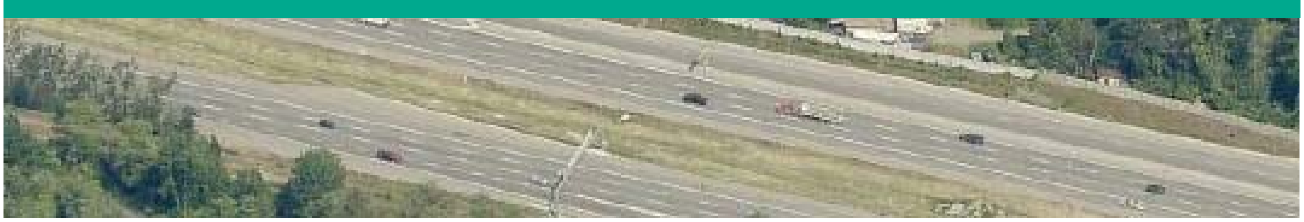
PART A

Planning, Land Use and Transportation



SECTION 1
Background and Context



1
BACKGROUND AND CONTEXT

The Local Area Plan and Land Use Concept for the Abbey Ridge area will guide future Official Community Plan ("OCP") and zoning bylaw amendments, as well as confirm many existing land use designations within the Neighbourhood.

The Abbey Ridge area has not been the subject of a secondary plan such as a General Land Use Plan or Neighbourhood Concept Plan or Local Area Plan; and is the only area within the Fraser Heights area of Surrey, to be part of a comprehensive secondary land use planning process.

The intent of the Abbey Ridge Local Area Plan is to:

1. Provide a level of certainty for residents, land owners and developers regarding the future character of the area;
2. Assist the City in responding to development applications and inquiries in the Abbey Ridge neighbourhood;
3. Ensure a comprehensive and coordinated land use, transportation, environmental, servicing, and financial strategy;
4. Ensure adequate infrastructure such as, parks, roads and utilities to support the land uses anticipated in the neighbourhood; and
5. Ensure broad neighbourhood consultation on the future of the area.

1.1 PLAN INITIATION AND PLANNING CONTEXT

On March 23, 2015 Council authorized City staff to initiate a land use planning and community consultation process for the East Fraser Heights area (now named Abbey Ridge), in response to increased development interest in the area, and to address servicing and community consultation issues.

The purpose of the planning process was to develop a coordinated land use concept and servicing strategy for the area.

Local Area Plan Intent

A Local Area Planning process addresses several issues for the Abbey Ridge Neighbourhood, including:

1. Identify appropriate land uses and densities to create an attractive and sustainable community, including particular consideration of transitions and the interface between existing neighbourhoods and new development;
2. Ensure Environmental conservation and biodiversity values are provided for through identifying key natural assets and developing a plan for conservation;
3. Providing a formal review of School capacities related to anticipated future growth;
4. Provide for Parks, recreation and open space needs related to current and future residential growth;
5. Provide for a coordinated street network that ensures pedestrian, cycling, transit and vehicular connectivity and access into and through the LAP area, and that also addresses issues related to traffic safety and which minimizes traffic impacts on existing neighbourhoods;
6. Ensure a coordinated servicing strategy (sanitary, water, drainage and other utilities) to ensure efficient and equitable of delivery of infrastructure;
7. Provide a mechanism for providing community amenities and benefits related to public needs imposed by development; and
8. Consult with the community in a comprehensive manner, rather than solely on individual development applications.

1.2 PLANNING AND CONSULTATION PROCESS

On June 25, 2015 a kick-off public meeting was held with property owners and the general public living within and around the East Fraser Heights area to provide an update on the status of the Local Area Planning process. The purpose of this first public consultation meeting was to:

- **provide background on the reasons for conducting the plan;**
- **introduce the City's planning team;**
- **discuss how the planning process will take place;**
- **provide initial draft results of an environmental study recently conducted in the area; and**
- **allow comments and suggestions about a future Land Use Concept and vision for the neighbourhood.**

Public Consultation Process

Stage I Kick-Off Public Open House

There were 132 people who attended the first public open house held at Fraser Heights Recreation Centre. The City received 31 completed feedback forms following the meeting, representing comments from 25 properties within the LAP area and within approximately 1.3 kilometres of the LAP area.

Environmental Study

On July 29, 2015 Phoenix Environmental Services Ltd completed an Environmental Assessment and Tree Study of the plan area. The Environmental Assessment and Tree Study provided a baseline environmental context as a first step in the development of a Land Use Concept for the area. The complete Environmental Study can be found in Appendix A-2.

Fraser Heights Community Association Consultation

On September 23, 2015 staff attended and presented two draft land use concept options to the Fraser Heights Community Association to provide the association members with an opportunity to comment on draft plans for the area.

Several comments, and recommendations were provided, and refinements were made to the working draft land use concept options in order to develop a preferred land use concept to present to the public.

Naming the Neighbourhood

The unique sense of identity, place, and community of a neighbourhood can be enhanced by a name that is associated with the history, heritage or a distinguishing feature of that area.

During the Stage I public open house, residents were asked to identify a preferred name for the LAP area from a list of four potential names that was proposed by staff.

Based on feedback from the public meeting, "Abbey Ridge" was selected as the proposed LAP name for the area. The existing Abbey Drive located within an existing suburban area of the LAP was significant in relation to this name, and distinguished this neighbourhood within the larger Fraser Heights community to the west.

Stage II Servicing Strategy Public Open House

On October 18, 2016 a final public open house was held with property owners and the general public living within and around the Abbey Ridge area to provide the draft Stage II servicing plans and financial strategy for the Local Area Plan, and provides an opportunity for comment on modifications to the Stage 1 land use concept plan.

56 people attended the Abbey Ridge LAP Public Open House which was held at Fraser Heights Secondary School.

1.3 BOUNDARIES AND GEOGRAPHY

The Abbey Ridge Local Area Plan ("LAP") comprises of 184 hectares (455 acres) of land and is generally bounded by Highway No. 1 to the south, 172 Street to the west, Highway 17, Daily Road and the CN Railway to the north, and Golden Ears Way to the east, as illustrated in Map 1.

The LAP is bisected north to south by the Big Bend major drainage catchment area to the west of 176 St. (Highway 15) and the large Port Kells drainage catchment area to the east of 176 Street.

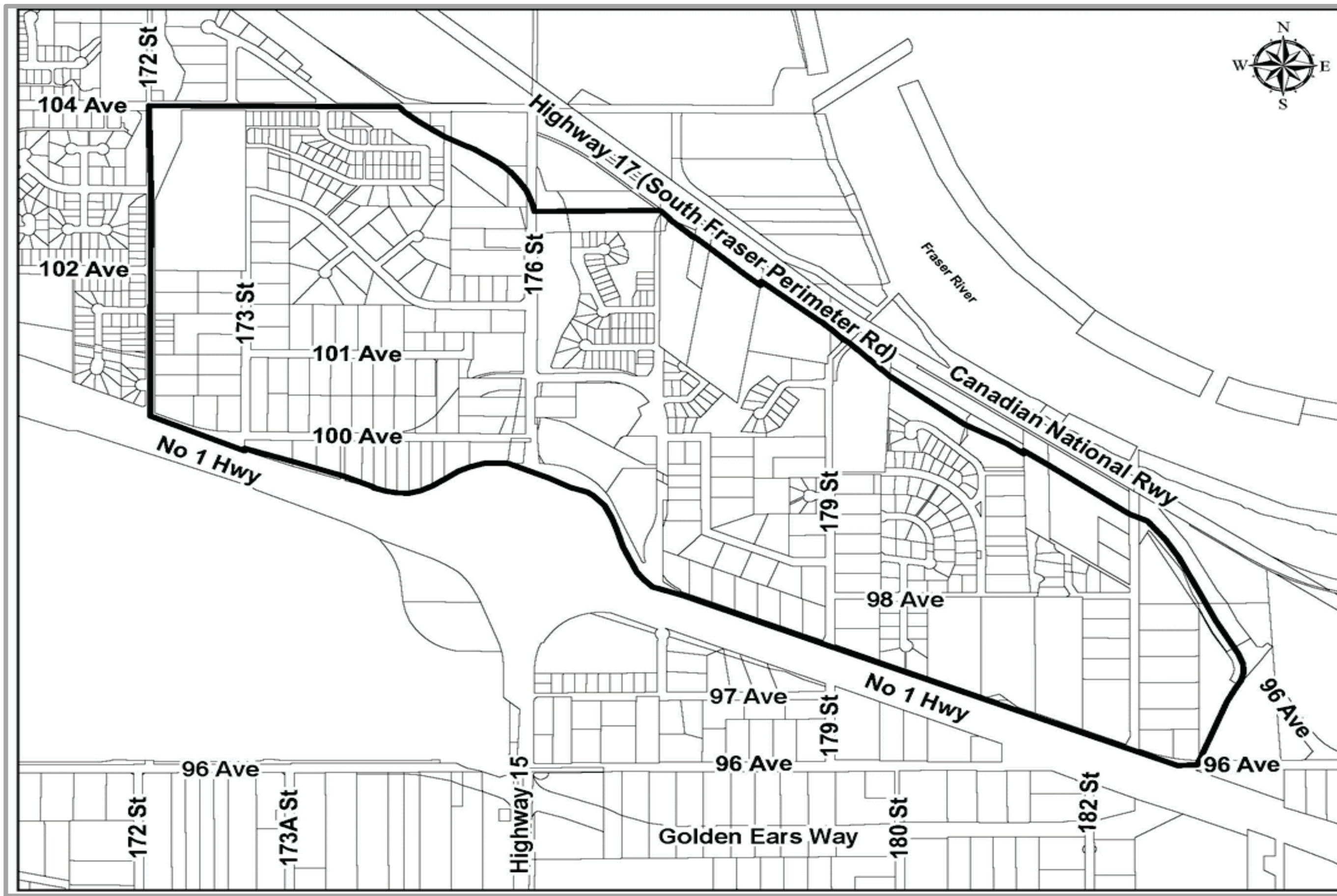
Environmental Characteristics

The area is characterized by land that slopes moderately towards the north, with excellent views over the Fraser River to the North Shore Mountains. A number of Class A and Class B fisheries habitat watercourses and associated riparian areas bisect the area and flow north towards the Fraser River. A Green Infrastructure Corridor has also been identified in the Biodiversity Conservation Strategy for protection.

The area also lies between two large natural area parks – Surrey Bend Regional Park to the north, across the South Fraser Perimeter Road and the CN rail corridor, and Tynehead Regional Park to the south, across Highway 1.

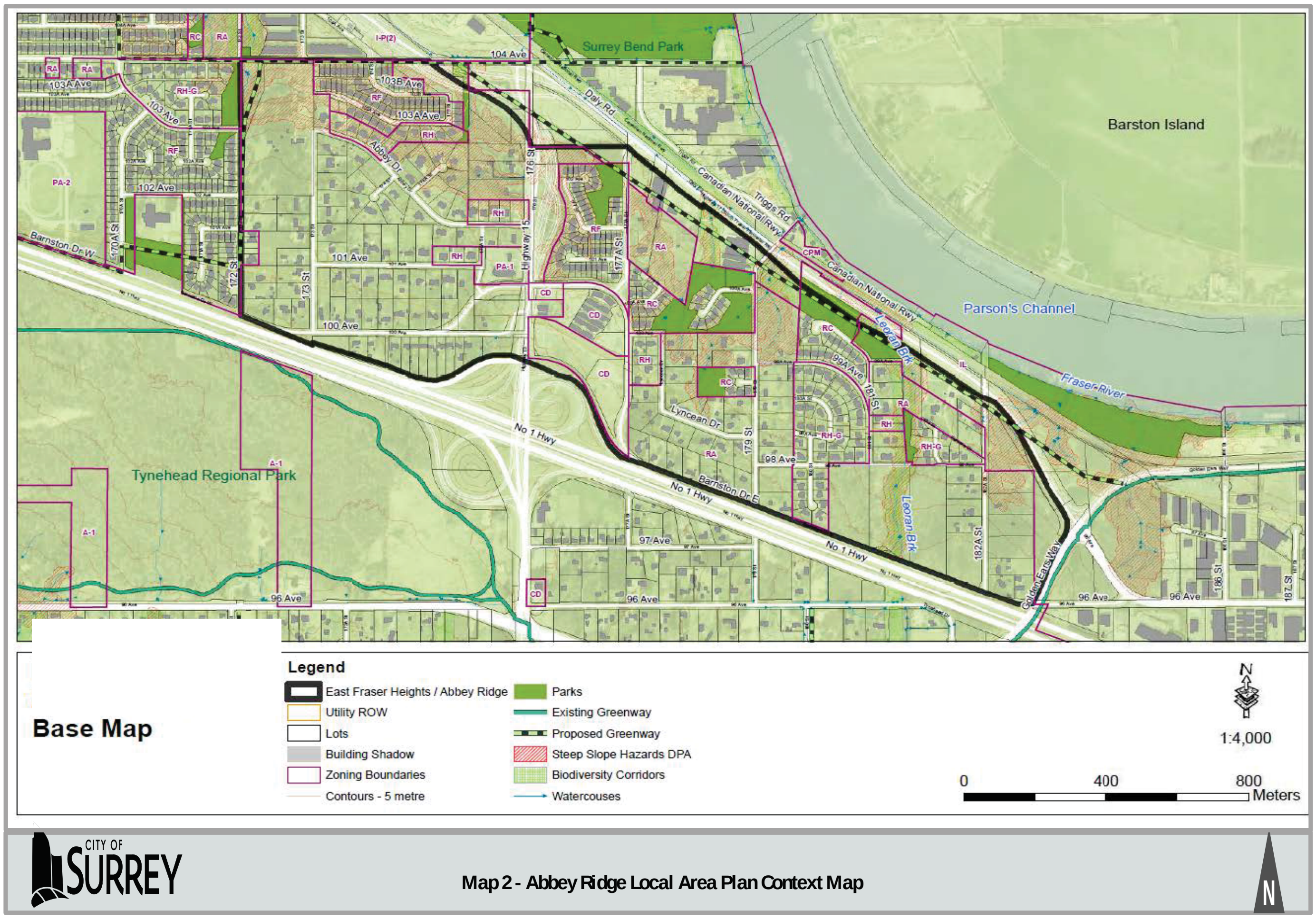
As part of the LAP process Phoenix Environmental Consultants were retained to complete the study with recommendations. This study was completed in June of 2015, and identified several significant environmental features within the LAP area, including Leoran Brook and several other Class A and Class B fisheries watercourses that receive groundwater base flows from springs along the escarpment and ravine slopes.

There are also numerous Class C drainage watercourses and ditches along property boundaries and roads within the LAP.



Map 1 - Abbey Ridge Local Area Plan Boundaries

1.3



Map 2 - Abbey Ridge Local Area Plan Context Map

1.4
CURRENT LAND USES & POPULATION

The majority of the Abbey Ridge LAP neighbourhood is currently occupied by residential uses.

The residential neighbourhood is made up of a mix of large suburban properties, undeveloped and rural lots and pockets of higher-density urban subdivisions and developments that have been approved on a case-by-case basis over the last 5 – 10 years.

Existing Land Uses

The majority of the area is designated Suburban in the Surrey Official Community Plan ("OCP"), with areas of Industrial designation in the north and east areas adjacent to Highway 17. The Suburban areas include,:

- 140 properties zoned One Acre Single Family Residential (RA) Zone;
- 25 properties zoned Half-Acre Single Family Residential (RH) Zone;
- 54 properties zoned Gross Density Half-Acre Single Family Residential (RH-G) Zone;
- 35 properties zoned Cluster Residential (RC) Zone; and
- 1 property zoned Assembly Hall 1 (PA-1) Zone, occupied by a church

Existing Residential Units & Population

There are approximately 522 residential dwelling units existing in Abbey Ridge LAP area, with a population of approximately 1,767 people. This works out to approximately one residential unit and 3.9 persons per acre.

It is also estimated that there a currently some 135 secondary suites within the existing residential areas with an estimated population of approximately 258. In total, the existing population for the area is estimated to be approximately 2,500 including residents in secondary suites.

1.4

Existing Parks

There are currently no active parks within the LAP area, however, a number of the cluster-zoned single-family neighbourhoods (RC or RH-G zones) include parkland areas that were conveyed to the City upon rezoning. These lands typically include riparian areas or other undevelopable lands, and total approximately 18.7 acres (7.7 hectares).

Two large regional parks are located adjacent to the LAP area. Surrey Bend Regional Park is primarily a natural area, with limited trail development along the Fraser River shoreline and a new playground and picnic area. Tynehead Regional Park is a large and diverse park with a mix of forests and fields, a fish hatchery, parking areas and a paved perimeter trail. The LAP area connects with Tynehead Regional Park via a pedestrian overpass across Highway 1 at 168 Street.

Schools

There are no schools located within the Abbey Ridge LAP area. Children living in the area fall within the Bothwell Elementary School catchment. This school is located along 102 Avenue, just to the west of the study area and, according to School District No. 36 staff, has current capacity for an additional 150 students.

The local public Secondary School is Fraser Heights Secondary, which is currently at capacity and includes portable classrooms. There is also a large independent school, Pacific Academy, located west of the study area at the corner of Barnston Drive and 168 Street.

Public Facilities

City of Surrey Fire Hall #5 is located on Barnston Drive, immediately east of Highway 15/176 Street.

Public Assembly Uses

A Korean Central Presbyterian Church is located 10110 175 a St, at the intersection of Highway 15/176 street and 100 Avenue.

1.5 OPPORTUNITIES AND CONSTRAINTS

Given the increased development interest and pressures, and the significant transportation and servicing related challenges and changes occurring in the area, a Land Use Concept Plan for the Abbey Ridge area ensures a coordinated plan which guides future development, and ensures appropriate neighbourhood consultation for envisioning the future Neighbourhood character of the Abbey Ridge area.

The Land Use Concept Plan, and LAP servicing and financial strategy are grounded in an overall vision and planning objective direction for the area, to ensure land use changes occur in a proactive and projected manner, rather than through incremental and piecemeal responses to individual development applications.

Main Planning Issues

Transportation

The street network in the LAP area is relatively disconnected due to the limited-access Provincial highways that surround and bisect the study area and ravines that limit the connectivity of local street networks. There is limited and disconnected pedestrian and cycling infrastructure in the area and there is no transit service available at this time.

The construction of the South Fraser Perimeter Road (Highway 17) and improvements to the Highway 1/Highway 15 interchange over the past few years have changed the character of the area and affected vehicular access into the existing neighbourhoods and between the western and eastern parts of the study area. While the major Provincial highways have made this area more readily accessible to and from other parts of the region, these highways also limit access points into parts of the neighbourhood.

Future connections to the Golden Ears Way Connector will address this issue to a degree, but connectivity across the area will remain a challenge.

Sanitary Sewer

The study area is currently serviced by a 600 mm to 750 mm diameter sanitary trunk sewer (known as the Big Bend Trunk) that traverses the hillside from east to west through the study area. The Big Bend Trunk captures sanitary flows from the southern portions of the study area, as well as pumped flows from the Port Kells Sanitary Pump Station (located at 98 Avenue and 190 Street) which services the Port Kells industrial area to the east. The trunk sewer discharges to the Big Bend Sanitary Pump Station at 176 Street and 104 Avenue. This pump station pumps sanitary flows via forcemain to Metro Vancouver’s North Surrey Interceptor at 173 Street and 104 Avenue. Most of the properties north of the Big Bend Trunk are not serviced by the City’s sanitary sewer system due to topographical constraints; instead, existing buildings in this area rely on private, on-lot septic field systems.

Several sections of the Big Bend Trunk have been identified as having capacity constraints under current flow conditions, including several sections east of 179 Street. Further, two sections of the trunk sewer west of 179 Street will experience capacity constraints in the near future. Limited upgrade works have been completed to date to address the capacity constraint issues. Some of the constrained trunk sewer sections traverse existing subdivisions, which may pose a challenge when implementing future upgrades.

The Big Bend Sanitary Pump Station does not have sufficient capacity to accommodate the projected increase in flows under future development conditions. Station upgrades will be required to accommodate future development and/or infill densification in the catchment area.

However, undertaking station upgrades may be challenging due to the station’s elevation (approximately 3 metres geodetic) and proximity to the Fraser River floodplain. Currently, the station has the potential to flood during freshet conditions (roughly corresponding to a 10 year return period). The City’s long term strategy is to relocate the Big Bend Sanitary Pump Station to a higher elevation.

Water

Under current conditions, some parts of the study area are serviced by the municipal water system, with the remaining areas serviced by private groundwater wells. In order to accommodate the proposed development in the study area, the municipal water system needs to be expanded and enhanced. Water supply to the area is currently provided by a 525 mm diameter feeder main on 96 Avenue, which is supplied by a direct connection to Metro Vancouver's transmission main. This feeder main does not have the capacity to support future development conditions in the study area; however, a secondary water source could be provided via the Whalley Reservoir at 14619 - 104A Avenue and its associated feeder main network.

Topographical conditions will require that two separate pressure zones be established for the study area. The majority of the study area is located within the lower pressure zone (90m). A 400mm feeder main, which has already been partially constructed and connected to the existing pressure reducing station at Cherryhill Court, would need to be extended to supply the 90m zone.

A network of distribution mains would also be required from this feeder main to service the study area and improve network connectivity. Due to its higher elevation, the southwestern portion of the study area is located within the high pressure zone (135m). Currently, there is no municipal water system in this area. The proposed feeder main identified in the Anniedale-Tynehead NCP could be used to provide water supply to this portion of the study area. A network of distribution mains would also be required.

Drainage

Based on topography and the existing drainage network, the LAP area is divided into two major catchments at 176 Street. Areas west of 176 Street drains to watercourses within Surrey Bend Regional Park (Metro Vancouver), while areas east of 176 Street drain to an industrial area on the shoreline of the Fraser River. Both of these catchments pass under the CN Railway via culvert crossings, which may be undersized for future development conditions. Existing drainage infrastructure consists of a combination of roadside ditches and storm sewers, which outfall to several Class A and B watercourses. The watercourses have well-defined channels and generally drain northeast towards the Fraser River. Most of these watercourses have previously identified erosion concerns.

The northern portion of the study area is within the Fraser River floodplain and is not protected by a dyke. Improvements may be required in this area to support future development.

Stormwater management, drainage infrastructure improvements and on-lot source controls will be required to support future development, mitigate upland creek erosion and flooding issues in the lowland portions of the LAP area, and ensure existing habitat values and base flows in the watercourses are not compromised.

Environment

Surrey's Biodiversity Conservation Strategy identifies a Green Infrastructure Corridor in the LAP area along Leoran Brook north to the Fraser River and east towards Surrey Bend Regional Park. This corridor is intended to be secured through the development process, to provide wildlife passage from the Fraser River to the Anniedale and Tynehead Biodiversity Hubs.

Kinder Morgan Trans-Mountain Pipeline

The existing Kinder Morgan Trans-Mountain pipeline transverses the LAP area. The Pipeline corridor consists of an 18.6 metre right-of-way. In the late 1990s, the Utilities Commission placed a 30 metre approval zone on either side of the pipeline right-of-way, with all land owners requiring permissions to do construction works on their properties in the approval zone. The approval zone was established in an effort to ensure the pipeline was not affected by adjacent works. The pipeline corridor and approval zone will need to be considered when making land use and servicing decisions for the area.

Kinder Morgan Trans-Mountain Pipeline is also planning to twin their infrastructure in this area. Due to the development that has already occurred adjacent to the existing alignment, the company is currently proposing to install the new pipeline near the base of the escarpment adjacent to Daly Road. The alignment of the new pipeline will also impact development in the LAP area. At this time, the corridor under investigation by Kinder Morgan and presented to the Utilities Commission should be considered in the land use planning for the area.

Development Applications

A number of development applications have been received by the City, seeking to develop residential areas at urban densities that involve an OCP amendment to Urban, Multiple Residential or Commercial designations.

These applications amended the OCP from suburban to urban, and include a total of 123 properties zoned Single Family Residential (RF) Zone in three locations, and the Multiple Residential and Commercial areas encompassing a single large development site zoned Comprehensive Development (CD) permitting the construction of up to 80 townhouse units and up to 435 units in six low-rise apartment buildings along with neighbourhood commercial space.

The build-out of the adjacent Fraser Heights west neighbourhoods, the improvement of access to the area brought by the South Fraser Perimeter Road, the excellent views available and the general shortage of serviceable lands for new single-family development in the Metro Vancouver region are cited as reasons for this development interest.

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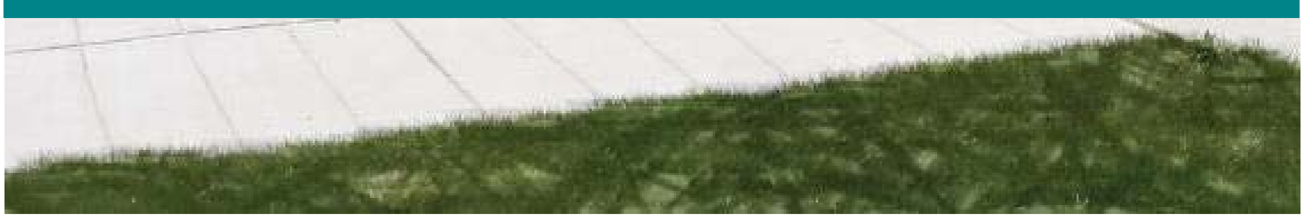
SECTION 2
Vision and Planning Objectives



2
VISION AND PLANNING OBJECTIVES

To develop a neighbourhood vision for the Abbey Ridge LAP, residents and stakeholders where asked what the neighbourhood was like before, what it is like currently, and what they want the neighboured to be like in the next five to twenty five years. A draft vision statement was then created based on the key words and feedback received during the consultation process for the LAP and based on sustainable development and sensitive infill best practices.

In addition to a vision statement for the Neighbourhood, eight Planning Objectives were developed to guide the Stage I Land Use Concept Plan during the consultation process.

The Abbey Ridge LAP is reflective of the Vision and Planning Objectives contained in Section 2. The Land Use Concept Plan incorporates feedback received from property owners, the Fraser Heights Community Association and other stakeholders, as well as comments received from the public the October 1, 2015 public open house and the October 18, 2016 public open house. Based on feedback forms returned to the City, over 68% of those residents within the plan area indicated some level of support for the Abbey Ridge LAP land use concept, and minor refinements to the plan where made to better address areas of expressed concern, specifically:

- adjustments to the densities and transitions along Lyncean Drive and Barnston Drive East;
- refinements to the transitional densities around the acreage properties in the Abbey Drive area;
- the location of a proposed neighbourhood park on Lyncean Drive; and
- adjustments to the land use and density in the eastern part of the LAP.

2.1 VISION

A Neighbourhood Vision for the Abbey Ridge Neighbourhood was developed in consultation with community residents which envisions:

"An attractive and beautiful neighbourhood whose growth is planned to respect and complement the character of existing residential areas and the unique location of Abbey Ridge within the City of Surrey."

Visioning Principles

Respectful Design

Building design respects the scale and character of the neighbourhood, while providing a range of ground oriented housing forms, and choices. There is compatibility of new development with existing, and higher density housing is located primarily on appropriate sites along Barnston Drive, and adjacent to Highway 1 and Golden Ears Way.

Appropriate Transitions

Appropriate setbacks and transition areas for building heights and scale are encouraged along the edges of lower density and suburban residential areas.

Preserved Environment

The preservation of key natural areas, wildlife passages, large trees, and a respectful transition between urban and natural areas is encouraged, with lower density and cluster townhouse forms of housing surrounding environmentally sensitive lands.

Connection to Nature

Access to nature and recreation is provided through parks and greenways connections provided through the centre of the community, with greenway connections continued to the West Fraser Heights area and to neighbouring Regional and City parks.

Integrating Green Places

Incorporation of Green spaces and the clustering of homes along riparian areas, steep slopes and areas of high value tree stands is preferred in order to buffer the impact of urban development on environmentally sensitive areas.

Sense of Place

The local history, heritage, and unique character of the Abbey ridge Neighbourhood is respected while promoting the creation of new places.

2.2 OBJECTIVES

Eight Planning Objectives were developed to guide the Land Use Concept Plan during the consultation process based on the overall Vision for the Neighbourhood outlined in section 2.1.

Planning Objectives

1. Protect established areas

Retain and protect existing established and stable suburban neighbourhoods.

2. Provide appropriate land use transitions

Provide an appropriate interface between new and established neighbourhoods through compatible density, form and scale of housing, and through landscaped and natural buffers.

3. Protect environmental areas

Protect riparian areas and wildlife corridors through dedication or land purchase, and retain significant stands of trees where feasible on development sites.

4. Provide housing choice

Provide for housing choice through selected areas of higher density along the Highway 1 corridor, supporting transit service and local retail.

5. Develop an integrated local road network

Develop an integrated local road network providing connections within the plan area, and connections to surrounding areas.

6. Develop pedestrian and cycling network

Develop a network of pedestrian and cycling routes, including connections to the Fraser Heights Greenway and to adjacent regional parks.

7. Establish neighbourhood level parks

Locate and develop neighbourhood parks in each sub-area, serving local residents.

8. Provide an equitable servicing and financial strategy

Develop a servicing strategy and financial strategy that ensures an equitable and sufficient contribution for development to infrastructure improvements and community amenities.

SECTION 3
Land Uses

3
Land Uses

The following section provides a general description of each of the land use designations in the Abbey ridge Land Use Concept, as shown in **Map 3.**

The Abbey Ridge Land Use Concept envisions a primarily single family residential neighbourhood with one small commercial area and a few strategically located townhouse and/or multiple family blocks. The plan also provides for the preservation of the majority of the industrial lands along the north eastern edge of the plan in order to maintain employment land opportunities.

The Abbey Ridge Local Area Plan includes specific provisions for:

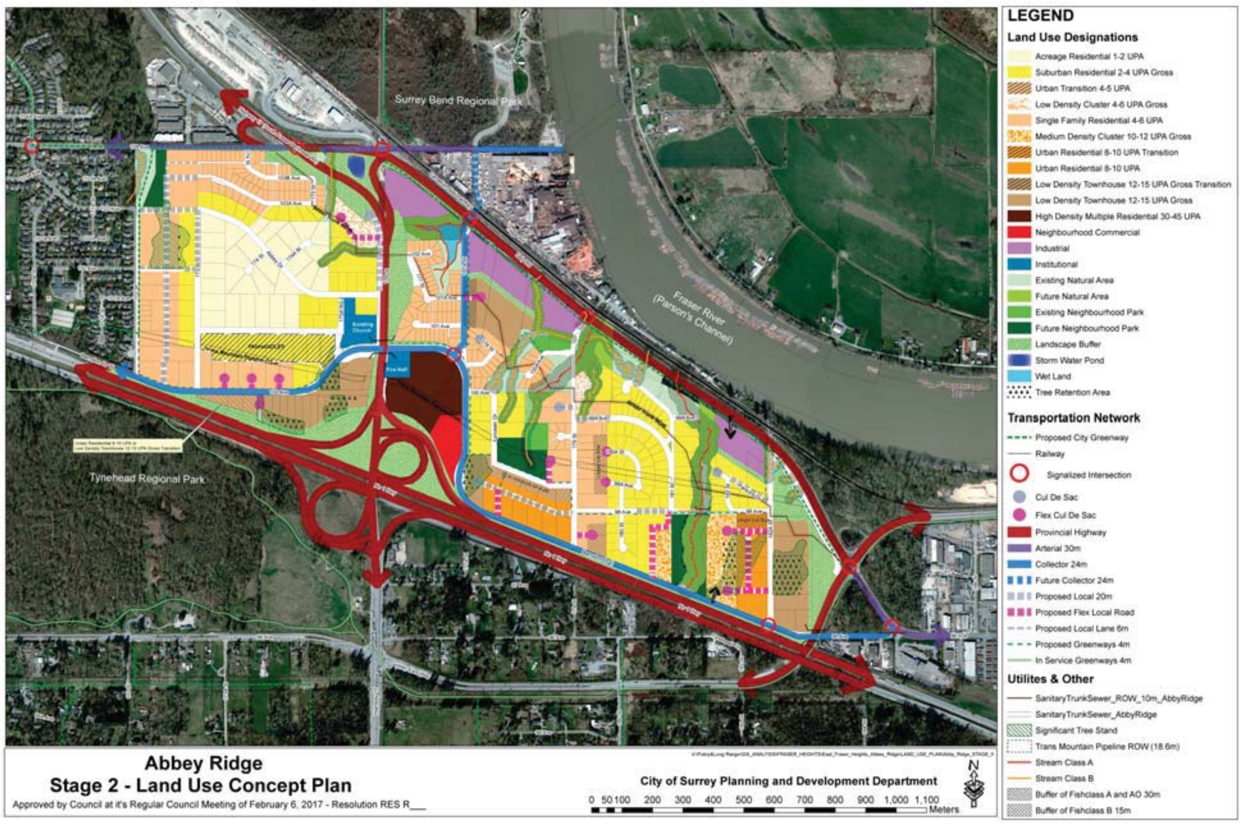
1. the retention of existing established and stable suburban/urban neighbourhoods;
2. appropriate interfaces between new and established areas;
3. protection of riparian areas and wildlife corridors and retention of significant tree stands;
4. additional housing choice through strategic areas of multifamily and urban single family areas along the Highway 1 corridor and Highway 17 (South Fraser Perimeter Road);
5. a more cohesive local road network providing connections within the plan area, and connections to the surrounding areas;
6. a network of pedestrian and cycling routes, including future connections to the Fraser Heights;
7. greenway and adjacent regional parks; and
8. inclusion of neighbourhood parks in each of the Neighbourhoods sub-areas, to serve local needs.

3.1 SUMMARY OF LAND USES

The summary of land use designation areas are shown in Table 1 below, with base densities requirements identified, as well as typical building form(s).

Table 1 - Summary of Land Uses

Land Use Designation	Density	Typical Building Form
Acreage Residential	1-2 UPA	Detached Single Family
Suburban Residential	2-4UPA	Detached Single Family
Urban Transition	4-5 UPA	Detached Single Family
Low Density Cluster	4-6 UPA	Detached Single Family
Single Family Residential	4-6 UPA	Detached Single Family, Semi-Detached
Urban Residential	8-10 UPA	Small Lot Detached Single Family
Urban Residential Transition	8-10 UPA	Single Family, Semi-Detached
Medium Density Cluster	10-12 UPA	Single Family, Semi-Detached, Multi-family, 2 Story Townhouse
Low Density Townhouse	12-15 UPA	2-3 Story Townhouse,
Low Density Townhouse Transition	12-15 UPA	2 Story Duplex, Semi Detached Form
High Density Multiple Residential	25-30 UPA	3 Story Townhouse, Low Rise 4 Storey Apartments
Commercial	0.5 FAR	1 to 2 Storey Commercial Buildings
Institutional	0.3 FAR	Public Institutional Buildings
Industrial	0.5 FAR	Light Industrial Buildings



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Map 3 - Abbey Ridge Land Use Concept Plan

3.2

3.2 LAND USE PROJECTIONS

Table 2 below, summarizes the residential unit and population projection estimates for the LAP area based on the Land Use Concept shown in Map 3. A summary of the existing population and units and the land use projections area are also generally provided.

Table 2- Abbey Ridge LAP Building Projections

Abby Ridge Stage 2 - Land Use Plan Buildout Unit and Population Scenario December 2016

Land Use	Acres	Area %	Existing Units	Projected Low Units	Projected Avg Units	Projected High Units	Existing Population	Projected Low Population	Projected Avg Population	Projected High Population	Number of Existing Secondary Suites	Projected Secondary Suites	Existing Secondary Suite Population	Projected Secondary Suite Population	Possible Non-residential Floor Area	Projected Employment
Roads	90.9	21.3%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wet Land	1.6	0.4%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storm Water Pond	0.9	0.2%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landscape Buffer	25.9	6.1%	1	0	0	0	2	0	0	0	0	0	0	0	0	0
Existing Natural Area	16.0	3.8%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Natural Area	21.9	5.1%	2	0	0	0	6	0	0	0	0	0	0	0	0	0
Sanitary Trunk Sewer Buffer	4.6	1.1%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Neighbourhood Park	2.7	0.6%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Neighbourhood Park	7.8	1.8%	4	0	0	0	14	0	0	0	0	0	0	0	0	0
Industrial	16.1	3.8%	2	0	0	0	7	0	0	0	0	0	0	0	351,699	382
Institutional	4.7	1.1%	0	0	0	0	0	0	0	0	0	0	0	0	53,372	67
Neighbourhood Commercial	3.6	0.8%	0	56	56	56	0	152	152	152	0	0	0	0	7,265	10
Acreage Residential 1-2 UPA	30.9	7.2%	29	30	31	31	104	104	106	107	0	2	0	4	0	0
Suburban Residential 2-4 UPA Gross	65.0	15.2%	161	189	222	254	536	682	798	914	24	111	48	378	0	0
Urban Transition 4-5 UPA	6.2	1.5%	6	25	28	31	21	85	95	106	0	14	0	57	0	0
Low Density Cluster 4-6 UPA Gross	3.1	0.7%	4	12	15	18	12	41	50	59	1	5	2	19	0	0
Single Family Residential 4-6 UPA	62.3	14.6%	305	415	450	485	914	1,285	1,404	1,523	107	225	204	586	0	0
Urban Residential 8-10 UPA	13.9	3.3%	19	112	126	140	64	313	352	391	2	60	4	160	0	0
Urban Residential 8-10 UPA Transition	1.2	0.3%	2	9	10	11	7	25	28	31	0	5	0	11	0	0
Medium Density Cluster 10-12 UPA Gross	9.3	2.2%	0	93	102	111	0	252	277	302	0	50	0	109	0	0
Low Density Townhouse 12-15 UPA Gross	26.4	6.2%	22	312	354	396	75	1,046	1,188	1,329	0	0	0	0	0	0
Low Density Townhouse 12-15 UPA Gross Transition	0.9	0.2%	0	10	12	13	0	35	40	44	0	0	0	0	0	0
High Density Multiple Residential 25-30 UPA	11.2	2.6%	190	335	408	480	481	876	1,073	1,269	0	0	0	0	0	0
Total	**427.2**	100.0%	**747**	**1,598**	**1,813**	**2,027**	**2,242**	**4,896**	**5,563**	**6,229**	**134**	**472**	**258**	**1,326**	**412,336**	**459**

Population and Dwelling Unit Estimates

Based on the proposed Stage 2 Land Use Concept shown in Map 3, approximately 1,090 new additional residential dwelling units and a population increase of approximately 3,432 people is expected based on average projections at full build out of the LAP. Of these, it is expected that 217 new residential units housing some 591 people are expected within the approved townhouse/apartment site located east of 176 Street and south of Barnston Drive.

At full-build out (approximately 15 to 20 years from today), Abbey Ridge is projected to have a total of 1,812 dwelling units, with a total projected population of 6,888 (including 1,326 within suites) based on the proposed Stage 2 Land Use Concept.

Residential Growth Potential Areas

The Abbey Ridge LAP contains a mix of developed and undeveloped lands, with small remnant areas of limited infill potential, enclaves of suburban estates and more recent urban subdivisions, as well as some areas where additional infill growth may be accommodated in the future.

Map 4 shows these anticipated "limited growth", "suburban infill", and "future growth" areas based on the Land Use Concept. A summary of the residential unit and population projections are summarized below:

Limited Growth Area

This area includes 103 Acres or nearly 23% of the LAP area. There are currently 412 residential units within this area and very limited or no additional growth is projected. This area contains about four units per acre.

Suburban Infill Area

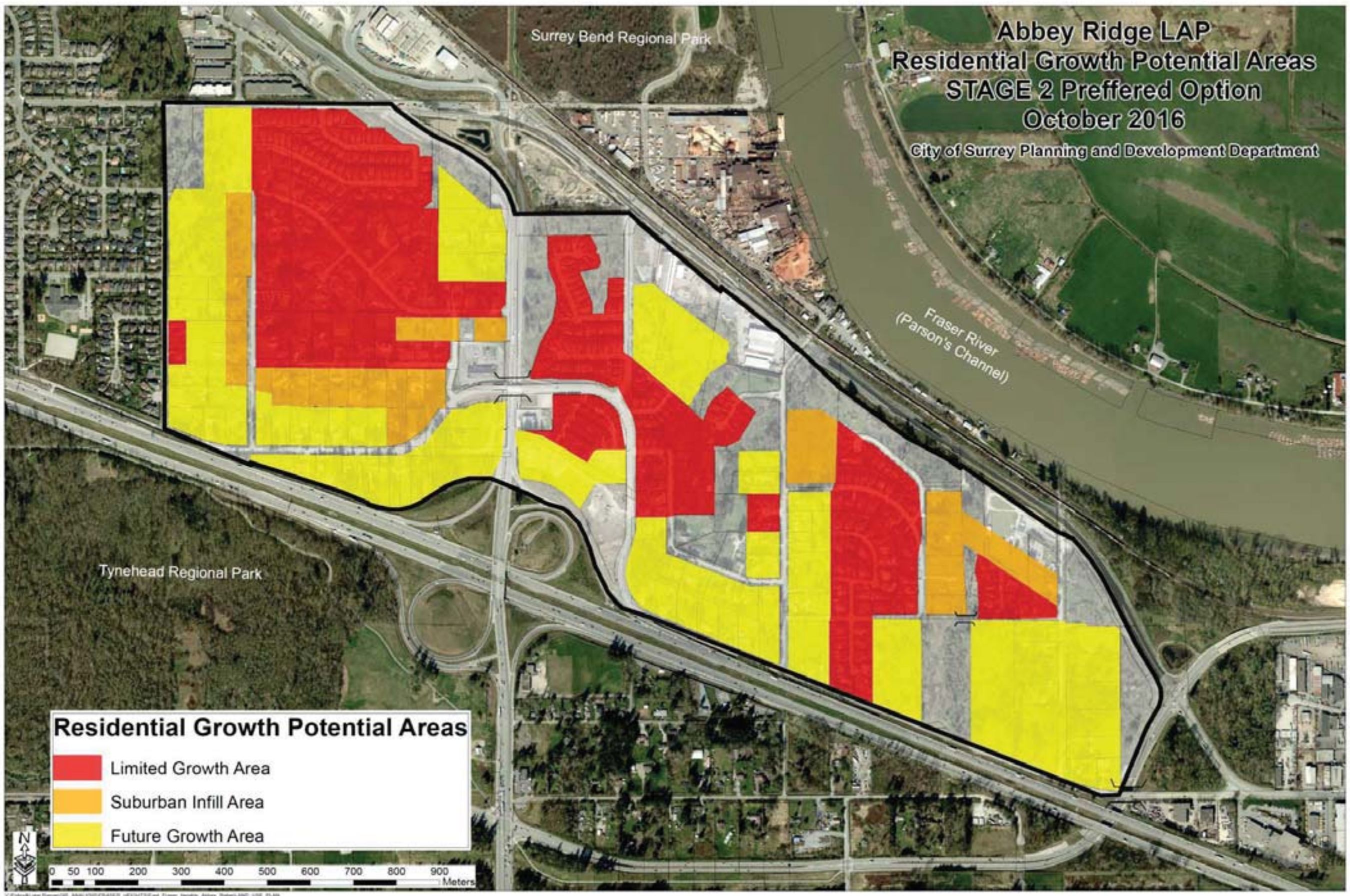
This area includes 25 Acres or 5 % of the LAP area. There are currently 23 existing residential units within this area, but has the potential for about 72 total units in the future. This area at build out will contain about three units per acre.

Future Growth Area

This area includes 136 Acres or 30% of the LAP area. There are currently 87 existing residential units within this area, but there is the potential for about 1,088 units in the future. This area at build out will contain about eight units per acre.

Areas not located within Future Urban Growth, Limited Growth, or Suburban Infill Areas

This area includes 188 Acres or 42% of the LAP area. There are no residential units within this area, and there are no units projected in the future. This area is intended for roads, landscape buffers, parks, industrial, institutional and commercial uses.



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Map 4 - Abbey Ridge Residential Growth Potential Areas

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3.3 RESIDENTIAL USES

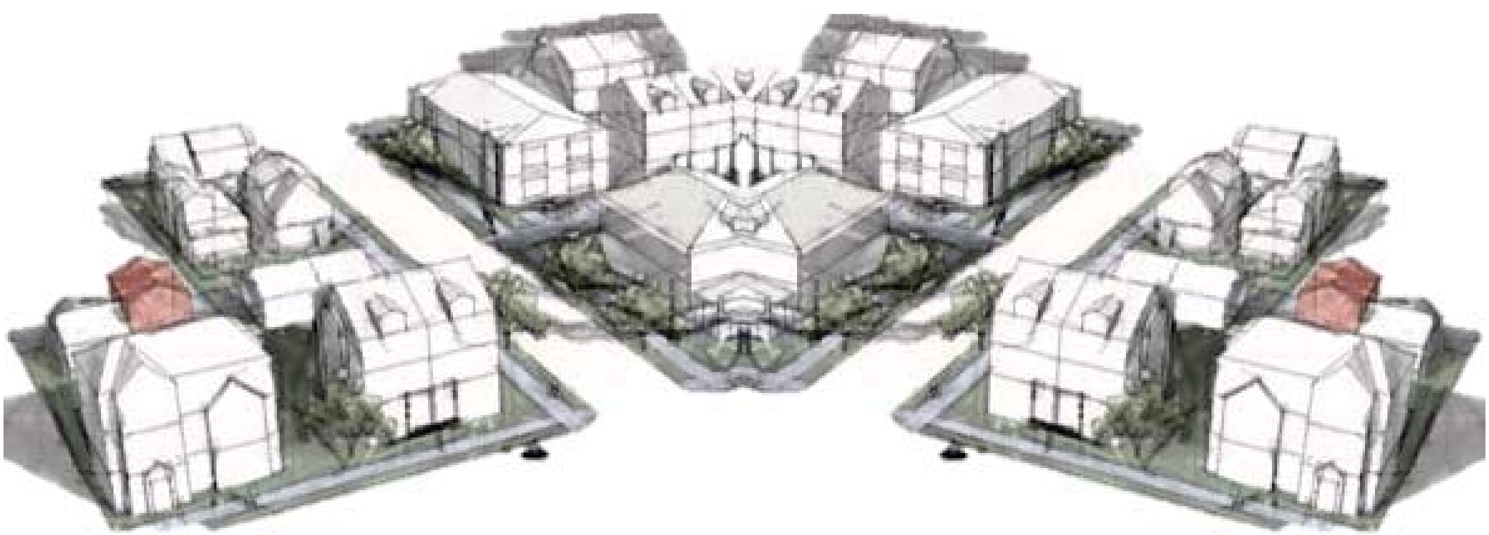
The Abbey Ridge Land Use Concept includes 10 residential land use designations, including:

- Acreage Residential
- Suburban Residential
- Single Family Residential
    - Urban Transition
- Low Density Cluster
- Medium Density Cluster
- Urban Residential
- Low Density Townhouse Residential
    - Low Density Townhouse Transition
- High Density Townhouse Residential

General Overview

Six of the designations allow only detached single family dwellings, and two are cluster housing designations that provide for both ground oriented single family dwellings and attached units depending on site conditions and open space provisions.

The two remaining designations allow multi-family development such as townhouses.



ACREAGE RESIDENTIAL

The Acreage Residential designation is intended to maintain an enclave of existing single family estates on one acre lots located in the Abbey Drive area. This designation may allow for subdivision to half acre suburban lots if site conditions permit, although it is expected that the majority of lots will remain one acre or larger for some time into the future, based on the current housing condition, housing age, and house location on the lots.

Development Guidelines:

- Densities may range up to a maximum of 5 units per hectare (2 units per acre).
- Densities may be calculated on a gross site area where sufficient parkland and/or community benefit is provided.
- Typical Zones or base zones that will be considered may include:
    - One-Acre Residential (RA) Zone;
    - Half-Acre Residential (RH) Zone;
    - Gross Density Half-Acre Residential (RH-G) Zone.

Example of Typical Acreage Residential lot with large single family home.

3.3

Suburban Residential

The Suburban Residential designation is intended to support larger residential lots. Three areas, totalling 66 acres of land, are designated Suburban Residential, including both existing subdivisions and areas that may be subdivided in the future to this density.

Development Guidelines:

- Densities may range up to a maximum of 10 units per hectare (4 units per acre).
- Densities may be calculated on a gross site area, where the minimum lot sizes may be reduced to no less than of 8,000 square feet and sufficient parkland or open space no less than 15% of the gross site area.
- Typical zones or base zones that will be considered may include:
  - o Gross Density Half-Acre Residential (RH-G) Zone.
  - o Single Family (RF) Zone.
  - o Residential Cluster (RC) Zone.
- Pan-handle lots may be considered for Suburban Residential designated areas encumbered by the Trans Mountain Gas Pipeline right-of-way for the areas south of 101 Avenue where deemed appropriate.

An example of a typical suburban panhandle lot with limited road access available, adjacent to an encumbrance.

Example of Typical Suburban Residential lot with large single family home.

Single Family Residential

The Single Family Residential designation is intended to support detached housing on typical urban sized lots. This designation is proposed in areas throughout the LAP, including both existing subdivisions and future subdivision areas.

Development Guidelines:

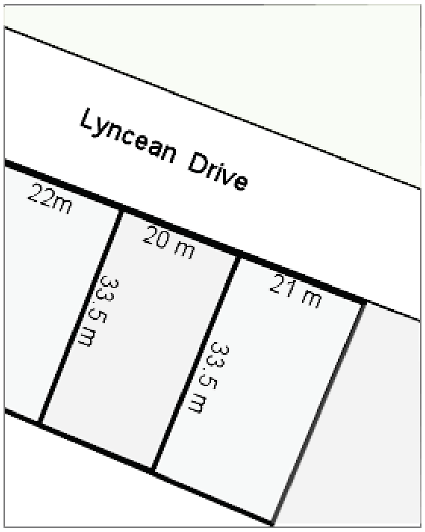
- Densities may range from 10 units per hectare (4 units per acre) up to a maximum of 15 units per hectare (6 units per acre).
- The calculation of unit density shall exclude the undevelopable area from the total area of the lot.
- Typical lot sizes may range between 7,200 to a minimum 6000 square feet.
- Typical Zones or base zones that will be considered may include:
    - Single Family Residential (RF) Zone;

Typical 15 m-20 m wide Residential Single Family (RF Zoned) 6000 square foot lot.

Urban Transition Area(s)

Special Considerations:

- Intended to support detached single-family residential development on lots that are somewhat wider and larger than the typical Single Family Residential designation to provide a sensitive interface transition for lands adjacent to existing Suburban Areas.
- Densities within the Urban Transition areas may range from 10 units per hectare (4 units per acre up to a maximum of 12.5 units per hectare (5 units per acre).
- The Urban Transition areas of the 180A Street and 98A Street cul-de-sacs are intended to provide an appropriate transition to adjacent, larger existing suburban lots, as well as adjacent to existing suburban lots west of 180 streets.
- Lots created through subdivision within the Urban Transition area adjacent to Lyceum Drive will have:
    - a minimum lot width of no less than 20 meters, and
    - a minimum lot area of no less than 7,200 square feet.



Example of Urban Transition sized lots along Lyncean Drive.

3.3

Low Density Cluster Residential

The Low Density Cluster Residential designation allows for housing on smaller urban lots, with substantial public parkland or strata open space set aside within the subdivision. This designation will only be considered if there are special amenities such as mature trees/vegetation, watercourses, steep slopes, ravines or other landscape features worthy of preservation; or the lot can contribute open space to a park and/or biodiversity preservation area.

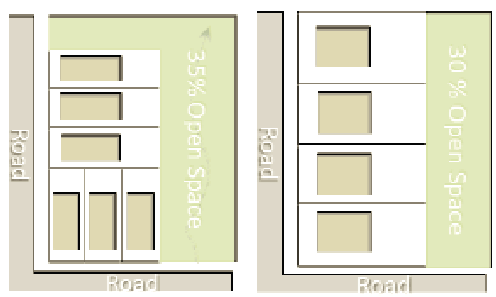
Development Guidelines:

- Densities may range from 10 units per hectare (4 units per acre) up to a maximum of 15 units per hectare (6 units per acre) calculated on the bases of the entire lot.
- The calculation of unit density may include gross site area where opens space in an amount of not less than 15%-30% of the lot is preserved in its natural state or retained for park or strata open space.
- If special amenities or open space are not provided, the calculation of unit density shall exclude the undevelopable area from the total area of the lot and be calculated on the net Developable Area of the lot only.
- Typical single family lot sizes may range between 6,000 to a minimum 4,000 square feet, with a minimum lot width of no less than 13.4 metres.
- Typical Zones or base zones that will be considered may include:
  - Single Family Residential (RF) Zone
  - Single Family Residential Gross Density Zone (RF-G);
  - CD Zone based on Cluster Residential (RC) Zone if Open Space provided.

Typical Cluster Residential Small lot development

Special Considerations:

- This designation may include a bare land strata housing to more efficiently and effectively utilize the land, at the discretion of the City of Surrey Approving Officer.
- Housing types may include: single family dwellings, and/or a combination of single family, semi-detached or duplex dwellings as long as the amount of open space is provided in proportion to the housing types.
- Special Amenity areas provided as Open space may include:
  - Utility rights-of-way, excluding City Services;
  - Tree Preservation Areas;
  - Steep slopes greater than 15%;
  - Riparian Areas beyond typical streamside protection setbacks;
- Green Infrastructure Areas, and/or similar features, which make the said portion of the lot unsuitable for the placement of buildings and structures.
- Streamside Protection Setbacks shall be determined by the Streamside Protection Section of the Surrey Zoning Bylaw, No 1200, and may not be included unit density calculation.



Example of 30-35% open space provided on a 1 acre Low Density Cluster lot at 4 and 6 UPA.

Medium Density Cluster Residential

The Low Density Cluster Residential designation allows for a mix of single family housing on smaller urban lots and/or ground oriented multiple family residential buildings such as semi-detached, duplex, triplex, or ground oriented townhouses, with substantial public parkland or strata open space set aside within the subdivision. This designation will only be considered if there are special amenities such as mature trees/vegetation, watercourses, steep slopes, ravines or other landscape features worthy of preservation; or the lot can contribute open space to a park and/or biodiversity preservation area.

Development Guidelines:

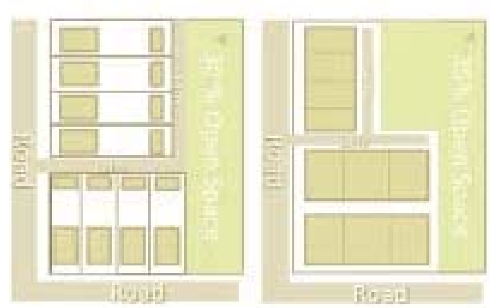
- Densities may range from 25 units per hectare (10 units per acre) up to a maximum of 30 units per hectare (12 units per acre) calculated on the bases of the entire lot.
- The calculation of unit density may include gross site area where opens space in an amount of not less than 15%-30% of the lot is preserved in its natural state or retained for park or strata open space.
- If special amenities or open space are not provided, the calculation of unit density shall exclude the undevelopable area from the total area of the lot and be calculated on the net Developable Area of the lot only.
- A minimum 1 Acre Parcel consolidation is required before within this designation before subdivision will be considered.
- Residential unit lot sizes will vary.
- Typical Zones or base zones that will be considered may include:

  - o CD Zone based on Cluster Residential (RC) Zone.
  - o CD Zone based on Single Family Residential-13 (R13) Zone
  - o CD Zone based on Single Family Residential Gross Density Zone (RF-G);
  - o Semi-Detached Residential (RF-SD) Zone
  - o Multiple Residential (RM-15) Zone

Special Considerations:

- May include a bare land strata housing to more efficiently and effectively utilize the land, at the discretion of the City of Surrey Approving Officer.
- Housing types may include: a combination of single family, semi-detached and/or multiple family housing as long as the amount of open space is provided in proportion to the housing types.
- Special Amenity areas provided as Open space may include:
  - o Utility rights-of-way, excluding City Services;
  - o Tree Preservation Areas;
  - o Steep slopes greater than 15%;
  - o Riparian Areas beyond typical *streamside protection setbacks;
  - o Green Infrastructure Areas, and/or similar features, which make the said portion of the lot unsuitable for the placement of buildings and structures.

**Streamside Protection Setbacks shall be determined by the Streamside Protection Section of the Surrey Zoning Bylaw, No 1200, and setback areas may not be included unit density calculation.*



Example of 30-35% open space provided on a 1 acre Medium Density Cluster lot at 8 and 10 UPA.

Urban Residential

The Urban Residential designation is intended to provide small single-family detached lots at urban densities. This form and density of housing may also be considered in designations that permit higher densities. The areas designated for Urban Residential are found adjacent to Highway 1 along Barnston Drive East:

Development Guidelines:

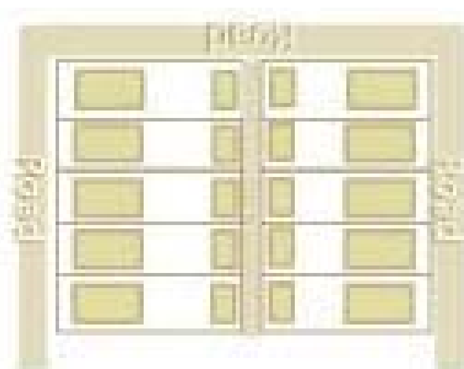
- Densities may range from 25 units per hectare (10 units per acre) up to a maximum of 30 units per hectare (12 units per acre) calculated on the bases of the net developable area of the lot.
- The calculation of unit density shall exclude the undevelopable area from the total area of the lot.
- Typical single family lot sizes may range between 5,000 to a minimum 3,500 square feet.
- For lots served by rear lanes, the minimum lot width may be a minimum of 12 metres, and for lots without rear lanes (front driveways) the minimum lot width is 13.4 metres.
- No front lot driveway access will be permitted along Barnston Drive East Avenue within this designation for traffic safety reasons.
- Typical Zones or base zones that will be considered in the Single Family Residential Designation may include:
    - o Single Family Residential (RF) Zone
    - o Single Family Residential-13 (R13) Zone.

Typical Urban Small Lot 13.4 meter wide front loaded single family lot.

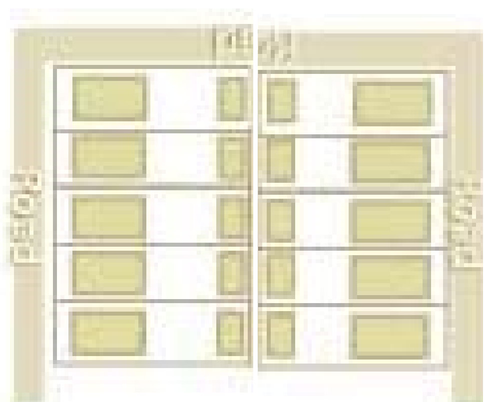
Large Lot Frontage Area

Special Considerations

- A small band of "large lot frontages" is identified within the Urban Residential designation west of 182 Street on the south side of 98 Avenue in order to provide an appropriate transition with existing suburban lots on the north side of 98 Avenue.
- For lots within this designated Larger Lot Frontage area, the minimum lot width must be no less than is 15 metres.



Example of Urban Residential sized lots with rear lane access.



Example of Urban Residential sized lots with 13.4 meter front driveway access.

Low Density Townhouse Residential

The Low Density Townhouse Residential designation is intended to support the development of ground-oriented multifamily residences such as townhouses or duplexes and/or row houses on individual fee simple or strata lots.

Portions of the lands in this designation may be appropriate for lower-density housing such as detached housing, and to provide complimentary transition to lower density areas, depending on site conditions and tree preservation potential.

Development Guidelines:

- Densities may range from 30 units per hectare (12 units per acre) up to a maximum of 37 units per hectare (15 units per acre) calculated on the bases of the entire lot.
- Typical Residential unit size will range between 2,000 to 1,200 square feet.
- Buildings should not exceed 11 meters (36 feet) in height) and will typically include 2 and 2 and ½ story buildings.
- A minimum 1 Acre Parcel consolidation is required before within this designation before subdivision will be considered.
- Typical Zones or base zones that will be considered in the Low Density Townhouse Residential Designation may include:
  - Multiple Family (RM-15) Zone
  - Semi-Detached Residential (RF-SD) Zone

Example of Townhouse Protect incorporating Tree protection in the rear of the lot.

Tree preservation Areas

Special Consideration:

- This designation includes areas of proposed tree preservation, where significant stands of trees have been identified in the Abbey Ridge Environmental Study. These tree retention areas may be incorporated into the open space of a strata development, landscape buffers, and/or may be conveyed to the City as parkland, at the City's discretion, at the time of development where feasible.
- A large landscape buffer of trees and vegetation adjacent to major highways and roads in encouraged to screen residential developments from high traffic areas.
- Incorporation of individual tree specimens within the development site is encouraged where feasible.

Example of tree protection

3.3

High Density Multiple Residential

The High Density Multiple Residential designation is intended to reflect a single, approved higher-density development in the area adjacent to the Highway 1 and Highway 15 interchange along Barnston Drive East.

Portions of this designation are built out, while other are currently under construction, or will be included in future phased development. The area is regulated by a Comprehensive Development Zone that includes townhouses, and low-rise four story apartments. The land use designations in the Abbey Ridge LAP are not intended to affect the current zoning of the site, but provide guidance for any future proposals if there are amendments to the prevailing Comprehensive Development Zone(s).

Development Guidelines:

- Densities may range from 74 units per hectare (30 units per acre) and may not exceed a floor area ratio (FAR) of 1.3 or 112 units per hectare (45 units per acre).
- May include apartment buildings (generally up to 5 storeys, and higher-density townhouses constructed as multiple family buildings.
- Typical Zones or base zones that will be considered in the Low Density Townhouse Residential Designation may include:
  - Multiple Family (RM-30) Zone
  - Multiple Family (RM-45) Zone
  - Multiple Family (RM-70) Zone

Example of typical ground oriented townhouse development.

Example of 5 Storey Residential Apartments proposed in the Hillcrest Comprehensive

3.4 COMMERCIAL

The Commercial designation is intended to support neighbourhood-servicing retail and office developments. Primary uses within the Commercial designation are retail and stand-alone office uses including institutional offices.

Multi-unit residential uses may also be permitted in mixed use development provided that ground-level uses are exclusively commercial. Public facilities may also be considered a permitted use within the Commercial designation.

Development Guidelines:

- Densities within the Commercial designation may range from 0.5 up to 1.0 FAR, subject to an appropriate interface with adjacent residential areas.
- Commercial, multiple unit residential, and mixed use office developments within this designation are subject to the issuance of a Development Permit, in accordance with DP1 of the Official Community Plan.

3.5 INDUSTRIAL USES

The Industrial designation supports light industrial uses, including manufacturing, warehouse, wholesale trade and equipment storage and repair.

Accessory uses that operate ancillary to a main industrial use may include limited office uses, and commercial uses that are strictly limited to those that support in industrial activities.

Development Guidelines:

- Densities within the Commercial designation may range from 0.3 up to 0.5 FAR, subject to an appropriate interface with adjacent residential areas.
- Industrial and mixed use office developments within this designation are subject to the issuance of a Development Permit, in accordance with DP1 of the Official Community Plan

3.6 INSTITUTIONAL USES

There are currently two Institutional designated areas within the LAP accounting for 2.0 hectares (5.0 acres) of land to accommodate existing institutional uses:

- A Korean Central Presbyterian Church, located at 10117 - 176 Street, planned to be maintained and expanded for church uses; and
- Fire Hall #5, located on Barnston Drive, immediately east of 176 Street along Barnston Drive East, which will also remain.

Existing City of Surrey Fire Hall #5 Detachment.

Existing Korean Central Presbyterian Church

School Projections

If current school participation rates in the area continue, it is estimated that as little as 150 elementary students and 150 secondary students would be generated by future development in the LAP. A more cautious scenario, however, is that participation rates may increase as the housing stock is varied to more family oriented housing.

Based upon this precautionary assumption, the Surrey School District No. 36 staff have indicated that the LAP could generate up to 300 additional elementary students and 250 additional secondary students in the Surrey School District system over the total buildout of the plan.

The local elementary school, Bothwell Elementary, has capacity to accommodate the expected growth in the student population, and I the event of higher than anticipated growth the school property is sufficient in size to permit school expansion if required. Based on growth projections, School District staff do not anticipate the need for a new elementary or secondary school site in this LAP.

If development occurs more rapidly than anticipated (two to seven years), and depending on how the rest of the neighbourhood's demographics evolve, it is possible that secondary school catchment changes would have to contemplate sending some of the area school aged children to a secondary school south of Highway 1 to reduce the pressure on Fraser Heights Secondary School.

3.7 LANDSCAPE BUFFER AREAS

Approximately 7.0 hectares (17.4 acres) of landscape buffers are identified in the Abbey Ridge LAP.

Some of these areas are currently within unconstructed road rights-of-way such as the area east of Highway 15, and some areas are future landscape buffers to ensure appropriate interface between industrial and residential areas or between highways and residential areas.

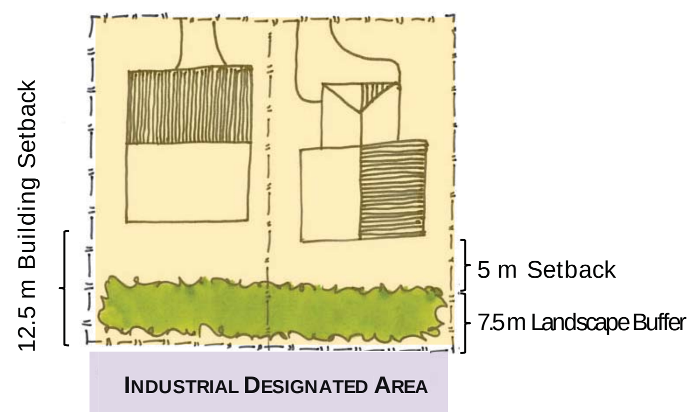
The following section identifies some of the building and landscape buffer guidelines for the LAP.

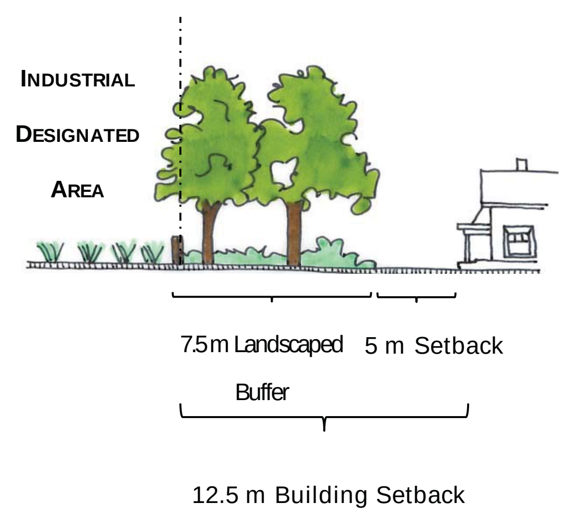
.

Industrial - Residential Buffers

For Residential Developments adjacent to the Industrial Designated lands the following Setback and Buffer requirements apply:

- Minimum building setback from the Industrial Designated Property is 12.5 m
- Zoning setbacks should be increased, where possible, to accommodate appropriate and effective rear yard space for buffers
- Provide a minimum of 5 m of rear yard space between the landscaped buffer and the rear face of a single family dwelling (illustr.)
- Minimum vegetated buffer width is 7.5 m
- Vegetated landscape buffer remains under private or strata ownership.

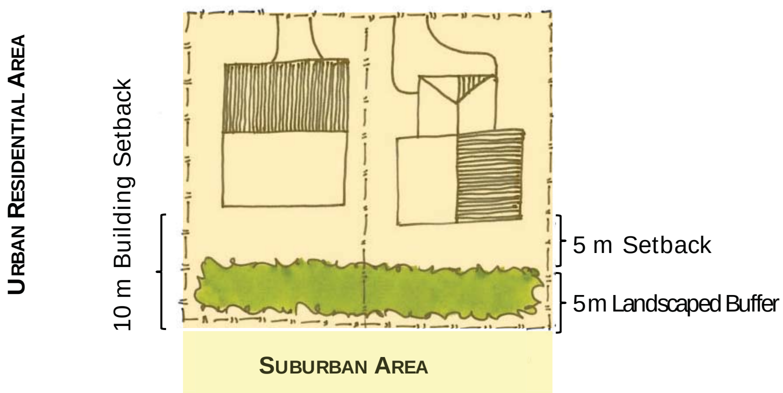


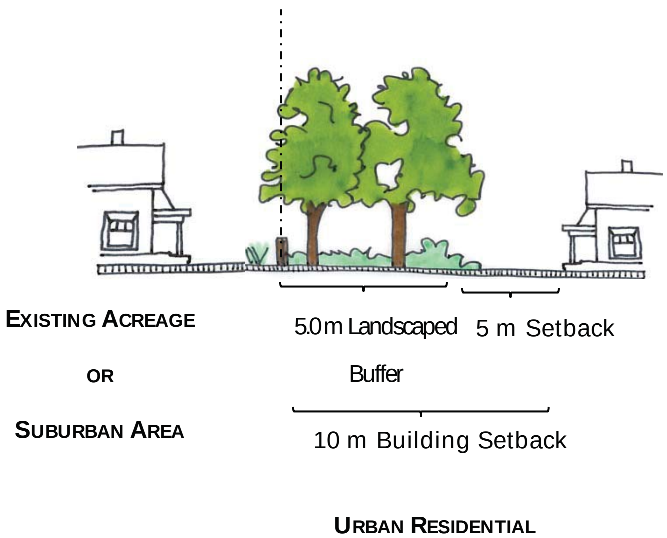


Suburban – Urban Residential Buffers

For Urban Residential Developments adjacent to existing Suburban Residential lands the following Setback and Buffer requirements apply:

- Minimum Urban Residential building setback from Acreage or Suburban Designated property is 10 m
- Zoning setbacks should be increased, where possible, to accommodate appropriate and effective rear yard space for buffers
- Provide a minimum of 5 m of rear yard space between the landscaped buffer and the rear face of a single family dwelling (illustr.)
- Minimum vegetated buffer width is 5 m
- Vegetated landscape buffer remains under private or strata ownership.

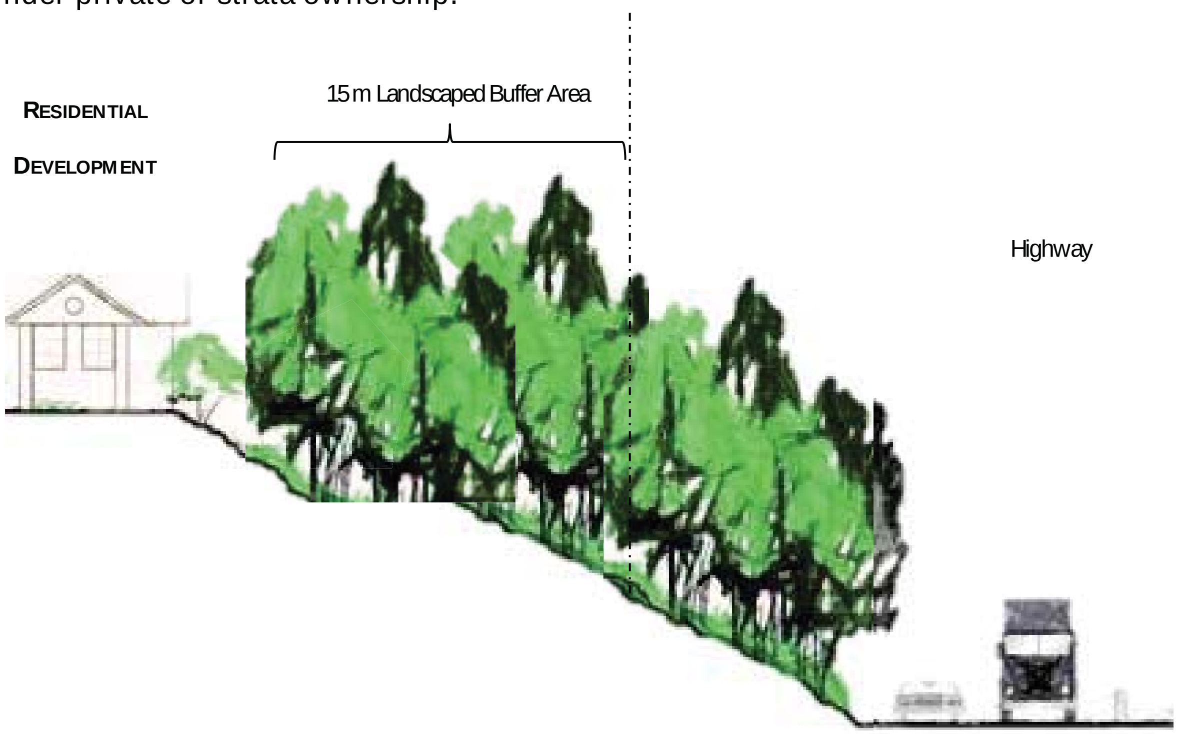




Highway – Residential Buffers

For Residential Developments adjacent to a Highway the following Setback and Buffer requirements apply:

- Minimum Residential building setback from Highway #1 Road Right of Way is 20 m
- Zoning setbacks should be increased, where possible, to accommodate appropriate and effective rear yard space for buffers
- Provide a minimum of 5 m of rear yard space between the landscaped buffer and the rear face of a residential dwelling.
- Minimum vegetated buffer width is 15 m Vegetated landscape buffer remains under private or strata ownership.



3.8
PARKS

Parks amount to approximately 20 hectares (51 acres), or just over 11% of the total LAP area as illustrated in Map 5.

There are currently 8.5 hectares (21 acres) of existing parkland in the LAP.

The LAP identifies, approximately 12 hectares (30 acres) of new parkland. Two types of parkland will be acquired in the LAP area, neighbourhood and natural area parks.

Neighbourhood Parks

A total of 3.1 hectares (7.8 acres) of neighbourhood parks are proposed within the LAP.

Neighbourhood parks provide local park amenities to serve residents and are located to be within walking distance of most residences. Neighbourhood park amenities may include:

- playgrounds;
- passive lawn/open space;
- sports courts (ball hockey/basketball);
- pathways/trails; and
- benches/picnic tables.

For all new neighbourhood park there will be a public engagement process to determine what amenities will be provided in each park.

Existing Natural Areas

A total of 7.5 hectares (18.5 acres) of existing natural area parkland and open space is located within the LAP.

These areas provide some active amenities, contribute to the identity and sense of place for residents living nearby and provide important ecosystem services

Proposed Natural Areas

A total of 8.8 hectares (21.7 acres) of additional natural area parkland is proposed within the LAP.

Natural area parkland accommodates natural amenities such as mature vegetation; watercourses, ravines or other landscape features worthy of preservation and contribute to the open space and green infrastructure of the area. These natural areas are made up of the following:

Riparian Areas

Riparian areas are located along Class A, Class AO and Class B fisheries watercourses that provide for limited or no public access, as their function is to protect sensitive habitat areas, including the land around all significant creeks.

The final amount and location of riparian areas will be subject to Section 7A – Streamside Protection of the *Surrey Zoning Bylaw, No, 12000, 1993*.

Natural Area Amenities

Natural area amenities may include:

- natural area replanting and re-naturalization;
- forest trails; and
- creek crossings where pathways or greenways cross a creek.

Tree Retention Areas

These include significant tree retention areas dedicated to the City as parkland or preserved as open space in strata developments, conveyed during the site development process;

Biodiversity Corridor Areas

Biodiversity Corridors include linear parks that provide natural areas and support wildlife movement to and through the plan area. Where these corridors include lands outside of riparian setbacks they may contain limited active park amenities such as:

- natural areas, reforestation and re-naturalization;
- pathways/trails; and
- benches/ rest areas and viewpoints along pathways and trails

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Map 5 - Abbey Ridge Parks and Natural Areas

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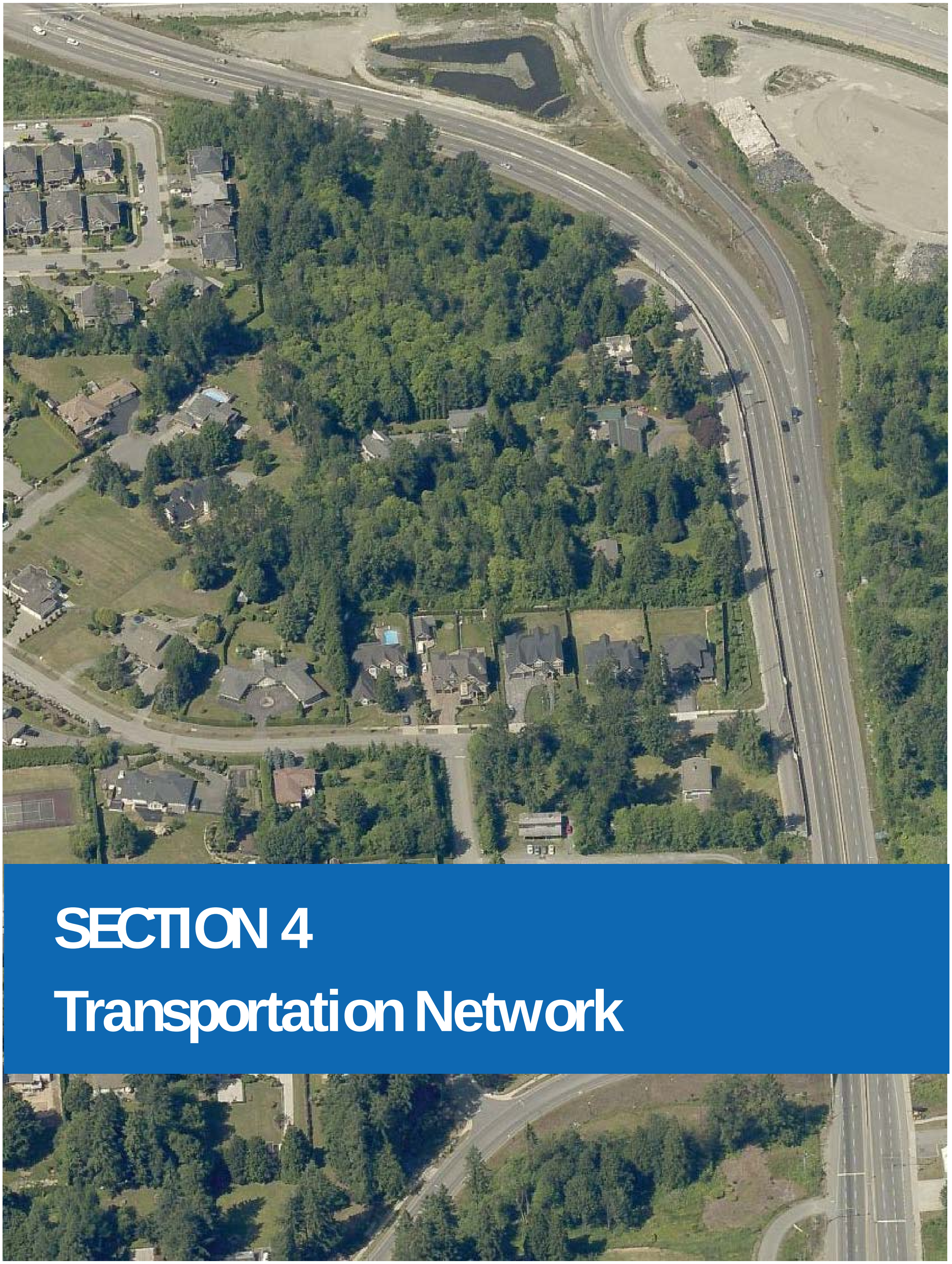


SECTION 4
Transportation Network

4
TRANSPORTATION NETWORK

This section of the report describes the current and proposed transportation networks and the transportation improvements required for the development of the Abbey Ridge Local Area Plan (LAP). A transportation assessment of the future traffic generated by the LAP was conducted to determine the effects on current transportation infrastructure and the required improvements for the network.

4.1 EXISTING ROAD NETWORK

The Abbey Ridge LAP is in close proximity to two major Provincial Highways (Highway 1, and Highway 17), and one future Provincial Highway (Golden Ears Connector), so from a regional-access perspective, the immediate area is well served with the multiple provincial highways.

Provincial Highways

Highway 1 (Trans Canada Highway)

Highway 1 is a Provincial Highway that is operated and maintained by the Ministry of Transportation and Infrastructure (MoTI). In 2013, the section along the Abbey Ridge LAP was widened along with the construction of the new Port Mann Bridge. The plan area has no direct connection to Highway, and is connected to Highway 1 through the Highway 15, and 160 Street interchange.

Highway 17 (South Fraser Perimeter Road)

Highway 17 is a Provincial Highway that opened in 2013 to provide a regional connection between the municipalities of Surrey, Delta, and New Westminster (via Pattullo Bridge). This highway creates a bypass through the City of Surrey, and has relieved the traffic demand along some of the City's arterial roadways. Highway 17 is a regional highway that also provides connections to Pattullo Bridge, Roberts Bank Deep Sea Terminal, and the Tsawwassen Ferry Terminal.

Golden Ears Connector

The Golden Ears Connector (GEC) is expected to be a future highway that is provincially owned and maintained. The main role of this highway is to provide a direct connection between Highway 17 and the Golden Ears Way that connects to the Golden Ears Bridge and the Provincial Highway system north of the Fraser River. Currently, vehicles are required to access Highway 15 to connect in between Highway 17 and Golden Ears Way.

Arterial Roads

104 Avenue – Arterial

104 Avenue borders the northwest corner of the Abbey Ridge LAP, which currently serves as one of the east-west options to access and egress the area. Further to the west, 104 Avenue connections to the Highway 1 Interchange located at 160 Street. To the east, 104 Avenue intersects with Highway 17, which links directly to Highway 15 and the Pacific Highway Crossing to the south. The existing 104 Avenue has not been widened to its ultimate cross section with one travel lane in each direction and limited pedestrian infrastructure.

Collector Roads

Barnston Drive and 100 Avenue

Barnston Drive and 100 Avenue are the main collector roads that service the existing Abbey Ridge LAP area. To the east, Barnston Drive connects to the Port Kells industrial area, North Langley, and the Golden Ears Bridge. To the west, Barnston Drive leads to 168 Street and 104 Avenue, and provides access into the Fraser Heights community. The current configuration of this corridor is one travel lane in each direction, with intermittent stretches of walking and cycling infrastructure.

177A Street

177A Street is a north-south collector road that connects the future Golden Ears Connector to Barnston Drive. As the Golden Ears Connector connects to Hwy 1, Hwy 15, and Hwy 17, it is anticipated that 177A Street will provide an important connection for existing and future residents of the Abbey Ridge LAP, and it is anticipated that traffic signals will be required at both ends of 177A Street. The ultimate cross section 177A Street is already achieved through previous adjacent development applications.

Local Roads

The existing local roads within the plan area are relatively disconnected due to several factors. The Highways act as barriers for local connections and eliminates the opportunity to develop a finer grid road network as typically found in other secondary plans. Further, environmental protection of existing riparian areas prohibits local road connections between previously established single family pockets have been taken into consideration when establishing the proposed road network

4.2 PROPOSED TRANSPORTATION NETWORK

A Traffic Impact Assessment (TIA, see Appendix A-2) was conducted by a Transportation Consultant to forecast and model the anticipated traffic volume increase as a result of the planned development.

The Proposed Transportation Network Plan is illustrated in Map 6 following descriptions of each of the Roadway Improvements.

Future Roadway Improvements

104 Avenue – Arterial

As explained in the section above, 104 Avenue is an arterial road that is not ultimately widened to the City's divided arterial standard. The traffic generated by the Abbey Ridge LAP area will create an impact on the portion of 104 Avenue within the existing Fraser Heights neighbourhood, which is beyond the Plan's boundary of 172 Street. Therefore, the servicing needs for 104 Avenue are considered for the whole 104 Avenue corridor (from 160 Street to Highway 17), and not only the portion within the Plan area.

The build-out scenario of the Abbey Ridge LAP will create additional vehicular demand along 104 Avenue, as it is one of main routes to access and egress the plan area to and from the west. However, the increase in traffic volume is not anticipated to trigger the need for additional vehicular capacity along this corridor. As such, 104 Avenue is envisioned to be constructed with sidewalks and cycling infrastructure will be installed, while maintaining one travel lane in each direction. This cross section is considered to be sufficient in the foreseeable future.

Barnston Drive and 100 Avenue - Collector

Typically, completion of collector roads occur through adjacent developments that fronts onto collector roads. The Abbey Ridge LAP identifies development along the Barnston Drive and 100 Avenue corridors, so it is expected that the ultimate cross section of the two roadways are to be secured through the development application process. The fronting development Ultimately, this corridor is designed to accommodate sidewalk along the north side, along with one travel lane in each direction, and on-street parking where space permits.

4.2

Local Roads

The opportunities to establish additional local roads within the LAP have been constrained due to Provincial Highways, and environmentally sensitive areas. Further, the Abbey Ridge LAP has experienced pockets of development in the past where local road networks were established through individual applications. This presented further limitations to plan additional local roads, as consideration must be taken for existing residential neighbourhoods. In areas where limited development had occurred, a finer grid road network was designed for as part of the Abbey Ridge LAP. This is a guiding principle of the Transportation Strategic Plan to ensure vehicles are distributed even to avoid significant burden on a particular road.

All local roads, both existing and future, within the Abbey Ridge LAP will ultimately accommodate sidewalks, boulevards, street lighting, and street trees as per the local road cross section in the Engineering Design Criteria. Depending on the fronting developments and its density, on-street parking will be available on both sides of all local roads.

Flex Roads

The Abbey Ridge LAP identifies several Flex Road, which provide flexibility in terms of the ultimate road alignment. These roads are present due to the uncertainties of development form and type, and environmental impacts and constraints. The appropriate width and alignment of flex roads will be determined through the development application process where the site and concept plans are more certain.

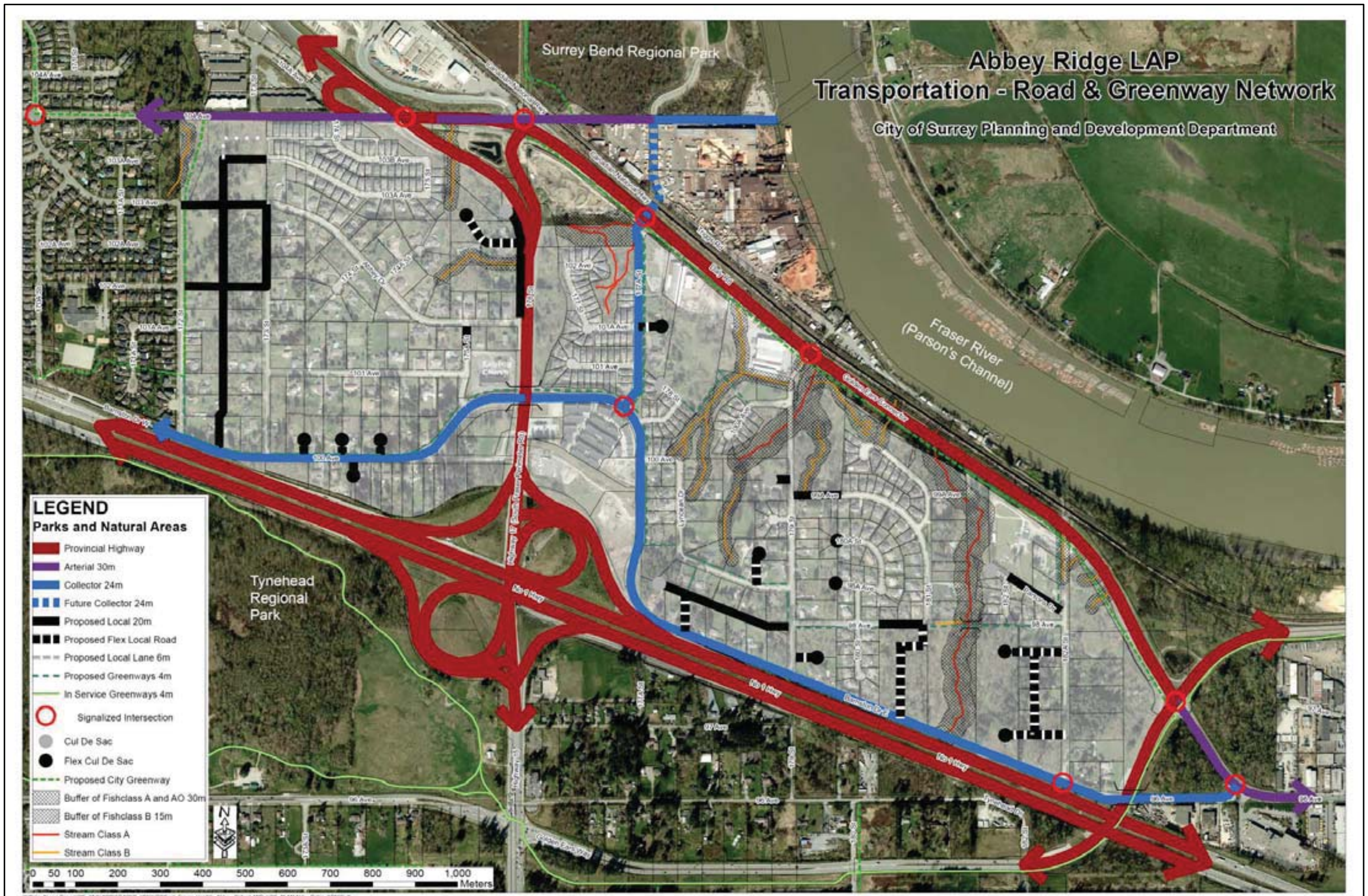
Intersection Improvements

Based on the submitted TIA by the Transportation consultant, it was determined that the anticipated traffic generated by the Abbey Ridge LAP will require multiple intersection improvements. Table 3 below identifies intersections that should be signalized.

Table 3 - Intersections that should be signalized

Location	Current Condition	Upgrade Rationale
Barnston Drive and 177A Street	Stop Controlled	177A Street connects the Plan area to the future Golden Ears Connector and Hwy 17, anticipated volume along this road and the intersection at Barnston Drive is expected to be higher than current day volume.
Barnston Drive and 182 Street	Stop Controlled	Additional traffic due to anticipated population will require signalization
104 Avenue and 170A Street	Stop Controlled	170A is outside of Plan area, but connections to anticipated development via 172 Street and 173 Street. Additional traffic due to anticipated population will require signalization
96 Avenue and Barnston Drive	Stop Controlled	Intersection is outside of Plan area, but Barnston Drive is a collector road that will experience additional traffic due to anticipated population, and will require signalization

The listed intersections identified in Table 3 above would only be considered for signalization if warranted due to population and traffic volumes increase. As the current traffic volumes do not meet the City's warrant, these intersection improvements will not be in Engineering's 10 year Servicing Plan. Staff will monitor the traffic volumes, and continue to evaluate the need for a traffic signal.



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Map 6 – Abbey Ridge Transportation & Greenway Network

4.3
TRANSPORTATION COSTS AND FINANCING

Table 4 below, summarizes the infrastructure improvements, and the total and DCC eligible cost of each improvement.

Table 4 - Transportation Infrastructure Improvements and DCC eligible Costs

Category	Road	Segment	Total Cost	DCC Eligible
Arterial Widening	104 Avenue	172 Street to Hwy 1	$12,000,000	$6,000,000
Collector Upsizing	100 Avenue and Barnston Drive	172 Street to 18300 Block	$2,967,000	$2,809,500
Category	**Treatment**	**Intersection**	**Total Cost**	**DCC Eligible**
Intersection Improvements	Signal	Barnston Drive and 177A Avenue	$250,000	$125,000
Intersection Improvements	Signal	Barnston Drive and 182 Street	$250,000	$250,000
Intersection Improvements	Signal	104 Avenue and 170A Street	$250,000	$125,000
Intersection Improvements	Signal	Barnston Drive and 96 Avenue	$250,000	$125,000

The servicing items identified above are not required prior to the City approving development applications within the Abbey Ridge LAP. Volumes for each of the associated roadways and intersections will be monitored by City staff to determine when the respective improvements are required, and will be subsequently listed in Engineering's 10 year Servicing Plan.

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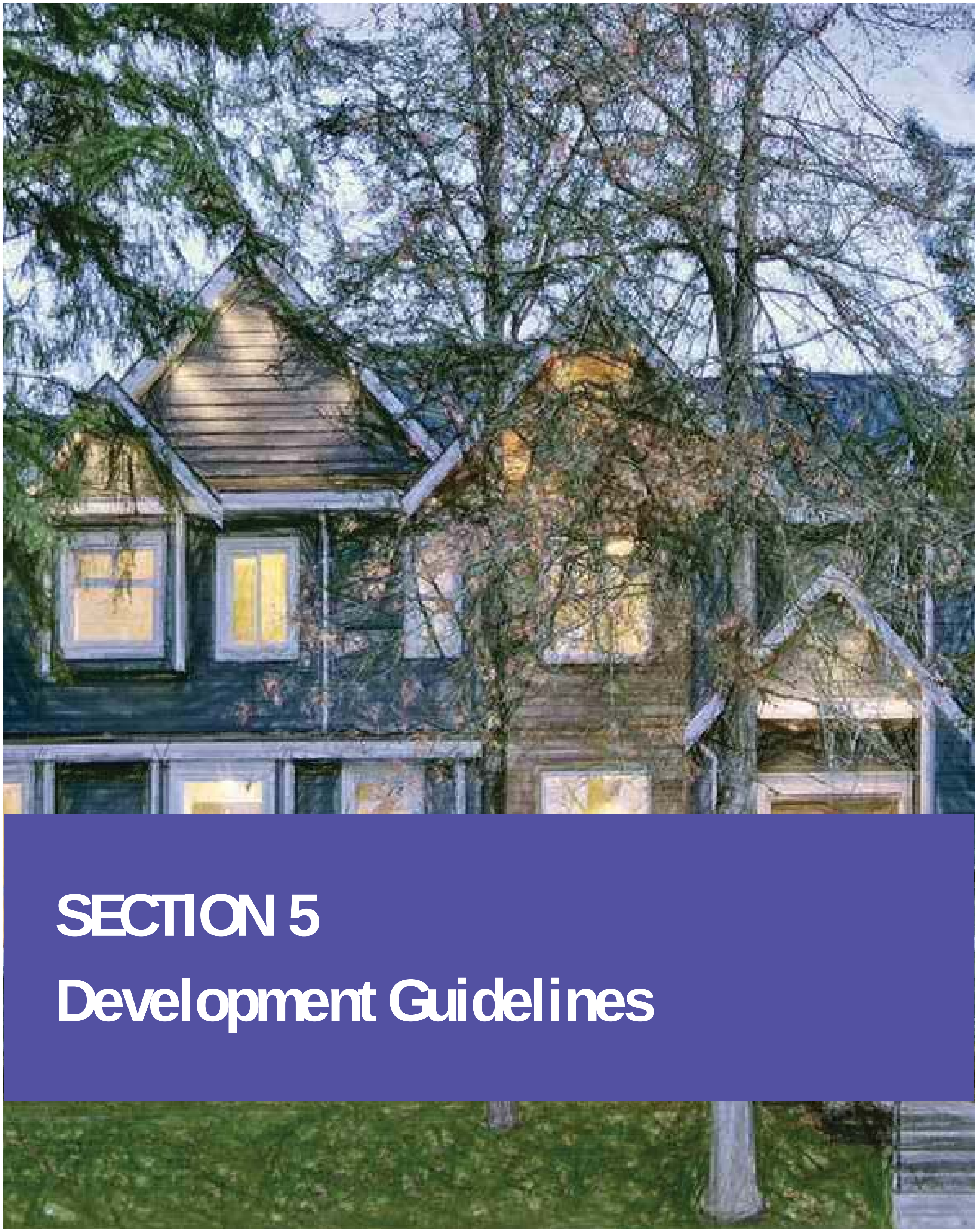


SECTION 5
Development Guidelines

5
DEVELOPMENT GUIDELINES

Development guidelines are to be used in the assessment of development applications in the Abbey Ridge LAP. The guidelines should assist developers and consultants to establish a development rationale and to create improved design associated with new projects, and improvement environmental management.

While not intended for rigid application, the guidelines highlight important considerations which, when appropriately selected and interpreted, can result in safe and useful outdoor places.

5.1 ENVIRONMENTAL MANAGEMENT

With urban development comes increased pressure on natural watercourses and streams. Within the Land use Concept Plan Riparian Buffers have been identified to protect Riparian areas.

The City of Surrey works with the federal Department of Fisheries and Oceans and the provincial Ministry of Environment to ensure that development respects these riparian resources and preserves and enhances them for all residents of Surrey.

Depending on the type of development proposed land dedication (riparian setbacks), restrictive covenants, or landscaping may be required.

Riparian Areas

Regulations and legislation to preserve riparian areas and prevent water pollution are identified the:

- Federal Fisheries Act;
- Provincial Water Act;
- Provincial Environmental Management Act;
- Stormwater Drainage Regulation and Charges By-Law;
- Surrey Zoning Bylaw *(Streamside Protection); and*
- City of Surrey Environmental Sensitive Areas Development Permit Areas.

See Drainage and Environment Section 8, and East Fraser Heights Environmental Study attached in Appendix A-2, as well as contact Planning and Development Department for information on environmental management and riparian area setback requirements and regulations.

5

Tree Preservation

Future development planning for the area should promote tree conservation to the extent possible. Tree Preservation, Protection, Replacement and Enhancement are the four cornerstones of a sustainable urban forest. The preservation of forests grown mature trees in relation to residential development presents many challenges. Selective preservation of trees from the protected confines of a forest stand often results in unpredictable tree behaviour. The typical tall and thin form of forest grown trees can result in unsuitable candidates to be retained.

There have been significant failures from selective and thin clusters of forest grown trees where preservation has been attempted in the past. Douglas Fir is known to release large limbs when under strong wind loading. The loss of limbs is how the tree responds to wind as opposed to full tree failure. When large Firs shed large limbs, the branches tend to be end weighted and can fall in a vertical spear like orientation. As a result, residential development directly under large mature Firs is not typically recommended.

General Tree Protection Objectives:

- A detailed assessment by a qualified expert should be undertaken for any development applications.
- Tree survey and topographic information must accompany the assessment report.
- Trees on steep slopes, watercourses, ravines and un-developable areas should be retained wherever possible.
- Wind throw and danger trees within the Stream protection and enhancement areas will need to be considered.
- Preserve existing trees, woodlots and natural features wherever possible. Where trees of large size are retained, large groups or wide leave strips are preferred. The seven stands of trees highlighted in the Land Use Concept plan as derived in the East Fraser Heights Environmental Study contained in Appendix A-2 represent some of the better opportunities to retain such groups of trees.
- Provide and enhance landscaping at the street level which contributes to the continuity of landscaping between adjacent properties.
- Stabilize slopes (where existing) with ground cover and trees.
- Select plant materials that are ecologically sound, appropriate for the existing and future site conditions and suitable for all seasons.
- Encouraging the consideration of the location of existing trees in the design of development plans prior to the submission of development applications
- Encouraging and enforcement of tree protection measures during development.
- Encouraging no net loss of trees through the planting of replacement trees.

5.2 CLUSTER HOUSING GUIDELINES

Within the Land Use Concept Plan (Map 3) Cluster Housing Designations Areas have been identified.

These areas allows for the development value (gross residential unit density) associated with one section of a property to be transferred and added to the amount of potential residential units available on another section of a property or development site.

These Cluster Designated Areas:

- **Serve as a mechanism that will help to permanently protects ecologically significant areas (Riparian areas, Significant Tree Patches, and Green Infrastructure) or landscape buffer areas without the expenditure of public funds or long term enforcement of landscape maintenance;**
- **Are applied at a LAP level within prescribed Cluster Designation Areas;**
- **Provides a mechanism that restricts building on portions of land while providing equity to the private landowner in correlation with that restriction;**
- **Promote preservation of green areas while allowing development to occur in predefined designated areas and near service infrastructure.**

Cluster Housing Application Areas

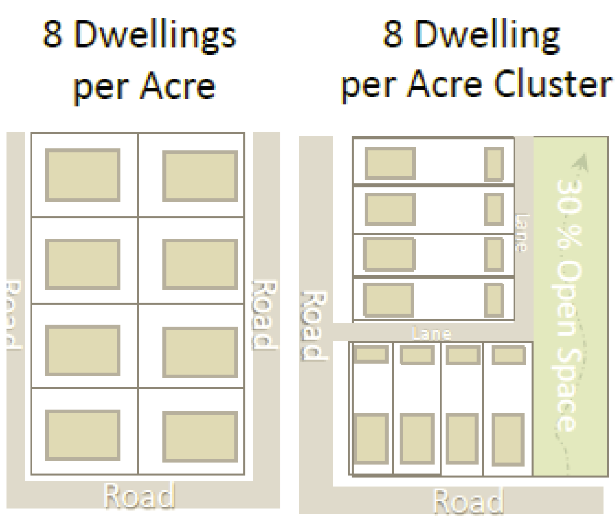
Cluster housing guidelines apply to the two "Cluster Residential" designation areas within West Clayton Neighbourhood.

The two "Cluster Designation" areas (identified and summarized in Section 3) enable the transfer of development potential at rezoning to conserve/enhance or as landscape Buffer Areas, or are biologically significant to improve and protect, to areas specifically designated to be developed.

These include the:

- Low Density Cluster Designation;
- Medium Density Cluster Designation;

These designation areas are provided to enable the redistribution of development potential from one location to another in a way that is fair and equitable to landowners, while supporting community development, landscape buffers, urban planning and environmental management goals.



Example of Cluster Housing at 8 Units Pera Acre with Single Family Development

Density Transfer Areas in Cluster Designations

Green Density Transfer areas in the Cluster Designations refer to the areas of a site where preservation of open space is to occur as identified on the development application plan.

The potential density from the green space transfer areas is intended to be transferred to the "development area" of a site. A formal survey will be required to outline exact location and amount of Green space transfer Areas and they must be identified as such on any subdivision plans.

The following areas or land uses may not be counted as a part of designated green space transfer areas:

- Areas Covered by any Structures or Buildings;
- Road Rights-of-ways;
- Strata Lanes;
- Property Setbacks and private front or backyard areas;

The following areas shall be high priorities for inclusion as designated Green Space Transfer areas:

- Riparian Dedication Setback Areas and Utility Corridors;
- Landscape Buffers separating uses;
- Landscape Buffers;
- Ecologically Significant Vegetation or possible tree preservation Areas shown in the East Fraser Heights Environmental Study);
- Passive Recreation and Trail Areas;
- Biodiversity Hub, Site, or Corridors areas as identified in Surrey BCS;
- Steep or unstable Slopes as identified in the OCP Hazard Land Development Permit;
- Green Infrastructure Network Areas shown in the OCP Environmental Sensitive Areas Maps.

In some circumstances, portions of the Green Space Transfer areas may be conveyed to the City, and/or may be used for public passive or active recreation, community gardens, or rainwater management facilities that meet all design, construction, maintenance, and public safety requirements set forth by the City of Surrey.

Development areas

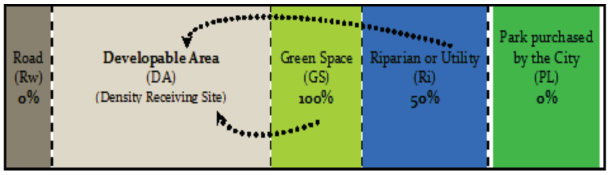
Development Areas refer to the portion of the site where building and development should ideally be located within the Cluster designation.

These areas are intended to be developed more intensely with buildings and structures, so that preservation in the form of buffers, tree preservation or environmental protection areas can occur on other portions of the site. It should be noted that individual Tree protection within Development Areas may still apply, as per the City of Surrey Tree Protection Bylaw.

Determining Cluster Densities

Density Transfer Values for sites with a "Cluster" Designation:

- 100% of site's density designation value from Green Space Transfer Areas
- 50% of site's density designation value from Riparian Areas, Gas, or Hydro ROW Areas;
- 0% from Road Dedication Areas;
- 0% from land purchased for Park by the City



Density Allocation in Cluster Areas

The amount of Green Space preservation required should generally increase with increase in land use density, because of the feasibility of protecting open space and to offset the cost of development.

In the Low density cluster designation, different techniques such as clustering homes into small groups may be used while in higher density urban areas small lots and attached single family dwellings can be used to intensify development in specific locations such as near roads, on flatter slopes, and away from environmentally sensitive features and stands of established trees.

In medium density cluster designation, a range of housing forms including single family, attached, and multiple family homes may be considered if the amount of open space provided allows.

The base and maximum densities in the Cluster designations should meet the requirements outlined in Section 3, including minimum lot sizes permitted. If no green space is provided as part of a development application, all densities shall revert to net developable area of the lot.

Green Space Area Plan Identification

The boundaries of designated green space areas, recreation areas, rainwater management facilities, and natural areas shall be clearly delineated on plans, including subdivision plans, rezoning plans, and marked in the field with signage during construction approved by the Surrey Planning and Development Department to distinguish these areas from private or common property.

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SECTION 6
Implementation Strategies

6
IMPLEMENTATION STRATEGIES

This section contains general implementation measures included in the adoption of the Local Area Plan for Abbey Ridge.

6.1 LAND CONSOLIDATION

Lot consolidation may result in the more equitable development of multiple parcels of land.

Lot consolidation may ensure that:

- **future development results in the most efficient development of properties;**
- **dedication of strategic road connections supports the plan objectives;**
- **construction of off-site works and services costs are distributed equitably among developments;**
- **small acreage and irregular shaped lots have equitable development potential.**

Consolidation Areas

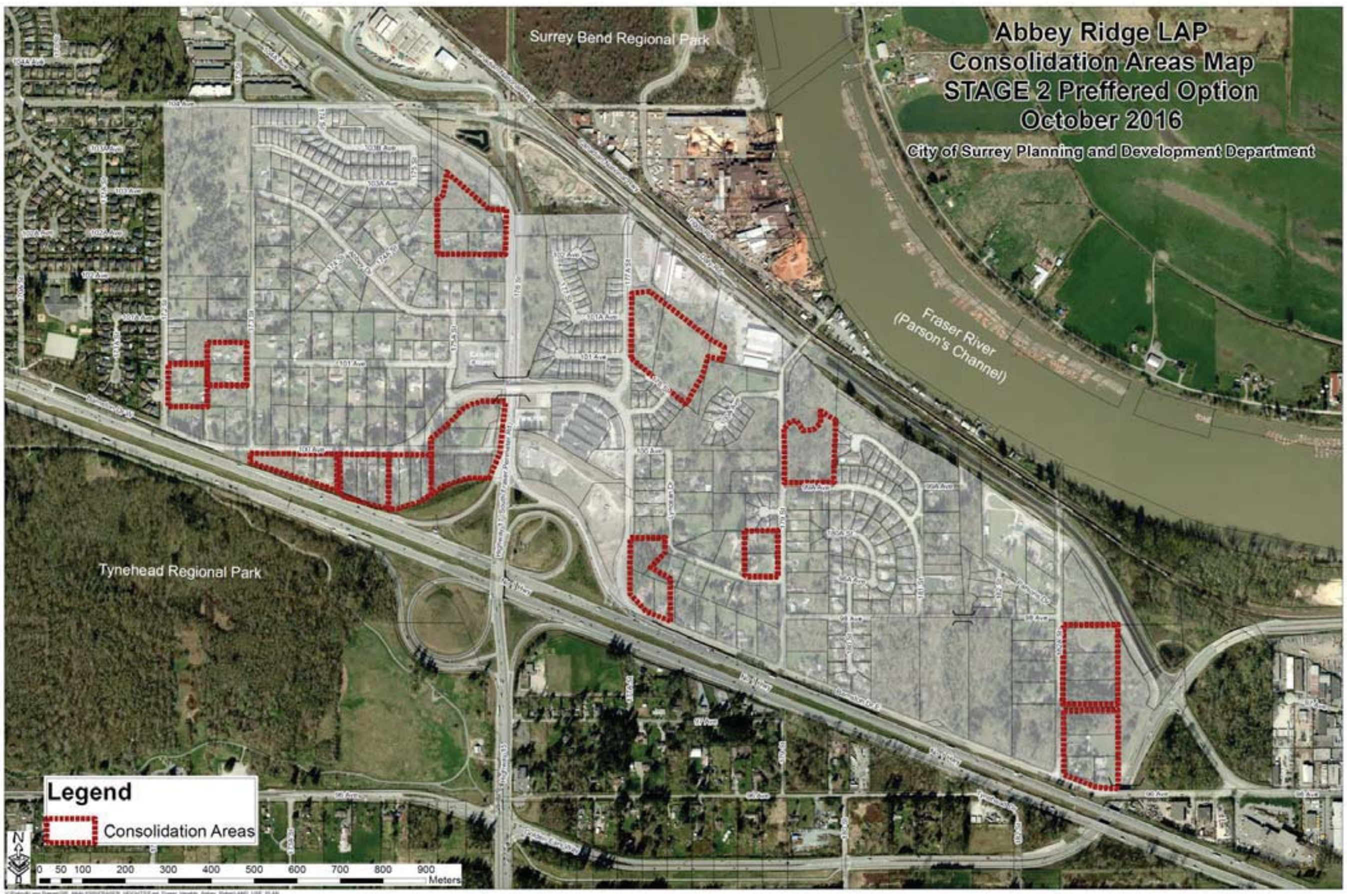
In a few areas of the LAP as illustrated in Map 7 identify where lot consolidation may be required to ensure efficient development of properties. These land consolidation opportunities will, in most circumstances, be determined on a case-by-case basis at development application stage dependant on the type and for of development proposed.

In some cases, consolidation requirements have been identified in the Land Use Plan to avoid creating remnant pieces created by fragmented ownership that would not be developable on their own or limit the development potential of an adjoining lot.

Land consolidation areas have been generally identified to inform developers and owners of the consolidation strategy guidelines, to ensure compatibility and feasible development areas, and to achieve an equitable distribution of road dedication and construction costs across properties.

If land consolidation is NOT proven to be possible or feasible during the development process, the developer must:

Demonstrate that the development potential of the excluded property is not compromised to the satisfaction of the City.



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Map 7 - Abbey Ridge Proposed Consolidation Areas

6.2 DEVELOPMENT APPLICATION PROCEDURES

Official Community Plan Designations

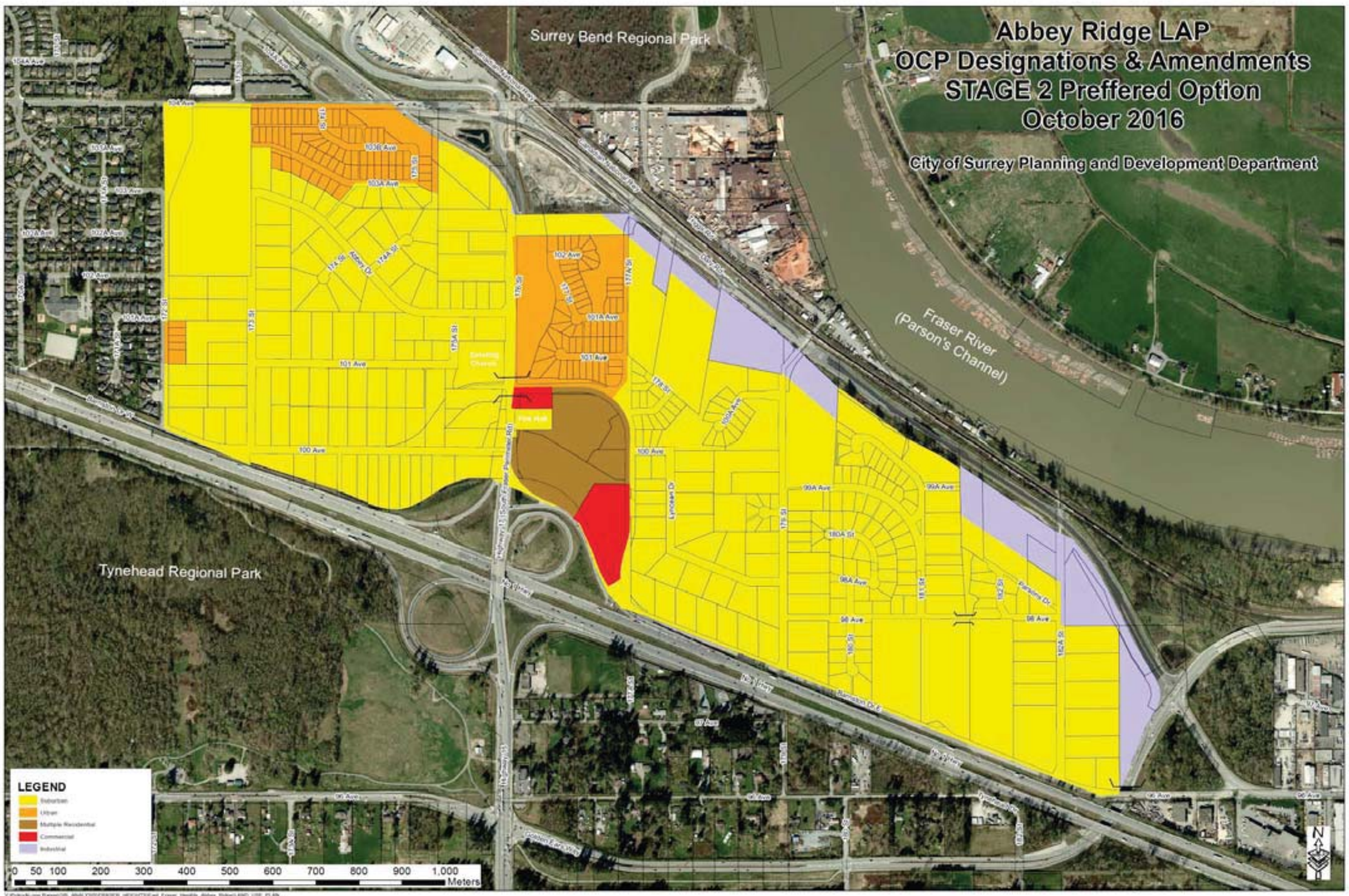
The current OCP designation and the existing zoning in many portions of the LAP may not permit the development of the densities envisioned in the Abbey Ridge Land Use Concept plan, as illustrated in Map 8.

As such, the plan densities envisioned will occur through individual land development applications brought forward by owners and/or developers that will include an OCP amendment, rezoning and subdivision consistent with the land uses and densities set out in the a Council approved Land Use Concept.

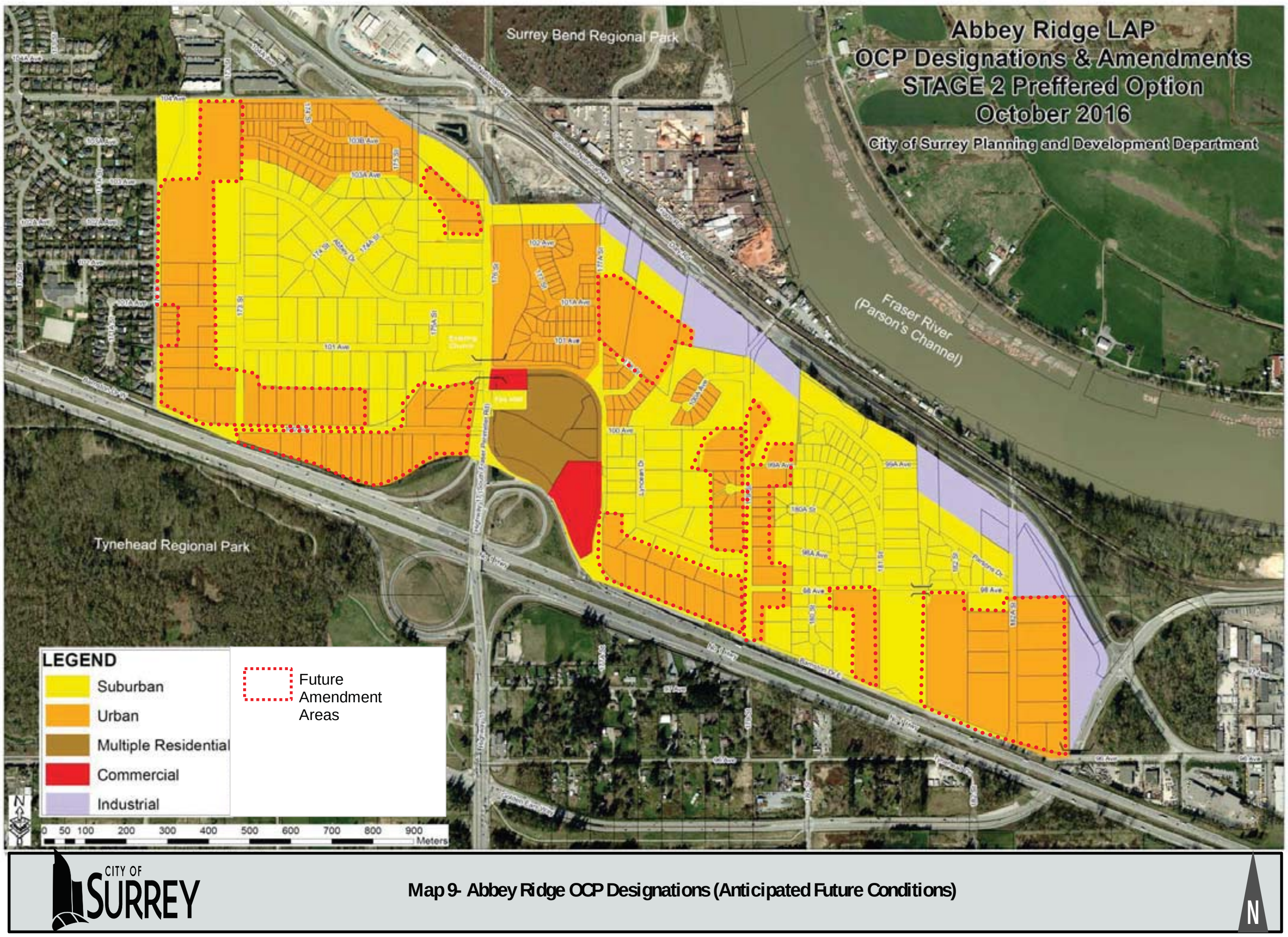
A projection of future OCP Designation boundaries is provided for general reference purposes in Map 9.

Parks and Greenways

The public elements of the LAP (parks, streets and greenways) will be secured through the development approval process by dedication, land conveyance or by purchase with funds generated from development in the area or through other agreements.



Map 8- Abbey Ridge OCP Designations (Existing Conditions)

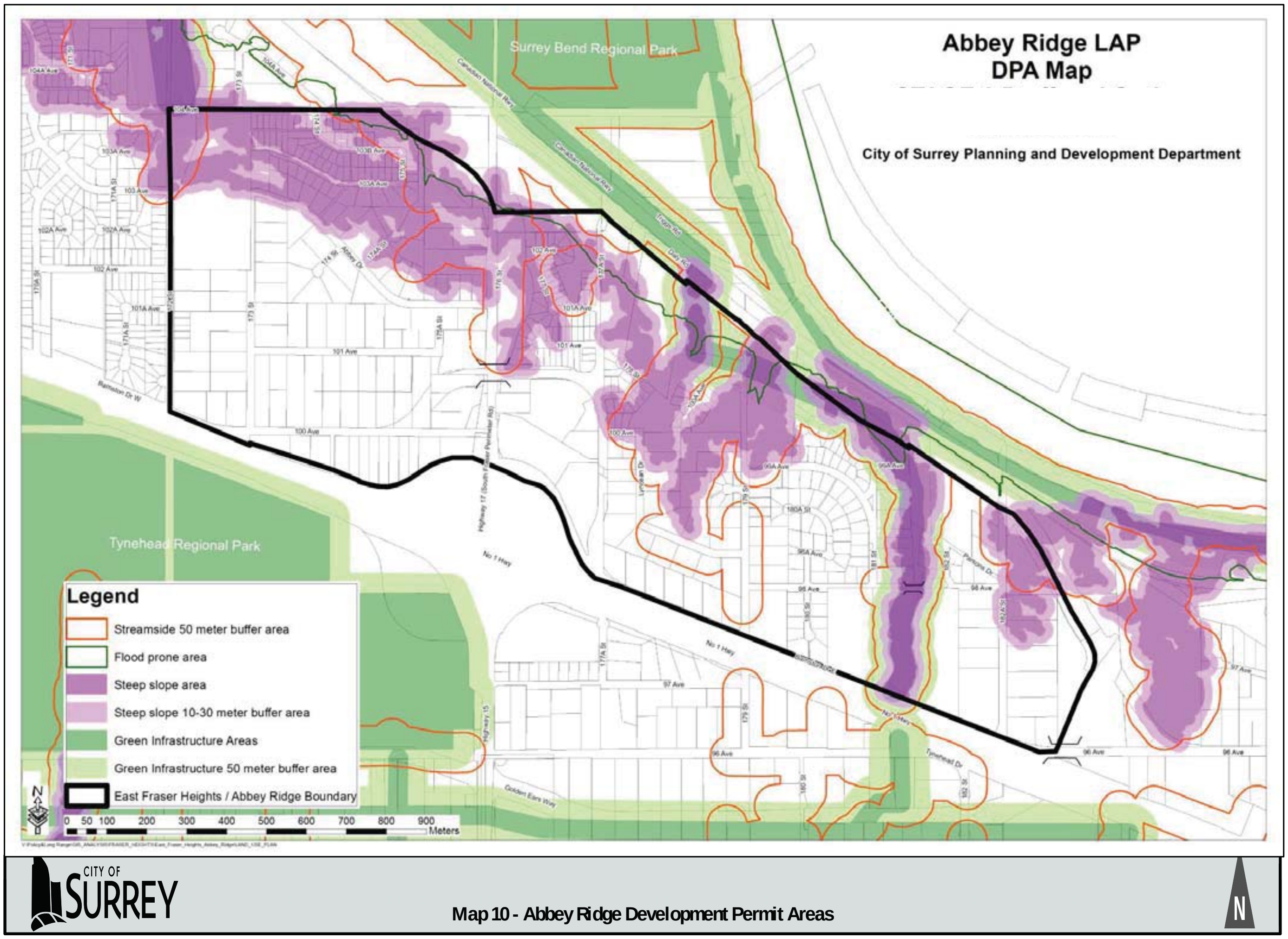


Map 9- Abbey Ridge OCP Designations (Anticipated Future Conditions)

Development Permit Areas

Where developments are located in designated Development Permit Areas as identified in the Surrey Official Community Plan (such as Hazard Lands and Sensitive Ecosystem areas) as well as in the case of multiple unit residential developments or commercial developments, the Official Community Plan Design Guidelines will be implemented through the process of reviewing and approving the related Development Permit at the time of development application review and approval.

The Environmental and Hazard Land Development Permit areas applicable to the Abbey Ridge LAP area shown in Map 10, for general reference purposes. Map 10 is shown for information purposes only and confirmation of exact OCP requirements to be made as part of future development applications.



Map 10 - Abbey Ridge Development Permit Areas

6.3 CONTRIBUTIONS FOR COMMUNITY AMENITIES AND SERVICES

In accordance with City Council policy to address the amenity needs of the proposed new development in Abbey Ridge, all development proposals at the time of rezoning or building permit issuance will be required to make a monetary contribution toward the provision of new police, fire protection and library services and toward the development of the parks and pathways.

To enact amenity contribution requirements for development within the LAP (described later in this section) the Surrey Zoning By-law will need to be amended to add Abbey Ridge to the list of Secondary Plan Areas within which monetary contributions are required.

The monetary contributions toward police, fire and library will offset the capital costs of providing these services to the new development and are applied on a standardized basis in all of Surrey's Neighbourhood Plan areas.

The monetary contributions toward parks, open spaces and pathway development are based upon an estimate of the capital costs of these improvements for this particular LAP area. The total cost is divided by the average anticipated number of dwelling units and acreages in the case of non-residential development to ensure an equitable contribution arrangement.

The amenity contributions noted above are payable upon subdivision for single-family subdivisions or upon issuance of building permits for multiple development and other uses.

The estimated costs of the various amenities are distributed evenly to each dwelling unit. Therefore, if the number of dwelling units in a proposed development is lower than that anticipated by the LAP, the applicant will be expected to "top up" the amenity fees based on the number of the dwelling units used to calculate the amenity charge to ensure that there is no shortfall in the funding for the proposed.

Amenities and Services

Parks Development

The scope of parkland development within the Abbey Ridge LAP will include an expanded Neighbourhood level park, an expanded Natural Areas Park, one new neighbourhood level park and three new Natural Area Parks, in addition to an expansion of the city's linear greenway network.

The estimated cost of developing park amenities is approximately $1,613,200.00, which results in a $1,480.00 (in 2016 dollars) per dwelling unit. This estimate includes the construction of on-site park amenities, such as playgrounds, Trail Bridge, washroom buildings, parking lots, sports courts, athletic fields, tree and horticultural plantings, park pathways and on-site plazas, seating areas, viewing platforms and passive open spaces. This also includes natural and riparian area management within land acquired by Parks.

Park amenity calculations do not include riparian area works on land conveyed to the City through the development process, such as invasive species removals, fence construction, replanting and naturalization, in-stream works and any other related riparian area costs, including planning and design costs, which are to be accounted for as part of the development process and subject to the Streamside Protection regulations.

Library Services

A study of library requirements in Surrey's new neighbourhoods has established that a contribution of $146.58 (in 2016 dollars) per dwelling unit (non-residential development is exempt) is necessary to cover the capital costs for library materials and services, which is sensitive to population growth. Consequently, a total of approximately $159,772.20 will be collected from Abbey Ridge towards materials such as books, computers and CDs.

Fire Services

Future development in this neighbourhood will drive the need to upgrade existing fire protection facilities. A study of fire protection requirements in Surrey's new neighbourhoods has established that a contribution of $65.16 per dwelling unit and $1,125.83 per acre of non-residential development (in 2016 dollars) will cover the capital costs for fire protection. This will result in a total capital contribution from Abbey Ridge of approximately $330,242.44 toward fire protection.

Police Services

Similar to Fire Services, a contribution of $65.16 per dwelling unit and $260.65 per acre of non-residential development will cover the capital costs for police protection. This will result in a total capital contribution from Abbey Ridge of approximately $76,453.74 toward police protection.

Summary of Fees

The Amenity Contributions rates are summarized in Table 5, and are derived from the average densities proposed in the residential designations of the Abbey Ridge LAP and the number of dwelling units (excluding any secondary suites) that are anticipated.

Table 5 - Summary of Amenity Contributions for Abbey Ridge LAP amenities

ABBEY RIDGE LAP COMMUNITY AMENITY CONTRIBUTIONS			
	Per Unit Contribution All Residential **(Approx. 1,090 new dwelling units @ average density)**	**Per Acre Contribution All Non-Residential Uses**	**Anticipated Total Revenue at Build Out**
Police Protection	$65.16 per dwelling unit	$260.65 per acre	$71,024.40 Residential $5,429.34 Non-Residential
Fire Protection	$281.46 per dwelling unit	$1,125.83 per acre	$306,791.40 Residential $23,451.04 Non-Residential
Development of Parks	$1,480.00 per dwelling unit	n/a	$1,613,200.00 Residential
Library Materials	$146.58 per dwelling unit	n/a	$159,772.20 Residential
Total Contribution (per unit or per acre)	$1,993.20 per dwelling unit	$1,386.48 per acre	$2,201468.38
Anticipated Total Revenue			**$2,201,468.38**

PART B

Engineering Servicing

SECTION 7
Financial Plan Summary

7
FINANCIAL PLAN SUMMARY

This section outlines the anticipated Development Cost Charge (DCC) revenues and construction costs for DCC eligible infrastructure to support development in the Abbey Ridge LAP.

Section 7 summarizes into one location all the financial costs for engineering related costs of development. This section lists and cross-references costs in the following sub-sections and sections.

- Section 4 Transportation
- Section 8 Drainage and Environment
- Section 9 Sanitary Sewer
- Section 10 Water

7.1

FINANCIAL ANALYSIS FOR ENGINEERING INFRASTRUCTURE

Development Cost Charge Revenues and Eligible Construction Costs

Table 6 summarizes the anticipated Development Cost Charge (DCC) revenues and construction costs for DCC eligible infrastructure to support development in the Abbey Ridge LAP. The anticipated DCC revenues are based on the City-wide DCC rates that came into effect on May 16, 2016. The DCC revenues are sufficient to fund the DCC eligible engineering infrastructure upgrades required, as documented within this report.

Error! Reference source not found. shows the estimated DCC Revenues and Costs Attributed to Growth (DCC Eligible Costs) The DCC revenues shown in Table 5 include the Municipal Assist Factor (MAF) (10% for utilities and 5% for transportation).

Table 6- Estimated DCC Revenues and Costs Attributed to Growth (DCC Eligible Costs)

Service	Estimated DCC Revenues	Costs Attributed to Growth (DCC Eligible Costs)
Drainage & Environment	$ 3,797,000	$ 578,000
Sanitary Sewer	$ 2,488,000	$ 2,340,000
Water	$ 1,924,000	$ 942,000
Arterial Roads	$ 11,277,000	$ 6,600,000
Collector Roads	$ 2,961,000	$ 2,900,000

7.2
10-YEAR SERVICING PLAN

The City's 10-Year Servicing Plan itemizes the City's capital expenditure plan for engineering infrastructure to service existing development and support new growth.

Table 7 summarizes the engineering infrastructure improvements within the Abbey Ridge LAP boundary that are included in the City's current 10-Year (2016-2025) Servicing Plan. Some of these projects are related to the Anniedale – Tynehead Neighbourhood Concept Plan (NCP) (located immediately south of the Abbey Ridge LAP), which requires off-site infrastructure to be built in Abbey Ridge to support development in the NCP area.

Infrastructure upgrades identified in this report for Abbey Ridge are eligible for inclusion in subsequent updates of the City's Ten Year Servicing Plan.

Table 7 - Projects in Current 10 Year (2016-2025) Servicing Plan

PTS ID	Utility	Location	Project Description	Cost
15238	Storm	Lyncean Creek West: Lyncean Dr – Daly Rd	Environmental Enhancements	$ 35,000
13195	Sewer	173 St: Hwy 1 – 104 Ave	800m of 600mm diameter	$ 785,000
13197	Sewer	Hwy 1 / 173 St crossing		$ 253,000
11280	Sewer	173 St / 104 Ave	Odour Control Facility	$ 667,800
15184	Sewer	104A Ave: lot 17337	Big Bend Pump Station relocation	$ 7,500,000
9716	Water	103 Ave: 172 St – 173 St	280m of 400mm diameter	$ 98,000
9717	Water	100 Ave: 177 St – 180 St	580m of 400mm diameter	$ 261,000
9718	Water	98 Ave: 181 St – 182A St 182A St: 96 Ave – 98 Ave	700m of 400mm diameter	$ 315,000
13174	Water	Hwy 1: 168 St – 173 St	1,060m of 450mm diameter	$ 901,000
13271	Water	Hwy 1 / 173 St crossing		$ 400,000

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SECTION 8
Drainage and Environment

8

8
DRAINAGE AND ENVIRONMENT

This section describes existing drainage and environmental conditions, and identifies the stormwater infrastructure required to service the Abbey Ridge LAP.

8.1 EXISTING STORMWATER SERVICING

Existing Watersheds

The two major watersheds within the Abbey Ridge LAP area are Big Bend and Port Kells, each containing various sub-catchments. The Big Bend watershed is comprised primarily of urban and suburban residential developments that drain northeast. The piped system discharges to multiple tributaries along the escarpment that discharge to the lowlands and drain into Surrey Bend Regional Park via Centre Creek. The Port Kells watershed is made up two distinctive halves with only the western half from Golden Ears Way within the Abbey Ridge area. Runoff from this area drains north to the Fraser River via one of three major watercourses: Lyncean Creek West, Lyncean Creek East, and Leoran Brook. Map 11 shows the existing drainage system for Abbey Ridge.

Drainage Infrastructure

The drainage infrastructure within the LAP area is predominantly open channels, storm sewers, and culverts. Many of these existing storm sewers will be maintained and utilized with some upgrades as needed to provide capacity for future development. There are three existing detention facilities in the Abbey Ridge LAP: a pond at 172 Street and 104 Avenue; a water quality pond at 104 Avenue and 176 Street; and an oversized detention pipe at 177 Street and 102 Avenue. In addition, there are additional ponds in the area constructed as fish habitat compensation sites.

Current erosion sites are identified along Leoran Brook, Lyncean Creek West and Lyncean Creek East. Additional sites are also found in a roadside ditch on 182A Street and in Centre Creek. In general, these identified erosion sites are considered low risk with the recommendation of continual site review and monitoring.

Environment

Watercourses and wetlands have been identified in the Abbey Ridge LAP. Lyncean Creek (West and East) and Leoran Brook are natural streams that flow through the area plus a number of unnamed creeks that also run downslope towards the Fraser River. Due to this connection with the Fraser River, several watercourses including roadside ditches within the study area are identified as fish bearing or provide overwintering habitat for fish. The riparian area of Leoran Brook is designated as a terrestrial corridor connecting fragmented patches of forest habitat within the development area to portions of Surrey Bend Regional Park.

Further details on existing drainage and environmental conditions can be found in Appendix A-2.

Map 11 – Existing Drainage System

8.2 DESIGN CRITERIA AND ANALYSIS

Design Criteria

The City's Design Criteria Manual (2016) specifies design and performance standards for stormwater systems. The primary criteria for stormwater networks are:

- In areas where the properties do not have basements, provide a storm sewer system (minor system) with capacity to convey the post-development peak flows from the 1:5-year return period storm and a major system with enough capacity to accommodate the peak flows from the 1:100-year return period storm.

- In areas where the properties have basements, provide a storm sewer system (minor system) with capacity to convey the post-development peak flows from the 1:100-year return period storm.

Minor system storm sewers are pipes with a contributing catchment area of less than 20 hectares (ha); major system is a storm sewer or open channel with a catchment area greater than 20 ha.

The City recently updated the Design Criteria Manual in January 2016. The City's Design Criteria Manual is updated from time to time to maintain current design standards and best practices. Future design of the stormwater system for the Abbey Ridge LAP must use the Design Criteria Manual that is current to the day of the design.

Analysis

Baseline conditions were established at several points of interest to compare peak flows and runoff volumes due to development. These general requirements described above result in the following specific requirements for the Abbey Ridge area:

- Provide a piped system for the major flow in areas that currently have or are expected to have basements.

- Control the post-development flows and volumes at or below pre-development conditions in areas where erosion is a concern.

- Implement Low Impact Development (LID) practices to attenuate post-development peak flows at the various erosion sites and improve water quality.

- Provide a drainage strategy that will not overload the culverts crossing the Golden Ears Connector.

8.3 PROPOSED SYSTEM

Recommended Infrastructure Improvements

The future development of Abbey Ridge will change the existing land use, increase the amount of impervious areas, reduce infiltration, and increase surface runoff. The overall approach for the proposed drainage system is to assess the existing system's performance and determine necessary upgrades to adequately convey runoff from the study area to the Fraser River.

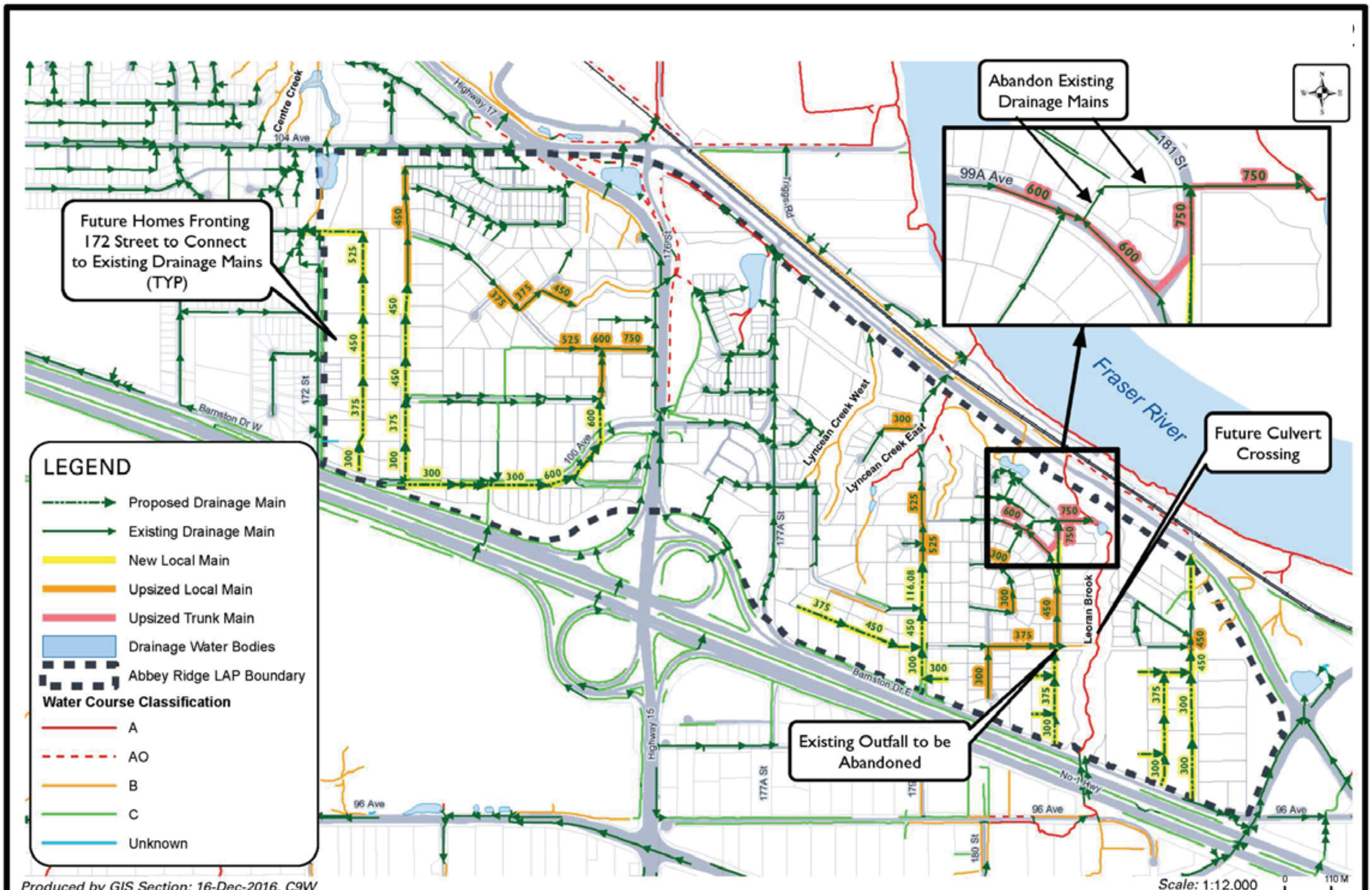
Hydraulic modelling of the existing drainage system revealed that many of the storm sewers do not have capacity to accommodate current or increased flows. Therefore, in addition to extending the existing storm sewer system, many of the existing pipes must be replaced to prevent flooding of existing properties. Additional detention ponds were not identified as a significant portion of the study area is already developed.

In order to attenuate flows, the future discharges on Leoran Brook and Lyncean Creek East should be limited through the use of Low Impact Development (LID) techniques in future roads and developments to reduce volume rates and as the primary erosion mitigation measure in sensitive areas.

Future developments are expected to install storm sewers to service their respective development and connect to the downstream storm sewer system. A major flow route must also be provided along the surface by installing curb and gutter along roadways. This will provide a safe route for flows that exceed the capacity of the piped system without flooding adjacent properties.

New storm sewers and upgrades to the existing system are required in many areas. Upgrade and re-alignment of existing trunk sewers are required on 99A Avenue and 181 Street to provide sufficient capacity and an additional outfall to Leoran Brook will also be required. The works include abandonment of the existing trunk sewer behind the existing homes on 99A Avenue and 181 Street.

Map 12 identifies the major system storm sewers recommended for upgrade.



Map 12 – Proposed Stormwater System Servicing Plan

On Lot Requirements

The following on-lot measures and LIDs to retain rainwater at the source along with water quality enhancements are recommended:

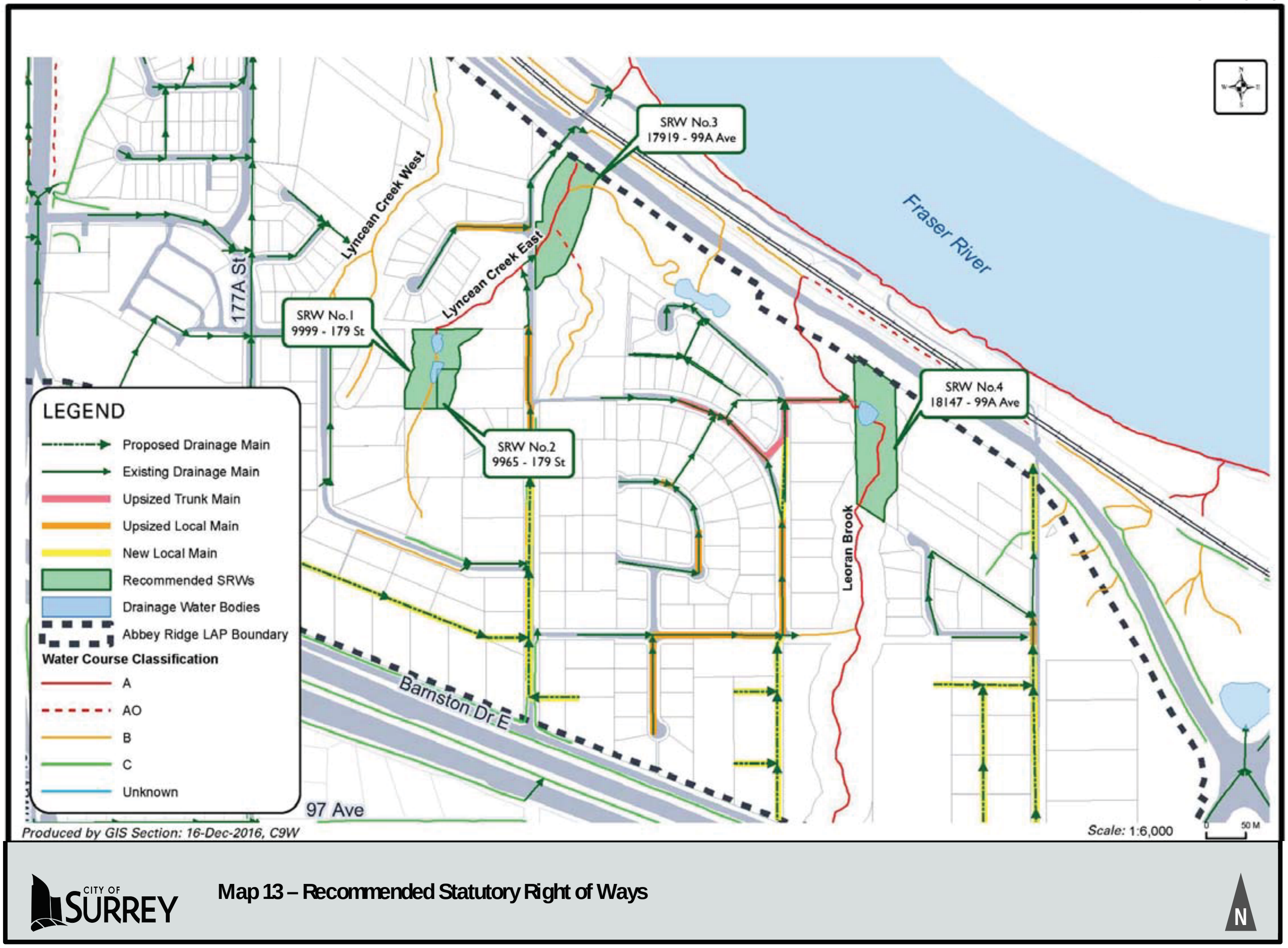
- All new industrial, institutional, commercial, and multi-family residential development will provide on-site detention storage to limit off-site runoff discharge to 15 l/s/ha for the 5-year storm and 25 l/s/ha for the 100-year storm.
- All land uses to provide 450mm of enhanced topsoil on all pervious areas.
- LID measures are required for road runoff. Road LIDs recommended are 450mm of topsoil for boulevard areas, grading sidewalks towards the boulevard, and infiltration galleries or rain gardens that occupy 5% of the road or lane area.
- Water quality treatment for multi-family sites.
- Oil-grit traps on roadway catch basins.
- Where applicable, establish riparian setbacks to comply with the Riparian Area Bylaw.

Erosion Mitigation

There are several sites in Abbey Ridge where erosion is a potential concern. However, there are no identified sites for immediate remediation. The primary mitigation measure for erosion in this LAP is to control the peak discharge rates and total runoff volumes through the use of on-lot LID measures and the continued operation of the existing detention facilities.

While some stretches of Lyncean Creek West, Lyncean Creek East, and Leoran Brook flow through lots owned by the City, other stretches flow through private property. The acquisition of Statutory Right-of-Way (SRW) for these stretches is recommended and is shown on Map 12. These identified SRW requirements are along fisheries watercourses and would encompass all of the streamside riparian area encumbered by the sensitive ecosystem setback.

Further details can be found in Appendix A-2.



Map 13 – Recommended Statutory Right of Ways

8.4 COSTS AND FINANCING

Storm sewer upgrades identified to service the Abbey Ridge LAP area are summarized in Table 8. These are major system trunk sewer upgrades required for development in Abbey Ridge and their costs can be attributed to growth. Costs for minor system storm sewers, with catchment areas less than 20 ha, are not included in this cost summary.

Table 8 – Stormwater Infrastructure Required to service the Abbey Ridge LAP (DCC Eligible)

Location	Length (m)	Size (mm diameter)	Cost Attributed to Growth (DCC Eligible Costs)
Storm sewer on 99A Avenue and 181 Street	106	600	$202,000
	123	750	$281,000
Outfall at 99A Ave and Leoran Brook			$95,000
		TOTAL	$ 578,000

Notes:

- Costs are as of December 2016
- Costs include engineering (12%), and contingency (15%).
- These cost estimates are based on the City's previous project experience. Actual costs may vary depending on unforeseen project design requirements, construction and economic market conditions, local interest in the project(s) and currency fluctuations.

Further details can be found in Appendix A-2.

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SECTION 9
Sanitary Sewer

9
SANITARY SEWER

This section describes existing sanitary sewer conditions and identifies the sanitary infrastructure required to service the Abbey Ridge LAP.

9.1 EXISTING SEWER SERVICING

Existing Sewer Infrastructure

The Abbey Ridge LAP area is currently serviced by the Big Bend Trunk Sewer (BBTS) and the Big Bend Pump Station (BBPS). The BBTS runs from east to west through Abbey Ridge, roughly following the 20 metre elevation contour. Originally constructed in 1977, the BBTS ranges from 600mm diameter to 750mm diameter in size, and contains both PVC and concrete pipe segments. Aside from servicing Abbey Ridge, the BBTS also conveys wastewater flows generated by the Port Kells industrial area to the east via the Port Kells pump station and a 500/400mm diameter forcemain, which discharges to the BBTS near the 18400 block of 96 Avenue.

The BBTS conveys flows to the BBPS, located at 176 Street and 104 Avenue, which in turn pumps wastewater west to Metro Vancouver's North Surrey Interceptor (NSI) via a 400/300mm diameter forcemain on 104 Avenue. The BBPS is within the 200 year floodplain of the Fraser River and is susceptible to flooding during freshet conditions. Given this risk, the City is currently undertaking the design to relocate the BBPS to a higher elevation. Once relocated, the BBPS will continue to discharge wastewater flows to the NSI.

Existing Servicing

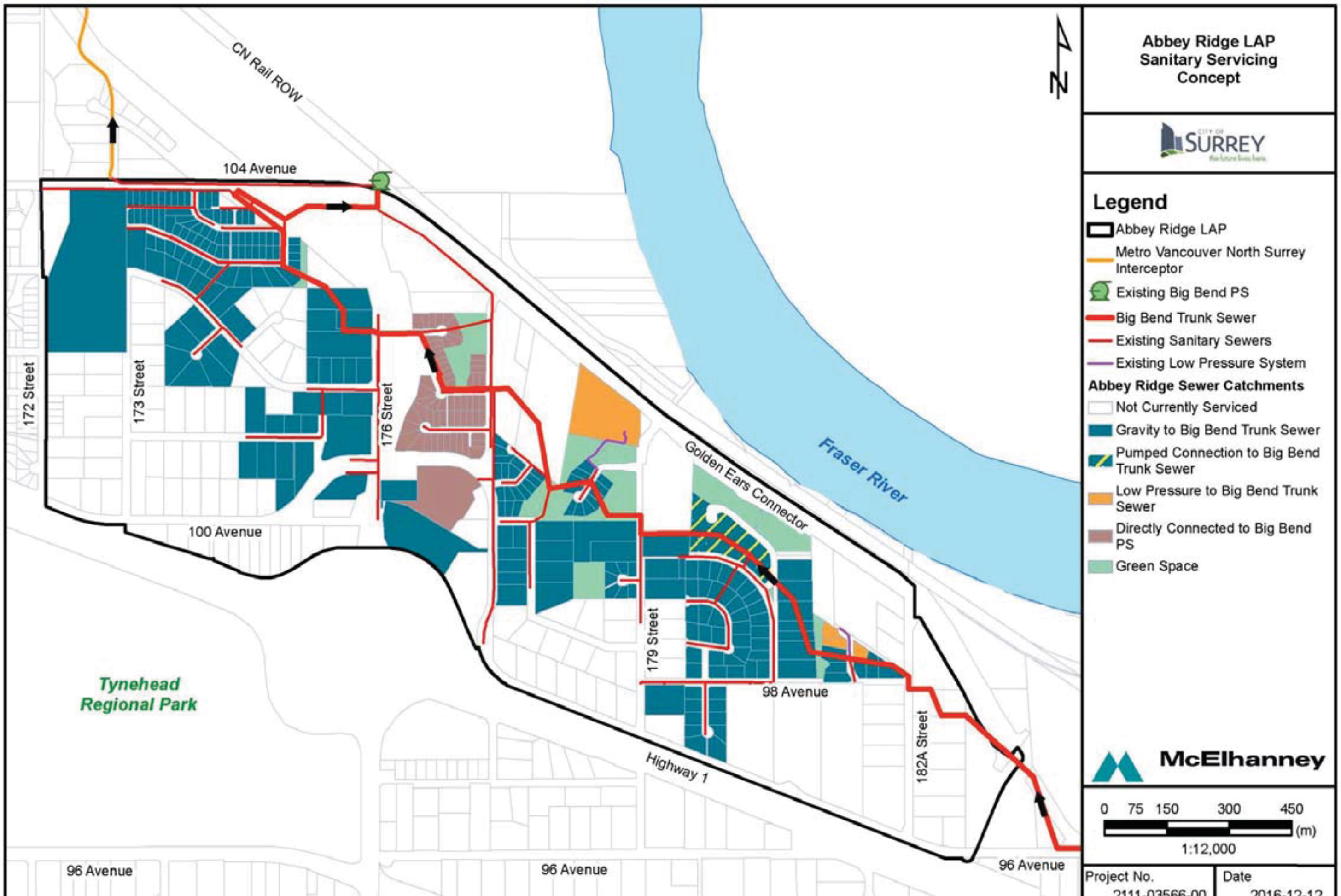
Existing development in Abbey Ridge is serviced in a variety of different ways. Several properties situated south of the BBTS are serviced by a 200mm diameter to 250mm diameter gravity sewer network that connects to the BBTS at several locations along its length. Properties south of the BBTS that are not serviced by the gravity sewer network rely on private on-lot septic field systems for wastewater treatment and disposal.

North of the BBTS, properties are either serviced by low pressure sewer (LPS) systems (since these properties are lower in elevation than the BBTS, they cannot be serviced by gravity sewers) or by private on-lot septic field systems. There is a pocket of existing development on the west side of 177A Street that is serviced by a gravity sewer that is directly connected to the BBPS via an alignment along the Golden Ears Connector. There are also several homes on 99A Avenue and 181 Street that have direct pumped connections to the BBTS.

The BBTS has flow capacity constraints under existing development conditions. The planned increase in development activity, the need to provide sanitary services to all developable lots within Abbey Ridge, and future build out of the Port Kells industrial area will contribute to further capacity issues within the BBTS. Many of the constrained sections are located in rear and side yards within narrow right-of-ways, making it challenging to repair or upgrade the BBTS along its current alignment to address capacity issues. Topographical constraints also make it challenging to consider an alternate alignment for the BBTS without significant impacts to existing development.

The existing sanitary infrastructure in Abbey Ridge and currently serviced areas are shown on Map 14. This infrastructure will need to be extended and upgraded to accommodate future development in Abbey Ridge.

Further details on existing sanitary infrastructure in Abbey Ridge can be found in Appendix A-2.



Map 14 - Big Bend Trunk Sewer Catchments (Existing Conditions)

9.2 DESIGN CRITERIA AND ANALYSIS

The City's Design Criteria Manual (2016) was used to establish the sanitary sewer servicing criteria for Abbey Ridge. Key sewer design criteria are summarized below:

Design Flow Generation

- Average Dry Weather Flow (ADWF) of 350 L/capita/day
- Peaking factor (PF) as per Harman's formula
- Inflow and Infiltration (I&I) allowance rate of 11,200 L/hectare/day

Pipe Capacity / Sizing

- Mannings "n" of 0.013 for all pipes (local and trunk)
- Sewers designed to convey Peak Wet Weather Flow (PWWF)
- Existing sewer capacity assessed using Qdesign/Qfull capacity = 0.70 (or 70%) for sewers with PWWF less than 40 L/s, and Qdesign/Qfull capacity = 0.837 (or 83.7%) for sewers with PWWF greater or equal to 40 L/s
- Minimum velocity of 0.6 m/s at 70% Peak Dry Weather Flow (PDWF) for new gravity sewers

Population projections for Abbey Ridge were provided by the City's Planning Department. For the purpose of the sanitary analysis, a full buildout scenario with high population estimates was assumed for Abbey Ridge to reflect anticipated future development conditions relevant to the design life of the sanitary infrastructure.

9.3 PROPOSED SYSTEM

The development proposed in the Abbey Ridge LAP, combined with the ultimate buildout of the Port Kells industrial area to the east, will result in significant capacity constraints in the BBTS. In order to support future development in the area, capacity constraints will need to be addressed.

Servicing Approaches

Options available to resolve the capacity constraints in the BBTS include:

- Upgrade or twin the BBTS
- Divert Port Kells flows from the BBTS
- Bypass Abbey Ridge flows around constrained sections of the BBTS

As noted earlier, many of the constrained sections in the BBTS are located in rear and side yards within narrow right-of-ways, making it challenging to upgrade or twin the BBTS along its current alignment. Topographical constraints also make it challenging to consider an alternate alignment for the BBTS without significant impacts to existing development. Given its location and the topographical constraints, it is not cost effective to upgrade or twin all of the constrained sections in the BBTS. However, there is an opportunity to address some of the constraints in the western portion of the LAP area (west of 179 Street) by upgrading the BBTS to allow some development in Abbey Ridge to proceed. These upgrades are discussed in further detail below.

The Port Kells industrial area is projected to see a modest increase in development over the next few decades. The Port Kells pump station and forcemain, which have an anticipated 30 to 40 years of design life remaining, can accommodate future development with some upgrades. If wastewater flows from Port Kells were removed from the BBTS, capacity issues in the BBTS would be eliminated.

However, in order to divert Port Kells flows, a new Port Kells pump station and forcemain would need to be constructed, complete with a direct connection to Metro Vancouver's NSI. A new Port Kells pump station and forcemain would cost in the order of $9 million, therefore this is not the most cost effective approach to address capacity issues in the BBTS.

Preferred Option

Given the above discussion, the preferred sanitary servicing strategy for Abbey Ridge focuses on servicing future development in the LAP area and bypassing Abbey Ridge wastewater flows around constrained sections in the BBTS in order to minimize the number of trunk sewer upgrades required.

There are several constraints in the BBTS east of 179 Street; a significant amount of future development in Abbey Ridge is also proposed in areas east of 179 Street. Given the expense and difficulty in upgrading the eastern segments of the BBTS to address constraints, it is recommended that a new local pump station be constructed to service future development east of 179 Street. The pump station would be located on 182A Street near the Golden Ears Connector in order to capture all wastewater flows generated by new development via a gravity sewer network. The pump station would pump flows south along 182A Street and west along 98 Avenue and discharge to a future gravity sewer at 179 Street and 98 Avenue. The gravity sewer would discharge to the BBTS at 179 Street near 99A Avenue. This configuration would allow areas east of 179 Street to develop while bypassing most of the constrained sections in the BBTS.

With the 182A Street pump station in place, the following BBTS upgrades west of 179 Street would still be required to address downstream capacity constraints:

- 101m of 750mm diameter to be upgraded to 900mm diameter in the 17800 block of 100A Avenue

- 70m of 750mm diameter to be upgraded to 900mm diameter at 10267 176 Street

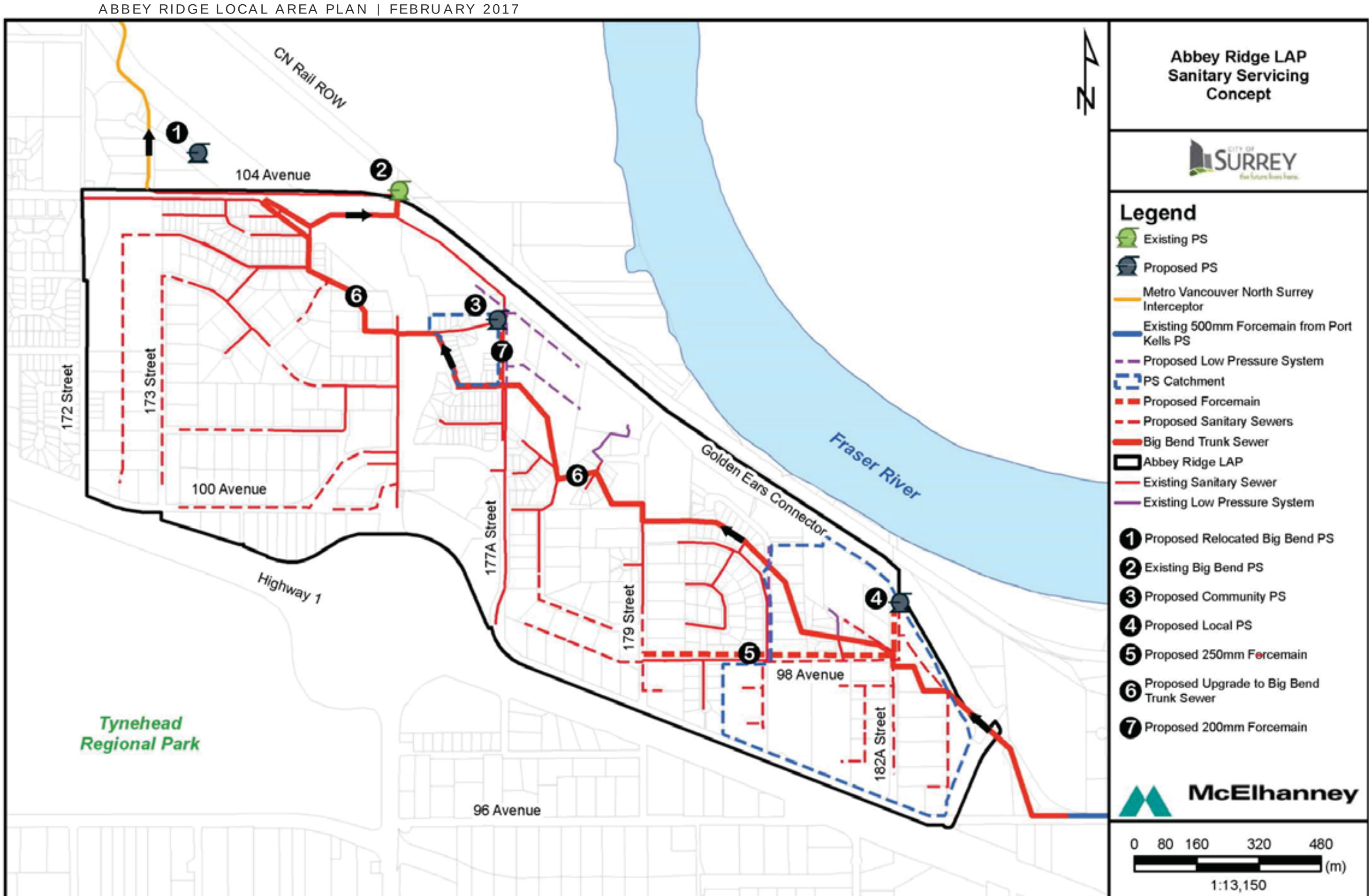
Developments fronting and west of 179 Street can proceed once the two BBTS upgrades noted above are in place. For developments east of 179 Street to proceed, the 182A Street pump station and forcemain should be implemented.

As noted in Section 9.1, the City is currently undertaking the design to relocate the BBPS to a higher elevation. Once the new pump station is in service, the gravity sewer that currently services the existing development on the west side of 177A Street will be abandoned and the catchment will need an alternate method of servicing. To address this issue, the portion of the gravity sewer that services development south of the BBTS will be connected directly to the BBTS. For development north of the BBTS, a small community pump station will be constructed to pump flows south to the BBTS via a short forcemain on 177A Street.

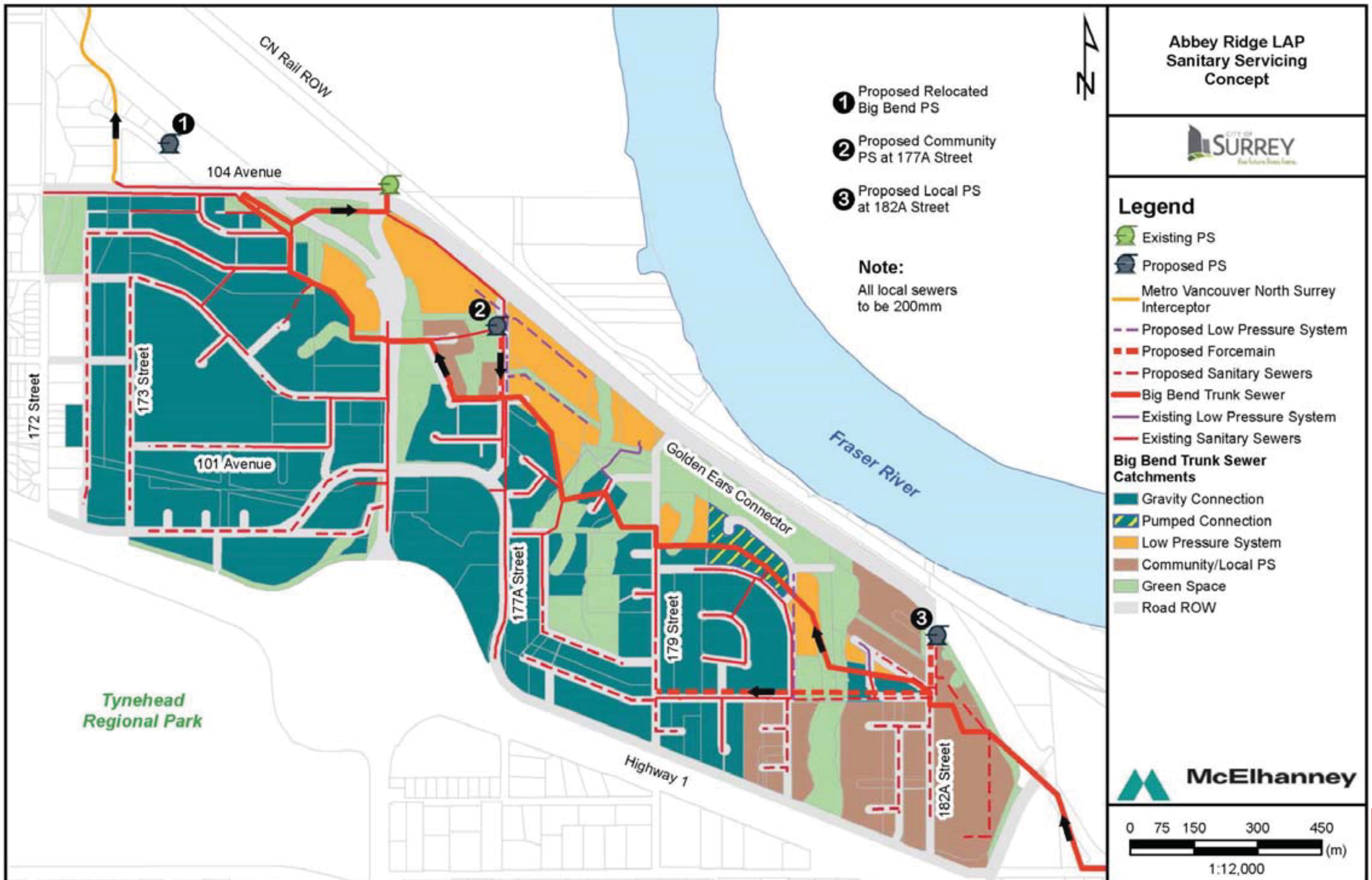
The remaining developable areas south of the BBTS will be serviced by extending the existing gravity sewer network, whereas remaining developable areas north of the BBTS will be serviced by low pressure sewer systems that will pump flows south to the BBTS. Existing developments in Abbey Ridge will continue to be serviced by the same sanitary infrastructure as they are today.

Map 15 illustrates the proposed sanitary infrastructure required to support future development in Abbey Ridge. Map 16 identifies the proposed sewer catchment areas and the servicing approach to be used for each property in the LAP area.

Details on the proposed local and community pump stations, BBTS upgrades, local gravity sewers and low pressure sewers can be found in Appendix A-2.



Map 15 – Proposed Sanitary Sewer System Servicing Plan



Map 16 - Proposed Catchment Areas and Local Sewer Network

9.3

9.4 COSTS AND FINANCING

Sanitary sewer upgrades identified to service the Abbey Ridge LAP area are summarized in Tables 9 and 10.

Table 9 itemizes major system upgrades required for development in Abbey Ridge; these costs can be attributed to growth.

Table 9 – Sanitary Infrastructure required to service the Abbey Ridge LAP (DCC Eligible)

Location	Length (m)	Size (mm diameter)	**Cost Attributed to Growth (DCC Eligible Costs)**
100A Ave: lot 17833 – lot 17845	101	900	$ 320,000
176 St: lot 10267	70	900	$ 290,000
179 St: north of 98 Ave *(upsize only)*	150	250	$ 15,000
182A St: north of 98 Ave *(upsize only)*	150	250	$ 15,000
182A Street Pump Station and Forcemain			$ 1,700,000
TOTAL (rounded up to nearest $10,000)			**$ 2,340,000**

Notes:

- Costs are as of December 2016
- Costs include engineering (12%), and contingency (15%).Pump Stations include 15% engineering and 30% contingency.
- These cost estimates are based on the City's previous project experience. Actual costs may vary depending on unforeseen project design requirements, construction and economic market conditions, local interest in the project(s) and currency fluctuations.

Further details can be found in Appendix A-2.

Local sewers (gravity and low pressure) will be funded by the fronting developer(s). The community pump station on 177A Street will be funded by the City as a capital work since the pump station is required due to the BBPS relocation, and is not a result of future development in Abbey Ridge.

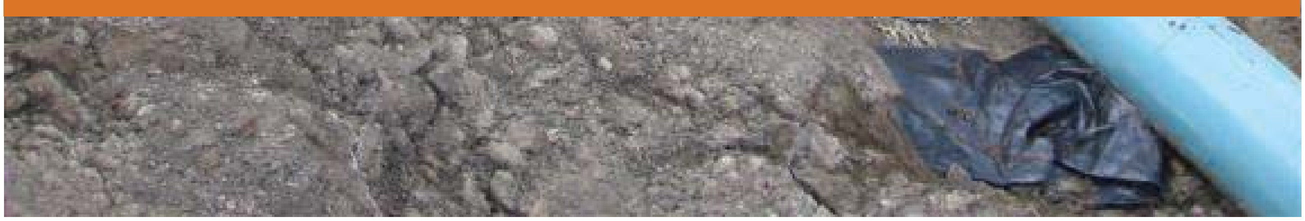
Table 10 summarizes the non-DCC eligible costs for proposed sanitary infrastructure in Abbey Ridge.

Table 9 - Sanitary Infrastructure required to service the Abbey (Non-DCC Eligible)

Item	Cost Attributed to Growth (Non-DCC Eligible)
Community Pump Station at 177A Street	$ 760,000
Local Gravity Sewers	$ 7,200,000
Low Pressure Sewers	$ 1,840,000
TOTAL	**$ 9,800,000**

Further details on sanitary infrastructure costs are provided in Appendix A-2.

SECTION 10
Water



10
WATER

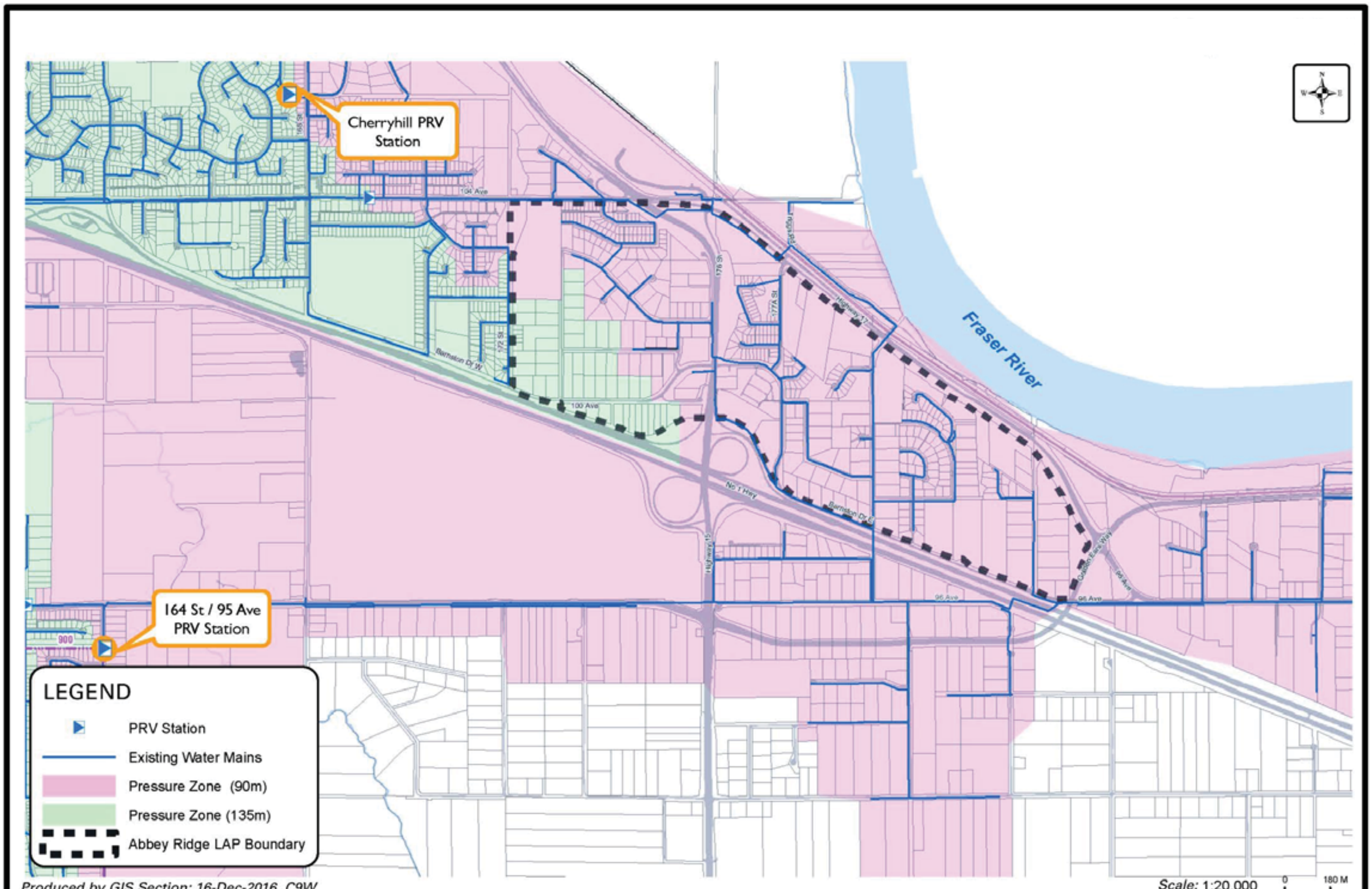
This section describes existing water servicing conditions and identifies the water infrastructure required to service the Abbey Ridge LAP.

10.1 EXISTING WATER SERVICING

Abbey Ridge is located in two water pressure zones, due to the elevation changes in the area. Water in the 90m pressure zone is supplied by a direct connection from Metro Vancouver's transmission main on 164 Street at 95 Avenue. From there, a 525mm feeder main along 96 Avenue delivers the water to areas in the eastern and northern extents of the pressure zone, including Abbey Ridge. The majority of areas within the 90m pressure zone are supplied with City water, with remaining areas serviced by private groundwater wells.

The portion of Abbey Ridge that falls within the 135m pressure zone is not currently serviced by the City's water system. These properties rely on private groundwater wells.

Map 17 summarizes the existing water system in Abbey Ridge. Further details can be found in Appendix A-2.



CITY OF SURREY

Map 17 - Existing Water Servicing

10.2 DESIGN CRITERIA AND ANALYSIS

The City's Design Criteria Manual (2016) was used to establish the standard level of service to be provided for Abbey Ridge. The following relevant parameters were considered:

- Maximum Day Demand is 1,000 L/capita/day
- Peak Hour Demand is 2,000 L/capita/day
- Fire Flow design requirement as per Table 3.1.1 of the Design Criteria Manual
- Minimum Residual Pressure is 14 m (20 psi) during maximum day plus fire flow conditions
- Operating Pressure is 28 m (40 psi) at all nodes during peak hour conditions
- Hydraulic grade in mains larger than 250mm diameter shall not exceed 0.5% or 5 m/km
- The velocity of flow shall not exceed 2 m/s
- Hazen-Williams Coefficient of 125 for all water mains 250mm diameter and larger
- Hazen-Williams Coefficient of 100 for all water mains 200mm diameter and smaller

Employment and residential population estimates were provided by the City's Planning Department. For the purpose of assessing system capacity under future conditions, the full buildout scenario with high population estimates were used.

10.3 PROPOSED SYSTEM

The topography within Abbey Ridge requires that two separate pressure zones be established. The majority of the LAP will be located in the lower 90m pressure zone, while the southwest portion of the LAP will be located in a higher 135m pressure zone, due to higher elevations.

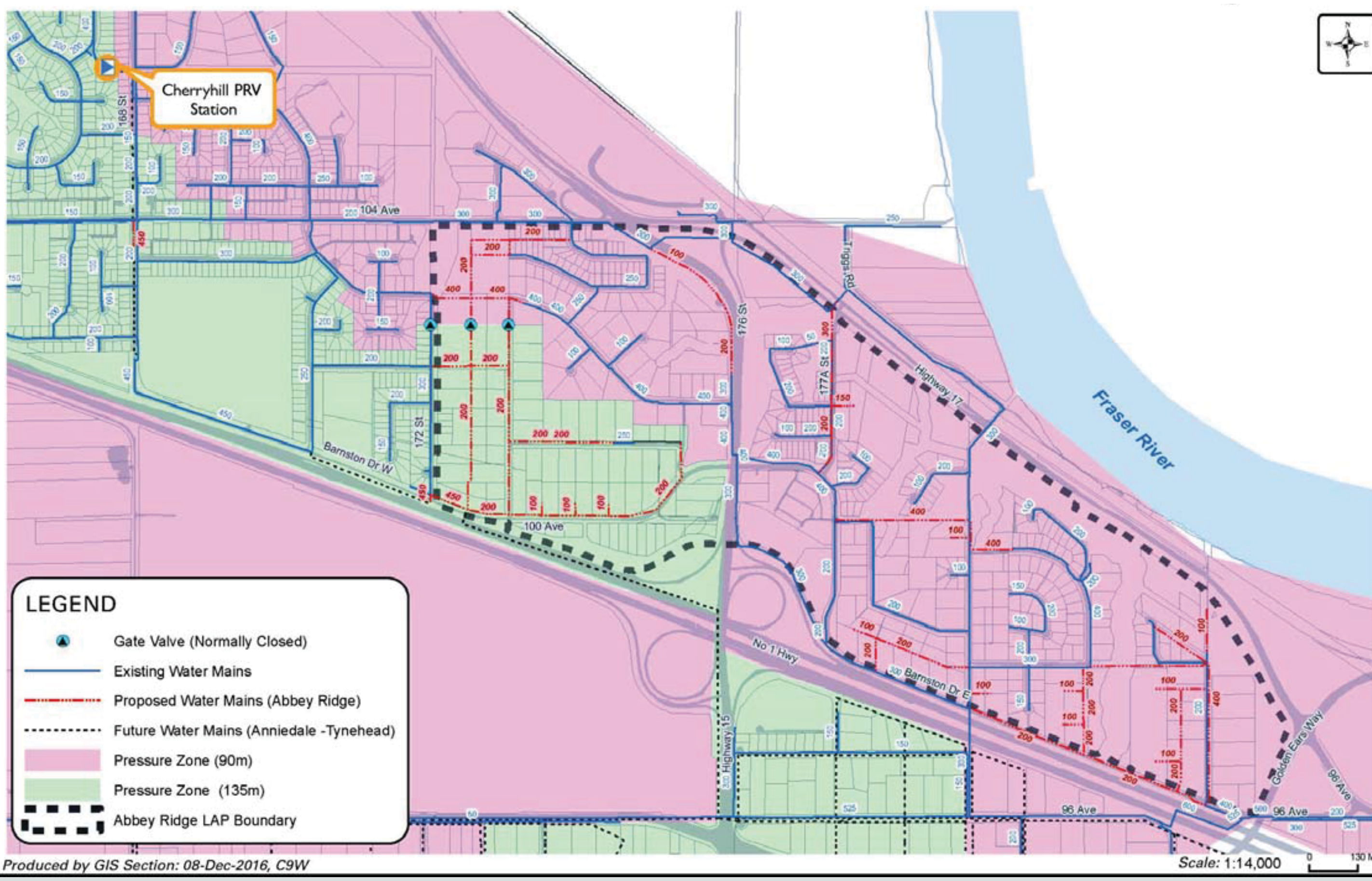
The proposed servicing strategy for the 90m pressure zone in Abbey Ridge is via the existing Cherryhill PRV station. The Cherryhill PRVs will need to be re-set to feed the 90m pressure zone as critical feeds. A flow meter will be required downstream of the Cherryhill PRV station to measure the flow into the 90m pressure zone. The Cherryhill PRV station is fed by the Whalley pump station via a network of feeder mains in the 135m pressure zone. The 90m pressure zone also requires the completion of a 400mm feeder main network to convey flows from the Cherryhill PRV station throughout the LAP area. The 400mm feeder main is partially complete with over 3,000 metres of main installed, but requires an additional 1,600 metres of main to complete the network.

The proposed servicing strategy for the 135m pressure zone in Abbey Ridge is from Whalley pump station via a network of feeder and distribution mains. In order to service this area, water distribution mains must be extended from the existing mains at 172 Street and Barnston Drive West. The infrastructure required to support the Anniedale-Tynehead Neighbourhood Concept Plan (NCP) will provide additional redundancy for the Abbey Ridge water supply, such as the 450mm feeder main on 168 Street and Barnston Drive West. The feeder main will extend through Abbey Ridge and across Highway 1 to feed the 135m pressure zone in Anniedale-Tynehead.

The 450mm main is sized for Anniedale-Tynehead, but has the capacity to also supply Abbey Ridge.

To reduce the number of dead-end water mains at the 90m / 135m pressure zone boundary, the existing zone boundary is shifted east for the proposed system. As a result, there are properties currently serviced by City water along 101 Avenue (west of 175A Street) that will be transferred from the 90m pressure zone to the 135m pressure zone.

Map 18 illustrates the proposed water servicing strategy for Abbey Ridge. Further details can be found in Appendix A-2.



CITY OF SURREY

Map 18 – Proposed Water System Servicing Plan

10.4 COSTS AND FINANCING

Water infrastructure upgrades identified to service the Abbey Ridge LAP area are summarized in Table 10.1. These are major system upgrades required for development in Abbey Ridge and the costs can be attributed to growth. The current 10-Year (2016-2025) Servicing Plan includes portions of the 400mm diameter watermain that extends from 172 Street to 182A Street in the 90m pressure zone and the 450mm diameter feeder main that extends along 168 Street and Barnston Drive West in the 135m pressure zone.

There is no new water infrastructure required for Abbey Ridge that is not already included in City's current 10-Year (2016-2025) Servicing Plan.

Table 11 Water Infrastructure required to support the development of the LAP area.

10.4

Table 11 - Water Infrastructure required to service the Abbey Ridge LAP (DCC Eligible)

Location	Length (m)	Diameter (mm)	Cost Attributed to Growth (DCC Eligible Costs)
177A: Barnston Dr E - Trigg Rd (Upsizing)	486	300	$ 36,450
103 Ave: 172 - 173 St (Upsizing)	255	400	$ 59,925
100 Ave: 177 - 179 St (Upsizing)	264	400	$ 62,070
100 Ave: 177 - 179 St	100	400	$ 60,000
179 St: 99A - 100 Ave	79	400	$ 47,573
99A Ave: 179 - 180 St (Upsizing)	120	400	$ 28,200
98 Ave: 181 - 182A St (Upsizing)	187	400	$ 43,833
98 Ave: 181 - 182A St (Upsizing)	130	400	$ 78,000
182A St: Barnston Dr E - 98 Ave	392	400	$ 235,487
Cherryhill Dr / 168 St (Flowmeter)	-	-	$ 60,000
168 St: 103A - 104 Ave (Upsizing)	107	450	$ 107,000
		Subtotal	$ 818,538
		Contingency	$ 122,781
		TOTAL (rounded)	**$ 942,000**

Notes:

- Costs are as of December 2016
- Costs include engineering (12%), and contingency (15%).
- These cost estimates are based on City's previous project experience. Actual costs may vary depending on unforeseen project design requirements, construction and economic market conditions, local interest in the project(s) and currency fluctuations.

Fronting development costs (to be funded by the development community) for Abbey Ridge are estimated to be $7.0 Million.

PART C

Appendices and Acknowledgements

Photo: Surrey City Hall

APPENDICES

Photo: City Centre Library

A-1
CORPORATE REPORTS

A collection of corporate reports that support the Abbey Ridge Local Area Plan.

List of Reports

A-2 CONSULTANT REPORTS

A list of consultant reports that informed the Abbey Ridge Local Area Plan is provided for convenience.

Reference List

A-2.1

Phoenix Environmental Services Ltd. East Fraser Heights Environmental Study: Ken Lambertsen and Associates, 2015

A-2.2

McElhanney Consulting Services Ltd. Abbey Ridge Servicing Reports; 2016 & City of Surrey Servicing Report(s);

A-2.3

R.F. Binnie and Associates Ltd. Road Network Evaluation and Recommendation – Abbey Ridge Local Area Plan (Stage 2) Transportation Servicing Plan;2016.

Appendix A-2.1 - East Fraser Heights Environmental Study

A-2

ENVIRONMENTAL ASSESSMENT REPORT

East Fraser Heights
Environmental Assessment and Tree Study

Surrey, B.C.

Prepared for:

City of Surrey

Prepared by:

PHOENIX ENVIRONMENTAL SERVICES LTD.

July 2015

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LIST OF APPENDICES

EXECUTIVE SUMMARY

Phoenix Environmental Services Ltd. (Phoenix) has completed this Environmental Assessment and Tree Study of the East Fraser Heights area of Surrey (Study Area) for the City of Surrey Planning & Development Department (the City). The Environmental Assessment and Tree Study is intended to provide a baseline environmental context as a first step in the development of a Land Use Concept for the area. The Environmental Assessment has included an analysis of stream riparian areas and fisheries watercourse classifications, assessment of vegetation communities, wildlife (including species at risk), and identification of environmentally sensitive areas as well as critical wildlife hubs, sites and corridors. The tree study has included the identification of significant trees, remnant patches of forests and those specimen trees with high arboriculture values and other relevant observations.

Surficial geology mapping shows that native soils in most of the Study Area comprise Capilano Sediments with a broad band of Pre-Vashon Deposits extending east-west across the Study Area, generally on escarpment slopes. Capilano Sediments are glacial till-like soils comprising stoneless silt loam and clay loam with minor sand and silt between 3 – 30 m thick. These soils tend to be densely consolidated, but are permeable. The Pre-Vashon Deposits in the Study Area can include Quadra (sandy) fluvial channel fill and floodplain deposits, as well as marine interbedded fine sand to clayey silt. The Pre-Vashon Deposits in the Study Area have significant potential for high yield groundwater aquifers. BC Soil Survey mapping indicates gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits are present over most of the Study Area. These are relatively permeable soils and are expected to support seasonal aquifers that may dry out in summer months, and which can support baseflows in streams. Land use planning in the area should take into account the need to maintain groundwater recharge capability by minimizing impervious ground surfaces, maintaining open vegetated ground in exchange for higher density development with surrounding greenspaces, and incorporating stormwater infiltration infrastructure.

The Study Area drainage areas discharge to the north into the Fraser River. The watercourses within the Study Area generally include: ravine streams and tributaries, wetlands, constructed ponds and streams, and constructed drainage ditches. Good channel complexity with large woody debris has been observed within the major ravine streams of the Study Area, including extensively occurring springs and wetlands. The extent of springs and groundwater baseflows in watercourses in the Study Area indicate the importance of preserving groundwater recharge areas to support the baseflows and productivity of streams in the East Fraser Heights area. Based on a desktop review combined with extensive field observations, several changes to watercourse classifications are proposed, including mapping corrections and additions. Several streams currently have barriers to fish migration (e.g. constructed ponds), which if removed could support fish populations. The potential to remove existing barriers to fish migration should be assessed and implemented in conjunction with any future re-development applications, as well as being taken into consideration for the proposed Land Use Concept for East Fraser Heights. To minimize negative impacts of future development on the hydrologic flow regime of watercourses, mitigation methods should be considered as part of the development process to reduce excessive creek flow during storm events, as well as maintain groundwater recharge and stream baseflow.

Within the Study Area, there is a wide range of tree species. In general terms, the forested areas predominantly comprise native tree species, with mostly introduced tree species in the developed single-family areas. It is estimated that approximately 35% of the Study Area is presently forested with closed canopy stands of native trees. There are many impressive trees within the Study Area, measured both by size and by landscape value. It is recommended that existing tree stands be protected as much as possible under future land use planning for East Fraser Heights.

The vegetation communities along the sloped portions of all creeks are similar, as they are generally dominated by western red cedar and western hemlock and interspersed with red alder, big leaf maple, and black cottonwood. The associated shrub layer is mainly dominated by salmonberry, vine maple, Indian plum, and thimbleberry and the herb layer is typically dominated by sword fern, lady fern, skunk cabbage, piggy-back plant, and fringecup. The lowland, floodplain areas of the creeks are dominated by deciduous tree species, including red alder and black cottonwood with the shrub and herb layers dominated by salmonberry, three-leaved foamflower, reed canary grass and sedges. Wetland and pond areas are dominated with salmonberry, lady fern, skunk cabbage, cattail, and reed canary grass. Based on the habitats observed, aerial imagery, and BC Conservation Data Centre records, few to no rare vegetation species are expected to occur within the Study Area. Invasive vegetation species have been encountered at many of the habitats observed within the Study Area and include species such as Himalayan blackberry, Japanese knotweed, scotch broom, and English ivy. These invasive plant species regularly occur along the forest edges next to disturbed or developed sites.

Two species of conservation concern, the Great Blue Heron and Oregon forestsnail have been observed within the Study Area during the field surveys. Moderately used wildlife trails, attributed to coyotes and black-tailed deer, occur within forested areas in the Study Area. These animals appeared to travel mainly along the watercourses and riparian areas. In addition to coyotes and deer, these corridors are likely used by many species of small mammals, birds, amphibians, and reptiles. The ponds, watercourses, and associated terrestrial habitats provide important habitat for many waterfowl, songbird and amphibian species. The riparian zones of all creeks, particularly Leoran Brook, are key environmentally sensitive areas. These riparian forests provide high habitat capability for the provincially and federally listed Pacific water shrew, Oregon forestsnail, Western Screech-owl, and northern red-legged frog, as well as the provincially listed Trowbridge’s shrew and Pacific sideband snail. A high number of Oregon forestsnail have been observed with the Green Infrastructure Network Corridor and adjacent forest along Leoran Brook. Pacific water shrews are expected to be closer to the Leoran Brook ravine. Consistent with the City’s Biodiversity Conservation Strategy, planning under the Land Use Concept should give priority to retaining larger forested areas and avoid fragmentation as much as possible, protect and (where possible) enhance the riparian forests and streams, and maintain wildlife corridors along existing streams and ravines such as Leoran Brook. Construction of the Golden Ears Connector (South Fraser Perimeter Road) along the north and east edges of the Study Area have included fish-passable and wildlife corridor culvert crossings for several streams in the Study area. A bridge crossing for Leoran Brook represents a major enhancement of the Green Infrastructure Network Corridor along Leoran Brook. Land acquisition opportunities for stream, forest and biodiversity conservation are limited by the extent of private property within the East Fraser Heights Study Area. However, potential land acquisition opportunities may exist where the Class A and Class B stream and associated springs and wetlands remain relatively undisturbed and intact and offer high fish and wildlife values.

1. INTRODUCTION

Phoenix Environmental Services Ltd. (Phoenix) has been retained by the City of Surrey Planning & Development Department (the City) to provide an Environmental Assessment and Tree Study of the East Fraser Heights area of Surrey (Study Area). Phoenix understands that there has been increasing development interest in the East Fraser Heights area, which has prompted the Surrey City Council to authorize Community Planning staff to initiate a land use planning and community consultation process for the East Fraser Heights area. The Environmental Assessment and Tree Study is intended to provide a baseline environmental context as a first step in the development of a Land Use Concept for the area that may guide future Official Community Plan (OCP) amendments, or may confirm the existing land use designations in the East Fraser Heights area.

The Environmental Assessment and Tree Study has included an assessment of stream riparian areas and fisheries watercourse classifications, assessment of vegetation communities, wildlife, and wildlife habitat, assessment and suitability mapping for Species at Risk Act (SARA) and Provincial red- or blue-listed species, identification of environmentally sensitive areas such as rare vegetation types, marshes, wetlands, as well as critical wildlife hubs, sites and corridors making up the City of Surrey Green Infrastructure Network in support of the 2014 Biodiversity Conservation Strategy. The tree study has included the identification of significant trees, remnant patches of forests, specimen trees with high arboriculture values, and other relevant observations.

This report documents key environmental and tree attributes in the Study Area and makes specific recommendations for the preservation and enhancement of fish habitat, groundwater resources, plant communities, wildlife (herpetofauna, mammals, and birds) habitat, rare, threatened and endangered species, and significant tree stands and specimens. Recommendations related to land use planning considerations are also provided.

1.1 STUDY AREA

The Study Area for the East Fraser Heights land use planning area comprises 175 ha (430 acres) and is generally bounded by Highway No. 1 to the south, 172 St. to the west, Highway 17, Daly Rd. and the CN Railway to the north, and Golden Ears Way to the east. The Study Area is divided by the Big Bend major drainage catchment area to the west of 176 St. (Highway 15) and the large Port Kells drainage catchment area to the east of 176 Street. The existing Kinder Morgan Trans-Mountain pipeline transverses the Study Area. Due to the development that has already occurred adjacent to the existing pipeline alignment, there is a proposal to install a new pipeline near the base of the escarpment adjacent to Daly Road; the alignment of which may also impact development in the Study Area, as well as potentially impact stream and groundwater resources.

Key existing environmental features include Leoran Brook and several other Class A and Class B fish habitats, which receive groundwater baseflows from springs along the escarpment and ravine slopes. There are numerous Class C drainage watercourses and ditches along property boundaries and roads within the Study Area as well. While extensively developed for primarily residential uses, there are several large parcels of forested lands offering wildlife habitat values; including a Regional Green Infrastructure Network (GIN) Corridor identified in the Biodiversity Conservation Strategy along Leoran Brook, with a wildlife crossing under Highway 1 into/from the Anniedale - South Port Kells area to the south of the Study Area. The large natural conservation areas of the Surrey Bend Regional Park and Tynehead Regional Park are situated nearby to the north and south respectively, but are separated from the East Fraser Heights area by highways and railway corridors that significantly limit connectivity. The western edge of the Study Area has been identified as part of a Critical Habitat Parcel for Pacific Water Shrew (Fraser Heights and Highway 1) under the 2014 Environment Canada report: "Recovery Strategy for the Pacific Water Shrew (*Sorex bendirii*) in Canada".

The Study Area generally slopes to the north offering views of the Fraser River and North Shore Mountains. The Study Area primarily comprises of a mix of suburban properties of varying sizes and with some multi-family and commercial uses. Recent re-development proposals for higher density residential urban subdivisions have involved an OCP amendment to Urban, Multiple Residential or Commercial designations, and rezoning to a CD (Comprehensive Development) zone. Industrial use is present along much of the northern edge adjacent to the South Fraser Perimeter Road /Golden Ears Connector and the CN Rail tracks. Refer to Figure 1: Study Area Map in Appendix A for a 2014 aerial photo showing the Study Area. A copy of the Corporate Report regarding the East Fraser Heights/Abbey Ridge Land Use Concept dated March 23, 2015 is presented for more detailed reference in Appendix D.

1.2 METHODOLOGY

The methodology for this Environmental Assessment and Tree Study has included use of existing information resources, mapping and reports, as well as field reconnaissance, to conduct an assessment of key environmental and tree attributes in the Study Area. The assessment has provided a basis for making specific recommendations for the preservation and enhancement of fish habitat, groundwater resources, plant communities, wildlife (herpetofauna, mammals, and birds) habitat, rare, threatened and endangered species, and significant tree stands and specimens.

1.3 SCOPE

The scope of work for this Environmental Assessment and Tree Study has included:

- An inventory of environmental features including watercourses, fish habitat, riparian areas, ecologically significant areas and tree specimens.
- An update of the City's existing watercourse classification map and compilation a broad-based terrestrial resources inventory database, including a description of ecological features and functions
- Identification, mapping and assessment of tree stands and specimens that have the potential for preservation and establishment of canopy cover targets for different land uses
- Recommendations regarding preservation of large core habitat areas and connectivity between habitat areas

- Determination of the significance of the groundwater resources in the Study Area and the level of sensitivity to impacts from potential further land development

- Recommendations regarding stormwater management to mitigate upland creek erosion and lowland flooding issues associated with potential development

- Preparation of recommendations for the preservation and enhancement of fish habitat, groundwater resources, plant communities, wildlife (herpetofauna, mammals, and birds) habitat, rare, threatened and endangered species, and significant tree stands and specimens generally for the Study Area, including recommendations regarding the extent of the environmentally significant areas, sites and corridors that should be protected.

1.4 BACKGROUND INFORMATION SEARCH

Prior to the field assessments, pertinent background information and online mapping resources (COSMOS) provided by the City have been reviewed in order to focus field observations on key watercourses, identified terrestrial habitats, and those species and habitats with a high potential for occurrence in the Study Area.

A collection of assessment reports previously completed pertaining to Study Area has been provided by the City. The Corporate Report: “East Fraser Heights/Abbey Ridge Land Use Concept” dated March 2015 (Appendix D) has provided background information and context regarding the neighbourhood characteristics and the proposed planning and public consultation process being undertaken by the City for the Study Area. The City’s Biodiversity Conservation Strategy and related COSMOS designations of hubs and corridors have been referenced, as has existing watercourse classification mapping. Key reports reviewed for this environmental assessment include, but were not limited to: Groundwater Water Supply Study – Phase 1 Report (Gartner Lee Limited, 1999) and Surrey Groundwater Strategy – Phase II (Gartner Lee Limited, 2004). Surficial geology mapping (Geological Survey of Canada) and BC Soil Survey Mapping (Soils of the Langley-Vancouver Map Area, Luttmerding, H.A. 1980) were also reviewed. Past reports of the Study Area that have been reviewed include the Port Mann Bridge/Highway 1 Terrestrial Resources Impact Assessment, and the Vegetation and Wildlife Impact Assessment and Fish Habitat Impact Assessment South Fraser Perimeter Road Environmental Assessment Application. Recent studies and drawings for the South Fraser Perimeter Road Golden Ears Connector segment along the Study Area also have been reviewed. In addition, the Anniedale-Tynehead NCP Area Overview Environmental Assessment (Madrone Environmental Services Ltd., 2009) was reviewed for information that may also apply to the Study Area.

The BC Conservation Data Centre (CDC) website was searched for all species listed under SARA, COSEWIC, Provincial Identified Wildlife and the Provincial *Wildlife Act* that are suspected to occur within habitats identified within the Study Area. In addition, species listed as Red and Blue-listed by the BCCDC but not specifically covered under legislation were also included. BCCDC data within the Study Area were also reviewed. The BC Ministry of Environment Habitat Wizard was reviewed for existing fish presence data within the Study Area. Aerial photographs and Lidar images of the Study Area were examined to identify possible unmapped streams and existing streams and ravines, and potential habitats and wildlife corridors were identified.

1.5 FIELD SURVEYS

Field observations of selected areas within the East Fraser Heights Study Area were conducted on May 14, 15, and 20 and June 1 and 8, 2015 by Ken Lambertsen, R.P.Bio. (Senior Consultant), Matt Fernandez (Environmental Technician), Claudio Bianchini, R.P.Bio. (Wildlife Biologist), Kate Fremlin, R.P.Bio. (Wildlife Biologist) and Michael Mills (Certified Arborist).

Field assessments for watercourses were completed during dry conditions (e.g. more than 48 hours after a significant rainfall event), and during a particularly dry weather period for the months of May and June. The objectives of the field assessments were to examine watercourse features, confirm the watercourse classifications or ascertain changes in existing classifications, and any identify unmapped watercourses or aquatic habitats within the Study Area. Selected watercourses were observed for fish and aquatic habitat attributes and to assess transitions from Class A to Class B (e.g. fish migration barriers), and significant features (e.g. wetlands, springs).

Field assessments also have been conducted to observe intact habitats and determine the potential to support wildlife, particularly rare and endangered species. Visual encounter foot transects were traversed within the Study Area beginning in the early morning hours throughout all forested areas and along the treed perimeter to verify breeding raptor and songbird activity. Evidence of bird use was evaluated by detecting and documenting bird observations, and searching for the presence of fecal wash, prey remains, regurgitated pellets, feathers, old and/or new open nests, and nest or roost cavities in wildlife trees. Standwatch surveys were conducted at the forest edges to maximize an overview of the forested areas and detect the potential activity of raptors soaring overhead or perched in the canopy or on various man-made structures. Any direct visual or auditory observations of wildlife or nest encounters were recorded. Foot encounter transects were used to comprehensively search in and beneath low vegetation, leaf litter, and cover objects (e.g. logs, boulders, debris) for the presence of birds, snails, reptiles, and amphibians.

Field visits for the Tree Study have been carried out to develop generalized stand delineation mapping utilizing available aerial photos of the Study Area to assist in identification of stand characteristics and individual trees of high arboricultural value.

2. TOPOGRAPHY

The Study Area slopes downward over a prominent, relatively steep escarpment toward the Fraser River. Surface elevations range from approximately 65 metres (geodetic) near the southeast corner of the Study Area where the topography is gently sloped to 5 m near the north Study Area boundary adjacent to the Fraser River lowlands and floodplain. There are several steeply sided and deep ravines that extend north through the Study Area containing significant watercourses (e.g. Leoran Brook).

Contour mapping by the City of Surrey (COSMOS) shown in Figure A below clearly indicate an increase in slope steepness along the north half of the Study Area along the lower extent of the escarpment, as well as where ravines occur along streams in the Study Area.

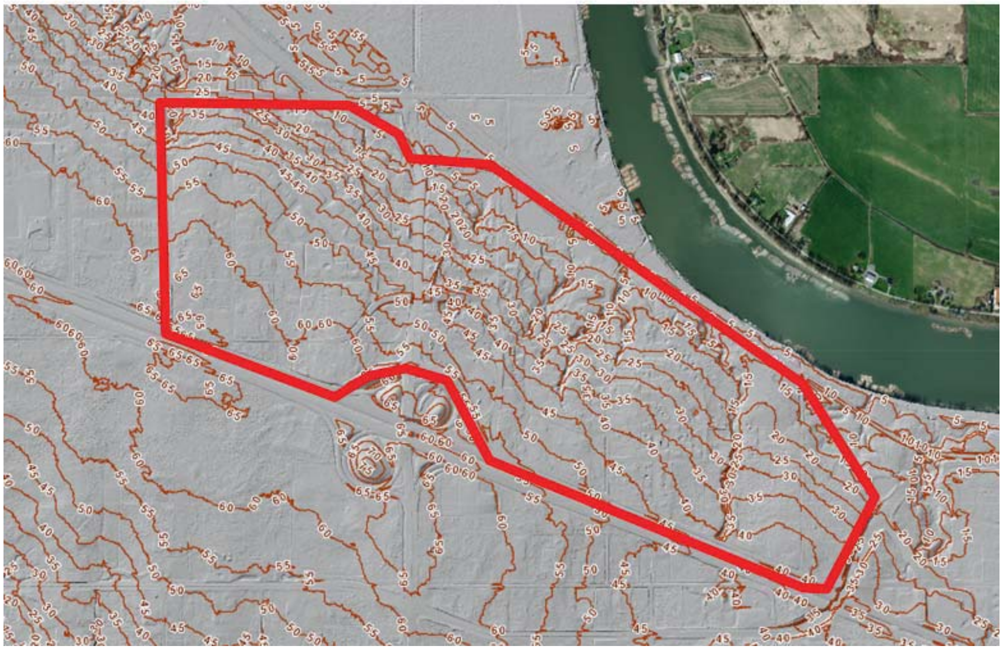

Figure A - Study Area Topography (City of Surrey COSMOS Mapping)

3. SOIL AND GEOLOGY

Surficial geology mapping by the Geological Survey of Canada (New Westminster, Map 1484A) shows that native soils (beneath topsoil) in most of the Study Area comprise Capilano Sediments (Cd) with a band of Pre-Vashon Deposits (PVa,c) extending east-west across the Study Area, generally on escarpment slopes. Capilano Sediments are raised marine, deltaic and fluvial deposits; which in the Study Area (Cd) are marine and glaciomarine stony (till-like) and stoneless silt loam and clay loam with minor sand and silt, commonly less than 3 m thick and up to 30 m thick. These soils tend to be densely consolidated, but are permeable. The Pre-Vashon Deposits are glacial, nonglacial and glaciomarine sediments; which in the Study Area include Quadra fluvial channel fill and floodplain deposits as well as marine interbedded fine sand to clayey silt. Typically, Capilano Sediments overlay the Pre-Vashon Deposits; however, in the Study Area the Pre-Vashon Deposits occur near the ground surface, as in commonly the case along the escarpment slopes of Surrey and elsewhere. The Pre-Vashon Deposits in the Study Area have significant potential for higher yield aquifers (Gartner Lee, 1999). Phoenix observed both soil types where exposed slopes and ground surfaces were encountered (e.g. ravines, highway construction areas).

According to BC Soil Survey mapping (Soils of the Langley-Vancouver Map Area. Luttmerding, H.A. 1980), the soils in the Study Area are primarily classified as Bose (BO) and Capilano (CP) soils (see Figure B below). Bose soil is described as 30 to 160 cm of gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits. Capilano soil is described as gravelly glacial outwash deposits. In the southeast portion of the Study Area there is a small area identified as Judson soil (JN), which is described as 40 to 160 cm of well-decomposed organic material underlain by moderately fine textured glaciomarine deposits. The Bose and Capilano Soils are relatively permeable soils and are expected to support seasonal aquifers that may dry out in summer months, and which can support baseflows in streams.

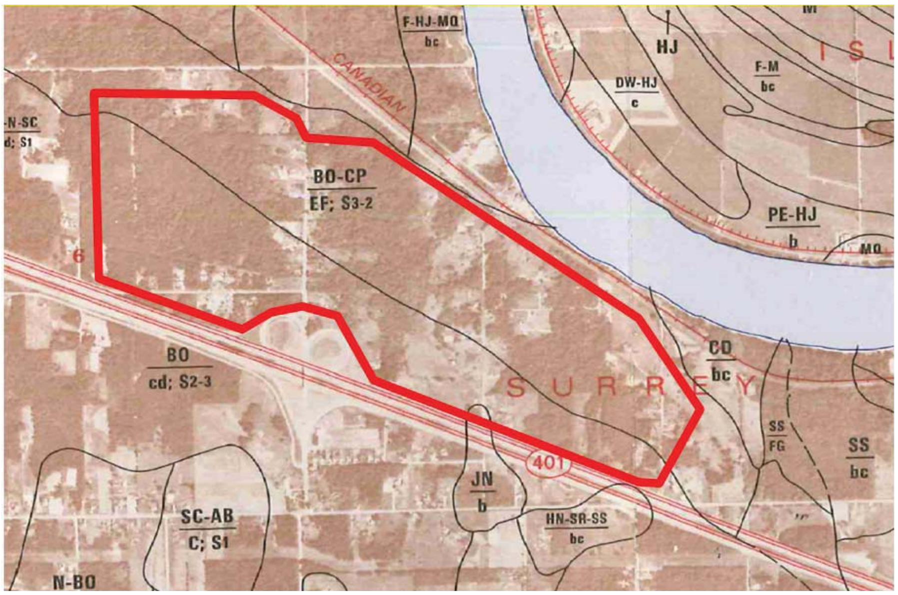

Figure B - Soil Map of Study Area (Luttmerding, 1980)

4. GROUNDWATER

Subsurface geological characteristics within the Study Area are discussed in the Surrey Groundwater Water Supply Study – Phase 1 Report (Gartner Lee Limited, 1999) as provided by the City and information relevant to this Environmental Assessment is discussed below. The report states that the surficial strata in the North Surrey upland areas (which describes the majority of the Study Area, other than the lowland region near the banks of the Fraser River) generally consist of a veneer of marine stony silt (Capilano Sediments) underlain by dense, sandy-silt glacial till (Vashon Drift). The Vashon Drift layer is underlain by older glacial tills, marine sediments and sand and gravel strata. These strata are exposed in places along the steep slopes that occur along the perimeter of the upland areas. The older sand and gravel strata often form high-yield confined aquifers.

According to the Surrey Groundwater Water Supply Study, the North Surrey uplands area is generally considered a groundwater recharge area with low permeability and the Fraser Lowlands at the north end of the Study Area is generally considered an area of groundwater discharge.

According to the Anniedale-Tynehead-NCP Area Overview Environmental Assessment (Madrone Environmental Services Ltd. 2009), Vashon Drift, which underlies the Study Area, is relatively impermeable (at least compared to the Quadra sands below it). The relatively low permeability of the Vashon Drift restricts groundwater recharge. The report suggests that the majority of infiltrated water probably flows in a shallow subsurface zone and that springs in the region are likely caused by shallow groundwater emergence.

According to the Gartner Lee Groundwater Supply Study, Quadra Sands underlie the Vashon Drift glacial deposits. Due to the coarse texture of these deposits, the Quadra Sands have a high permeability, high storage capacity, and high hydraulic conductivity, resulting in good groundwater aquifer productivity.

A desktop review of geologic and topographic features, including the reports mentioned above, indicates there is potential for groundwater to produce springs and streams along the sloped areas in the northern portion of the Site where the North Surrey uplands slope down to meet the Fraser Lowlands. The potential for springs to occur is highest along the relatively steep slopes where geological layers which are otherwise subsurface will be exposed (i.e. dense till overlain by sands and silts). Where the exposed soil layer is acting as an aquifer, including shallow subsurface groundwater flow, there is high potential for springs. During field assessments, springs supporting streams were observed along the base of ravine slopes, including flowing artesian wells installed nearby streams (see Figure 2, Appendix A).

Continued development in the Study Area has the potential to reduce groundwater recharge if there is a significant increase in impervious surfaces which prevent infiltration of precipitation to the subsurface. A decrease in groundwater recharge can result in a decrease in stream base flow and an overall increase in stream water temperature as groundwater discharge into streams tends to be relatively cool. This effect would be particularly significant during the drier summer months when there is the highest concern regarding insufficient flow and warmer water temperatures. Reduced groundwater recharge will result in a generally decreased groundwater elevation which will restrict the supply of groundwater to wetland environments.

5. WATERCOURSES

The following sections describe the types and features of watercourses in the Study Area, existing and proposed fisheries watercourse classifications, and key issues associated with the ecological function and integrity of the watercourses.

5.1 WATERCOURSE CLASSIFICATIONS

The City of Surrey has classified streams according to their ability to support fish populations:

- Class A – watercourses support fish populations year round or have the potential to support fish populations year round, if migration barriers are removed

- Class A(O) – watercourses support fish populations generally only during the winter months; often roadside ditches that have very low flows and warm temperatures in the summer

- Class B – do not support fish populations, but provide food and nutrients to downstream fish habitats and often are supported all year or most of the year by groundwater

- Class C – do not support fish populations and generally only convey flows associated with rainfall events; often shallow roadside or property line ditches in headwater areas

Based on the background data, aerial photography, Lidar topographic relief mapping and extensive ground-truthing, the majority of the streams in the Study Area have been classified correctly, as currently shown on the City of Surrey GIS mapping system (COSMOS). However, Phoenix has identified several watercourses that warrant re-classification from current fisheries watercourse classifications on COSMOS. As well, instances of inaccurate stream mapping have been corrected, and some watercourses and associated features have not been mapped on COSMOS to date.

Verification in the field primarily consisted of locating the reach breaks between Class A and Class B designations to see if fish barriers or flow restrictions were consistent with the classifications, as well as investigating potential unmapped watercourses as indicated by Lidar topographical relief mapping. Fish have been observed during the field assessments, but fish sampling has not been conducted for this assessment. Locations where flowing water (i.e. groundwater) during dry weather (e.g. more than 48 hours following rainfall) was observed have been noted. Field assessments have been conducted during prolonged dry weather conditions, which facilitated differentiation between Class B and Class C watercourses, but also has imposed limitations of confirming Class B and Class C classifications. The study period for this environmental assessment (May/June 2015) has been unusually dry, such that confirming that existing Class C watercourses only convey runoff for short durations has not been possible. Further assessment of some constructed Class C and Class B watercourses should be conducted in conjunction with any future re-development plans for the Study Area.

5.2 Aquatic Habitat Descriptions

The Study Area contains portions of two major drainage catchment areas identified as Big Bend (west of Highway 15/176 Street) and Port Kells (east) on COSMOS. These drainage areas discharge to the north into the Fraser River. The watercourses within the Study Area can be separated roughly into the following categories:

- Ravine streams and tributaries
- Wetlands
- Constructed pond and stream
- Constructed drainage ditches

Refer to Figure 2: Watercourse Classification Map in Appendix A for locations of watercourses in the Study Area.

5.2.1 Ravine Streams

The ravine streams and most natural creeks within the Study Area generally flow to the north/northeast and have formed ravines over the escarpment slopes. In the lower reaches towards the north, the ravine streams generally discharge into roadside drainage ditches or storm sewers just outside the Study Area (e.g. Highway 17/Golden Ears Connector, CN Rail tracks) before discharging into the Fraser River.

Key ravine stream locations in the Study Area include:

- Leoran Brook
- Barnston Park
- Abbey Glen Park

5.2.1.1 Leoran Brook

Leoran Brook is a Class A watercourse and provides very good juvenile salmonid rearing habitat with spawning potential limited by low flows, and downstream migration obstacles (i.e. CN Rail track culvert). Leoran Brook is known to support populations of cutthroat trout, rainbow trout and coho salmon, as identified on the Habitat Wizard database, in the *Anniedale-Tynehead NCP Area Overview Environmental Assessment* report (Madrone Environmental Services, 2009), and by the *Environmental Assessment Report, Anniedale "A" Neighbourhood Concept Plan* (Phoenix Environmental, 2007), and South Fraser Perimeter Road, Fish Habitat Impact Assessment (Coast River Environmental, 2006).

There are fishway weirs and a culvert downstream of a pond in Leoran Brook at 18147 – 99A Ave. that are impassable to fish during low flow conditions (see Photos 35 and 36, Appendix B). However, the fishway and culvert apparently are not barriers to fish migration, as salmonids were observed by Phoenix in Leoran Brook upstream of the pond. Downstream, Leoran Brook flows across the South Fraser Perimeter Road (SFPR)/Golden Ears Connector, and then across the Canadian National Railway tracks, and presumably under a road/storage yard north of the tracks to the Fraser River. Phoenix did not investigate the Leoran Brook confluence with the Fraser River, as this was well beyond the Study Area boundaries and on a federal (Port Metro Vancouver) foreshore lease area and private industrial lands.

The 2014 Ravine Stability Assessment (Tetra Tech, 2014) identifies a location of "medium risk" bank erosion within the Leoran Brook ravine at the rear (east boundary) of 9820 – 181 Street. The location details were identified as a tributary flowing down the left bank which had created a small gulley and eroding soil near a fence and shed on residential property. The location was investigated by Phoenix in the field and was consistent with the Ravine Stability Assessment (Photo 40, Appendix B). The tributary watercourse was unmapped on COSMOS, but has been updated on Figure 2 (Appendix A).

Phoenix observed a long length of unidentified plastic (water) pipe which extended along Leoran Brook in general the vicinity of the bank erosion location (Photo 42). The pipe was located within the stream channel. The source and destination of this pipe is unknown. Also of note, in the vicinity of the identified bank erosion location, a plant appearing similar to Giant Hogweed was observed during the May 14, 2015 Site visit (Photo 33). The plant was located along Leoran Brook and in-line with 98 Ave.

The furthest upstream reach of Leoran Brook within the Study Area enters a large culvert which conveys flow under No. 1 Highway (Photo 38). The culvert has a relatively new (multi-plate) extension and contains baffle plates along with gravel and cobble within the culvert. There is also a skylight installed part way through the culvert in the median with Barnston Drive East (Photo 39). During field assessments, Phoenix observed salmonid fry just downstream of the culvert (Photo 37) indicating that Leoran brook is fish accessible to that point. The culvert itself appears to provide a migration route for fish to the upstream end of Leoran, south of No. 1 Highway, and also is a suitable wildlife corridor crossing of Highway 1.

As part of the Golden Ears Connector, a bridge has been constructed for the crossing of Leoran Brook. The bridge ensures fish passage across the highway, and also provides a major enhancement of wildlife corridor values for the Leoran Brook Green Infrastructure Network (GIN) Corridor under the Surrey Biodiversity Conservation Strategy. The Environmental Baseline and Impact Assessment Report by Hatfield Consultants (Hatfield, 2014) has noted, however, that the culvert crossing of the CN Rail tracks is about 50% blocked; which impedes fish passage across the railway. It is clear from field observations by Phoenix that Leoran Brook is extensively utilized by juvenile salmonids throughout the reaches within the Study Area. In general, Leoran Brook appears to be stable and has good channel complexity with large woody debris.

5.2.1.2 Barnston Park Area

The Barnston Park area contains several watercourses (see Figure 2). For the purposes of this report, the watercourses associated with the Barnston Park Area, shown in Figure C below (based on existing COSMOS mapping), are identified as follows:

- A – Main Stream
- B – Main Stream East Branch
- C – West Stream
    - C1 – West Stream 1
    - C2 –West Stream 2
    - C3 – West Stream 3

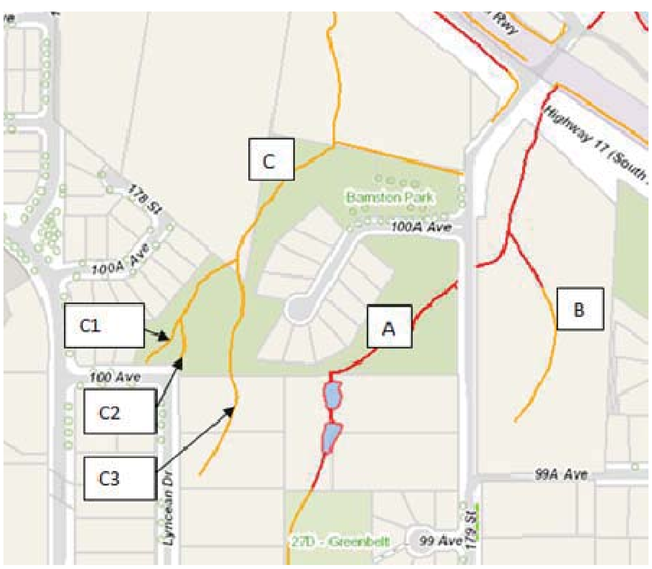

Figure C - Barnston Park Stream Identifications for this report

There is a stream flowing through the southeast portion of Barnston Park (Main Stream), which is currently identified as Class A on COSMOS. The South Fraser Perimeter Road Fish Habitat Impact Assessment (Coast River Environmental Services Ltd., 2006) identified this watercourse as containing coho salmon and cutthroat trout. The Main Stream contains two ponds in line with the watercourse just south of Barnston Park. Field observations by Phoenix revealed multiple barriers to fish migration along the Main Stream. Between the two ponds is a barrier to fish migration as the outflow of the upper pond discharges from an elevated culvert crossing of an old access road or driveway (Photo 25). The furthest downstream barrier to fish migration observed was located immediately below the lower pond as the outflow from the pond discharges from an elevated culvert.

Field assessments in the Barnston Park area revealed a unmapped pond associated with an observed flowing artesian well to the west of 179 St and north of 99 A Ave. (Photos 15-18), and as shown on Figure 2. At the time of the May 14, 2015 field assessment, the well was observed to be producing a substantial quantity of water into the pond, which was discharging into a culvert on the west side of 179 Street. Based on the field observations and storm sewer mapping on COSMOS, the observed culvert connects with the storm sewer under 179 St. which then discharges to the Class A stream (Main Stream) to the north. In addition to the observed artesian well, unmapped spring streams in the vicinity of the pond were also observed to discharge to the Barnston Park Class A stream. In the general vicinity of the springs, the ground surfaces were soft and wet and contained extensive skunk cabbage (*Lysichiton americanus*). The springs in the vicinity indicate extensive groundwater emergence from the escarpment slope in that vicinity, and likely elsewhere along the escarpment in the Study Area.

The Barnston Park Main Stream (Class A) flows under 179 St. and meets with a Class A tributary (East Branch) before flowing downstream across the Golden Ears Connector within pre-existing culverts, under the CN Railway, and into the Fraser River. According to COSMOS, the East Branch changes from a Class A to a Class B somewhere upstream. Field observations could not confirm an obvious barrier to fish migration; however, the stream channel gets progressively shallower moving upstream and at some point there will be insufficient water to provide accessible fish habitat. There may be an intermediate zone of the East Branch, which will provide sufficient water during the winter months when there is increased precipitation. On the east side of 179 Street, more springs and skunk cabbage wetlands were observed which contributed baseflows to the East Branch.

At the west end of Barnston Park is another watercourse, categorized as a Class B (West Stream). Upstream, this watercourse splits into three branches (West Stream 1, 2 and 3). The western two branches meet stormwater headwalls at 100 Ave (Photo 11). The eastern branch continues out of the park for a short distance. There were several groundwater springs observed in this area of the Park (near the intersection of 100 Ave and Lyncean Dr). In the general vicinity of the springs, near the base of the ravine slopes, the ground was soft and wet. There was also another flowing artesian well noted in this area, close to West Stream 3 (Photo 28) and as shown on Figure 2. This well was providing a substantial amount of surface flow to the watercourse and has the potential to be a significant contributor to downstream flow during drier months. However, the artesian well is far from being the only source of baseflow, given extensive springs along the lower ravine slopes downstream. Downstream of Barnston Park, the West Stream is culverted beneath an industrial property (Photo 30). Water then enters a new culvert that conveys flow under the SFPR/Hwy.17 (Photo 31 and 32). The steel pipe culvert under the industrial site appears to be a barrier to upstream fish migration.

The West Stream has been referred to as the "178A Street Watercourse" in reports (Coast River Environmental, 2006; Hatfield, 2014) and design drawings (Associated Engineering, 2013) relating to the South Fraser Perimeter Road/Golden Ears Connector. As part of the habitat compensation works for the SFPR, a culvert crossing of the Golden Ears Connector at the 178A Street alignment at the above industrial site (Solid Rock Steel Fabrication Co.) has been designed (Associated Engineering, 2013) to provide fish passage and a wildlife corridor (Photo 31). The wildlife crossing features have not yet been constructed pending completion of the Golden Ears Connector. Although there is a fish passable culvert installation across the Golden Ears Connector, it remains unclear if there are barriers to fish migration between the Golden Ears Connector and the Fraser River between the CN tracks and industrial land along the Fraser River. The area on the west side of the Solid Rock Steel Fabrication property appears to have been recently filled (i.e. since 2013), and as noted above, the steel pipe culvert conveying the Barnston Park West Stream/178A Street Watercourse through the Solid Rock site is likely a barrier to fish migration upstream. If lower reach barriers were removed in the future, the Barnston Park West watercourse could become fish-bearing (Class A); as Phoenix has not observed fish migration barriers upstream of the Solid Rock industrial site. As the existing lower reach barriers are not readily removed, the current Class B classification has been retained.

Observed springs are located at roughly the same elevation (25-27 mGSC) along the escarpment slopes in the Study Area. These may occur due to shallow groundwater emergence where less permeable soil layers underlying the shallow groundwater-bearing soils are exposed along escarpment slopes. It is also possible, given the extent of springs within ravines and two artesian wells observed in the Study Area, that the groundwater source of the springs are the Pre-Vashon/Quadra sandy aquifer zones noted in the Gartner Lee Groundwater Water Supply studies. As a result, it is possible that additional springs or seepage areas may be present at similar elevations along the escarpment slope to those observed. The extent of springs and groundwater baseflows in watercourses in the Study Area indicate the importance of preserving groundwater recharge areas in supporting the baseflows and productivity of streams in the East Fraser Heights area.

5.2.1.3 Abbey Glen Park

Abbey Glen Park, situated at the far northwest portion of the Study Area, contains a Class B stream and wetland pond. Based on field reconnaissance, although appearing mapped as a pond on COSMOS, the downstream wetland area (Photo 9) contains significant sediment accumulation. Upstream of the wetland, the watercourse exists in a narrow ravine with down-cut channels and eroded banks (Photo 10). There may be significant scour and erosion within the Abbey Glen Park stream. The Abbey Glen Park watercourse receives stormwater flow from a connection just north of 103 Ave. Phoenix observed flow in the Class B stream during field assessments on May 14, 2015. As the observed flow was noted during dry weather, it is suspected that the stream receives flow input from shallow groundwater, potentially due to groundwater infiltration into the upstream stormwater utility trenches. The majority of this stream system exists outside the Study Area, to the north of the Study Area.

5.2.2 Wetlands

5.2.2.1 Wetland Area West of 177 A St

Field assessments revealed the presence of an unmapped watercourse and wetland in the greenbelt area to the west of 177 A Street. Water from the wetland and stream enters a culvert just south of the SFPR/Hwy. 17. Based on Lidar mapping and limited field reconnaissance, the upstream end of the wetland area appears to emerge from a shallow ravine with two reaches. A storm sewer outlet discharges into the ravine just north of 101A Ave. The wetland area and associated stream were observed to contain water during dry weather. It is suspected that the wetland area also receives groundwater input. The wetland was heavily vegetated including a significant amount of skunk cabbage The South Fraser Perimeter Road Fish Habitat Impact Assessment (Coast River Environmental Services Ltd., 2006) identified the 177A St. watercourse (as it existed prior to the SFPR construction) as providing potential rearing and overwintering habitat for salmonids if fish access to the watercourse were established. The report goes on to state that the 177A Street watercourse is part of a proposed compensation project that will divert its flow into an existing wetland, constructing a channel through the wetland and connecting it to the 176 St watercourse, opening the entire system to anadromous salmonids. In addition, according to the British Columbia Ministry of Environment HabitatWizard, a map-based fish and wildlife information tool, coho salmon were identified in the wetland area in 2007. Based on the above information, it is proposed to conservatively classify the 177 A St wetland and stream as Class A. However, actual completed fish access compensation project components as discussed in the South Fraser Perimeter Road Fish Habitat Impact Assessment will need to be confirmed. The planned compensation project appears to be reflected in recent Drainage and Utilities drawings for the Golden Ears Connector (Associated Engineering, 2013) indicate that the 177A watercourse will be diverted west along the south side of the highway to the Detention Pond (Constructed Wetland) at the Highway 17/Highway 15 and 104th Avenue intersections. Phoenix observed flows in the new constructed channel along the south side of the Golden Ears Connector west of 177A Street. However, the Environmental Baseline and Impact Assessment Report, Final Design Submission (Hatfield, 2014) indicates that fish habitat compensation habitats for the SFPR and Golden Ears Connector have been constructed in Surrey Bend east of the 176th Street Trail; and a large area of recently constructed aquatic habitat is visible in Surrey Bend Regional Park on the COSMOS 2014 orthophoto.

5.2.2.2 Abbey Glen Park Wetland

Downstream of the Abbey Glen Class B ravine stream, a shallow, broad wetland exists. This wetland area has become extensively vegetated including skunk cabbage and common horsetail (Photo 9). The wetland area was observed to have accumulated a significant amount of sediment and the water level throughout the wetland was shallow. As the observed flow was noted during dry weather, it is suspected that the stream receives flow input from shallow groundwater, potentially due to groundwater infiltration into the upstream stormwater utility trenches. This wetland also has been discussed in section 5.2.1.3 of this report.

5.2.3 Constructed Pond and Stream Habitat

Immediately north of 181 Street, there is a constructed pond and stream. These features were unmapped on COSMOS, as the pond and stream have been recently constructed (2012) as a fish habitat compensation site for the South Fraser Perimeter Road (SFPR)/Golden Ears Connector project. Referred to as the 99A Avenue Compensation Habitat, the constructed pond collects stormwater and likely groundwater, and acts as a headwater pond to a new constructed stream channel draining to the Barnston Park Main Stream on the east side of 179th Street (also referred to as the 179 Street Watercourse; Envirowest, 2013; Hatfield, 2014). An overflow berm at the north end of the pond directs water towards a previously existing Class B watercourse to the north. The constructed pond and stream at the 99A Avenue Compensation Habitat was completed in accordance with a Canada Fisheries Act (DFO) Authorization to offset unavoidable impacts of the SFPR project to fish habitat with the intent of achieving no net loss of productive capacity. A post-construction "As-Built Completion Report" for the 99A Avenue Habitat Enhancement Project by Envirowest Consultants Inc. (Envirowest, 2013) confirmed that habitat replacement of aquatic and riparian habitat has met (slightly exceeded) the required amount of habitat compensation specified by the DFO Authorization.

Another constructed pond and channel provided for habitat compensation purposes, as part of the South Fraser Perimeter Road, is situated at intersection of Highway 17 (SFPR), 104th Avenue, and Highway 15/176 Street. A constructed channel extends along the south side of the Golden Ears Connector west of 177A Street, which connects with a triangular-shaped detention pond west of 176 Street, north of Highway 17, and south of 104th Avenue (as discussed in section 5.2.2.1). As the Golden Ears Connector nears completion, it is anticipated thatthe triangular pond will be planted as a wetland. Under Fish Habitat Impact Assessment Report for the South Fraser Perimeter Road Environmental Assessment Application (Coast River Environmental, 2006), these constructed channels and detention pond/wetland are intended to enhance the fish habitat attributes and fish migration through the "176 Street Watercourse" and "177A Street Watercourse" across the SFPR to the Surrey Bend section of the "104th Avenue Ditch" as one of the numerous fish habitat compensation projects for the SFPR. These constructed channels and wetland pond are outside of the Study Area; however, the future constructed wetland compensation pond is visible on Figure 2: Watercourse Classification Map (Appendix 2).

5.2.4 Constructed Drainage Ditches

These drainage ditches are typically shallow, constructed roadside drainage watercourses that appear to primarily convey stormwater runoff for limited periods, and generally go dry quickly after rainfall ends. These ditches typically do not convey groundwater, and have insignificant fish habitat value. Roadside drainage ditches exist extensively throughout the Study Area. Some ditches currently classified as Class C were observed to be conveying water during dry weather and are therefore considered to be intersecting the high water table. Dry weather flow combined with observed vegetation characteristics and perceived food/nutrient value warrant re-classification of some drainage ditches currently classified as Class C to be upgraded to Class B.

5.3 PROPOSED WATERCOURSE RE-CLASSIFICATIONS AND UNMAPPED FEATURES

Based on a desktop review, including examination of information on the COSMOS mapping system, combined with field observations at selected locations, several changes to watercourse classifications are proposed, including mapping corrections and additions. Details are discussed below and proposed watercourse mapping changes are shown on Figure 2 in Appendix A.

5.3.1 Leoran Brook

The watercourse mapping of Leoran Brook required updating for several reasons. Immediately upstream of the pond near 99A Avenue, there were two branches of the Leoran Brook currently shown on COSMOS. This did not appear consistent with the Lidar topographical relief mapping and so was flagged as a point of interest to investigate. A field survey on May 14, 2015 revealed that the western mapped reach does not exist. In addition, topographical relief mapping indicates that the existing stream mapping was not accurate and has been re-mapped to match Lidar-based indicators of the stream channel. These changes are shown (Location 1) in Figure 2, Appendix A.

To the west of Leoran Brook, directly in line with 98 Ave. is an unmapped watercourse. Desktop review of topographical relief followed up with a field survey confirmed the presence of this stream. Before discharging into Leoran Brook, the watercourse takes a very steep drop in elevation, which based on field observation is a clear barrier to fish migration. This watercourse is the same tributary identified as causing “medium risk” bank erosion within the 2014 Ravine Stability Assessment (Tetra Tech, 2014). The observed conveyance of water during dry weather, along with the vegetation characteristics of this watercourse (Photo 21), indicates that the appropriate classification is Class B for this stream. This mapping addition is shown in Figure 2, Appendix A (Location 2).

5.3.2 Wetland (Greenbelt 27E west of 177 A St)

Field assessment revealed the presence of an unmapped watercourse and wetland in the greenbelt area to the west of 177 A St. and north of 101 A Ave. Water from the wetland and stream was flowing into a culvert just south of the SFPR/Hwy. 17. This wetland and stream have been previously discussed in section 5.2.2.1 of this report. Based on documented fish presence data, associated SFPR habitat compensation plans, and observed conditions, it is proposed that the 177 A St wetland and stream be classified as Class A. This mapping addition and watercourse classification is shown in Figure 2 (Location 3).

5.3.3 Greenbelt East of 175 St

To the east of 175 St (Green Belt 26C) is a mapped Class B stream (Photo 6). Based on field assessments, this watercourse extends further upstream than currently mapped. This area contains an unmapped watercourse and was also evidently mapped prior to the Highway 15 & 17 roadwork in this area, and so requires updating associated with these changes. To the east of the mapped Class B, field assessments revealed an unmapped watercourse (Photo 7). The watercourse contained a significant amount of discarded refuse. At the upstream end of this unmapped watercourse, the presence of small piping was noted; evidently a residential lot drainage outlet. Based on the potential food/nutrient value, this watercourse would be best classified as a Class B, which is shown in Figure 2, Location 4. Both the unmapped watercourse and the mapped Class B stream flow north and discharge into an unmapped roadside ditch recently constructed along SFPR/Hwy. 17. Based on the observed presence of water and vegetation characteristics, the roadside ditch would appropriately be classified as a Class B stream shown in Figure 2. The roadside ditch discharges into a culvert (Photo 8) which conveys flow under the SFPR and connects with a triangular stormwater detention pond/ compensation wetland habitat to the North of the highway and south of 104th Avenue (Hatfield, 2014). See discussion in section 5.2.3 of this report.

5.3.4 Barnston Park Area

The East Branch of the Main Stream of Barnston Park (east of 179 St) was mapped on COSMOS as a Class A, which changes to a Class B further upstream. Field observations did not reveal an obvious barrier to fish migration; however, the stream gets progressively shallower moving upstream and at some point there will be insufficient water to provide accessible fish habitat. There will be an intermediate zone of the East Branch which will provide sufficient water during the winter months when there is an increase in precipitation. This intermediate, seasonal zone is reflected in Figure 2, Appendix A as a section of Class A(O) between the Class A and Class B reaches of the watercourse. In addition, based on field observations, the Class B watercourse extends further upstream than currently mapped, and this change is also reflected. These proposed mapping changes are shown in Figure 2 (Location 5).

The Main Stream watercourse of Barnston Park requires an adjustment of where the Class A mapping changes to a Class B. Currently, the break between classes is mapped upstream of the two ponds which exists just south of the park. The existing break appears to be associated with an elevated culvert which would in fact be a barrier to fish migration if fish could make it that far. Field observations by Phoenix revealed multiple barriers to fish migration along the Main Stream, due to abandoned former access roads across the stream when larger parcels existed prior to more recent subdivisions. Between the two ponds is an additional barrier to fish migration as the outflow of the upper pond discharges from an elevated culvert (see Appendix B – Photo 25). The furthest downstream barrier to fish migration observed was located immediately below the lower pond; as the outflow from the pond discharges from an elevated culvert, which is where the Class A stream would appropriately be reclassified as a Class B. Due to access restrictions for reaching these old constructed barriers, it is considered unlikely that these barriers can be potentially removed, short of major engineering and land acquisition. This change is shown in Figure 2 (Location 6).

Field assessment of the Barnston Park Area revealed that the mapped Class B watercourse along the northern park border towards the West Stream does not exist. The removal of this mapped watercourse is reflected in Figure 2, Appendix A (Location 12).

5.3.5 East of 182 A St

At the far east end of the Study Area, the construction of the Golden Ears Connector has altered a Class B watercourse; a portion of which exists within the Study Area. The road was constructed over a portion of the watercourse which is now culverted beneath the highway. In addition, there was an observed unmapped Class C roadside ditch associated with the new Connector. The Class C ditch and the upstream branches of the Class B watercourse are connected at the roadside ditch constructed along the west side of the new highway and enter a pair of culverts which conveys flow under the highway and out of the Study Area. These changes are shown in Figure 2 (Location 7).

5.3.6 Constructed Pond and Stream

The observed constructed pond and stream immediately north of 181 St. were unmapped features on COSMOS. The mapped Class B stream immediately north of the pond remains in this location although the pond now discharges into this watercourse only during overflow conditions. At the west end of the pond, the constructed stream conveys water from the pond and discharges into the downstream Barnston Park Main Stream Class A watercourse. The constructed pond and stream (99A Avenue Compensation Habitat) have been discussed previously in section 5.2.3. The appropriate classification for this pond and the associated stream is Class B. This mapping addition is shown in Figure 2 (Location 8).

5.3.7 Constructed Drainage Ditches

The majority of the drainage ditches within the Study Area appear to drain runoff only during rainfall events (i.e. Class C watercourses); however, some locations were observed to be conveying water during dry weather field inspections and are therefore considered to be intersecting a high water table. Dry weather flow, combined with observed vegetation characteristics and perceived food/nutrient value, warrant that select drainage ditches currently classified as Class C to be upgraded to Class B. The weather leading up to the field surveys was so dry (significantly drier than seasonal average) that even some Class B ditches would be expected to be dry at the time of surveying. Therefore, in order to identify possible additional Class B ditches currently classified as Class C, field assessments performed after some wet weather and groundwater recharge would be more effective. The proposed constructed ditch mapping additions and reclassifications are as follows:

- At the south end of 182A St, on the west side an unmapped Class C ditch was observed (Figure 2 – Location 9)

- Near the intersection of 179 St and Lyncean Dr several ditches mapped as Class C were observed to be significantly vegetated and wet during dry weather (see Photos 13 and 22) and so are proposed as Class B watercourses. (Figure 2 – Location 10)

- On the west side of Hwy 15, between No. 1 Hwy and Barnston Dr. E, some unmapped roadside ditches were observed. These ditches appear to be associated with recent roadwork and are proposed as Class C watercourses (Figure 2 – Location 11)

5.3.8 No 1 Hwy and Hwy 15 Interchange

A review of COSMOS aerial imagery and watercourse mapping indicates that the area in the vicinity of the No 1 Hwy and Hwy 15 interchange has not had the fish classification mapping updated since the completion of the interchange roadwork. Although the interchange itself is not within the Study Area, a comparison of the current watercourse mapping in the area to aerial images both pre- and post-roadwork indicates that the drainage in this general area has been reworked and relevant changes are identified in the report where appropriate. It is evident that the mapping of stormwater infrastructure, including roadside ditching associated with the roadwork, requires updating; although this is outside the scope of this report.

5.3.9 South Fraser Perimeter Road

A review of COSMOS aerial imagery and watercourse mapping, as well as field observations, indicates that the area in the vicinity of the SFPR/Golden Ears Connector has changed significantly. Although the majority of the roadwork is not within the Study Area, the roadwork has had some impact on watercourses within the Study Area and these impacts are identified in the report where appropriate. It is evident that the mapping of stormwater infrastructure, including roadside ditching associated with the roadwork requires updating; although this is outside the scope of this report.

6. TERRESTRIAL HABITATS

This component of the Environmental Assessment has assessed vegetation communities, wildlife, and wildlife habitat in East Fraser Heights, including an assessment and suitability mapping for rare and threatened species listed under the federal Species at Risk Act (SARA) and B.C. red- or blue-listed species. Environmentally sensitive areas have been identified, as well as wildlife habitat hubs, sites and corridors making up the City of Surrey Green Infrastructure Network (GIN) that supports the implementation strategy of the 2014 Biodiversity Conservation Strategy.

6.1 VEGETATION OVERVIEW

Field assessments have been conducted in several forested greenbelt areas in the Study Area, which have been identified on the City of Surrey's COSMOS mapping program as the following:

- Abbey Glen Park – 16D-Greenbelt
- 26C-Greenbelt
- 27E-Greenbelt
- Barnston Park
- 27D-Greenbelt
- 27A-Greenbelt
- 27C-Greenbelt

Also forested private and Transit-owned lands near the Golden Ears Connector have been observed from a distance.

Three vegetation types were identified within these parks and greenbelts in the Study Area:

1. Riparian Vegetation Type
2. Forested Blocks Vegetation Type

3. Right-of-ways Vegetation Type

Representative photographs of each of the vegetation types are presented in Appendix B. A list of observed vegetation within the vegetation types is included in Table 1. The three vegetation types identified within the Study Area are described below.

6.1.1 Riparian

The Riparian Vegetation Type occurred along all streams and greenbelts and included wetlands and ponds along Leoran Brook and within Barnston Park and Abbey Glen Park. The largest riparian areas occurred along Leoran Brook, which extends into 27A-Greenbelt and through 27C-Greenbelt (Figure 3, Appendix A), and within Barnston Park, which has two stream systems flowing through it (Figure 3).

Table 1. Vegetation Observed within the Study Area, 2015

Group	Common Name	Scientific Name
Trees		
	Black Cottonwood	*Populus balsamifera* ssp. *Trichocarpa*
	Big-leaf Maple	*Acer macrophyllum*
	Douglas-fir	*Pseudotsuga menziesii*
	English Oak	*Quercus robur*
	Paper Birch	*Betula papyrifera*
	Red Alder	*Alnus rubra*
	Western Red Cedar	*Thuja plicata*
	Western Hemlock	*Tsuga heterophylla*
Shrubs		
	Beaked Hazelnut	*Corylus cornuta*
Introduced	English Holly	*Ilex aquifolium*
Introduced	English Ivy	*Hedera helix*
	Evergreen Blackberry	*Rubus laciniatus*
	Hardhack	*Spiraea douglasii*
Introduced	Himalayan Blackberry	*Rubus discolor*
	Indian Plum	*Oemleria cerasiformis*
Introduced	Japanese Knotweed	*Polygonum cuspidatum*
	Red Elderberry	*Sambucus racemosa*
	Red Huckleberry	*Vaccinium parvifolium*
	Salal	*Gaultheria shallon*
	Salmonberry	*Rubus spectabilis*
	Saskatoon Bush	*Rubus laciniatus*
Introduced	Scotch Broom	*Cytisus scoparius*
Introduced	Silver Nettle	*Lamium maculatum*
	Sitka Alder	*Alnus viridis*
	Thimbleberry	*Rubus parviflorus*
	Trailing Blackberry	*Rubus ursinus*
	Vine Maple	*Acer circinatum*
	White-Flowered Rhododendron	*Rhododendron albiflorum*

Group	Common Name	Scientific Name
Herbs		
	Bunchberry	*Cornus canadensis*
	Cattail	*Typha latifolia*
	Cleavers	*Galium aparine*
Introduced	Common Burdock	*Arctium minus*
Introduced	Common Dandelion	*Taraxacum officinale*
	Common Horsetail	*Equisetum arvense*
Introduced	Common Muellin	*Verbascum thapsus*
Introduced	Common Plantain	*Plantago major*
Introduced	Creeping Buttercup	*Ranunculus repens*
	False-Lily-of-the-Valley	*Maianthemum dilatatum*
	Foamflower	*Tiarella trifoliata*
	Fringecup	*Tellima grandiflora*
	Giant Horsetail	*Equisetum telmatiea*
	Large-Leaved Avens	*Geum macrophyllum*
	Pacific Bleeding Heart	*Dicentra formosa*
	Piggy-Back Plant	*Tolmiea menziesii*
Introduced	Policemen's Helmet	*Impatiens glandulifera*
	Rattlesnake Plaintain	*Goodyera oblongifolia*
	Reed Canary Grass	*Phalaris arundinacea*
Introduced	Robert's Geranium	*Geranium robertianum*
	Skunk Cabbage	*Lysichiton americanus*
	Stinging Nettle	*Urtica dioica*
	Sweet-Scented Bedstraw	*Galium triflorum*
	Tall Bluebells	*Mertensia paniculata*
	Western Dock	*Rumex occidentalis*
Introduced	White Clover	*Trifolium repens*
Ferns		
	Bracken Fern	*Pteridium aquilinum*
	Deer Fern	*Blechnum spicant*
	Licorice Fern	*Polypodium glycyrrhiza*
	Lady Fern	*Athyrium filix-femina*
	Western Sword Fern	*Polystichum munitum*
Mosses and Lichens		
	Frog Pelt Lichen	*Peltigera neopolydactyla*
	Oregon Beaked Moss	*Kindbergia oregana*
	Red Roof Moss	*Ceratodon purpureus*
	Spear Moss	*Calliergonella cuspidata*
	Step Moss	*Hylocomium splendens*

The vegetation composition along the sloped portions of all creeks were similar, as they were generally dominated by western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) and interspersed with red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and black cottonwood (*Populus balsamifera*) (see Photos 50, 52 56, 66, 70, 71, 75, 80, and 81). The shrub layer was mainly dominated by salmonberry (*Rubus spectabilis*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), and thimbleberry (*Rubus parviflorus*). Sword fern (*Polystichum munitum*), lady fern (*Arthyrium filix-femina*), skunk cabbage (*Lysichiton americanus*), piggy-back plant (*Tolmiea menziesii*), and fringecup (*Tellima grandiflora*) typically dominated the herb layer.

The lowland, floodplain areas of the creeks were dominated by deciduous tree species including red alder and black cottonwood. Salmonberry, three-leaved foamflower, reed canarygrass (*Phalaris arundinacea*) and sedges (*Carex spp.*) dominated the shrub and herb layers (Photo 52).

Wetland and pond areas within 27E-Greenbelt and 27A-Greenbelt were dominated with salmonberry, lady fern, skunk cabbage, cattail (*Typha latifolia*), and reed canary grass (Photos 60, 61, 63, 72, and 73).

6.1.2 Forested Blocks

The Forested Blocks Vegetation Type was associated mainly with escarpments and a number of small parks or greenbelts within the Study Area. Most forested areas were broadleaf dominated with mature big-leaf maple, red alder, and black cottonwood or mixed with mature coniferous trees including western redcedar, Douglas-fir (*Pseudotsuga menziesii*) and western hemlock. The shrub understorey was composed mostly of sparse to moderate (5 - 50%) cover of shrubs including salmonberry, vine maple, red huckleberry (*Vaccinium parvifolium*), trailing blackberry (*Rubus ursinus*), and red elderberry (*Sambucus racemosa*). Sword fern, three-leaved foamflower (*Tiarella trifoliate*), and Pacific bleeding heart (*Dicentra formosa*) typically dominated the herb layer (Photos 51, 57, 65, 69, 71, 74, and 76). Several areas within the greenbelts and parks had extensive stinging nettle (*Urtica dioica*) coverage associated with mature big-leaf maple trees and adjacent to riparian areas (Photo 53).

Invasive species such as Himalayan blackberry (*Rubus discolour*), silver nettle (*Lamium maculatum*), English ivy (*Hedera helix*), and Japanese knotweed (*Polygonum cuspidatum*) were regularly encountered at the edges of the forested areas (Photo 49).

6.1.3 Right-of-Ways and Fallow Fields

The Right-of-Ways (ROW) and Fallow Fields Vegetation Type was situated mainly along the Kinder Morgan Trans Mountain Pipeline route and the proposed City of Surrey Greenway route with the fallow fields portion generally associated with the lowland industrial areas and roads/highways.

The vegetation along the ROW were semi-forested and dominated mainly by red alder, Himalayan blackberry, buttercup (*Ranunculus spp.*) and reed canary grass. The fallow field habitats were dominated by invasive species such as Himalayan blackberry and scotch broom (*Cytisus scoparius*) as well as reed canary grass and other gramanoid species.

6.2 Wildlife Trees

A wildlife tree is any standing dead or living tree with special features that provides present or future critical habitats for the maintenance or enhancement of wildlife. There are nine classifications of coniferous and six classes of deciduous wildlife trees in various successions from live and healthy with no decay, to stumps and debris (Fenger et al. 2006). All of these wildlife tree stages provide important habitat, and are known to support more than 90 animal species in British Columbia, including cavity nesting birds and mammals (Backhouse 1993). Some of the uses include nesting, feeding, territoriality (i.e. bear mark trees, bird singing sites, etc.), roosting, shelter, and overwintering (Backhouse 1993).

There are nine decay classes of coniferous trees and six decay classes of deciduous trees within British Columbia (Fenger et al. 2006). Most of the trees observed in the Study Area were identified as Class 1 wildlife trees. Class 1 wildlife trees are described as live healthy trees with no decay. Class 2 to 9 wildlife trees were also identified within the Study Area. Most of the decayed trees were situated within the riparian areas of all watercourses. The density of wildlife trees (snags with nesting cavities in particular) within the parks, greenbelts, and forested riparian areas varied from 5 – 15 trees per hectare.

6.3 Coarse Woody Debris

CWD is typically described as woody debris greater than 0.3 m in diameter. CWD provides important foraging, nesting, and cover components in the forested ecosystem for small mammals, amphibians, reptiles and invertebrates (BC Environment 1991). Many insectivorous small mammals, birds, and black bears feed on insects found in decomposing woody material. CWD provides a safe, moist environment in which species such as salamanders and shrews can forage and seek shelter.

Good CWD cover (5-15%) was recorded within most of the riparian habitats within the Study Area (Photos 55 and 66). CWD cover within the forested blocks varied from sparse to moderate (1-5%). Sparse CWD was observed within the ROWs and Fallow Fields Vegetation Type.

6.4 Sensitive Ecological Communities and Vegetation Species

The BC Conservation Data Centre (BCCDC) defines listed ecological communities as natural plant communities and plant associations. These communities and associations include a wide range of known ecosystems with their environmental site requirements such as soil moisture and nutrients, climate, physiographic features and energy cycles. These sites are generally old growth stands that are usually 500 m^2 or greater. These ecosystems are often the remnants of the natural ecosystems that once occupied a much larger area. Typically, mature and old growth upland ecological communities are of concern to the BCCDC. In addition, all listed riparian, wetland and estuarine communities at any growth stage are also of concern to the BCCDC (K.A. McIntosh pers. comm.). The listed ecological communities are classified using methodologies and nomenclature developed by Green and Klinka (1994).

The Study Area falls within the Coastal Western Hemlock Very Dry Maritime (CWHxm1) biogeoclimatic subzone. The forested portions within the Study Area were second (80 to 250 years) to third growth (40 to 80 years) stands. Of the 15 forested ecological communities identified within the CWHxm1, all 15 have been identified as either Red or Blue-listed by the BCCDC. In addition, eight (8) non-forested ecological communities have also been listed.

Previous studies have identified three of these ecological communities within the Study Area – the blue-listed Western Redcedar/Sword Fern, the blue-listed Western Redcedar/Three-leaved Foamflower, and the blue-listed Western Redcedar-Sitka Spruce/Skunk Cabbage (Port Mann-Hwy 1 and SFPR studies – and associated SFPR map). The greenbelt and park areas associated with these sensitive communities within the Study area include Abbey Glen Park – 16D-Greenbelt, 27E-Greenbelt, Barnston Park and the adjacent forest east of 179th Street, 27A-Greenbelt, and 27C-Greenbelt (Photos 50, 52, 60, 61, 65, 66, 68, 75, 80, and 81).

Based on the habitats observed, aerial imagery, and BCCDC records, few to no rare vegetation species are expected to occur within the Study Area. One blue-listed vegetation species, slender-spiked mannagrass (*Glyceria leptostachya*), has a mapped known occurrence approximately 200 m outside the Study Area near the intersection of 104th Avenue and 176th Street adjacent to the railroad tracks. It was last observed growing in a shallow ditch with moist, dredged sand in 1991. With construction of the SFPR/Hwy. 17, it is not known if the spiked mannagrass remains in the area where it was found. The ditches, ponds, and wetlands within the lowland portions of the Study Area near 176th Street and Highway 15 may provide habitat for this blue-listed species.

Invasive vegetation species were encountered at many of the habitats and ecological communities observed within the Study Area and included species such as Himalayan blackberry, Japanese knotweed, scotch broom, and English ivy. These invasive plant species were regularly encountered along interfaces of forested and disturbed or developed sites.

7. WILDLIFE INVENTORY AND HABITAT

Wildlife sign and activity was recorded throughout the Study Area both historically and during the field surveys on May 15 and May 20, 2015 (Figure 3: Terrestrial Habitat Map, Appendix A). Songbirds were observed flying, nesting, and feeding in vegetation throughout the Study Area. Suitable nesting habitat for raptors such as Red-tailed Hawk, Cooper's Hawk (*Accipiter cooperii*), and owls were observed in most forested and riparian areas (Photos 68, 76, 77, 78, and 79). All animal species detected during field surveys are listed in Table 2.

Sign of Douglas squirrel, grey squirrel, and woodpecker were also detected within the Study Area. Most of the treed portions within the Study Area provided potential breeding/roosting habitat for raptors, passerines, woodpeckers and a number of bat species. The homeowner of 10366 - 175th Street near the 26C-Greenbelt stated that black-tailed deer (*Odocoileus hemionus columbianus*) and coyotes (*Canis latrans*) are often observed moving through the greenbelt behind the houses.

Invertebrate species, such as butterflies and dragonflies, were not extensively searched for during the field surveys; however, one red admiral butterfly (*Vanessa atalanta*) was observed near Leoran Brook along Barnston Drive E (Photo 83).

Active nests and bird breeding behaviour were observed within the Study Area during the field program. Several active American Robin (*Turdus migratorius*) or thrush nests were observed in forested and riparian areas. Active nest cavities were detected in many of the wildlife trees observed; an active Tree Swallow (*Tachycineta bicolor*) nest cavity was detected near 177A Street (Photo 63). A number of old cavities were also observed in many of the wildlife trees encountered. Pileated Woodpecker (*Dryocopus pileatus*) foraging sign was observed on many of the wildlife trees. These wildlife trees also provide habitat for many bird and mammal species including songbirds, squirrels and bats.

A Red-tailed Hawk (*Buteo jamaicensis*) and Turkey Vulture (*Cathartes aura*) were observed flying over the southeastern portion of the Study Area near Highway 1 and 182A Street during the field surveys. No raptor nests were observed in the Study Area during the field surveys but historical nest records indicate that raptors do nest in the area (Figure 3: Terrestrial Habitat Map; Photos 76, 77, and 78).

One Great Blue Heron (Ardea herodias fannini) was observed flying over the Study Area near 177A Street during the field investigation, but no nests were observed within the Study Area.

Table 2. Wildlife Species Observed During Field Surveys, 2015

Group	Common Name	Scientific Name	Status
Songbird			
	Alder Flycatcher	*Empidonax alnorum*	
	American Robin	*Turdus migratorius*	
	Black-capped Chickadee	*Poecile atricapillus*	
	Black-headed Grosbeak	*Pheucticus melanocephalus*	
	Chestnut-backed Chickadee	*Poecile rufescens*	
	Dark-eyed Junco	*Junco hyemalis*	
	European Starling	*Sturnus vulgaris*	Introduced
	Eurasian Collared-Dove	*Streptopelia decaocto*	
	Fox Sparrow	*Passerella iliaca*	
	Golden-crowned Kinglet	*Regulus satrapa*	
	Hammond’s Flycatcher	*Empidonax hammondii*	
	House Finch	*Haemorhous mexicanus*	
	House Sparrow	*Passer domesticus*	Introduced
	Orange-crowned Warbler	*Vermivora celata*	
	Pacific-slope Flycatcher	*Empidonax difficilis*	
Group	**Common Name**	**Scientific Name**	**Status**
	Pine Siskin	*Spinus pinus*	
	Purple Finch	*Carpodacus purpureus*	
	Red-Winged Blackbird	*Agelaius phoeniceus*	
	Rufous Hummingbird	*Selasphorus rufus*	

Group	Common Name	Scientific Name	Status
	Song Sparrow	*Melospiza melodia*	
	Spotted Towhee	*Pipilo maculatus*	
	Swainson's Thrush	*Catharus ustulatus*	
	Tree Swallow	*Tachycineta bicolor*	
	Wilson's Warbler	*Cardellina pusilla*	
	White-crowned Sparrow	*Zonotrichia leucophrys*	
	Yellow-rumped Warbler	*Dendroica coronata*	
Woodpecker			
	Northern Flicker	*Colaptes auratus*	
	Pileated Woodpecker	*Dryocopus pileatus*	
Corvid			
	Northwestern Crow	*Corvus caurinus*	
Waterbird			
	Great Blue Heron	*Ardea herodias fannini*	Blue Listed
Raptor			
	Red-tailed Hawk	*Buteo jamaicensis*	
	Turkey Vulture	*Cathartes aura*	
Mammal			
	Black-tailed Deer	*Odocoileus hemionus columbianus*	
	Douglas Squirrel	*Tamiasciurus douglasii*	
	Eastern Grey Squirrel	*Sciurus carolinensis*	
Invertebrate			
	Red Admiral Butterfly	*Vanessa atalanta*	

7.1 Wildlife Species of Conservation Concern

Eight species of conservation concern (i.e. provincially and/or federally listed species at risk) either have high potential to occur or have been detected within the Study Area during the site assessment on May 15 and May 20, 2015 (Table 3). Two species of conservation concern, the Great Blue Heron (*Ardea herodias fanini*) and Oregon forestsnail (*Allogona townsendiana*) were observed within the Study Area during the field surveys. In addition, two provincially blue-listed dragonfly species, the blue dasher (*Pachydiplax longipennis*) and beaverpond baskettail (*Epitheca canis*), have high potential to occur within wetlands in the Study Area, as they were previously observed in the Fraser Heights area during the South Fraser Perimeter Road (SFPR) environmental impact assessment (Robertson 2006). The following are the results of the habitat assessment for each of the eight species listed in Table 3.

Table 3. Wildlife Species of Conservation Concern with High Potential to Occur

Common Name	Scientific Name	Provincial Status	COSEWIC	SARA	Observed During 2015 Site Visits
Great Blue Heron	*Ardea herodias fannini*	Blue-list	Special Concern	Special Concern	Yes
Green Heron	*Butorides virescens*	Blue-list	-	-	No
Northern Red-legged Frog	*Rana aurora*	Blue-list	Special Concern	Special Concern	No
Oregon Forestsnail	*Allogona townsendiana*	Red-list	Endangered	Endangered	Yes
Pacific Sideband Snail	*Monadenia fidelis*	Blue-list	-	-	No
Pacific Water Shrew	*Sorex bendirii*	Red-list	Endangered	Endangered	No
Trowbridge's Shrew	*Sorex trowbridgii*	Blue-list	-	-	No
Western Screech Owl	*Megascops kennicottii kennicottii*	Blue-list	Threatened	Endangered	No

7.1.1 Great Blue Heron

In addition to being listed on Schedule 1 (Special Concern) of SARA, the Great Blue Heron fannini subspecies is also listed on the Provincial Blue List (BCCDC, 2015). In British Columbia, Great Blue Heron populations have been decreasing, resulting in the listing of this species (MELP 1998). Population decreases are believed to be the result of human disturbance (EC 2013). Great Blue Herons nest in a wide variety of tree species. Foraging habitat does not appear to be limiting factor for this subspecies, as not all available habitat is used by herons each year (Campbell et al. 1990). Critical nesting habitat includes both an established colony and a suite of alternative sites to which a heron could seek refuge should disturbance occur. No Great Blue Heron nests were detected during the field survey, but one individual was observed flying over the Study Area on May 20, 2015.

7.1.2 Green Heron

The Green Heron is on the Provincial Blue List (BCCDC). This species typically breeds in secluded and heavily wooded wetlands, usually where there is an abundance of overhanging brushy vegetation around the perimeter of the wetland (Campbell et al. 1990). It is uncommon and local on the south coast, where it is restricted to the Lower Mainland and along the southeast coast of Vancouver Island from Sooke to Campbell River (Campbell et al. 1990). This species is primarily a summer resident in BC, but some individuals spend the winter months in the province each year (Campbell et al. 1990). As at 1990, the total population of green herons may number fewer than 100 pairs in the province (Campbell et al. 1990). No Green Heron nests were detected during the field surveys, but individuals were detected in wetlands in close proximity to the Study Area near the CN Intermodal Yard close to 108 Ave.

7.1.3 Northern Red-legged Frog

In addition to being listed on Schedule 1 (Special Concern) of SARA, the northern red-legged frog (*Rana aurora*) is also listed on the provincial Blue List (BCCDC). Northern red-legged frogs in BC are found in moist forests and in forested wetlands (Corkran and Thoms 1996). Adults will often wander far from standing water to forage on small insects or forest invertebrates (Nussbaum et al. 1983 in Ovaska and Sopuck 2004). Generally, they breed in cool, shaded temporary ponds where they attach their eggs to submerged woody debris or vegetation (Corkran and Thoms 1996). Critical habitats for the red-legged frog would include all temporary and permanent breeding ponds. CWD would also be considered a critical habitat element for cover and foraging.

No northern red-legged frogs were detected during the field surveys. Northern red-legged frogs have been detected in ditches and wetlands approximately 1 km outside of the Study Area near 168th Street and the CN Railway (see Inset on Figure 2). The stormwater ponds, springs and side-channel pools in ravine streams, and cattail ponds within the Study Area provide suitable breeding habitat for red-legged frog. The recently constructed compensation pond on the north side of 181 St. was observed to be populated by several American bull frog (*Lithobates catesbeiana*); and it is likely that red-legged frog would be out-competed in that pond with potential breeding habitat (B.C. Frogwatch Program, MOE). The forested blocks and creeks; especially near Abbey Glen Park, Barnston Park, and Leoran Brook, provided suitable rearing habitat for red-legged frog and many other amphibian species.

7.1.4 Oregon Forestsnail

The Oregon forestsnail is federally listed as Endangered on Schedule 1 of SARA and provincially Red-listed by the BCCDC. This large snail species is found from western Oregon and Washington states and northwards into southwestern BC. The Oregon forestsnail occupies older mixed-wood and deciduous lowland forests, typically dominated by big-leaf maple and stinging nettle. Habitat requirements generally include some woody debris, a generous amount of leaf litter, and both living and dying vegetation. These conditions help prevent the loss of moisture and extreme fluctuations in temperature that are thought to be particularly detrimental to hibernating snails.

Two Oregon forestsnails were detected within the Study Area in a forested area between 182A Street and Leoran Brook during the site visit on May 15, 2015. In addition, there are 11 known detection sites within riparian and forested areas adjacent to Leoran Brook (Figure 3: Terrestrial Habitat Map). Other forested areas within the Study Area dominated with big-leaf maple and stinging nettle that could provide potential habitat for Oregon forestsnail include Abbey Glen Park – 16D-Greenbelt, 26C-Greenbelt, and Barnston Park (Figure 3).

7.1.5 Pacific Sideband Snail

The Pacific sideband snail is Blue-listed by the BCCDC. This large snail species is found from Alaska to California; west of the Coast and Cascade Mountains. Pacific sidebands live in deciduous, coniferous or mixed forests as well as in open forests and grassy areas (Forsyth 2004).

No Pacific sideband snails were detected within the Study Area. The riparian areas and forested blocks within the Study Area provided potential habitat for Pacific sideband snail.

7.1.6 Pacific Water Shrew

Pacific water shrews (PWS) are usually associated with riparian areas (Nagorsen 1996; Craig 2003). Past studies have reported that the majority of water shrews were captured within 25 m of streams in moist forests. PWS can be found up to 1 km from water (Pattie 1973 in Craig 2003). The home range of the PWS is suspected to be 400 m along a waterbody (Craig 2003).

In British Columbia, capture sites appear to be primarily associated with coniferous or deciduous forest with capture sites located very close to water. Habitat components usually found at PWS sites include the presence of red alder, bigleaf maple, western hemlock or western redcedar that border streams and skunk cabbage marshes (Nagorsen 1996). In addition, PWS have also been captured in more open habitat, with dense marsh vegetation. These include reed canary grass vegetated roadside ditches and water bodies within highway medians (C. Schmidt, pers. comm.). CWD also seems to be an important habitat component. The presence of moist habitat appears to be more important than forest age (Craig 2003).

No PWS were detected during the field surveys. However, a known capture site is approximately 1.5 km outside of the Study Area near 168th Street and the CN Railway (see inset in Figure 3) and connects with habitat in Abbey Glen Park – 16D-Greenbelt. The likelihood that Pacific water shrews occur within the northwestern portion of the Study Area is high (see Figure 3). All creeks, ponds and wetlands within the Study Area provided moderate to high rated habitat for this species, particularly along the southern extent of Leoran Brook and within Barnston Park streams, where skunk cabbage wetland and CWD have been observed (e.g. the adjacent forest east of 179th Street. Potential areas of PWS occurrence are shown on Figure 3 (Appendix A). Although Figure 3 shows areas shaded as "Significant Pacific Water Shrew and Oregon Forestsnail Habitat", it should be noted that the Pacific water shrew habitats are more likely nearby streams, such as Leoran Brook ravine.

In addition, the federal PWS recovery strategy has identified critical PWS habitat in the northwestern portion of the Study Area along the stream system that flows through Abbey Glen Park-16D Greenbelt. This critical habitat is associated with the known capture site near 168th Street and 109th Avenue. The PWS Critical Habitat polygon (Environment Canada 2014) near and within the northwest corner of the East Fraser Heights Study Area is also shown on Figure 3: Terrestrial Habitat Map.

7.1.7 Trowbridge's Shrew

The Trowbridge's shrew is Blue-listed by the BCCDC. Trowbridge's shrew use both riparian and non-riparian forest (Zuleta and Galindo-Leal 1994). In non-riparian forests, the Trowbridge's shrew has shown a preference for areas with a high moisture regime (Nagorsen 1996).

Critical habitat elements for this species include rich soils and abundant decaying CWD and leaf litter on the forest floor (Nagorsen 1996). Ground litter, woody debris and shrub cover provides a secure environment for tunneling and nesting.

All riparian habitats that provided moderate to high rated habitat for PWS also provided moderate to high rated habitat for Trowbridge's shrew, based on the presence of preferred vegetation and habitat features.

7.1.8 Western Screech-owl

In addition to being listed as a species of Special Concern on Schedule 1 of SARA, the kennicottii subspecies of the Western Screech-owl is also listed on the provincial Blue List (BCCDC). Along the Pacific coast, the Western Screech-owl seems to be mostly found in either coniferous or mixed (deciduous or coniferous) forests, particularly near riparian areas. This owl prefers open forest for foraging and requires cavities in old, large trees for nesting and roosting. During the daytime, it roosts in either coniferous or deciduous trees (COSEWIC 2002).

Although this species was not detected during the field surveys, the forested riparian zones of all creeks, particularly Leoran Brook and east of 179th Street, within the Study Area provided potential breeding and roosting habitat for this owl species.

7.2 WILDLIFE CORRIDORS

Moderately used wildlife trails, attributed to coyotes and black-tailed deer, were detected within forested areas in the Study Area. These animals appeared to travel mainly along the watercourses and riparian areas. In addition to coyotes and deer, these corridors are likely used by many species of small mammals, birds, amphibians, and reptiles.

Urban, recreational trails in forested and riparian habitat beside residential homes were also detected within the Study Area. These non-official trails are likely used by many wildlife species. The City of Surrey has also identified a Green Infrastructure Network (GIN) Corridor along Leoran Brook ravine and west along the lower escarpment areas, including existing greenbelts (e.g. Greenbelt 27A) adjacent to the SFPR/Hwy. 17. The location of the potential wildlife movement corridor (BCS GIN Corridor) designated on existing COSMOS mapping is shown in Figure 3. Phoenix has observed the large culvert crossing of Highway 1 for Leoran Brook and stood inside the culvert; which has ample potential for use as a wildlife crossing, including deer. The Ministry of Transportation and Infrastructure has provided the City and Phoenix with reports (Hatfield, 2014; Envirowest, 2013)and design drawings (Associated Engineering, 2013) for the Golden Ears Connector segment of the SFPR/Hwy. 17, as previously referenced in this report. Construction of the Golden Ears Connector along the north and east edges of the Study Area have included fish-passable and wildlife corridor culvert crossings for several streams in the Study area (e.g. 178A Street Watercourse). A bridge crossing for Leoran Brook represents a major enhancement of the Green Infrastructure Network Corridor along Leoran Brook. The challenge for wildlife movement along the designated GIN Corridor through Leoran Brook is passage across the CN Rail tracks to the major GIN Hub at Surrey Bend Regional Park.

8. SENSITIVE ENVIRONMENTAL AREAS

8.1 WATERCOURSES AND RIPARIAN HABITATS

The priority areas for protection include the Class A and B streams and their riparian areas and remaining forest stands of >1 hectare. Watercourses and their riparian areas in the City are currently protected by the Land Development Guidelines for the Protection of Aquatic Habitat. Under this guideline, setbacks for streams range from 15-30 meters from the high water mark or from the top of ravine (if slopes steeper than 3:1 exist) depending on the density of development at a site. Currently, the City is unfolding a new Riparian Bylaw, which is in the stakeholder consultation phase of its development. It is evident that much of the existing development around streams in the Study Area occurred prior to the application of stream setback guidelines, bylaws or regulations.

8.2 INTERIOR FOREST HABITAT

Interior forests habitat are areas beyond the microclimatic and biotic effects of forest edges. Interior forests provide stable environmental conditions that are required for certain plant and animal communities. This habitat type can occur in any forest type of any age, however, as development continues, and large forested areas become fragmented, the quality and quantity of interior forest habitat decreases (Bannerman 1998). Interior forest habitats are present in the Study Area in small forested blocks along 172nd Street, 179th Street, and Leoran Brook.

The City of Surrey's Biodiversity Conservation Strategy (BCS), adopted by the City in 2014, has identified a GIN Corridor within the Study Area. The Biodiversity Conservation Strategy, building on the earlier Ecosystem Management Study prepared for the City, has identified key habitat areas across the City; which vary in type, size and condition. Large intact core habitat areas (Hubs) are essential to supporting and conserving biodiversity within the City. Smaller patches of habitat (<10 ha) have been identified as Sites, which provide habitat for fewer species with smaller home ranges, and often species tolerant of human disturbance. Two large hubs are in close proximity to the Study Area; Tynehead Park to the southwest and Surrey Bend to the north, and one small hub is located within the Study Area along Leoran Brook. Corridors are linear habitat areas that encourage the movement of species between fragmented hubs and sites.

A substantial length of GIN Corridor extends northward along Leoran Brook from the South Port Kells/Anniedale area on the south side of Highway 1 and runs parallel to the South Fraser Perimeter Road until it connects to Barnston Park then crosses the Golden Ears Connector and the CN Railway to connect to the Surrey Bend hub. This Corridor may be fragmented as it appears to be separated from the Surrey Bend GIN Hub by the CN Railway, as discussed in section 7.2 of this report. Current Design Drawings for the Golden Ears Connector (Associated Engineering and Hatfield, 2013) show a multiple use path (MUP) extending along the south side of the highway as a greenway with extensive plantings of native trees and shrubs targeted for both fish and wildlife habitat enhancement. The MUP/Greenway provides further potential as a wildlife corridor in support of the designated GIN Corridor extending along Leoran Brook toward interior forest habitat in Surrey Bend, subject to overcoming current limitations for safe road/rail crossings meant for wildlife.

Further fragmentation of forested areas along 172nd Street, 179th Street, and Leoran Brook should be avoided to preserve the remaining forest habitat and corridor values identified under Biodiversity Conservation Strategy.

9. TREE STUDY

An assessment of tree stands and arboricultural values was conducted by Michael J. Mills Consulting (Certified Arborist) on May 14 and June 1, 2015. A report was prepared outlining the findings of the tree assessment, and is included as Appendix C for detailed reference. Some of the key findings are discussed below, and are presented in Figure 4: Tree Study Map in Appendix A.

Within the East Fraser Heights Study Area, there is a wide range of tree species. In general terms, native tree species dominate the forested areas and introduced species dominate in the developed single family areas. It is estimated that approximately 35% of the Study Area is presently forested with closed canopy stands native trees. There are many impressive trees within the Study Area, measured both by size and by landscape value.

The largest tree by trunk diameter within the study area would be found within the stand of Douglas Firs in the southeast corner. The majority of the undeveloped properties within the East Fraser Heights Study Area are forested with a mix of native tree species. Stands with mixed Alder, Cottonwood, Big leaf Maple with a small percentage of native conifers intermixed tend to dominate the lower slopes and bottom land along the South Fraser Perimeter Road. Stands of larger trees with a higher percentage of native conifers tend to be located further to the south along the upper plateau. The oldest native trees in the area are thought to be located in the stand of Douglas Firs (see Area "G", Figure 4) in the south east corner of the East Fraser Heights study area (9684 & 9716 182A Street). There are no trees in the study area that would be considered as old growth specimens.

There are no trees within the study area that are included in the City's "Significant Tree" list, Schedule B of the Surrey Tree Bylaw. Of the "protected tree" species, as specifically identified in the Surrey Tree bylaw, a total of six Giant Redwoods and three Monkey Puzzle trees within the Study Area were observed. Of note, there are two English Oaks located at the north of 179^{th} Street in front of the industrial site at 10090 - 179^{th} Street, and another open grown oak at 9999 - 179^{th} Street.

The Tree Assessment Report included as Appendix C contains recommendations regarding Tree Preservation, Protection, Replacement and Enhancement, as the four cornerstones of a sustainable urban forest.

10. CONCLUSIONS

The Study Area for the East Fraser Heights land use planning area comprises 175 ha (430 acres) and is generally bounded by Highway No. 1 to the south, 172 St. to the west, Highway 17, Daly Rd. and the CN Railway to the north, and Golden Ears Way to the east, as shown on Figure 1

(Appendix A). The Study Area slopes downward over a prominent, relatively steep escarpment toward the Fraser River. The Study Area primarily comprises of a mix of suburban properties of varying sizes and with some multi-family and commercial uses. Recent re-development proposals for higher density residential urban subdivisions have involved an OCP amendment to Urban, Multiple Residential or Commercial designations, and rezoning to a CD (Comprehensive Development) zone. Light industrial use is present along much of the northern edge adjacent to the South Fraser Perimeter Road and CN Rail tracks.

Surficial geology mapping shows that native soils in most of the Study Area comprise Capilano Sediments (Cd) with a broad band of Pre-Vashon Deposits (PVa,c) extending east-west across the Study Area, generally on escarpment slopes. Capilano Sediments are marine and glaciomarine stony (till-like) and stoneless silt loam and clay loam with minor sand and silt between 3 – 30 m thick. While these soils tend to be densely consolidated, they are (slowly) permeable. The Pre-Vashon Deposits are glacial, nonglacial and glaciomarine sediments; which in the Study Area can include Quadra (sandy) fluvial channel fill and floodplain deposits, as well as marine interbedded fine sand to clayey silt. The Pre-Vashon Deposits in the Study Area have significant potential for higher yield aquifers. Soils mapping (BC Soil Survey) indicates gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits are present over most of the Study Area. These are relatively permeable soils and are expected to support seasonal aquifers that may dry out in summer months, and which can support baseflows in streams.

According to the Surrey Groundwater Water Supply Study, the North Surrey uplands area is generally considered a groundwater recharge area with low permeability, and the Fraser Lowlands at the north end of the Study Area is generally considered an area of groundwater discharge. Phoenix observed soil types consistent with existing mapping and descriptions where exposed slopes and ground surfaces were encountered. Phoenix has observed extensively occurring springs supporting streams, including flowing artesian wells, along the base of ravine slopes. As well, wetlands supported by springs and containing minor flows are present at numerous locations within the Study Area (e.g. lowland, lower escarpment slopes), even after prolonged dry weather.

Extensive field observations of all Class A and Class B streams have been completed. While there have been indications of some localized bank erosion, the ravine streams (e.g. Leoran Brook) offer very good juvenile salmonid rearing habitat with spawning potential limited by low flows. Good channel complexity with large woody debris has been observed within the major streams within the Study Area, including extensively occurring springs and wetlands. The extent of springs and groundwater baseflows in watercourses in the Study Area indicate the importance of preserving groundwater recharge areas in supporting the baseflows and productivity of streams in the East Fraser Heights area. Most of the Class B streams likewise appear to be supported by groundwater-fed baseflows; with some high runoff erosion evident, but largely stable channels and banks. Several of the Class B streams have barriers to fish migration, which if removed could support fish populations. However, there is low potential for expanding Class A (fish-bearing) watercourses in the Study Area where barriers have not be removed (CN Rail tracks), or where old driveways between recent residential subdivisions across ravine streams are not accessible for removal. Phoenix has identified several unmapped watercourses, as well as numerous instances of existing watercourse classifications that warrant reclassification (see

Figure 2, Appendix A). The prolonged dry weather during the Study period has imposed limitations on re-classifications for Class C ditches, but some have been observed to be flowing and are recommended to be mapped as Class B.

As part of the Golden Ears Connector, a bridge has been constructed for the crossing of Leoran Brook. The bridge ensures fish passage across the highway, and also provides a major enhancement of wildlife corridor values for the Leoran Brook Green Infrastructure Network (GIN) Corridor under the Surrey Biodiversity Conservation Strategy. Other fish passage and wildlife crossings of the Golden Ears Connector have been included in that project (e.g. 178A Watercourse).

Photographs of select areas of environmental value, with reference to their mapped location, are displayed on Figure 5 (Appendix A) to convey a general sense of the environmental features observed within the Study Area.

All riparian areas (creeks, ponds and wetlands), forested blocks, fallow fields and undeveloped right-of-ways (ROW) encountered were assessed during the wildlife field assessment. Many of these areas were associated with potential wildlife corridors and habitats that may be used by at least eight federally or provincially listed terrestrial wildlife species. The riparian habitats, forested blocks, and ponds were identified as having high wildlife values within the Study Area and provided moderate to high rated habitat for species of conservation concern. These riparian areas and forested stands also provided important nesting habitat for raptors such as Red-tailed Hawk and Cooper's Hawk.

Moderately used wildlife trails, attributed to coyotes and black-tailed deer, were detected within forested areas in the Study Area. These animals appeared to travel mainly along the watercourses and riparian areas. In addition to coyotes and deer, these corridors are likely used by many species of small mammals, birds, amphibians, and reptiles. Deer and coyote have been observed by residents moving through greenbelts in East Fraser Heights.

The ponds, watercourses, and associated terrestrial habitats provided important habitat for many waterfowl, songbird and amphibian species. The riparian zones of all creeks, particularly Leoran Brook, provided high rated habitat for the provincially and federally listed Pacific water shrew, Oregon forestsnail, Western Screech-owl, and northern red-legged frog as well as the provincially listed Trowbridge's shrew and Pacific sideband snail. Moreover, the GIN corridor and adjacent forest along Leoran Brook had a high concentration of Oregon forestsnail detections, and as such further fragmentation or development of this area should be avoided to preserve the remaining forest and snail habitat and corridor values identified under the Biodiversity Conservation Strategy (BCS).

The City of Surrey has also identified a Green Infrastructure Network (GIN) Corridor along Leoran Brook ravine and west along the lower escarpment areas, including existing greenbelts (e.g. Greenbelt 27A) adjacent to the SFPR/Hwy. 17. A proposed City of Surrey Greenway (Golden Ears Connector MUP) would extend northwest through the north portion of the Study Area, which can aid in the establishment of the BCS GIN Corridor in East Fraser Heights. The location of the potential wildlife movement corridor (BCS GIN Corridor) designated on existing COSMOS mapping is shown in Figure 3. Phoenix has observed the large culvert crossing of

Highway 1 for Leoran Brook and stood inside the culvert; which has ample potential for use as a wildlife crossing, including deer. While the wildlife corridor provided by the Leoran Brook Bridge (Associated Engineering, 2013) on the Golden Ears Connector represents a substantial enhancement (e.g. Pacific Water Shrew), there remains obstacles for wildlife corridor utilization associated with the existing conditions along the CN tracks and industrial (e.g. sawmill) facilities north of the rail tracks and along the Fraser River between Leoran Brook and the major GIN Hub at Surrey Bend.

There is a proposal by Kinder Morgan Trans-Mountain to install the new pipeline near the base of the escarpment adjacent to Daly Road; the alignment of which may also impact development in the Study Area, as well as potentially impact stream and groundwater resources. The details associated with the possible oil pipeline alignment have not been obtained by Phoenix to enable independent analysis of potential environmental impacts, other than the obvious impacts that would be associated with a pipeline rupture. Collection of groundwater and stream conveyance with fish migration maintained along and beyond a possible pipeline alignment in the lowland area in and adjacent to the Study Area would be the type of potential impacts that can be readily mitigated, as with the South Fraser Perimeter Road highway project. Unlike the SFPR, there may also be potential for the alternate oil pipeline twinning alignment to enable establishment of wildlife movement corridors and implementation of the BCS objectives for the GIN Corridor in this area of East Fraser Heights.

The Tree Study has made note of the extensive tree cover in East Fraser Heights. The existing trees within the Study Area represent a significant part of the urban forest in North Surrey. In viewing the aerial photos of the City, it is immediately apparent that the Study Area represents the most densely forested portion of the City north of Highway 1. The Tree Study has identified seven stands of trees that represent some of the better opportunities to retain such groups of trees, which are shown as significant forest stands in Figure 4. Several specimen trees (e.g. redwoods, oak) identified through the Tree Study are also shown in Figure 4.

11. RECOMMENDATIONS

Phoenix recommends that the updated watercourse mapping and proposed watercourse classifications identified by this Environmental Assessment be adopted. Due to the record dry weather in May 2015 during which this assessment has been conducted, it is also recommended that additional assessment of potential re-classifications of Class C watercourses be conducted during wetter weather periods when there are periods of no rainfall for 48-72 hours following rainfall events.

The potential to remove existing barriers to fish migration (e.g. constructed ponds) should be assessed and implemented in conjunction with any future re-development applications, as well as taken into consideration for the proposed Land Use Concept for East Fraser Heights. Land use planning in the area should take into account the need to maintain groundwater recharge capability by minimizing impervious ground surfaces, maintaining open vegetated ground in exchange for higher density development with surrounding greenspaces, and incorporating infiltration structures (e.g. open drainage ditches retained, bioswales, rock pits).

As an important measure to maintain groundwater baseflows for streams in the Study Area, it is recommended that the existing (abandoned) artesian wells nearby streams in the Barnston Park area be protected and retained. The two artesian wells observed by Phoenix are shown on Figure 2, and are already protected as greenbelts. Further investigation of the nature of these artesian wells (e.g. driller logs) is recommended to ensure that the associated groundwater aquifer is protected from potential aquifer contamination, while assuring the continued contribution of groundwater baseflows by these wells to the nearby streams.

There are barriers to fish migration at the ponds that have been formed on the Main Stream in Barnston Park (see Figure C and Figure 2). The former access roads or driveways that cross the stream and appear to be remnants of large lots prior to more recent subdivision are very difficult to access, as they are behind existing residential yards between Lyncean Drive and 179th Street. In order to remove these barriers, extensive excavation of the old road beds to restore a natural stream channel, or construction of fishways and replacing existing perched culverts with baffled culverts, would be required to restore fish migration through this segment of the stream. Access restrictions to remove these barriers may be prohibitive, and has resulted in the recommended re-classification of the watercourse from Class A to Class B. However, during field assessments, Phoenix noted that the house at 9999 – 179th St. has been boarded up and a temporary construction fence as been erected at this property. If there is an opportunity for the City to negotiate access through this lot to remove these fish migration barriers in conjunction with the apparently imminent re-development of this property, it is recommended that the City pursue this possibility as soon as possible. This may be the only opportunity to address these fish migration barriers without incurring major disturbance of the forest and aquatic habitat in the adjacent Barnston Park.

Similarly, there may future potential under a re-development application to eliminate or replace the steel pipe barrier to fish migration on the Barnston Park West Stream that extends underneath the existing industrial site at 10095 – 179th Street. It would appear that a fish passable culvert crossing of the SFPR/Hwy. 17 has been recently constructed, and the removal of the culvert barrier at the industrial site could restore fish populations into the very good salmonid-rearing habitat in this watercourse.

To minimize negative impacts of future development on groundwater, as well as the hydrologic flow regime of watercourses, mitigation methods should be considered as part of the development process. Low Impact Development (LID) land planning and design approaches aim to manage stormwater runoff and generally preserve the pre-development hydrologic regime. LID methods incorporated into development plans can increase the effective infiltration of stormwater to reduce excessive creek flow during storm events as well as increase groundwater recharge. LID practices will help to mitigate upland creek erosion and lowland flooding issues associated with urban storm flow.

As a note of interest, south of Barnston Park on the west side of Lyncean Dr, is a residential property with a rocky lawn landscaped with some characteristics of a creek (Photo 12, Appendix B). This landscaped area was noted dry at the time of field assessment on May 14, 2015. Based on the information available on COSMOS, there appears to be a drainage lateral line connecting this property to the main stormwater line on Lyncean Dr. This “dry creek bed” landscaping in a single family residential lot is an example of numerous means by which groundwater infiltration can be incorporated into residential re-development in East Fraser Heights where "density-bonus" opportunities to secure forested or open vegetated lands may not be possible.

It is recommended that existing tree stands be protected as much as possible under future land use planning for East Fraser Heights. The current 35% closed canopy cover estimated for the Study Area is a good feature to protect and maintain, including potential for tree replacement where re-development occurs or around and within existing greenbelts to increase the overall tree canopy cover. A detailed assessment by a qualified expert should be undertaken for any development applications, which is commonly required by the City. This is the best time to assess danger trees. The Tree Study report prepared for this assessment (see Appendix C) presents several general and specific recommendations.

Vegetation species listed under the Species at Risk Act (SARA) were not detected during the field program. The Study Area may provide habitat for one listed plant species, slender-spiked mannagrass. During the appropriate season and prior to clearing activities within the Study Area, a rare plant survey for this species should be completed in suitable habitats as described in this report that are in close proximity to 176th Street and 104th Avenue. Invasive vegetation species were regularly encountered along interfaces of forested and disturbed or developed sites. These invasive species included Himalayan blackberry, Japanese knotweed, scotch broom, and English ivy. Removal of these invasive plant species at strategic sites (e.g. within critical to high rated Pacific water shrew and Oregon forestsnail habitat in Abbey Glen Park, Barnston Park, and the south end of Leoran Brook), within the designated GIN Corridor, and other forested sites would benefit many native wildlife and vegetation species and improve existing wildlife and ecosystem corridors.

The ponds, watercourses, and associated terrestrial habitats provided important habitat for many waterfowl, songbird and amphibian species. Moreover, the GIN corridor and adjacent forest along Leoran Brook had a high concentration of Oregon forestsnail detections. Any further fragmentation or development of this area should be avoided to preserve the remaining forest and snail habitat and corridor values identified under the Biodiversity Conservation Strategy.

The GIN Corridor along Leoran Brook may be fragmented as it appears to be separated from the Surrey Bend GIN Hub by the CN Railway. Current Design Drawings for the Golden Ears Connector (Associated Engineering and Hatfield, 2013) show a multiple use path (MUP) extending along the south side of the highway as a greenway with extensive plantings of native trees and shrubs targeted for both fish and wildlife habitat enhancement. The MUP/Greenway provides further potential as a wildlife corridor in support of the designated GIN Corridor extending along Leoran Brook toward interior forest habitat in Surrey Bend, subject to overcoming current limitations for safe road/rail crossings meant for wildlife.

Further consideration could be given to designing the proposed MUP/Greenway with minimized paved surfaces. Many neotropical migrant birds, insectivore birds, and other development-sensitive bird species decrease in diversity and abundance as suburban development increases; however, appropriately designed greenways may provide habitat for these displaced species in suburban environments (Mason et al. 2007). Studies have shown that as percent cover of pavement and disturbed/managed areas (i.e. mowed lawns) in greenways increased, the abundance and diversity of bird species decreased (Mason et al. 2007). Moreover, greenways with little or no pavement or managed areas typically had twice as many development-sensitive bird species as compared to greenways with 2 – 4 m wide paved paths with adjacent mowed lawns (Mason et al. 2007). Generally, neotropical migrant and forest-interior bird species were absent in greenways with pavement or high building cover in the adjacent landscape (Mason et al. 2007).

Remaining forest patches need to be protected and wildlife movement corridors need to be maintained or established to improve the ecological integrity of the Study Area and to provide suitable living habitats for sensitive species. Privately and transit owned forest patches adjacent to Abbey Glen Park, 26C-Greenbelt, 27E-Greeneblt, Barnston Park, and between Leoran Brook and 182A Street, should be protected and established as greenbelts to encourage wildlife movement corridors and to improve the ecological integrity of the Study Area. These privately owned forested areas provide suitable living habitats for several sensitive species so further development and fragmentation of these areas should be avoided. Provision of natural habitats that have protected corridors will result in increased biodiversity within the Study Area.

Potential land acquisition opportunities for stream, forest and biodiversity conservation appear to be relatively limited, given the extent of private property within the East Fraser Heights Study Area. Based on ecological values present at the property, a prospective land acquisition opportunity that may be considered by the City pertains to the large parcel at 17919 – 99A Avenue, where the Class A and Class B stream and associated springs and wetlands remain relatively undisturbed and intact and offer high fish and wildlife values. Phoenix had a brief discussion with the owner of the large forested farm parcel in the northwest corner of the Study Area (10295 – 173 Street) adjacent to Abbey Glen Park, and it was evident that many offers to purchase that large parcel by prospective developers have been rebuffed. Likewise, it seemed that there was low likelihood that acquisition for park would be entertained. Now that the South Golden Ears Connector has been largely completed along the Study Area, there may be opportunities for the City to negotiate acquisition of most southern and forested Transit-owned property (10264 – 176th St.) between 177 A Street and Highway 15 (176th St.). Both of these potential land acquisition opportunities would substantially aid in the implementation of the GIN Corridor under the City's Biodiversity Conservation Strategy.

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APPENDIX A

Figures

Study Area Outline

SCALE:
0m 100m 200m 400m 600m 800m

FIGURE 1: Study Area Map

City of Surrey - Environmental Study
East Fraser Heights

PHOENIX
ENVIRONMENTAL SERVICES LTD.
505 • 1755 W. Broadway, Vancouver V6J 1R3
tel. 604.689.3888 fax. 604.689.3880

DATE: June 2015	DRAWN BY: NGL	SCALE: As Shown	DWG: Fig.1 - Study Area Map.dwg

Study Area Outline

Pond

Wetland

Class A or A(0) Watercourse

Class B Watercourse

Class C Watercourse

Artesian Well

FIGURE 2: Watercourse Classification Map

City of Surrey - Environmental Study
East Fraser Heights

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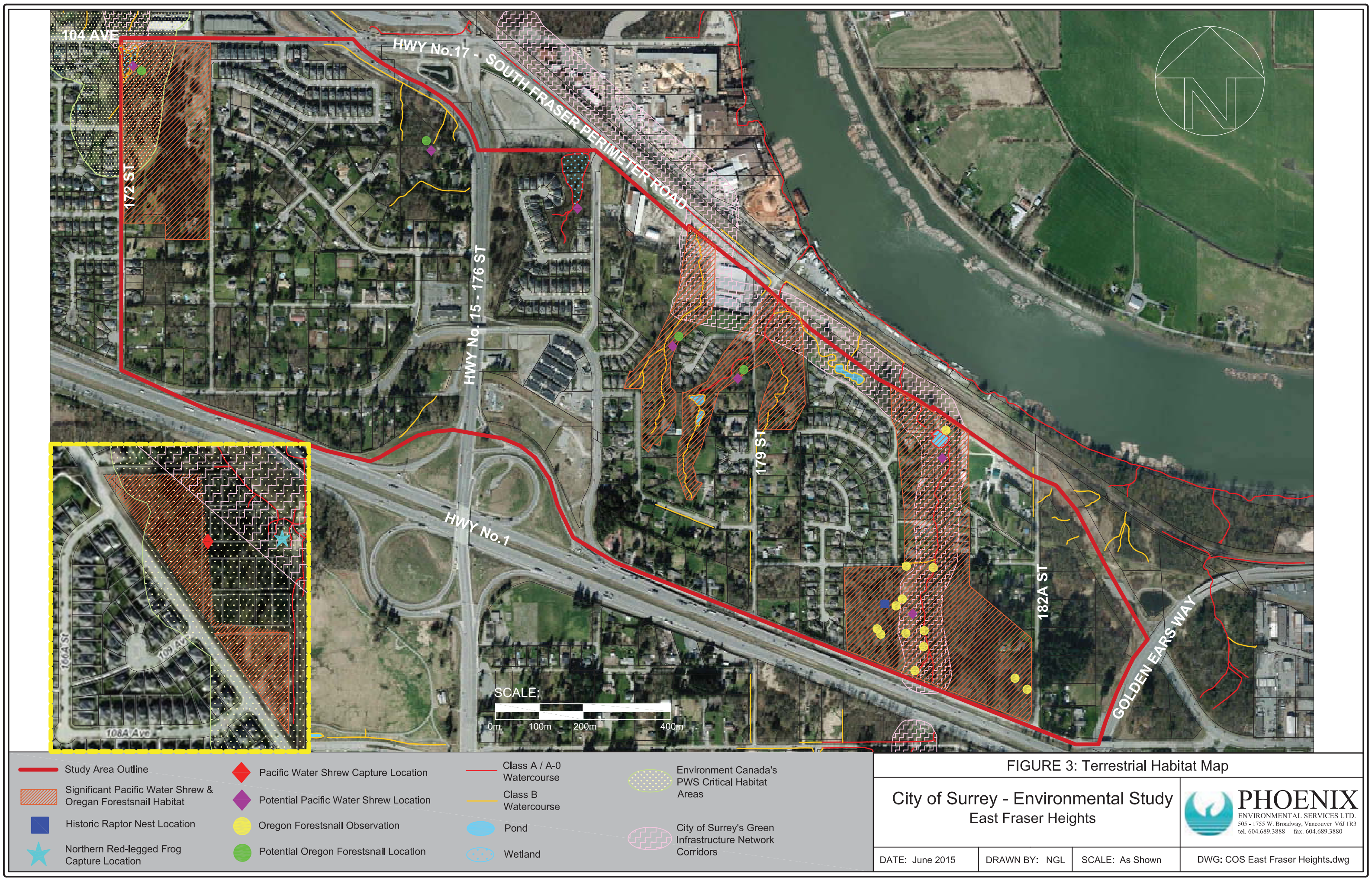
DATE: June 2015	DRAWN BY: NGL	SCALE: As Shown	DWG: Fig.2 - WCCMap.dwg


104 AVE
172 ST
HWY No.17 - SOUTH FRASER PERIMETER ROAD
HWY No. 15 - 176 ST
179 ST
182A ST
HWY No.1
GOLDEN EARS WAY
108A Ave
SCALE:
0m
100m
200m
400m
Study Area Outline
Significant Pacific Water Shrew & Oregan Forestsnail Habitat
Historic Raptor Nest Location
Northern Red-legged Frog Capture Location
Pacific Water Shrew Capture Location
Potential Pacific Water Shrew Location
Oregon Forestsnail Observation
Potential Oregon Forestsnail Location
Class A / A-0 Watercourse
Class B Watercourse
Pond
Wetland
Environment Canada's PWS Critical Habitat Areas
City of Surrey's Green Infrastructure Network Corridors
FIGURE 3: Terrestrial Habitat Map
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SCALE: As Shown
DWG: COS East Fraser Heights.dwg

Study Area Outline

Significant Forest Stands

Giant Redwood Location

Monkey Puzzle Location

Oak Location

FIGURE 4: Tree Study Map

City of Surrey - Environmental Study
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FIGURE 5: Photo Location Map

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DATE: June 2015 | DRAWN BY: NGL | SCALE: As Shown | DWG: Fig.1 - Study Area Map.dwg

APPENDIX B

Photographs

Photo Area - 177A St Wetland

Photo 1. Unmapped Class B stream alongside wetland (looking upstream)

Photo Area - 177A St Wetland

Photo 2. Unmapped stream/wetland outlet

Photo Area - 177A St Wetland

Photo 3. Upstream wetland area

Photo Area - 177A St Wetland

Photo 4. Wildlife tracks near wetland

Photo Area - 173 St near Abbey Dr

Photo 5. Forested area looking west

Photo Area - Greenbelt 26C East of 103 A Ave and 175 St

Photo 6. Upstream portion of mapped Class B

Photo Area - Greenbelt 26C East of 103 A Ave and 175 St

Photo 7. Unmapped watercourse near mapped Class B (significant refuse)

Photo Area - Greenbelt 26C East of 103 A Ave and 175 St

Photo 7. Outlet of Class B to ditch and culvert (leads to stormwater pond)

Photo Area - Abbey Glen Park

Photo 8. Mapped Class B ponded area (looking downstream). Significant sediment build up.

Photo Area - Abbey Glen Park

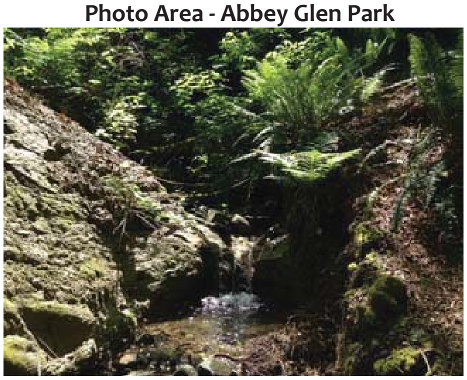


Photo 9. Class B upstream of ponded area.

Photo Area - Barnston Park Area

Photo 10. Class B (West Stream 1) downstream from headwall (off of 100 Ave)

Photo Area - Barnston Park Area

Photo 11. Landscaped lawn upstream from park (off Lyncean Dr)

Photo Area - Barnston Park Area

Photo 12. Potential watercourse reclassification, Class C → Class B (179 St and Lyncean Dr, looking south)

Photo Area - Barnston Park Area

Photo 14. Barrier to fish migration on Main Stream near 27D Greenbelt (additional barriers exist downstream)

Photo Area - Barnston Park Area

Photo 15. Unmapped artesian well pond upstream of Main Stream (near 179 St)

Photo Area - Barnston Park Area

Photo 13. Artesian well outflow (enters storm culvert which discharges to Main Stream)

Photo Area - Barnston Park Area

Photo 14. Artesian well pond from west

Photo Area - Barnston Park Area

Photo 15. Artesian well

Photo Area - Barnston Park Area

Photo 16. Unmapped spring tributary stream to Main Stream (near artesian well)

Photo Area - Barnston Park Area.

Photo 18. Unmapped spring tributary to Main Stream (near artesian well area)

Photo Area - Barnston Park Area

Photo 21. Unmapped spring tributary to Main Stream East Branch (East of 179 St)

Photo Area - Barnston Park Area

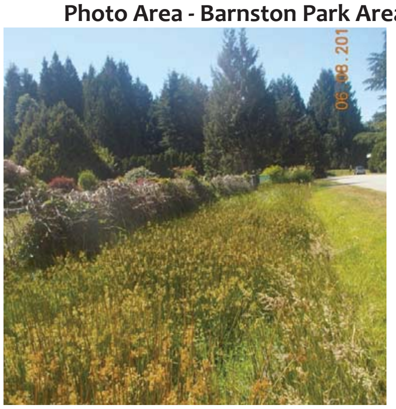


Photo 22. Reclassification of Class C ditch to a Class B. South of Lyncean Dr, west of 179 St.

Photo Area - Barnston Park Area.

Photo 23. Springs in Park near Lyncean Dr and 100 Ave.

Photo Area - Barnston Park Area

Photo 194. Old road blocking upper end of West Stream 3 (looking upstream)

Photo Area - Barnston Park Area

Photo 2517. Main Stream - lower pond. Looking upstream. Culvert draining upstream pond visible. (Neither pond is fish accessible)

Photo Area - Barnston Park Area

Photo 26. Main Stream – upper pond. (Not fish accessible)

Photo Area - Barnston Park Area

Photo 27. Twin culverts downstream of lower pond

Photo Area - Barnston Park Area

Photo 28. Artesian well near West Stream 3

Photo Area - Barnston Park Area

Photo 29. Downstream of Artesian well in previous photo (significant flow evident)

Photo Area - Barnston Park Area

Photo 30. Downstream end of West Stream. Near SFPR. Looking upstream.

Photo Area - Barnston Park Area

Photo 31. Downstream end of West Stream. Near SFPR. Looking downstream.

Photo Area - Barnston Park Area

Photo 32. Looking in culvert shown in previous photo. Note side baffle plates and gravel.

Photo Area - Leoran Brook

Photo 33. Giant Hogweed in Leoran Brook ravine (near 98 Ave)

Photo Area - Leoran Brook

Photo 34. Pond on Leoran Brook (fishway immediately downstream)

Photo Area - Leoran Brook

Photo 35. Culvert below pond and fishway. Fish barrier during low flow.

Photo Area - Leoran Brook

Photo 36. Weirs below pond and fishway. Impassable during low flow.

Photo Area - Leoran Brook

Photo 37. Looking upstream towards No 1 Hwy. Salmonid fry observed.

Photo Area - Leoran Brook

Photo 38. Culvert under No 1 Hwy. Looking upstream.

Photo Area - Leoran Brook

Photo 39. Skylight for culvert in previous photo.

Photo Area - Leoran Brook

Photo 40. Previously identified medium risk bank erosion location (tributary near property)

Photo Area - Leoran Brook

Photo 41. Unmapped Class B watercourse. Same watercourse causing the erosion in previous photo. Near 98 Ave

Photo Area - Leoran Brook

Photo 42. Unidentifed flexible small diameter pipe following Leoran Brook

Photo Area - East of 182 A St

Photo 43. Roadside ditching of SFPR. Looking south.

Photo Area - East of 182 A St

Photo 44. Looking upstream of previous photo. West of SFPR.

Photo Area - East of 182 A St

Photo 45. Downstream of previous photo. East of SFPR.

Photo Area - East of 182 A St

Photo 46. Potential wildlife corridor. Looking west from SFPR

Photo Area - East of 182 A St

Photo 47. Potential wildlife corridor looking east

Photo Area - East of 182 A St

Photo 48. Well forested area east of 182 A St.

Photo 49. Forested vegetation of Abbey Glen Park – 16D-Greenbelt with invasive vegetation along public trail and roadside.

Photo 50. Riparian vegetation within Abbey Glen Park dominated by salmonberry, piggy-back plant, and common horsetail.

Photo 51. Forested vegetation within Abbey Glen Park – 16D Greenbelt dominated with red alder, big-leaf maple, salmonberry, and sword fern.

Photo 52. Critical Pacific water shrew habitat in the north end of Abbey Glen Park – 16D-Greenbelt that connects to critical habitat associated with known capture site.

Photo 53. Potential Oregon forestsnail habitat with stinging nettle and big-leaf maple in Abbey-Glen Park – 16D-Greenbelt.

Photo 54. Ephemeral stream and riparian habitat in south portion of 26C-Greenbelt dominated with red alder, western redcedar, Indian plum, salmonberry, and sword fern.

Photo 55. Ephemeral stream with CWD looking south in 26C-Greenbelt.

Photo 56. Wetted north end of stream in 26C-Greenbelt with dense salmonberry, skunk cabbage, sword fern, and red alder.

Photo 57. Forest vegetation within 26C-Greenbelt and adjacent lots west of 176th Street dominated with deciduous trees.

Photo 58. Potential wildlife corridor between 26C-Greenbelt and 176th St. Frontage Road looking east.

Photo 59. Potential wildlife corridor between 26C-Greenbelt and 176th St. Frontage Road looking west.

Photo 60. Wetland within 27E-Greeneblt and adjoining lots to the north dominated with skunk cabbage, lady fern, and wildlife trees.

Photo 61. Wetland within northern section of 27E-Greenbelt looking northwest.

Photo 62. Overview of wetland/forest connected to 27E-Greenbelt looking northwest along 177A Street.

Photo 63. Wetland habitat with cattail, skunk cabbage, and wildlife trees north of 27E-Greeneblt at 177A Street and Daly Road.

Photo 64. Mature mixed forest within Barnston Park dominated with black cottonwood, big-leaf maple, and western redcedar.

Photo 65. Forest vegetation within Barnston Park dominated with salmonberry, sword fern, fringecup, and piggy-back plant.

Photo 66. Riparian habitat in Barnston Park provides high quality Pacific water shrew habitat.

Photo 67. Riparian forest habitat with mature big-leaf maple and stinging nettle provide potential Oregon forestsnail habitat in Barnston Park.

Photo 68. Mature riparian forest habitat adjacent to Barnston Park on east side of 179th Street provides high quality habitat for Pacific water shrew, western screech-owl, and northern red-legged frog.

Photo 69. Forested vegetation in southwest portion of Barnston Park dominated with red alder, salmonberry, Pacific bleeding heart, and sparse stinging nettle.

Photo 70. Riparian habitat in southwest portion of Barnston Park dominated with skunk cabbabe, lady fern, and salmonberry.

Photo 71. Riparian – forest vegetation with mixed decidous and coniferous trees in southwest portion of Barnston Park.

Photo 72. Wetland/pond habtat in 27A-Greenbelt connected to Leoran Brook provides breeding and foraging habitat for birds.

Photo 73. Pond habiat in 27A-Greeneblt looking east towards forest habitat adjacent to Leoran Brook.

Photo 74. Mixed forest habitat adjacent Leoran Brook dominated with red alder, big-leaf maple, salmonberry, Indian plum, and Pacific bleeding heart.

Photo 75. Riparian habitat along the north end of Leoran Brook dominated with red alder, western redcedar, salmonberry, and sword fern provides Pacific water shrew habitat.

Photo 76. Mature mixed forest habitat south of 27C-Greenbelt adajcent to Leoran Brook provides quality habitat for Western screech-owl, Pacific water shrew, and Oregon forestsnail.

Photo 77. Overview of mature mixed forest facing west along Barnston Drive E with historical raptor nests indicates the area is used for breeding raptors.

Photo 78. Mature forest along Barnston Drive E facing east within the GIN Corridor along Leoran Brook.

Photo 79. Riparian forest vegetation of Leoran Brook facing north, which provides Pacific water shrew, Western screech-owl, and Oregon forestsnail habitat.

Photo 80. Riparian vegetation along Leoran Brook facing north dominated with western redcedar, vine maple, salmonberry, lady fern, and sword fern.

Photo 81. Riparian vegetation along Leoran Brook facing south dominated with western redcedar, vine maple, salmonberry, and piggy-back plant.

Photo 82. Oregon forestsnail detected during field surveys on May 15, 2015 within forested habitat adjacent to Leoran Brook and west of 182A Street.

Photo 83. Red admiral butterfly detected during field surveys on May 15, 2015 within riparian habitat along Leoran Brook adjacent to Barnston Drive E.

APPENDIX C

Existing Tree Assessment Report

East Fraser Heights Environmental Study

By Michael J. Mills

MICHAEL J. MILLS CONSULTING
CERTIFIED ARBORIST

Existing Tree Assessment Report
East Fraser Heights Environmental Study

Prepared for Phoenix Environmental Services
June 2nd, 2015

Surrey Reference # 1220-030-2015 EFH

Introduction:
The following report has been prepared to address the terms of reference associated with Arboricultural and Urban Forestry issues as part of the greater Environmental Study prepared by Phoenix Environmental Services for the East Fraser Heights study area.

We were asked to assess and map the Arboricultural values associated with the study area. We visited the site on May 14th 2015 with the Phoenix Environmental team to gain an appreciation for the study methodology and again on our own on June 1st 2015 to review the area in greater detail. Tree survey information for the study area was not available to us and as such we have developed a generalized stand delineation map utilizing the available aerial photos of the area to assist in identification of stand characteristics and individual trees of high value.

The East Fraser Heights study area comprises approximately 175 Hectares. The study area is bounded by 172nd Street to the west, Highway 17 (South Fraser Perimeter Road) to the north, 182nd A Street to the east (Langley border) and Highway #1 to the south.

Observations:
In general terms, the study area is comprised of approximately 417 legal lots of varying size. The majority of the properties are utilized for single family residential use and a number of properties remain undeveloped. There is only one multifamily residential complex, the relatively new "Highcrest Townhouse" development on Barnston Drive. There is one Church property (Korean Presbyterian Church @10110 175A Street) and one institutional site (Surrey Fire Hall #5). There are six dedicated park spaces, five Greenbelts and one formal park site (Barnston Park). The park areas collectively cover approximately 7.7 hectares of the study area. Light industrial use is present along much of the northern edge adjacent to the South Fraser Perimeter Road. The largest property and the only obvious working farm operation is located in the North West corner of the study area with a civic address of 10295 172nd Street.

Within the East Fraser Heights study area there is a wide range of tree species. In general terms, native tree species dominate the forested areas and introduced species dominate in the developed single family areas. There are two types of single family properties, the larger more established properties that tend to be located toward the southern sections and the smaller relatively newer single family properties on the north slope and along the bottom of the slope. Within the larger lots, pockets of pre exiting native trees were retained on many of the properties. The newer lots were, for the most part, clear cut and as such they now have only newly planted small trees. Most of the new subdivision area have relatively young street trees installed while the more established area tend to have no formal street trees and a more random look to the streetscape.

The undeveloped properties tend to have mixed stand of native trees that are thought to be associated with post clear cutting natural re vegetation. We estimate that +/- 35% of the study area is presently forested with closed canopy stands native trees. .

We observed the following tree species:
Native Tree Species
- Douglas Fir
- Western Red Cedar
- Western Hemlock
- Big Leaf Maple
- Red Alder
- Mountain Ash
- Hawthorne
- Sitka Spruce
- Pin Cherry
- Dogwood
- Black Cottonwood
- Shore Pine

Introduced Tree Species
- Cedrus (deodara and atlantica)
- Austrian Pine
- Monkey Puzzle
- Blue Spruce, Norway Spruce
- Juniper
- Lawson Cypress)
- Giant Redwood
- Japanese Maple (many different cultivars)
- Horse Chestnut
- Ornamental Cherry (several different varieties)

- Magnolia (several different varieties)
- Norway Maple
- English Oak
- European Beech
- English Holly
- Black Walnut
- Lombardy Poplar
- Weeping willow
- Dogwood (ornamental varieties)

The most common introduced tree species appears to be Cedrus Deodara (Lebonese Cypress). For some undetermined reason, many of the single family properties west of176th Street has one or more of this tree species planted in the landscape.

Trees of Note:
There are no trees within the study area that are included in the "Significant Tree" list, Schedule B of the Surrey tree bylaw. There are many impressive trees within the study area, measured both by size and by landscape value. The largest tree by trunk diameter within the study area would be found within the stand of Douglas Firs in the south east corner (Stand "G"). We estimate the largest trees to be in the 120cm dbh range with a height of over 45m. Trees within the developed areas tend to be smaller, however, some larger trees such as the fast growing Giant Redwoods are found on several lots.

Many of the larger single family lots have extensive and well maintained gardens. Selective tree retention within these larger lots has allowed for small cluster of good quality native trees to remain. Tree installation associated with the larger more established properties has resulted in a good selection of 20 – 40 year old landscape trees, in particular the south west corner of the study area. The more recently developed single family areas did not retained trees due to their relative small lot size. As a result, all of the trees found in these areas are relatively young and of a uniform age.

The City has installed a wide variety of street trees along most of the newly developed single family residential streets. The tree planting program is relatively new with none of the existing street trees having achieved any significant size. The only non – street trees identified on the Cosmos "Parks Specimen Tree" list are a cluster of semi mature Cedars located in the corner of Green Belt 27D (17844 – 99th Ave).

Of the "protected tree" species, as specifically identified in the Surrey Tree bylaw, we observed a total of six Giant Redwoods and three Monkey Puzzle trees within the study area.

Redwoods
17378 104th Ave, 10165 173rd Street, 17379 101 Ave (2 trees), 17403 101Ave & 17430 100 Ave.
Monkey Puzzle:
17539 100 Ave, 17360 100 Ave & 10045 173 Street.

No trees of obvious heritage value were identified. Some of the more notable trees would include:

- 2 English Oaks located at the north of 179th Street in front of the industrial site @ 10090 179th Street (PD Seaside). There are actually three Oaks in this area, however, one tree is in serious decline. These trees are considered to be the oldest of the introduced tree species in the study area.
- One large open grown Oak in the centre of the property at 9999 179th Street. This property was fenced off and close examination of this tree was not possible.

- The oldest native trees in the area are thought to be located in the stand of Douglas Firs (stand "G") in the south east corner of the East Fraser Heights study area (9684 & 9716 182A Street). There are no trees in the study area that would be considered as old growth specimens.

The majority of the undeveloped properties within the East Fraser Heights Study Area are forested with a mix of native tree species. Stands with mixed Alder, Cottonwood, Big leaf Maple with a small percentage of native conifers intermixed tend to dominate the lower slopes and bottom land along the South Perimeter Road. Stands of larger trees with a higher percentage of native conifers tend to be located further to the south along the upper plateau.

We identified seven distinct stands of trees where the majority of the larger, more significant trees are located. Refer to the Cosmos mark up at the end of this section of the report for the reference location:

Area "A":
Stand of mixed conifers within the large farm property in the north west corner of the study area (10290 173rd Street). Quality trees are generally found toward the central and southern sections of this lot. The trees to the south on the lower slopes tend to be of lesser quality. Stand is comprised of semi mature Douglas Fir, Western Red Cedar and Western Hemlock. This stand is somewhat unique in that the site is utilized for sheep grazing and as such the understorey is open and clear with a meadow like character. Stand is intermixed with smaller Alder, Big Leaf Maple and Hazelnut trees.

View showing the open grass areas under the trees within Area "A".

Area "B":
Stand of semi mature Douglas Fir on the north side of Barnston Drive at the intersection of 175A Street. Located along the southern edge of a double lot with a single home (17505 / 17517 – 101Ave). Good open grown form. Good understorey planting of young Cedars.

View of the trees within Area “B”.

Area “C”:
Small stand of good quality Cedars and Douglas Fir located along the south side of Barnston Drive at the intersection of 100 Ave. Stand is partially located within the Barnston Drive road allowance and on lot 17538 100th Ave with the majority of the better quality trees being located on public property.

Partial view of the stand of trees within Area “C” and of the Monkey tree on lot 17538 – 100 Ave.

Area “D”:
Open stand of semi mature conifers located between 100Ave and Highway 1. The biggest concentration of quality trees in this area is located within a single family property (17524 100th Ave.). The stand continues along the south edge of all of the lots along this section of 100th Ave with the exception of the property at 17480 (which has been fully cleared of trees) but with less density. Comprised primarily of good quality Douglas Firs with some small Cedars intermixed. Good open grown form. Many of the lots also have good quality introduced landscape trees closer to the 100th Ave frontage.

View of the trees within Area "D".

Area "E":
Located on the north side of Barnston Drive at the big curve in the road just east of the Highway 15 interchange. A stand unique to the study area in that it is comprised almost exclusively of Western Red Cedar with a few Douglas Fir intermixed. A dense and healthy stand of trees. Located on three lots, 17755 Barnston Drive and 9883 / 9897 Lyncean Drive.

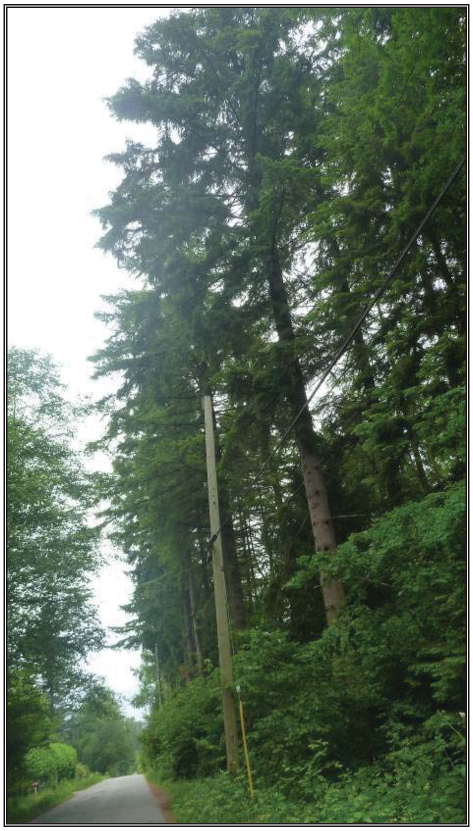
View of stand "E" as seen from the south.

View of stand "E" as seen from Lyncean Drive.

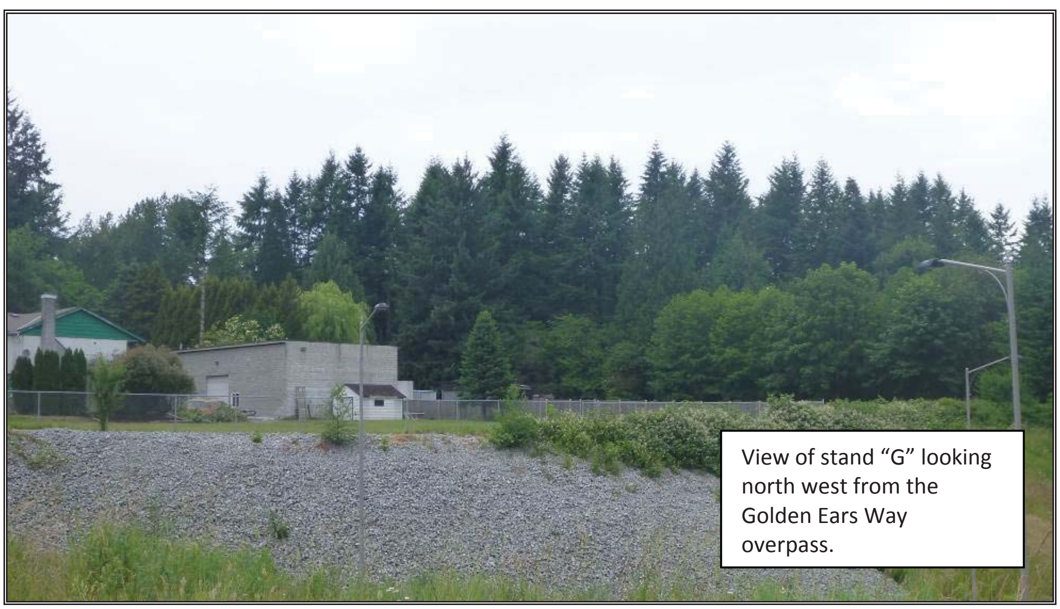
Stand "F:
Area of quality Douglas Firs within a larger stand of mixed deciduous trees north of Barnston Drive at the intersection of 182A Street. Comprised on many good quality specimens spreading across four properties, 18175 Barnston Drive and 9713 – 9749 182A Street.

View of the trees within stand "F", trees to the rear of 9713 182A Street shown.

Stand "G""
Large stand of mature Douglas Firs located on two lots on the east side of 182A Street (9684 – 9716). Stand extends into the next property to the north (9736) but with less density. Largest and likely the oldest trees within the study area are located within this stand. Good health and form.



View of the trees within Stand "G" along the edge of 182A Street.



View of stand "G" looking north west from the Golden Ears Way overpass.

Stand Delineation Map:

Photos:

View of the two English Oaks at the north end of 179th Street.

Many of the more established single family properties, especially in the south west corner, have substantial gardens and introduced tree plantings.

Example of a newer single family area where all pre-existing trees were removed.

Example of one of the large Redwoods on a residential property.

Example of remnant cluster of native trees retained on a larger single family property.

Tree Health Issues:
Overall, the trees within the study area were observed to be in good health. We did identify a few minor problems that have affected the health of a limited number of trees.

- **Disease and insect problems**: Overall, the extent of disease and insect problems within the study area is quite minor. We observed two problems,
  - There are several Lawson Cypress that have recnelty died. The symptoms suggest that this tree has succumbed to the Pytopthera root disease (P laterallis) that is very common to this species. The extent of the problem is not considered to be significant due to the fact that there are only a few Lawson Cypress within the inventory of East Fraser Heights study area.
  - The mixed forested area in the northwest corner of the site contains many dead and dying trees. The problem is also obvious along other sections of the deciduous forested areas along the base of the slope. The cause of the decline was not immediately evident but is thought to be related to man made changes to the natural site conditions.

Example of a forested area in decline along the lower sections of the study area.

- **Invasive plants**: The East Fraser Heights study area is not dissimilar to many areas of Surrey where invasive plant species have become a problem. English Ivy, Lamium, Vinca, Blackberry and Knotweed were all found to varying degrees within the forested areas. An extensive and unusuall infestation of Wisteria was observed in the forested section of Barnston Park, to the north of 100A Ave.

View of the Wisteria infestation in Barnston Park.

Comment and General Recommendation:
The existing trees within the study area represent a significant part of the urban forest in North Surrey. In viewing the aerial photos of the City, it is immediately apparent that the study area represents the most densely forested portion of the City north of Highway 1.

Future development planning for the area should promote tree conservation to the extent possible. Tree Preservation, Protection, Replacement and Enhancement are the four cornerstones of a sustainable urban forest.

Tree Preservation:
The preservation of forests grown mature trees in relation to residential development presents many challenges. Selective preservation of trees from the protected confines of a forest stand often results in unpredictable tree behaviour. The typical tall and thin form of forest grown trees can result in unsuitable candidates to be retained. There have been significant failures from selective and thin clusters of forest grown trees where preservation has been attempted in the past. Douglas Fir is known to release large limbs when under strong wind loading. The loss of limbs is how the tree responds to wind as opposed to full tree failure. When large Firs shed large limbs, the branches tend to be end weighted and can fall in a vertical spear like orientation. As a result, residential development directly under large mature Firs is not typically recommended.

Various studies and experience on the north shore slopes has resulted in a base recommendation that the width of leave strips of forest grown trees should at a minimum equal the height of the tallest trees in the group. The wider the leave strip, the more stable trees within the retained group tend to be.

The location of existing trees should be considered in the design of development. Trees of high quality or those with wildlife, cultural or heritage value should be identified before the site plan has been completed. Within all of the more recent single family areas and the lone Townhouse development within the study area, no tree preservation has occurred, the sites have been clear cut, developed and re landscaped.

Tree Protection:
Where trees have been identified for preservation, tree protection measure must be assured. The City of Surrey has a well-established system in place to ensure trees are properly protected during all phases of development.

Tree Replacement:
Where development is approved, a policy of no net loss of trees through the planting of replacement trees should be encouraged. Surrey’s current policy of two to one replacement is supported, however, when development is approved for forested sites, it is often not feasible to achieve this goal due to the high number of trees that need to be removed.

Tree Enhancement:
Encouraging the planting of additional trees to enhance development properties and streetscapes beyond the requirements of boulevard trees is suggested. The developed areas with no immediate development plans should also be encouraged to add trees and landscape where appropriate. Whenever possible, the installation of Douglas Fir and Western Red Cedar should be encouraged as these are the native climax species of trees for this area of Surrey.

General Recommendations:

- A detailed assessment by a qualified expert should be undertaken for any development applications. Tree survey and topographic information must accompany the assessment report.
- Trees on steep slopes, watercourses, ravines and un-developable areas should be retained wherever possible. Wind throw and danger trees within the Stream protection and enhancement areas will need to be considered.
- Preserve existing trees, woodlots and natural features wherever possible. Where trees of large size are retained, large groups or wide leave strips are preferred. The seven stands of trees highlighted in this report represent some of the better opportunities to retain such groups of trees.
- Provide and enhance landscaping at the street level which contributes to the continuity of landscaping between adjacent properties.
- Stabilize slopes (where existing) with ground cover and trees
- Select plant materials that are ecologically sound, appropriate for the existing and future site conditions and suitable for all seasons.
- Encouraging the consideration of the location of existing trees in the design of development plans prior to the submission of development applications.
- Encouraging and enforcement of tree protection measures during development.
- Encouraging no net loss of trees through the planting of replacement trees.

Limitations:
Due to the limits of our terms of reference, trees within the defined area have been reviewed only in general terms, no detailed assessments of any of the site trees has been included in this study. The stand delineation map provided is intended only to serve as a reference for the general comment provided and should not be relied upon for actual planning decisions. Detailed mapping, survey and tree assessment studies should be provided for each individual site in conjunction with any proposed land use changes.

We attach the following clauses to this document to ensure you are fully aware of what is technically and professionally realistic in the assessment and preservation of trees.

This Arboricultural field review report is based only on site observations on the date noted. Effort has been made to ensure that the opinions expressed are a reasonable and accurate representation of the trees reviewed, however, conditions influencing the opinion and recommendation as provided in this report can change quickly and without warning. Any trees retained should be reviewed on a regular basis to ensure reasonable safety and to minimize the associated risk.

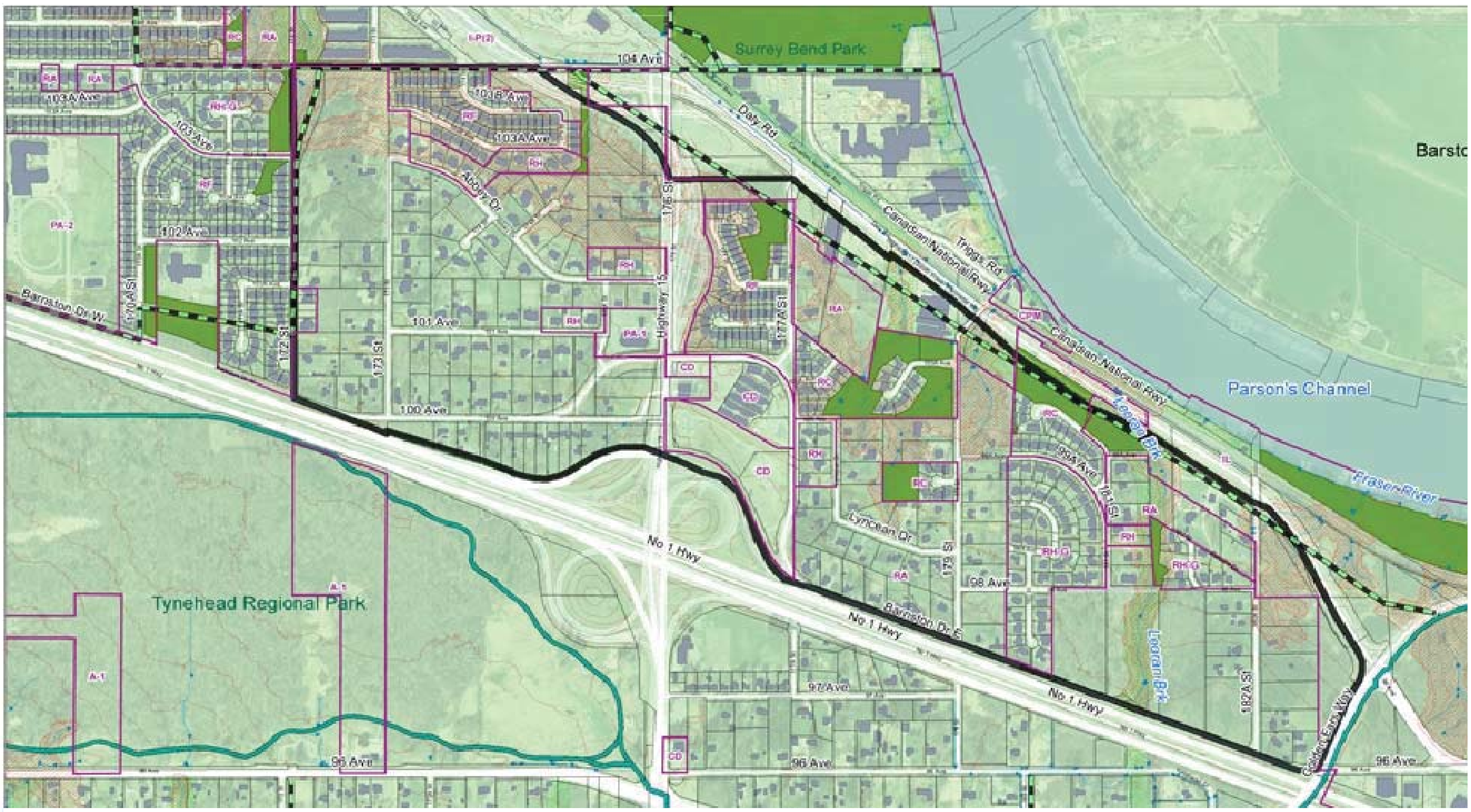
The assessment was completed based on visual review only and none of the existing trees were reviewed in detail. None of the trees were dissected, cored, probed or climbed. All trees or groups of trees have the potential to fail. No guarantees are offered or implied by Michael J Mills Consulting or their employees that the trees are safe given all conditions. Trees can be managed, but they cannot be controlled. To live work or play near trees is to accept some degree of risk. The only way to eliminate all risk associated with trees is to eliminate all trees.

The comments provided are intended only to offer general information with respect to an overall study of the issues that might affect future development planning for this area of Surrey. No information with respect to the form of development proposed for any of the properties within the study area was provided to us.

Appendix A-2.2 - Abbey Ridge Servicing Reports

Prepared for:

Abbey Ridge Local Area Plan
Sanitary Sewer Servicing Strategy
15 December 2016



McElhanney

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Executive Summary

Project Objective

The redevelopment of Abbey Ridge (located in northeast Surrey) is intended to accommodate the anticipated increase in its residential density. As part of this, the basic sanitary collection system needs to be extended and the available capacity of the Big Bend Trunk Sewer that services the area increased. Sections of the Big Bend Trunk Sewer, which conveys flows from a portion of the Abbey Ridge Local Area Plan (LAP) and the Port Kells Industrial Area, have significant capacity issues that will only worsen as the LAP's build-out occurs. As a result, a sanitary servicing strategy is needed to address these issues.

Servicing Options

During the initial part of the servicing strategy development, McElhanney Consulting Services Ltd (McElhanney) reviewed and evaluated preliminary servicing concepts identified by the City. These concepts included regional pump stations and forcemain options to bypass the Big Bend Truck Sewer and provide capacity relief within the LAP. However, these options had significant capital costs and included infrastructure improvement within neighbouring plan areas.

In addition, the City solicited public feedback at an Open House held on October 18, 2016. Based on the analysis of the existing sanitary system, the required system upgrades to service the LAP based on the proposed Stage 2 Land Use, and feedback from the public open house, the preferred servicing option will incorporate specific sanitary sewer upgrades along the Big Bend Trunk, a new community pump station at 177A Street (required due to the future relocation of the Big Bend Pump Station), a new local pump station to service the eastern portion of the LAP, east of 179 Street, low pressure sewers and local sewer improvements.

Proposed Servicing Strategy

The proposed servicing strategy includes the following components:

- Upgrades to two segments of the Big Bend Trunk Sewer:
    - SMH S-13 to S-14, 70 metres, from existing 750 mm diameter to 900mm diameter
    - SMH S-28 to S-29, 101 metres, from existing 750 mm diameter to 900mm diameter
- New sanitary pump station at 182A Street south of Golden Ears Connector and forcemain connection to the future local sewer at 179 Street and 98 Avenue
- New community pump station at 177A Street servicing a neighbourhood downslope of the Big Bend Trunk Sewer
- New local sewers to service areas not previously serviced or those with on-site sewage disposal systems
- New low pressure sewer systems to service areas downslope of the Big Bend Trunk Sewer.

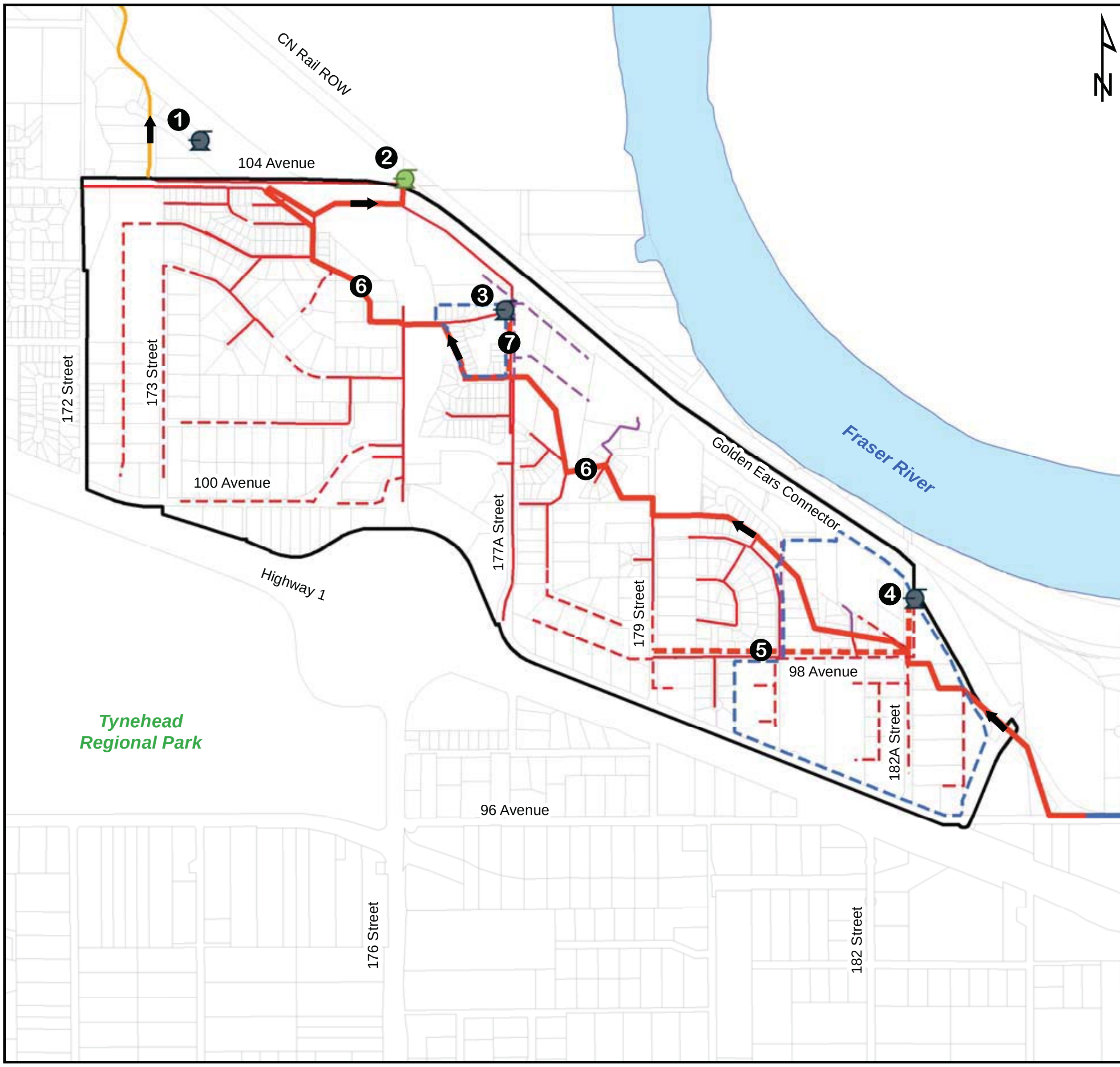
The proposed servicing strategy is shown on *Figure ES-1*.

Summary Cost Estimate

A summary cost estimate for the proposed components of the sanitary servicing strategy, including Sanitary DCC eligible items, is presented in *Table ES-1*. The costs shown in the tables below have been rounded up to the nearest $10,000.00.

Table ES-1: Summary Cost Estimate for Abbey Ridge LAP

Item	DCC Eligible Cost	Non-DCC Eligible Cost
Big Bend Trunk Sewer Upgrades	$610,000	
Pump Station (182A Street) & Forcemain	$1,700,000	
Pump Station (177A Street) & Forcemain		$760,000
Local Sewers	$30,000	$7,200,000
Low Pressure Sewer Systems		$1,840,000
Sub-Total	**$2,340,000**	**$9,800,000**
Total	**$12,140,000**	



Abbey Ridge LAP Sanitary Servicing Concept

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Legend

- Existing PS
- Proposed PS
- Metro Vancouver North Surrey Interceptor
- Existing 500mm Forcemain from Port Kells PS
- Proposed Low Pressure System
- PS Catchment
- Proposed Forcemain
- Proposed Sanitary Sewers
- Big Bend Trunk Sewer
- Abbey Ridge LAP
- Existing Sanitary Sewer
- Existing Low Pressure System

1. Proposed Relocated Big Bend PS
2. Existing Big Bend PS
3. Proposed Community PS
4. Proposed Local PS
5. Proposed 250mm Forcemain
6. Proposed Upgrade to Big Bend Trunk Sewer
7. Proposed 200mm Forcemain

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Project No.	Date
2111-03566-00	2016-09-20

Summary of Proposed Works

Figure ES-1

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1. Introduction

This document describes the existing sanitary infrastructure within the Abbey Ridge LAP, including the Big Bend Trunk Sewer and Pump Station, Port Kells Pump Station, and local sewers. The performance of the existing sanitary system is summarized and key constraints and opportunities are identified.

1.1. Project Background and Objectives

Abbey Ridge, located in northeast Surrey, is bordered by the Fraser River to the northeast, Highway 1 to the south, Golden Ears Way and Golden Ears Connector to the east, 104 Avenue to the north, and 172 Street to the west. Its current redevelopment to accommodate increased residential density requires extending the basic sanitary collection system and increasing available capacity in the Big Bend Trunk Sewer.

This project's objective is to identify the sanitary infrastructure needed to service the planned ultimate land uses within the Abbey Ridge LAP. The recommended servicing strategy shall meet or exceed the requirements of the City's current design guidelines. This document will recommend new infrastructure and upgrades to existing infrastructure.

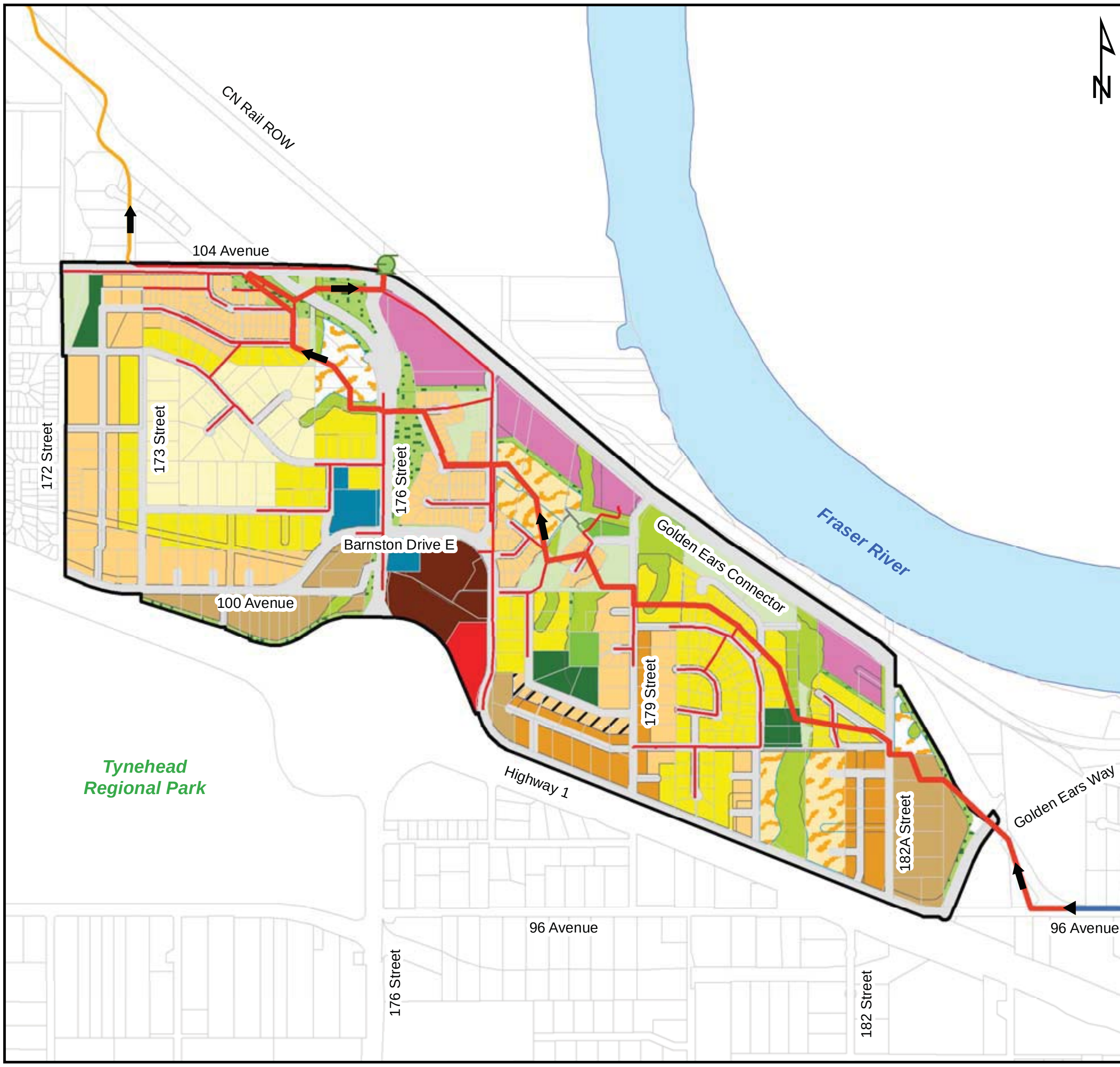
City Council approved the Stage 1 Land Use Concept for the Abbey Ridge LAP in December 2015. As part of the Stage 2 work, the City requires an updated sanitary servicing study, including a phasing and financial strategy. The current Stage 2 Land Use Concept (September 2016) was incorporated during the development of the sanitary servicing strategy presented in this report.

2. Existing Sewer Servicing

The Big Bend Trunk Sewer and Pump Station currently service the Abbey Ridge LAP and Port Kells areas. The major components of the existing sanitary sewer system within the Abbey Ridge LAP consist of:

- Big Bend Pump Station (PS)
- Big Bend Trunk Sewer
- Local sewers, including low pressure sewer systems
- Private on-site sewage systems

An overview of the existing sanitary system within Abbey Ridge and the future land use plan is shown on *Figure 1*.



Abbey Ridge LAP Sanitary Servicing Concept

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Legend

- Abbey Ridge LAP
- Metro Vancouver North Surrey Interceptor
- Existing Big Bend PS
- Big Bend Trunk Sewer
- Existing Sanitary Sewers
- Existing Forcemain from Port Kells

Land Use Plan, Stage 2, Sept 2016

- Acreage Residential 1-2 UPA
- Suburban Residential 2-4 UPA Gross
- Urban Transition 4-5 UPA
- Low Density Cluster 4-6 UPA Gross
- Single Family Residential 4-6 UPA
- Medium Density Cluster 10-12 UPA Gross
- Urban Residential 8-10 UPA
- Low Density Multiple Residential 10-15 UPA Gross
- High Density Multiple Residential 25-30 UPA
- Neighbourhood Commercial
- Industrial
- Institutional
- Existing Natural
- Future Natural
- Existing Neighbourhood Park
- Future Neighbourhood Park
- Landscape Buffer
- Road

McElhanney

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Project No.	Date
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Existing Sanitary Infrastructure & Stage 2 Land Use

Figure 1

2.1. Big Bend Pump Station

The Big Bend Pump Station, located at 176 Street and 104 Avenue, was upgraded in 2009 by replacement of all mechanical piping and pumping equipment as well as installation of a temporary bypass station. The pump station has a current capacity of 170 L/s and consists of a wet well, a dry well with three dry well pumps, electrical equipment and controls housed in a small building, and a generator set in a steel enclosure (*Figure 2).*

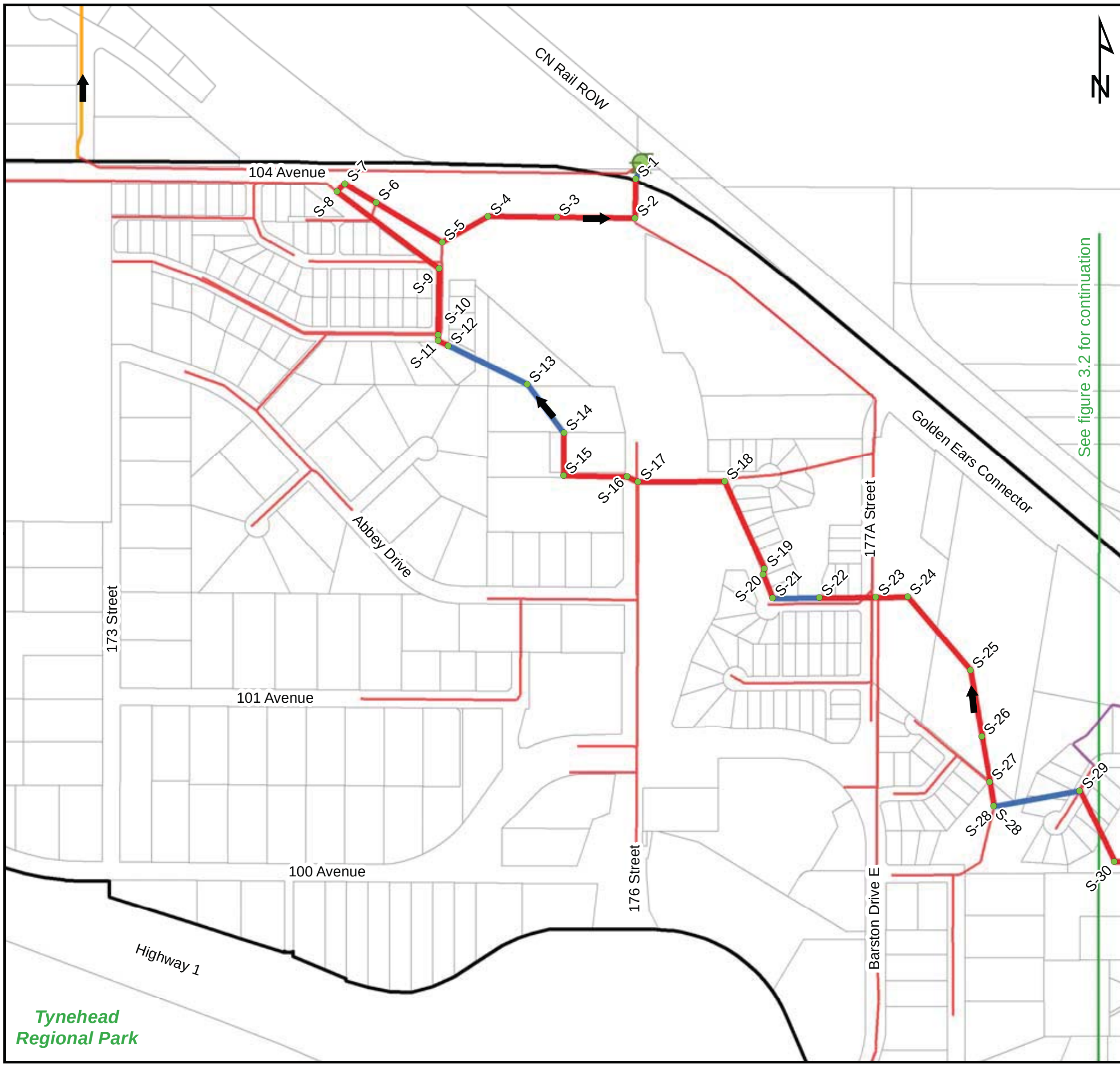
Figure 2: Existing Big Bend Pump Station

The pump station is located at 3 metre geodetic ground elevation. This is within the 200-year floodplain of the Fraser River, which makes it susceptible to flooding during extreme freshet events and a challenge to access and operate. The City has installed temporary flood protection works at the pump station site and has begun developing plans for the relocation and upgrade of the Big Bend Pump Station to ensure its long term operation.

2.2. Big Bend Trunk Sewer

The Big Bend Trunk Sewer was constructed in 1977 and currently consists of 600 mm diameter to 750 mm diameter concrete and plastic (PVC) pipe sections along its 3,200 m length. It conveys sewage to the Big Bend Pump Station, which pumps to Metro Vancouver's NSI sewer. Sewage flows originate from the Port Kells area (east of Abbey Ridge) via a pump station and 1500 m of forcemain. Currently, approximately 36% of the LAP is serviced by the Big Bend Trunk Sewer via local sewer connections. The trunk sewer starts just west of 186 Street along 96 Avenue and travels northwest through the LAP where it connects to the Big Bend Pump Station.

The planned increase in development activity and the need to provide sanitary servicing to lots within the Abbey Ridge LAP, as well as further build out of the Port Kells Industrial Area, will cause significant capacity issues along the existing trunk sewer. *Figures 3.1 and 3.2* identify the existing trunk sewer segments with significant capacity issues based on the full build out of the Abbey Ridge LAP and Port Kells areas.



Abbey Ridge LAP
Sanitary Servicing
Concept

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Legend

- Abbey Ridge LAP
- Metro Vancouver North Surrey Interceptor
- Existing Big Bend PS
- Big Bend Trunk Sewer
- Big Bend Trunk Sewer with Capacity Constraints
- Big Bend Manholes
- Existing Sanitary Sewer
- Existing Low Pressure System
- Matchline

McElhanney

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Project No.	Date
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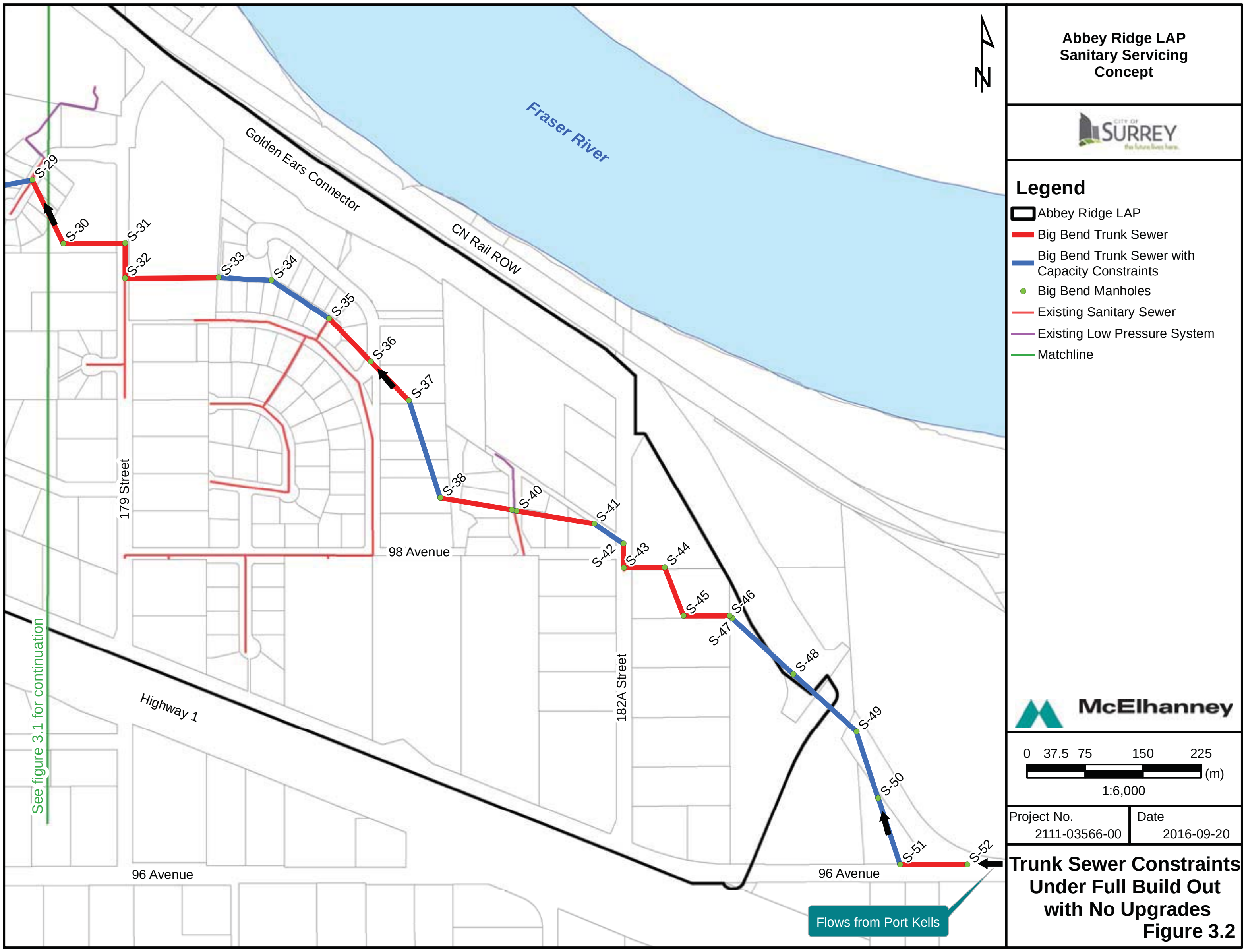
Trunk Sewer Constraints Under Full Build Out with No Upgrades
Figure 3.1


Abbey Ridge LAP
Sanitary Servicing
Concept
SURREY
Legend
Abbey Ridge LAP
Big Bend Trunk Sewer
Big Bend Trunk Sewer with Capacity Constraints
Big Bend Manholes
Existing Sanitary Sewer
Existing Low Pressure System
Matchline
Fraser River
Golden Ears Connector
CN Rail ROW
179 Street
98 Avenue
182A Street
Highway 1
96 Avenue
See figure 3.1 for continuation
Flows from Port Kells
S-29
S-30
S-31
S-32
S-33
S-34
S-35
S-36
S-37
S-38
S-40
S-41
S-42
S-43
S-44
S-45
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Project No.
2111-03566-00
Date
2016-09-20
Trunk Sewer Constraints
Under Full Build Out
with No Upgrades
Figure 3.2

Figure 4 shows the existing sewer catchments and servicing conditions. Although the trunk sewer services the high density areas, there are three areas within the LAP that are not currently serviced by the Big Bend Trunk Sewer:

1. Properties located north (down slope areas) of the Big Bend Trunk Sewer are serviced by individual septic fields. As gravity drainage to the trunk sewer is not feasible, a Low Pressure Sewer system is proposed for these properties
2. Properties located south (up slope areas) of the Big Bend Trunk Sewer catchment are serviced by individual septic fields. Gravity drainage to the trunk sewer can be provided
3. Properties west of 177A Steet and south of the Golden Ears Connector are serviced by a sewer that conveys flow along the Golden Ears Connector / 104 Avenue ROW directly to the Big Bend Pump Station

The sewer subcatchments used in the analysis and development of the servicing strategy are shown on *Figure C1* in *Appendix C*.

2.3. Local Sewers

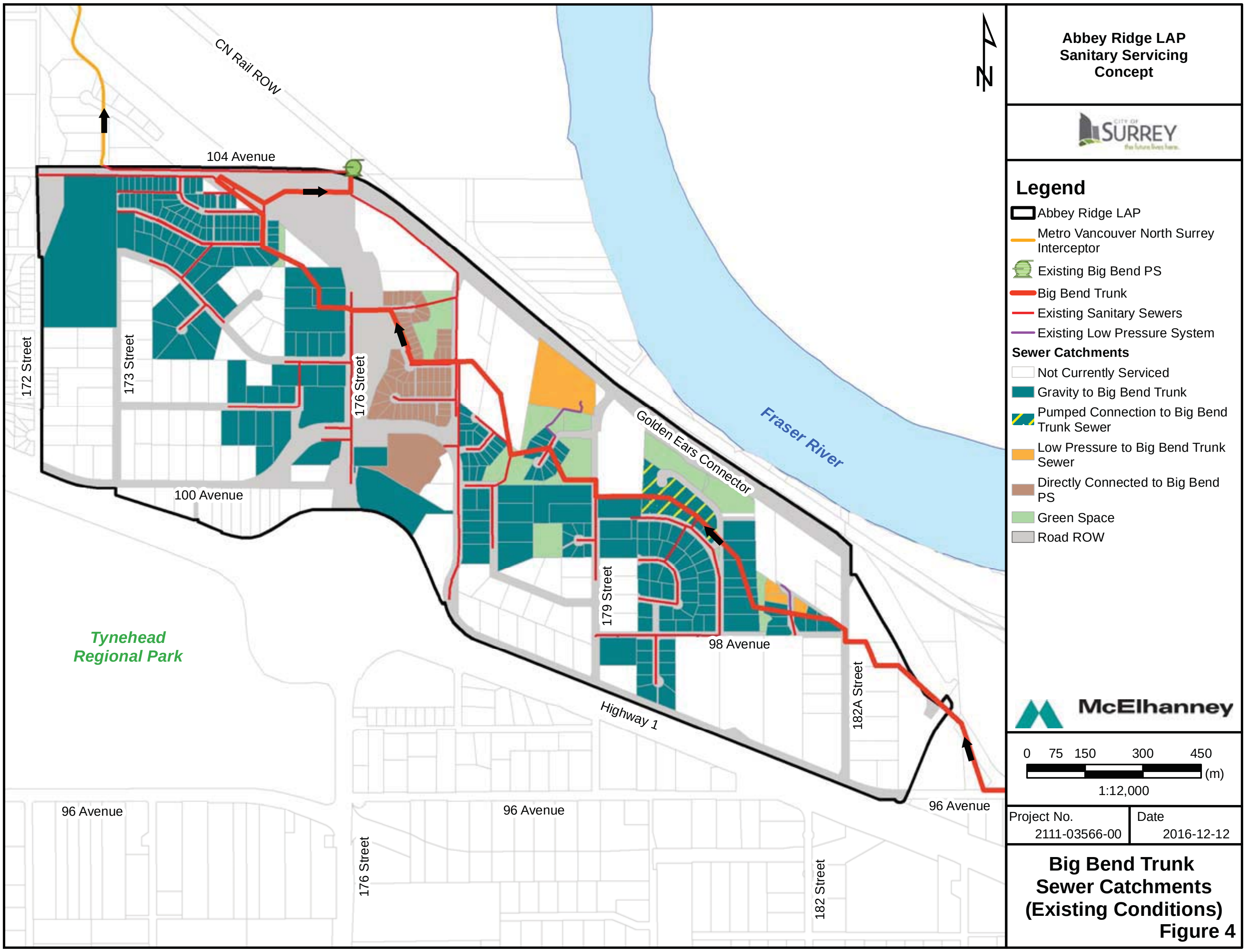
The existing local (collection) sewer system servicing the Abbey Ridge LAP consists of 200mm diameter to 250mm diameter mains that tie into the trunk sewer at several locations along its length. The local sewers are generally comprised of PVC pipe. This system will require expansion to accommodate the ultimate build out, as some areas within the LAP are not currently serviced by sewer (*Figure 4*).

There are several developments planned in the eastern portion of the Abbey Ridge LAP, east of 179 Street. In this area, there are several sections of the Big Bend Trunk Sewer that do not have sufficient capacity to accept additional sewage flows from these developments; therefore, to efficiently service this area, a new local pump station will be required with a forcemain connection to the Big Bend Trunk Sewer at 179 Street, downstream of the constrained trunk sewer segments. Further details of this proposed infrastructure is provided in Section 4.

In addition to the existing local gravity sewers, there are two areas currently serviced by low pressure sewers connected to the Big Bend Trunk Sewer, specifically:

- Three homes (9838, 9855, 9869) along 182 Street north of the trunk sewer
- The industrial development located at 10095 179 Street north of Barnston Park

There are also a small number of lots that have pumped service connections directly to the Big Bend Trunk Sewer.



Abbey Ridge LAP
Sanitary Servicing
Concept
SURREY
the future lives here.
Legend
Abbey Ridge LAP
Metro Vancouver North Surrey Interceptor
Existing Big Bend PS
Big Bend Trunk
Existing Sanitary Sewers
Existing Low Pressure System
Sewer Catchments
Not Currently Serviced
Gravity to Big Bend Trunk
Pumped Connection to Big Bend Trunk Sewer
Low Pressure to Big Bend Trunk Sewer
Directly Connected to Big Bend PS
Green Space
Road ROW
McElhanney
0 75 150 300 450
(m)
1:12,000
Project No.
2111-03566-00
Date
2016-12-12
Big Bend Trunk
Sewer Catchments
(Existing Conditions)
Figure 4
N
CN Rail ROW
104 Avenue
172 Street
173 Street
176 Street
100 Avenue
Golden Ears Connector
Fraser River
179 Street
98 Avenue
182A Street
Highway 1
Tynehead
Regional Park
96 Avenue
96 Avenue
96 Avenue
176 Street
182 Street

2.4. Private On-Site Sewage Systems

Private on-site sewage systems are located on properties to the north and south of the Big Bend Trunk Sewer catchment. Properties to the north (down slope) cannot drain by gravity to the trunk sewer and will require an alternate servicing strategy. Properties to the south (up slope) can be serviced by gravity sewers connected to the trunk sewer.

The City has indicated that the properties north of the trunk sewer that are currently serviced by individual septic fields may be serviced by a low pressure sewer system and routed to the Big Bend Pump Station via the Big Bend Trunk Sewer. Potential upgrades to the Big Bend Pump Station will need to take into account the additional sewage flows from these properties.

2.5. Port Kells Industrial Area

The Port Kells Pump Station and forcemain services the Port Kells Industrial Area, which is located east of the Abbey Ridge LAP area. The forcemain connects to the Big Bend Trunk Sewer along 96 Avenue, west of 186 Street.

Since the Port Kells Industrial Area has not reached its full development potential, sewage flows from the Port Kells area were estimated based on zoning and areas obtained from the City's online mapping system (COSMOS and Open Data Surrey). Population and design flow estimates for Port Kells are provided in *Section 3.3*.

The City is considering diverting flows from the Port Kells area directly to Metro Vancouver's NSI to provide additional capacity within the Big Bend Trunk Sewer to support further development within the LAP. Initial discussions have been conducted with Metro Vancouver but an agreed upon strategy for this future diversion is currently not in place. In addition, the costs of these upgrades, which would include a new pump station and sanitary forcemain, are estimated to be close to $9 million. This option did not provide a reasonable cost structure for the property owners within the Abbey Ridge LAP.

2.6. Consultation with Metro Vancouver

As the Big Bend Pump Station conveys sewage to the NSI, a stakeholder consultation meeting with Metro Vancouver was conducted on April 11, 2016. This introduced the Abbey Ridge LAP and involved reviewing Metro Vancouver's short- and long-term regional plans for sanitary servicing near the study area. Key outcomes are summarized as follows:

- Metro Vancouver confirmed their intention to make the existing Northwest Langley Wastewater Treatment Plant (NWLWWTP) into a regional facility by expanding its servicing area, including possibly redirecting flow to the plant from the NSI system. This would relieve pressure on the Annacis Island Wastewater Treatment Plant. The overall timing for this is approximately 7 to 10 years.
- Metro Vancouver is currently completing the 104 Avenue Sewer Extension Project as part of their NSI improvements. Scheduled for completion by the end of 2016, this section of the NSI consists of a 1050mm diameter sewer that will increase capacity to approximately 1,100 l/s. Metro Vancouver has indicated that there will be sufficient capacity to accommodate additional flows from the build out of the Abbey Ridge LAP in their upgraded system (see *Appendix B*).

3. Design Criteria and Analysis

3.1. Design Criteria

Several City documents were reviewed to support the existing infrastructure analysis and preliminary design of the proposed options. These documents were:

- *Design Criteria Manual* (January 2016)
- *Guideline for the Design & Construction of Sanitary Sewage Pumping Stations* (July 1998)

A summary of the pertinent criteria from both documents is provided in *Table 1*.

Table 1: Summary of Pertinent Design Criteria

Property	Design Criterion
Average Dry Weather Flow (ADWF)	350 Litres/capita/day
Peaking Factor	Harman equation
Infiltration and Inflow	11,200 Litres/hectare/day
Population Densities	Section 2.3.1, which includes Tables 2.3.1 and 2.3.2, of the City's *Design Criteria Manual*
Forcemain Velocity (recommended)	1.0 – 1.8 m/s
Minimum Proposed Gravity Sewer Velocity	0.6 m/s, assessed at 70% of Peak Dry Weather Flow (PDWF) for pipes with grade less than 0.5%
Maximum Proposed Gravity Trunk Sewer Flow Depth (where Q ≥ 40 l/s)	70% of internal diameter (during PWWF)
Capacity of Existing Trunk Sewers to Convey the PWWF (where Q ≥ 40 l/s)	0.837 * Q_{cap} (Q_{cap} is defined as the Manning's capacity of the pipe)
Minimum Low Pressure Sewage Forcemain Size	50 mm ID
Maximum operating TDH for Low Pressure Forcemains	35 m
Minimum Velocity in Low Pressure Forcemains	0.6 m/s
Low Pressure Design Flow	Q (Lps) = 0.008 * Population + 2.10

3.2. Analysis Methodology

Flow estimates were obtained by following the City's *Design Criteria Manual*. The population was calculated differently for residential and non-residential areas (see *Tables C1, C2* and *C3* in *Appendix C* for summary):

- Residential population was calculated by multiplying the area of a particular zoning by the units-per-area (as given in the land use plan provided by the City) and by the people-per-units (as found in Table 2.3.2 in the City's *Design Criteria Manual* – including secondary suites).
- Non-residential population equivalent was calculated by multiplying the area of a particular zoning by population densities found in Table 2.3.1 in the City's *Design Criteria Manual.*

A peaking factor was used to determine flows when assessing the hydraulic performance of the Big Bend Trunk Sewer under the "do nothing" scenario.

ADWF, PDWF, and PWWF were estimated based on the criteria listed above. *Table C1* is for existing sanitary system geometry and land use, *Table C2* is for existing sanitary system geometry and the future Stage 2 land use, and *Table C3* is for the proposed servicing conditions. A sanitary sewer control plan was developed, which included further discretization of sanitary catchments, to assess pipe capacities along the existing trunk sewer. Sewer capacity was calculated as 83.7% of the conduit's hydraulic capacity at full bore (when the flow in the pipe is flowing full or 100% of the pipe) and then compared to the PWWF to determine which pipes will be under capacity at ultimate build out.

Sewage flow contributions from the Port Kells Industrial Area were assessed based on zoning and areas obtained from the City's online mapping system (COSMOS and Open Data Surrey). Although a review of the land use plan for the Port Kells area identified a 1.1 ha portion of detached residential land (RA), it will most likely be developed as industrial land, similar to surrounding properties. Therefore, secondary suites were not included in the Port Kells population estimates. Population estimates were based on Tables 2.3.1 and 2.3.2 of the City's *Design Criteria Manual,* as described above*.* The ADWF, PDWF, and PWWF rates were calculated based on the criteria above and are summarized in *Section 3.3.*

3.3. Design Flows

Table 2 presents the design flows used in assessing existing infrastructure, as well as preliminary design of the proposed options.

Table 2: Design Flows

Area	Population *	Land Area (ha)	ADWF (L/s)	PDWF (L/s)	PWWF (L/s)
Abbey Ridge	8,334	106**	33.8	102	116
Port Kells	22,021	245**	89.2	233	265
Abbey Ridge and Port Kells	30,343	351**	221	289	303

* Inclusive of secondary suites where applicable

** Includes developable land only in Abbey Ridge as per the Stage 2 Land Use Plan (September 2016)

The City determined a theoretical peak flow of 187 Lps for the Port Kells Pump Station. This static value was used in the detailed flow calculations for the Big Bend Trunk Sewer and the flow estimations for "Abbey Ridge and Port Kells" above.

3.4. Review of Potential Servicing Options

The following initial servicing options were identified and evaluated for the Abbey Ridge LAP:

- Option 1: Upgrade or twin portions of the Big Bend Trunk Sewer
- Option 2: Divert flows from Port Kells to the NSI
- Option 3: Divert flows from Port Kells to the Northwest Langley Wastewater Treatment Plant

Each servicing option was evaluated based on the following criteria:

- Capital costs
- Operations and maintenance considerations
- Constructability
- Property and public impacts
- Level of coordination with outside agencies and approvals

The draft technical memorandum in *Appendix A* summarizes the evaluation. Based on this evaluation Options 1 and 2 had the lowest estimated (Class D) capital costs; however, all three options did not provide a reasonable cost structure for the residents within the Abbey Ridge LAP, as the costs of all three options were between $16 million to $19 million.

Based on these findings and subsequent feedback from the Open House held on October 18, 2016, the City identified the following components of the proposed servicing strategy:

- Construct a new Big Bend Pump Station outside of the 200-year floodplain (initiated by the City independently from this servicing strategy)
- Upgrade two key sections of the Big Bend Trunk Sewer that are currently undersized
- Construct a local pump station at 182A Street and forcemain to provide service to the eastern portion of the LAP
- Construct community pump station at 177A Street
- Construct additional local sewers to provide service to all neighbourhoods with the LAP

The following section provides descriptions for each component of the proposed sanitary servicing system.

4. Proposed System

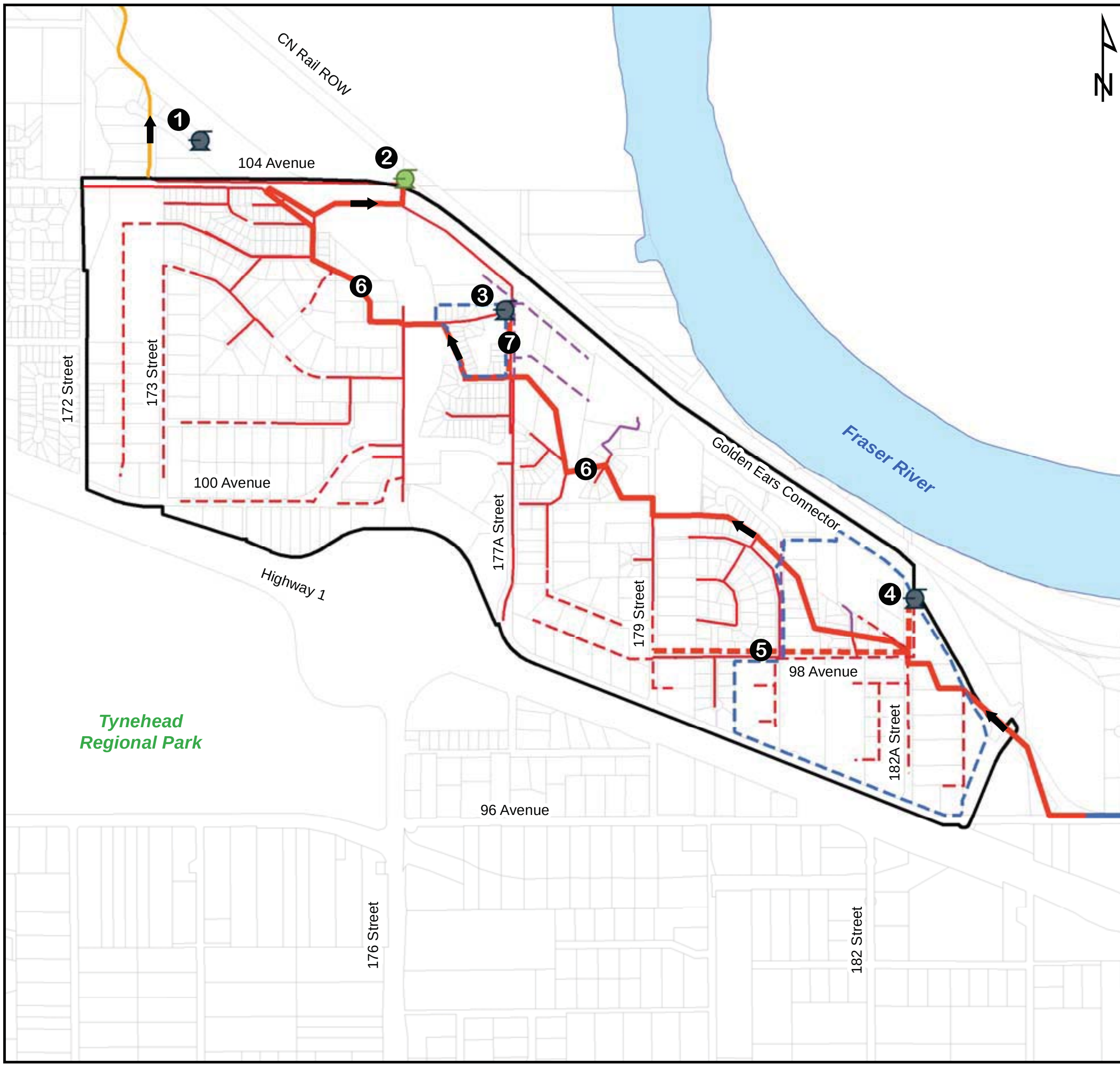
The proposed servicing strategy for the Abbey Ridge LAP is to continue operating the existing Big Bend Trunk Sewer and provide local sewer service to each property within the LAP area.

The proposed servicing strategy for the Abbey Ridge LAP consists of the following infrastructure components:

- **Big Bend Trunk Sewer**
  - Keep the existing trunk sewer in service and connect it to the new Big Bend Pump Station. Upgrade two constrained sections of the trunk sewer.
- **Big Bend Pump Station**
  - A new pump station, to be located outside the 200-year floodplain, is currently in the planning and design stage. Route sewer connections from the existing pump station to this new location
- **New Local Pump Station and Forcemain for East Abbey Ridge**
  - A new pump station, to be located at 182A Street to service the eastern portion of the LAP, including a new forcemain connection to the future local sewer at 179 Street and 98 Avenue, connecting to the Big Bend Trunk Sewer
- **New Community Pump Station at 177A Street**
  - Service a neighbourhood located north of the Big Bend Trunk Sewer between 177 Street and 177A Street via a community pump station connected to the trunk sewer
- **Local Sewers**
  - Service additional areas in the LAP by connecting local sewers to the Big Bend Trunk Sewer
  - Service several areas north of the Big Bend Trunk Sewer with new low pressure sewers connected to the trunk sewer, in addition to the two areas already serviced by low pressure sewers

Figure 5 presents an overview of all proposed sanitary works.

This proposed strategy will provide sanitary service to all areas of the Abbey Ridge LAP. The following sections detail the sanitary system components.



Abbey Ridge LAP
Sanitary Servicing
Concept

CITY OF SURREY
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Legend

- Existing PS
- Proposed PS
- Metro Vancouver North Surrey Interceptor
- Existing 500mm Forcemain from Port Kells PS
- Proposed Low Pressure System
- PS Catchment
- Proposed Forcemain
- Proposed Sanitary Sewers
- Big Bend Trunk Sewer
- Abbey Ridge LAP
- Existing Sanitary Sewer
- Existing Low Pressure System

1. Proposed Relocated Big Bend PS
2. Existing Big Bend PS
3. Proposed Community PS
4. Proposed Local PS
5. Proposed 250mm Forcemain
6. Proposed Upgrade to Big Bend Trunk Sewer
7. Proposed 200mm Forcemain

McElhanney

0 80 160 320 480 (m)

1:13,150

Project No.	Date
2111-03566-00	2016-09-20

Summary of
Proposed Works

Figure 5

4.1. Big Bend Trunk Sewer

The Big Bend Trunk Sewer will continue to service the Abbey Ridge LAP area as it develops. *Figure 6* shows the proposed catchment areas and sanitary sewer network for the Big Bend Trunk Sewer. *Tables C4, C5,* and *C6* in *Appendix C* summarize the design sewer flows within the Big Bend Trunk Sewer under existing and proposed conditions, specifically:

- *Table C4 -* existing infrastructure with existing land use
- *Table C5 -* existing infrastructure with full build out as per the Stage 2 land use
- *Table C6 -* proposed infrastructure with full build out as per the Stage 2 land use

The analysis of the existing Big Bend Trunk Sewer under existing land use identified seven out of 52 pipe segments with capacity constraints based on the City's Design Criteria to convey the PWWF. Under Stage 2 land use, 15 of 52 pipe segments were "over capacity". Depending on where future development is occurring within the Abbey Ridge LAP, there is some capacity within the Big Bend Trunk Sewer to accept sewage flows north of 103A Avenue (S-12) and between 100A Avenue to the 176 Street Frontage Road (S-28 to S-22). Potential sewage flows from proposed development within this area were estimated based on the Stage 2 Land Use and were used in the analysis of the Big Bend Trunk Sewer.

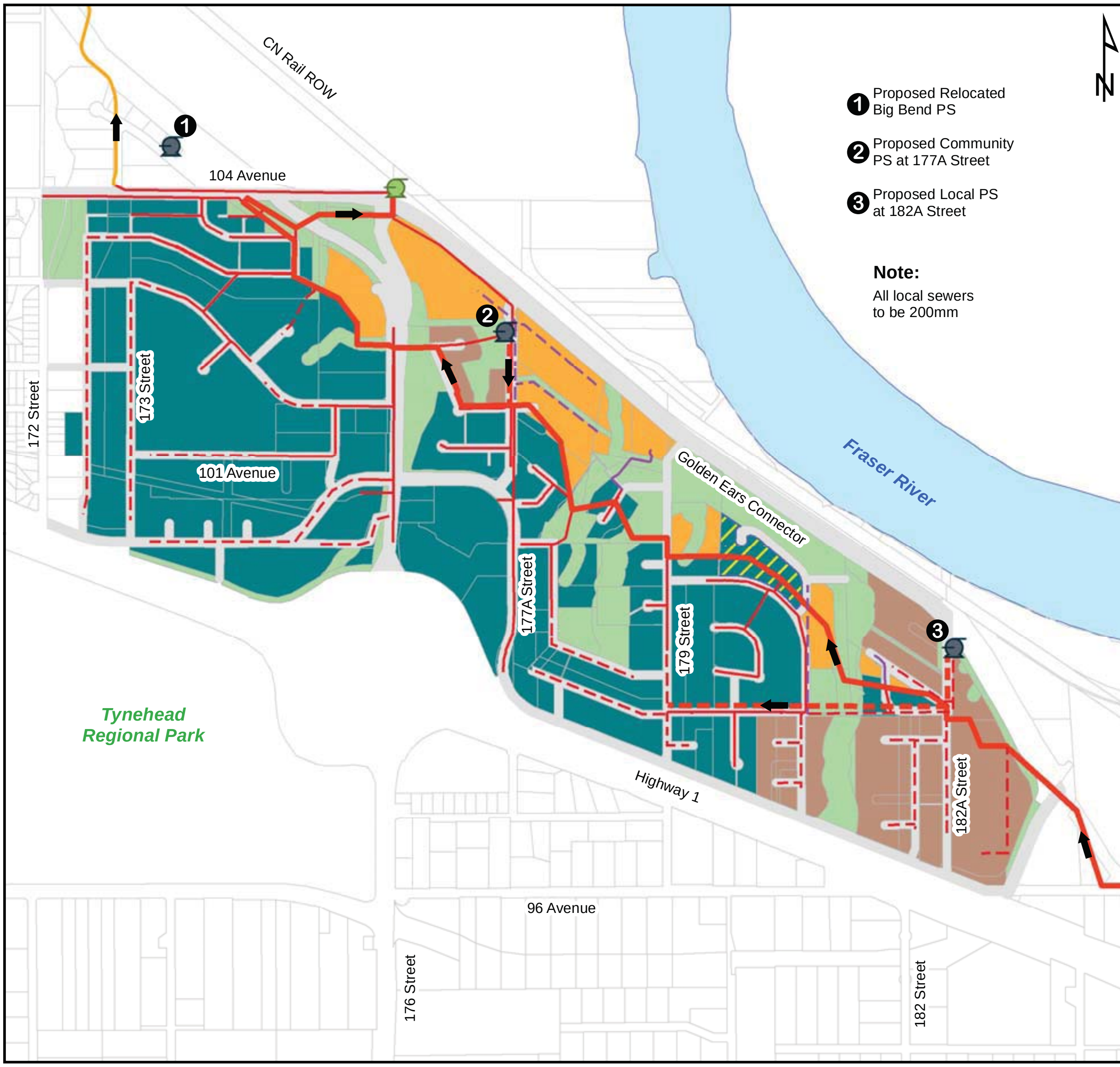
Structural lining of the trunk sewer may become necessary if the pipe material degrades in difficult to access locations.

With the proposed local pump station at 182A Street, only two sections of the trunk sewer will be upgraded to alleviate flow constraints during full build-out conditions, specifically:

- SMH S-13 to S-14, 70 metres, from existing 750 mm diameter to 900mm diameter
- SMH S-28 to S-29, 101 metres, from existing 750 mm diameter to 900mm diameter

The first section is from manhole S-13 to manhole S-14. It is located within a 3m ROW on private property (*Figure 7*). The sewer is 750mm in diameter and 70m long and is almost entirely within 10267 176 Street. The upstream manhole is located just inside 10245 176 Street and the downstream manhole is located just inside an unaddressed private property on the north side of 10267 176 Street. The sewer would have a flow ratio of 1.08 under full build-out conditions (0.837 is maximum allowed by the City's Design Criteria. The sewer will be replaced by a 900mm diameter sewer by matching inverts and will reduce the flow ratio to 0.66. The upgrade will be completed by standard cut and cover methods, requiring a 5m ROW as per the City of Surrey's Design Criteria. An additional 600m^2 of ROW will be acquired to provide a 5m ROW along the length of the sewer being upgraded and for access to the manholes. ROW acquisition costs are included in the cost estimates prepared (*Section 5*).

The second section is from manhole S-28 to manhole S-29. The sewer is 750mm in diameter, 101m in length, and is located within a ROW that crosses private and public property (*Figure 8*). It originates in the 100A Street ROW and crosses 17845 100A Avenue and 17833 100A Avenue before terminating in City-owned park land. The sewer would have a flow ratio of 1.06 under full build-out conditions. The sewer will be replaced by a 900mm diameter sewer by matching inverts, reducing the flow ratio to 0.65. The upgrade will be completed by standard cut and cover methods which requires a 5m ROW. There is an existing 3m wide ROW across the two private properties and a 5m ROW across the park land. There is also an existing 5m ROW across park land and 17786 100A Street to provide access to the downstream manhole. An additional 110m^2 of ROW will be acquired to provide a 5m wide ROW along the length of the sewer. The upstream manhole is located within the 100A Street ROW. In addition, the sewer will be crossing an creek and will needed encasement (similar to the existing pipe segment). Coordination with environmental requirements will also be needed.



Abbey Ridge LAP
Sanitary Servicing
Concept

SURREY

Legend

- Existing PS
- Proposed PS
- Metro Vancouver North Surrey Interceptor
- Proposed Low Pressure System
- Proposed Forcemain
- Proposed Sanitary Sewers
- Big Bend Trunk Sewer
- Existing Low Pressure System
- Existing Sanitary Sewers

Big Bend Trunk Sewer Catchments

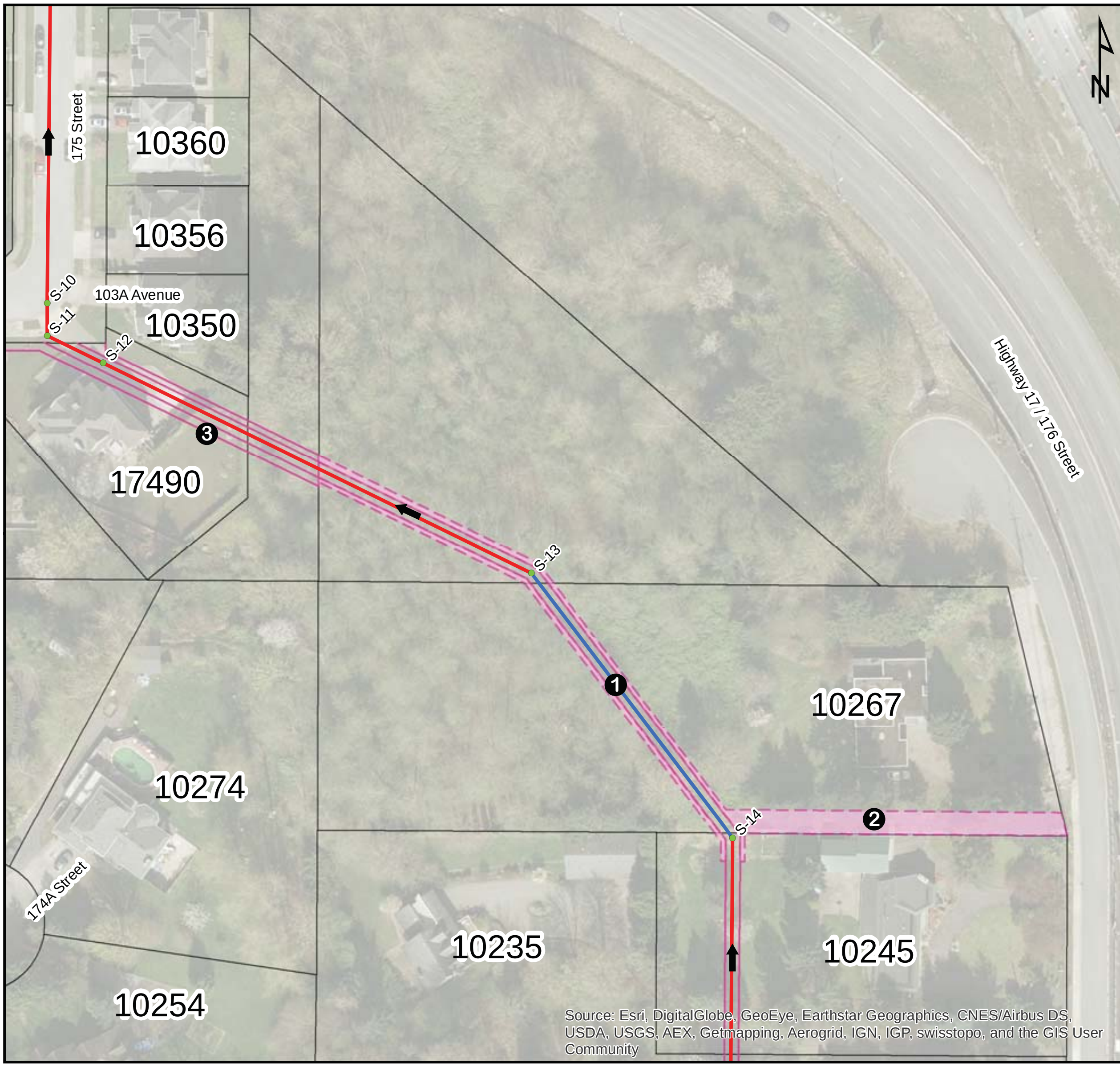
- Gravity Connection
- Pumped Connection
- Low Pressure System
- Community/Local PS
- Green Space
- Road ROW

McElhanney

0 75 150 300 450 (m)
1:12,000

Project No.	Date
2111-03566-00	2016-12-12

Proposed Catchment Areas and Local Sewer Network
Figure 6



Abbey Ridge LAP Sanitary Servicing Concept

SURREY
the future lives here.

Legend

- Big Bend Trunk Sewer
- Big Bend Trunk Sewer with Capacity Constraints
- Big Bend Manholes
- Proposed ROW
- Existing ROW

1 Replace 70m of Existing 750mm Dia Sewer with 900mm Dia Sewer

2 Proposed 600sq m ROW

3 Existing 5m wide ROW

McElhanney

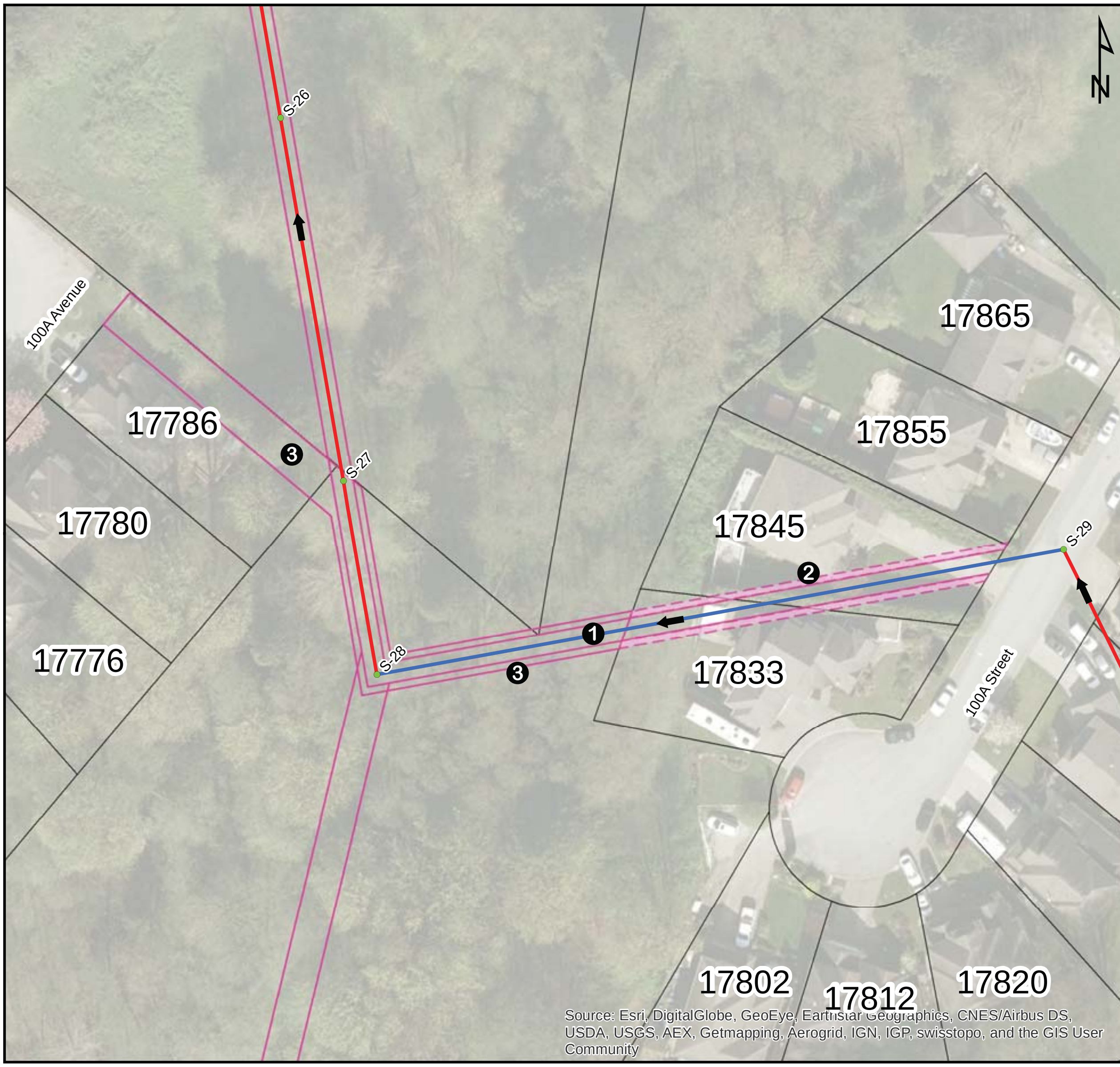
0 5 10 20 30 (m)

1:1,100

Project No.	Date
2111-03566-00	2016-12-12

Big Bend Trunk Sewer Upgrade Section 1

Figure 7



Abbey Ridge LAP
Sanitary Servicing
Concept

SURREY
the future lives here.

Legend

- Big Bend Trunk Sewer
- Big Bend Trunk Sewer with Capacity Constraints
- Big Bend Manholes
- Proposed ROW
- Existing ROW

1. Replace 101m of Existing 750mm Dia Sewer with 900mm Dia Sewer
2. Proposed 110sq m ROW
3. Existing 5m wide ROW

McElhanney

0 4.75 9.5 19 28.5 (m)

1:750

Project No.	Date
2111-03566-00	2016-12-12

Big Bend Trunk Sewer Upgrades Section 2

Figure 8

4.2. Big Bend Pump Station

The City is currently in the planning and design stage for the relocation of the Big Bend Pump Station to approximately 530m west on 104A Avenue and upgrading it to accommodate the full buildout sewage flows of the Abbey Ridge LAP and Port Kells areas. The new location secured by the City was included in the analysis and development of the area servicing strategy.

4.3. Local Pump Station and Forcemain

The servicing strategy for the east portion of Abbey Ridge (*Figure 9*) includes four components that will allow flow to bypass sections of the Big Bend Trunk Sewer that would have capacity constraints under full build out conditions. The components are discussed below from upstream to downstream.

4.3.1. Local Gravity Sewer

The catchment that will ultimately be serviced by this infrastructure is 17.8 ha of residential and industrial land. This land will have a full build out population of 2,131 which will produce a PWWF of 33 Lps. The calculations are further detailed in *Appendix C*. All existing low pressure systems will remain connected to the Big Bend Trunk Sewer.

The longest length of gravity sewer will consist of 550m of 200mm diameter sewer and 150m of 250mm diameter sewer. This pipe will be laid at approximately 3% slope along 98 Avenue and 182A Street. This pipe will cross Leoran Brook and will be hung from a future crossing bridge. There is sufficient grade upstream and downstream of this crossing that it will not be a major challenge to cross the sewer above the design flood level of Leoran Brook and return it to a suitable depth on the far side.

4.3.2. Pump Station

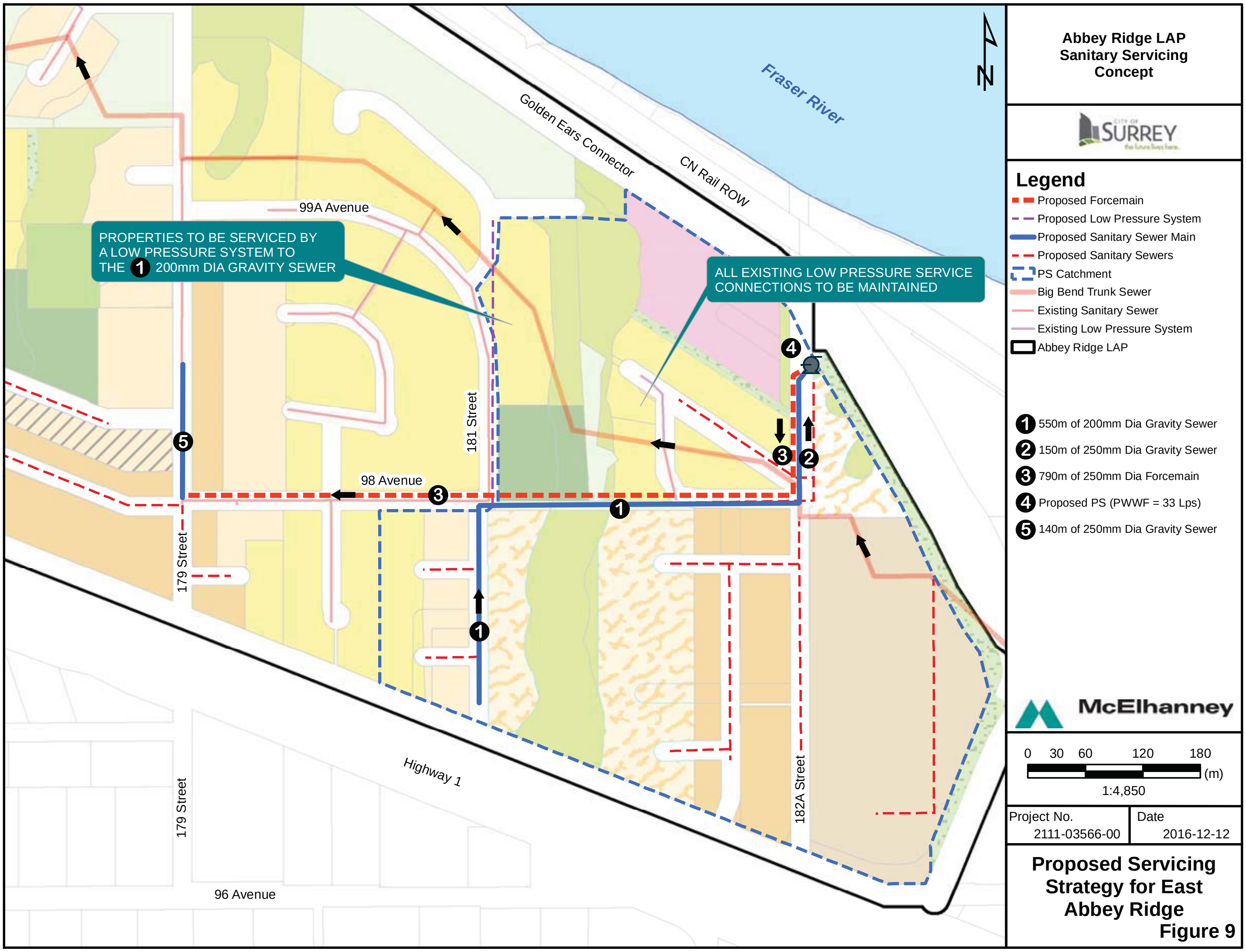
The pump station will be located in the east boulevard of 182A Street just south of Golden Ears Connector. There is approximately 580m^2 of land available in this area. This area looks to be part of road ROW for Golden Ears Connector, therefore coordination with the BC MoTI may be required. The proposed duplex pump station has a design flow of 33 Lps and have a wet well between 3-4 metres in diameter. It is expect that this would be an underground unit with an external controls cabinet.

4.3.3. Forcemain

Flow will be pumped through 790m of 200mm diameter forcemain that will be installed along 182A Street 98 Avenue to tie into a local gravity sewer at 179 Street. This forcemain will also cross Leoran Brook and will have to be suspended from the underside of the bridge above the design flood level in the Brook.

4.3.4. Downstream Connection to Big Bend Trunk Sewer

The forcemain will discharge into a manhole at 179 Street and 98 Avenue where flow will be conveyed to an existing gravity sewer via 140m of 250mm diameter sewer installed at a minimum slope of 3%. This flow will enter the Big Bend Trunk Sewer just north of the intersection of 99A Avenue and 179 Street in manhole S-32.



Fraser River
Golden Ears Connector
CN Rail ROW
99A Avenue
98 Avenue
181 Street
179 Street
182A Street
Highway 1
96 Avenue
PROPERTIES TO BE SERVICED BY A LOW PRESSURE SYSTEM TO THE 1 200mm DIA GRAVITY SEWER
ALL EXISTING LOW PRESSURE SERVICE CONNECTIONS TO BE MAINTAINED
Abbey Ridge LAP Sanitary Servicing Concept
SURREY the future lives here.
Legend
Proposed Forcemain
Proposed Low Pressure System
Proposed Sanitary Sewer Main
Proposed Sanitary Sewers
PS Catchment
Big Bend Trunk Sewer
Existing Sanitary Sewer
Existing Low Pressure System
Abbey Ridge LAP
1 550m of 200mm Dia Gravity Sewer
2 150m of 250mm Dia Gravity Sewer
3 790m of 250mm Dia Forcemain
4 Proposed PS (PWWF = 33 Lps)
5 140m of 250mm Dia Gravity Sewer
McElhanney
0 30 60 120 180 (m)
1:4,850
Project No. 2111-03566-00
Date 2016-12-12
Proposed Servicing Strategy for East Abbey Ridge
Figure 9

The existing gravity sewer on 179 Street is 200mm diameter with a minimum slope of 4.1%. This will convey 36 Lps when the pipe is half full (depth of flow is 100mm). This is compliant with the City of Surrey Design Criteria.

4.4. Local Sewers and Community Pump Station

Additional local sewers will be required as Abbey Ridge experiences further build out. These sewers are proposed to be 200mm in diameter. Subcatchment areas and detailed calculations are shown in *Appendix C*.

Several properties north of 99A Avenue and west of 181 Street will continue to have individual pumped service connections.

Figure 6 identifies several areas of developable lands that will require servicing by a low pressure sewer system. Additionally, several properties will continue to be serviced by low pressure serer systems that convey flows to the Big Bend Trunk Sewer, including:

1. 10095 179 Street located west of 179 Street and south of Golden Ears Connector.
2. 9838, 9855, and 9869 182 Street located near the intersection of 182 Street and Parsons Drive

With the relocation of the Big Bend Pump Station, the existing local sewer along Golden Ears Connector between 177A Street and 176 Street that directly connects to the Big Bend Pump Station will be abandoned. Properties that currently are directly connected to the Big Bend Pump Station (see *Figure 4*) via this local sewer will be serviced by the Big Bend Trunk Sewer in one of two ways:

1. Properties south (up slope) of the Big Bend Trunk Sewer will drain by gravity to the trunk sewer.
2. Properties north (down slope) of the Big Bend Trunk Sewer will drain by gravity to a community pump station located on 177A Street where flows will be pumped up to the trunk sewer via a 100mm forcemain.

5. Costs and Financing

5.1. Summary Cost Estimate

A summary cost estimate for the proposed components of the sanitary servicing strategy is presented in the *Table 3*. Development Cost Charges (DCC) calculations are provided in *Appendix D*. The values shown in *Table 3* have been rounded up to the nearest $10,000.00.

Table 3: Summary Cost Estimate

Item	DCC Eligible Cost	Non-DCC Eligible Cost
Big Bend Trunk Sewer Upgrades	$610,000	
Pump Station (182A Street) & Forcemain	$1,700,000	
Pump Station (177A Street) & Forcemain		$760,000
Local Sewers	$30,000	$7,200,000
Low Pressure Sewer Systems		$1,840,000
Sub-Total	**$2,340,000**	**$9,800,000**
Total	**$12,140,000**	

It should be noted that this financial summary is subject to fluctuations in market conditions related to rate of development and capital construction costs, ultimate development form and densities, and other variables that may alter projected DCC revenues and/or expenditures.

5.2. Projected Sanitary DCC Revenue

As the City of Surrey will calculate revenue from DCCs, detailed calculations are excluded from this report.

5.3. Projected Sanitary DCC Expenditures

Sanitary DCC expenditures benefitting Abbey Ridge consists of the upgrades of the existing Big Bend Trunk Sewer, the new local pump station at 182A Street and its forcemain, and the upsize costs for the 250mm diameter gravity sewer servicing the eastern portion of the Abbey Ridge LAP. The construction cost estimates provided include an estimate of engineering and contingencies based on the following:

- Sewer improvements (i.e. piping and associated structures)
    - Engineering, 12%
    - Contingency, 15% (20% for forcemains)
- Pump stations
    - Engineering, 15%
    - Contingency, 30%

All construction costs are based on current (2016) construction cost data and do not include applicable taxes such as GST.

Table 4 presents an itemized list of Sanitary DCC Eligible Sanitary Works for Abbey Ridge. Total costs shown in the table below are rounded to the nearest $5,000.00.

Table 4: DCC Eligible Sanitary Works

Item	Unit	Unit Price	Quantity	Total	Comment
Big Bend Trunk Sewer Upgrades					
Segment 1: S-13 to S-14, 900mm dia	m	$1,898	70	$135,000	Unit rate based on City data, 0.75x “raw” land factor applied to $2,530 unit rate
Segment 2: S-28 to S-29, 900mm dia	m	$2,530	120	$255,000	Unit rate based on City data
Easement, 5m, S-13 to S-14	m^2	$242	600	$145,000	Land costs provided by the City
Easement, 5m, S-28 to S-29	m^2	464	110	$55,000	Land costs provided by the City
Working easement year rental	m^2	$17	1200	$20,000	Land costs provided by the City
Local Pump Station (182A Street) and Forcemain					
Pump station, 33 Lps	ea	$1,000,000	1	$1,000,000	Includes 15% Eng and 30% contingency
Forcemain, 200mm dia. HDPE	m	880	790	$700,000	Land costs provided by the City
Local Sewers, 250mm from 200mm upsize					
Difference in pricing from 200mm to 250mm	m	$100	300	$30,000	Includes 15% Eng and 20% contingency
Total				**$2,340,000**	

Appendix A – Technical Memorandum: Existing Conditions Summary, May 19, 2016

McElhanney

Technical Memo

McElhanney

TO	FROM
May Petretta, PEng, Project Engineer Samantha Ward, PEng, Project Engineer	Michael Florendo, PEng, Sr Engineer, MCSL Nav Sandhu, PEng, Project Manager, MCSL
COMPANY	**MCSL BRANCH**
City of Surrey	2111 – Surrey
RE	**DATE**
Sanitary Servicing Strategy for the Abbey Ridge Local Area Plan Area: Existing Conditions Summary - DRAFT Surrey Sanitary Project No. 4716-7020-00	May 19, 2016 **FILE NUMBER** 2111-03566-00

1. Introduction

McElhanney Consulting Service Ltd. (MCSL) has been retained by the City of Surrey (City) to review sanitary servicing options and constraints for the Abbey Ridge Local Area Plan (LAP) and develop a conceptual design for sewer system upgrades, including a phasing and financial strategy.

This technical memorandum describes the existing sanitary servicing conditions within the Abbey Ridge plan area, including the existing sewer collection and conveyance infrastructure, a listing of the background information collected and reviewed, and results of a preliminary assessment of the existing Big Bend Trunk Sewer (trunk sewer). We will also identify and compare various servicing options, including constraints of each option with order of magnitude cost estimates.

The information presented in this technical memorandum will be incorporated into the Sanitary Servicing Report that we will prepare for this assignment.

2. Project Background and Objectives

Abbey Ridge is being developed to higher residential density. City Council approved the Stage 1 Land Use Concept for the Abbey Ridge Local Area Plan (LAP) in December 2015. As part of the Stage 2 work, the City requires an updated sanitary servicing study, including a phasing and financial strategy.

A significant amount of assessment and concept design work has already been completed on the existing sanitary sewer network within this area, including preliminary servicing options and conceptual upgrades to various sanitary sewer facilities such as the Big Bend Pump Station (Big Bend PS) and trunk sewer. Now that the Stage 1 Land Use Concept has been approved, a thorough review of the existing work, servicing options, and constraints is required for incorporation into the future servicing strategy.

The City has already identified various servicing options to address sewer capacity constraints as well as provision of services to properties currently on private systems. These options will be reviewed against the City's design and operational requirements to develop the overall servicing strategy for the area. As well, the City has begun the preliminary design process for the relocation of the Big Bend PS to address logistic difficulties in operating the pump station during extreme freshet conditions. The new site for the pump station has been secured and we will incorporate this current work in our development of the area servicing strategy.

Key stakeholders will be consulted, including Metro Vancouver, Kinder Morgan, Ministry of Transportation and Infrastructure (MOTI), Canadian National Railway (CNR), and environmental regulators.

2.1 Background Information

The following background reports were reviewed for information relevant to the development of the sanitary servicing strategy options identified as part of this study:

- City of Surrey, Abbey Ridge Land Use Concept Plan, Stage 1 Preferred Option, December 2015
- City of Surrey, Corporate Report on East Fraser Heights Local Area Plan – Stage 1 Land Use Concept, December 14, 2015
- City of Surrey, Anniedale-Tynehead Neighbourhood Concept Plan (NCP), April 2012
- HydraTek, Port Kells Sanitary Forcemain System Hydraulic Transient Analysis – Final Report, June 11, 2008
- Omni Engineering Inc., Port Kells Sewage Pump Station – Issues Pertaining to Increasing Capacity, March 2008
- Earth Tech, Big Bend Sanitary Pump Station Long Term Servicing Study, February 2008
- Earth Tech, South Port Kells and Big Bend Sanitary Service Concept Study - Final Report, March 21, 2006
- Dayton & Knight Ltd., Concept Report on Big Bend Lift Station Alternatives to 104th Avenue Extension, Second Draft, July 2004

3. Existing Conditions Overview

The following sections provide additional details regarding specific components within the study area.

3.1 Location and Terrain Conditions

3.1.1 Study Area Location

The Abbey Ridge study area is located in northeast Surrey. It is bounded by the Fraser River to the north, 172 Street to the west, Golden Ears Way to the east, and Highway 1 to the south (*Figure 1*).

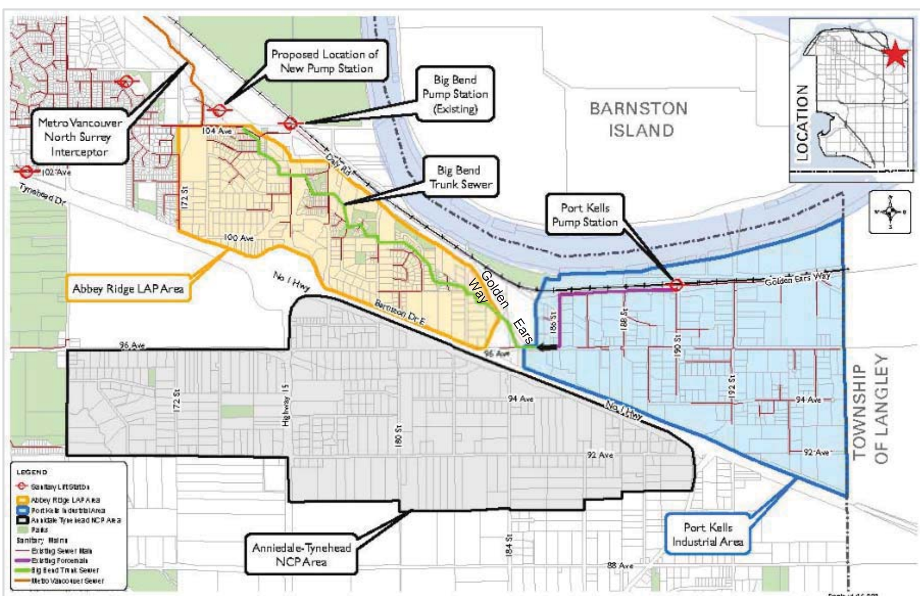


Figure 1 – Abbey Ridge Local Area Plan Area (Source: City of Surrey, 2016)

3.1.2 Terrain Conditions

The terrain within the study area is characterized by three distinct landscapes: a gently sloping upland area to the south, a relatively flat lowland area along the north boundary, and a moderately steep transition zone between the upland and the lowland, known commonly as the Surrey escarpment. The majority of the Abbey Ridge plan area is located within this escarpment zone.

The upland areas have elevations ranging between 40m and 65m. This area is mostly located in the south-west of Abbey Ridge and is sparsely developed with suburban residences. In general, it slopes down to the north and east.

The escarpment zone has elevations ranging between 15m and 55m. Some areas have been developed with urban residential projects and transportation corridors. Other areas remains largely undeveloped, especially those adjacent to watercourses. The escarpment slopes downs to the north-east direction, with slopes as steep as 50%.

Lowlands at the base of the escarpment are located within the Fraser River floodplain and have elevations ranging between 3m and 15m. The area is highly developed with transportation corridors and light impact industry, including the newly constructed Golden Ears Connector.

The existing Big Bend PS is located within the lowland area, which is not dyked. As dykes are not planned to be built in the future, the City has proceeded to look at relocation options for this pump station.

3.2 Existing Sanitary Infrastructure

The major components of the sanitary sewer system within the Abbey Ridge LAP include a 600mm to 750mm trunk sewer (Big Bend Trunk Sewer) and the Big Bend PS. The trunk sewer is comprised of concrete and plastic (PVC) pipe sections and conveys sewage to the Big Bend PS, which pumps to Metro Vancouver's North Surrey Interceptor (NSI) sewer. Although the trunk sewer services the majority of the area, most of the properties located north (down slope) of the sewer are not tied into this system and are serviced by individual septic fields. The trunk sewer also receives sewage from the Port Kells Industrial Area via the Port Kells Pump Station (Port Kells PS).

Several sections of the trunk sewer have been identified as having capacity constraints under various flow conditions. With the planned increase in development density in the Abbey Ridge LAP and further build-out of the Port Kells Industrial area, these sewer sections will have further capacity issues.

The collection sewer system servicing the Abbey Ridge LAP consists of 200mm to 250mm diameter mains that tie into the trunk sewer at several locations along its length. The local sewers are generally comprised of PVC pipe.

The North West Langley Wastewater Treatment Plant (NWLWWTP) is located approximately 3km north-east of the Port Kells PS near the Golden Ears Bridge and is the potential discharge location for Option 4 (see *Section 5.4* below). Discussions with Metro Vancouver have yielded this as a feasible option for servicing the Port Kells area.

Anniedale-Tynehead is currently not serviced by or connected to the City sanitary sewer network. The NCP indicates that Anniedale-Tynehead will be serviced by the NSI via a new trunk sewer; however, the north portion could potentially be directed to the Big Bend Trunk Sewer once additional capacity is available.

The City has indicated that there are several sanitary projects either recently completed, in progress, or pending that will be relevant to this project, specifically:

- Metro Vancouver recently completed an upgrade to the NSI, the 104 Avenue Sewer Extension Project, from the intersection of 104 Avenue and 173 Street. This is a potential discharge point for sewage flows being redirected from the Port Kells PS, Option 3 (see *Section 5.3* below).
- The City is developing plans for the relocation and upgrade of the Big Bend PS. The pump station will be relocated to a nearby location and sized to accommodate the full buildout sewage flows of the Abbey Ridge LAP area; it will be a key component of the servicing strategy for the Abbey Ridge, Port Kells, and Anniedale-Tynehead areas. This is a potential discharge point for Option 2 (see *Section 5.2* below).
- The City has indicated that the properties north of the trunk sewer currently serviced by individual septic fields may be serviced by a low pressure sewer system and routed to the Big Bend PS via the Big Bend Trunk Sewer. Should this occur, potential upgrades to the Big Bend PS will need to take the additional sewage flows from these properties into account.

3.2.1 Known Areas of Concern

Several areas were highlighted during our analysis and discussions with the City as being of particular concern, specifically:

- North Surrey Interceptor
    - The NSI has been reported as close to capacity directly downstream of the Big Bend PS. Discussions with Metro Vancouver revealed that this section of the NSI has recently been upgraded from approximately a 600mm pipe to a 1050mm pipe. Metro Vancouver has indicated that there will be sufficient capacity for flows into their upgraded system. We have made a request to Metro Vancouver for copies of the plans and engineering reports related to this sewer upgrade project.
- Big Bend Trunk Sewer
    - Portions of the trunk sewer are over capacity for the Peak Wet Weather Flow (PWWF). We have not received reports indicating that there have been flooding or sewer back-up issues within the area. However, as Abbey Ridge and Port Kells continue to develop and densify, additional sewer flows may cause significant surcharging and potential back-ups and odour issues.
    - There are also several individual sewer pipes that do not achieve the minimum velocity requirement set in the City's Design Criteria Manual. This may further compound the capacity constraint if particulates are allowed to accumulate in these pipes.
- Big Bend PS
    - The Big Bend PS is within the 200 year flood elevation of the Fraser River. Although the PS is protected from this event, there is still a risk of the pump station being inundated. To mitigate this risk, the City is currently in the preliminary design stage of relocating the pump station to a more suitable location and incorporating flood protection measures. We have

requested a copy of the current plans and engineering reports related to the relocation and upgrade of this pump station.

- Abbey Ridge Lowlands
  - o Most of the properties adjacent to the Fraser River along the north east edge of Abbey Ridge are currently serviced by individual septic fields. Future servicing is expected to be by low pressure sewer, which would increase flow to the Big Bend PS.

3.2.2 Consultation with Metro Vancouver

A stakeholder consultation meeting was conducted on April 11, 2016, at Metro Vancouver with representatives from the City of Surrey, Metro Vancouver, and MCSL present to introduce the proposed Abbey Ridge LAP and review Metro Vancouver's short and long-term regional plans for sanitary servicing in the vicinity of the study area.

Key outcomes of the meeting are summarized as follows.

- Metro Vancouver confirmed that they are intending to expand the existing NWLWWTP to a regional facility by expanding its servicing area, including redirecting flow to the plant from the existing NSI system. This would relieve pressure from the Annacis Island WWTP.
- The overall timing to turn the NWLWWTP into a regional facility is approximately 7 to 10 years.
- Metro Vancouver is currently completing the 104 Avenue Sewer Extension Project as part of improvements to the NSI. This project is scheduled to be completed by the end of 2016. This section of the NSI consists of a 1050mm sewer that will increase capacity to approximately 1100 l/s.

The above confirms that there is an opportunity to re-direct sewage flows away from the trunk sewer and NSI system towards the NWLWWTP, thereby freeing capacity within the trunk sewer. These options are further discussed in later sections of this document.

Minutes of the meeting are provided under *Appendix B*.

3.3 Land Use

Currently, there are 522 residential lots / units within the Abbey Ridge neighbourhood area. The Abbey Ridge neighbourhood area also includes approximately 8.6 hectares (21.3ac) of industrial, 2.0 hectares (5ac) of institutional and 1.5 hectares (3.7ac) of commercial use. In the case of industrial use, it appears that a significant amount of this zoned, industrial land base is under-utilized based on 2015 air photo data. The current land use plan for the area is provided in *Appendix C*.

The preferred land use plan concept for Abbey Ridge includes a range of future uses including urban residential, multi-family and transition suburban residential that would contribute to increased sanitary capacity demand. Based on the "Stage 1" land use concept, the existing area is expected to add between 884 and 1,228 new residential units with the majority of this new growth in the form of multiple residential units. However, these values do not include secondary suites, which would add approximately 849 more units. The Abbey Ridge Plan does not currently plan for additional commercial, institutional or industrial uses beyond current zoning. The growth in residential use, as well as intensification / in-fill development of zoned industrial land, represents the majority of future sanitary capacity pressure for this area.

The Port Kells area is an industrial-designated subarea located east of the Abbey Ridge NCP, north of Highway 1. This area is almost entirely zoned Light Impact Industrial (IL) with a small number of Comprehensive Development (CD) spot-zoned parcels for light industrial uses. Based on 2015 air photo data, the Port Kells area appears to be fully utilized with only a small percentage of parcels not having any buildings present. The amount of in-stream development application activity in this area is also nominal at only seven in-process applications known, indicating a fairly 'stable' condition is present. It should be noted that a significant number of parcels include a large amount of outside storage of bulk materials, so there is a potential for land use 'intensification' (e.g. more building area to be constructed). Over time this could be expected to achieve perhaps another 20 to 30 percent building site coverage and corresponding sanitary capacity demand. The time horizon for this to occur is expected to be long (e.g. >25 years) and actual increase in building footprint in the Port Kells industrial area is difficult to predict.

There is one application of note located at 9010 192 Street (Surrey Project 7915-0196-00) that involves a rezoning to Light Industrial (IB3 Zone). This property is located on the south side of Highway 1 and is not located in the Port Kells area. However, this is a 26 hectare (64 ac) site so it could potentially represent a large demand on infrastructure capacity. It is not known how this site is planned to be serviced if it is successfully rezoned.

3.4 Environmental Review

Several recent environmental assessments have been completed in and around the East Fraser Heights / Abbey Ridge study area. A BCEAA environmental application submitted for the construction of the South Fraser Perimeter Road included an environmental features study of the area (MOTI 2006). The North Bluff ISMP Study (City of Surrey) detailed baseline environmental studies focused on the East Fraser Heights / Abbey Ridge local area plans (LAP). This environmental review of previous studies and published information was conducted to inform the plans for the water and sewer local area servicing (LAS) for Abbey Ridge.

Environmental features summarized here for the Abbey Ridge LAS include watercourses and wetlands.

3.4.1 Aquatic Habitat Overview

A number of unnamed creeks run northward towards the Fraser Ridge off the study area (*Figure 2*). All watercourses and wetlands have been identified on the Abbey Ridge Land Use Concept plan.

Watercourses and Wetlands

The City of Surrey (City of Surrey 2014) has adopted a watercourse classification system which categorizes the general productivity of fish habitat in its local watercourses. This colour coding is shown in *Table 1.*

This classification system is used in *Figure 2* to provide the location of areas of environmental sensitivity with respect to this project.

Figure 2. Abbey Ridge Study Area (yellow outline) comprises several yellow and red-coded watercourses (see text for definitions), wetlands, and detention ponds. City of Surrey Cosmos Mapping has been updated with the recommendations of the East Fraser Heights Environmental Assessment (Surrey 2015a).

Table 1 – Watercourse classification system (City of Surrey 2014).

Colour Code	Habitat Type	Description
Red-Coded	Class A (High Productivity) habitat	Inhabited or potentially inhabited by salmonids year round
Red-Dashed Coded	Class A(O) (High Productivity) habitat	Inhabited by salmonids primarily during the overwintering period or potentially inhabited seasonally with access enhancement
Yellow-Coded	Class B (Moderate Productivity) habitat	Significant food and nutrient value but no fish present
Green-Coded	Class C (Low Productivity) habitat	Insignificant food and nutrient value and no fish present, usually roadside ditches.

Roadside ditches, constructed ponds and streams, wetlands, natural ravine creeks and tributaries make up the variety of watercourses in the study area. The East Fraser Heights Environmental Assessment (Phoenix 2015) reviewed the classification of the watercourses in the study area, proposing several classification change recommendations, which the City of Surrey accepted and included in their COSMOS mapping (Surrey 2016). The Land Use Concept plan provides for appropriate riparian buffers around the yellow and red coded watercourses and wetlands. No works should be planned within these watercourses and their riparian buffer zones.

An unnamed watercourse at 172 Street and 104 Avenue flows downslope towards an off-site wetland (Watershed Code: 100-028278-000000) located several hundred metres to the northwest of the study site. The environmental studies conducted around the SFPR reported that these watercourses and riparian wetlands provide spawning habitat for Coho salmon and juvenile rearing of coastal cutthroat trout. Flows towards these wetlands should not be modified or disrupted.

Flow in all red and yellow coded watercourses must not be disrupted and volumes should be maintained at levels as set by the City of Surrey's ISMP and drainage plans. All works below high water mark or that affect flows or result in diversion of flows requires approval under the *Water Sustainability Act*.

Aquatic Habitat and Wildlife Species at Risk

Abbey Ridge lies adjacent to federally designated critical habitat for the Pacific Water shrew (*Sorex bendirii*) (see *Figure 3*). This small area of habitat at the corner of 172 Street and 104 Avenue lies within Abbey Glen Park, which is owned by the City of Surrey. This park and habitat is at or against the northeast corner of the study area. No works can occur within this habitat without permits from Environment Canada.

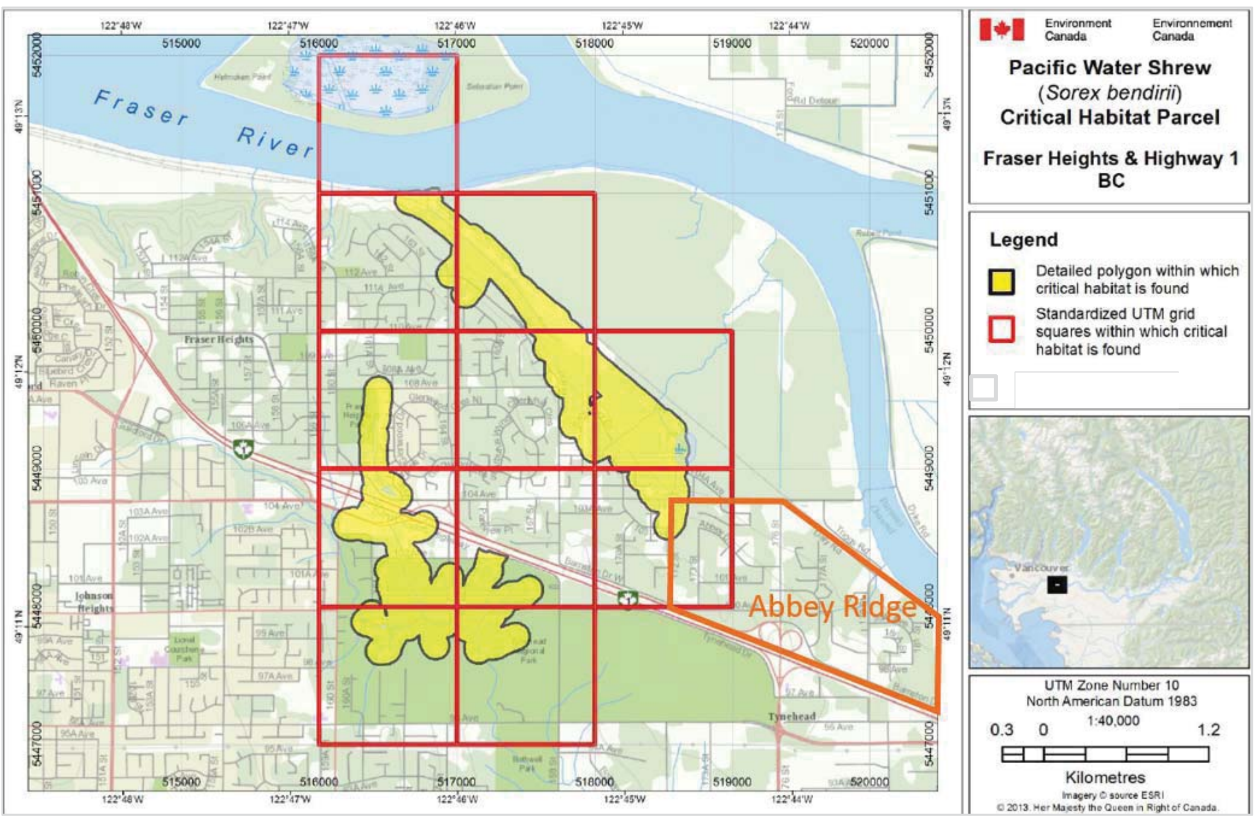


Figure 3 – The Abbey Ridge LAP touches federally designated critical habitat for the Sorex bendirii*. Obtained from URL http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_pacific_water_shrew_e_final.pdf*

Leoran Brook is not indicated as critical habitat for the Pacific Water Shrew; however, it does provide a potential habitat for this SARA listed species.

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4. Design Criteria

Several City of Surrey documents were reviewed to support our analysis of the existing infrastructure and preliminary design of the proposed options. These documents were:

- Design Criteria Manual (January 2016)
- Guideline for the Design & Construction of Sanitary Sewage Pumping Stations (July 1998)

A summary of the pertinent criteria from both documents can be found in *Table 2*.

Table 2: Summary of Pertinent Criteria

Property	Criteria
Average Dry Weather Flow (ADWF)	350 Litres/capita/day
Peaking Factor	Harman equation
Infiltration and Inflow	11,200 Litres/hectare/day
Population Densities	Section 2.3.1, which includes Tables 2.3.1 and 2.3.2 of the City's Design Criteria Manual
Forcemain Velocity (recommended)	1.0 – 1.8 m/s
Minimum New Gravity Sewer Velocity	0.6 m/s, assessed at 70% of Peak Dry Weather Flow (PDWF) for pipes with grade less than 0.5%
Maximum New Gravity Trunk Sewer Flow Depth (where Q ≥ 40 l/s)	70% of internal diameter (during PWWF)
Capacity of Existing Trunk Sewers to Convey the PWWF (where Q ≥ 40 l/s)	$0.837 * Q_{cap}$

4.1 Analysis Methodology

Flow estimates were obtained by following the criteria outlined in the City's Design Criteria Manual. Population was calculated differently for residential and non residential areas. Residential population was calculated by multiplying the area of a particular zoning by the units-per-area (as given in the land use plan provided by the City) and by the people-per-units (as found in Table 2.3.2 in the City's Design Criteria Manual - including secondary suites). Non residential population equivalent was calculated by multiplying the area of a particular zoning by population densities found in Table 2.3.1 in the City's Design Criteria Manual. A peaking factor that included the population of Port Kells was used to determine flows when assessing the hydraulic performance of the Big Bend Trunk Sewer under a "do nothing" scenario. A peaking factor that included the population of Anniedale-Tynehead was used to determine flows when assessing the hydraulic performance of the Big Bend Trunk Sewer under that proposed scenario.

Estimates of the ADWF, PDWF, and PWWF were made based on the criteria listed above. Further discretization of sanitary catchments allowed for a sanitary sewer control plan to be made to assess the capacity of each pipe in the existing trunk sewer. Capacity of the sewer was calculated as 83.7% of the hydraulic capacity of the conduit and then compared to the PWWF to determine which pipes will be under capacity at ultimate build out.

Sewage flow contributions from the Port Kells Industrial area were assessed based on zoning and areas obtained from the City's online mapping system (COSMOS and Open Data Surrey). Population was estimated based on Tables 2.3.1 and 2.3.2 of the City's *Design Criteria Manual* as described above. The ADWF, PDWF, and PWWF were also calculated for the Port Kells area based on the criteria above.

The City is also considering the option of routing flows from a portion of the Anniedale-Tynehead area to the Big Bend Trunk Sewer if flows from the Port Kells Industrial area are conveyed directly to the NSI; therefore, population estimates for the Anniedale-Tynehead area were obtained from the Anniedale-Tynehead Neighbourhood Concept Plan (Surrey, April 2012). criteria above. The optional new sanitary forcemain from Port Kells was designed based on the above listed velocity constraints and professional judgement.

4.2 Design Flows

Table 3 presents the design flows used in assessing existing infrastructure as well as preliminary design of the proposed options.

Table 3: Design Flows

Area	Population (inclusive of secondary suites)	ADWF (Lps)	PDWF (Lps)	PWWF (Lps)
Abbey Ridge	6,733	27.3	85	99
Port Kells	22,021	89.2	233	265
Anniedale-Tynehead	37,638	149	-	-
Abbey Ridge and Port Kells	28,682	116	290	340
Abbey Ridge and 4 subcatchments within Anniedale-Tynehead	15,278	61.9	171	201

5. Preliminary Servicing Options

The current Big Bend Trunk Sewer is comprised of 600mm to 750mm diameter pipe. The City has identified several sections that are currently overcapacity or surcharged (see *Figure 4* and *Table 4*).

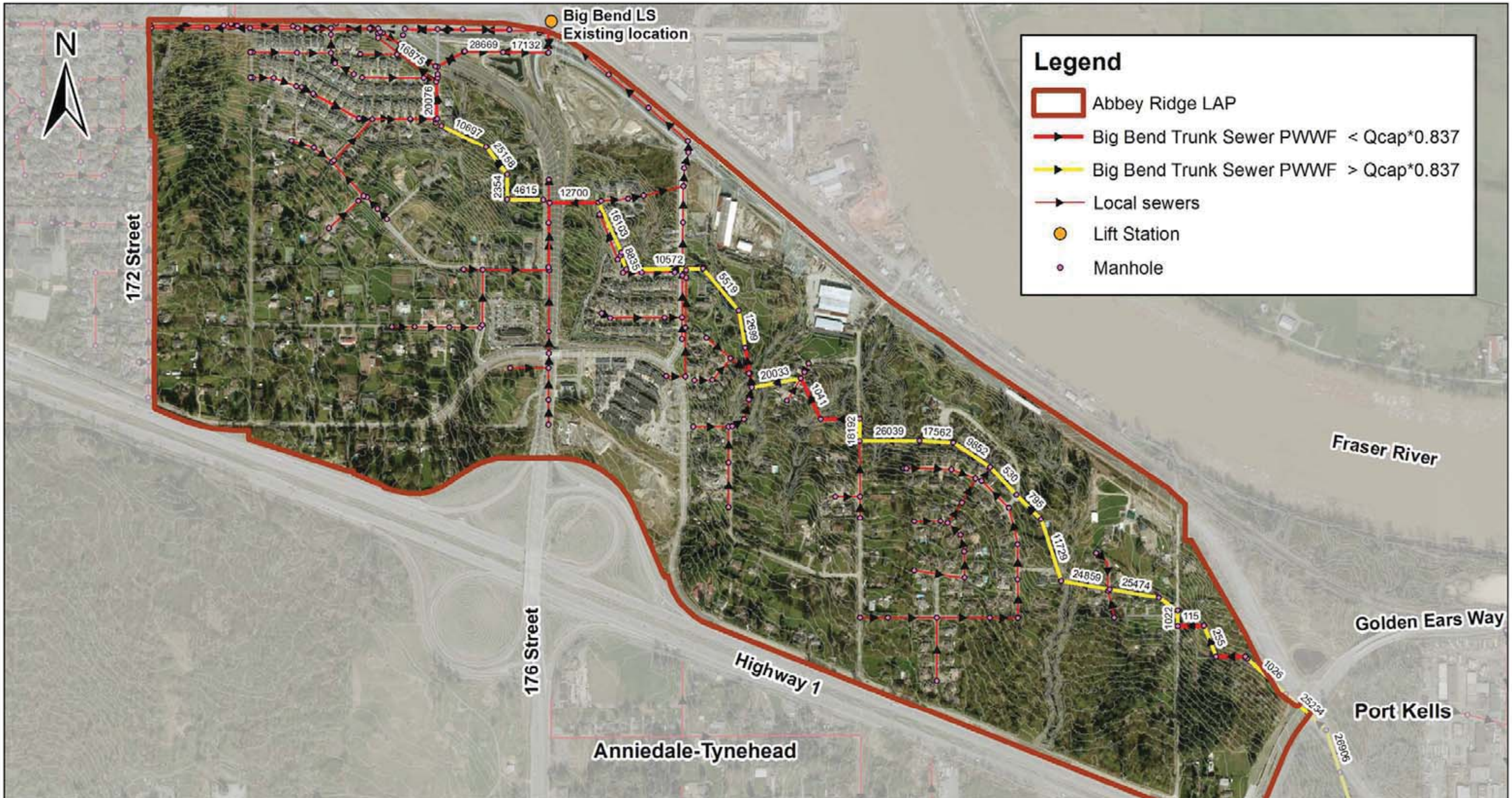

Figure 4
ExistingTrunk Sewers

Table 4: Pipes Requiring Upgrading

PIPE ID	PWWF (l/s)	Pipe Capacity x 0.837 (l/s)	Over Capacity?
2378	268.5	191	YES
28106	268.5	179	YES
26906	268.5	179	YES
25234	273.2	190	YES
1026	273.2	175	YES
248	273.2	49	YES
256	273.2	297	NO
255	273.2	217	YES
115	277.7	286	NO
1022	277.7	281	NO
28115	280.2	180	YES
25474	280.2	270	YES
16104	280.2	196	YES
24859	288.6	286	YES
11729	288.6	220	YES
795	288.6	252	YES
530	288.6	252	YES
9852	288.6	197	YES
17562	288.6	209	YES
26039	288.6	264	YES
18192	292.3	297	NO
29271	292.3	362	NO
1041	292.3	377	NO
20033	293.9	186	YES
17563	296.6	392	NO
14665	296.6	384	NO
12699	296.6	258	YES
5519	296.6	280	YES
1464	301.4	407	NO
10572	307.4	282	YES
4039	307.4	255	YES
8835	307.4	295	YES
28235	307.4	360	NO
16103	307.4	319	NO
12700	307.4	337	NO
16501	324.4	0	YES

PIPE ID	PWWF (l/s)	Pipe Capacity x 0.837 (l/s)	Over Capacity?
4615	324.4	308	YES
2354	324.4	323	YES
25158	324.4	222	YES
10697	324.4	278	YES
28709	324.4	574	NO
24583	324.4	2038	NO
20076	332.0	2347	NO
16875	332.0	1316	NO
16724	332.0	1722	NO
29116	333.6	561	NO
28499	333.6	520	NO
28664	335.0	558	NO
28669	335.0	627	NO
17132	335.0	519	NO
10808	340.3	530	NO

With additional development occurring within the Abbey Ridge area, there will be further capacity issues within the existing sewer trunk; therefore, the following servicing options were identified for the Abbey Ridge area:

- Option 1: Upgrade or twin portions of the Big Bend Trunk Sewer
- Option 2: Divert flows from Port Kells to the North Surrey Interceptor
- Option 3: Divert flows from Port Kells to the Northwest Langley Wastewater Treatment Plant

Each of the servicing options are described in the following sections. We identify the key infrastructure components of each of the options, benefits, and potential issues related to funding, timing, or construction. In *Section 5.5*, we summarize our preliminary option comparison.

5.1 Option 1 – Upgrade or Twin Portions of the Big Bend Trunk Sewer

Option 1 provides additional capacity within the Big Bend Trunk Sewer by twinning or upsizing various sewer segments. This option assumes that Port Kells continues to drain to the trunk sewer and that flows from Anniedale-Tynehead bypass Abbey Ridge and are discharged directly to the NSI. The alignment of the trunk sewer currently crosses private properties via rights-of-way, with existing sections of sewer and manholes in areas with difficult access, such as backyards or underneath homes and outbuilding structures. *Figure 5* shows the sewer sections that require upgrading, as well as manholes in difficult access locations.

Preliminary calculations have shown that in order to upgrade the pipe size of the trunk sewer to meet future demand, all constrained pipes would have to increase by approximately two pipe sizes (e.g. Replace 600mm diameter pipes with 750mm diameter pipes). Twinning the Big Bend TS to meet the future demand

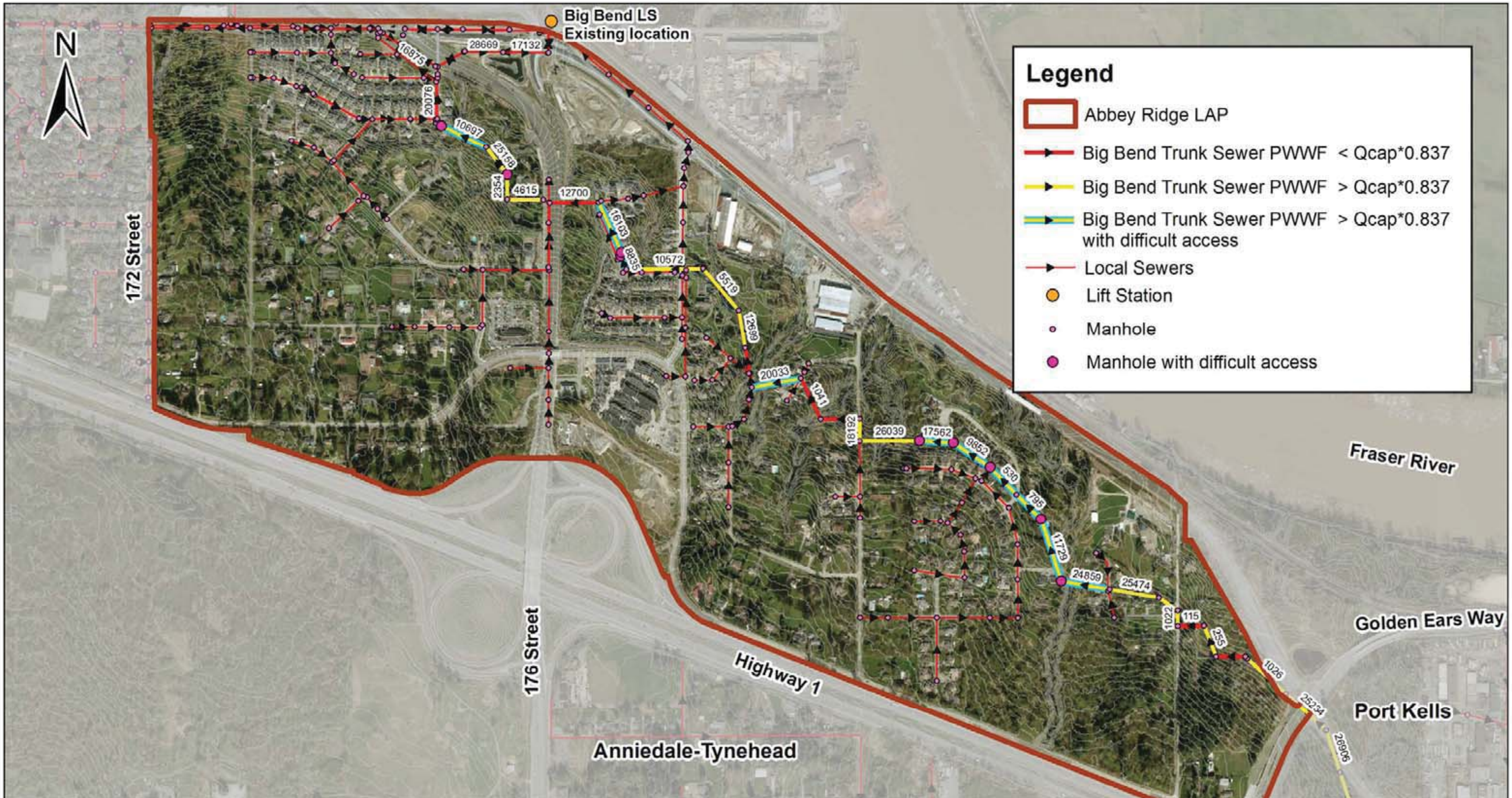

Figure 5
Big Bend Trunk Sewer Upgrades
For Option 1

would require a similar increase in capacity, which would require all constrained pipes to be twinned with a pipe of the same diameter. Given the capacity constraints of the Big Bend TS and the physical constructability of upsizing or twinning the sewer in key locations, this option will be extremely challenging. Several pipes lie underneath private property and some are underneath existing houses, creating a risk for significant property impacts if this option is selected.

Installation options for twinning the sewer include directional drilling, auger boring, and pipe ramming. This would include accessing manholes to dig launching / receiving pits as well as bringing all the material and equipment to the pits, some of which will be located in difficult areas. There is also a risk of affecting houses, driveways, pools, and other private property, which could be a serious liability for the City.

Trenchless methods could also be employed for upgrading the existing trunk sewer; however, these methods would incur the same risks to private property as twinning.

5.2 Option 2 – Divert Flows from Port Kells to the North Surrey Interceptor

This option would divert flows from Port Kells around Abbey Ridge with a new forcemain. It would include constructing a new pump station for the Port Kells area (see *Section 5.2.1* and *Figure 6* below) and a new 3.9km long 450mm diameter forcemain along the Golden Ears Connector to 104 Avenue, discharging directly into the upgraded portion of Metro Vancouver's North Surrey Interceptor.

This option bypasses the Big Bend PS, which has the advantage of reducing the demand on the Big Bend PS and may allow for cost savings for the new Big Bend PS.

5.2.1 New Port Kells Pump Station

Options 2 and 3 would require the Port Kells PS to relocate as the existing site is too constrained by the Canadian National Railway to the north and the Golden Ears Bridge approach highway to the south for the necessary upgrades to occur. The new station may require surge tanks, chemical dosing facilities for odour mitigation, and an emergency overflow storage tank.

The new pump station could be located at one of three potential sites described in *Table 5* and shown in *Figure 7*. Forcemain distances given in this memo are from the existing pump station location. Option PK1 for the new Port Kells PS site is higher and further than the other options; therefore, the new pump station will be approximately 4.5m below existing ground than at the other sites. However, if Option 3 – Divert Flows from Port Kells to the Northwest Langley Wastewater Treatment Plant is selected there could be savings on the length of forcemain required.

Table 5 – Port Kells Pump Station Relocation Options

Option	Location	Zoning	Area (ha)	Distance to Existing Port Kells Pump Station (m)
1	190 Street ROW near CNR	-	0.05	69
2	9779 190 Street	IL	0.11	78
3	9810 192 Street	CD	1.36	570

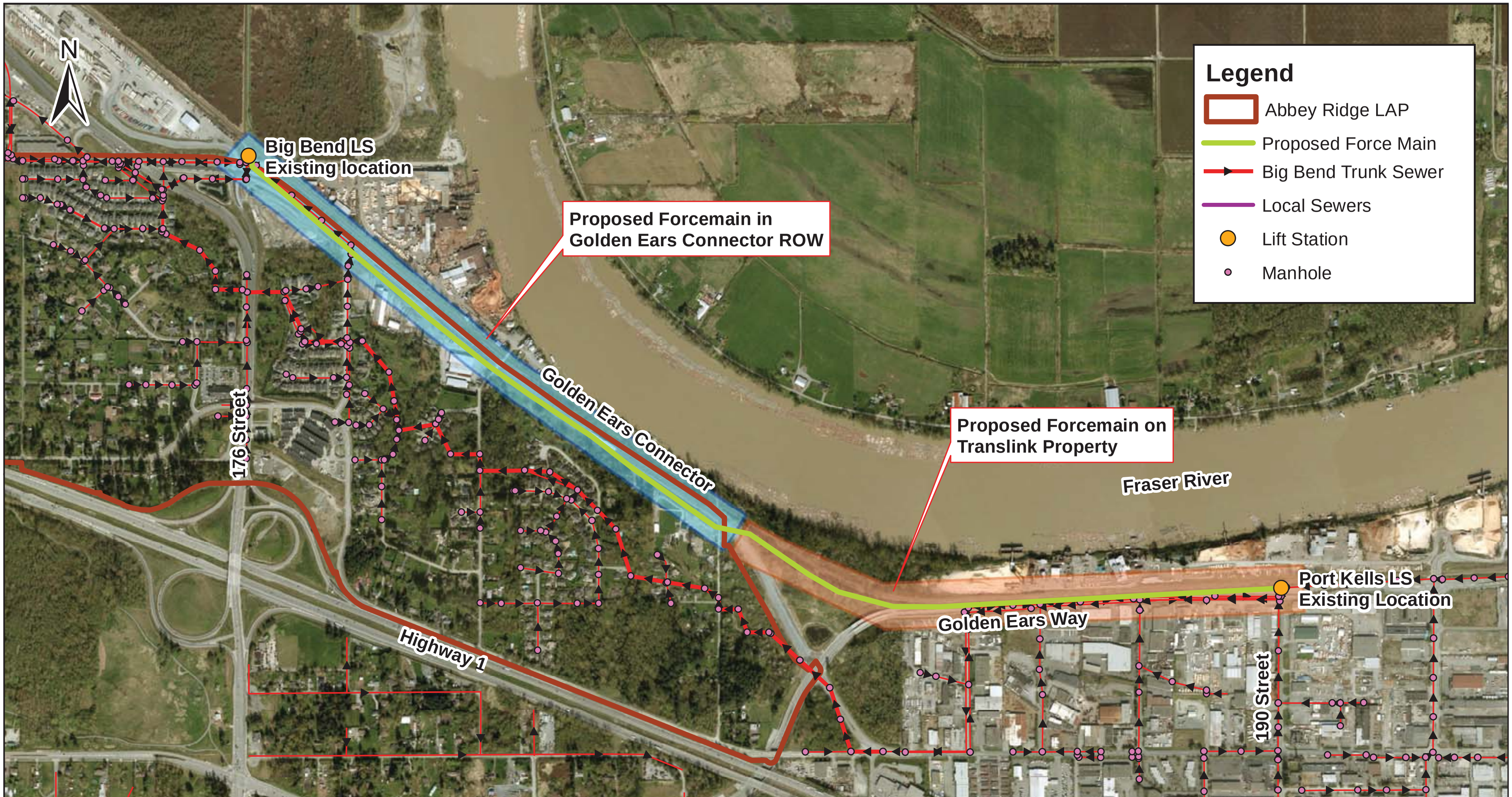

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Figure 6
New Forcemain
Alignment for Option 2

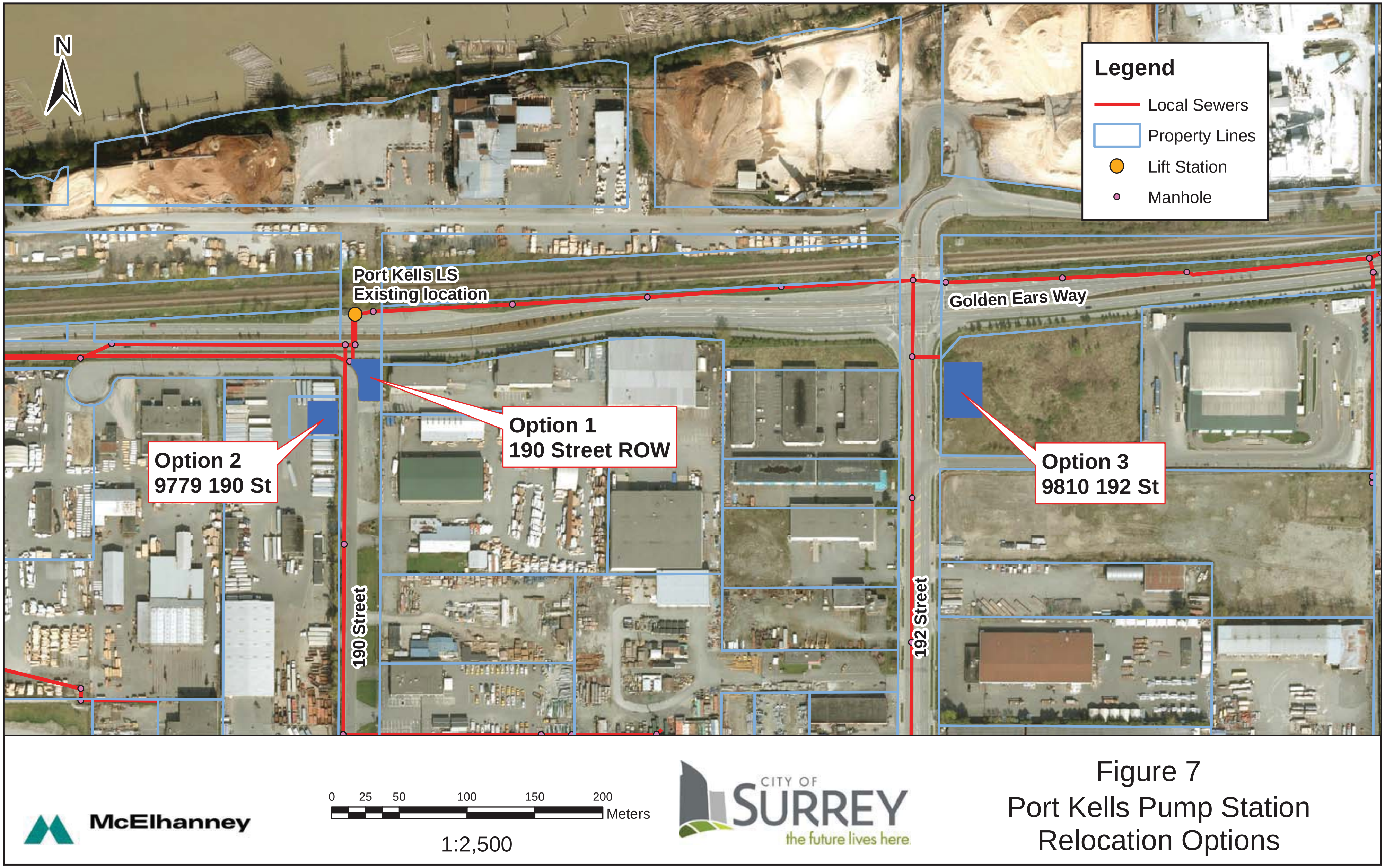

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Figure 7
Port Kells Pump Station
Relocation Options

5.2.2 Flow Diversion Options

While diverting flows from the trunk sewer may free capacity to support development of the LAP area, it will likely result in increased operational and maintenance costs as the flows generated from the LAP area alone will not be enough to produce adequate cleansing velocity in the trunk sewer. To address this challenge, some of the infrastructure already planned to support the development of a portion of the Anniedale-Tynehead (A/T) NCP area may be revised so that some flows from the A/T NCP area can be diverted north to the trunk sewer. The A/T NCP was established in 2011; it has not since developed and has no existing sanitary infrastructure.

It is planned to have a portion of Anniedale-Tynehead serviced by the trunk sewer by routing flows along the Golden Ears Way Right-of-Way to the upstream end of the trunk sewer. Assuming that sewage flows from Port Kells are diverted, the trunk sewer can accept approximately 135 Lps of additional flow at the upstream end before its capacity is constrained. Diverting flows from Anniedale-Tynehead through the trunk sewer would have the benefit of allowing development to proceed ahead of the current expected schedule by providing sanitary servicing sooner.

The trunk sewer requires a minimum of 60 Lps to attain cleansing velocities throughout its length. The additional sewage flows can come from Anniedale-Tynehead or the City can invest in additional maintenance, such as line flushing, until flows within the trunk increase to provide the required cleansing velocities.

5.3 Option 3 – Divert Flows from Port Kells to the Northwest Langley Wastewater Treatment Plant

Option 3 would construct a new 3.0km long 450mm diameter forcemain heading east to Metro Vancouver's North West Langley Wastewater Treatment Plant (NWLWWTP) (see *Figure 8*). The downstream section may be a trunk sewer if Anniedale-Tynehead decide to connect to the NWLWWTP. This option would require Port Kells to be serviced by a new pump station (see *Section 5.2.1* above).

This option depends on Metro Vancouver's review of the Maple Ridge flow diversion to NWLWWTP and Metro Vancouver's approval in allowing Port Kells to be diverted to NWLWWTP. Even if Metro Vancouver allows Port Kells to be diverted to NWLWWTP, the schedule for upgrading NWLWWTP was identified as seven (7) to ten (10) years and may be too far in the future to support additional development in the Abbey Ridge area. The feasibility of this option will be reviewed further if and when Metro Vancouver agrees with this arrangement.

McElhanney

0 0.1 0.2 0.4 0.6 0.8 Km.

1:10,000

CITY OF SURREY the future lives here.

Figure 8
New Forcemain
Alignment for Option 3

5.4 Preliminary Options Comparison

The options were compared by a weighted scoring based on the following criteria.

- Capital cost
  - o Based on a Class D cost estimate that can be found in *Appendix D*
- Short and long term operations and maintenance cost
  - o How much effort and money will the City have to spend to maintain the infrastructure in service
- Constructability
  - o How likely is the construction methodology to cause delays and additional costs
- Impacts to private property and the public
  - o How much is the minimum amount that the City will have to spend to reinstate existing features on private properties
- Coordination effort with outside agencies and to obtain approvals
  - o How much effort will be required to liaise with and inform stakeholders and obtain approvals

As part of our options comparison, we prepared a Class 'D' cost estimate for the design options presented which can be found in *Appendix E*. A summary of the cost estimate is presented here in *Table 7.*

Table 7 – Class 'D' cost estimate summary

Option	Class 'D' cost estimate (NPV)
1*	$16.0M
2	$16.1M
3	$18.4M

**The estimate for option 1 is the net present value assuming an initial investment of 25% of the capital value and the remaining upgrade costs to be spread over the next 40 years at a discount rate of 3%.*

This estimate was made for comparison purposes and includes direct costs for forcemains, gravity mains, and pump stations. This estimate does not include estimates for easement acquisition or utility conflicts, nor does it take into the service life of the various options – these factors would be significant in option 1. Twinning or upgrading the Big Bend Trunk Sewer would require a significant amount of work on private property for which the City may want to acquire maintenance easements or ROW to maintain the new infrastructure. This would incur a significant cost in time and compensation which was not included in this cost estimate.

If Option 1 is selected, then the Port Kells PS could remain in service. As it was constructed in 1977, it may require replacing in the near future, which would negate the savings that would come from selecting Option 1.

The options comparison scoring table is presented here as *Table 8.*

Abbey Ridge Sanitary Servicing Study --- Options Assessment Matrix

		Option 1 Twinning / Upgrading Big Bend Sewer		**Option 2** New Port Kells Pump Stataion and Forcemain to 104 Avenue North Surrey Interceptor Extension		**Option 3** New PS and Forcemain to NWLWWTP	
Category	**Weight**	**Description**	**Score**	**Description**	**Score**	**Description**	**Score**
Capital Costs 40 – lowest 30 – middle 20 – highest	40	$21.6 million (for twinning option, full expenditure in first year)	20	$16.1 million	40	$18.5 million	30
O&M Considerations 20 – minimal 15 – standard 10 – additional 5 – major 0 – significant	20	• Maintenance access to manholes and infrastructure on private property would require coordination with property owner and easements • Existing design does not meet current City design criteria • Maintaining of the aging Port Kells PS may become problematic, current PS not designed to current seismic codes	5	• New infrastructure to be constructed to current codes and standards and provide level of resiliency • New pump station and forcemain will incur less O&M costs than existing infrastructure over planned lifecycle • All proposed works are within City of Surrey boundary and under City O&M responsibilities • Flushing of the Big Bend Trunk may be required as flows and cleansing velocities will be lower due to bypass of this sewer	15	• New infrastructure to be constructed to current codes and standards and provide level of resiliency • New pump station and forcemain will incur less O&M costs than existing infrastructure over planned lifecycle • Jurisdictional considerations for maintenance and operations of new forcemain since it will cross municipal boundaries • Flushing of the Big Bend Trunk may be required as flows and cleansing velocities will be lower due to bypass of this sewer	10
Constructability 20 – standard 10 – difficult 0 – challenging	20	• Construction via open trench methods will be difficult and portions of the sewer will need to be constructed using trenchless methods, such as microtunnelling • Difficult access to infrastructure within private properties • Twinning will require modification or replacement of existing manholes to facilitate flow split	0	• Construction of forcemain can incorporate both open trench and trenchless technologies, whichever will provide the best value for the City • Connection to upgraded NSI available • Will use exiting forcemain constructed by the City within Golden Ears Way • Forcemain construction along Golden Ears Connector will be less costly due to a lower number of potential utilities impacts to accommodate	20	• Construction of forcemain can incorporate both open trench and trenchless technologies, whichever will provide the best value for the City • No current capacity at NWLWWTP to accept flows from Abbey Ridge • Construction will need to address a greater number of potential utility impacts since forcemain will be constructed within arterial/local roads	10
Property / Public Impacts 15 – none 10 – standard 5 – major 0 – significant	15	• Reinstating landscaping, fencing, etc. • Risk of damage to houses and private infrastructure • Construction and maintenance access easements required	0	• New pump station to be constructed on City owned property • Traffic disruption during construction of new forcemain	10	• New pump station to be constructed on City owned property • Traffic disruption during construction of new forcemain	10
Coordination with outside agencies and approvals (i.e MV, CN, etc.) 5 – minimal 0 – significant	5	• Coordinating access with private land owners	5	• Translink and MOTI for constructing the forcemain along Golden Ears Way and the Golden Ears Connector • Metro Vancouver to approve connection to NSI	5	• Translink, MOTI, and Township of Langley for constructing the forcemain along Golden Ears Way and the Golden Ears Connector • Metro Vancouver to approve connection to NWLWWTP • Multi-jurisdictional issues related to operations and maintenance of the forcemain since it crosses municipal boundaries	0
Total Score =	**100**		**30**		**90**		**60**

Revised: 10 June 2016

6. Next Steps

After review of the information contained within this technical memorandum by the City, we shall proceed with the following next steps of the assignment:

- **Review Meeting with the City** – We will present and review the information contained within this technical memorandum and discuss the options investigated and identify any additional assessment that may be warranted.
- **Sanitary Catchment Analysis & Plan on Preferred Option** – A detailed sanitary catchment analysis will be completed on the preferred option using refined catchment areas and local sewer configurations.
- **Conceptual Design & Plan / Profile Drawings** – Conceptual designs drawings will be prepared for the proposed trunk system.
- **Cost Estimates, Financial Analysis, & Implementation Strategy** – We will identify the DCC-eligible trunk sewer / infrastructure to service the LAP. Class "C" Cost estimates will be prepared for these items and a financial analysis will be completed to compare anticipated DCC revenues for the LAP with anticipated costs and identify funding strategies to overcome potential deficits. A phasing plan will also be prepared.
- **Draft and Final Servicing Reports** – A draft report will be prepared and submitted to the City and its information presented and discussed at an additional review meeting. A final servicing report will the prepared to address any comments and revisions.

7. Closure

The information provided in this technical memorandum will be included in the Sanitary Servicing Report that we are preparing as part of this assignment.

We look forward to receiving your review comments and discussing the next steps of this project. Should you have any questions, please feel free to contact either of the undersigned.

McELHANNEY CONSULTING SERVICES LTD.

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APPENDIX A – Meeting Minutes

McElhanney

MEETING AGENDA

Project Name	Sanitary Sewer Servicing for the Abbey Ridge Local Area Plan (LAP)		
Location	Metro Vancouver	MCSL Project No.	2111 03566-00
Meeting Purpose	Review NWLWTP Plans	Meeting Date / Time	April 11, 2016 / 9:30am

Attended by:

May Petretta (MP)	CoS	John McMahon (JM)	MV
Samantha Ward (SW)	SW	Ed von Euw (EE)	MV
Nav Sandhu (NS)	MCSL	Terry Hoff (TH)	MV
Michael Florendo (MF)	MCSL	Yao Hung Lan (YL)	MV
		Mike Boss (MB)	MV

ITEM	DISCUSSION	ACTION WHO	ACTION WHEN
1.0	**Introduction of Attendees**		
2.0	**Project Introduction/Abbey-Ridge Servicing Options**		
	Discussion by MP: • Sewage from Abbey-Ridge currently flows to the existing North Surrey Interceptor (NSI) at 104 Avenue through the Big Bend Pump Station (BBPS) • Development expected in the future within Abbey-Ridge, but relatively low density (approximately 7000 total population) • The existing Big Bend Trunk Sewer (BBTS) will not be able to accommodate the increase in sewage flows • BBTS is located in a very narrow ROW and has several access issues making upgrades or twinning very challenging • City of Surrey looking at various options for future sanitary servicing for the Abbey-Ridge area • BBPS is currently planned to be relocated to outside of the floodplain. City to provide design of new station to MCSL • Looking to redirect flows away from BBTS, either to NW Langley Wastewater Treatment Plant (NWLWTP) via a new Pump Station and forcemain or directly to the NSI via a bypass Pump Station and forcemain. • The Port Kells Industrial Area also discharges to the BBTS via an existing pump station and forcemain • Existing peak (wet-weather) flows in BBPS is approximately 300 l/s • Anniedale-Tynehead (A-T), located to the south of Abbey-Ridge, is currently all septic fields • Current Sanitary Study for the Abbey-Ridge Local Area Plan to be completed by end of May 2016 (by MCSL) • Looking at approximately 5-10 year horizon for development activity and resulting sanitary sewer improvements in the Abbey-Ridge area (dependent on development activity/funding)	CoS	
3.0	**Information from Metro Vancouver**		
	Discussion by EE:		

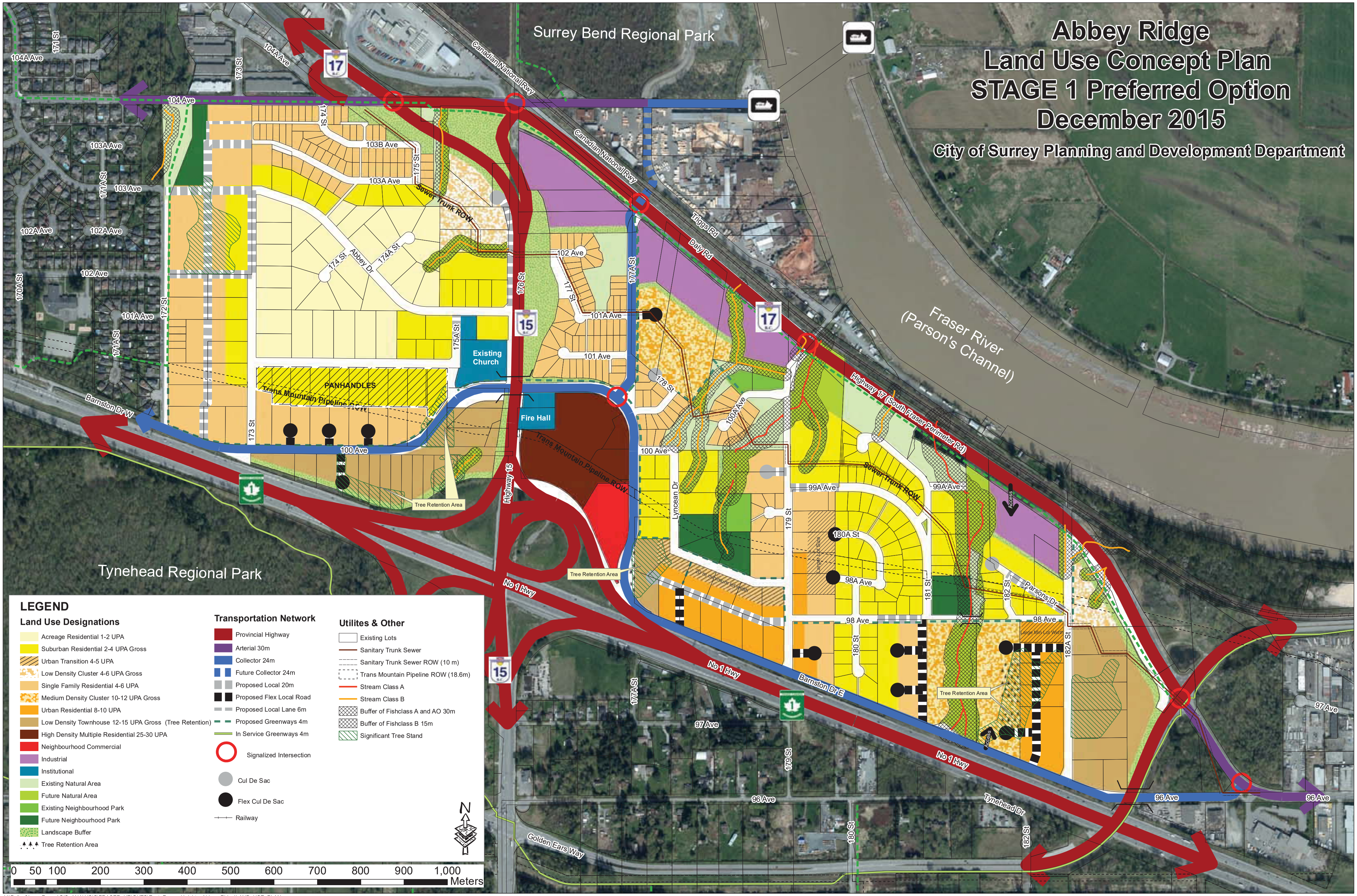
ITEM	DISCUSSION	ACTION WHO	ACTION WHEN
	• The option of a new pump station and forcemain to NWLWTP aligns with MVs long term plan to re-direct flows to the plant from areas serviced by the NSI/104th Ave extension. • A "three-party" agreement may be needed between Surrey/Langley/MV for the new forcemain to the NWLWTP. • Surrey's portion of the forcemain would be owned and operated by Surrey; forcemain located within Langley would be owned and operated by MV. • The agreement would likely take 6 months to 1 year to prepare and would occur prior to implementation/construction. Discussion by TH: • Long range planning numbers/ population is okay and will update catchment information once the Local Area Plan study is finalized. Discussion by NS: • Population projections and sewage flow rates have been calculated for Port Kells and Abbey Ridge by MCSL • Sewage flows from future development within the A-T area will be conveyed directly to NSI via several pump stations located in A-T area. This was studied by Urban System Ltd. under the A-T NCP Engineering Services Plan. Discussion by YL: • The 104th Ave extension consists of a 1050mm diameter high capacity (aprox. 1100l/s) upgrade which is almost constructed (to be completed by end of 2016). • MV can provide design/record drawings information of the 104 Ave extension. MCSL to contact Tony Zhang directly for design information.	MCSL/MV	
	Discussion by JM: • MV looking to re-direct flows east towards the NWLWTP in the future to relieve pressure from the Annacis Island WWTP. The extent/boundary of re-directing flows is approximately Port Mann Bridge towards the NWLWTP. • The overall timing to turn NWLWTP into a regional facility is in the 7 to 10 year range to start accepting additional/re-directed flows (2022 is the earliest; most likely a couple of years after). • JM suggested the City complete a condition assessment of BBTS if flows from outside of Abbey-Ridge (eg. A-T) will be sent through it once capacity is available. • JM requested MV be provided potential population that may be directed to the NWLWTP – MCSL to provide the servicing plan once complete. Discussion by MB: • Odour control problems currently exist at the Surrey works yard; try to look at options to address this.	MCSL/CoS	

ITEM	DISCUSSION	ACTION	
		WHO	WHEN

Meeting Minutes Prepared by: Nav Sandhu

Meeting Minutes Reviewed by: Michael Florendo

APPENDIX B – Abbey Ridge Land Use Plan



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APPENDIX C – Anniedale-Tynehead NCP Excerpt

Population Estimates and Demands

Populations for the study area were calculated using parcel size and zoning densities as outlined in Table 2.6 of the City of Surrey Engineering Department Design Criteria Manual.

The future land use for the 171 ha Port Kells area (which is outside of the Anniedale-Tynehead study area, but part of the sanitary service area) is yet to be determined. However, for purposes of this sanitary review, potential flow from Port Kells was estimated using 2 different methods:

- Using 10 upa (units per acre) density with an occupation rate of 3.2 persons/unit (corresponding to the Guilford Area, as per section 2.6 in the City of Surrey Engineering Department Design Criteria Manual)
- Using 89 PPha (corresponding to RF-12 SF Residential as per section 2.6 in the City of Surrey Engineering Department Design Criteria Manual)

The developable area was reduced to 60% of the total area, to account for RoWs, parks, etc. The resulting equivalent populations for each method were 8,100 and 9,100 persons, respectively. The average population of 8,600 persons was used in the analysis.

The total equivalent build out population is presented in **Table 6.2** below and categorized by Pump Station Catchment. Unit rates as specified above were applied to the populations to determine respective demands for each catchment.

PDWF was estimated using the Harmon peaking factor equation.

Table 6.2: Population and Catchment Flow Summary for Land Use Option

Pump Station Catchment	Development Areas	Total Equiv. Population	Gross Land Area (ha)	ADWF (L/s)	Peaking Factor (Harmon's)	PDWF (L/s)	I&I (L/s)	PWWF (L/s)
Anniedale PS	Anniedale A – West 1 Anniedale A – East 1 Anniedale B1	8082	105.1	32.7	3.05	99.7	13.6	113.3
184th St PS	Anniedale B2	3621	54.5	12.8	4.09	52.4	6.0	58.4
176th St PS	Anniedale B3 Anniedale B4 Annidale A – West 2	10674	125.1	43.2	2.93	126.6	16.2	142.8
172nd St PS	Tynehead	6661	121.0	25.4	3.49	88.6	13.7	102.3
Port Kells PS	Port Kells	8600	171.0	34.8	3.02	105.2	22.2	127.4
TOTAL		**37,638**	**376.7**	**148.9**				

APPENDIX D – Class ‘D’ Cost Estimate

Abbey Ridge Sanitary Servicing Study

Estimate of Probable Capital Costs --- Options Summary

Option Description		Probable Capital Costs	40-year Upgrade Costs
1A	Twinning of Big Bend Trunk Sewer, various segments	$ 21,571,009.10	$ 14,854,217.97
1B	Upgrade of Big Bend Trunk Sewer, various segments	$ 24,722,036.00	$ 17,024,076.61
2	New Port Kells Lift Station and Forcemain to NSI	$ 16,124,561.88	n/a
3	New Port Kells Lift Station and Forcemain to NWLWWTP	$ 18,457,412.50	n/a

Notes and assumptions:

a. sewer unit rates were provided by the City based on their 10-yr plan
b. sewer unit rates were factored based on:
    i. installation type --- cut and cover vs. microtunnelling (Options 1A & 1B)
    ii. road type --- arterial vs. highway/expressway (Options 2 & 3)
c. 40-year upgrade costs were based on 20% of total improvements constructed every 10 years
d. land costs were provided by the City, $5.7M per hectare within NCP areas
e. existing forcemain along Golden Ears Way to be used as part of Option 3
f. additional property impact costs for repairs/reinstatement and easements include in Options 1A & 1B

40-year Net Present Value Calculation

Option 1A - Twinning						
	Discount Rate			*3%*		
	Year		**Expense**	**PV/FV**		**NPV**
Today	0	$	5,392,752.28	1.000	$	5,392,752.28
	1	$	414,827.10	0.971	$	402,744.76
	2	$	414,827.10	0.943	$	391,014.33
	3	$	414,827.10	0.915	$	379,625.56
	4	$	414,827.10	0.888	$	368,568.50
	5	$	414,827.10	0.863	$	357,833.50
	6	$	414,827.10	0.837	$	347,411.16
	7	$	414,827.10	0.813	$	337,292.39
	8	$	414,827.10	0.789	$	327,468.34
	9	$	414,827.10	0.766	$	317,930.43
	10	$	414,827.10	0.744	$	308,670.32
	11	$	414,827.10	0.722	$	299,679.92
	12	$	414,827.10	0.701	$	290,951.38
	13	$	414,827.10	0.681	$	282,477.07
	14	$	414,827.10	0.661	$	274,249.58
	15	$	414,827.10	0.642	$	266,261.73
	16	$	414,827.10	0.623	$	258,506.53
	17	$	414,827.10	0.605	$	250,977.22
	18	$	414,827.10	0.587	$	243,667.20
	19	$	414,827.10	0.570	$	236,570.10
	20	$	414,827.10	0.554	$	229,679.71
	21	$	414,827.10	0.538	$	222,990.01
	22	$	414,827.10	0.522	$	216,495.15
	23	$	414,827.10	0.507	$	210,189.47
	24	$	414,827.10	0.492	$	204,067.44
	25	$	414,827.10	0.478	$	198,123.73
	26	$	414,827.10	0.464	$	192,353.14
	27	$	414,827.10	0.450	$	186,750.62
	28	$	414,827.10	0.437	$	181,311.28
	29	$	414,827.10	0.424	$	176,030.37
	30	$	414,827.10	0.412	$	170,903.27
	31	$	414,827.10	0.400	$	165,925.51
	32	$	414,827.10	0.388	$	161,092.72
	33	$	414,827.10	0.377	$	156,400.70
	34	$	414,827.10	0.366	$	151,845.34
	35	$	414,827.10	0.355	$	147,422.66
	36	$	414,827.10	0.345	$	143,128.80
	37	$	414,827.10	0.335	$	138,960.00
	38	$	414,827.10	0.325	$	134,912.62
	39	$	414,827.10	0.316	$	130,983.13
Total		**$**	**21,571,009.10**		**$**	**14,854,217.97**

Option 1B - Upgrade						
	Discount Rate			*3%*		
	Year		**Expense**	**PV/FV**		**NPV**
Today	0	$	6,180,509.00	1.000	$	6,180,509.00
	1	$	475,423.77	0.971	$	461,576.47
	2	$	475,423.77	0.943	$	448,132.50
	3	$	475,423.77	0.915	$	435,080.10
	4	$	475,423.77	0.888	$	422,407.86
	5	$	475,423.77	0.863	$	410,104.72
	6	$	475,423.77	0.837	$	398,159.92
	7	$	475,423.77	0.813	$	386,563.03
	8	$	475,423.77	0.789	$	375,303.91
	9	$	475,423.77	0.766	$	364,372.73
	10	$	475,423.77	0.744	$	353,759.93
	11	$	475,423.77	0.722	$	343,456.25
	12	$	475,423.77	0.701	$	333,452.67
	13	$	475,423.77	0.681	$	323,740.45
	14	$	475,423.77	0.661	$	314,311.12
	15	$	475,423.77	0.642	$	305,156.43
	16	$	475,423.77	0.623	$	296,268.38
	17	$	475,423.77	0.605	$	287,639.20
	18	$	475,423.77	0.587	$	279,261.36
	19	$	475,423.77	0.570	$	271,127.53
	20	$	475,423.77	0.554	$	263,230.61
	21	$	475,423.77	0.538	$	255,563.70
	22	$	475,423.77	0.522	$	248,120.10
	23	$	475,423.77	0.507	$	240,893.30
	24	$	475,423.77	0.492	$	233,876.99
	25	$	475,423.77	0.478	$	227,065.04
	26	$	475,423.77	0.464	$	220,451.50
	27	$	475,423.77	0.450	$	214,030.58
	28	$	475,423.77	0.437	$	207,796.68
	29	$	475,423.77	0.424	$	201,744.35
	30	$	475,423.77	0.412	$	195,868.30
	31	$	475,423.77	0.400	$	190,163.40
	32	$	475,423.77	0.388	$	184,624.66
	33	$	475,423.77	0.377	$	179,247.24
	34	$	475,423.77	0.366	$	174,026.45
	35	$	475,423.77	0.355	$	168,957.71
	36	$	475,423.77	0.345	$	164,036.62
	37	$	475,423.77	0.335	$	159,258.85
	38	$	475,423.77	0.325	$	154,620.24
	39	$	475,423.77	0.316	$	150,116.74
Total		**$**	**24,722,036.00**		**$**	**17,024,076.61**

This analysis assumes that 25% of the capital value is spent in the first year and the remainder of the value is spent over the subsequent 39 years

Appendix B – Minutes from Meeting with Metro Vancouver, April 11, 2016

McElhanney

MEETING AGENDA

Project Name	Sanitary Sewer Servicing for the Abbey Ridge Local Area Plan (LAP)		
Location	Metro Vancouver	MCSL Project No.	2111 03566-00
Meeting Purpose	Review NWLWTP Plans	Meeting Date / Time	April 11, 2016 / 9:30am

Attended by:

May Petretta (MP)	CoS	John McMahon (JM)	MV
Samantha Ward (SW)	SW	Ed von Euw (EE)	MV
Nav Sandhu (NS)	MCSL	Terry Hoff (TH)	MV
Michael Florendo (MF)	MCSL	Yao Hung Lan (YL)	MV
		Mike Boss (MB)	MV

Item	Discussion	Action: Who	Action: When
1.0	**Introduction of Attendees**		
2.0	**Project Introduction/Abbey-Ridge Servicing Options**		
	Discussion by MP: • Sewage from Abbey-Ridge currently flows to the existing North Surrey Interceptor (NSI) at 104 Avenue through the Big Bend Pump Station (BBPS) • Development expected in the future within Abbey-Ridge, but relatively low density (approximately 7000 total population) • The existing Big Bend Trunk Sewer (BBTS) will not be able to accommodate the increase in sewage flows • BBTS is located in a very narrow ROW and has several access issues making upgrades or twinning very challenging • City of Surrey looking at various options for future sanitary servicing for the Abbey-Ridge area • BBPS is currently planned to be relocated to outside of the floodplain. City to provide design of new station to MCSL • Looking to redirect flows away from BBTS, either to NW Langley Wastewater Treatment Plant (NWLWTP) via a new Pump Station and forcemain or directly to the NSI via a bypass Pump Station and forcemain. • The Port Kells Industrial Area also discharges to the BBTS via an existing pump station and forcemain • Existing peak (wet-weather) flows in BBPS is approximately 300 l/s • Anniedale-Tynehead (A-T), located to the south of Abbey-Ridge, is currently all septic fields • Current Sanitary Study for the Abbey-Ridge Local Area Plan to be completed by end of May 2016 (by MCSL) • Looking at approximately 5-10 year horizon for development activity and resulting sanitary sewer improvements in the Abbey-Ridge area (dependent on development activity/funding)	CoS	
3.0	**Information from Metro Vancouver**		
	Discussion by EE:		

<table>
<tr><th rowspan="2">Item</th><th rowspan="2">Discussion</th><th colspan="2">Action</th></tr>
<tr><th>Who</th><th>When</th></tr>
<tr><td></td><td>

The option of a new pump station and forcemain to NWLWTP aligns with MVs long term plan to re-direct flows to the plant from areas serviced by the NSI/104th Ave extension.
A “three-party” agreement may be needed between Surrey/Langley/MV for the new forcemain to the NWLWTP.
Surrey’s portion of the forcemain would be owned and operated by Surrey; forcemain located within Langley would be owned and operated by MV.
The agreement would likely take 6 months to 1 year to prepare and would occur prior to implementation/construction.

Discussion by TH:

Long range planning numbers/ population is okay and will update catchment information once the Local Area Plan study is finalized.

Discussion by NS:

Population projections and sewage flow rates have been calculated for Port Kells and Abbey Ridge by MCSL
Sewage flows from future development within the A-T area will be conveyed directly to NSI via several pump stations located in A-T area. This was studied by Urban System Ltd. under the A-T NCP Engineering Services Plan.

Discussion by YL:

The 104th Ave extension consists of a 1050mm diameter high capacity (aprox. 1100l/s) upgrade which is almost constructed (to be completed by end of 2016).
MV can provide design/record drawings information of the 104 Ave extension. MCSL to contact Tony Zhang directly for design information.

Discussion by JM:

MV looking to re-direct flows east towards the NWLWTP in the future to relieve pressure from the Annacis Island WWTP. The extent/boundary of re-directing flows is approximately Port Mann Bridge towards the NWLWTP.
The overall timing to turn NWLWTP into a regional facility is in the 7 to 10 year range to start accepting additional/re-directed flows (2022 is the earliest; most likely a couple of years after).
JM suggested the City complete a condition assessment of BBTS if flows from outside of Abbey-Ridge (eg. A-T) will be sent through it once capacity is available.
JM requested MV be provided potential population that may be directed to the NWLWTP – MCSL to provide the servicing plan once complete.

Discussion by MB:

Odour control problems currently exist at the Surrey works yard; try to look at options to address this.

</td><td>MCSL/MV

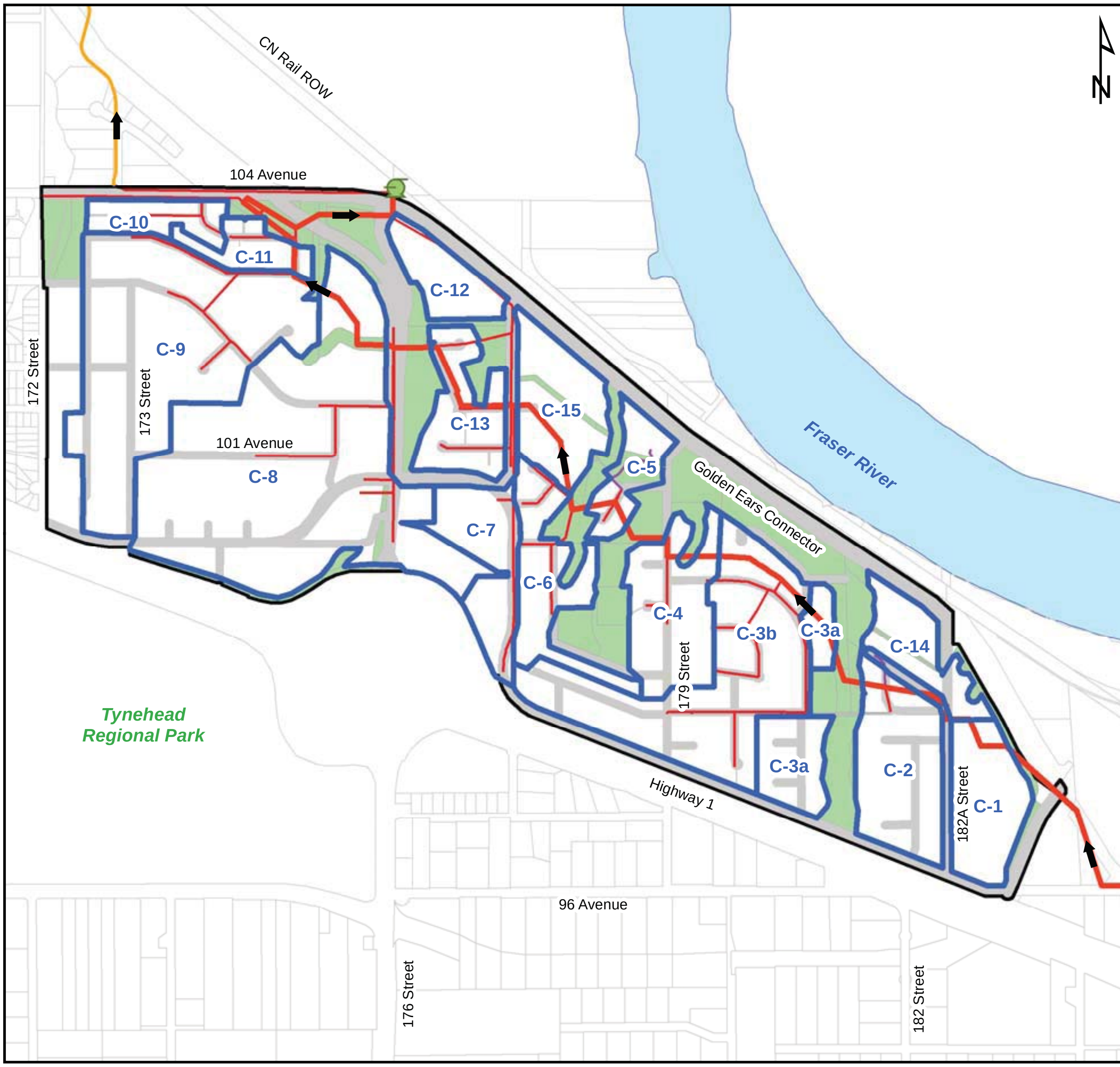
MCSL/CoS</td><td></td></tr>
</table>

ITEM	DISCUSSION	ACTION	
		WHO	WHEN

Meeting Minutes Prepared by: Nav Sandhu

Meeting Minutes Reviewed by: Michael Florendo

Appendix C – Supporting Calculations



Abbey Ridge LAP Sanitary Servicing Concept

SURREY

McElhanney

Project No.	Date
2111-03566-00	2016-09-20

Proposed Subcatchment Areas

Figure C1

Table C1: Abbey Ridge Subcatchment Flow Calculations (Existing Conditions)

Sewage flow per capita:	350	l/capita/day
Infiltration and inflow (I&I):	11200	l/hectare/day

Notes:
1. Population densities were obtained from the City of Surrey Planning Department
2. Peaking factor of 3.57 is based on the Abbey Ridge population of 2,112

						Subcatchment Areas (ha)																
	Zoning (Per Bylaw)	Gross Density (ppha)	UPA	UPHA	Ppl per unit	C-1	C-2	C-3a	C-3b	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14	C-15	Combined
Acreage Residential 1-2 UPA	RH	9	2	4.9	1.76				1.7	3.0		2.2		6.2	3.7							**16.7**
Suburban Residential 2-4 UPA Gross	RH	48	4	9.9	4.88		1.4	1.1	6.7			1.0		1.6	2.9							**14.6**
Urban Transition 4-5 UPA	RF	64	5	12.4	5.15																	**0.0**
Low Density Cluster 4-6 UPA Gross	RF-G	61	6	14.8	4.11																	**0.0**
Single Family Residential 4-6 UPA	RF	82	6	14.8	5.53					0.6	0.9	1.2				1.6	1.8		4.0			**10.0**
Medium Density Cluster 10-12 UPA Gross	RF-10	107	12	29.7	3.62								1.8									**1.8**
Urban Residential 8-10 UPA	RF-12	96	10	24.7	3.89																	**0.0**
Low Density Townhouse 12-15 UPA Gross	RF-SD	122	15	37.1	3.29																	**0.0**
High Density Multiple Residential 25-30 UPA	RM-30	274	30	74.1	3.70																	**0.0**
Neighbourhood Commercial	C-5	102																				**0.0**
Industrial	IL	90									2.2											**2.2**
Institutional	PA-1	50												1.1								**1.1**
Existing Natural Area	N/A																					
Future Natural Area																						
Existing Neighbourhood Park																						
Future Neighbourhood Park																						
Landscape Buffer																						
Total Area						**0.0**	**1.4**	**1.1**	**8.3**	**3.5**	**3.0**	**4.5**	**1.8**	**8.8**	**6.6**	**1.6**	**1.8**	**0.0**	**4.0**	**0.0**	**0.0**	**46**
Total Population						**0**	**66**	**52**	**337**	**71**	**265**	**169**	**195**	**183**	**174**	**131**	**145**	**0**	**325**	**0**	**0**	**2112**
ADWF (Lps)						0.00	0.27	0.21	1.36	0.29	1.07	0.68	0.79	0.74	0.70	0.53	0.59	0.00	1.32	0.00	0.00	8.6
Peaking Factor						4.50	4.29	4.31	4.06	4.28	4.10	4.17	4.15	4.16	4.17	4.21	4.20	4.50	4.06	4.50	4.50	3.57
PDWF (Lps)						0.0	1.1	0.9	5.5	1.2	4.4	2.9	3.3	3.1	2.9	2.2	2.5	0.0	5.3	0.0	0.0	31
I&I (Lps)						0.0	0.2	0.1	1.1	0.5	0.4	0.6	0.2	1.1	0.9	0.2	0.2	0.0	0.5	0.0	0.0	6.0
PWWF (Lps)						0.0	1.3	1.0	6.6	1.7	4.8	3.4	3.5	4.2	3.8	2.4	2.7	0.0	5.9	0.0	0.0	37

Table C2: Abbey Ridge Subcatchment Flow Calculations (see Figure C1)

Sewage flow per capita:	350	l/capita/day
Infiltration and inflow (I&I):	11200	l/hectare/day

Notes:

1. Population densities were obtained from the City of Surrey Planning Department

2. Peaking factor of 3.03 is based on the Abbey Ridge population of 8,321

						Subcatchment Areas (ha)																
	Zoning (Per Bylaw)	Gross Density (ppha)	UPA	UPHA	Ppl per unit	C-1	C-2	C-3a	C-3b	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14	C-15	Combined
Acreage Residential 1-2 UPA	RH	9	2	4.9	1.76			1.3						4.3	8.3							**13.9**
Suburban Residential 2-4 UPA Gross	RH	48	4	9.9	4.88			0.6	7.6	1.3		2.3		7.4	4.0					1.0		**24.2**
Urban Transition 4-5 UPA	RF	64	5	12.4	5.15					0.2		0.9										**1.1**
Low Density Cluster 4-6 UPA Gross	RF-G	61	6	14.8	4.11									2.3						0.7		**3.0**
Single Family Residential 4-6 UPA	RF	82	6	14.8	5.53				1.8	4.0	0.9	1.2		3.3	4.5	2.3	1.9		3.9			**23.8**
Medium Density Cluster 10-12 UPA Gross	RF-10	107	12	29.7	3.62		2.6	1.0													2.7	**6.3**
Urban Residential 8-10 UPA	RF-12	96	10	24.7	3.89		2.6	0.8	2.3	0.3												**6.0**
Low Density Townhouse 12-15 UPA Gross	RF-SD	122	15	37.1	3.29	5.6			0.4			0.4		4.9								**11.3**
High Density Multiple Residential 25-30 UPA	RM-30	274	30	74.1	3.70								2.6	1.9								**4.5**
Neighbourhood Commercial	C-5	102											1.5									**1.5**
Industrial	IL	90									1.1							2.9		1.7	2.4	**8.1**
Institutional	PA-1	50												1.9								**1.9**
Existing Natural Area	N/A																					
Future Natural Area																						
Existing Neighbourhood Park																						
Future Neighbourhood Park																						
Landscape Buffer																						
Total Area						**5.6**	**5.1**	**3.7**	**12.1**	**5.8**	**2.0**	**4.8**	**4.1**	**26.0**	**16.8**	**2.3**	**1.9**	**2.9**	**3.9**	**3.4**	**5.1**	**106**
Total Population						**682**	**523**	**225**	**785**	**434**	**173**	**318**	**867**	**2018**	**634**	**189**	**156**	**261**	**320**	**244**	**506**	**8334**
ADWF (Lps)						2.76	2.12	0.91	3.18	1.76	0.70	1.29	3.51	8.17	2.57	0.76	0.63	1.06	1.30	0.99	2.05	33.8
Peaking Factor						3.90	3.96	4.13	3.87	4.00	4.17	4.07	3.84	3.58	3.92	4.16	4.19	4.10	4.07	4.12	3.97	3.03
PDWF (Lps)						10.8	8.4	3.8	12.3	7.0	2.9	5.2	13.5	29.3	10.1	3.2	2.6	4.3	5.3	4.1	8.1	102
I&I (Lps)						0.7	0.7	0.5	1.6	0.8	0.3	0.6	0.5	3.4	2.2	0.3	0.2	0.4	0.5	0.4	0.7	13.7
PWWF (Lps)						11.5	9.1	4.2	13.9	7.8	3.2	5.9	14.0	32.7	12.2	3.5	2.9	4.7	5.8	4.5	8.8	116

Table C3: Port Kells Flow Calculations

Sewage flow per capita:	350	l/capita/day
Infiltration and inflow (I&I):	11200	l/hectare/day

	Zoning (Per Bylaw)	Gross Density (ppha)	Catchment Area (ha) 1
Light Industrial	IL	90	224.1
Comprehensive Development Zone	CD (modeled as C-8A)	90	20.2
Local/Community Commercial Zone	C-4 / C-8	60	0.6
Total Area			**244.9**
Total Population			**22021**
ADWF (Lps)			89.2
Peaking Factor			2.6
PDWF (Lps)			233
I&I (Lps)			32
PWWF (Lps)			265

Table C4: Proposed Pump Station Catchment Flows

Sewage flow per capita:	350	l/capita/day
Infiltration and inflow (I&I):	11200	l/hectare/day

Notes:
1. Population densities were obtained from the City of Surrey Planning Department

	Zoning (Per Bylaw)	Gross Density (ppha)	UPA	UPHA	Ppl per unit	Subcatchment Areas (ha) C-1	C-2	C-3a	C-14	Combined
Half-Acre Residential	RH	22	2	4.9	4.45			1.9	1.0	**2.8**
Single Family Residential	RF-10	112	12.6	31.1	3.60		2.6	1.0		**3.7**
Single Family Residential	RF-12	89	10	24.7	3.60		2.6	0.8	0.8	**4.1**
Multi Family Residential	RM-10/15/30	206	10/15/30	25/37/74	8.3/5.6/2.8	5.6				**5.6**
Industrial	IL	90							1.6	**1.6**
Institutional	PA-1	50								**0.0**
Existing Natural Area	N/A									
Future Natural Area										
Existing Neighbourhood Park										
Future Neighbourhood Park										
Landscape Buffer										
Total Area						**5.6**	**5.2**	**3.7**	**3.4**	**17.8**
Total Population						**1147**	**523**	**225**	**236**	**2131**
ADWF (Lps)						4.65	2.12	0.91	0.96	8.6
Peaking Factor						3.76	3.96	4.13	4.12	3.56
PDWF (Lps)						17.5	8.4	3.8	3.9	31
I&I (Lps)						0.7	0.7	0.5	0.4	2.3
PWWF (Lps)						18.2	9.1	4.2	4.4	33

Table C5: Sanitary Flows in the Big Bend Trunk Sewer Under Existing Conditions

Subcatchments													Pipe Parameters					
Up Stream Manhole	Down Stream Manhole	Subcatchment No.	Area (ha)	Popl'n	Accum. Area (ha)	Accum. Popl'n	Avg Flow ADWF (L/s)	Peak Factor	Peak Flow PDWF (L/s)	I&I (L/s)	PWWF (L/s)	Design Flow Qdes (L/s)	Pipe Capacity Qcap (L/s)	Flow Ratio Qdes/Qcap	Pipe Dia. (mm)	Slope (%)	Length (m)	Actual Flow Velocity (m/s)
		Port Kells	245	22021	245	22,021	187.0	N/A	187.0	31.8	187.0	187.0						
S-52	S-51				0	0	0.0	4.50	0.0	0.0	0.0	187.0	228.3	0.82	600	0.14%	86.83	0.00
S-51	S-50				0	0	0.0	4.50	0.0	0.0	0.0	187.0	213.8	0.87	600	0.12%	90.76	0.00
S-50	S-49				0	0	0.0	4.50	0.0	0.0	0.0	187.0	214.1	0.87	600	0.12%	90.46	0.00
S-49	S-48				0	0	0.0	4.50	0.0	0.0	0.0	187.0	226.4	0.83	600	0.14%	110.29	0.00
S-48	S-47				0	0	0.0	4.50	0.0	0.0	0.0	187.0	209.4	0.89	600	0.12%	111.82	0.00
S-47	S-46				0	0	0.0	4.50	0.0	0.0	0.0	187.0	203.6	0.92	600	0.11%	5.00	0.00
S-46	S-45				0	0	0.0	4.50	0.0	0.0	0.0	187.0	354.7	0.53	750	0.10%	59.09	0.00
S-45	S-44				0	0	0.0	4.50	0.0	0.0	0.0	187.0	259.1	0.72	600	0.18%	67.40	0.00
S-44	S-43	C-2	1.40	66	1	66	0.3	4.29	1.1	0.2	1.3	188.3	342.3	0.55	750	0.09%	52.89	0.14
S-43	S-42				1	66	0.3	4.29	1.1	0.2	1.3	188.3	335.8	0.56	675	0.16%	31.34	0.17
S-42	S-41				1	66	0.3	4.29	1.1	0.2	1.3	188.3	215.0	0.88	675	0.07%	45.85	0.13
S-41	S-40				1	66	0.3	4.29	1.1	0.2	1.3	188.3	323.1	0.58	675	0.15%	101.50	0.17
S-40	S-39				1	66	0.3	4.29	1.1	0.2	1.3	188.3	234.3	0.80	675	0.08%	6.44	0.15
S-39	S-38	C-3a & C-3b	9.40	388	11	454	1.8	4.00	7.3	1.4	8.7	195.7	342.2	0.57	675	0.17%	93.54	0.33
S-38	S-37				11	454	1.8	4.00	7.3	1.4	8.7	195.7	263.3	0.74	675	0.10%	132.53	0.28
S-37	S-36				11	454	1.8	4.00	7.3	1.4	8.7	195.7	301.4	0.65	675	0.13%	70.01	0.32
S-36	S-35				11	454	1.8	4.00	7.3	1.4	8.7	195.7	301.3	0.65	675	0.13%	77.84	0.32
S-35	S-34				11	454	1.8	4.00	7.3	1.4	8.7	195.7	234.9	0.83	675	0.08%	89.61	0.26
S-34	S-33				11	454	1.8	4.00	7.3	1.4	8.7	195.7	249.2	0.79	675	0.09%	68.27	0.26
S-33	S-32				11	454	1.8	4.00	7.3	1.4	8.7	195.7	315.0	0.62	675	0.14%	121.07	0.31
S-32	S-31	C-4	3.50	71	14	525	2.1	3.96	8.4	1.9	10.3	197.3	354.5	0.56	675	0.18%	44.99	0.34
S-31	S-30				14	525	2.1	3.96	8.4	1.9	10.3	197.3	432.4	0.46	750	0.15%	79.56	0.34
S-30	S-29				14	525	2.1	3.96	8.4	1.9	10.3	197.3	451.0	0.44	750	0.16%	91.40	0.36
S-29	S-28	C-5	3.00	265	17	790	3.2	3.86	12.4	2.2	14.6	201.6	221.8	0.91	750	0.04%	100.73	0.24
S-28	S-27	C-6	4.50	169	22	959	3.9	3.81	14.8	2.8	17.6	204.6	468.0	0.44	750	0.18%	28.29	0.42
S-27	S-26				22	959	3.9	3.81	14.8	2.8	17.6	204.6	458.4	0.45	750	0.17%	53.08	0.42
S-26	S-25				22	959	3.9	3.81	14.8	2.8	17.6	204.6	308.8	0.66	750	0.08%	78.00	0.31
S-25	S-24				22	959	3.9	3.81	14.8	2.8	17.6	204.6	333.9	0.61	750	0.09%	111.14	0.34
S-24	S-23				22	959	3.9	3.81	14.8	2.8	17.6	204.6	485.8	0.42	750	0.19%	36.76	0.44
S-23	S-22	C-7	1.80	195	24	1,154	4.7	3.76	17.6	3.1	20.6	207.6	337.4	0.62	750	0.09%	65.33	0.36
S-22	S-21				24	1,154	4.7	3.76	17.6	3.1	20.6	207.6	304.5	0.68	750	0.07%	53.46	0.33
S-21	S-20				24	1,154	4.7	3.76	17.6	3.1	20.6	207.6	352.2	0.59	750	0.10%	29.98	0.36
S-20	S-19				24	1,154	4.7	3.76	17.6	3.1	20.6	207.6	430.1	0.48	750	0.15%	6.70	0.41
S-19	S-18				24	1,154	4.7	3.76	17.6	3.1	20.6	207.6	381.6	0.54	750	0.12%	110.65	0.39
S-18	S-17				24	1,154	4.7	3.76	17.6	3.1	20.6	207.6	402.1	0.52	750	0.13%	99.64	0.41
S-17	S-16	C-8	8.80	183	32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	677.2	0.31	750	0.37%	14.31	0.58
S-16	S-15				32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	367.7	0.57	750	0.11%	73.32	0.39
S-15	S-14				32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	386.2	0.55	750	0.12%	49.85	0.41
S-14	S-13				32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	265.7	0.80	750	0.06%	70.24	0.31
S-13	S-12				32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	332.5	0.64	750	0.09%	100.91	0.37
S-12	S-11				32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	685.2	0.31	750	0.38%	13.20	0.58
S-11	S-10				32	1,337	5.4	3.72	20.1	4.2	24.3	211.3	2434.6	0.09	750	4.78%	6.90	1.42
S-10	S-9	C-9	6.60	174	39	1,511	6.1	3.68	22.5	5.1	27.6	214.6	2803.5	0.08	750	6.34%	76.64	1.63
S-9	S-8				39	1,511	6.1	3.68	22.5	5.1	27.6	214.6	1572.2	0.14	750	1.99%	146.92	1.14
S-8	S-7				39	1,511	6.1	3.68	22.5	5.1	27.6	214.6	2057.2	0.10	600	11.23%	13.09	2.10
S-7	S-6	C-10	1.60	131	41	1,642	6.7	3.65	24.3	5.3	29.5	216.5	670.1	0.32	600	1.19%	41.98	0.95
S-6	S-5				41	1,642	6.7	3.65	24.3	5.3	29.5	216.5	621.2	0.35	600	1.02%	88.90	0.94
S-5	S-4	C-11	1.80	145	42	1,787	7.2	3.62	26.2	5.5	31.7	218.7	666.6	0.33	600	1.18%	61.09	1.00
S-4	S-3				42	1,787	7.2	3.62	26.2	5.5	31.7	218.7	748.8	0.29	600	1.49%	79.34	1.06
S-3	S-2				42	1,787	7.2	3.62	26.2	5.5	31.7	218.7	619.8	0.35	600	1.02%	90.30	0.93
S-2	S-1	C-13	4.00	325	46	2,112	8.6	3.57	30.5	6.0	36.5	223.5	633.0	0.35	600	1.06%	45.17	1.01
S-1	Big Bend PS				46	2,112	8.6	3.57	30.5	6.0	36.5	223.5	30.8	7.25	300	0.10%	19.65	0.47

Table C6: Sanitary Flows in the Big Bend Trunk Sewer Under Full Build Out Conditions with No Trunk Upgrades (see Figures 3.1 & 3.2)

Subcatchments													Pipe Parameters					
Up Stream Manhole	Down Stream Manhole	Subcatchment No.	Area (ha)	Popl'n	Accum. Area (ha)	Accum. Popl'n	Avg Flow ADWF (L/s)	Peak Factor	Peak Flow PDWF (L/s)	I&I (L/s)	PWWF (L/s)	Design Flow Qdes (L/s)	Pipe Capacity Qcap (L/s)	Flow Ratio Qdes/Qcap	Pipe Dia. (mm)	Slope (%)	Length (m)	Actual Flow Velocity (m/s)
		Port Kells	245	22021	245	22,021	187.0	N/A	187.0	31.8	187.0	187.0						
S-52	S-51				0	0	0.0	4.50	0.0	0.0	0.0	187.0	228.3	0.82	600	0.14%	86.83	0.00
S-51	S-50				0	0	0.0	4.50	0.0	0.0	0.0	187.0	213.8	0.87	600	0.12%	90.76	0.00
S-50	S-49				0	0	0.0	4.50	0.0	0.0	0.0	187.0	214.1	0.87	600	0.12%	90.46	0.00
S-49	S-48	C-1	5.60	682	6	682	2.8	3.90	10.8	0.7	11.5	198.5	226.4	0.88	600	0.14%	110.29	0.36
S-48	S-47				6	682	2.8	3.90	10.8	0.7	11.5	198.5	209.4	0.95	600	0.12%	111.82	0.33
S-47	S-46				6	682	2.8	3.90	10.8	0.7	11.5	198.5	203.6	0.97	600	0.11%	5.00	0.34
S-46	S-45				6	682	2.8	3.90	10.8	0.7	11.5	198.5	354.7	0.56	750	0.10%	59.09	0.32
S-45	S-44				6	682	2.8	3.90	10.8	0.7	11.5	198.5	259.1	0.77	600	0.18%	67.40	0.39
S-44	S-43	C-2	5.10	523	11	1,205	4.9	3.75	18.3	1.4	19.7	206.7	342.3	0.60	750	0.09%	52.89	0.37
S-43	S-42				11	1,205	4.9	3.75	18.3	1.4	19.7	206.7	335.8	0.62	675	0.16%	31.34	0.44
S-42	S-41	C-14	3.40	244	14	1,449	5.9	3.69	21.7	1.8	23.5	210.5	215.0	0.98	675	0.07%	45.85	0.34
S-41	S-40				14	1,449	5.9	3.69	21.7	1.8	23.5	210.5	323.1	0.65	675	0.15%	101.50	0.45
S-40	S-39				14	1,449	5.9	3.69	21.7	1.8	23.5	210.5	234.3	0.90	675	0.08%	6.44	0.37
S-39	S-38	C-3a & C-3b	15.80	1009	30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	342.2	0.66	675	0.17%	93.54	0.55
S-38	S-37				30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	263.3	0.86	675	0.10%	132.53	0.45
S-37	S-36				30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	301.4	0.75	675	0.13%	70.01	0.50
S-36	S-35				30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	301.3	0.75	675	0.13%	77.84	0.50
S-35	S-34				30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	234.9	0.96	675	0.08%	89.61	0.42
S-34	S-33				30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	249.2	0.91	675	0.09%	68.27	0.44
S-33	S-32				30	2,458	10.0	3.51	35.0	3.9	38.9	225.9	315.0	0.72	675	0.14%	121.07	0.51
S-32	S-31	C-4	5.80	434	36	2,892	11.7	3.46	40.5	4.6	45.1	232.1	354.5	0.65	675	0.18%	44.99	0.59
S-31	S-30				36	2,892	11.7	3.46	40.5	4.6	45.1	232.1	432.4	0.54	750	0.15%	79.56	0.55
S-30	S-29				36	2,892	11.7	3.46	40.5	4.6	45.1	232.1	451.0	0.51	750	0.16%	91.40	0.55
S-29	S-28	C-5	2.00	173	38	3,065	12.4	3.43	42.6	4.9	47.5	234.5	221.8	1.06	750	0.04%	100.73	0.34
S-28	S-27	C-6	4.80	318	43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	468.0	0.51	750	0.18%	28.29	0.59
S-27	S-26				43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	458.4	0.52	750	0.17%	53.08	0.60
S-26	S-25				43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	308.8	0.77	750	0.08%	78.00	0.44
S-25	S-24				43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	333.9	0.72	750	0.09%	111.14	0.48
S-24	S-23	C-15 & C-12	8.00	767	51	4,150	16.8	3.32	55.8	6.5	62.3	249.3	485.8	0.51	750	0.19%	36.76	0.66
S-23	S-22	C-7	4.10	867	55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	337.4	0.77	750	0.09%	65.33	0.52
S-22	S-21				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	304.5	0.85	750	0.07%	53.46	0.49
S-21	S-20				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	352.2	0.74	750	0.10%	29.98	0.55
S-20	S-19				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	430.1	0.60	750	0.15%	6.70	0.63
S-19	S-18				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	381.6	0.68	750	0.12%	110.65	0.58
S-18	S-17				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	402.1	0.65	750	0.13%	99.64	0.59
S-17	S-16	C-8	26.00	2018	81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	677.2	0.42	750	0.37%	14.31	0.94
S-16	S-15				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	367.7	0.78	750	0.11%	73.32	0.61
S-15	S-14				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	386.2	0.74	750	0.12%	49.85	0.64
S-14	S-13				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	265.7	1.08	750	0.06%	70.24	0.48
S-13	S-12				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	332.5	0.86	750	0.09%	100.91	0.57
S-12	S-11				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	685.2	0.42	750	0.38%	13.20	0.95
S-11	S-10				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	2434.6	0.12	750	4.78%	6.90	2.21
S-10	S-9	C-9	16.80	634	97	7,669	31.1	3.07	95.3	12.6	107.9	294.9	2803.5	0.11	750	6.34%	76.64	2.55
S-9	S-8				97	7,669	31.1	3.07	95.3	12.6	107.9	294.9	1572.2	0.19	750	1.99%	146.92	1.76
S-8	S-7				97	7,669	31.1	3.07	95.3	12.6	107.9	294.9	2057.2	0.14	600	11.23%	13.09	3.27
S-7	S-6	C-10	2.30	189	100	7,858	31.8	3.06	97.3	12.9	110.3	297.3	670.1	0.44	600	1.19%	41.98	1.50
S-6	S-5				100	7,858	31.8	3.06	97.3	12.9	110.3	297.3	621.2	0.48	600	1.02%	88.90	1.43
S-5	S-4	C-11	1.90	156	102	8,014	32.5	3.05	99.0	13.2	112.2	299.2	666.6	0.45	600	1.18%	61.09	1.49
S-4	S-3				102	8,014	32.5	3.05	99.0	13.2	112.2	299.2	748.8	0.40	600	1.49%	79.34	1.63
S-3	S-2				102	8,014	32.5	3.05	99.0	13.2	112.2	299.2	619.8	0.48	600	1.02%	90.30	1.43
S-2	S-1	C-13	3.90	320	106	8,334	33.8	3.03	102.4	13.7	116.1	303.1	633.0	0.48	600	1.06%	45.17	1.46
S-1	Big Bend PS				106	8,334	33.8	3.03	102.4	13.7	116.1	303.1	30.8	9.82	300	0.10%	19.65	0.46

Table C7: Sanitary Flows in the Big Bend Trunk Sewer Under Full Build Out Conditions with Upgrades (see Figures 7-9)

Subcatchments													Pipe Parameters					
Up Stream Manhole	Down Stream Manhole	Subcatchment No.	Area (ha)	Popl'n	Accum. Area (ha)	Accum. Popl'n	Avg Flow ADWF (L/s)	Peak Factor	Peak Flow PDWF (L/s)	I&I (L/s)	PWWF (L/s)	Design Flow Qdes (L/s)	Pipe Capacity Qcap (L/s)	Flow Ratio Qdes/Qcap	Pipe Dia. (mm)	Slope (%)	Length (m)	Actual Flow Velocity (m/s)
		Port Kells	245	22021	245	22,021	187.0	N/A	187.0	31.8	187.0	187.0						
S-52	S-51				0	0	0.0	4.50	0.0	0.0	0.0	187.0	228.3	0.82	600	0.14%	86.83	0.00
S-51	S-50				0	0	0.0	4.50	0.0	0.0	0.0	187.0	213.8	0.87	600	0.12%	90.76	0.00
S-50	S-49				0	0	0.0	4.50	0.0	0.0	0.0	187.0	214.1	0.87	600	0.12%	90.46	0.00
S-49	S-48				0	0	0.0	4.50	0.0	0.0	0.0	187.0	226.4	0.83	600	0.14%	110.29	0.00
S-48	S-47				0	0	0.0	4.50	0.0	0.0	0.0	187.0	209.4	0.89	600	0.12%	111.82	0.00
S-47	S-46				0	0	0.0	4.50	0.0	0.0	0.0	187.0	203.6	0.92	600	0.11%	5.00	0.00
S-46	S-45				0	0	0.0	4.50	0.0	0.0	0.0	187.0	354.7	0.53	750	0.10%	59.09	0.00
S-45	S-44				0	0	0.0	4.50	0.0	0.0	0.0	187.0	259.1	0.72	600	0.18%	67.40	0.00
S-44	S-43				0	0	0.0	4.50	0.0	0.0	0.0	187.0	342.3	0.55	750	0.09%	52.89	0.00
S-43	S-42				0	0	0.0	4.50	0.0	0.0	0.0	187.0	335.8	0.56	675	0.16%	31.34	0.00
S-42	S-41				0	0	0.0	4.50	0.0	0.0	0.0	187.0	215.0	0.87	675	0.07%	45.85	0.00
S-41	S-40				0	0	0.0	4.50	0.0	0.0	0.0	187.0	323.1	0.58	675	0.15%	101.50	0.00
S-40	S-39				0	0	0.0	4.50	0.0	0.0	0.0	187.0	234.3	0.80	675	0.08%	6.44	0.00
S-39	S-38	C-3b	12.10	785	12	785	3.2	3.87	12.3	1.6	13.9	200.9	342.2	0.59	675	0.17%	93.54	0.38
S-38	S-37				12	785	3.2	3.87	12.3	1.6	13.9	200.9	263.3	0.76	675	0.10%	132.53	0.33
S-37	S-36				12	785	3.2	3.87	12.3	1.6	13.9	200.9	301.4	0.67	675	0.13%	70.01	0.36
S-36	S-35				12	785	3.2	3.87	12.3	1.6	13.9	200.9	301.3	0.67	675	0.13%	77.84	0.36
S-35	S-34				12	785	3.2	3.87	12.3	1.6	13.9	200.9	234.9	0.85	675	0.08%	89.61	0.31
S-34	S-33				12	785	3.2	3.87	12.3	1.6	13.9	200.9	249.2	0.81	675	0.09%	68.27	0.31
S-33	S-32				12	785	3.2	3.87	12.3	1.6	13.9	200.9	315.0	0.64	675	0.14%	121.07	0.38
S-32	S-31	C-1, C-2, C-3a, C-4, & C-14	23.60	2107	36	2,892	11.7	3.46	40.5	4.6	45.1	232.1	354.5	0.65	675	0.18%	44.99	0.59
S-31	S-30				36	2,892	11.7	3.46	40.5	4.6	45.1	232.1	432.4	0.54	750	0.15%	79.56	0.55
S-30	S-29				36	2,892	11.7	3.46	40.5	4.6	45.1	232.1	451.0	0.51	750	0.16%	91.40	0.55
S-29	S-28	C-5	2.00	173	38	3,065	12.4	3.43	42.6	4.9	47.5	234.5	360.7	0.65	900	0.04%	100.73	0.34
S-28	S-27	C-6	4.80	318	43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	468.0	0.51	750	0.18%	28.29	0.59
S-27	S-26				43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	458.4	0.52	750	0.17%	53.08	0.60
S-26	S-25				43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	308.8	0.77	750	0.08%	78.00	0.44
S-25	S-24				43	3,383	13.7	3.40	46.6	5.5	52.1	239.1	333.9	0.72	750	0.09%	111.14	0.48
S-24	S-23	C-15 & C-12	8.00	767	51	4,150	16.8	3.32	55.8	6.5	62.3	249.3	485.8	0.51	750	0.19%	36.76	0.66
S-23	S-22	C-7	4.10	867	55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	337.4	0.77	750	0.09%	65.33	0.52
S-22	S-21				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	304.5	0.85	750	0.07%	53.46	0.49
S-21	S-20				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	352.2	0.74	750	0.10%	29.98	0.55
S-20	S-19				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	430.1	0.60	750	0.15%	6.70	0.63
S-19	S-18				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	381.6	0.68	750	0.12%	110.65	0.58
S-18	S-17				55	5,017	20.3	3.24	65.9	7.1	73.0	260.0	402.1	0.65	750	0.13%	99.64	0.59
S-17	S-16	C-8	26.00	2018	81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	677.2	0.42	750	0.37%	14.31	0.94
S-16	S-15				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	367.7	0.78	750	0.11%	73.32	0.61
S-15	S-14				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	386.2	0.74	750	0.12%	49.85	0.64
S-14	S-13				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	432.0	0.66	900	0.06%	70.24	0.48
S-13	S-12				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	332.5	0.86	750	0.09%	100.91	0.57
S-12	S-11				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	685.2	0.42	750	0.38%	13.20	0.95
S-11	S-10				81	7,035	28.5	3.10	88.5	10.4	98.9	285.9	2434.6	0.12	750	4.78%	6.90	2.21
S-10	S-9	C-9	16.80	634	97	7,669	31.1	3.07	95.3	12.6	107.9	294.9	2803.5	0.11	750	6.34%	76.64	2.55
S-9	S-8				97	7,669	31.1	3.07	95.3	12.6	107.9	294.9	1572.2	0.19	750	1.99%	146.92	1.76
S-8	S-7				97	7,669	31.1	3.07	95.3	12.6	107.9	294.9	2057.2	0.14	600	11.23%	13.09	3.27
S-7	S-6	C-10	2.30	189	100	7,858	31.8	3.06	97.3	12.9	110.3	297.3	670.1	0.44	600	1.19%	41.98	1.50
S-6	S-5				100	7,858	31.8	3.06	97.3	12.9	110.3	297.3	621.2	0.48	600	1.02%	88.90	1.43
S-5	S-4	C-11	1.90	156	102	8,014	32.5	3.05	99.0	13.2	112.2	299.2	666.6	0.45	600	1.18%	61.09	1.49
S-4	S-3				102	8,014	32.5	3.05	99.0	13.2	112.2	299.2	748.8	0.40	600	1.49%	79.34	1.63
S-3	S-2				102	8,014	32.5	3.05	99.0	13.2	112.2	299.2	619.8	0.48	600	1.02%	90.30	1.43
S-2	S-1	C-13	3.90	320	106	8,334	33.8	3.03	102.4	13.7	116.1	303.1	633.0	0.48	600	1.06%	45.17	1.46
S-1	Big Bend PS				106	8,334	33.8	3.03	102.4	13.7	116.1	303.1	30.8	9.82	300	0.10%	19.65	0.46

Appendix D – Cost Estimate Calculations

Abbey Ridge Sanitary Servicing Strategy **13 December 2016**
Proposed Improvements

Sewer Pipe Improvements

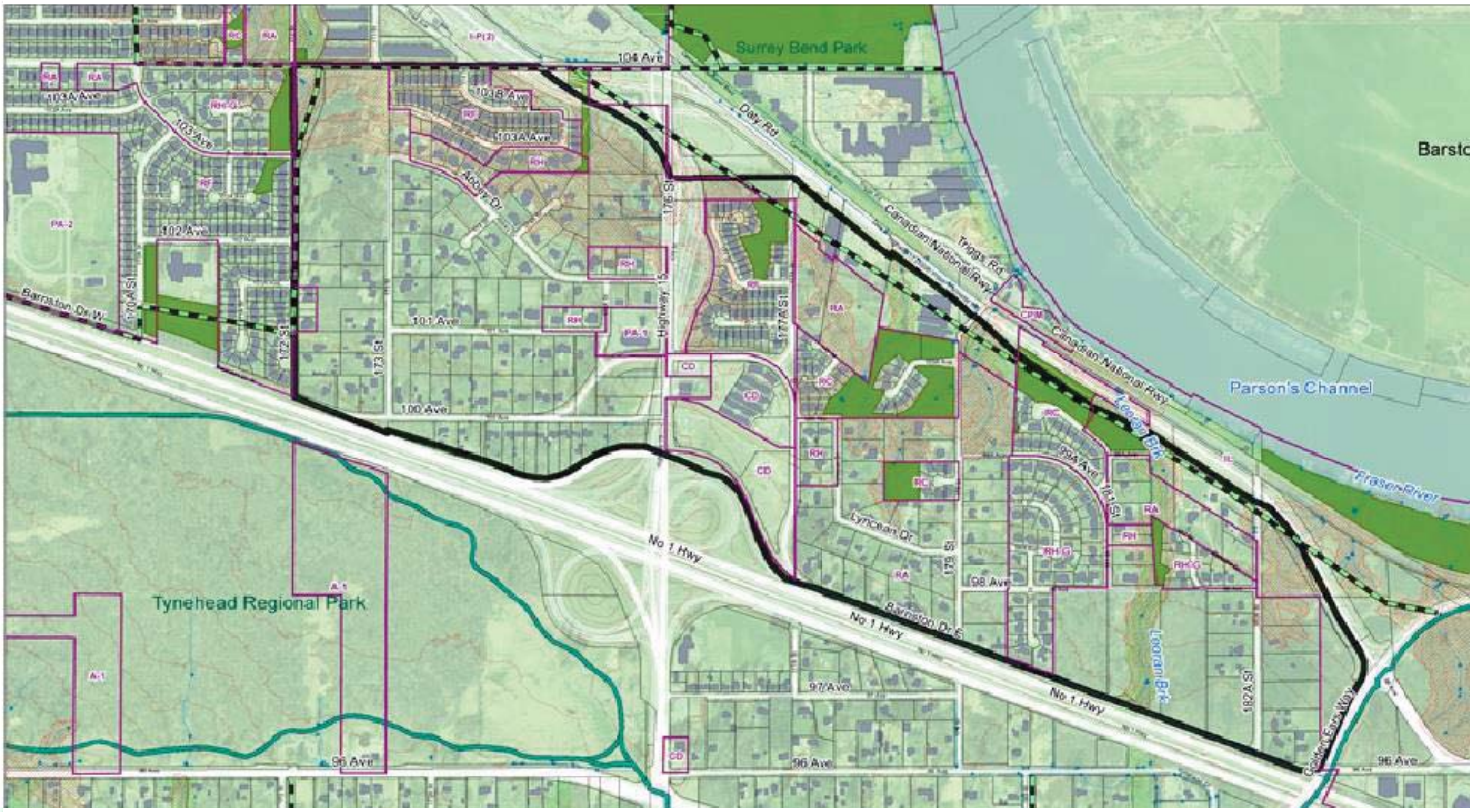
	Unit	Quantity	Unit Rate	Sub-total			Total	Notes
Big Bend Trunk Sewer Upgrades								
Segment 1 - S-13 to S-14 (900mm dia.)	m	70	$2,530	$132,825			$132,825	unit rate based on City data, 0.75x factor for raw land
Segment 2 - S-28 to S-29 (900mm dia.)	m	101	$2,530	$255,530			$255,530	unit rate based on City data
Easement, 5m, S-13 to S-14	m^2	600	$242.00	$145,200			$145,200	land acquisition unit rates provided by City
Easement, 5m, S-28 to S-29	m^2	110	$464.00	$51,040			$51,040	land acquisition unit rates provided by City
Working easement, year rental	m^2	684	$30.00	$20,520			$20,520	working easement rental unit rates provided by City, L=171m, W=4m
sub-total				**$605,115**			**$605,115**	
New Local Sewers								
200mm PVC, incl. service connections	m	5320	$1,281	$6,814,920			$6,814,920	installed costs, cut and cover method, does not include traffic control
250mm PVC, incl. service connections	m	300	$1,371	$411,300			$411,300	installed costs, cut and cover method, does not include traffic control
sub-total				**$7,226,220**			**$7,226,220**	
New Low Pressure System								
100mm PVC, incl. intermediate/terminal COs	m	1100	$800	$880,000			$880,000	installed costs, cut and cover method, does not include traffic control
Private pumps and service connections	ea	24	$40,000	$960,000			$960,000	incls. valve chamber, pump wet well, vent pipe, electrial work, materials
sub-total				**$1,840,000**			**$1,840,000**	
SUB-TOTAL SEWER PIPE IMPROVEMENTS							**$9,671,335**	

Pump Stations and Forcemains

	Unit	Quantity	Unit Rate	Sub-total	Eng, 15%	Cont, 30%	Total	Notes
Local Pump Station, 182A Street c/w duplex pumps, wet well, chamber, hatch, accessories, piping, connections, controls, etc., Q=33 Lps	LS	1	$690,000	$690,000	$103,500	$207,000	$1,000,500	incls. $150k for pumps / equipment, land acquisition, ROW assumes underground station with controls cabinet
Forcemain, 200mm HDPE	m	790	$880	$695,200	incl. in unit rates		$695,200	eng/contingency 12%/20%
sub-total				**$1,385,200**			**$1,695,700**	
Community Pump Station, 177A Street c/w duplex pumps, wet well, chamber, hatch, accessories, piping, connections, controls, etc., Q=2.2 lps	LS	1	$415,000	$415,000	$62,250	$124,500	$601,750	incls. $100k for pumps / equipment, land acquisition, ROW assumes underground station with controls cabinet
Forcemain, 100mm HDPE	m	200	$780	$156,000	incl. in unit rates		$156,000	eng/contingency 12%/20%
sub-total							**$757,750**	
SUB-TOTAL PUMP STATIONS & FORCEMAINS							**$2,453,450**	
TOTAL ALL ITEMS							**$12,124,785**	

Prepared for:

Abbey Ridge Local Area Plan
Stormwater Servicing Strategy
Final Report – 8 December 2016



McElhanney

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2111-03570-00

McElhanney

December 09, 2016
Our File: 2111-03570-00

City of Surrey
Engineering Department – Drainage Section
13450 104 Avenue
Surrey, BC V3T 1V8

Attention: Jeannie Lee, M.A.Sc, P.Eng.
Project Engineer

RE: Abbey Ridge Local Area Plan Stormwater Servicing Strategy

McElhanney Consulting Services Ltd. is pleased to provide a signed and sealed copy of the Stormwater Servicing Strategy for the Abbey Ridge Local Area Plan.

The report provides a summary of the analysis completed during the study and outlines the recommended stormwater servicing strategy to allow further development of Abbey Ridge. We believe this strategy is most appropriate for the study area to achieve the objectives for development.

Please contact the undersigned should you have any questions or comments related to this study.

Yours truly,

MCELHANNEY CONSULTING SERVICES LTD.

Prepared by:

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Senior Water Resources Engineer

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Executive Summary

The City of Surrey (the City) retained McElhanney Consulting Services Ltd. (McElhanney) to complete a stormwater servicing strategy for the Abbey Ridge Local Area Plan (LAP) area. Currently, Abbey Ridge is not developed to its full potential, with approximately half of the study area slated for rezoning and future development. It is mostly occupied by large acreages and single family residential lots along with some institutional and commercial areas. The future land use plan adopted by the City indicates a mix of single and multi-family residential, commercial, and industrial land uses. This development will increase the imperviousness of the catchment, increasing runoff rates and volumes.

Hydrology and hydraulics analysis of the existing system confirmed various locations where the existing system is undersized to accommodate current and future flows. An in-field erosion and stability assessment of the various existing erosion sites within the watercourses determined two particular sites that are of concern and sensitive to any increase in runoff rates and volumes.

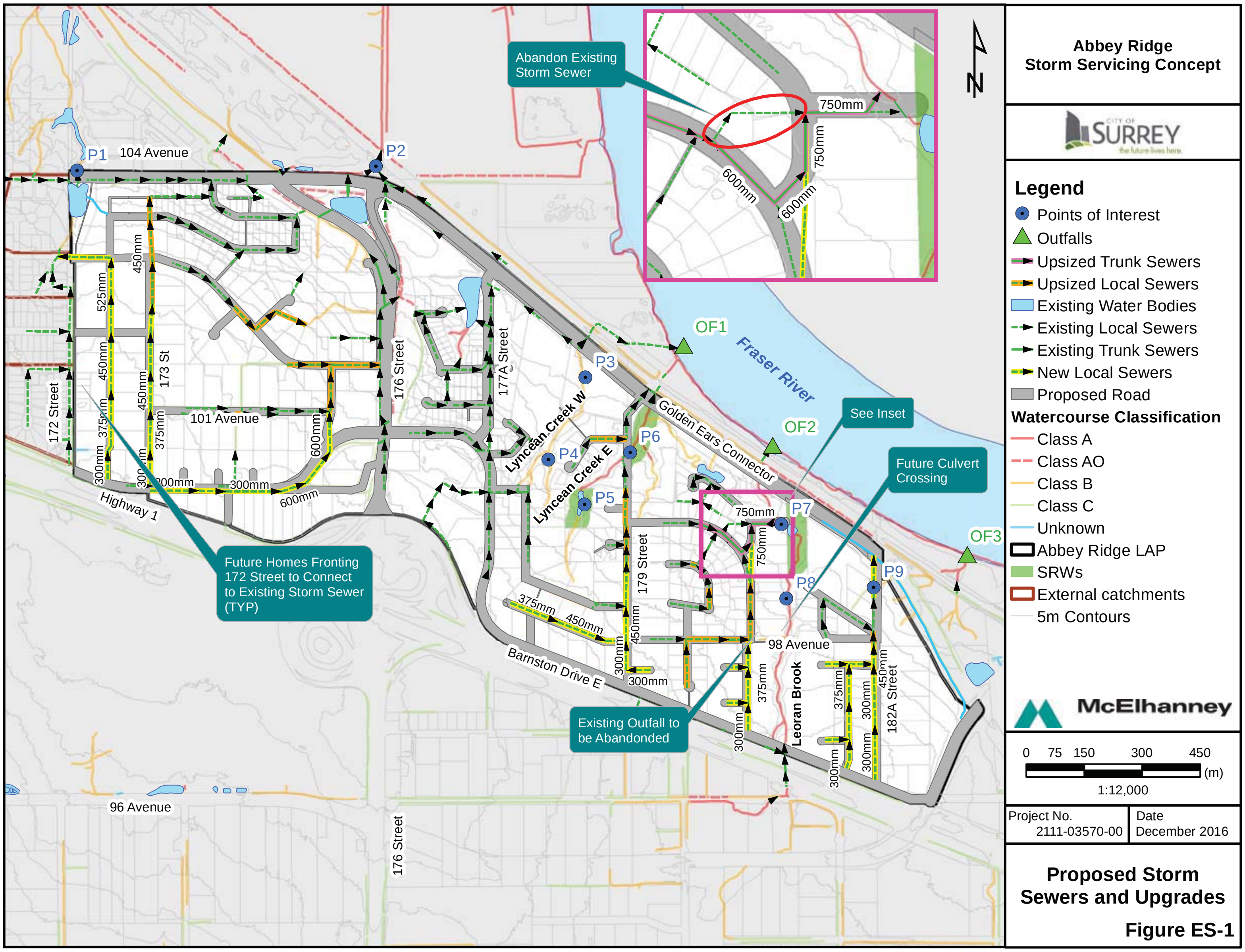
The general approach to the proposed stormwater servicing was to identify required local and trunk sewer upgrades, on-site detention and provide Low Impact Development (LID) systems that promote impervious disconnection, absorption, and some partial infiltration of runoff to reduce discharge rates and volumes to the receiving downstream systems. This approach provides the necessary upgrades and rates / volume controls at key locations to allow for development while providing the required conveyance capacity and drainage level of service for the area.

The proposed conveyance upgrades are shown in *Figure ES-1*. The proposed stormwater controls consist of on-site detention and LIDs placed on private lots and within the road Right-of-Way (ROW). A Statutory Right-of-Way (SRW) would be required at the outlet of the culvert beneath 179 Street along Lyncean Creek (east tributary). *Figure ES-2* shows the locations requiring these controls, and *Table ES-1* presents a summary of the required controls for each zone.

Table ES-1: Pre and Post-development flow at Control Points

Land Use	Zoning	LIDs required
Single Family Residential / Cluster (1-10 UPA)	RH-G, RF, RF-9/12	- Disconnected Roof Leaders directing runoff to splash pads - 450mm enhanced / amended top soil on all pervious areas
Multiple Family Residential (12-30 UPA)	RM-15, RM-30, RM-45	- On-site detention to reduce offsite discharges to 15 and 25 l/s/ha during the 5 year and 100 years events respectively. - 450mm enhanced / amended top soil on all pervious areas
Commercial and Industrial	IL, C-5	- On-site detention to reduce offsite discharges to 15 and 25 l/s/ha during the 5 year and 100 years events respectively. - 450mm enhanced / amended top soil on all pervious areas
Institution, School, Church	PA-1	- On-site detention to reduce offsite discharges to 15 and 25 l/s/ha during the 5 year and 100 years events respectively. - 450mm enhanced / amended top soil on all pervious areas

Storm DCC expenditures benefitting Abbey Ridge are limited to the 106m of 600mm and 123m of 750mm diameter trunk sewer upgrade and associated outfall works within the study area's eastern portion. The estimated construction cost for this item is $660,330, while the projected drainage DCC revenue calculation for the Abbey Ridge Area estimated a revenue of $5,367,522. Based on the total costs of the proposed storm works, we anticipate that storm DCC revenues will be adequate to fund the DCC eligible storm works for the area.


Abbey Ridge
Storm Servicing Concept
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Legend
Points of Interest
Outfalls
Upsized Trunk Sewers
Upsized Local Sewers
Existing Water Bodies
Existing Local Sewers
Existing Trunk Sewers
New Local Sewers
Proposed Road
Watercourse Classification
Class A
Class AO
Class B
Class C
Unknown
Abbey Ridge LAP
SRWs
External catchments
5m Contours
McElhanney
0 75 150 300 450 (m)
1:12,000
Project No.
2111-03570-00
Date
December 2016
Proposed Storm
Sewers and Upgrades
Figure ES-1
Abandon Existing
Storm Sewer
750mm
600mm
750mm
600mm
See Inset
Future Culvert
Crossing
Future Homes Fronting
172 Street to Connect
to Existing Storm Sewer
(TYP)
Existing Outfall to
be Abandonded
P1
P2
P3
P4
P5
P6
P7
P8
P9
OF1
OF2
OF3
104 Avenue
101 Avenue
98 Avenue
96 Avenue
172 Street
173 St
176 Street
177A Street
179 Street
182A Street
Highway 1
Barnston Drive E
Golden Ears Connector
Fraser River
Lyncean Creek W
Lyncean Creek E
Leoran Brook
525mm
450mm
450mm
450mm
375mm
375mm
300mm
300mm
300mm
300mm
600mm
600mm
375mm
450mm
450mm
300mm
300mm
750mm
750mm
375mm
300mm
375mm
300mm
450mm
300mm
300mm

Abbey Ridge
Storm Servicing Concept

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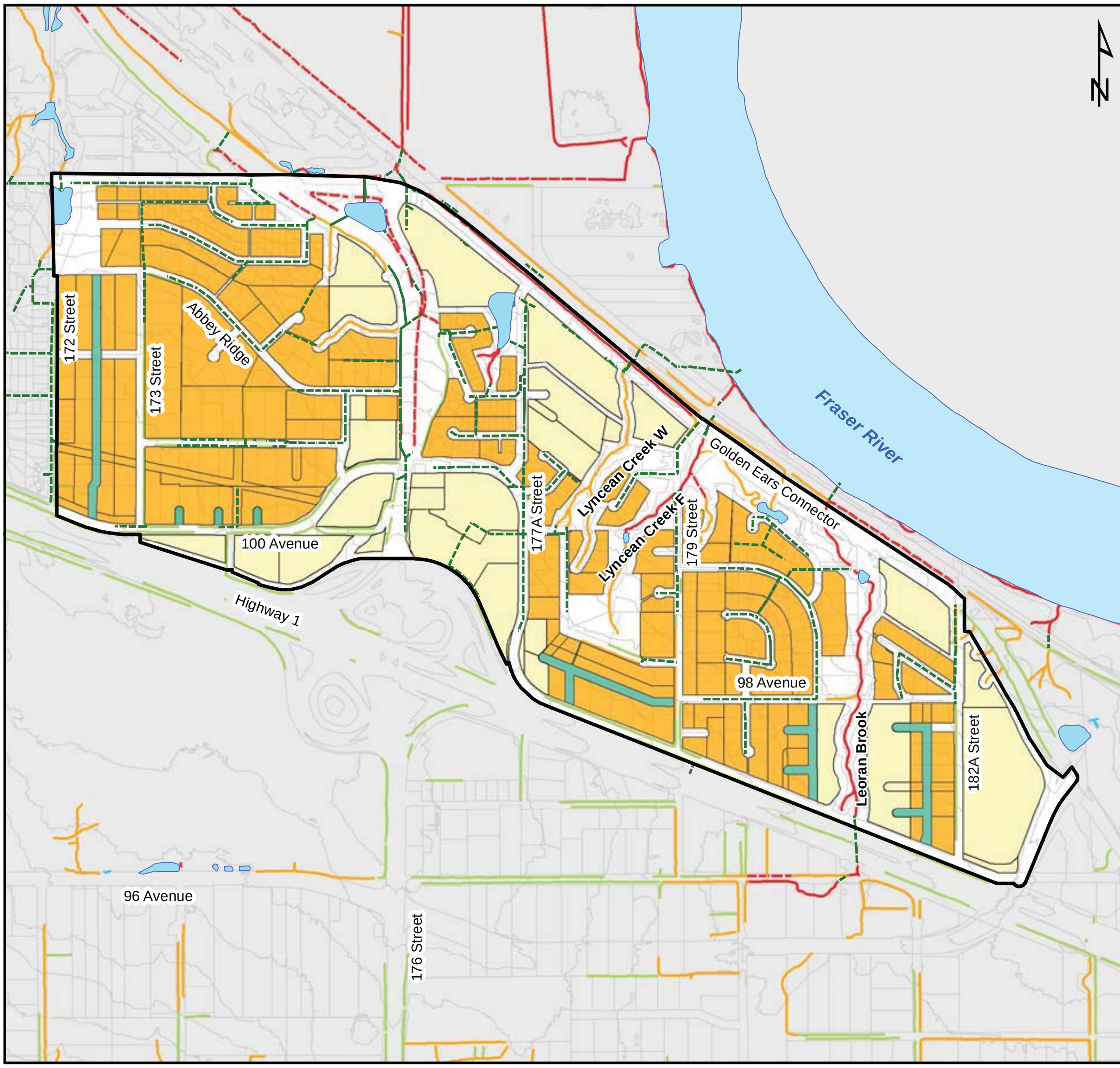

Legend

- Abbey Ridge LAP
- Existing Water Bodies
- Existing Local Sewers
- Existing Trunk Sewers
- On Lot LIDs
- Road ROW LIDs
- On-site Detention

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- 5m Contours

McElhanney

0 75 150 300 450 (m)

1:12,000

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LID Locations and On-site Detention

Figure ES-2

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Appendix A: Geotechnical Report

Appendix B: Design Storm Hyetographs

Appendix C: Model Results

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1. Introduction

This stormwater servicing study completed by McElhanney was commissioned by the City as a result of a new land use proposed and adopted by the City in late 2015. This study reviewed current and future stormwater uses in preparation for the proposed densification of Abbey Ridge.

In this document you will find:

- The existing watershed conditions within the Abbey Ridge LAP, including topography and terrain, drainage catchments, land use, environmental resources, and anticipated development trends
- A summary of the existing drainage system's performance
- Key constraints and opportunities
- The location of existing and future local and trunk storm sewers and outfalls
- A summary of the geotechnical investigation of slope stability and key erosion sites as it relates to the existing drainage system and proposed upgrades

1.1. Project Background & Objectives

Abbey Ridge is located in northeast Surrey and is bordered by the Fraser River to the northeast, Highway 1 to the south, Port Kells to the east, 104 Avenue to the north, and 172 Street to the west. The primary increase in densification will come from development of existing acreage lots to higher density residential areas. This proposed re-development requires extending the basic stormwater collection system and involves upgrades to some of the larger pipes as flows reach low-lying areas. In addition, several small streams with known erosion concerns drain to lands at the toe of slope, and flooding has historically been a concern within the lowland areas including along Daly Road and lumber mill located between the CN Railway and Fraser River. Therefore, a review of area servicing is needed to confirm that development can proceed without impacting existing lands, both within the development area and in surrounding areas.

The project objective is to identify the stormwater infrastructure needed to service the planned ultimate development land use within the Abbey Ridge LAP area. The recommended servicing must meet or exceed the requirements of the City's current design guidelines and the Bon Accord – North Slope (East) Integrated Stormwater Management Plan (ISMP).

This document recommends Best Management Practices (BMPs) developers shall implement to meet runoff rates, volumes, and water quality objectives for the area. These BMP recommendations provide sufficient detail for consistent implementation by developers. They also provide the City with a reasonable level of confidence that the development will meet area design objectives, which include:

- Managing road runoff and mitigating residential and commercial development impacts in order to maintain pervious surfaces, trees, and infiltration
- Providing clear instructions on suitable mitigation measures to include in the development designs so they meet the ISMP requirements and good design standards
- Obtaining sufficient water quality for the safety of fish and the enjoyment of local waters by residents
- Obtaining acceptance by the City Planning and Engineering Operations departments, residents, and development community

1.2. Background Information

McElhanney reviewed the following background information relevant to the stormwater planning undertaken as part of this study:

- Golden Ears Connector – Detail Design Drawings, MoTI, 2016
- Abbey Ridge Land Use Concept Plan, Stage 1 Preferred Option, City of Surrey, December 2015
- Bon Accord – North Slope (East) Integrated Stormwater Management Plan, Associated Engineering, May 2015
- East Fraser Heights Environmental Assessment Report. 2015. Phoenix Environmental
- Ravine Stability Assessment, Tetra Tech, 2014
- Anniedale-Tynehead Neighbourhood Concept Plan (NCP), City of Surrey, April 2012
- Port Mann / Highway 1 Project Environmental Assessment Certificate Application, September 2007
- South Fraser Perimeter Road Fish Habitat Impact Assessment, Coast River Environmental Services, September 2006
- South Fraser Perimeter Road Environmental Assessment Application, Hemmera, September 2006
- North Bluff Drainage and Slope Stability Assessment, Final Report, Stantec, March 2000

2. Existing Stormwater Servicing

The Abbey Ridge LAP is approximately 183 hectares (ha) in size and is bounded by the Fraser River to the north, 172 Street to the west, Golden Ears Way to the east, and Highway 1 to the south. Located within the Big Bend and Port Kells watersheds, the study area is comprised of single family residential lots, transportation corridors, and industrial, institutional, and commercial areas.

2.1. Study Area

Figure 1 shows the Abbey Ridge LAP area boundaries along with the proposed land use plan adopted by the City. The area's terrain is characterized by three distinct landscapes:

- A gently sloped upland area to the south of the terrain
- A relatively flat lowland area along the north boundary
- A moderately steep transition zone between the upland and the lowland, known commonly as the Surrey escarpment (the majority of the Abbey Ridge LAP area is within this escarpment zone)

The upland area has elevations ranging between 40m and 65m. This area is mostly located in the southwest of the terrain and is sparsely developed with suburban residences. In general, it slopes down to the north and east.

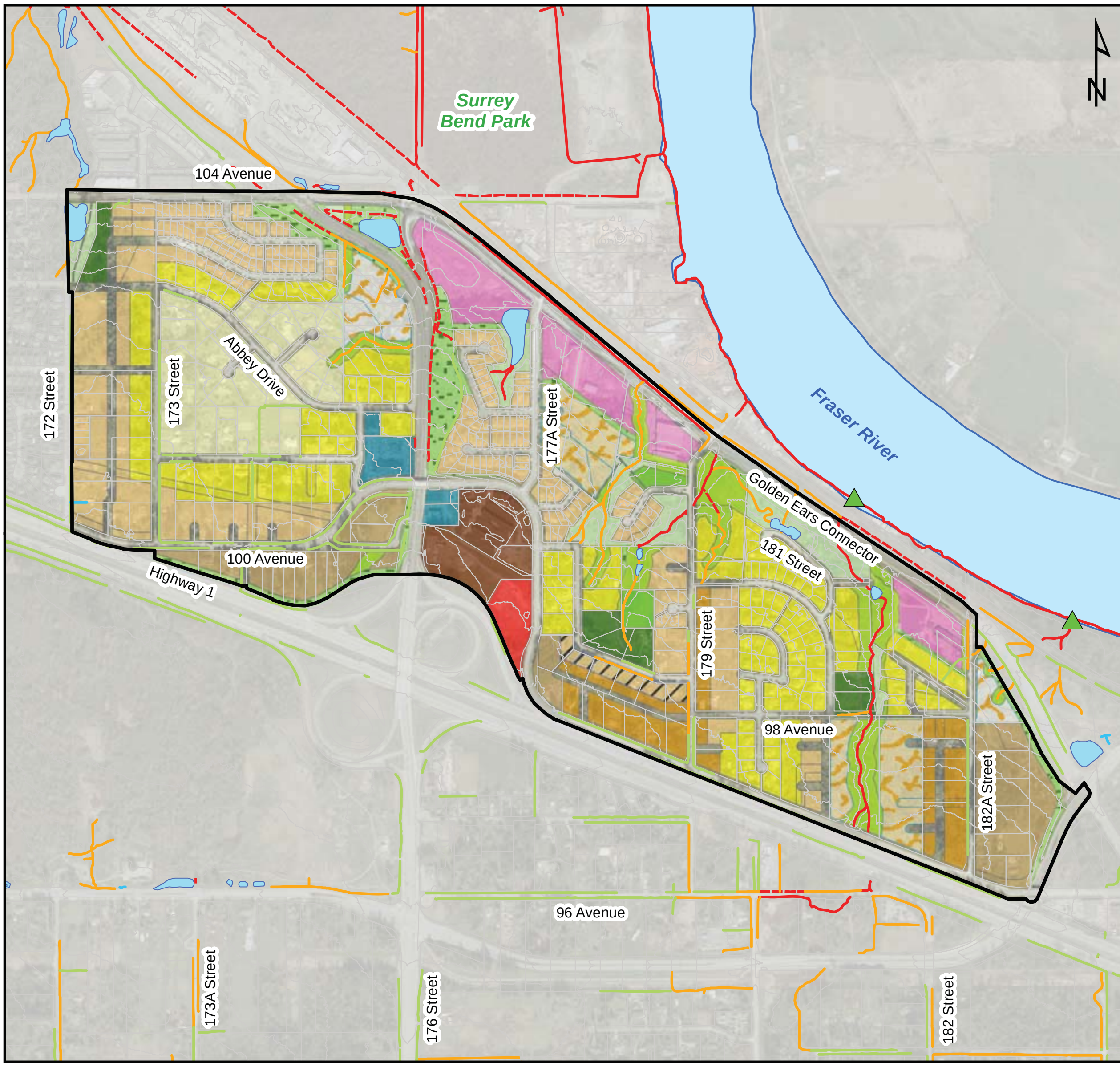
The escarpment zone has elevations ranging between 15m and 55m. Some areas have already been developed with urban residential and transportation corridors. Other areas remain largely undeveloped, especially those adjacent to watercourses. The escarpment slopes down in the northeast direction with slopes as steep as 50%. Some pools have formed in the transition of the escarpment to the lowlands along the watercourses.

Lowlands at the base of the escarpment are located within the Fraser River floodplain and have elevations ranging between 3m and 15m. The area is highly developed with transportation corridors and light impact industry, including the newly constructed Golden Ears Connector. Runoff coming from the uplands and the escarpment zone flows towards the Fraser River through culverts beneath the Golden Ears Connector and CN railway. The lowland areas are not dyked and the 2015 Bon Accord – North Slope ISMP reports that dykes are unlikely to be built in the future. The fluctuating water levels within the Fraser River therefore dictate water levels and performance of the drainage system within the lowland areas, particularly during high winter water levels periods and the spring freshet. The current 200-year flood plain elevation (with 0.6m freeboard) ranges from 5.9m at the western extent of the study area at 172 Street to 6.2m at the eastern extent at 182A Street, as reported by the Fraser River Hydraulics Model Updated Report (March 2008).

2.2. Land Use

Currently, there are 522 residential lots / units within the Abbey Ridge neighbourhood area. The Abbey Ridge neighbourhood area also includes approximately 8.6 ha (21.3ac) of industrial, 2.0 ha (5ac) of institutional and 1.5 ha (3.7ac) of commercial use.

The Port Kells area is an industrial-designated subarea located east of the Abbey Ridge NCP, north of Highway 1. This area is almost entirely zoned Light Impact Industrial (IL) with a small number of Comprehensive Development (CD) spot-zoned parcels for light industrial uses. Based on 2015 air photo data, the Port Kells area appears to be fully utilized with only a small percentage of parcels not having any buildings present.



**Abbey Ridge
Storm Servicing Concept**

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Legend

Outfalls
Abbey Ridge LAP
Existing Water Bodies
Watercourse Classification
Class A
Class AO
Class B
Class C
Unknown
5m Contours
Future land use
Acreage Residential 1-2 UPA
Suburban Residential 2-4 UPA Gross
Urban Transition 4-5 UPA
Low Density Cluster 4-6 UPA Gross
Single Family Residential 4-6 UPA
Medium Density Cluster 10-12 UPA Gross
Urban Residential 8-10 UPA
Low Density Multiple Residential 10-15 UPA Gross
High Density Multiple Residential 25-30 UPA
Neighbourhood Commercial
Industrial
Institutional
Existing Natural Area
Future Natural Area
Existing Neighbourhood Park
Future Neighbourhood Park
Landscape Buffer
External Area

McElhanney

0 75 150 300 450 (m)
1:12,000

Project No.	Date
2111-03570-00	December 2016

**Abbey Ridge
Local Area Plan**

Figure 1

2.3. Climate

According to the City's Design Criteria Manual, the Abbey Ridge LAP lies within the North Rainfall Area and experiences similar rainfall as the Kwantlen Park rainfall gauge.

Table 1 summarizes the 1980-2010 climatic normal data at this station. It can be observed that the average total annual rainfall is 1521.5mm, with 97% of the precipitation in the form of rainfall. On average, 41% of the total yearly rainfall occurs between November and January. The driest months are July and August when only 6% of the average total annual rainfall occurs.

Table 1: Canadian Climate Normals Station Data, 1981-2010, Surrey Kwantlen Park

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation (mm)	219.2	137.4	142.2	124.8	93.9	73.7	48.1	49.3	68.4	167.4	241.4	196.5	1562.3
Rainfall (mm)	204.4	128.6	139.0	124.7	93.9	73.7	48.1	49.3	68.4	167.1	238.2	186.2	1521.5
Snowfall (mm)	14.8	8.8	3.1	0.2	0.0	0.0	0.0	0.0	0.0	0.3	3.3	10.4	40.8
Greatest Precipitation in 24 hrs (mm)	139.7	65.2	65	51.2	38	46.6	59.9	55.6	57.9	70.9	85	100.8	
Greatest Rainfall in 24 hrs (mm)	139.7	65.2	65	51.2	38	46.6	59.9	55.6	57.9	70.9	85	100.8	
Greatest Snowfall in 24 hrs (mm)	35.6	29	24.6	4	0	0	0	0	0	5	20.8	38	

2.4. Watersheds & Catchments

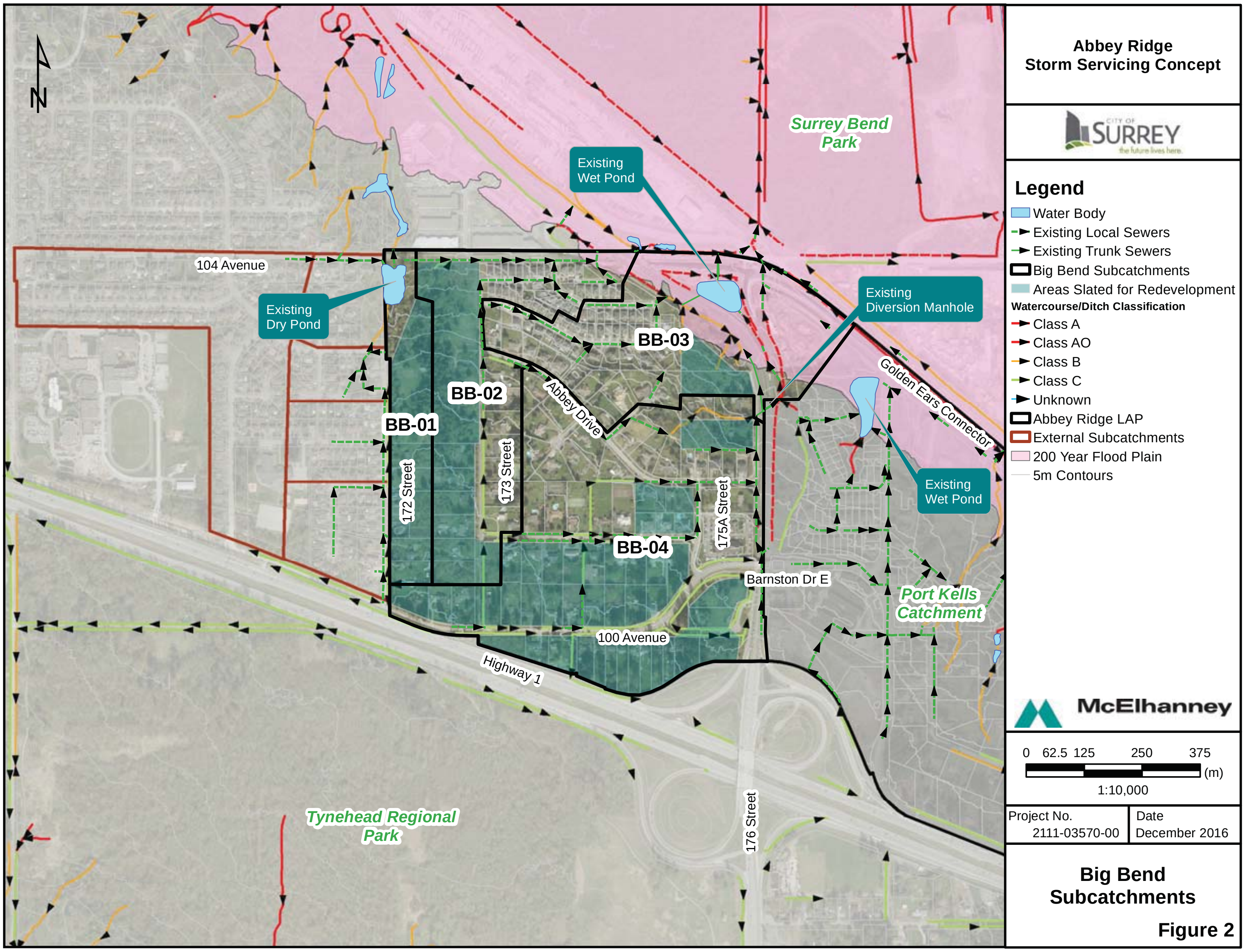
Big Bend Catchment

The two major watersheds within the study area are Big Bend and Port Kells, each containing various sub-catchments. The Big Bend watershed is comprised primarily of urban and suburban residential developments that drains southeast. The piped system discharges to multiple tributaries along the Surrey escarpment that discharge to the lowlands and drain into Surrey Bend Regional Park via Centre Creek. *Figure 2* shows that only the eastern portion of the Big Bend watershed (approx. 75.13 ha), east of 172 Street and south of 104 Avenue is within the Abbey Ridge study area. *Table 2* provides a brief description of the catchments located within the study area.

Approximately half of the Big Bend catchment is already built-out to the zoning identified under the proposed land use plan. Future development will generally occur to the west and south as shown on *Figure 2*.

Table 2: Catchments Conditions, Big Bend Watershed

Name	General Description
BB-01	Sparsely developed, the runoff from this sub-catchment drains northwest to a dry detention pond located at 172 Street and 104 Avenue. This pond also receives runoff from urban residential developments located west of 172nd Street, outside of the Abbey Ridge area. These external sub-catchments are shown in *Figure 2*. The pond discharges through a 1050mm culvert beneath 104 Avenue and drains into one of the tributaries of Centre Creek in Surrey Bend Regional Park.
BB-02	Comprised primarily of suburban residences and an urban land development in the east side of the lowlands. The land slopes down to the north east direction and the runoff is collected by storm sewers along 104 Avenue, 173 Street, and 103B Avenue. These sewers discharge through a 600mm culvert beneath 104 Avenue and drain north into a roadside ditch of Highway 17.
BB-03	This sub-catchment is traversed by two major transport corridors: Highway 17 and the Golden Ears Connector. The area to the east is classified as light impact industrial zone, while the area to the west is comprised of suburban and urban residences. In general, the land slopes downward to the northeast direction, somewhat steeply in the areas to the west and more gently at the industrial zone. The runoff from the residential areas is collected by storm sewers along 103A and 103B Avenues which discharge into a roadside ditch of Highway 17. This ditch conveys the runoff into a pond located between the Golden Ears Connector and Highway 17.
BB-04	The majority of the area in this sub-catchment is comprised of suburban residences. Highway 17 runs north to south in the east side of the catchment. The Korean Central Presbyterian Church is located at 175A Street and Barnston Drive East. The land slopes down to the northeast direction and the runoff is collected by pipes and ditches which eventually drain into the storm sewer along Highway 17. A diversion manhole in this sewer provides base flow to an AO class channel and diverts larger flows to a roadside ditch of Highway 17. This ditch discharges into the wet pond located in sub-catchment BB-03.



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Storm Servicing Concept
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Legend
Water Body
Existing Local Sewers
Existing Trunk Sewers
Big Bend Subcatchments
Areas Slated for Redevelopment
Watercourse/Ditch Classification
Class A
Class AO
Class B
Class C
Unknown
Abbey Ridge LAP
External Subcatchments
200 Year Flood Plain
5m Contours
McElhanney
0 62.5 125 250 375
(m)
1:10,000
Project No.
2111-03570-00
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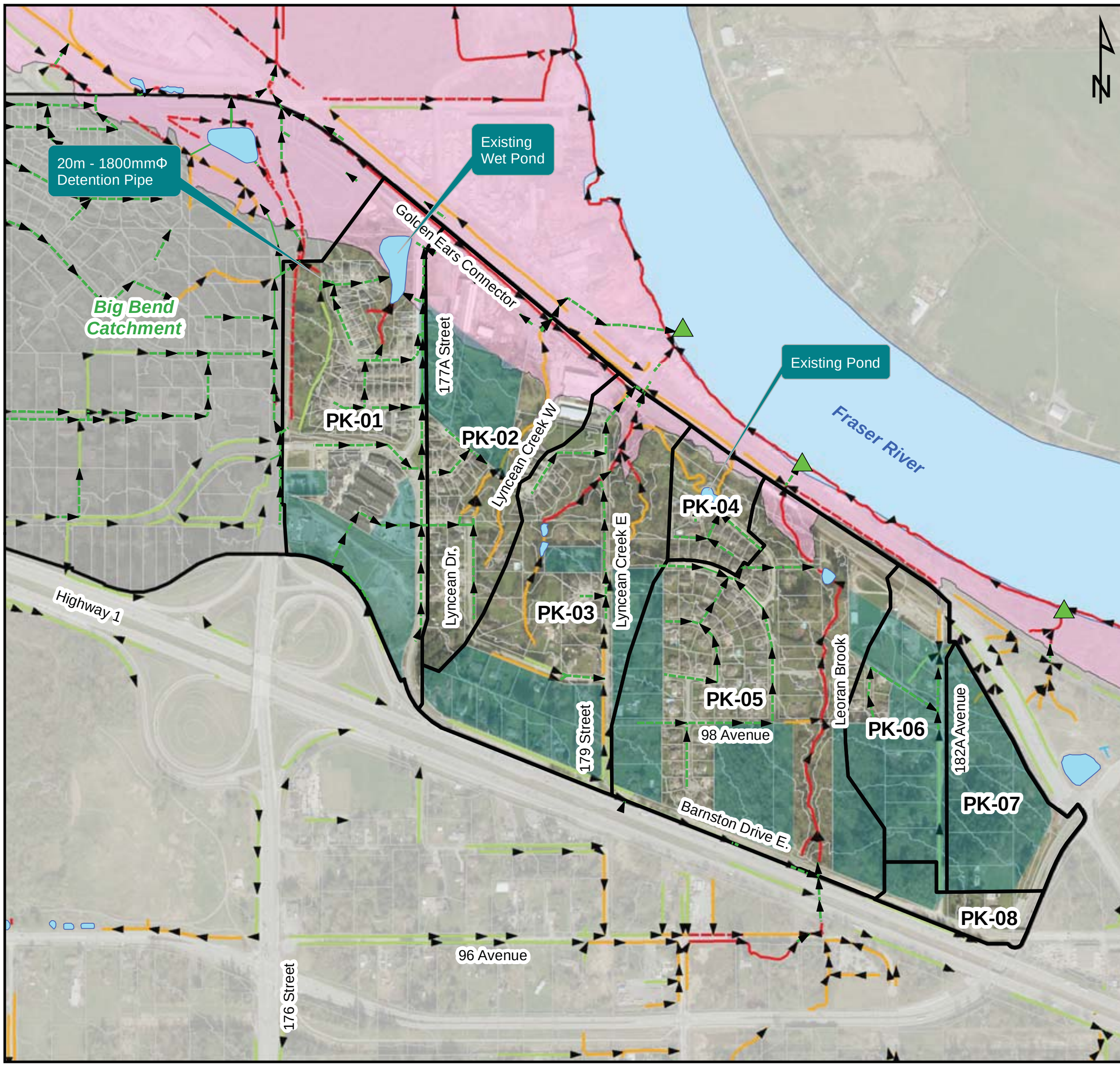
December 2016
Big Bend
Subcatchments
Figure 2
Surrey Bend Park
Existing Wet Pond
104 Avenue
Existing Dry Pond
Existing Diversion Manhole
BB-01
BB-02
BB-03
BB-04
Abbey Drive
Golden Ears Connector
172 Street
173 Street
175A Street
Existing Wet Pond
Barnston Dr E
Port Kells Catchment
100 Avenue
Highway 1
176 Street
Tynehead Regional Park

Port Kells Catchment

The Port Kells watershed is made up of two distinct halves. Only the western half (approx. 107.93 ha), from Golden Ears Way, is within the Abbey Ridge area (*Figure 3*) and is sparsely developed with residential and light-industrial land uses. Runoff from these areas drains north to the Fraser River via one of three major watercourses: Lyncean Creek West, Lyncean Creek East, and Leoran Brook. Past studies, including a geotechnical and erosion assessment completed for this study, identify several existing and ongoing erosion locations within these and other local water courses. Erosion risk and mitigation are further discussed in *Section 2.6* of this document. *Table 3* provides a brief description of the catchments located within the study area. Approximately half of the Port Kells catchment is already built out to the zoning identified under the proposed land use plan. Future development will generally occur to the south and eastern areas, in addition to some isolated pockets as shown on *Figure 3*.

Table 3: Catchments Conditions, Port Kells Watershed

Name	General Description
PK-01	The southern area of this sub-catchment is a combination of undeveloped land and multi-family residential developments. North of Barnston Drive East, the area is primarily of urban residential developments. The land slopes down towards the north and northeast directions. Most of the runoff from residential areas is conveyed to the storm sewer along 177A Street. This sewer connects to a 900mm culvert and drains into the roadside ditch of the Golden Ears Connector. The runoff from the undeveloped area north of Barnston Drive and west of the residential developments is collected by a ditch that drains into a 20m-1800mm detention pipe. This pipe also detains the runoff from the properties along 177 Street before discharging into the creek / wetland to the northwest of the sub-catchment.
PK-02	This sub-catchment is suburban and urban residences to the south and an industrial area to the north. In general, the area slopes down to the northeast direction. The runoff from properties along 100 Avenue, 178 Street, and Lyncean Drive is collected by pipes that discharge into Lyncean Creek West.
PK-03	This sub-catchment is crossed by Lyncean Creek East and its tributaries. The area to the north consists primarily of a large private lot that is currently undeveloped, while the area to the south is comprised of suburban residences. In general, the land slopes down to the north and northeast directions, although some areas in the lowlands slopes down to the northwest direction towards Lyncean Creek East. Runoff from the developed areas is collected via pipes and ditches and is conveyed to the storm sewer along 179 Street. This sewer discharges on Lyncean Creek East, upstream of the 1800mm culvert that crosses 179 Street. The properties along 100A Avenue are served by pipes that drain into the sewer that runs along 179 Street. This sewer discharges into a ditch of Daly Road (Golden Ears Connector).
PK-04	This sub-catchment is an urban residential development and vacant lots owned by the City. The land slopes down to the northeast direction and the runoff is collected by a storm sewer network that discharges into a detention pond north of 181 Street. Originally used as detention and then modified by MoTI, it is now part of a wetland system located within the City's land. The pond appears to have two overflow pathways: one flowing north towards a ditch of the Golden Ears Connector and the other flowing west to Lyncean Creek East.
PK-05	This is the largest sub-catchment in the Abbey Ridge LAP. It is crossed by Leoran Brook and is comprised of suburban and urban residential developments to the north and southwest, and vacant lots owned by the Province to the southeast. The land slopes down towards Leoran Brook primarily to the north and northeast directions. Storm sewers in the developed areas discharge on Leoran Brook in two locations: on 98 Avenue and on 99A Avenue. Leoran Brook also receives the runoff from areas south of Highway 1.
PK-06	The area to the south of 98 Avenue slopes down to the north and is comprised of undeveloped areas and suburban residences. The runoff from these areas is collected by a ditch along 182A Avenue. The area to the north of 98 Avenue slopes down to the northeast direction and includes urban residences and a light impact industrial zone in the lowland. The urban residences are served by sewers along 98 Avenue and Parsons Drive, which drain into a storm sewer that runs along a segment of 182A Avenue. In the industrial zone, this sewer becomes an open ditch that drains to the roadside ditches of the Golden Ears Connector.
PK-07	This sub-catchment is largely undeveloped, consisting primarily of suburban residences. The land slopes down to the northeast direction. There are no records of existing stormwater infrastructure in the area.
PK-08	Sparsely developed, this area slopes down to the southeast direction and part of the runoff is collected by a storm sewer along Barnston Drive East. This connects to the storm sewer network along Golden Ears Way.



Abbey Ridge
Storm Servicing Concept

Legend

- Outfalls
- Water Body
- Existing Local Sewers
- Existing Trunk Sewers
- Port Kells Subcatchments
- Areas Slated for Redevelopment
- Abbey Ridge LAP

Watercourse/Ditch Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- 200 Year Flood Plain
- 5m Contours

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0 62.5 125 250 375 (m)

1:10,000

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Port Kells Subcatchments

Figure 3

2.5. Existing Drainage Infrastructure

The drainage infrastructure within the study area is predominantly open channels, storm sewers, culverts, and ditches along roads. *Table 4* summarizes active pipes according to the City's GIS information, including storm sewer pipes and culverts.

Table 4: Summary of Active Pipes in Abbey Ridge LAP

Material	Smallest Size (mm)	Largest size (mm)	Pipe lengths (m)				
			Installation Date				Total
			Unknown	1970-1985	1986-2000	2001-2016	
CMP	600	1800	12.5	0	34.2	372.3	**419**
Concrete	200	1800	264.1	1109.3	1839.2	1743.4	**4956**
PVC	100	675	16.2	201.4	2096.3	3902.2	**6216.1**
PE	375	900	0	0	0	193.5	**193.5**
Unknown	375	900	50.1	61.7	8.3	83.3	**203.4**
TOTAL							**11,988**

Storm sewers in the Big Bend sub-catchments discharge into roadside ditches and then drain through culverts beneath Highway 17 and the CN Railway. The runoff eventually reaches Centre Creek in Surrey Bend Regional Park. In the Port Kells sub-catchments, several storm sewers outfall into wetlands and watercourses, including Lyncean Creek West, Lyncean Creek East, and Leoran Brook. Sewers in sub-catchments PK-01 and PK-02 discharge directly on roadside ditches. Many of these existing storm sewers in both catchments will be maintained and utilized, with some sections upgraded as needed to provide adequate capacity for future development. Proposed storm sewers and upgrade requirements are further discussed in *Section 4.0* of this document.

There are three detention facilities in the Abbey Ridge LAP. Record drawings show that the dry detention pond at 172 Street and 104 Avenue has a capacity of 2,800m^3 at a water elevation of 28.70m (0.60m of freeboard). This pond retains runoff from residential developments west of 172 Street and from open areas in Abbey Ridge. The wet detention pond at the intersection of 104 Avenue and 176 Street (*Figure 2*) is used for water quality improvement, with an estimated capacity of 5,000m^3. The 20m-1800mm pipe at 177 Street and 102 Avenue has a detention capacity of approximately 50m^3. In addition to these detention facilities, there is a wetland area to the west of 177A Street and North of 101A Avenue, and a constructed pond immediately north of 181 Street which receive discharges from storm sewers. The East Fraser Heights Environmental Assessment and Tree Study prepared by Phoenix Environmental Services Ltd describes these ponds as fish habitat compensation sites.

The ongoing construction of the Golden Ears Connector Road includes constructing new drainage infrastructure to improve existing drainage patterns. This includes new culverts, a new bridge over Leoran Brook, and flap gate installation that will prevent peak flows from going through the sewer system at the Teal Jones Lumber Plant. All of these proposed upgrades have been included in our analysis of the proposed drainage scenario.

2.6. Geotechnical Conditions & Erosion Assessment

General Soils Conditions

The preliminary geotechnical assessment completed by Braun Geotechnical Ltd. (Braun) in April 2016 indicates that the Capilano Sediments and Pre-Vashon Deposits underlay the Abbey Ridge area. The Capilano Sediments include marine and glaciomarine stony deposits to stoneless silt loam to clay loam with minor sand and silt. The Pre-Vashon Deposits include Quadra fluvial channel fill and floodplain deposits, cross-bedded sand containing minor silt, and gravel lenses.

This preliminary information indicates that a low to moderate amount of rainfall may currently be lost to sub-surface infiltration and some infiltration should be replicated in the future by development conditions. The Bon Accord ISMP also notes the local physiography is generally not conducive to successful infiltration as only low to moderate infiltration potential exists at the surface due to perched water table conditions resulting from subsurface soils that restrict any deep infiltration. Therefore, infiltration based source controls must be approached with caution. As such, only partial infiltration measures are considered for inclusion into the overall stormwater servicing and LID strategy for future developments. Site specific infiltration rates should be measured during the design of such LID measures, as rates can vary throughout the study area.

Groundwater Considerations

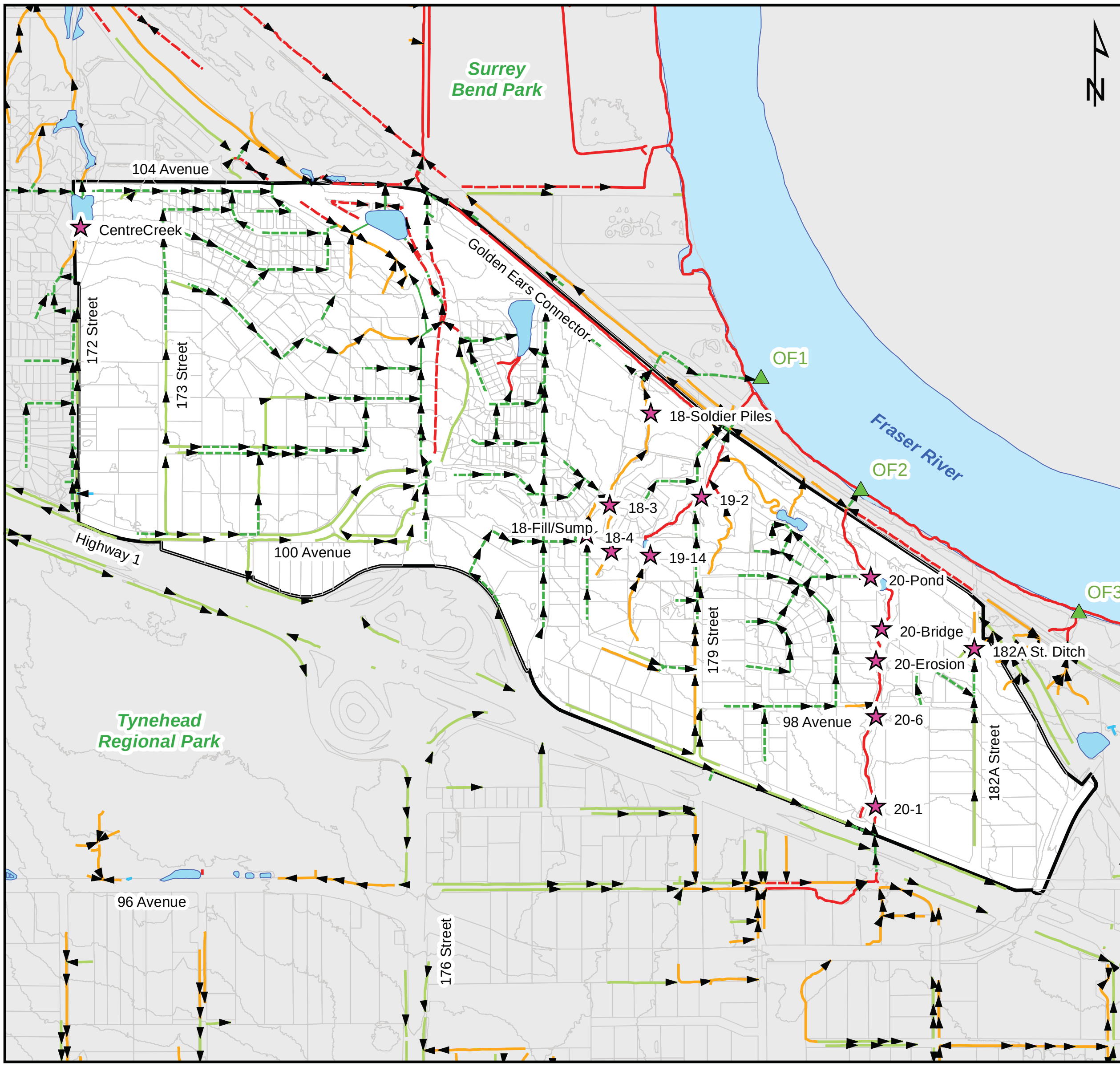
In the past the City has experienced extensive groundwater emergence after homes are constructed on steep slopes, similar to some areas of Abbey Ridge. This is usually a result of structures such as foundations, retaining walls, and roads that are constructed and often cut into high permeable soil lenses. As noted above, localized perched water table conditions exist throughout the Abbey Ridge area which tend to cause lateral movement of infiltrated water within the upper soil layer.

Future developments will need to consider the implications of shallow groundwater movement during design. Site specific geotechnical investigation should further investigate groundwater conditions and provide recommendations for controlling any groundwater emergence.

Erosion Assessment

As part of this assessment, Braun also reviewed the finding of previous studies for the Abbey Ridge area, including the 2000-North Bluff Overview Geotechnical Erosion and Hazard Assessment carried out by Thurber Engineering Ltd. and the 2014-Ravine Stability Assessment prepared by Tetra Tech EBA Inc. These studies identified areas affected by erosion and soil slope instability. Braun conducted a site reconnaissance and prepared an updated assessment of significant changes in the site. They also described current hazard conditions and provided recommendations for additional work.

Most of the areas mentioned in Braun's report are located along Lorean Brook, Lyncean Creek West, and Lyncean Creek East. Braun also reported ongoing erosion in a roadside ditch of 182A Street and in a short reach of Centre Creek. *Figure 4* identifies the location of these erosion sites and *Table 5* summarizes the existing conditions at these locations and describes how these conditions can be improved in the proposed drainage system.



Abbey Ridge
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Legend

- Erosion Site / ID*
- Existing Local Sewers
- Outfalls
- Existing Trunk Sewers
- Existing Water Bodies

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

* ID per Braun geotechnical report

McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Erosion Sites

Figure 4

Table 5: Erosion and Hazard Assessment

Location	Site ID[1]	Existing Conditions	Recommendations	Risk	Considerations during Future Development
182A Street	182A St. Ditch	Ongoing erosion of the left bank of ditch along property west of 182A Street. The short timber wall retaining the landscaped private property is in an undermined state.	Extend existing driveway culvert northward and/or provide rip-rap protection.	Low	This existing ditch would eventually be replaced with a closed drainage system as development occurs within the area. In the interim, provide rock rip-rap protection to mitigate against any increase in flows from upstream development.
Leoran Brook	20-1	Minor erosion downstream of new culvert beneath Highway 1.	The banks should be reviewed periodically for potential changes in erosion rates.	Low	None
	20-6	Left bank erosion in reach southeast of 9820 181 Street.	The banks should be reviewed periodically for potential changes in erosion rates.	Low	None
	20-Erosion	Left bank erosion in the middle section of the creek.	The banks should be reviewed periodically for potential changes in erosion rates.	Low	None
	20-Bridge	Woody debris is accumulating under low clearance of amateur footbridge.	The bridge should be removed or replaced. Accumulated debris should be removed.	Low	None
	20-Pond	Man-made pond discharges onto a fish ladder that flows through a culvert installed in ravine fill. Potential risk to downstream highway and Railway crossing in the event of a pond overtopping or damn breach.	The stability of the fish ladder and associated ravine fill should be reviewed. An assessment of the pond structures should be carried out. Develop an operation and inspection plan for the pond.	Medium	Flows to the 99A Ave outfall to Leoron Brook to be maintained at or below existing conditions. The stability of the existing driveway culvert and fish ladder to be reviewed. A new outfall to be installed immediately downstream of the existing Culvert / Fish Ladder as part of the storm upgrade required at 99A Avenue

Location	Site ID[1]	Existing Conditions	Recommendations	Risk	Considerations during Future Development
Lyncean Creek East	19-14	A 7m high dam behind the property at 9999 179 Street creates a pond. A second dam to the north creates another pond. The main pond trash rack is damaged and partially clogged with debris. These dams are located on private property.	Geotechnical exploration and assessment of the existing fills and dams should be undertaken. Develop an operation and inspection plan for the pond.	High	No additional flows to this section of the Creek. Maintain or reduce discharge rates and volumes at this location.
	19-2	Over-steepened rip rap slope at west side of 179 Street culvert crossing (1H: 1.5V). Erosion below the Lock-Block wall causing undermining.	The condition of the rip rap should be reviewed periodically and repairs completed if required. Erosion below the Lock-Block wall should be reviewed and repaired as needed. Additional fill and/or slope reconfiguration should be completed.	Medium	Repairs should be made to the culvert inlet and outlet prior to any increase in flows at this location from upstream development.
Lyncean Creek West	18-Fill / Sump	Dumping of residential garden waste was observed at intersection of 100 Avenue and Lyncean Drive.	Residents should be informed of potential damage if uncontrolled dumping continues.	Low	None
	18-4	Bank erosion above culvert at 100 Avenue and Lyncean Drive.	The replacement of the culvert should be carried out if its current design is considered inadequate.	Low	None
	18-3	A tree located southeast of 17780 100A Avenue has water flowing below it.	The tree should be reviewed by an arborist and removed if deemed unstable.	Low	None
	18-Soldier Piles	Soldier piles had been installed to stabilize the bank at the industrial property at 10095 179 Street.	The slopes should be assessed for long term stability under static and seismic loading conditions.	Low	None
Centre Creek	Centre Creek	Minor erosion in a short reach between 103 and 104 Avenue along 172 Street.	The banks should be reviewed periodically for changing conditions.	Low	None

[1]*See Site ID Location in Figure 4*

In general, a majority of the identified erosion site are considered low risk and continual review and monitoring of these sites is recommended as part of the City's ongoing Ravine and Slope Stability Assessments. There are two erosion sites (ID 20-Pond and 19-14) that are considered particularly sensitive as both sites include a water retaining structure of relatively unknown condition and capacity. These structures are on private property and are not City infrastructure.

Also important to note is that no statutory ROWs are in place along Leoran Brook and Lyncean Creek (East & West tributaries) where these erosion sites are located. Further exacerbation of these erosion sites is of concern to the City as this has the potential to impact private property. This is a key constraint considered in development of the future drainage servicing for the area. Mitigation will primarily consist of either:

- Maintain existing discharge rates and runoff volumes where existing ROWs are not in place and/or access is a constraint to complete restoration of the erosion sites; or
- Provide appropriate rehabilitation of erosion sites where access is available and ROWs can be obtained.

The full report prepared by Braun is included in *Appendix A*.

2.7. Environment

Several recent environmental assessments have been completed in and around the East Fraser Heights / Abbey Ridge study area. A British Columbia Environmental Assessment Act (BCEAA) application submitted for the construction of the South Fraser Perimeter Road (SFPR) included a study of the environmental features and sensitivities in the study area (MOTI 2006). The City conducted detailed baseline environmental studies focused on the East Fraser Heights / Abbey Ridge LAP (Surrey 2015a) and the North Bluff for its ISMP studies (Surrey 2015b). This environmental review of these previous studies and published information was conducted to inform the plans for the water and sewer local area servicing (LAS) for Abbey Ridge.

The City has developed a Biodiversity Conservation Strategy (BCS) which promotes the preservation and maintenance of habitat and species biodiversity (Surrey 2014a). The Surrey's Green Infrastructure Network (GIN) (hubs and corridors) comprise contiguous natural areas including natural areas, parks, streams, riparian areas and natural corridors which serve to provide habitat within the City as an application of the BCS. The City's Ecosystem Development Permit Guidelines (Surrey 2014b), detailed below, are intended to support this biodiversity strategy through application of environmental protection policies outlined in the City's Official Community Plan. Implementation of the City's BCS provides a means to protect riparian and streamside habitat from development while also satisfying the City's requirements to ensure that development complies with the Provincial regulations. Other development permit considerations include development near areas designated as hazardous slopes and tree protection policies. Please note that the construction, maintenance or operation of municipal or public utility works and services are exempt from development permit requirements.

The City's OCP outlines Development Permit Guidelines for Sensitive Ecosystems (Surrey 2014b) identified as green infrastructure areas and streamside areas. Green infrastructure areas have been identified as areas to facilitate biodiversity management and protection of wildlife habitat corridors. Streamside areas are those adjacent to watercourses providing protection of fish habitat.

The Sensitive Ecosystem Development Permit Area and Zoning Streamside Setback provisions of these Development Permit Guidelines (Surrey 2014b), states that any portion of a property that falls within 50 m of a GIN Hub, wildlife corridor, watercourse or biodiversity management area is subject to these provisions.

GIN Hubs are natural areas greater than 10 ha that provide habitat, refuge and movement corridors for wildlife. The BCS objectives for Hubs are to protect these natural areas from development though acquisition of land within each Hub. The objectives for local wildlife corridors are to provide a 10 to 50 m wide natural vegetated corridor to facilitate wildlife movement though an urban environment. These wildlife corridors are often located within the riparian corridors of creeks.

Part 7a – Riparian Protection of Surrey's Zoning Bylaw (Surrey 1993), is to be used to determine the area of riparian protection or 'buffer' required from development adjacent to a stream. For fish bearing creeks these buffers are 15 to 30 m in width, from top of bank, depending on specified conditions.

The study area lies within the Tynehead biodiversity management area. Biodiversity goals for the area include maintenance and enhancement of habitat connectivity of the Abbey Ridge escarpment towards the Fraser River and Surrey Bend Regional Park. Providing riparian buffers around watercourses and enhancing riparian areas to support fish and wildlife are a means to assist in achieving these goals. Retention of forest habitat along the Fraser River is also an objective of the City's Biodiversity Conservation Strategy BCS (BCS 2014a).

Environmental features summarized here for the Abbey Ridge LAP include terrestrial features such as watercourses and wetlands, forest and vegetation communities, wildlife habitat, and species at risk.

Aquatic Habitat Overview

Watercourses and wetlands have been identified and are marked on the Abbey Ridge Land Use Concept plan. Lyncean Creek (east and west) and Leoran Brook are natural streams that flow through the area. A number of unnamed creeks run downslope towards the Fraser River. Many of the watercourses flowing downslope off the Abbey Ridge area are connected to the Fraser River through culverts that convey water under the South Fraser Perimeter Road. Due to this connection with the Fraser River, several watercourses including roadside ditches within the study area have become watercourses that are either fish bearing or provide overwintering habitat for fish.

Watercourses and Wetlands

The City (Surrey 2014) adopted a watercourse classification system categorizing the general productivity of fish habitat in its local watercourses. The East Fraser Heights Environmental Assessment (Surrey 2015a) reviewed the area's watercourse classifications, proposing several recommendations for changes, which the City accepted and included in their COSMOS mapping. *Table 6* provides definitions for the colour coding which is also presented on the City watercourse classification maps and indicated on *Figure 5*. These watercourse classifications for fish productivity are used to develop appropriately sized protective riparian corridors around various watercourses or stream types.

Table 6: Watercourse / stream classification system (Surrey 1995)

Colour Code	Stream Type	Description
Red	Class A (High Productivity) habitat	Inhabited or potentially inhabited by salmonids year round.
Red-Dashed	Class A(O) (High Productivity) habitat	Inhabited by salmonids primarily during the overwintering period or potentially inhabited seasonally with access enhancement.
Yellow	Class B (Moderate Productivity) habitat	Significant food and nutrient value but no fish present.
Green	Class C (Low Productivity) habitat	Insignificant food and nutrient value and no fish present, usually roadside ditches.

Under Part 7a of Surrey's Zoning Bylaw (Surrey 1993), riparian protection or 'buffer' required from development adjacent to a stream have been defined. Generally, all stream types that are classed as fish bearing have 30m setbacks (*Table 7*), unless they are channelized or are roadside ditches. Development occurring within 50m of these watercourses requires a confirmation of the watercourse classification and determination of the appropriate setbacks to apply from top of bank of the watercourse.

Table 7: City of Surrey prescribed riparian setbacks from watercourses modified from the City of Surrey OCP

Development Minimum Distance From Top of Bank		
	Stream Type	
	A or A/O **Fish bearing**	B **Non-fish bearing**
All *Stream* Types (except as shown below):	**30 metres**	**20 metres**
Channelized Stream that has been dyked, diverted or straightened carrying drainage flows from headwaters or significant sources of groundwater, and can include channels that divert irrigation from a *stream* and send overflow water back to a *stream*.	25	15
Ditches: a Stream that is a constructed drainage channel, carrying water that does not originate from a headwater or significant source of groundwater.	10	7
Natural Stream predominantly in its natural state that is not significantly altered by human activity.	30	15
Large Ravines: *Stream* with a narrow, steep-sided valley with a minimum of 60m between the *top of bank* from either side of the *stream*.	15	15

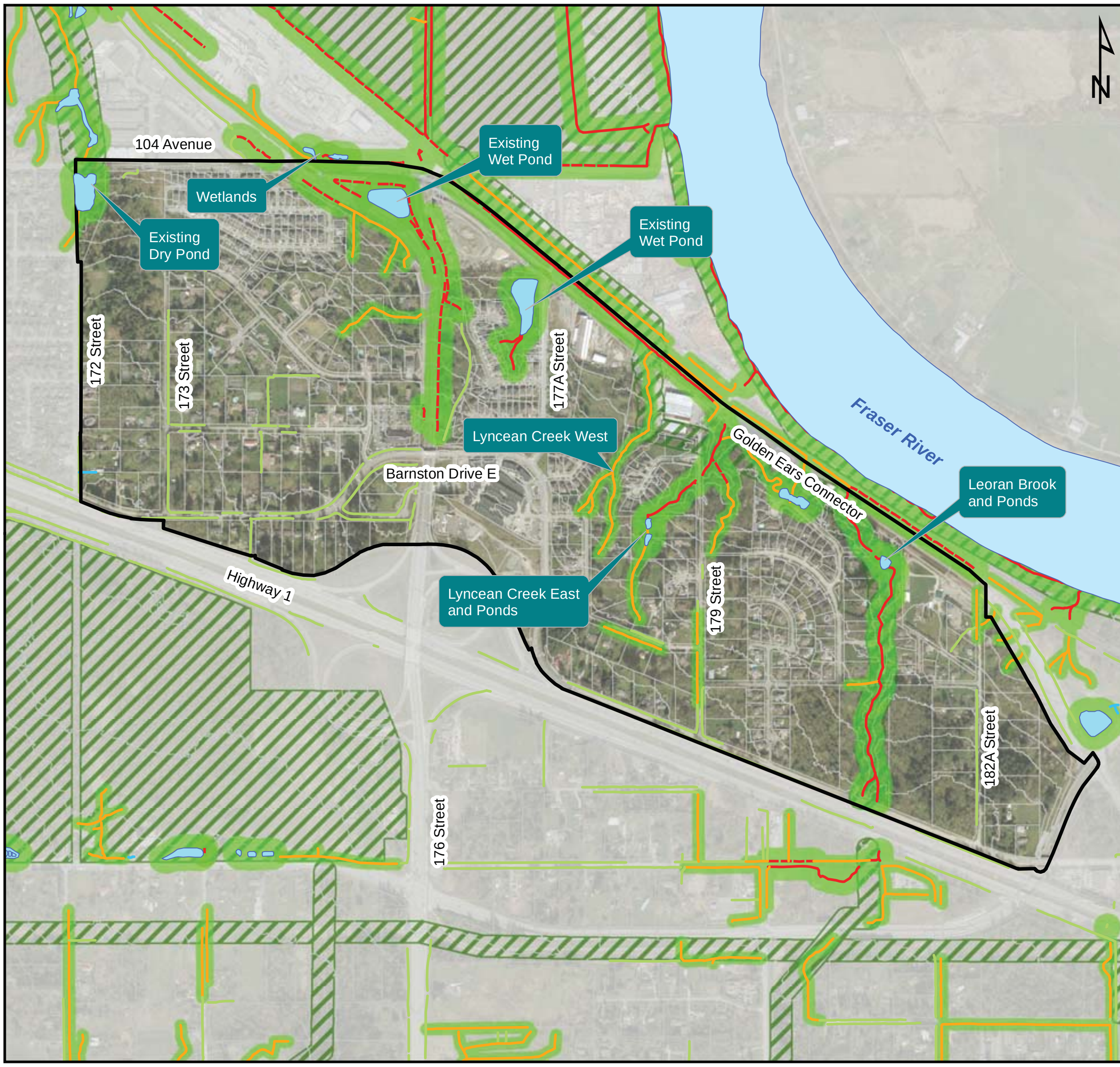
Figure 5 diagrams the watercourses and wetlands within the Abbey Ridge area, provides a stream type colour coding as per *Table 7*, and shows the riparian setbacks for watercourse protection. Roadside ditches, constructed stormwater management ponds and streams, wetlands, natural ravine creeks, and tributaries make up the variety of watercourses in the study area.

At 172 Street and 104 Avenue, Centre Creek flows northwest out from the Abbey Ridge area. This creek joins with its several tributaries downslope and is culverted under South Fraser Perimeter Road, flowing through Surrey Bend Regional Park before entering the Fraser River (MOE 2016). This creek provides an important wildlife and fisheries corridor and linkage between upslope habitat and the Fraser River. The environmental studies conducted prior to the construction of the South Fraser Perimeter Road (SFPR) reported that this watercourse, its tributaries, and riparian wetlands provided spawning habitat for coho salmon and juvenile rearing of coastal cutthroat trout.

Numerous other wetlands and wet detention ponds have been developed or enhanced at the base of the Abbey Ridge slope as habitat replacement and compensation that was specified in a Fisheries and Oceans Canada authorization for the construction of the SFPR (Surrey 2015a). Much of this replacement and enhanced habitat provides habitat for salmonids and other fish species. Leoran Brook is a natural fish bearing watercourse supporting populations of cutthroat trout, rainbow trout, and coho salmon. This brook was evaluated in an environmental assessment report which indicated that Leoran Brook provided good rearing habitat (2015a). The study found that spawning potential was limited by low flows and downstream migration obstacles such as culverts and fishway weirs that are impassable during low flow conditions.

Lycean Creek and ponds in and around Barnston Park contain water from seeps, springs, and artesian wells. These springs and seeps are important water sources, conveying water downslope to fish habitat. Most of this creek system’s reaches are yellow coded (non-fishbearing) due to natural and manmade fish passage barriers. Banks of some reaches are eroding, which may be mitigated by riparian planting enhancements or through a reduction in storm water inputs into these watercourses (Surrey 2015a,b).

With respect to development, flows in all red and yellow coded watercourses should be maintained at levels set by the City’s ISMP and drainage plans (2015b). Water sources, water quality and water quantity are protected by the Province under the *Water Sustainability Act.* No works should be planned within these watercourses and their riparian buffer zones or setbacks except with the permission of the Province.



Abbey Ridge
Storm Servicing Concept

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Legend

Abbey Ridge LAP
Riparian Set Back Area
Water Body
Watercourse Classification
Class A
Class AO
Class B
Class C
Unknown
5m Contours
Green Infrastructure Network (GIN)
External Area

McElhanney

0 75 150 300 450 (m)
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Aquatic Habitat

Figure 5

Terrestrial Overview

The Abbey Ridge area is characterized by a sloping topography towards the Fraser River to the north, with numerous creeks conveyed off an escarpment down naturally forested ravines. The City's Biodiversity Strategy recommends maintaining the forested character of the slope.

The riparian area of Leoran Brook is designated as a terrestrial corridor connecting fragmented patches of forest habitat within the developed portions of the City to Surrey Bend Regional Park.

Parks and greenbelts have been planned along these corridors and the City has purchased or dedicated land to protect many of these green spaces (*Figure 5*).

Federal Species at Risk

Abbey Ridge lies adjacent to federally designated critical habitat for the Pacific Water shrew (*Sorex bendirii*), a federally designated species at risk under the *Species at Risk Act (SARA) (*Figure *6).* This small area of habitat at the corner of 172 Street and 104 Avenue (northeast corner of the study area) lies within Abbey Glen Park which is owned by the City. No works can occur within this critical habitat without permits from Environment Canada concerning alterations to the habitat of a Schedule 1 species at risk.

Leoran Brook and Lycean Creek East and West are not indicated as critical habitat for the Pacific Water Shrew. However, there is the potential habitat along these watercourses and riparian areas for this *SARA* listed species. Any works or development impacting these watercourses should have a qualified environmental professional review the site for this species.

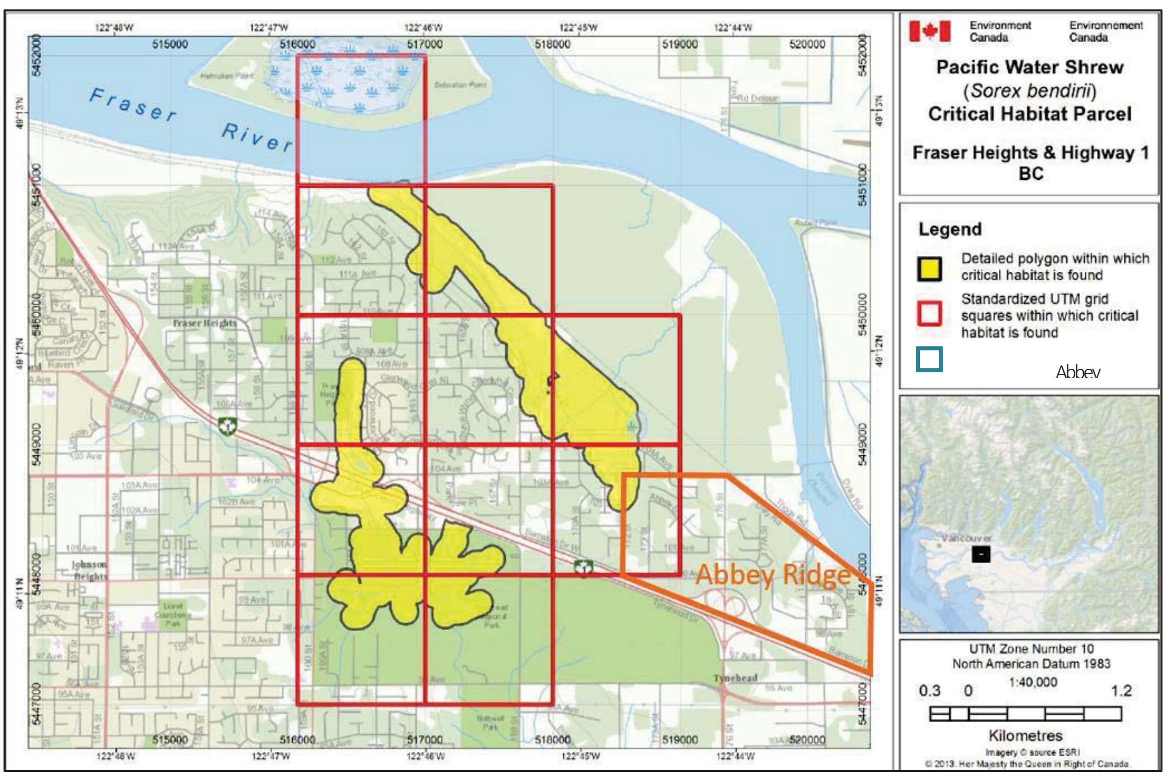


Figure 6*: Pacific Water Shrew Critical Habitat Parcel.*
The Abbey Ridge LAP touches federally designated critical habitat for the Sorex bendirii.
URL: http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_pacific_water_shrew_e_final.pdf (EC 2014)

Wildlife Corridors

The City's Green Infrastructure Network (GIN) is a conservation strategy which assists in achieving habitat connectivity for wildlife by identifying terrestrial hubs (forested habitat) and potential wildlife corridors throughout the urban environment. The GIN is included in the City's Biodiversity Conservation Strategy and in land use planning for the City as habitat to be protected from development. The land use plan for Abbey Ridge has provided for one main wildlife corridor through the Abbey Ridge area following Leoran Brook and providing connectivity with the regional hub at Surrey Bend Regional Park (*Figure 5*). Numerous small 'greenbelts' are proposed for some of the lower slope drainages. The Leoran Brook culvert under the SFPR is large enough to accommodate wildlife movement northward providing connectivity of the Abbey Ridge escarpment to the Fraser River and Surrey Bend Regional Park.

Deer, coyotes, raccoon, voles, and squirrel are the primary mammals utilizing these wildlife corridors. Provincially listed species are discussed below. Birds such as the bald eagle, woodpecker, various passerines, and raptors have been observed in the area (Surrey 2015a). The forested slopes and watercourse ravines provide habitat for nesting of various bird species. To comply with the BC *Wildlife Act S 34,* bird nest surveys should be undertaken prior to constructing any land development or municipal projects within 50m of a designated corridor or hub.

Provincial Species at Risk

The Leoran Brook riparian and wildlife corridor provides high potential habitat for provincially listed species such as the Oregon forestsnail and Pacific sideband, Northern red-legged frog, Trowbridge's shrew, and Western Screech-owl (Surrey 2015a). The Leoran Brook corridor, recommended to be 60m wide, provides connectivity between the escarpment and Surrey Bend Regional Park (Surrey 2015a). Though these species are not provided provincially legislated protections, the City's Biodiversity Conservation Strategy provides for the management of these native species through preservation and connectivity of patches of the natural diverse habitats in which these species are found.T

Significant Trees

Trees protected under the City's Tree Protection Bylaw 16100 occur throughout the Abbey Ridge area. Though the bylaw exempts all trees on provincial, federal, Metro Vancouver, and City owned land from the protection provisions of the bylaw, it is mentioned here with respect to construction associated with the land use plan. The tree protection bylaw requires protecting or replacing trees that are removed for residential and commercial development. Priority should be given to retaining forest / tree resources as much as possible to enhance Surrey's GIN.

3. Design Criteria & Analysis

The design criteria for this study is from the City's 2016 Design Criteria Manual and the Bon Accord – North Slope (East) ISMP. General design requirements for the Abbey Ridge LAP include the following:

- In areas where the properties do not have basements, provide a storm sewer system (minor system) with capacity to convey the post-development peak flows from the 1:5-year storm and a major system with enough capacity to accommodate the peak flows from the 1:100-year storm
- In areas where the properties have basements, provide a storm sewer system (minor system) with capacity to convey the post-development peak flows from the 1:100-year storm
- Control the post-development flows and volumes to or below pre-development conditions in areas where erosion is a concern
- Implement LID practices to attenuate post-development peak flows and improve water quality

These general requirements result in the following specific requirements for the Abbey Ridge area:

- Provide a piped system for the major flow in areas that currently have or are expected to have basements
- Use LIDs to control the post development runoff rate and volumes at the various erosion sites
- Provide a drainage strategy that will not overload the culverts crossing the Golden Ears Connector

3.1. Methodology

McElhanney assessed the existing conditions and stormwater infrastructure in the Abbey Ridge LAP by reviewing information available for the study area. This includes background reports, construction record drawings, aerial photos, and the City's GIS database.

Computational modelling was used to determine peak flows from the catchments. PCSWMM version 6.2.2070 was used to simulate the rainfall to runoff process through single event modelling, with five model scenarios developed to compare pre-development, existing and future conditions. *Table 8* describes the purpose of each scenario. These models were built over the Bon Accord / North Slope SWMM-model developed for the 2015 Integrated Stormwater Management Plan of this area.

Table 8: Model Scenarios

Scenario Number	Development Condition	Description
0	Pre-development	Determine pre-development runoff values and establish maximum unit discharges for the future on-site detention.
1	Existing	Analyze the performance of the existing storm sewers under existing conditions and determine existing peak flows (ie baseline conditions)
2	Future	Analyze the performance of the existing storm sewers under future build-out conditions without any upgrades.
3	Future	Analyze and propose the extension and upgrading of the existing storm sewer.
4	Future	Assess the benefits of implementing on-site detention and LID practices within the proposed storm sewer system.

The catchments identified in *Tables 3* and *4* were further divided into multiple sub-catchments. We obtained the average slope of these sub-catchments from a DEM surface built with the City's existing contours. For Scenario

1 (existing conditions), we determined the percentage of total imperviousness by completing a weighted multiplication of the total areas for different land uses (delineated in the aerial photo) and their corresponding imperviousness, as defined in the 2016 City of Surrey's Design Criteria Manual. For Scenarios 2, 3, and 4 (future conditions), we calculated the imperviousness assuming full build out of the Abbey Ridge LAP.

We matched the hydrologic input parameters to those used in the Bon Accord ISMP, which are summarized in *Table 9*.

Table 9: Catchment Modeling Input Parameters

Parameter	Value
Impervious Manning n	0.012
Pervious Manning n	0.24
Impervious Depression Storage	1.3mm / hr
Pervious Depression Storage	3.8mm
Maximum infiltration rate	5mm / hr
Minimum infiltration rate	1.5mm / hr
Decay constant	5.4 1 / hr
Drying time	7 days

3.2. Rainfall Data

The synthetic design storms used for the single event modeling were derived with IDF data from the Kwantlen Park rainfall station. This data was obtained from the City's 2016 Design Criteria Manual. *Appendix B* includes the hyetographs of these design storms, which have durations from 1 hour to 24 hours for 5 and 100-year return periods. *Table 10* shows total rainfall depths for each of the design storms.

Table 10: Design Storms Rainfall Depths (mm)

Duration	Return Period in Years	
	5 year	100 year
1 hours	15.00	23.90
2 hours	21.20	31.90
6 hours	40.30	58.40
12 hours	61.39	94.39
24 hours	85.67	137.90

Appendix C provides more details on model input parameters used.

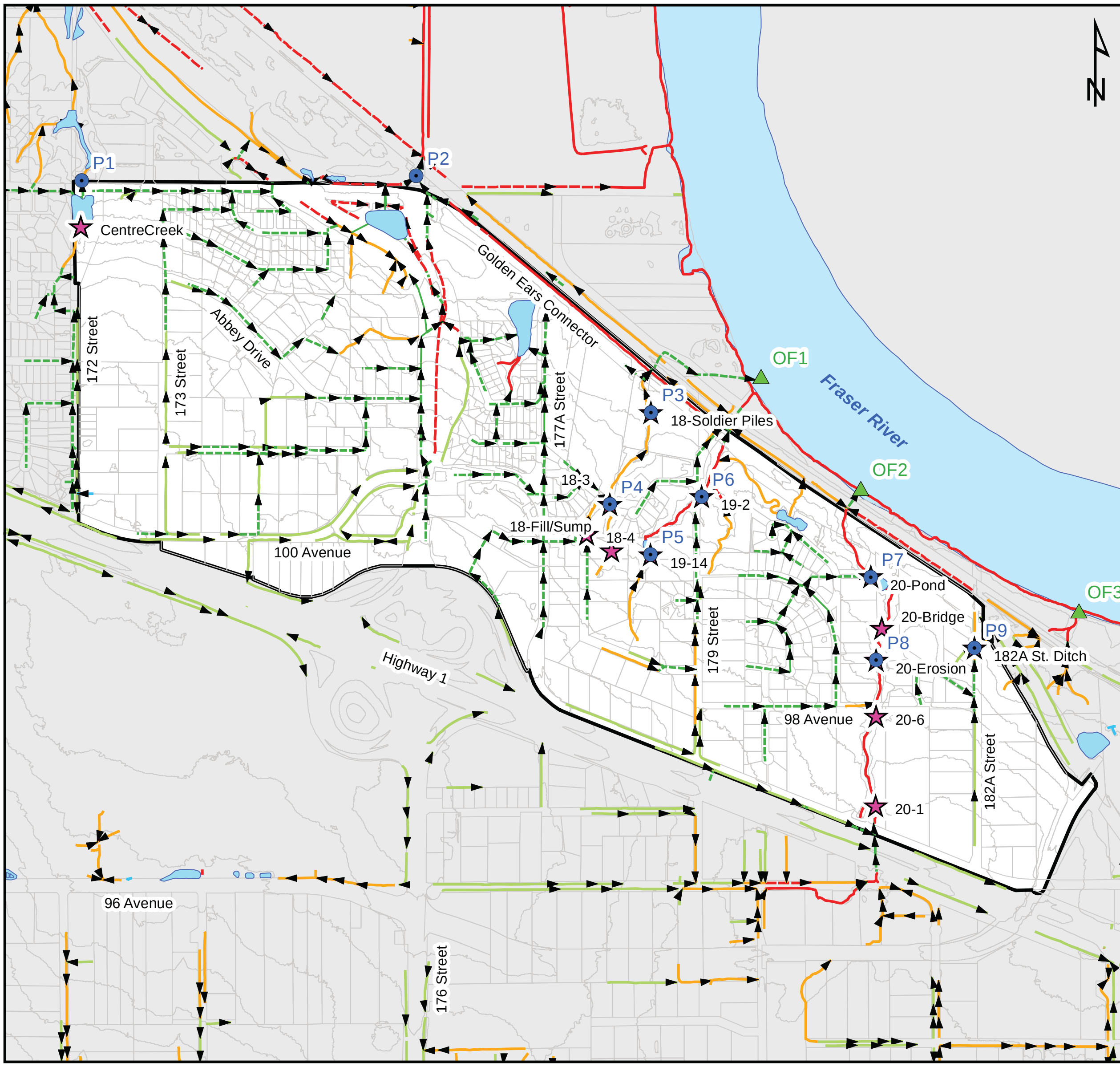
3.3. Baseline Conditions

Baseline conditions were established at several Points of Interest (POI) to compare peak flows and runoff volumes between modeling scenarios. *Figure 7* outlines the location of the POIs for the study area which are generally located at several key erosion sites and along the perimeter of Abbey Ridge where flows exit the study limits.

Results from the existing drainage scenario model were used to establish the pre-development peak flow rates at each POI and are summarized in *Table 11* below.

Table 11: Existing development flow at each Point of Interest

Point of Interest ID	Control Point / Location	5-year 1h (m^3/s)	5-year 24h (m^3/s)	100-year 1h (m^3/s)	100-year 24h (m^3/s)
OF1	Fraser River Outfall	1.27	1.40	1.96	2.00
OF2	Fraser River Outfall	1.33	1.69	1.86	2.44
OF3	Fraser River Outfall	0.81	0.52	1.17	0.87
POI 1	Centre Creek / 104 Avenue	0.32	0.81	0.91	1.40
POI 2	Big Bend Park / 104 Avenue	1.48	1.44	2.73	2.49
POI 3	Erosion Site 18-Soldier Piles	0.32	0.18	0.63	0.30
POI 4	Erosion Site 18-3	0.05	0.03	0.09	0.04
POI 5	Erosion Site 19-14	0.09	0.07	0.18	0.12
POI 6	Erosion Site 19-2	0.46	0.31	0.91	0.54
POI 7	Erosion Site 20-Pond	2.04	1.74	3.60	2.92
POI 8	Erosion Site 20-Erosion	2.02	1.72	3.55	2.87
POI 9	Erosion Site 182A Street Ditch	0.31	0.18	0.59	0.30



Abbey Ridge
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Legend

- Points of Interest
- Erosion Site / ID*
- Existing Local Sewers
- Outfalls
- Existing Trunk Sewers
- Existing Water Bodies

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

* ID per Braun geotechnical report

McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Points of Interest & Erosion Sites

Figure 7

4. Proposed System

The future development of Abbey Ridge will change the existing land use distribution. These changes will increase the amount of impervious areas, reducing infiltration and increasing surface runoff. *Table 12* below compares the imperviousness between current and future conditions indicating a modest 23% increase in percent imperviousness that is expected to the Abbey Ridge area when full build-out is realized per the approved land use plan.

Table 12: Comparison of % Imperviousness

	Big Bend Catchment	Port Kells Catchment
Existing Development Conditions	47.2%	42.3%
Future Development Conditions	69.3%	66.0%

Our overall approach to determining the proposed drainage system was to assess the existing system's performance and determine necessary upgrades to adequately convey runoff from the study area to the Fraser River. We assumed at the onset of the study that additional detention ponds were not required since a significant portion of the study area is already developed and is in close proximity to the Fraser River.

Hydraulic modeling of the existing drainage system revealed that many of the sewers do not have capacity to accommodate current or increased flows. Therefore, in addition to extending the existing sewer system, many of the installed pipes will have to be replaced to prevent flooding of existing properties, including existing areas with basements. In order to attenuate flows at the POIs shown on *Figure 7*, the development discharges on Leoran Brook and Lyncean Creek East should be limited. In addition, we recommend the use of LID techniques in future roads and developments to reduce volume rates and as the primary erosion mitigation measure in sensitive areas.

4.1. Minor System Conveyance

The minor system, defined by the City as the drainage system component with marginal capacity to convey the five-year return period flow, will generally consist of curb and gutters and catch basins that discharge water to an underground storm sewer system. Future developments will be expected to install storm sewers to service their respective development and connect to the existing storm sewer system.

The design criteria also require that all habitable areas, including basements, be above the 100-year hydraulic grade line. A cursory visual inspection revealed that many existing properties in the Abbey Ridge area have basements. However, the hydraulic modelling of the existing sewer system (Scenario 1 of *Table 7*) showed that many of the installed sewers in these areas do not have capacity to convey the current peak flows from the 100-year return period storm therefore, flooding would occur. This situation is aggravated if the increased runoff from future development is considered (Scenario 2 of *Table 7*).

We recommend upsizing the existing local and trunk sewers, as shown on *Figure 8*. These minimum upgrades are required to prevent flooding of any existing basements by providing in-pipe capacity for the 100-year flow.

Big Bend Catchment

As shown previously on *Figure 2*, future development within the Big Bend catchment will primarily consist of future residential development concentrated along the western and southern perimeters of the catchment with a small pocket located along 176 Street. Future development along 172 Street can be serviced by the existing storm sewer on 172 Street that conveys runoff to the existing detention pond at 104 Avenue and 172 Street. Limited opportunity exists for expansion of this detention facility. However analysis shows some capacity is available to convey some additional flows from Abbey Ridge to this facility provided upstream LIDs are utilized.

LIDs can be used to provide adequate rate control to provide sufficient conveyance capacity up to and downstream of the detention pond to the Fraser River. New storm sewers will be required between 172 Street and 173 Street to convey runoff south towards 104 Avenue. Upgrade of an existing section of local sewer along 173 Street will be required to provide adequate conveyance capacity.

A new storm sewer system would be required along 100 Avenue / Barnston Drive that would convey runoff to 175A Street. Upgrades to the existing system would be required along 175A Street and Abbey Drive due to existing flooding issues and additional flows being generated and conveyed by upstream development. No trunk sewers will be required in this catchment.

All other existing drainage infrastructure was reviewed under the modeling analysis and the majority are shown to have adequate conveyance capacity to meet the design criteria. View the modeling results located under *Appendix C*.

Port Kells Catchment

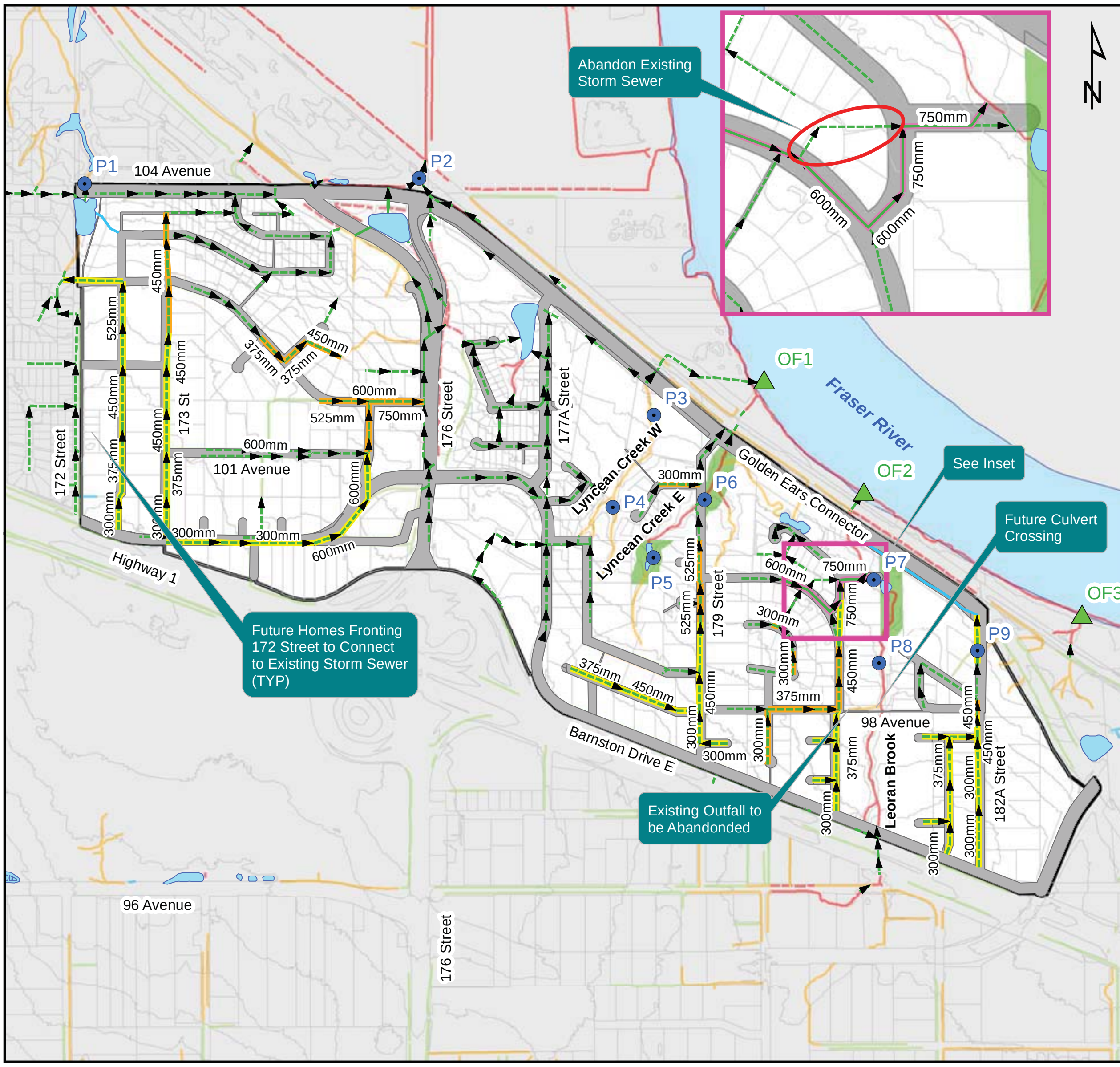
As shown previously on *Figure 3*, future development within the Port Kells catchment will primarily consist of urban residential and low / high multifamily residential with a small pocket of commercial located along the southern half of the catchment along 177A Street, 179 Street, Barnston Drive, and 182A Street.

New storm sewers and upgrades to sections of existing storm sewers will be required throughout the eastern half of the catchment, generally along 98 Avenue, 179 Street, 181 Street, and 182A Street where majority of development will occur. Upgrade to existing local trunk sewers will be required (shown on *Figure 8)* to provide adequate conveyance for existing and future developments in the area.

Upgrade and re-alignment of an existing storm trunk sewer will also be required at 99A Avenue and 181 Street to provide sufficient capacity. The works would include abandonment of the existing trunk sewer behind the existing homes along 99A Avenue / 181 Street. An additional outfall will also be required immediately downstream of the existing fish ladder and culvert structure as the capacity and structural integrity of these structures are questionable.

All other existing outfalls to Lyncean Creek, Leoran Brook and the unnamed yellow coded ditch at 182A Avenue / Golden Ears Connector will be maintained and utilized. It is recommended the existing outfall to Leoran Brook at 98 Avenue be abandoned as a mitigation measure to the ongoing erosion occurring within Leoran Brook. This abandonment will have negligible impact to the existing base flow. A future culvert crossing will also be required along 98 Avenue at Leoran Brook when 98 Avenue is extended through.

All other existing drainage infrastructure was reviewed under the modeling analysis and the majority are shown to have adequate conveyance capacity to meet the design criteria. View the modeling results located under *Appendix C*.



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Legend

- Points of Interest
- Outfalls
- Upsized Local Sewers
- Upsized Trunk Sewers
- Existing Local Sewers
- Existing Trunk Sewers
- New Local Sewers
- Proposed Road
- Existing Water Bodies

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- SRWs
- 5m Contours

McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Proposed Storm Sewers and Upgrades

Figure 8

4.2. Major System Conveyance

Future developments within the Abbey Ridge area must provide for a major flow route along the surface by installing curb and gutter along roadways. This will provide a safe route for flows that exceed the piped system's capacity without flooding adjacent properties. In areas where the piped (minor) system is designed to convey the 100-year storm, a safe surface route must be present to be provided for redundancy. A review of the existing and future overland flow routes were completed under this study to confirm a safe route is available without impact to existing property. In general, a safe route flood route is available along all road corridors to an appropriate outfall. The only exception is the existing cul-de-sac along 174A Street within the Big Bend catchment. Any overland flows would be directed down towards existing private properties. However, this section of storm sewer is recommended for upgrade to provide capacity for the 100-year discharge, and as part of the upgrade, an additional grated inlet at the low-point of the cul-de-sac should be provided to collect any overland flows.

4.3. Existing Detention Facilities

The detention ponds and wetlands described in *Section 2.5* of this document are proposed to operate as is, without any further upgrades or modifications. The inflow volumes at these facilities will be maintained or reduced through the use of on-site detention and LID techniques. A small portion of Abbey Ridge, from 172 Street to 172A Street (north of Highway 1), can be directed to the detention pond at 172 Street and 104 Avenue. This pond was modelled to include this additional area and result show the pond has the capacity to accept the additional flow.

Table 14 presents the existing and post-development inflow volumes at these facilities.

Table 13: Inflow Volume into Existing Detention Facilities

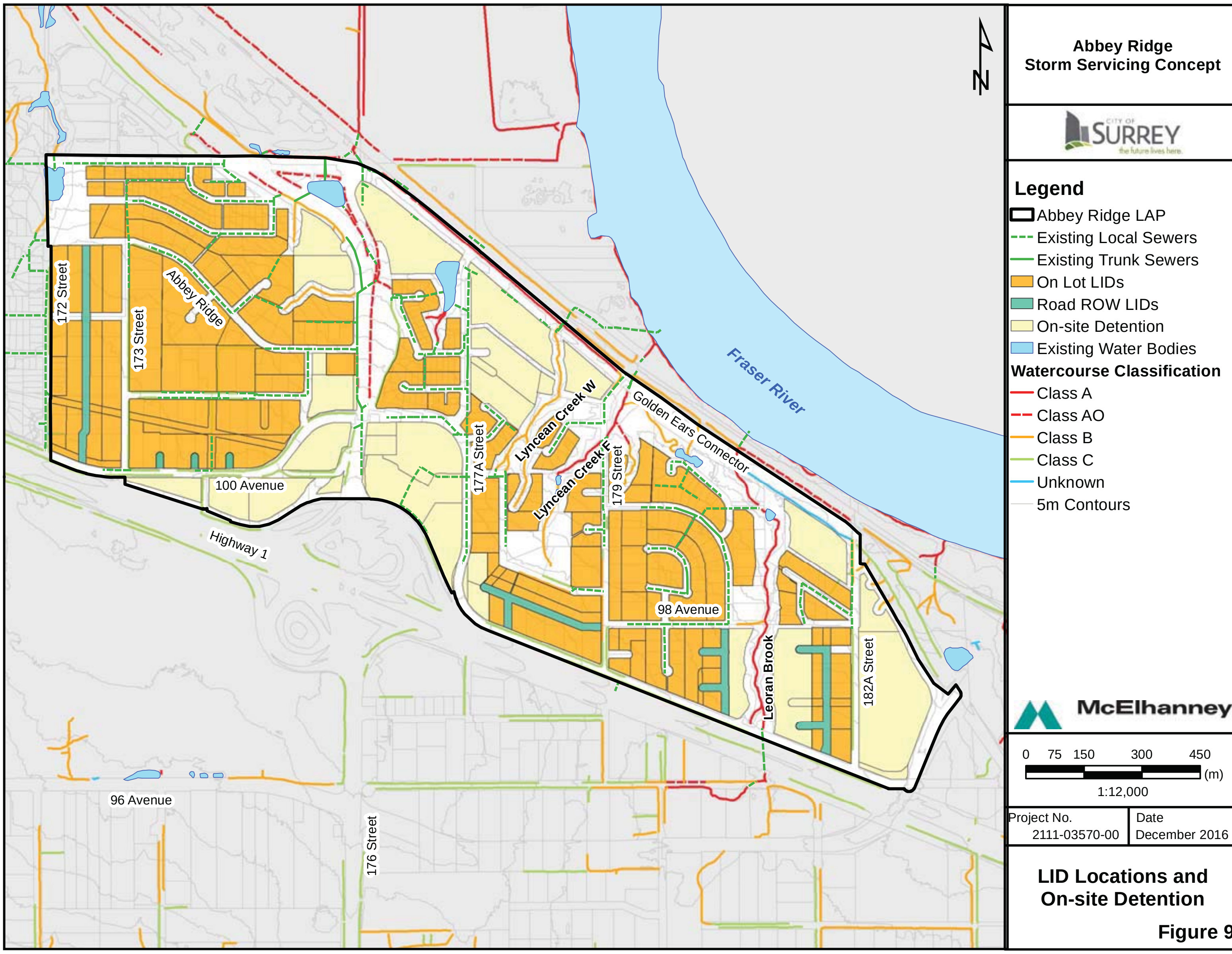
Detention Facility	5-year-24h (Existing) (m^3)	5-year 24h (Future) (m^3)	100-year-24h (Existing) (m^3)	100-year 24h (Future) (m^3)
Dry detention pond at 172 St. and 104 Av.	28,300	28,100	48,900	46,600
Wet detention pond at 104 Av. and 176 St.	30,900	23,500	54,600	39,100
Wetland west of 177A St.	4,380	3,690	7,200	6,000
Pond North of 181 St.	2,860	2,040	5,180	3,710

4.4. On-site Detention

All new industrial, institutional, commercial and multiple family residential developments will be required to have on-site detention storage to control offsite discharges to below 15 l/s/ha and 25 l/s/ha during the 5-year and 100-year events respectively. These targets were established through the pre-development model (Scenario 0 in *Table 8*) with the 5-year and 100-year storm events and durations from 1 hour to 24 hours. *Table 13* shows the average unit pre-development flows from the industrial, institutional, commercial and multiple family residential areas. The 15 l/s/ha and 25 l/s/ha targets will limit the offsite discharges to flow rates below the pre-development runoff during all storm events. *Figure 9* shows the areas where on-site detention is recommended.

Table 14: Average unit pre-development runoff (l/s/ha)

Duration	Return Period in Years	
	5 year	100 year
1 hours	20	47
2 hours	21	46
6 hours	17	26
12 hours	23	42
24 hours	18	32



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Project No.	Date
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LID Locations and On-site Detention

Figure 9

4.5. Runoff Rates

Implementing the on-side detention and the LID techniques will also reduce the runoff rates at the various POIs, including within Leoran Brook and Lyncean Creek. *Table 15* presents the existing and post-development runoff rates at these locations.

Table 15: Pre and Post-development flow at Points of Interest

Point of Interest ID	Control Point / Location	5-year-1h (Existing) (m^3/s)	5-year 1h (Future) (m^3/s)	100-year-1h (Existing) (m^3/s)	100-year 1h (Future) (m^3/s)
OF1	Fraser River Outfall	1.27	1.06	1.96	1.72
OF2	Fraser River Outfall	1.33	1.26	1.86	1.77
OF3	Fraser River Outfall	0.81	0.67	1.17	1.33
POI 1	Centre Creek / 104 Avenue	0.32	0.26	0.91	0.75
POI 2	Big Bend Park / 104 Avenue	1.48	0.64	2.73	1.31.
POI 3	Erosion Site 18-Soldier Piles	0.32	0.20	0.63	0.43
POI 4	Erosion Site 18-3	0.05	0.03	0.09	0.08
POI 5	Erosion Site 19-14	0.09	0.08	0.18	0.17
POI 6	Erosion Site 19-2	0.46	0.50	0.91	1.00
POI 7	Erosion Site 20-Pond	2.04	1.89	3.60	3.28
POI 8	Erosion Site 20-Erosion	2.02	1.87	3.55	3.24
POI 9	Erosion Site 182A Street Ditch	0.31	0.37	0.59	0.76

As shown, post-development rates would match closely to pre-development conditions with the exception of OF3, POI 6, and POI 9.

Outfall 3 (OF3) and POI 9 represent flow conditions at the eastern most outfall to the Fraser River and the erosion occurring along the 182A Avenue roadside ditch, respectively. The existing system in this area has sufficient hydraulic capacity to convey future runoff without any flooding. This roadside ditch along 182A Street will be replaced by a storm sewer system as development proceeds along 182A Street. In the interim, temporary erosion protection works such as ditch restoration and placement of rock rip-rap can be utilized to stabilize the erosion occurring at this location until the ditch is replaced with a storm sewer. As such, the increase in discharge rates as shown in *Table 12* above at POI 9 can be accommodated with these temporary works in place.

POI 6 is an erosion site located at the inlet and outlet of the existing culvert along 179 Street along Lyncean Creek (east tributary). The culvert does have the hydraulic capacity to accept the additional increase in discharge and the erosion concern can be mitigated with some minor rehabilitation works. This work includes review and repair of the existing rip-rap at the culvert inlet and placement of additional fill or slope reconfiguration at the culvert outlet. A Statutory Right-of-Way (SRW) would be required at the outlet of the culvert to complete this work.

4.6. Runoff Volume Control

More development will increase runoff volume. While the Bon Accord – North Slope (East) ISMP did not establish runoff volume constraints, the City's current design standards encourage more effective methods to manage post-development flows, runoff volumes, and maintaining base flows in efforts to protect properties and sensitive receiving watercourses.

Using PCSWMM, McElhanney used both single event and continuous simulation to evaluate the water balance and assess the performance of the proposed LIDs.

Single-Event Analysis

Similar to the peak flow analysis, single event modeling was used to determine the effectiveness of LIDs to reduce total runoff volumes from the significant long duration SCS storms throughout the system. *Table 17* compares the total runoff volumes from significant (5-year and 100-year) 24-hour events.

Table 16: Pre- and Post-development volumes at Points of Interest using Single Event Modeling

Point of Interest ID	Control Point / Location	5-year-24h (Existing) (m^3)	5-year 24h (Future) (m^3)	100-year-24h (Existing) (m^3)	100-year 24h (Future) (m^3)
OF1	Fraser River Outfall	49,500	44,800	86,400	79,500
OF2	Fraser River Outfall	69,400	65,000	123,000	114,000
OF3	Fraser River Outfall	14,400	17,300	26,300	30,200
POI 1	Centre Creek / 104 Avenue	27,600	27,200	48,300	47,600
POI 2	Big Bend Park / 104 Avenue	43,400	29,700	81,200	53,800
POI 3	Erosion Site 18-Soldier Piles	4,970	4,200	9,060	7,720
POI 4	Erosion Site 18-3	710	385	1,280	759
POI 5	Erosion Site 19-14	2,890	2,830	4,370	4,310
POI 6	Erosion Site 19-2	9,470	8,580	16,300	14,900
POI 7	Erosion Site 20-Pond	60,100	55,200	105,000	97,100
POI 8	Erosion Site 20-Erosion	59,700	54,700	104,000	96,100
POI 9	Erosion Site 182A Street Ditch	4,950	6,670	8,980	11,700

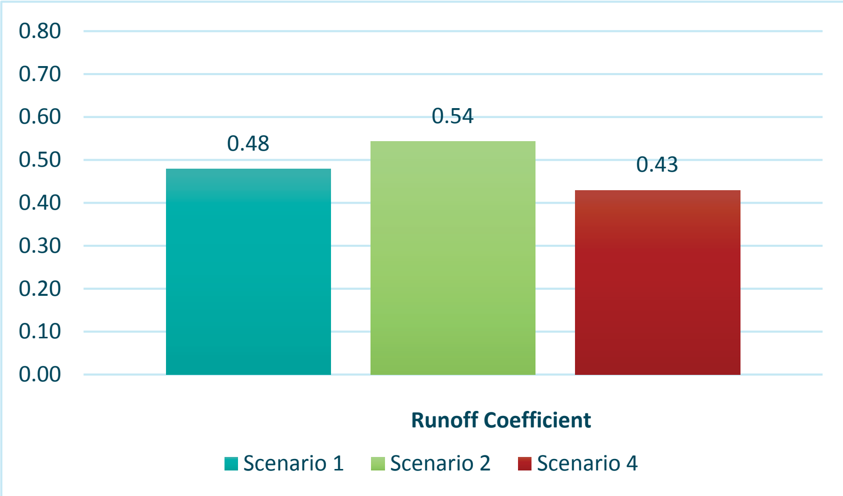
Similar to the comparison of pre- and post-development discharge rates, the total runoff volumes at the POIs in the future will generally be at or below the current conditions, with the exception of OF3 and POI 9. However, as discussed in *Section 4.2*, the existing system in this area has sufficient hydraulic capacity to convey future runoff without any flooding. Temporary erosion protection works are recommended to stabilize the erosion occurring at this location until the ditch is replaced with the ultimate storm sewer.

Continuous Simulation

Continuous simulation based on historical rainfall from a typical year (Surrey Kwantlen Park gauging station) was also used to determine runoff volume and discharge rates for Scenario 1 (existing conditions), Scenario 3 (proposed development with no LIDs), and Scenario 4 (proposed development with LIDs in place).

The rainfall and runoff mass balance from the continuous simulation (represented by the total runoff coefficient) for the LIDs are indicated in *Figure 11*, with the runoff coefficient representing the ratio of runoff to total rainfall volume. This shows that the proposed development with no LIDs increases the overall runoff volume due to increased imperviousness and decreased potential infiltration. However, using the recommended LIDs, the runoff coefficient (and therefore runoff volume) is smaller than the pre-development level.

Figure 10: Runoff Coefficient Comparison from Continuous Simulation



4.7. Proposed LIDs

Attenuation of future runoff rates will also be accomplished through the use of three LID techniques: impervious disconnection, absorbent landscaping and infiltration trenches in roads.

The implementation of these strategies will help to minimize impacts to downstream infrastructure and maintain existing discharge rates and volumes at key vulnerable erosion sites. The recommendation of these LIDs can be separated into two areas for the study: On-Lot LIDs and Road ROW LIDs, as described below.

On Lot LIDs

The simplest non-structural source control is the disconnection of roof leaders from the storm sewer service connections to allow roof runoff onto splash pads directing runoff to the surrounding yard area. The disconnection of roof leaders is an existing criterion for new single family residential developments in Surrey.

The other primary on-lot LID to be implemented for all developments is the use of amended topsoil throughout all landscaped areas of the development. Metro Vancouver's Stormwater Source Control Design Guidelines 2012 describes an absorbent landscape as a layer of soil with vegetation designed to infiltrate the rain that falls on it and from upstream impervious areas. Impervious areas and roof leaders must be disconnected from the storm sewer and drain into the absorbent landscape with only an overflow to the drainage system. The required thickness of the top soil layer is 450mmn which is cited by the Bon Accord – North Slope ISMP study and a maximum of impervious area to absorbent landscape ratio shall be 1.5:1. Additionally, the enhanced topsoil would be applied to all pervious surfaces on the private property and fronting boulevard areas within the municipal ROWs. *Table 17* summarizes the required LID for each zone.

Table 17: Summary of Required LID for Each Zoning

Land Use	Zoning	LIDs required
Single Family Residential / Cluster (1-10 UPA)	RH-G, RF, RF-9/12	Disconnected Roof Leaders directing runoff to splash pads 450mm enhanced / amended top soil on all pervious areas
Multiple Family Residential (12-30 UPA)	RM-15, RM-30, RM-45	450mm enhanced / amended top soil on all pervious areas
Commercial and Industrial	IL, C-5	450mm enhanced / amended top soil on all pervious areas
Institution, School, Church	PA-1	450mm enhanced / amended top soil on all pervious areas

Road ROW LIDs

The road ROW areas also require their own designated LID measures separate from measures located on private property. Road ROW LIDs may include any combination of rain gardens, roadside swales, and infiltration trenches. The total area of road ROW LIDs are a function of the total area being serviced, and through several iterations of modeling/analysis the footprint of the LIDs was determined to be a minimum 5% of the road ROW area.

All pervious and impervious surfaces must be directly connected to the LID such that no uncontrolled runoff enters the piped system. Retention of stormwater runoff from the ROW areas, particularly from impervious road surfaces, is important as significant runoff contribution and pollutant loadings originate from the pavement areas of local roads and rear access lanes in the neighbourhood.

Boulevards within the road ROW provide opportunities to apply the 450mm layer of enhanced / amended topsoil, consistent with the on-lot developments. This installation of topsoil within the ROW would coincide with topsoil placement during construction of the frontage roads for each particular development. The topsoil will help to retain rainfall and promote rainwater absorption within the boulevard.

Two options have been identified to apply source control measures for the road ROW areas.

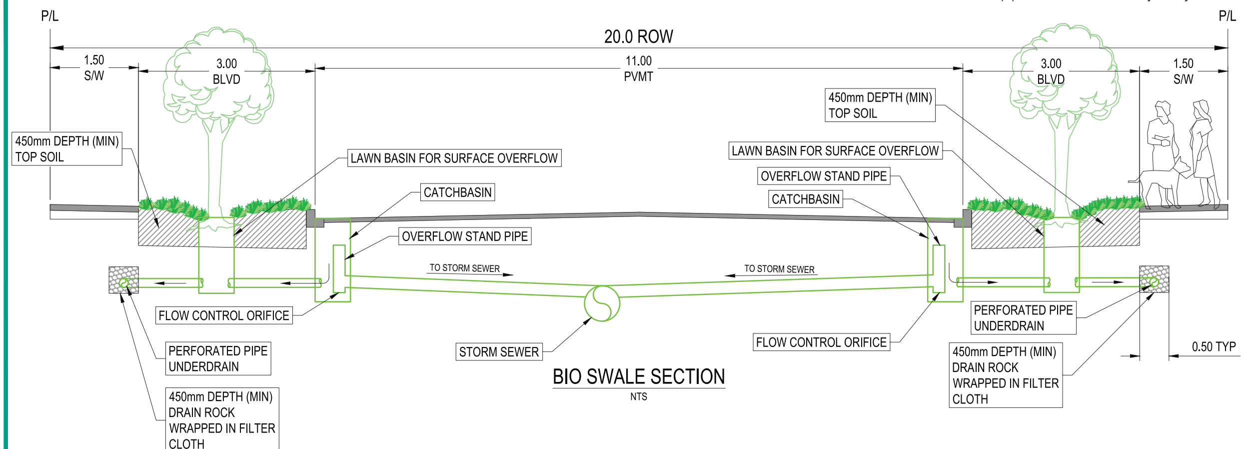
- The first option utilizes a 0.5m wide by 0.45m deep infiltration trench located along both sides of the road ROW to provide retention volume to meet the stormwater retention targets for road ROW areas. Flow control orifices are required to act as an underdrain within the catchbasins to provide a slow release to the storm sewer main. The infiltration trench and flow control catchbasins for a typical 20m road cross section are shown in *Figure 11*.
- The second option is to incorporate the use of an above ground rain garden within the boulevards of the road ROW. *Figure 12* provides detail of how rain gardens could be incorporated into the local road ROW cross-section to provide stormwater retention. Runoff from the roadway area is directed to the rain garden using a curb-cut inlet instead of a traditional catchbasin. An overflow grated drain is provided within the rain garden to discharge overflows to the storm sewer main. In addition, an underflow would be required as previously described.

The rear access lanes located throughout the single family development areas also require an infiltration trench system similar to the local road section described above. The required infiltration trench width, however, is reduced while maintaining the same depth of 0.45m.

An infiltration trench or rain garden covering 5% of the ROW area must be installed in the boulevards and/or curb bump outs. One of the biggest challenges in incorporating LIDs, such as infiltration trenches, is the limitation of installing flat infiltration trenches or rain gardens on steep roadways. From a practicality standpoint, we have assumed infiltration trenches can be located within the road ROW for roadways that have a maximum longitudinal slope of 4%.

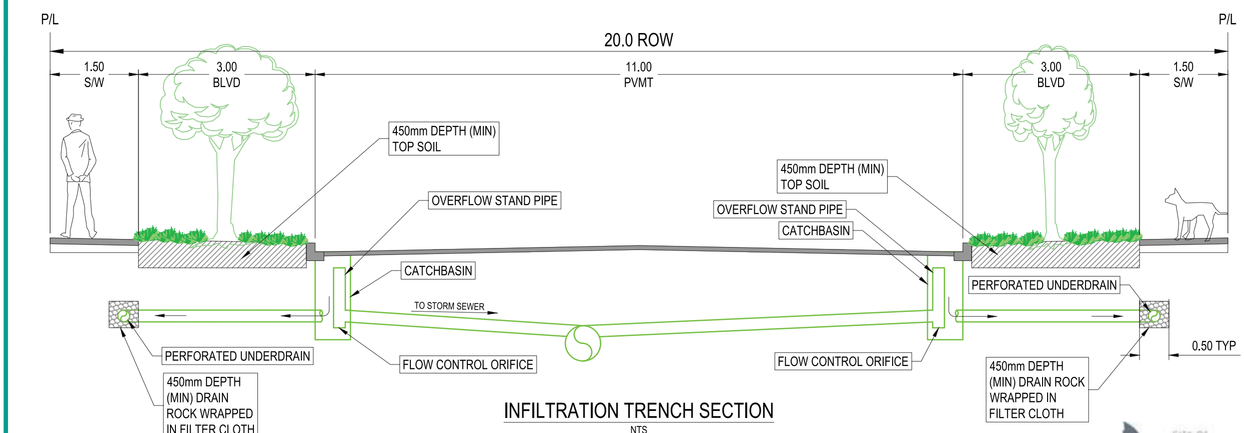
In summary, recommended source control measures for road ROW areas include:

- 450mm layer of enhanced or amended topsoil placed on all pervious areas of the boulevard.
- Sidewalks and pathways graded towards the boulevard.
- Infiltration galleries and/or rain gardens installed within the boulevard and rear lanes that occupies 5% of the road or lane ROW area, assuming a 0.45m deep infiltration trench shall be provided.



BIO SWALE SECTION

NTS



INFILTRATION TRENCH SECTION

NTS

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SCALE: NTS AUGUST 2016 2111-03570-0

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NOTES:

FLOW CONTROL ORIFICE TO BE SIZED TO DRAIN THE DRAIN ROCK RESERVOIR IN 3 - 4 DAYS.

PLAN VIEW AREA OF DRAIN ROCK TO BE 5% MIN. OF TOTAL ROAD ROW AREA

DRAIN ROCK RESERVOIR TO BE 450mm DEEP MIN. AND WRAPPED IN FILTER CLOTH ON ALL SIDES TO PREVENT CLOGGING

UNDERDRAIN TO BE 150mm PERFORATED PVC PIPE WITH INVERT 100mm ABOVE DRAIN ROCK RESERVOIR INVERT

OVERFLOW STAND PIPE OPENING TO BE AT SAME HEIGHT AS TOP OF DRAIN ROCK RESERVOIR

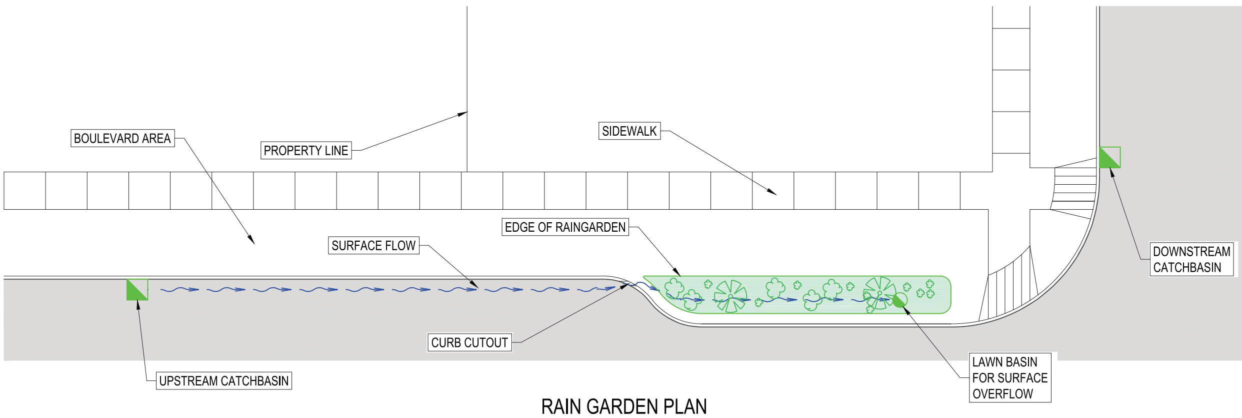
THE DRAIN ROCK RESERVOIR IS TO BE PROTECTED FROM SEDIMENT DURING CONSTRUCTION IN THE ROAD ROW AND ADJACENT PROPERTIES

THE DRAIN ROCK RESERVOIR IS TO BE MIN 300mm FROM THE PROPERTY LINE AND NOT TO CONFLICT WITH THE WATERMAIN, SHALLOW UTILITIES, OR STREET LIGHTING

ABBEY RIDGE
STORMWATER SERVICING

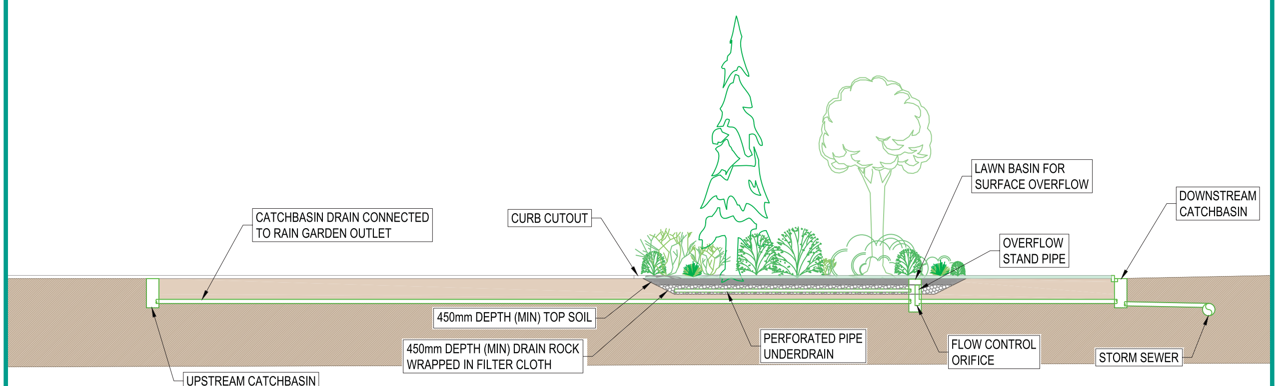
20m ROW LID DETAILS

FIGURE 11



RAIN GARDEN PLAN

NTS



RAIN GARDEN PROFILE

NTS

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ABBEY RIDGE
STORMWATER SERVICING

RAIN GARDEN
LID DETAILS

FIGURE 12

McElhanney

SCALE: NTS   AUGUST 2016   2111-03570-0

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4.8. Runoff Quality

Runoff from Abbey Ridge will drain into the Fraser River through several smaller watercourses. Stormwater runoff quality is a critical issue for the Fraser River and these small watercourses. As development progresses, the tendency is for increased levels of pollutants to enter the drainage system. Applying LIDs in the Abbey Ridge area will mitigate and bio-remediate some of the pollutant loading into the downstream watercourses. LIDs such as bio-swales, raingardens, and infiltration trenches can provide water quality benefits through settling-out of suspended solids in storage zones of such LIDs and by reducing water volume through absorption, evapotranspiration, and infiltration. Literature and analysis undertaken in past studies have reported similar benefits to LIDs with respect to removal of total suspended solids.

In addition to the recommended source control measures previously described, water quality BMPs that are recommended for use within this neighbourhood include:

- Use of oil / water separators and/or vortex separators for multi-family sites;
- Use of oil-grit traps on catchbasins located with roadways; and
- Regular street sweeping and maintenance to remove sediment at the roadway source.

4.9. Erosion Mitigation

There are several sites in Abbey Ridge where erosion is a potential concern. Braun completed a report detailing each location, which determined that no site required immediate remediation but, that all sites listed should be monitored for signs of bank destabilization and habitat loss.

The primary mitigation measure against the noted erosion occurring throughout the study area is to control the peak discharge rates and total runoff volumes to at or below the current levels at the erosion sites. This should be considered for locations at high risk and/or located within private property with no direct access or statutory ROW.

Table 18 below provides a summary of the erosion sites to be addressed as development proceeds.

Table 18: Erosion Mitigation

Location	Site ID[1]	Existing Conditions	Recommendation during Future Development
182A Street	182A Street Ditch	Ongoing erosion of the left bank of ditch along property west of 182A Street. The short timber wall retaining the landscaped private property is in an undermined state.	This existing ditch would eventually be replaced with a closed drainage system as development occurs within the area. In the interim, rock rip-rap protection can mitigate against any increase in flows from upstream development.
Leoran Brook	20-Pond	Man-made pond discharges onto a fish ladder that flows through a culvert installed in ravine fill. Potential risk to downstream highway and railway crossing in the event of a pond overtopping or damn breach.	Flows to the 99A Avenue outfall to Leoron Brook to be maintained at or below existing conditions. The stability of the existing driveway culvert and fish ladder to be reviewed. A new outfall to be installed immediately downstream of the existing Culvert / Fish Ladder as part of the storm upgrade required at 99A Avenue.
Lyncean Creek East	19-2	Over-steepened rip-rap slope at west side of 179 Street culvert crossing (1H: 1.5V). Erosion below the Lock-Block wall causing undermining.	Repairs should be made to the culvert inlet and outlet prior to any increase in flows at this location from upstream development.

4.10. Right of Way Acquisition

While some stretches of Lyncean Creek West, Lyncean Creek East and Leoran Brook flow through lots owned by the City of Surrey, other stretches flow through private property. This includes some sites where the erosion and hazard assessment (*Section 2.6*) identified some locations as medium and high risk, such as sites 19-14 and 19-2 in Lyncean Creek East (POI 5 and 6), and site 20-pond in Leoran Brook (POI 7). Therefore, the acquisition of a Statutory Right-of-Way (SRWs) for these stretches is recommended. *Table 19* presents a list of the recommended SRWs acquisitions. Their location is shown on *Figure 13*. The recommended SRWs are located in areas identified as *Future Natural Areas* in the Abbey Ridge-Local Area Plan.

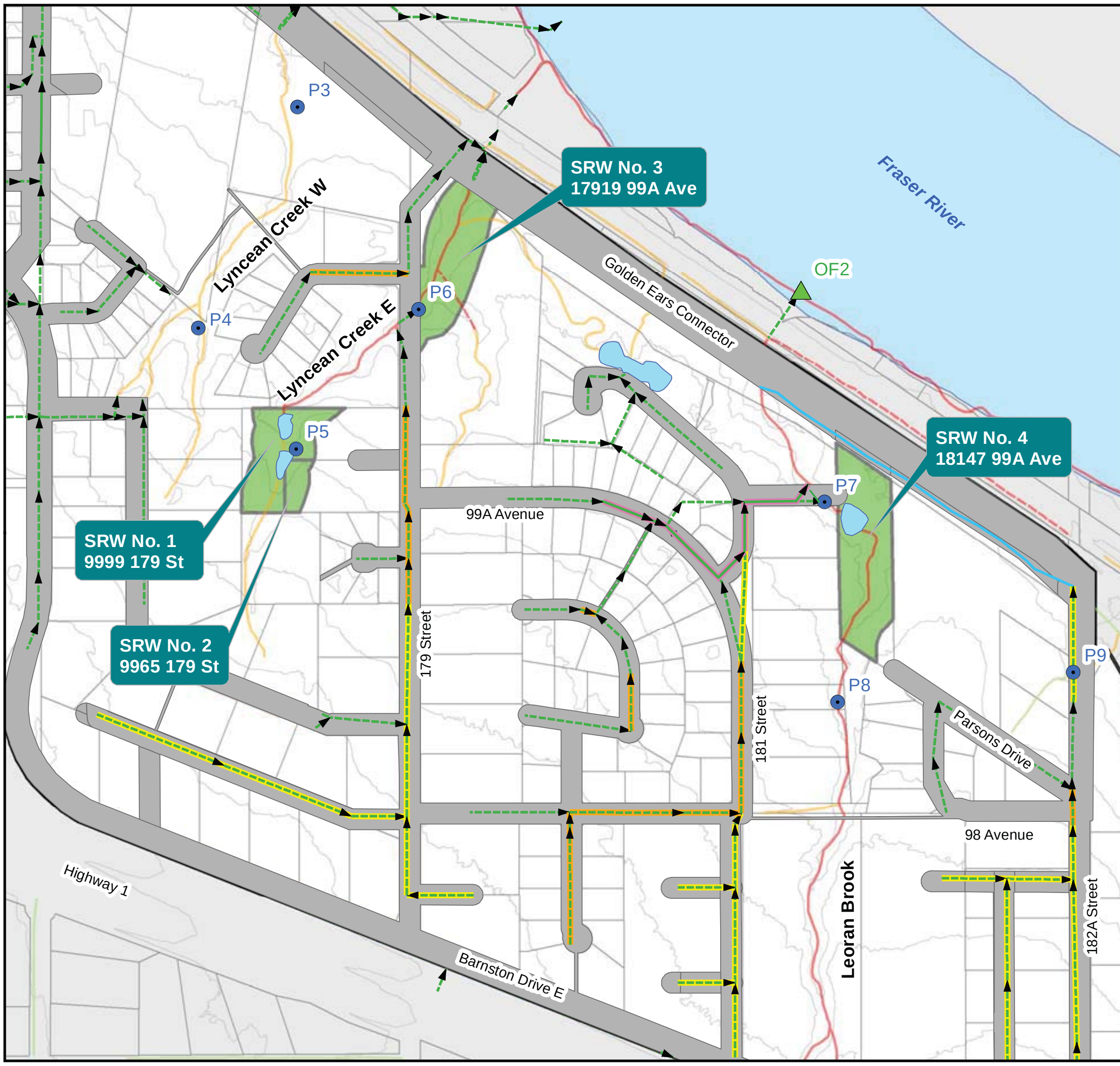
Table 19: Statutory Right-of-Way Acquisition

No.	PID	Address	Location	Area (ha)
1	002-772-400	9965 179 St	Lyncean Creek E	0.11
2	002-772-388	9999 179 St	Lyncean Creek E	0.52
3	011-931-001	17919 99A Ave	Lyncean Creek E	0.75
4	002-519-968	18147 99A Ave	Leoran Brook	0.90

It should be noted that of the four SRW's recommended above, SRW #3 is only one required prior to any development due to the increase in flows and repairs the erosion at the culvert outlet. The other three SRWs are recommendations for the City to facilitate on-going monitoring, maintenance of the existing creek and wet ponds/dams within them.

4.11. Phasing & Implementation

All future drainage infrastructure required to support development of the Abbey Ridge LAP will consist of new or replacement of existing storm sewers, in addition to the Road ROW LIDs at select locations. As build-out of the area proceeds, each development will need to extend the existing drainage system to their development that follows the proposed storm sewer and upgrades recommended by this study. No formal phasing of development will be required to meet the stormwater objectives and upgrade strategy. However, future development will need to be cognizant of the active erosion sites located at 182A Street and 179 Street and ensure appropriate mitigation is applied prior to increasing any flows at these locations.



Abbey Ridge
Storm Servicing Concept

Legend

- SRWs
- Points of Interest
- Outfalls
- Upsized Trunk Sewers
- Upsized Local Sewers
- Existing Local Sewers
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- New Local Sewers
- Proposed Road
- Existing Water Bodies

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

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0 30 60 120 180 (m)
1:5,000

Project No.	Date
2111-03570-00	December 2016

Recommended Statutory Right-of-ways

Figure 13

5. Costs & Financing

5.1. Projected Storm DCC Revenue

As the City of Surrey will calculate revenue from DCCs, detailed calculations are excluded from this report.

5.2. Projected Storm DCC Expenditures

Storm DCC expenditures benefitting Abbey Ridge are limited to 106m of 600mm and 123m of 750mm diameter trunk sewer and outfall works located within the Port Kells sub-catchment.

Construction cost estimates include a 15% allowance for engineering and contract administration, and a 30% allowance for contingency. All construction costs are based on current (2016) construction cost data. Construction costs do not include applicable taxes such as GST. *Table 20* presents the Storm DCC Eligible Works for the Abbey Ridge.

Table 20: DCC Eligible Storm Works

Item	Unit	Unit Price	Quantity	Total
600mm Storm	m	1,500.00	106	$ 159,000.00
750mm Storm	m	1,800.00	123	$ 221,400.00
Outfall	LS	75,000.00	1	$ 75,000.00
Total				**$ 455,400.00**
Engineering (12%)				$ 54.648.00
Contingency (15%)				$ 68,310.00
Total				**$ 578,358.00**

5.3. Financial Summary

It should be noted that this financial summary is subject to fluctuations in market conditions related to the rate of development and capital construction costs, ultimate development form and densities, and other variables which may alter projected DCC revenues and/or expenditures. These projections may also change with the adoption of new DCC rates.

Based on the total costs of the proposed storm works, we anticipate that revenues generated from the storm DCC will be adequate to fund the DCC eligible storm works for the area.

6. References

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Appendix A – Geotechnical Report

Foundations,
Excavation &
Shoring
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Foundations

Excavation & Shoring

Slope Stability

Natural Hazards

Pavement Design and Management

Reinforced Soil Walls and Slopes

April 15, 2016
Our File: 16-6720

Via email: nsandhu@mcelhanney.com

McElhanney Consulting Services Ltd.
2300 – 13450 102nd Avenue
Surrey, BC V3T 5X3

Attn: Mr. Nav Sandhu, P.Eng.

Re: Preliminary Geotechnical Assessment
Abbey Ridge Local Area Servicing, Surrey, BC

1.0 INTRODUCTION & PROPOSED PROJECT

As requested, Braun Geotechnical Ltd. has carried out a preliminary geotechnical assessment at an overview level of effort for the above-referenced study site area. The geotechnical work was completed in general accordance with the Braun Geotechnical Ltd. proposal Ref. P16-4883 dated February 9, 2016

The scope of work included:

- Compilation, review, and update of geological, geotechnical and slope hazard mapping information that is available from published, in-house, and Surrey sources. The desk study work included review of Google Earth imagery and historical air photos dating back to the 1940's.
- Field site reconnaissance at select slope areas of potential geotechnical concern identified during the desk study phase.
- Provision of a geotechnical report with preliminary discussion comments and recommendations pertaining to geotechnical related site conditions including highlight of slope areas that may warrant detailed geotechnical assessment and/or avoidance.

The geotechnical assessment is required in support of Local Area Servicing (LAS) for future densification in the Abbey Ridge area of north Surrey. The subject area is bordered by 172nd Street to the west, Highway 1 to the south, Golden Ears Way to the east, and 104 Ave and Daly Road / Golden Ears Connector to the north.

A geotechnical erosion and hazard assessment of the Surrey North Bluff was carried out at an overview level of effort by Thurber Engineering Ltd. (Thurber) and their findings presented in a report dated February 22, 2000. Tetra Tech EBA Inc. (EBA) produced an overview report dated December 24, 2014 which covers all ravines in the City of Surrey. The Abbey Ridge area constitutes a small area entirely within the limits of the previous studies carried out by Thurber and EBA. As such, the purpose of the current assessment was to review the findings of the previous assessments for the Abbey Ridge area, and to provide an updated assessment which considers any significant changes that may have occurred and provide recommendations for additional assessment if deemed necessary.

The previous studies included identification of erosion areas within the creeks by Stantec followed by review of the identified areas by Thurber, and subsequent review of a much larger area of Surrey by EBA. The reviews took into consideration erosion and soil slope instability, and provided priorities for geotechnical repair or site monitoring. The areas of concern were given a high, medium or low priority rating. For consistency, Braun adopted similar qualitative assignments of geotechnical areas of potential concern presented in the Thurber and EBA studies.

It is anticipated that setback requirements for any developments adjacent to the ravines would be carried out by a qualified engineer.

2.0 HAZARD & RISK ASSESSMENT

A hazard is a phenomenon with the potential to cause harm; it is usually represented by a magnitude and recurrence interval (see Table 1). The product of the factors Hazard and Consequence equals Risk. Consequence itself is a product of factors, including 1) whether an event will reach a site, 2) whether elements at risk will be present when the site is affected by the hazard, 3) how vulnerable the elements at risk are to the hazard affecting the site, and 4) the value of the elements at risk, or the number of persons exposed.

Table 1. Qualitative Hazard Frequency Categories.

Qualitative Frequency	Annual Return Frequency	Comments
Very high	>1/20	Hazard is well within the lifetime of a person or typical structure. Clear fresh signs of hazard are present.
High	1/100 to 1/20	Hazard could happen within the lifetime of a person or structure. Events are identifiable from deposits and vegetation, but may not appear fresh.
Moderate	1/500 to 1/100	Hazard within a given lifetime is possible, but not likely. Signs of previous events may not be easily noted.
Low	1/2500 to 1/500	The hazard is of uncertain significance.
Very low	<1/2500	The occurrence of the hazard is remote.

Source: BC MoE (1999)

In Canada and BC there is no legislated guidance for risk tolerance to landslides and associated phenomenon, and the term "safe" has not been legally defined. In considering risk tolerance, an important concept is that risk of loss of life from natural hazards should not add substantially to that from usual life factors combined (i.e. driving, health, recreation, etc.). This consideration may also be extended to risk of property damage or loss.

The Association of Professional Engineers and Geoscientists of BC (APEGBC) document, "Legislated Landslide Assessments for Proposed Residential Development in BC, May, 2010" presented and supported hazard acceptability criteria adopted by Fraser Valley Regional District for hazard risk management (Cave 1993). The criteria are presented as a risk matrix with different development proposals versus different hazard levels for a suite of hazard types.

A hazard acceptability risk matrix considered relevant to the study site area is presented below in Table 2.

Table 2. Hazard acceptability thresholds for various levels of development considering select geologic hazards. See Cave (1993) for full description.

Stream Erosion/ Flooding	>1/10	1/10-1/100	1/100-1/200	1/200-1/500	<1/500
New Building	5	5	4	2	1
Subdivision (densification)	5	5	5	4	1
Sediment flood	**>1/50**	**1/50-1/200**	**1/200-1/500**	**1/500-1/10K**	**<1/10K**
New Building	4	4	3	1	1
Subdivision (densification)	5	5	4	2	1
Property-Scale Landslide	**>1/10**	**1/10-1/100**	**1/100-1/200**	**1/200-1/500**	**<1/500**
New Building	5	5	4	2	1
Subdivision (densification)	5	5	5	4	1

1 - Approval without conditions relating to hazards.
2 – Approval without siting conditions or protective works conditions, but with a registered covenant against title.
3 – Approval, but with siting requirements to avoid the hazard, or with requirements for protective works to mitigate the hazard.
4 – Approval as (3) above, but with a registered covenant against title as well as siting conditions, protective works, or both
5 – Not approvable.

3.0 STUDY AREA DESCRIPTION

Based on surficial geology mapping information from the Canadian Geological Survey, the Abbey Ridge area is underlain by Capilano Sediments and Pre-Vashon Deposits. The Capilano Sediments include marine and glaciomarine stony (including till-like) deposits to stoneless silt loam to clay loam with minor sand and silt normally less than 3m thick but up to 30 to 60m thick, containing marine shells. The Pre-Vashon Deposits include Quadra fluvial channel fill and floodplain deposits, cross-bedded sand containing minor silt and gravel lenses and interbeds, or Quadra marine interbedded fine sand to clayey silt believed to be off shore equivalent to the Quadra fluvial channel fill.

The creeks in the Abbey Ridge area generally flow from the Surrey uplands north towards the Fraser River. The creeks have eroded the above materials to form ravines in many areas.

Mean annual precipitation at Surrey is 1500mm with less than 2% falling as snow. Prolonged, sometimes intense rainfall occurs in fall and winter. Late summer (Aug/Sep) storms may also deliver intense precipitation.

4.0 CLIMATE CHANGE

Climate change is expected to result in an increase in winter temperatures, precipitation intensity and strong storm frequencies (Madsen and Figdor 2007, and others).

A summary of research opinions regarding climate impacts on precipitation is provided below in Table 3, (Sutton, 2011).

Table 3. Summary of climate change impacts on precipitation (Sutton, 2011)

Precipitation Condition	Expected Change Condition	Authors
Short Term (Intense)	-6 percent increase by 2100 -increase in 1990 data compared to pre-1977 data -small increase +/- annual maximums Sept, Oct, Nov, 2100	-Jakob & Lambert, (2009) -Jakob et al, (2003) -Salathe et al, (2010) -Mailhout et al, (2010)
Long Term (Annual)	-10% increase by 2070 to 2100 -1% to 2% annual increase by 2100 -1% to 5% increase by ~2050 -2% to 11% increase by ~2050 -11% to 12% increase by ~2040 & 0% to 21% increase by ~2080	-Jakob & Lambert, (2009) -Mote et al, (2010) -Murdock et al, (2007) -PCIC, (2010) -Elsner et al, (2010)
Seasonal Shift	-winter increase/ summer decrease -winter increase/ summer decrease -winter increase (4% to 14%)/ summer decrease (14% to 33%) -increase in autumn -winter increase or decrease (-2% to 16%)/ summer increase or decrease (-8% to 6%) -increase/ decrease disagreement between models	-Elsner et al, (2010) -Mote et al, (2010) -Murdock et al, (2007) -Salathe et al, (2008) -PCIC, (2010) -Salathe et al (2010)
Climate Oscillations (PDO/ ENSO)[1]	-increase associated with high precipitation -increase in intensity with positive PDO -increase in PDO winter daily maximums -changes in stochasticity complicates predictions	-Jakob et al, (2003) -Murdck et al (2007) -Zhang et al, (2010) -Jakob & Lambert, (2009)

1. Pacific Decadal Oscillations & El-Nino Southern Oscillations

Climate change impact on precipitation is expected to result in a change in rate and magnitude of natural hazards, including floods (Whitfield et al 2003a, b) and landslides (Jakob and Lambert 2009). It is beyond the scope of this report to evaluate the magnitude of the impact of these changed conditions.

However, in view of uncertainty in current understanding of climate change impacts, caution is warranted in application of current precipitation simulation modelling for use in stormwater management designs, including effectiveness of overflow protection measures.

5.0 REFERENCE MATERIAL

Background reports provided in the Surrey RFP documents included the above noted overview reports by Thurber and EBA. These documents, summarized in the following section, were reviewed and those hazards that were identified were noted along with frequency of occurrence and other pertinent details.

Airphotos for the study area were obtained from the Geographical Information Centre at UBC. The airphotos were used to follow up specific events identified in the background review and the field portions of the work. Airphotos were reviewed for 1940, 1949, 1954, 1963, 1969, 1974, 1979, 1986, 1991, 1997, 2002, and 2009.

6.0 UPDATES TO PREVIOUS FINDINGS

This section provides a summary of the findings of the previous studies by Thurber (2000) and EBA (2014), updates previous findings, and makes recommendations for additional work, where required, based on review of recent air photos and on site reconnaissance findings.

Site ID numbers used by EBA are included where EBA completed reviews, and shown on the attached plan. A majority of descriptions of previous work are from the Thurber report. Select photos of the subject areas are attached in Appendix A.

6.1 182A Street Ditch (Thurber ID 182A Street Ditch/ EBA no ID, did not assess)

Previous observations, comments and recommendations by others included:

- Erosion of a ditch channel adjacent to an anchor fence along private property west of 182A Street was observed. A low timber retaining wall was observed to be undermined and slightly damaged. It was considered that additional erosion could impact the private property.
- Exposed natural soils were observed to comprise stiff, fissured pale grey to brown, moist clayey silt with a trace of sand.
- Extension of a driveway culvert northward to limit the localized ditch erosion, or provision of rip-rap armour to the ditch was recommended. This work was given a high priority.

The following observations were made during the recent site reconnaissance:

- The condition of the ditch was similar to that described previously. Soil is exposed on the side slopes of the ditch below the relatively short timber wall on the private property located adjacent and to the west of the ditch. The base of the timber wall is located well above the base of the ditch, and the timber wall is currently in an undermined condition.
- The previous recommendation to extend the culvert to the north was not carried out.
- Further erosion could impact the landscaped areas on the private property, and possibly underground utilities that may be present.
- Many of the landscape ties used to construct the left bank retaining walls appear to be in an advanced state of decay.

Current Hazard Condition

- Ongoing erosion of the left bank of the ditch and advanced decay of the wood retaining wall timbers mean that potential for collapse of portions of the left bank are considered Very High.
- Loss of public and private property along the left bank of the channel at a property scale.
- Channel avulsion is considered likely for left bank collapse during the wet weather season when average ditch flows are near maximum annual levels or during an extended period of heavy rainfall. Avulsion flows could inundate downgradient private and public property.

Recommendations

- Previous recommendations were provided that included extension of an existing driveway culvert northward to limit the localized ditch erosion. This is considered a low cost solution to the hazard and is also recommended by Braun.

6.2 Leoran Brook (Thurber ID Leoran Creek/ EBA ID Drainage # 20)

Previous observations, comments and recommendations by others included:

- In the upper section of Leoran Brook, minor lateral scour at the toe of the slope was observed by Thurber between Barnston Drive and a sediment filled pond just north of a high driveway fill approximately aligned with 99 Ave. Geotechnical hazards noted in the upper portion of Leoran Brook were considered to be small scale or low consequence. Erosion was reviewed by EBA within the left bank area southeast of 9820 181 Street, which they considered to be of medium risk.
- A pond, low earth dam with a culvert outlet, an old concrete fish ladder, and a small pool just upstream of the culvert inlet through deep ravine fill was identified within the mid-section of the creek alignment by Thurber. This area was observed to be landscaped and open, with only small scale erosion concerns. Periodic clean out of the middle section pond was recommended if the private land owner wished to continue to operate the structures.
- The lower section of the creek was forested, with a newer concrete fish ladder below the culvert outlet. Leoran Brook was noted to have eroded its banks at several locations and minor slope stability problems associated with the erosion were observed. A high soil face just north of the fill, possibly excavated with heavy equipment was observed. Downstream, erosion of the base of the ravine slopes and portions of the creek terraces was observed. The lower forested portion of the creek was considered to have the highest potential for erosion, but this area of the creek was not considered to pose a significant geotechnical risk based on the development density at that time (2000).
- Native soils along the ravine slopes were noted to comprise erosion-resistant stiff, fissured, pale grey to brown, moist clayey silt with a trace to some sand and gravel.

The following observations were made during the recent site reconnaissance:

Upper Section

- A new culvert has been installed under Highway 1, and some re-alignment of the creek channel to the north of the culvert has been completed. Beyond the area of realignment, minor erosion of the right and left banks was observed. The ravine slopes and crest areas are generally heavily treed.
- Additional erosion of the left bank area southeast of 9820 181 Street since the time of the EBA review was not observed.

Current Hazard Condition

- Ongoing erosion could impact trees.
- Surface water flow could accelerate erosion of the left bank area southeast of 9820 181 Street.

Recommendations

- Obvious visible evidence of accelerated left or right bank erosion was not identified. However, the area of the downstream channel re-aligned during the recent Hwy 1 full-width culvert crossing should be reviewed periodically for potential changes in erosion rates.
- The area of erosion southeast of 9820 181 Street should be reviewed periodically for changing conditions.

Middle Section

- Left bank erosion/ shallow sloughing, and right bank erosion were observed in the middle section of the creek. An amateur (non-engineered) bridge constructed using steel beams with 2x6 timber decking crossed the channel at a low bank location. The bridge has low clearance (maximum 0.4m clearance at the channel invert), and woody debris is accumulating against the steel beams.
- A large number of trees have toppled into the creek downstream of the bridge, and stream sediments are accumulating in the woody debris.
- The middle section opens up into a pond area with a landscaped perimeter. A high clearance, (likely non-engineered) bridge is present just upstream of the pond. The pond discharges onto a fish ladder that flows through a culvert installed in ravine fill for a driveway crossing.

Current Hazard Condition

- The low clearance bridge and downstream accumulation of woody debris is expected to continue to accumulate debris and may shift the channel. In the event that a channel dam develops, sudden release of water and debris may overload or clog the pond structures located immediately downstream.
- The stability of the ravine fill for the driveway crossing below the pond structure is unknown.

Recommendations

- The creek banks should be reviewed periodically for accelerated erosion. The non-engineered bridge structures should be removed from the channel or replaced.
- Accumulated woody debris should be removed from within the creek channel.
- The stability of the fish ladder and associated ravine fill should be reviewed. Due to the height of the ravine fill the potential head that could be developed behind fill in the event the culvert through the fill becomes clogged would be significant, and in a breach event, the accelerated erosion and associated de-stabilization of existing ravine slopes in a breach event could occur. Current receptors are limited due to low density development below the ravine fill. However, this consequence condition can be expected to change with development densification.
- Geotechnical exploration and stability assessment of the pond structures should be carried out. The findings of the geotechnical study should be used to develop an operation and inspection plan that meets the provincial requirements for management of small dams.

Lower Section

- Below the fish ladder and dam, ravine slopes become setback and Lorean Brook meanders in a wide channel area. The creek flows under a recently constructed bridge for the Golden Ears Connector.

Recommendations

- The lower section of the creek should be reviewed periodically for potential changes in erosion rates.

6.3 Lyncean Creek East (Thurber ID "Unnamed"/ EBA ID Drainage #19)

Previous observations, comments and recommendations by others included:

- Significant erosion within this creek was not observed.
- A pond behind a 7m high dam with a vertical downstream face was located west of 9999 179 Street. It was observed that each face of the dam may have been constructed using driven piles with soil placed between the row of piles. A narrow roadway crossed the dam crest, and another pond was observed downstream of the dam.
- Settlement of the dam crest was evident. The dam was not considered to have been engineered, and the safety of the public and property was a concern should the dam fail suddenly.
- Exposed soil was not observed at this location. However, soils exposed at a nearby construction site indicated that clayey silt and sand is present at depth.
- The risks of erosion associated with a sudden failure of the dam were considered to be severe. It was recommended that the property owner be requested to have a professional engineer complete a dam safety review. This work was given a high priority.

The following observations were made during the recent site reconnaissance:

- The dam behind the property at 9999 179 Street was still present, creating a pond to the south. The dam is approximately 7m high, and a second dam is present to the north creating a second pond. Both dams appear to be non-engineered structures.
- Rip rap placed on the west side of 179 Street where the creek flows under the road appears to be oversteepened as it has a slope of approximately 1H:1.5V (Horizontal to Vertical).
- Portions of a concrete block wall supporting the east side the 179 Street creek crossing are undermined.

Current Hazard Condition

- Stability of the existing dam structures and fill embankments is unknown. A dam breach could be expected to impact residential areas and municipal infrastructure downstream due to flooding/inundation, and accelerating erosion at the toe of ravine slopes and promoting instability.
- Ongoing erosion below the rip rap or erosion below the concrete block wall adjacent to 179 Street could impact the roadway over time.

Recommendations

- Dam breach or embankment failure can be expected to impact downstream residential subdivision development or municipal infrastructure. Geotechnical exploration and assessment of the existing ravine fills / dams should be undertaken to review stability of the embankments. The findings of the geotechnical study should be used to develop an operation and inspection plan that meets the provincial requirements for management of small dams. This work should be given a high priority.
- The condition of the rip-rap should be reviewed periodically, and repairs completed if required.

- Erosion below the lock blocks should be reviewed and repaired as needed. Additional fill and/or slope reconfiguration should be completed to remediate the undermined portions of the wall.

6.4 Lyncean Creek West (Thurber ID "Unnamed"/ EBA ID Drainage #18)

Previous observations, comments and recommendations by others included:

- Minor creek bank erosion just above a small pond created by a low earth dam was observed. A fish ladder was not present, and the overflow CMP culvert appeared to be too steep for fish to traverse. Some soil erosion around the culvert was observed. North of the outlet, the creek was observed to flow to a ditch on the south side of Daly Road.
- Soils exposures were not observed, but it was considered that clayey silt and sand are present at depth.
- Several dams that created ponds behind them were observed west of the creek. However, none discharged into the creek. Breaching of the dams was not considered to pose a significant risk at that time. Removal of the dams was recommended if they did not have environment value. This work was given a low priority.
- EBA noted a culvert with an undermined concrete headwall immediately south of the intersection 100 Ave and Lyncean Drive.
- The creek was noted to flow under a tree located southeast of 17780 100A Avenue.

The following observations were made during the recent site reconnaissance:

- The confluence of two creek tributaries to Lyncean Creek West is located at the approximate alignment of 100A Avenue.
- The west tributary extends south to approximately the intersection of Lyncean Drive and 100 Avenue to a headwall which discharges water into the creek. Dumping of residential garden waste and relatively high, steep slopes were observed in this area. Further, the catch basin at the corner of the adjacent roadway was observed to be plugged with leaves and debris. Surface water appears to have been flowing past the catch basin, north and down the ravine bank, and erosion of the bank above the culvert headwall was observed. The water likely contributed to undermining of the culvert headwall.
- The east tributary extends approximately 125m further south than the west tributary. The ground surface near the creek was observed to be wet and soft, and seepage from the side slopes was observed at many locations. A culverted creek crossing was present just south of the approximate alignment of 100 Avenue. The thickness of fill was approximately 4.5m, and 300mm diameter culverts had been installed near the base of the fill and 3m above the base. An open top concrete sump was installed downstream of the crossing, and discharged to the creek through a PVC pipe extending from the side of the sump down to the base of the creek. A considerable volume of water was discharging out of the slope adjacent to the sump.
- A tree located southeast of 17780 100A Avenue was observed to be in similar condition as described previously, with water flowing below it. The tree is leaning.
- Further downstream, the creek flows through the industrial property located at 10095 179 Street. Within the property, the banks of the creek were observed to be oversteepened. Horizontal steel beams restrained with driven steel piles had been installed to stabilize the

bank. The creek flows into a culvert within the private property and under Daly Road to the north.

Current Hazard Condition

- Uncontrolled disposal of residential garden waste is accumulating substantial debris at the crest of ravine slopes. If allowed to continue unabated, this material can be expected to fail at some point in the future. Previous experience with failures of slope crest debris noted that underlying natural soils may be scoured and accumulated in the slide mass as the material slides downslope thus reducing stability to a condition less stable than pre-development natural slopes condition.
- A catch basin located near the crest of slope at Lyncean Drive and 100 Avenue was observed to be fully clogged. Visible evidence of uncontrolled surface run-off and slope erosion was noted below the catch basin location
- If the culverted crossing just south of the 100 Avenue alignment becomes plugged, potential exists for development of conditions that may promote a dam breach event.
- The leaning tree below which the creek flows southeast of 17780 100A Avenue could impact adjacent properties if it topples.

Recommendations

- Residents should be informed of potential damage that may occur if uncontrolled dumping is allowed to continue. Appropriate signage should be installed.
- The catch basin at the corner of Lyncean Drive and 100 Avenue should be cleared regularly. Erosion of the bank and the culvert headwall to the north should be repaired.
- Details of the culvert at the filled creek crossing just south of the 100 Avenue alignment should be reviewed. Replacement of the culvert should be carried out if the design is inadequate. If deemed adequate, regular maintenance and inspection should be carried out to reduce potential for development of fully plugged condition.
- Details of the sump and water leakage adjacent to the sump should be reviewed.
- The tree located southeast of 17780 100A Avenue should be reviewed by an arborist, and removed if deemed unstable.
- The oversteepened slopes within the private property at 10095 179 Street should be assessed for long term stability under static and seismic loading conditions.

6.5 Centre Creek Tributary Creek, Along 172 St. Alignment, Between 103 and 104 Ave

The following observations were made during the recent site reconnaissance:

- A short reach of a Centre Creek tributary is located within the limits of the study area between 103 and 104 Avenue along the alignment of 172 Street. The side slopes around the creek are relatively steep (~1H:1V) at some locations. Minor to moderate bank erosion was evident. A right bank slump with a volume of approximately 15 cubic metres was observed, and was estimated to be approximately 5 to 10 years old. Downstream from the slump, there were two trees that had toppled at different times to indicate active bank erosion.
- The creek flows north through a culvert under 104 Avenue towards Centre Creek.

Current Hazard Condition

- The erosion and slump are relatively minor, and are not considered to pose a risk to adjacent properties at this time.

Recommendations

- The ravine should be reviewed periodically for changing conditions.
- Review of this tributary channel beyond the study limits noted conditions to indicate that accelerated erosion of the channel and ravine slopes may be occurring. This suggests that development-related changes to the stream basin have resulted in more frequent flooding. A detailed stream channel assessment of Centre Creek is recommended

7.0 ADDITIONAL COMMENTS AND RECOMMENDATIONS

The current preliminary study was completed to obtain a reconnaissance level review of the subject creeks, and update previous assessments. Additional detailed geotechnical assessment is recommended to assess stability of ravine slopes. The detailed assessment would be carried out with a view to focus intrusive exploration efforts at selected locations in order to determine performance expectations of the slopes under both static and seismic conditions.

Detailed stream channel assessments of the selected creeks are recommended to assess the baseline condition of each channel for use in assessing potential impacts of additional development that is expected to occur.

8.0 CLOSURE

This report is prepared for the exclusive use of McElhanney Consulting Services and their designated representatives and may not be used by other parties without the written permission of Braun Geotechnical Ltd. The City of Surrey may also rely upon the contents of this report.

The use of this geotechnical report is subject to the conditions on the attached Report Interpretation and Limitations sheet. The reader's attention is drawn specifically to those conditions, as it is considered essential that they be followed for proper use and interpretation of this report.

We hope the above meets with your requirements. Should any questions arise, please do not hesitate to contact the undersigned.

Yours truly,

Braun Geotechnical Ltd.	***Braun Geotechnical Ltd***
Original Signed by Authors	Original Signed by Authors
James Wetherill, P.Eng. Geotechnical Engineer	Sonny Singha, P.Eng. Geotechnical Engineer

Encl: Report Interpretation and Limitations
Site Plan
Appendix A – Annotated Site Photographs

REPORT INTERPRETATION AND LIMITATIONS

1. STANDARD OF CARE

Braun Geotechnical Ltd. (Braun) has prepared this report in a manner consistent with generally accepted engineering consulting practices in this area, subject to the time and physical constraints applicable. No other warranty, expressed or implied, is made.

2. COMPLETENESS OF THIS REPORT

This Report represents a summary of paper, electronic and other documents, records, data and files and is not intended to stand alone without reference to the instructions given to Braun by the Client, communications between Braun and the Client, and/or to any other reports, writings, proposals or documents prepared by Braun for the Client relating to the specific site described herein.

This report is intended to be used and quoted in its entirety. Any references to this report must include the whole of the report and any appendices or supporting material. Braun cannot be responsible for use by any party of portions of this report without reference to the entire report.

3. BASIS OF THIS REPORT

This report has been prepared for the specific site, development, design objective, and purpose described to Braun by the Client or the Client's Representatives or Consultants. The applicability and reliability of any of the factual data, findings, recommendations or opinions expressed in this document pertain to a specific project at described in this report and are not applicable to any other project or site, and are valid only to the extent that there has been no material alteration to or variation from any of the descriptions provided to Braun. Braun cannot be responsible for use of this report, or portions thereof, unless we were specifically requested by the Client to review and revise the Report in light of any alterations or variations to the project description provided by the Client.

If the project does not commence within 18 months of the report date, the report may become invalid and further review may be required.

The recommendations of this report should only be used for design. The extent of exploration including number of test pits or test holes necessary to thoroughly investigate the site for conditions that may affect construction costs will generally be greater than that required for design purposes. Contractors should rely upon their own explorations and interpretation of the factual data provided for costing purposes, equipment requirements, construction techniques, or to establish project schedule.

The information provided in this report is based on limited exploration, for a specific project scope. Braun cannot accept responsibility for independent conclusions, interpretations, interpolations or decisions by the Client or others based on information contained in this Report. This restriction of liability includes decisions made to purchase or sell land.

4. USE OF THIS REPORT

The contents of this report, including plans, data, drawings and all other documents including electronic and hard copies remain the copyright property of Braun Geotechnical Ltd. However, we will consider any reasonable request by the Client to approve the use of this report by other parties as "Approved Users." With regard to the duplication and distribution of this Report or its contents, we authorize only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of this Report by those parties. The Client and "Approved Users" may not give, lend, sell or otherwise make this Report or any portion thereof available to any other party without express written permission from Braun. Any use which a third party makes of this Report – in its entirety or portions thereof – is the sole responsibility of such third parties. BRAUN GEOTECHNICAL LTD. ACCEPTS NO RESPONSIBILITY FOR DAMAGES SUFFERED BY ANY PARTY RESULTING FROM THE UNAUTHORIZED USE OF THIS REPORT.

Electronic media is susceptible to unauthorized modification or unintended alteration, and the Client should not rely on electronic versions of reports or other documents. All documents should be obtained directly from Braun.

5. INTERPRETATION OF THIS REPORT

Classification and identification of soils and rock and other geological units, including groundwater conditions have been based on exploration(s) performed in accordance with the standards set out in Paragraph 1. These tasks are judgemental in nature; despite comprehensive sampling and testing programs properly performed by experienced personnel with the appropriate equipment, some conditions may elude detection. As such, all explorations involve an inherent risk that some conditions will not be detected.

Further, all documents or records summarizing such exploration will be based on assumptions of what exists between the actual points sampled at the time of the site exploration. Actual conditions may vary

significantly between the points investigated and all persons making use of such documents or records should be aware of and accept this risk.
The Client and "Approved Users" accept that subsurface conditions may change with time and this report only represents the soil conditions encountered at the time of exploration and/or review. Soil and ground water conditions may change due to construction activity on the site or on adjacent sites, and also from other causes, including climactic conditions.
The exploration and review provided in this report were for geotechnical purposes only. Environmental aspects of soil and groundwater have not been included in the exploration or review, or addressed in any other way.
The exploration and Report is based on information provided by the Client or the Client's Consultants, and conditions observed at the time of our site reconnaissance or exploration. Braun has relied in good faith upon all information provided. Accordingly, Braun cannot accept responsibility for inaccuracies, misstatements, omissions, or deficiencies in this Report resulting from misstatements, omissions, misrepresentations or fraudulent acts of persons or sources providing this information.

6. DESIGN AND CONSTRUCTION REVIEW

This report assumes that Braun will be retained to work and coordinate design and construction with other Design Professionals and the Contractor. Further, it is assumed that Braun will be retained to provide field reviews during construction to confirm adherence to building code guidelines and generally accepted engineering practices, and the recommendations provided in this report. Field services recommended for the project represent the minimum necessary to confirm that the work is being carried out in general conformance with Braun's recommendations and generally accepted engineering standards. It is the Client's or the Client's Contractor's responsibility to provide timely notice to Braun to carry out site reviews. The Client acknowledges that unsatisfactory or unsafe conditions may be missed by intermittent site reviews by Braun. Accordingly, it is the Client's or Client's Contractor's responsibility to inform Braun of any such conditions.
Work that is covered prior to review by Braun may have to be re-exposed at considerable cost to the Client. Review of all Geotechnical aspects of the project are required for submittal of unconditional Letters of Assurance to regulatory authorities. The site reviews are not carried out for the benefit of the Contractor(s) and therefore do not in any way effect the Contractor(s) obligations to perform under the terms of his/her Contract.

7. SAMPLE DISPOSAL

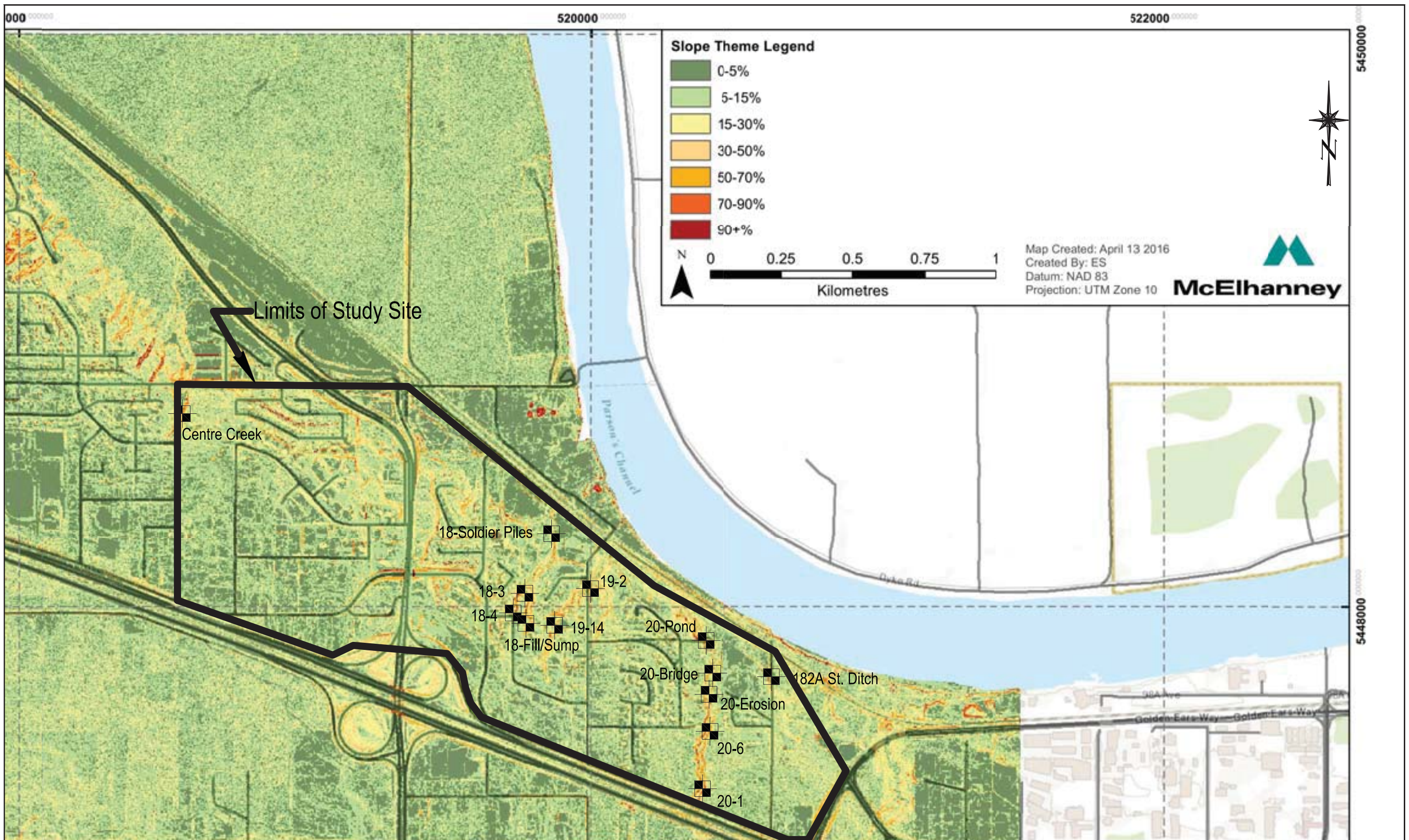
Braun will dispose of all samples 3 months after issuance of this report, or after a longer period of time at the Client's expense if requested by the Client. All contaminated samples remain the property of the Client and it will be the Client's responsibility to dispose of them properly.

8. SUBCONSULTANTS AND CONTRACTORS

Engineering studies frequently requires hiring the services of individuals and companies with special expertise and/or services which Braun Geotechnical Ltd. does not provide. These services are arranged as a convenience to our Clients, for the Client's benefit. Accordingly, the Client agrees to hold the Company harmless and to indemnify and defend Braun Geotechnical Ltd. from and against all claims arising through such Subconsultants or Contractors as though the Client had retained those services directly. This includes responsibility for payment of services rendered and the pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. These conditions apply to specialized subconsultants and the use of drilling, excavation and laboratory testing services, and any other Subconsultant or Contractor.

9. SITE SAFETY

Braun Geotechnical Ltd. assumes responsibility for site safety solely for the activities of our employees on the jobsite. The Client or any Contractors on the site will be responsible for their own personnel. The Client or his representatives, Contractors or others retain control of the site. It is the Client's or the Client's Contractors responsibility to inform Braun of conditions pertaining to the safety and security of the site – hazardous or otherwise – of which the Client or Contractor is aware.
Exploration or construction activities could uncover previously unknown hazardous conditions, materials, or substances that may result in the necessity to undertake emergency procedures to protect workers, the public or the environment. Additional work may be required that is outside of any previously established budget(s). The Client agrees to reimburse Braun for fees and expenses resulting from such discoveries. The Client acknowledges that some discoveries require that certain regulatory bodies be informed. The Client agrees that notification to such bodies by Braun Geotechnical Ltd. will not be a cause for either action or dispute.



BRAUN GEOTECHNICAL LTD.

Rev.	Description	Date

Client: McElhanney Consulting Services Ltd.

Project: Abbey Ridge Local Area Servicing
Surrey, BC

Project no.	Drawn	Design	Checked
16-6720	DD	SS	JW

Title: SITE ID
LOCATION PLAN

Date	Scale	Drawing no.
April 13, 2016	1:12500	16-6720-01

Appendix A: Annotated Photos

Photo 1. (WP-182A ST DITCH) 182A Street Ditch. View of left bank decaying and toppling landscape tie retaining walls and wall debris.

Photo 2. **(WP20-1)** Leoran Brook (upper section at Hwy 1). View of right bank erosion and recent instream works (~5 yrs old).

Photo 3. (WP20-6) Leoran Brook (upper section). Left bank erosion (southeast of 9820 181 Street).

Photo 4. **(WP20-EROSION)** Leoran Brook (middle section). View of left bank erosion and woody debris

Photo 5. (WP20-BRIDGE). Leoran Brook (middle section). View of amatuer footbridge crossing with woody debris accumulating under the bridge against the stringers.

Photo 6. (WP20-BRIDGE). Leoran Brook (middle section). View of woody debris accumulation and aggrading stream channel approximately 25m upstream from man-made pond.

Photo 7. (WP20-POND). Leoran Brook (middle section). View of man-made pond. Outfall wier with fish ladder structure visible at centre of image.

Photo 8. (WP19-14). Lyncean Creek East. View of upper pond (access road ravine fill). Culvert trash rack partially clogged with debris

Photo 9 (WP19-14). Lyncean Creek East. View of main pond showing flow from upper pond through access road ravine fill. Main pond trash rack damaged and partially clogged with debris.

Photo 10 (WP19-2). Lyncean Creek East (179 Street culvert crossing). View of 200mm pipe draining northbound roadway scupper and Lock Block retaining wall erosion.

Photo 11. (WP19-2). Lyncean Creek East (179 Street culvert crossing). View of over-steepened rip rap slope at inlet culvert crossing

Photo 12. (WP18-FILL/SUMP). Lyncean Creek West (East Tributary). Small scale stormwater control structure (vandalized) flowing approximalely 5gpm.

Photo 13. (WP18-FILL/SUMP). Lyncean Creek West (East Tributary). Ravine Fill with High/Low Inlet Culverts

Photo 14. (WP18-4). Lyncean Creek West (West Tributary). Undermined Culvert Headwall at 100 Ave & Lyncean Drive.

Photo 15. (WP18-4). Lyncean Creek West (West Tributary). Bank Erosion Above Culvert at 100 Ave & Lyncean Dr.

Photo 16. (WP18-3). Lyncean Creek West. Tree With Water Flowing Below East of 17780 100A Ave

Photo 17. (WP18-SOLDIER PILES). Lyncean Creek West. View of left bank tiered solderpile walls (~300mm steel pipe piles with various metal lagging).

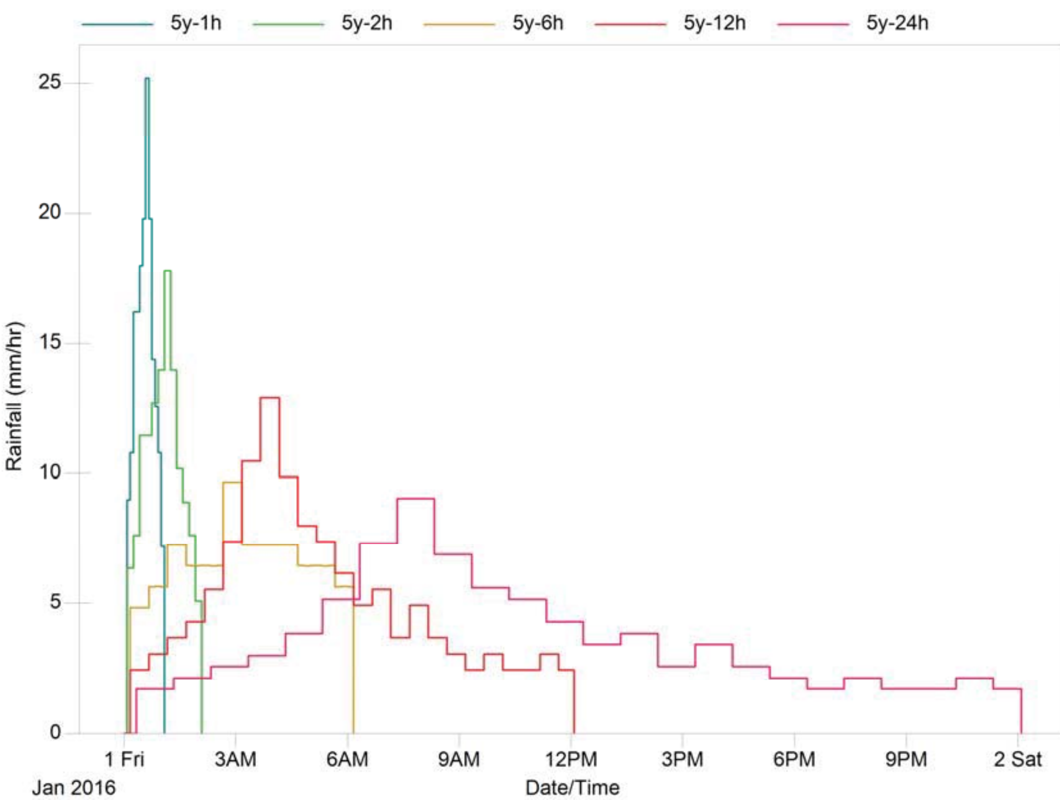
Photo 18. (WP18-SOLDIER PILES). Lyncean Creek West. View of right bank fill and near vertical (excavated) left bank slopes

Photo 19. (WP CENTER CREEK). Centre Creek. Right Bank erosion and slide scar (~15m^3). Age of event ~5-10 yrs

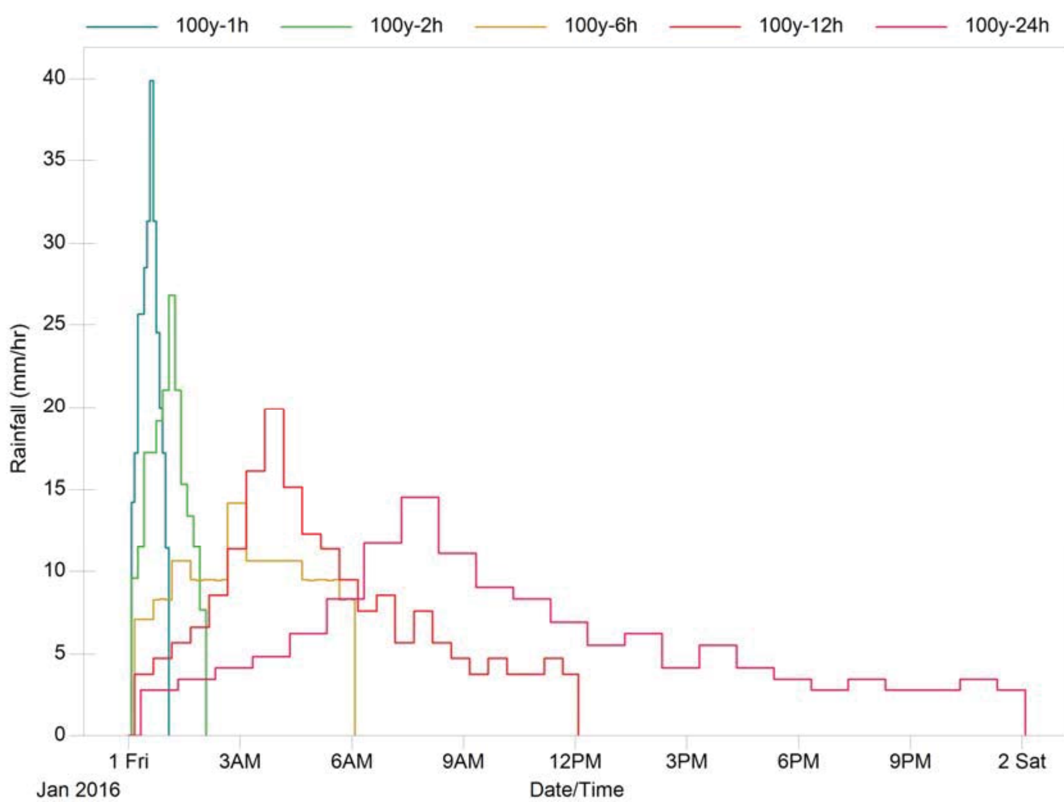
Photo 20 (WP CENTER CREEK). Centre Creek. View of Left Bank erosion and topple of 2 large trees. The older topple ~5-6 yrs ago based on tree top growth, the younger topple recent (<1 yr ago).

Appendix B – Design Storm Hyetographs

5-year Design Storm Hyetographs



100-year Design Storm Hyetographs

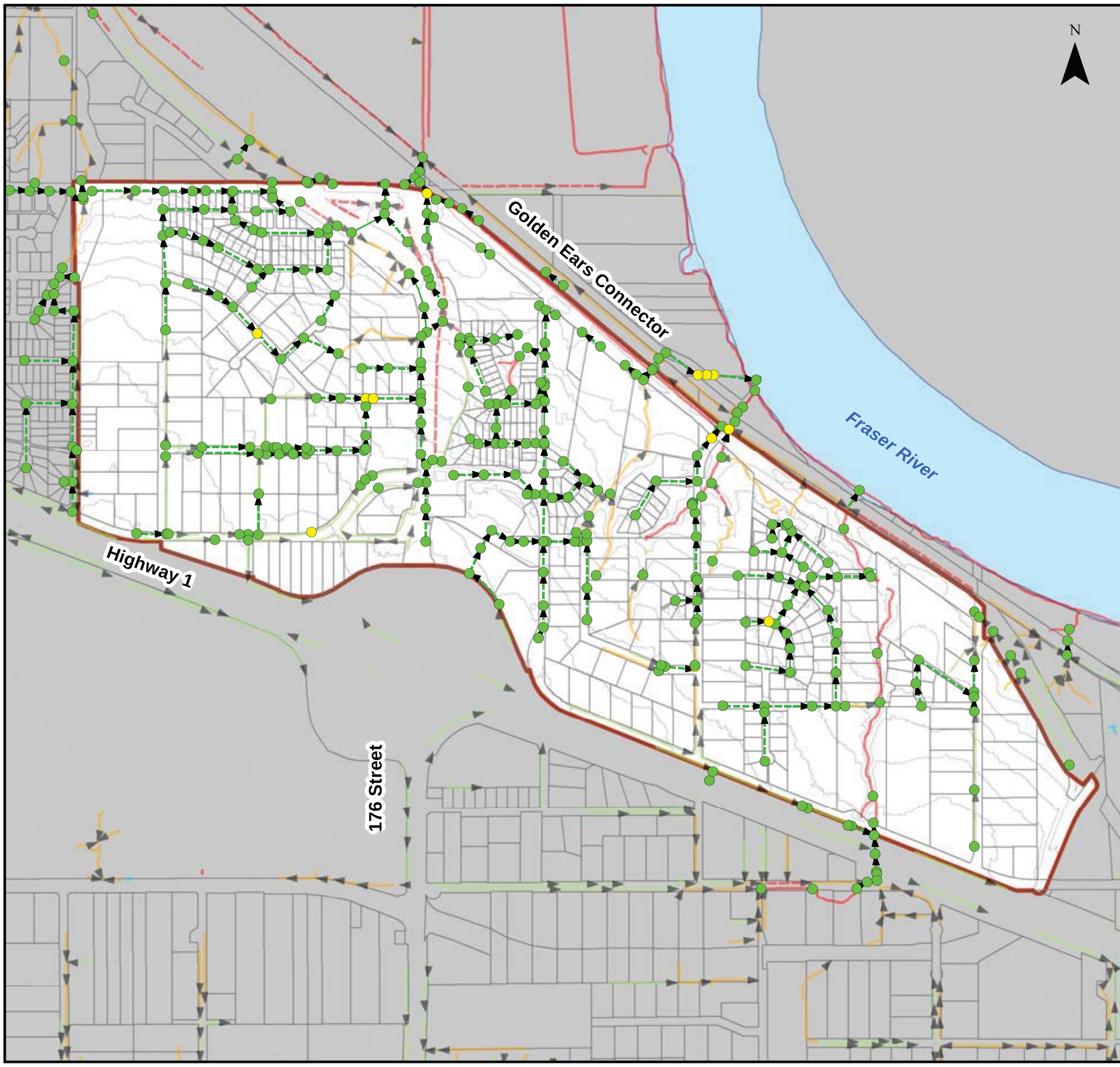


Appendix C – Model Results

PCSWMM Modeling Assumptions

Project Name Surrey - Abbey Ridge Stormwater Servicing
MCSL No. 2111-03570-00
Prepared by: Daniel Archila
Review by: Nav Sandhu
Date: April 15, 2016

Layer	Parameter	Associated Assumptions*
Subcatchment	Rainfall parameters	• Used hyetographs from Kwantlen Park rainfall gauge as per 2016 - City of Surrey Design Criteria Manual
	Catchment area (ha)	• Sub-catchment were delineated using existing contours from the City and considering the existing drainage infrastructure.
	Width (m)	$Width = \frac{Area}{FlowLength}$
	Flow length (m)	$FlowLength = 1.75 * \sqrt{Area}$
	Slope (%)	• The average slope for the sub-catchment areas was obtained from a Civil 3D 2016 surface built with contour information from the City. The slopes were found to be between 7-13%.
	Percent impervious (%)	• The percent of imperviousness for the sub-catchments was defined based on a review of the existing land use and typical imperviousness values used by the City of Surrey: o Commercial, industrial, transportation corridor = 90% o Residential – Acreage = 50% o Residential – Half-Acreage = 55% o Residential – Other = 65% o Institutional (School, Churches) = 80% o Parks, Agricultural, Cemeteries = 20% The percent impervious values were found to be between 29-53%.
	Manning's N for impervious area	• A Manning's "n" roughness value of 0.012 was used for impervious areas.
	Manning's N for pervious area	• A Manning's "n" roughness value of 0.24 was used for pervious areas.
	Infiltration method	• Based on Bon Accord – North Slope Integrated Stormwater Management Plan (2015), the Horton infiltration method was used with the following parameters: o Max infiltration rate (mm/hr) = 5 o Min infiltration rate (mm/hr) = 1.5 o Decay constant (a/hr) = 5.4 o Drying time (days) = 7
	Depression Storage	• Based on Bon Accord – North Slope Integrated Stormwater Management Plan (2015), the following depression storage values were used: o Impervious surface (mm) = 1.3 o Pervious surface (mm) = 3.8



Abbey Ridge
Storm Servicing Concept

CITY OF SURREY
the future lives here.

Legend

Existing Local Sewers
Existing Trunk Sewers

Watercourse Classification

Class A
Class AO
Class B
Class C
Unknown
Abbey Ridge LAP
5m Contours

Flooding

Surcharged
In pipe

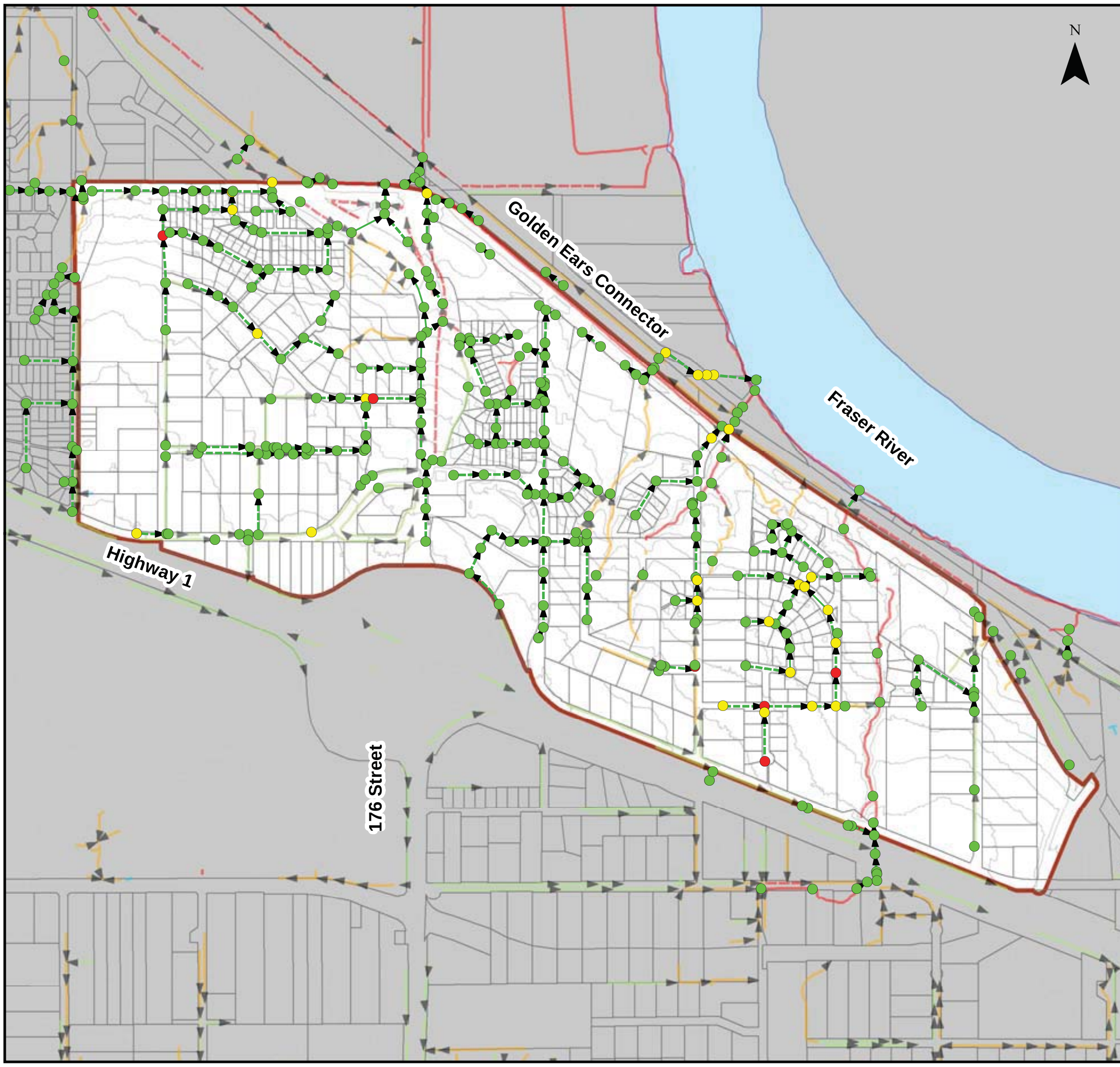
McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Scenario 1
5 year 1 hour storm



Abbey Ridge
Storm Servicing Concept

CITY OF SURREY
the future lives here.

Legend

Existing Local Sewers
Existing Trunk Sewers

Watercourse Classification

Class A
Class AO
Class B
Class C
Unknown
Abbey Ridge LAP
5m Contours

Flooding

Flooded
Surcharged
In pipe

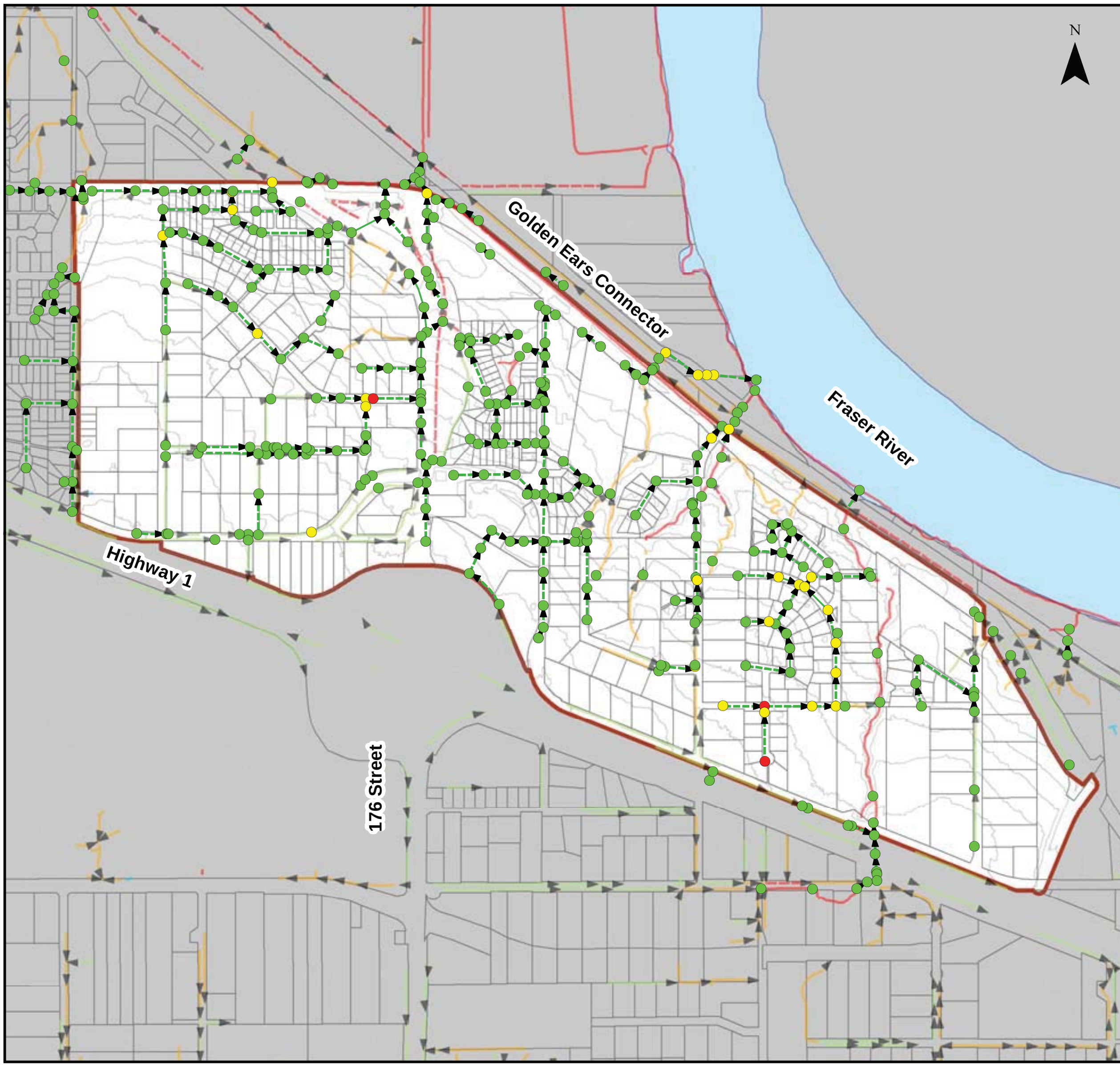
* ID per Braun geotechnical report

McElhanney

0 75 150 300 450 (m)
1:12,000

Project No.	Date
2111-03570-00	December 2016

Scenario 1
100 year 1 hour storm



Abbey Ridge
Storm Servicing Concept

CITY OF SURREY
the future lives here.

Legend

- Existing Local Sewers
- Existing Trunk Sewers

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

Flooding

- Flooded
- Surcharged
- In pipe

* ID per Braun geotechnical report

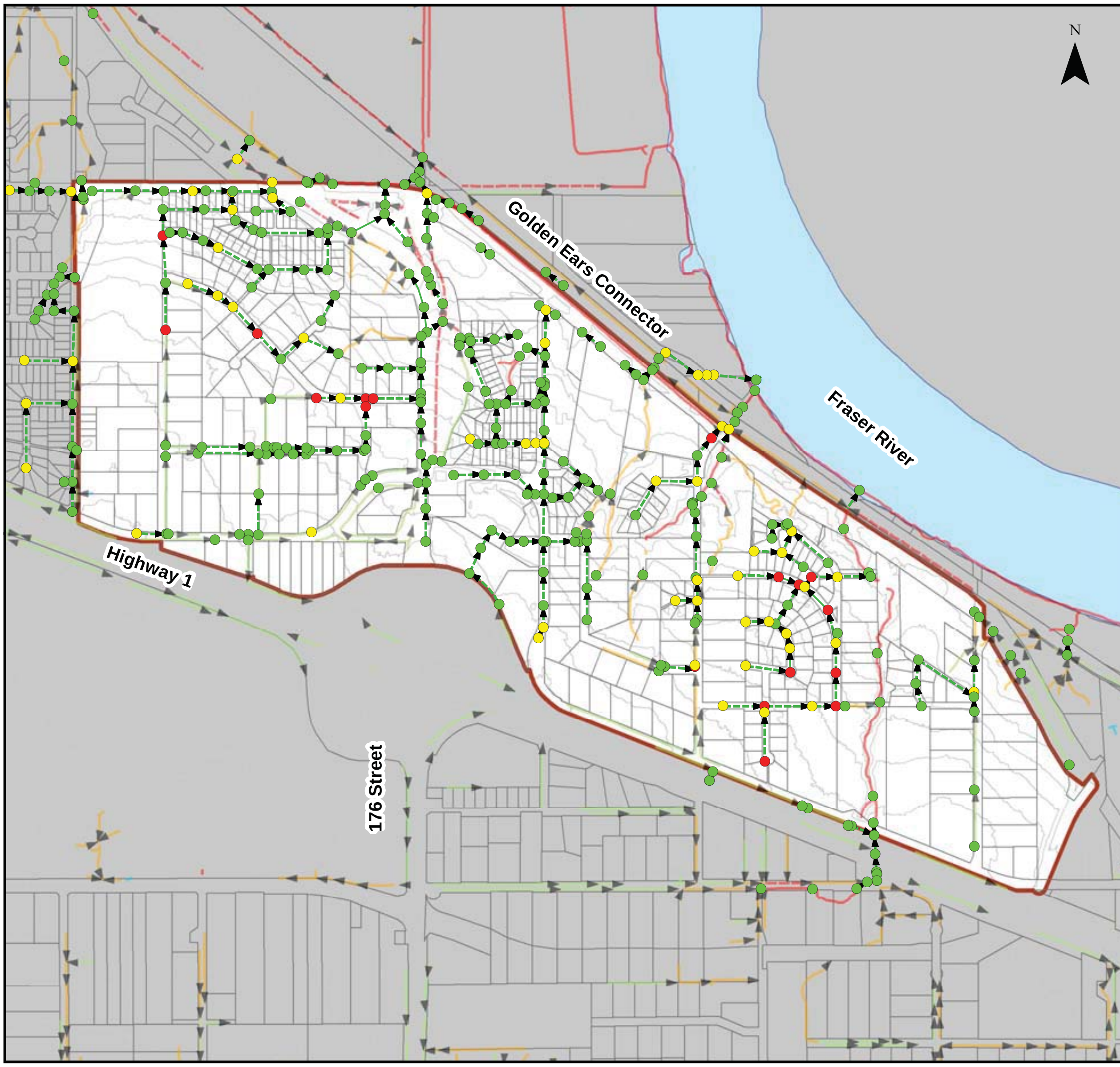
McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Scenario 2
5 year 1 hour storm



Abbey Ridge
Storm Servicing Concept

CITY OF SURREY
the future lives here.

Legend

- Existing Local Sewers
- Existing Trunk Sewers

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

Flooding

- Flooded
- Surcharged
- In pipe

* ID per Braun geotechnical report

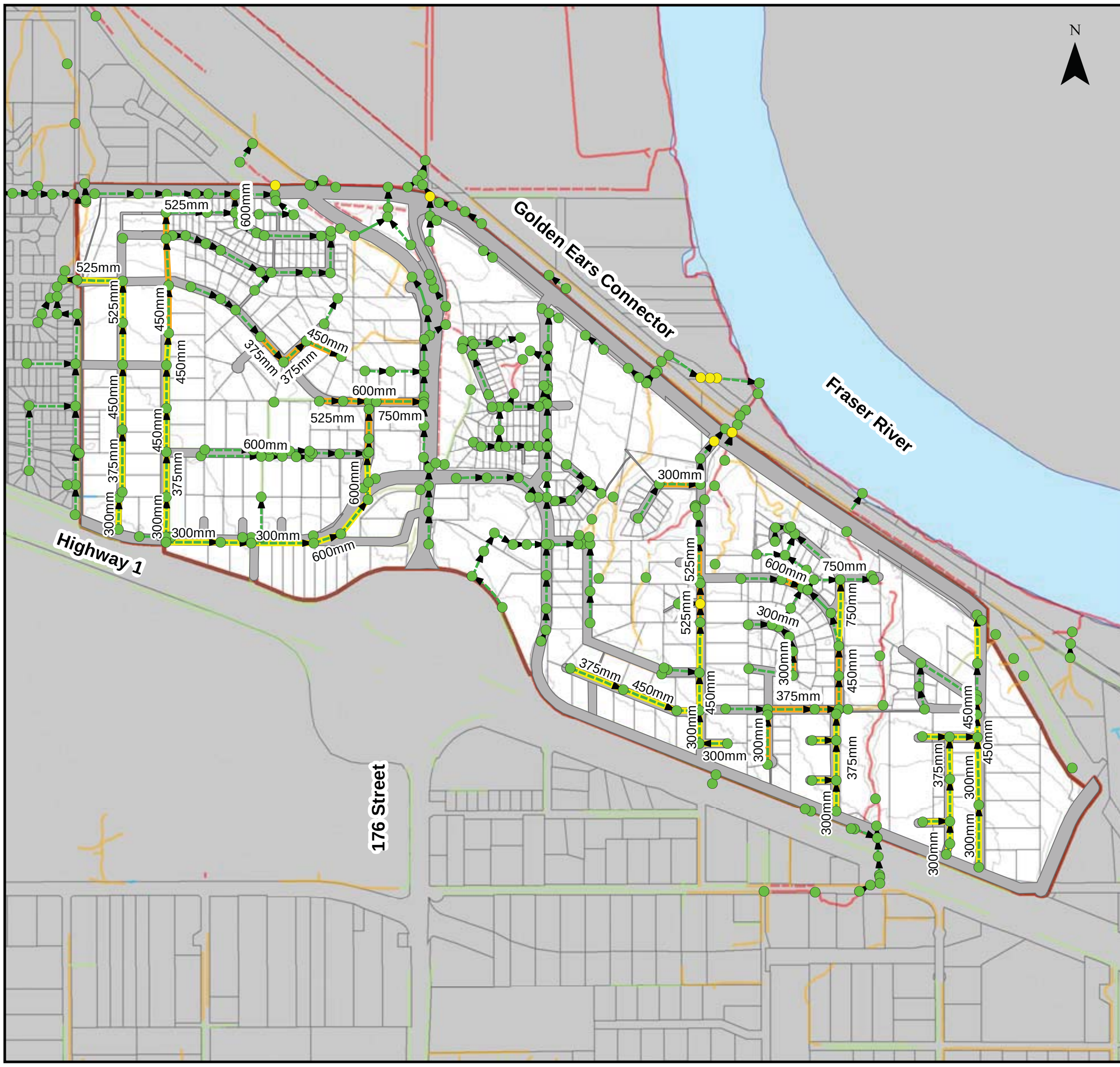
McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Scenario 2
100 year 1 hour storm



Abbey Ridge
Storm Servicing Concept

CITY OF SURREY
the future lives here.

Legend

Flooding
- Surcharged
- In pipe
- Upsized Trunk Sewers
- Upsized Local Sewers
- Existing Local Sewers
- Existing Trunk Sewers
- New Local Sewers
- Proposed Road

Watercourse Classification
- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

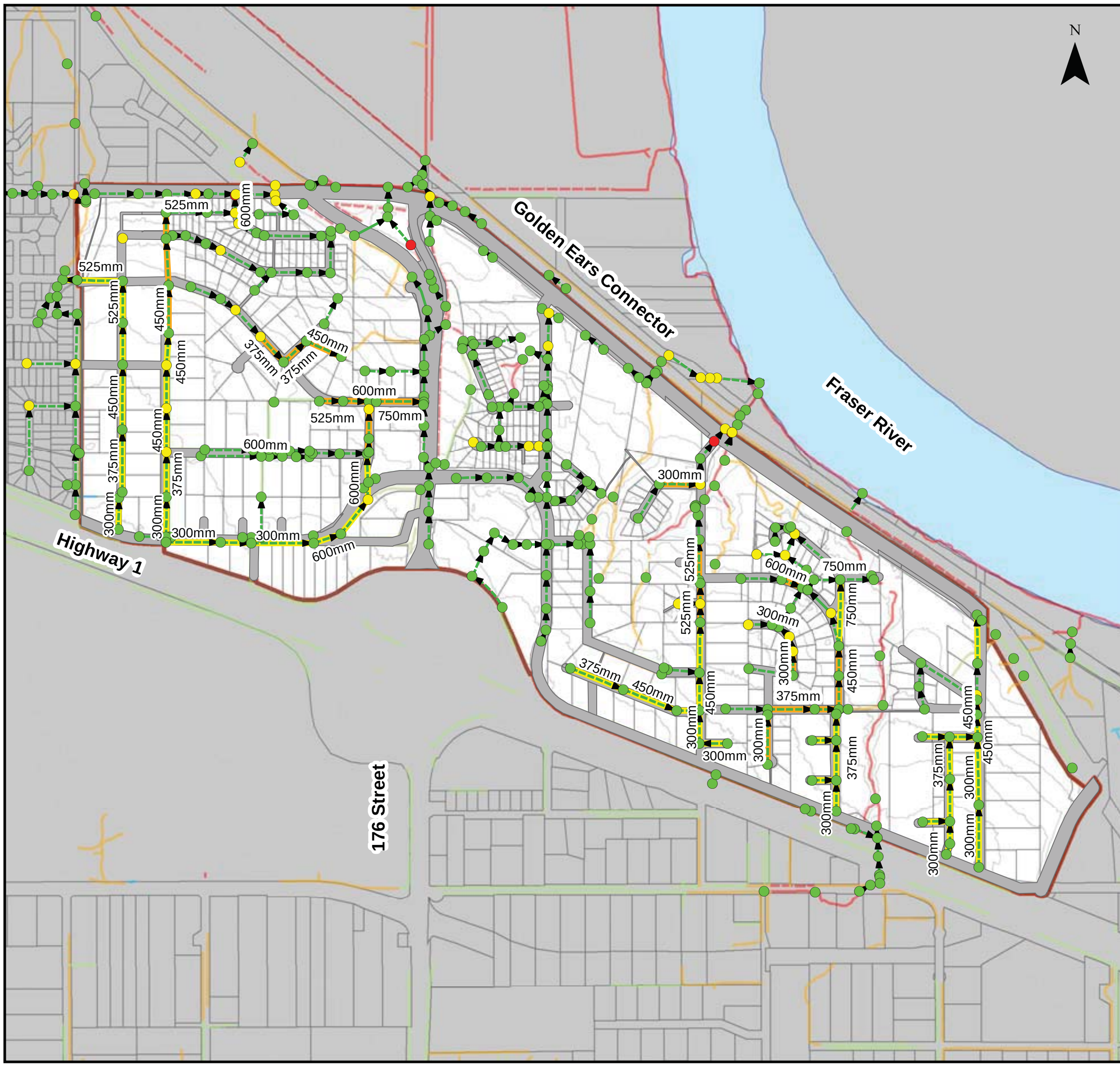
McElhanney

0 75 150 300 450 (m)

1:12,000

Project No.	Date
2111-03570-00	December 2016

Scenario 3
5 year 1 hour



Abbey Ridge
Storm Servicing Concept

CITY OF SURREY
the future lives here.

Legend

Flooding

- Flooded
- Surchaged
- In pipe
- Upsized Trunk Sewers
- Upsized Local Sewers
- Existing Local Sewers
- Existing Trunk Sewers
- New Local Sewers
- Proposed Road

Watercourse Classification

- Class A
- Class AO
- Class B
- Class C
- Unknown
- Abbey Ridge LAP
- 5m Contours

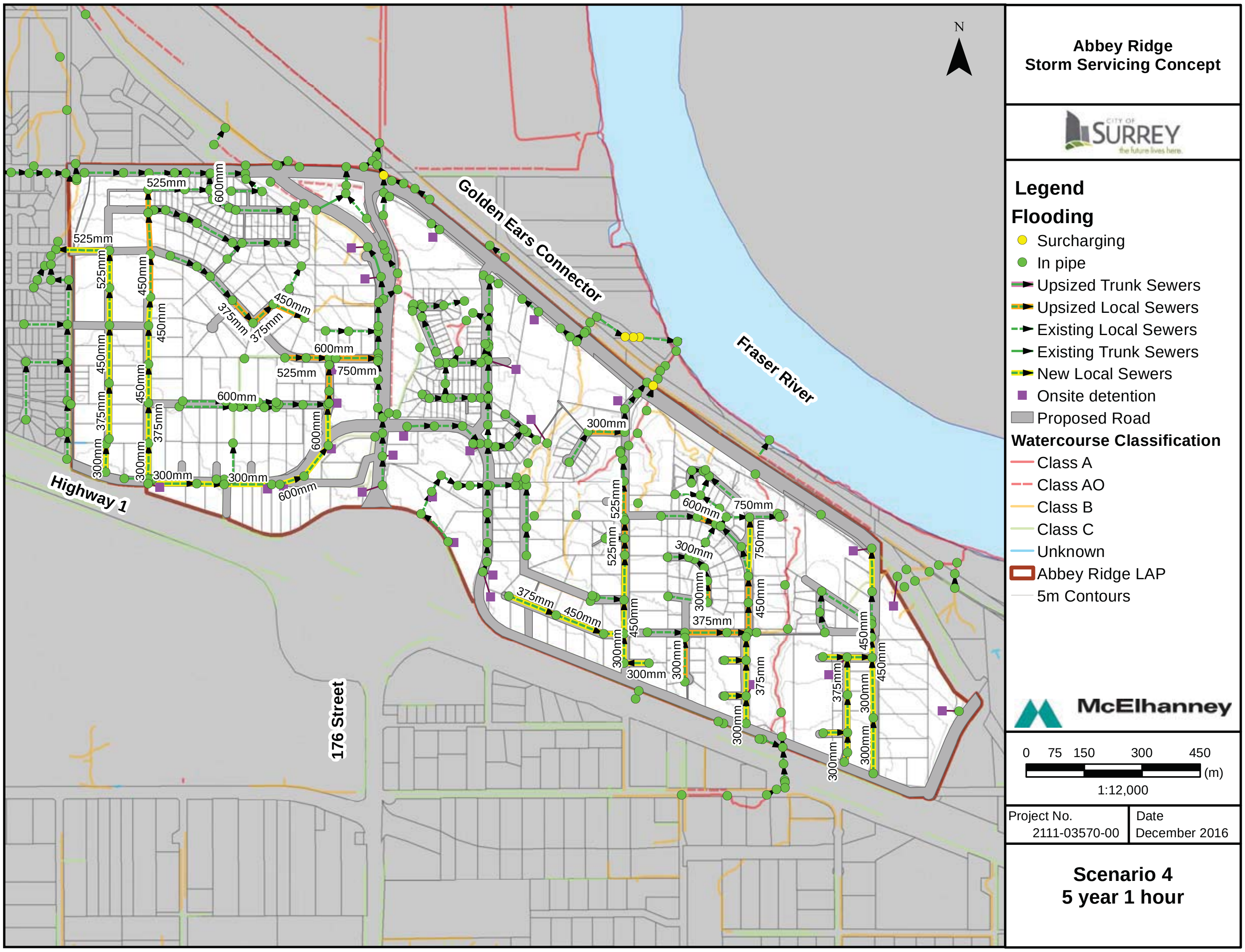
McElhanney

0 75 150 300 450 (m)

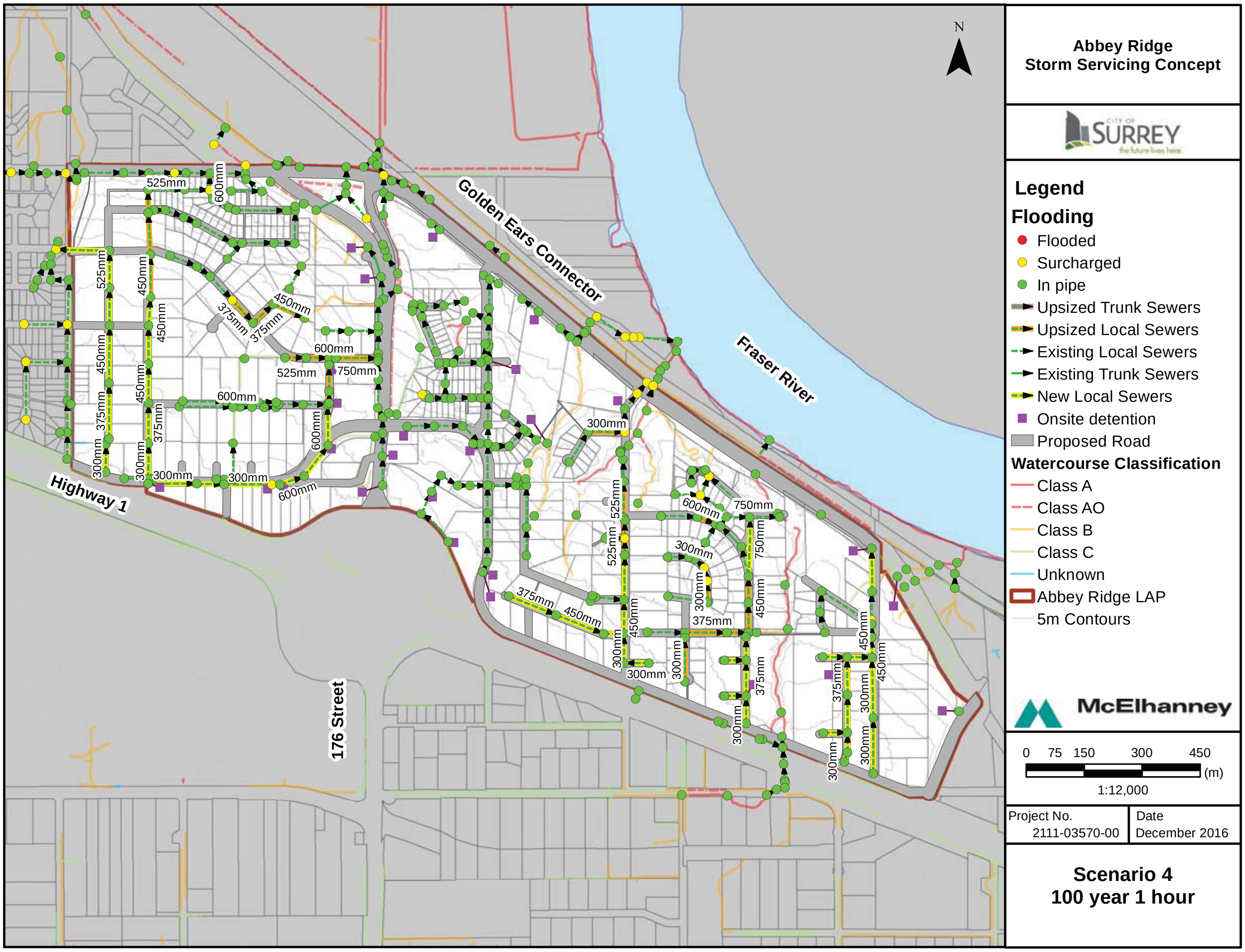
1:12,000

Project No.	Date
2111-03570-00	December 2016

Scenario 3
100 year 1 hour



Abbey Ridge
Storm Servicing Concept
SURREY
the future lives here.
Legend
Flooding
Surcharging
In pipe
Upsized Trunk Sewers
Upsized Local Sewers
Existing Local Sewers
Existing Trunk Sewers
New Local Sewers
Onsite detention
Proposed Road
Watercourse Classification
Class A
Class AO
Class B
Class C
Unknown
Abbey Ridge LAP
5m Contours
McElhanney
0 75 150 300 450
(m)
1:12,000
Project No.
2111-03570-00
Date
December 2016
Scenario 4
5 year 1 hour
N
Golden Ears Connector
Fraser River
Highway 1
176 Street
525mm
600mm
450mm
375mm
300mm
750mm



Abbey Ridge
Storm Servicing Concept
CITY OF SURREY
the future lives here.
Legend
Flooding
Flooded
Surcharged
In pipe
Upsized Trunk Sewers
Upsized Local Sewers
Existing Local Sewers
Existing Trunk Sewers
New Local Sewers
Onsite detention
Proposed Road
Watercourse Classification
Class A
Class AO
Class B
Class C
Unknown
Abbey Ridge LAP
5m Contours
McElhanney
0 75 150 300 450
(m)
1:12,000
Project No.
2111-03570-00
Date
December 2016
Scenario 4
100 year 1 hour
N
Golden Ears Connector
Fraser River
Highway 1
176 Street

Abbey Ridge Local Area Plan
Water Servicing

EXISTING WATER SERVICING

Some parts of the Abbey Ridge LAP are currently serviced by the City's water system, with the remaining areas serviced by private groundwater wells. The area serviced by municipal water is within the 90m Port Kells pressure zone. Water to the 90m pressure zone is supplied by a direct connection to Metro Vancouver's transmission main on 164 Street at 95 Avenue; a 525mm feeder main along 96 Avenue delivers the water to the areas to eastern and northern extents of the pressure zone, including Abbey Ridge.

The area within the 135m Whalley pressure zone is not currently serviced by the City's water system. **Figure 1** provides a map of the existing water servicing in the Abbey Ridge LAP.

DESIGN CRITERIA AND ANALYSIS

The City's current (2016) InfoWater model was used to determine the sizing and routing of feeder mains and the conceptual layout of distribution mains within the LAP, based on the future City-wide population in year 2046 and the proposed land uses and populations projections for Abbey Ridge and Anniedale-Tynehead.

The City's 2016 Design Criteria has been used to forecast the servicing requirements for the Abbey Ridge and provisions for future development. The following criteria were used in the analysis:

- Average day demand (ADD) of 500 L/cap/day
- Maximum day demand (MDD) of 1,000 L/cap/day
- Peak day demand (PDD) of 2,000 L/cap/day
- Hazen-Williams Coefficient of 125 for all water mains 250mm diameter and larger
- Hazen-Williams Coefficient of 100 for all water mains 200mm diameter and smaller
- A minimum required residual of 28m hydraulic head at all nodes under PHD
- A minimum required residual fire flow pressure of 14m at the fire flow node under MDD plus fire flow
- Hydraulic grade in mains larger than 250mm diameter shall not exceed 0.5% or 5 m/km
- The velocity of flow shall not exceed 2 m/s
- All water mains shall be looped, except for short dead-ends that are 100m or less in length

Population Projections

The Abbey Ridge LAP proposes a mainly single family residential neighbourhood with a few townhouse blocks located off Barnston Drive East, west of 176 Street and east of Golden Ears Way. In addition, a small commercial area off Highway 1, east of 176 Street and north of Barnston Drive East, is proposed. The existing industrial land along the north eastern edge of the LAP will mostly remain as they provide good access to Highway 17 and buffer the residential lands from the highway.

Land use designations and population projections were provided by the City's Planning & Development Department. The projected residential population for Abbey Ridge LAP is 7,636, as shown in Table 3. Secondary suites were considered for single-family and low density multi-family (RM-10) residential land uses.

For industrial, commercial and institutional (ICI) land uses, the equivalent populations were calculated based on the gross density in the Design Criteria table 2.3.1 and are provided in Table 1, below. The total equivalent population for the ICI land uses is 771.

Table 1: Equivalent Population Projections for ICI Land Uses

Land Use	Zoning	Area (Hectare)	Gross Density (People per Hectare)	Equivalent Population
Industrial	IL	6.5	90	586
Institutional	PI	1.9	50	97
Neighbourhood Commercial	C-5	1.5	60	87

The fire flow requirements for the land uses within the LAP are based on Table 3.1.1 in the Design Criteria and are provided in Table 2, below.

Table 2: Fire Flow Requirements for the Abbey Ridge LAP

Land Use	Land Use Designation	Fire Flow (L/s)
Acreage Residential 1-2 UPA	RA	60
Suburban Residential 2-4 UPA Gross	RA	60
Urban Transition 4-5 UPA	RA	60
Low Density Cluster 4-6 UPA Gross	RF	60
Single Family Residential 4-6 UPA	RF	60
Urban Residential 8-10 UPA	RF	60
Medium Density Cluster 10-12 UPA Gross	RF-10	60
Low Density Multiple Residential 10-15 UPA Gross	RM-10	120
High Density Multiple Residential 25-30 UPA	RM-30	120
Industrial	IL	250
Institutional	PI	120
Neighbourhood Commercial	C-5	90

Table 3: Residential Population Projections by Pressure Zone

135m Pressure Zone

Land Use	Zoning	Units			Secondary Suites			Total Population
		Units	Population	People per Unit	Secondary Suites	Population	People per Secondary Suite	
Acreage Residential 1-2 UPA	RA	11	37	3.4	0	0	0	37
Suburban Residential 2-4 UPA Gross	RA	67	241	3.6	50	96	1.9	337
Single Family Residential 4-6 UPA	RF	128	428	3.4	78	149	1.9	577
Low Density Multiple Residential 10-15 UPA Gross	RM-10	128	424	3.3	0	0	0	424
Total		**333**	**1,131**		**128**	**244**		**1,375**

90m Pressure Zone

Land Use	Zoning	Units			Secondary Suites			Total Population
		Units	Population	People per Unit	Secondary Suites	Population	People per Secondary Suite	
Acreage Residential 1-2 UPA	RA	20	70	3.5	2	4	1.9	74
Suburban Residential 2-4 UPA Gross	RA	182	654	3.6	146	279	1.9	933
Urban Transition 4-5 UPA	RA	31	106	3.4	30	57	1.9	163
Low Density Cluster 4-6 UPA Gross	RF	18	59	3.2	10	19	1.9	78
Single Family Residential 4-6 UPA	RF	358	1,096	3.1	229	437	1.9	1,533
Urban Residential 8-10 UPA	RF	151	423	2.8	90	172	1.9	595
Medium Density Cluster 10-12 UPA Gross	RF-10	138	377	2.7	72	138	1.9	514
Low Density Multiple Residential 10-15 UPA Gross	RM-10	281	949	3.4	0	0	0	949
High Density Multiple Residential 25-30 UPA	RM-30	480	1,269	2.6	0	0	0	1,269
Neignbourhood Commercial (Mixed Use)	C-5	56	152	2.7	0	0	0	152
Total		**1,716**	**5,155**		**579**	**1,106**		**6,261**

Water Demands

Three (3) water servicing scenarios were considered for Abbey Ridge, based on the timing of development in Abbey Ridge LAP and Anniedale-Tynehead Neighbourhood Concept Plan (NCP). All scenarios are based on the projected population and water demands in the year 2046. The scenarios are as follows:

1. Current Condition — Future (2046)
2. Interim Condition — Future (2046) + Abbey Ridge LAP
3. Long-range Condition — Future (2046) + Abbey Ridge LAP + Anniedale-Tynehead NCP

Anniedale-Tynehead NCP is located to the south of Abbey Ridge LAP, between 168 Street and 192 Street. The NCP was approved by Council in April 2012, but has yet to see significant development and infrastructure improvements due to the very high costs to service the NCP area. The water infrastructure required to service Anniedale-Tynehead will also support some of the growth in the Abbey Ridge LAP. **Figure 2** shows the future water servicing for the Anniedale-Tynehead NCP.

The water demands for Abbey Ridge were calculated using the population projections and design criteria values for per capita water consumption. **Table 4** and **Table 5** provide the water demands, by pressure zone, for Abbey Ridge and Anniedale-Tynehead, respectively. The tables include the water demands for the current condition land uses and at build-out. The difference between these demands is the increase attributed to the LAP or NCP, respectively.

Table 4: Water Demands for Abbey Ridge

Pressure Zone	Abbey Ridge (Current Condition)		Abbey Ridge (LAP Build-out)		Demand Increase	
	MDD (L/s)	PHD (L/s)	MDD (L/s)	PHD (L/s)	MDD (L/s)	PHD (L/s)
90m Zone (Port Kells)	31	53	76	152	45	99
135m Zone (Whalley PS)	0	15	19	37	19	22
Total	31	68	95	189	64	121

Table 5: Water Demands for Anniedale-Tynehead

Pressure Zone	Anniedale-Tynhead (Current Condition)		Anniedale-Tynehead (NCP Build-out)		Demand Increase	
	MDD (L/s)	PHD (L/s)	MDD (L/s)	PHD (L/s)	MDD (L/s)	PHD (L/s)
90m Zone (Port Kells)	4	199	364	728	360	529
135m Zone (Whalley PS)	0	73	60	120	60	47
Total	4	272	424	848	420	576

Table 6: Future Water Demands

Pressure Zone	Current Condition		Interim Condition (Existing + Abbey Ridge)		Future Condition (Existing + Abbey Ridge + Anniedale-Tynehead)	
	MDD (L/s)	PHD (L/s)	MDD (L/s)	PHD (L/s)	MDD (L/s)	PHD (L/s)
90m Zone (Port Kells)	146	190	191	289	552	818
135m Zone (Whalley PS)	558	883	576	906	635	953
Total	704	1,073	767	1,195	1,187	1,771

In **Table 6**, the water demands are provides for the three (3) water servicing scenarios. Under the current condition, there are demands attributed to Abbey Ridge and Anniedale-Tynehead.

The water servicing for Abbey Ridge LAP aims to utilize existing water supplies and infrastructure with surplus capacity in order to service the area. If new infrastructure is required to support the new water demands in the LAP, consideration is given to upsizing and/or advancing infrastructure that is already planned in the Engineering 10-Year Servicing Plan and infrastructure required for the Anniedale-Tynehead NCP.

Hydraulic Analysis

The hydraulic analysis for the study area was conducted using the City's 2016 InfoWater model. The proposed pipe network for Abbey Ridge LAP and the approved servicing plan for Anniedale-Tynehead NCP were added to the model.

Integrating the servicing for Anniedale-Tynehead into the model included the future Fleetwood reservoir. Metro Vancouver plans to construct a new reservoir in Fleetwood with a completion date in 2018. The reservoir will be located at 9008 Fleetwood Way in Meagan Anne MacDougall Park. This new reservoir connection will supplement the existing PRV station at 95 Avenue/164 Street and Cherryhill PRV station, all feeding the Port Kells 90m pressure zone.

The model was run for the proposed pipe network to analyze the MDD plus fire flow and PHD. The results were provided for residual pressure (psi) at each node and velocities (m/s) and headloss gradient (m/km) for each pipe.

Figures are provided in Appendix A showing the results from the water model for the following:

- **Figure 4** Proposed Water Servicing at MDD plus Fire Flow (Available Fire Flow)
- **Figure 5** Proposed Water Servicing at MDD plus Fire Flow (Residual Pressure)
- **Figure 6** Proposed Water Servicing at PHD (Residual Pressure and Velocities)
- **Figure 7** Proposed Water Servicing at PHD (Headloss Gradient)

The available fire flows meet the fire flow requirements for the proposed land uses, as shown in **Figure 3**. The available fire flows maintain node pressures above 20 psi and pipe velocities below 3.25 m/s.

In **Figure 5**, the 300mm water main to the north of the Highway 1 west-bound off-ramp at 176 Street is shown to have residual pressure under the required 40 psi during the PHD. This is because the model uses the existing ground elevation instead of the water main elevation. At this location, the water main is installed 4m below ground and the elevation was further increased in 2012, when the west-bound off-ramp was constructed. Based on the water main elevation, the pressure should be approximately 44 psi at PHD, which meets the City's design criteria.

Pipe velocities and headloss gradients are within the requirements of less than 2.0 m/s and less than 5 m/km, respectively.

PROPOSED SYSTEM

The topography within Abbey Ridge LAP requires that two separate pressure zones be established. The majority of the LAP will be located in the lower 90m pressure zone, while the area in the south-eastern portion of the LAP will be located in a higher 135m pressure zone, due to higher elevations. The LAP area within the 135m pressure zone is not currently serviced by the City's water system; thus infrastructure improvements are required to supply water to this area.

The recommended long-range servicing strategy and infrastructure improvements to service Abbey Ridge are illustrated in **Figure 3.**

90m Pressure Zone

The recommended long-range servicing strategy for Abbey Ridge is to service the 90m pressure zone via the existing Cherryhill PRV station. The existing Metro Vancouver direct connection at the 164 Street/95 Avenue PRV station has the capacity to feed the 90m pressure zone in Abbey Ridge under peak hour demand (PHD). However, it is recommended that the Cherryhill PRV station be operated to maintain flow to the Abbey Ridge 90m pressure zone for network redundancy and to maintain water age.

The existing Cherryhill PRV station consists of two (2) PRVs: a 100mm PRV and a 250mm PRV and operates as a supplementary PRV station for the Port Kells 90m pressure zone. The Cherryhill PRVs will need to be re-set to feed the 90m pressure zone as critical feeds. A flow meter will be required downstream of the Cherryhill PRV station to measure the flow into the 90m pressure zone. The Cherryhill PRV station is fed by the Whalley pump station via a network of feeder mains in the 135m pressure zone.

The 90m pressure zone requires the completion of a 400mm feeder main network within the Abbey Ridge LAP to convey flows from the Cherryhill PRV station throughout the LAP area. The 400mm feeder main is partially complete with over 3,000 metres of main installed, but requires an additional 1,600 metres of main to complete the network. Between Lyncean Drive and 179 Street, the proposed 400mm feeder main crosses City parkland with two (2) watercourses: a class A watercourse and a class B watercourse. A 6.0 metre right-of-way has been registered along this proposed feeder main alignment.

135m Pressure Zone

The recommended long-range servicing strategy for Abbey Ridge is to service the 135m pressure zone from Whalley pump station via a network of feeder and distribution mains. Infrastructure improvements are required for this portion of the LAP area in order to supply City water.

The infrastructure required to support the Anniedale-Tynehead NCP will provide additional redundancy for the Abbey Ridge LAP water supply, such as the 450mm feeder main on 168 Street and Barnston Drive West. The feeder main will extend through Abbey Ridge LAP and across Highway 1 to feed the 135m pressure zone in Anniedale-Tynehead. The 450mm main is sized for Anniedale-Tynehead, but has the capacity to also supply Abbey Ridge.

There is a section of 200mm main on 168 Street, between 103A Avenue and 104 Avenue, that that is under-sized to supply the Abbey Ridge 135m pressure zone. This section of water main must be upgraded to a minimum 300mm main in order to meet the requirements for hydraulic grade. Since a future 450mm main is required along this section of 168 Street for Anniedale-Tynehead, a 450mm main is proposed for Abbey Ridge. Similarly, a section of 450mm main is proposed on Barnston Drive West, between 172 Street and 172A Street. A minimum 200mm main is required in order to service Abbey Ridge; however, if no service connections are installed along this section of main, a 450mm feeder main is proposed to service both Abbey Ridge and Anniedale-Tynehead. A portion of the costs for these 450mm mains may be recoverable from Anniedale-Tynehead's area specific development cost charges (DCCs).

To reduce the number of dead-end water mains at the 90m / 135m pressure zone boundary, the existing zone boundary is shifted east for the proposed system. As a result, there are properties currently serviced by City water along 101 Avenue, west of 175A Street, that will be transferred from the 90m pressure zone into the 135m pressure zone. These property owners should be notified, as this higher water pressure will require that the properties have pressure reducing valves, per the BC Plumbing Code.

The proposed water mains on 171A St and 172 St, between 102 Ave and 104 Ave, fall within the pressure zone boundary. Closed valves are proposed along the water mains, at 102 Ave, to isolate the pressure zones; however the valves will create dead-ends greater than 100 meter in length. To eliminate these dead-end water mains, looping is required in accordance with the City's *Design Criteria Manual*.

Whalley Pump Station and Feeder Mains

The Whalley pump station has adequate capacity to meet to demands for Abbey Ridge LAP. Under the long-range condition, with the build-out of Abbey Ridge and Anniedale-Tynehead, the maximum flow at the pump station is 1,160 L/s. The pump station has a capacity of 2,520 L/s with 4 pumps operating.

The existing network of feeder mains from the Whalley pump station to the Cherryhill PRV station are adequately sized to supply the additional demands of Abbey Ridge and Anniedale-Tynehead. To confirm the system has adequate water supply and capacity for future growth in the larger north-east Surrey area, including Abbey Ridge, Anniedale-Tynehead, Port Kells and Cloverdale, the City plans to conduct a thorough modelling study in 2017.

Phasing

A flow meter at the Cherryhill PRV station must be installed at the onset of Abbey Ridge development within the 90m pressure zone. With the flow meter installed, the Cherryhill PRV station will be a primary feed to the 90m pressure zone. Abbey Ridge can be developed without the completion of the 400mm main within the 90m pressure zone. As a result, the proposed sections of 400mm main will be constructed by fronting developments with upsizing costs being paid by the City. In some cases, the 400mm main may not be constructed by development, because there is an existing, adequately-sized frontage main. As a result, these mains may be constructed by the City as Capital projects. Ultimately, the 400mm main will be the primary feed for Abbey Ridge's 90m pressure zone.

For the Abbey Ridge's 135m pressure zone to develop, a 450mm main on 168 Street, between 103A Avenue and 104 Avenue, is required. Since this main is also required for Anniedale-Tynehead, the costs are eligible for reimbursement through the Anniedale-Tynehead area specific DCCs. This main may be constructed by the City as a Capital project. The other 450mm feeder mains required for the Anniedale-Tynehead's 135m pressure zone are not required for Abbey Ridge.

The proposed changes to the pressure boundary within Abbey Ridge, between the 135m and 90m pressure zones, require that the 135m pressure zone be fed by the existing 300mm on 172 Street, between 102 Avenue and Barnston Drive West. In order to develop within Abbey Ridge's 135m pressure zone, distribution mains must be extended from the existing 300mm on 172 Street to the developing area. For development in the 135m pressure zone, interim servicing from the 90m pressure zone will not be permitted.

Cost Estimate

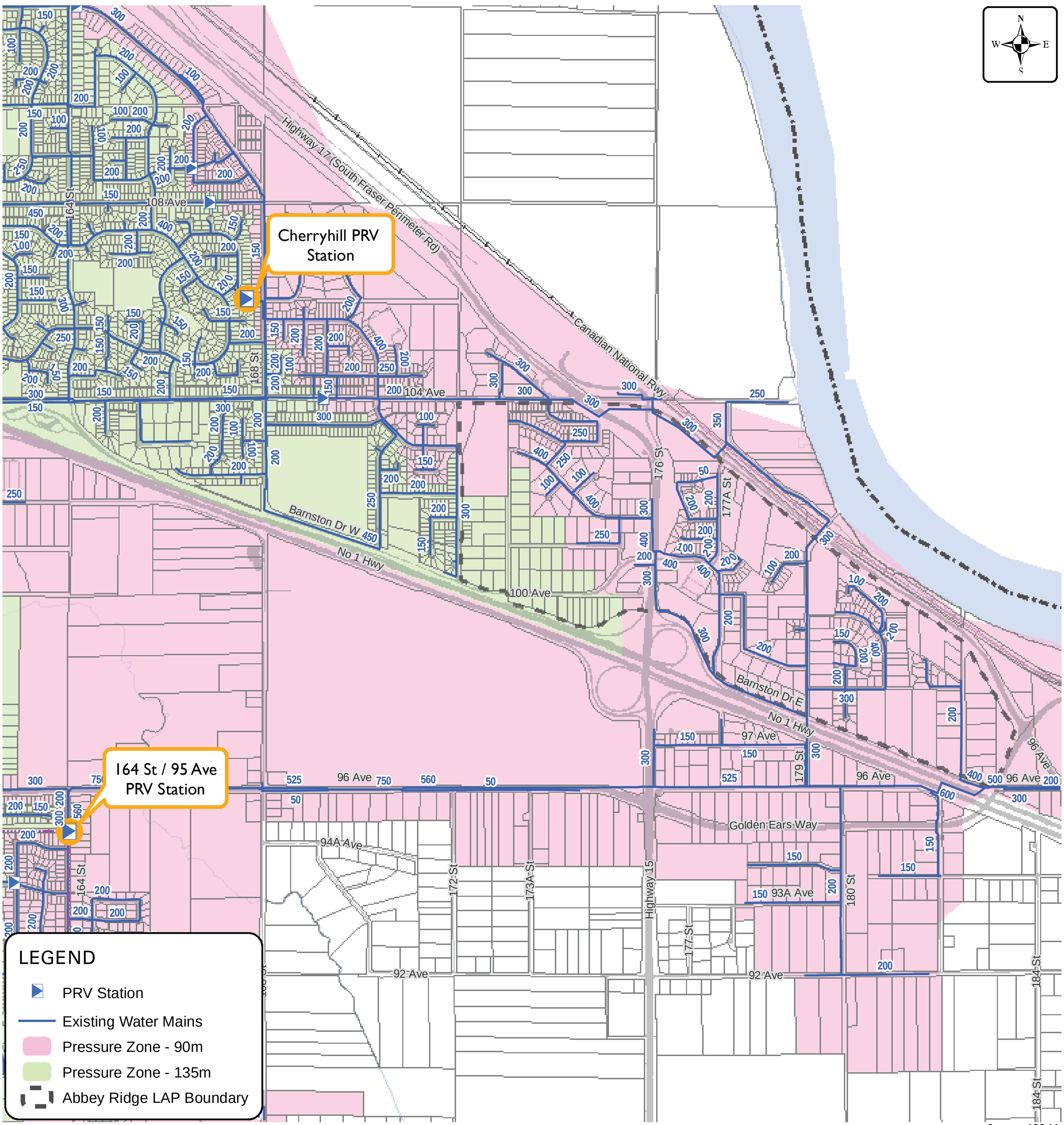
The cost estimate for water infrastructure servicing is provided in Table 6.

Table 6: Water Servicing Cost Estimate for Abbey Ridge LAP

No.	Description	Location	Unit	Unit Cost [1]	Quantity	Total Cost	Type of Cost		
							Developer Cost	DCC Cost Attributable to Abbey Ridge	DCC Cost Attributable to Areas Outside Abbey Ridge
1	**Water Servicing - 90m Pressure Zone**								
1.1	300mm Distribution Main (Base 200mm)	177A: Barnston Dr E - Trigg Rd	lin.m.	$850	486	$413,100	$413,100		
	300mm Distribution Main (Upsizing to 300mm)		lin.m.	$150	486	$72,900		$36,450	$36,450
1.2	400mm Distribution Main (Base 200mm)	103 Ave: 172 - 173 St	lin.m.	$850	255	$216,750	$216,750		
	400mm Distribution Main (Upsizing to 400mm)		lin.m.	$470	255	$119,850		$59,925	$59,925
1.3	400mm Distribution Main (Base 200mm)	100 Ave: 177 - 179 St	lin.m.	$850	264	$224,508	$224,508		
	400mm Distribution Main (Upsizing to 400mm)		lin.m.	$470	264	$124,140		$62,070	$62,070
	400mm Distribution Main		lin.m.	$1,200	100	$120,000		$60,000	$60,000
1.4	400mm Distribution Main	179 St: 99A - 100 Ave	lin.m.	$1,200	79	$95,146		$47,573	$47,573
1.5	400mm Distribution Main (Base 200mm)	99A Ave: 179 - 180 St	lin.m.	$850	120	$102,347	$102,347		
	400mm Distribution Main (Upsizing to 400mm)		lin.m.	$470	120	$56,400		$28,200	$28,200
1.6	400mm Distribution Main (Base 200mm)	98 Ave: 181 - 182A St	lin.m.	$850	187	$158,546	$158,546		
	400mm Distribution Main (Upsizing to 400mm)		lin.m.	$470	187	$87,667		$43,833	$43,833
	400mm Distribution Main		lin.m.	$1,200	130	$156,000		$78,000	$78,000
1.7	400mm Distribution Main	182A St: Barnston Dr E - 98 Ave	lin.m.	$1,200	392	$470,975		$235,487	$235,487
1.8	Flow Meter w/ Kiosk [2]	Cherryhill Dr / 168 St	each	$120,000	1	$120,000		$60,000	$60,000
1.9	200mm Distribution Main	-	lin.m.	$850	2,116	$1,798,600	$1,798,600		
1.10	100mm Distribution Main	-	lin.m.	$800	102	$81,600	$81,600		
					Sub-Total 1	**$4,418,528**	**$2,995,451**	**$711,538**	**$711,538**
2	**Water Servicing - 135m Pressure Zone**								
2.1	450mm Feeder Main (Base 300mm)	168 St: 103A - 104 Ave	lin.m.	$1,000	107	$107,000		$107,000	
	450mm Feeder Main (Upsizing to 450mm) [3]		lin.m.	$420	107	$44,940			$44,940
2.2	450mm Feeder Main (Base 200mm)	Barnston Dr W: 172 - 172A St	lin.m.	$850	150	$127,500	$127,500		
	450mm Feeder Main (Upsizing to 450mm) [3]		lin.m.	$670	150	$100,500			$100,500
2.4	200mm Distribution Main	-	lin.m.	$850	2,896	$2,461,600	$2,461,600		
2.4	100mm Distribution Main	-	lin.m.	$800	609	$487,200	$487,200		
					Sub-Total 2	**$3,328,740**	**$3,076,300**	**$107,000**	**$145,440**
					TOTAL	**$7,747,268**	**$6,071,751**	**$818,538**	**$856,978**

[1] Unit costs are based on projects constructed between 2011-2015.
[2] Cost is based on 2014 tender prices for the flow meters (contract 1213-328).
[3] A portion of the costs may be eligible for reimbursement from Anniedale-Tynehead DCCs.

Figure 1



Produced by GIS Section: 12-Oct-2016, EM9

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Existing Water Servicing

ENGINEERING DEPARTMENT

Source:
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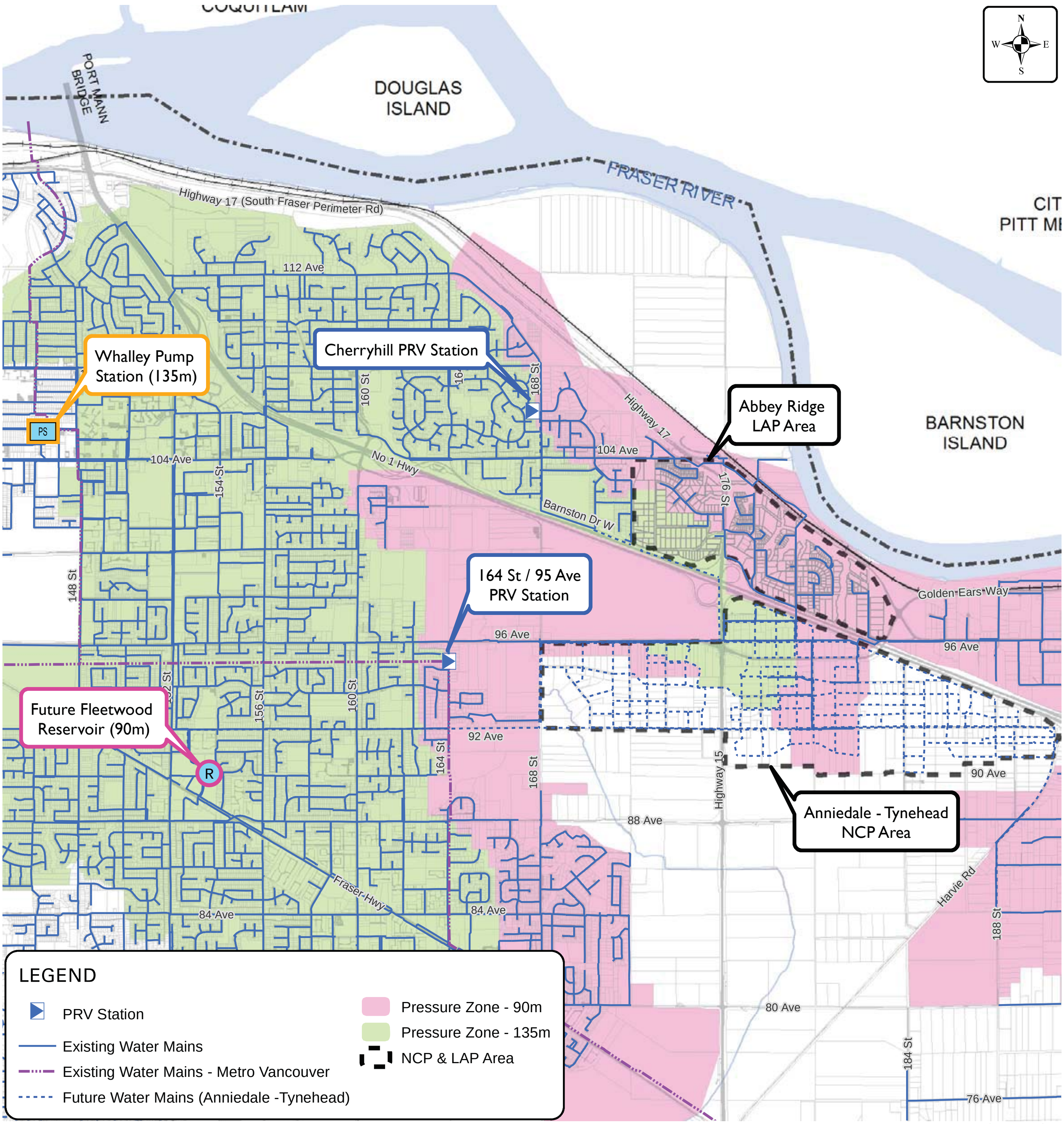
Figure 2



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Future Water Servicing for Anniedale - Tynehead NCP

ENGINEERING DEPARTMENT

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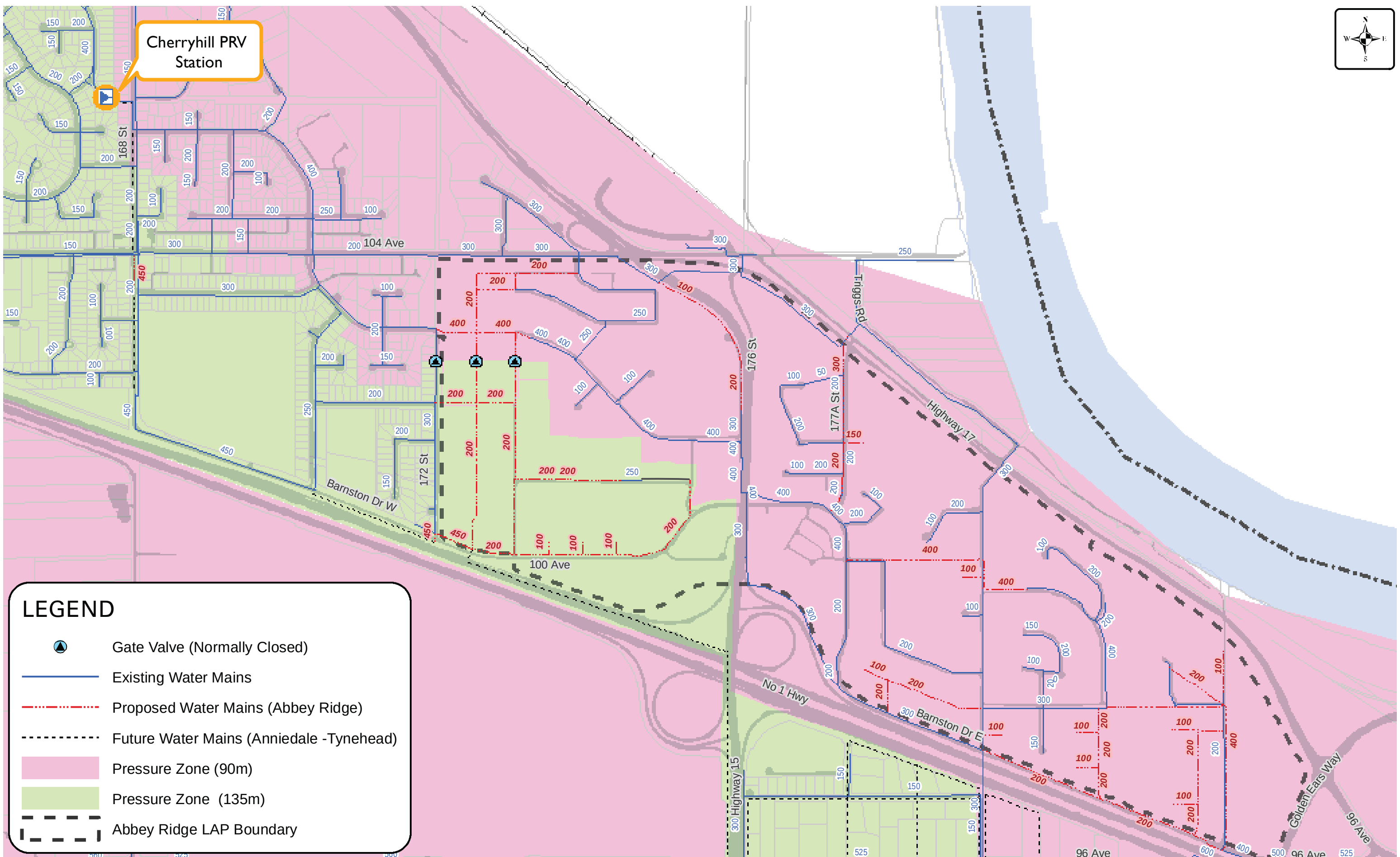
Figure 3



Produced by GIS Section: 12-Oct-2016, EM9

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0 130 M

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Proposed Water Servicing

ENGINEERING DEPARTMENT

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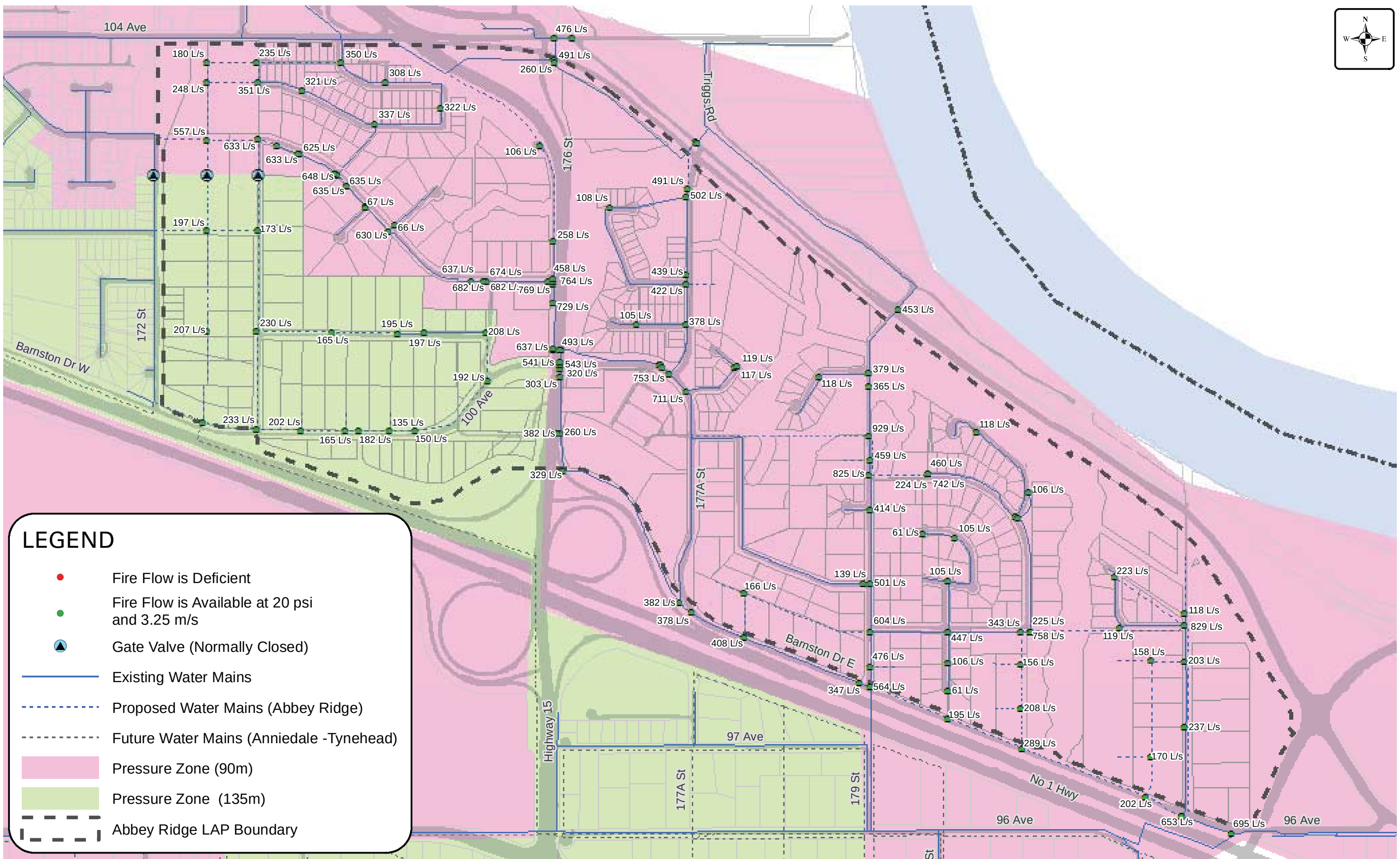
Figure 4



Produced by GIS Section: 30-Sep-2016, C9W

Scale: 1:10,700

CITY OF SURREY the future lives here.	Proposed Water Servicing at MDD+FF (Available Fire Flow)	ENGINEERING DEPARTMENT

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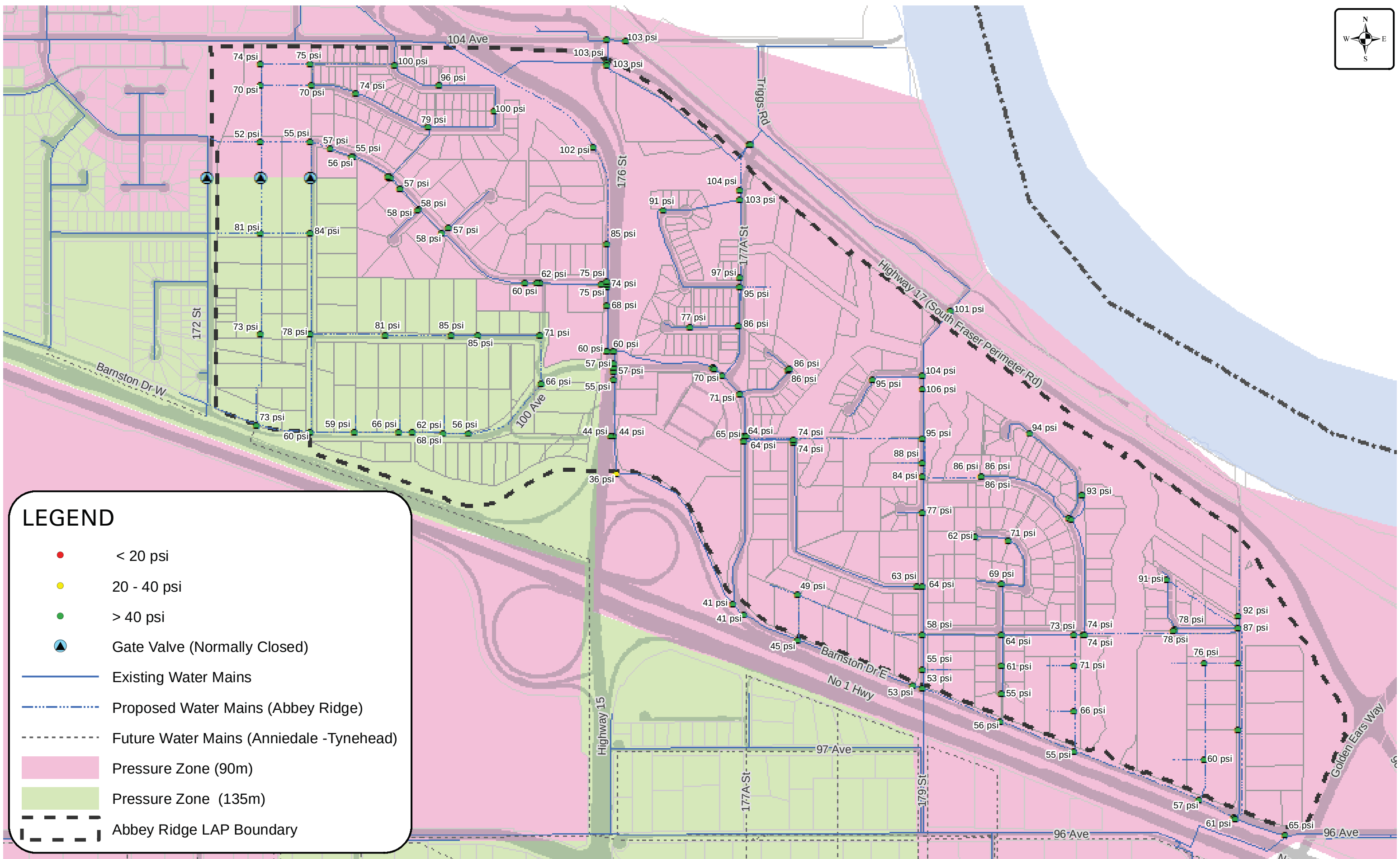
Figure 5



Produced by GIS Section: 30-Sep-2016, C9W

Scale: 1:10,700

CITY OF SURREY the future lives here.	Proposed Water Servicing at MDD+FF (Residual Pressure)	ENGINEERING DEPARTMENT

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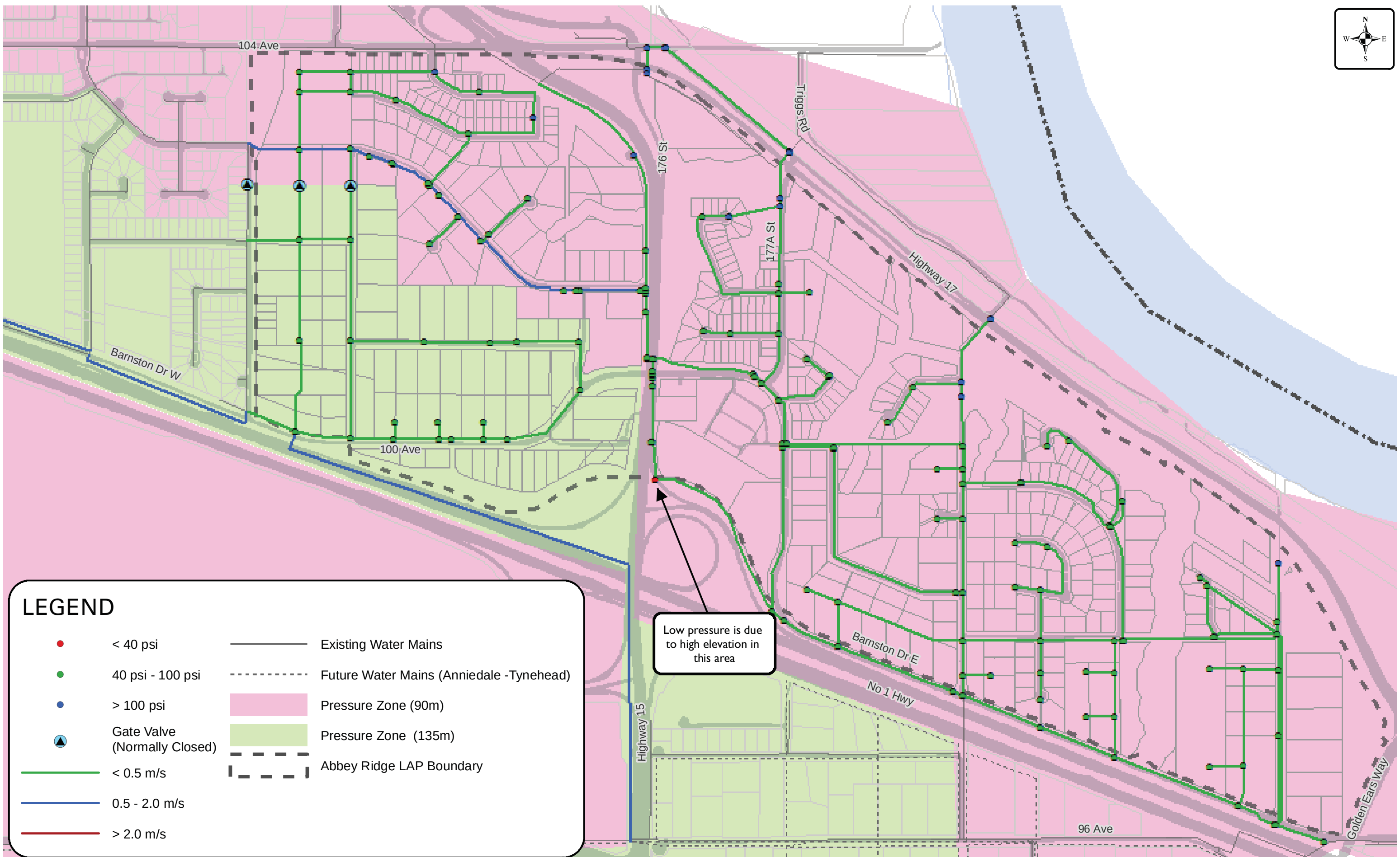
Figure 6



Produced by GIS Section: 30-Sep-2016, C9W

Scale: 1:10,700 — 0 — 100 M

CITY OF SURREY — the future lives here.

Proposed Water Servicing at PHD
(Pressure and Velocity)

ENGINEERING DEPARTMENT

Source:
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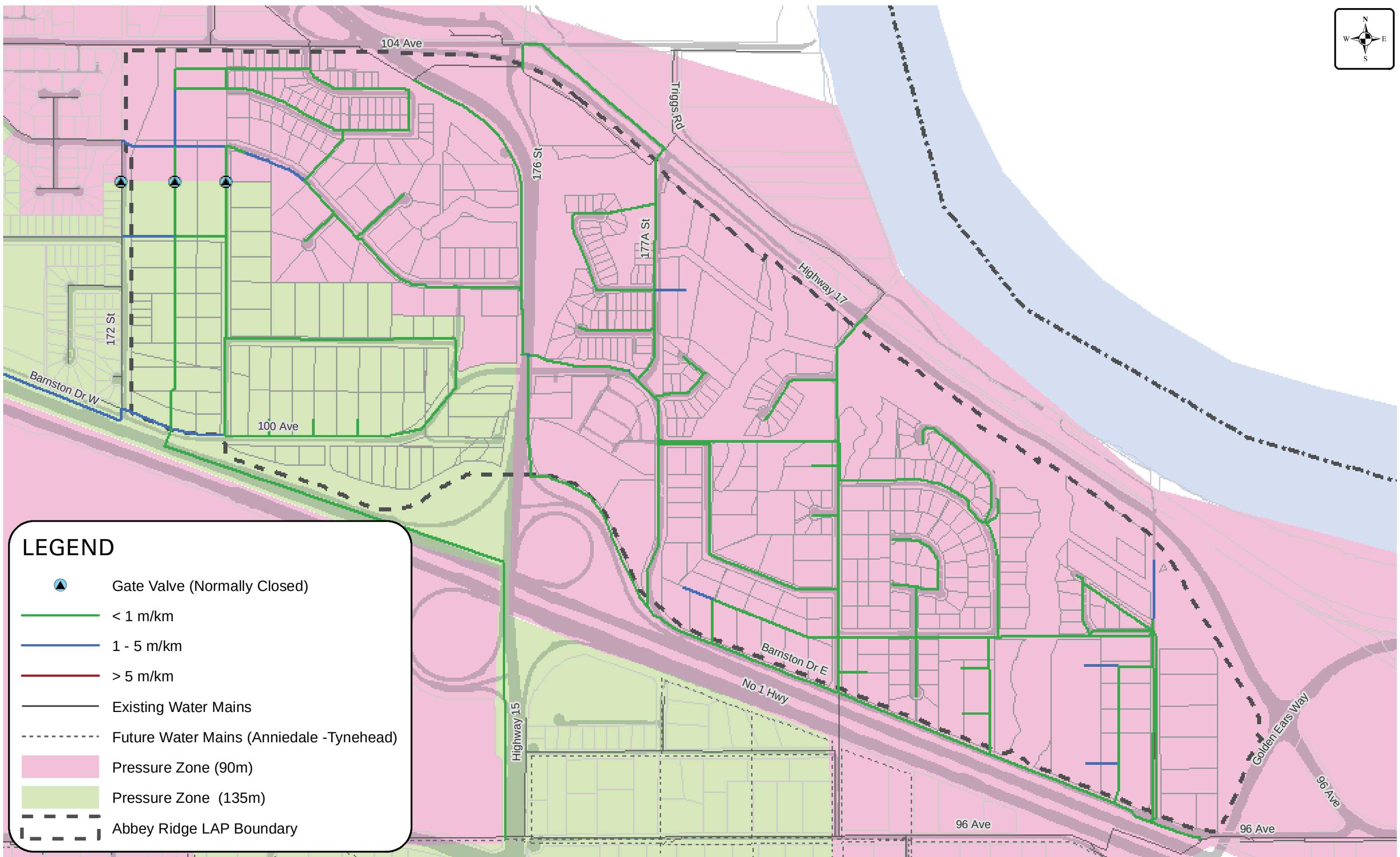
Figure 7



Produced by GIS Section: 30-Sep-2016, C9W

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Proposed Water Servicing at PHD (Headloss)

ENGINEERING DEPARTMENT

Source:
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Appendix A-2.3 - Abbey Ridge Transportation Servicing Plan

A-2

Binnie File No. 16-0148-05

Road Network Evaluation and Recommendation – Draft Report Rev. 1

City of Surrey

Abbey Ridge Local Area Plan (Stage 2) Transportation Servicing Plan

October 9, 2016

Reviewed by:
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Traffic Engineer

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OQM | Organizational Quality Management Program

BINNIE

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1 INTRODUCTION

1.1 Background

R.F. Binnie & Associates Ltd. (Binnie) was retained by the City of Surrey (the City) to provide transportation consulting services to model the anticipated build-out neighbourhood of Abbey Ridge in Surrey. This study will estimate the number of vehicular trips and their impacts on the study road network based on the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge, which was approved by the City Council in December 2015. The study findings will propose necessary transportation infrastructure improvements to accommodate the project traffic volumes on the study road network.

The Abbey Ridge neighbourhood will mainly consist of residential dwelling units (primary and secondary suits), neighbourhood commercial developments, and industrial properties along the future Golden Ears Connector. Based on the past feedback received at the public information meetings, the long-term growth areas are expected to be zoned for single-family residential developments rather than multi-family or comprehensive developments. Inbound and outbound vehicular traffic is expected to be distributed onto the study road network, namely the Highway 17 South Fraser Perimeter Road (SFPR), Golden Ears Connector, 100 Avenue/Barnston Drive East, Highway 1, and 176 Street.

The analysis procedures, study results, and transportation servicing recommendations are outlined in the following sections of this report.

1.2 Project Location

The proposed Abbey Ridge neighbourhood is located in the northeastern part of Surrey, as shown in **Figure 1-1**Figure 1-1. Abbey Ridge is bounded by 104 Avenue and Golden Ears Connector to the north, with the latter currently being constructed, 100 Avenue/Barnston Drive East to the south, Golden Ears Way to the east, and 172 Street to the west. Along 100 Avenue/Barnston Drive East and Golden Ears Connector, 177A Street and 179 Street will provide vital transportation connections to Abbey Ridge.

1.3 Study Objectives

The objectives of this road network evaluation are as follows based on the City's Terms of Reference (TOR):

- Confirm the transportation servicing plan developed in the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge.
- Estimate the site generated traffic volumes from Abbey Ridge at the build-out stage.
- Distribute the vehicular trips generated from the approved population growth areas.
- Perform traffic operation analysis of the study area and road network based on the forecast traffic volumes.
- Identify any major traffic impacts on the existing and planned road network.
- Identify any major traffic impacts on the adjacent road network.
- Recommend necessary transportation infrastructure updates required within Abbey Ridge and outside of the Local Area Plan (LAP) area.

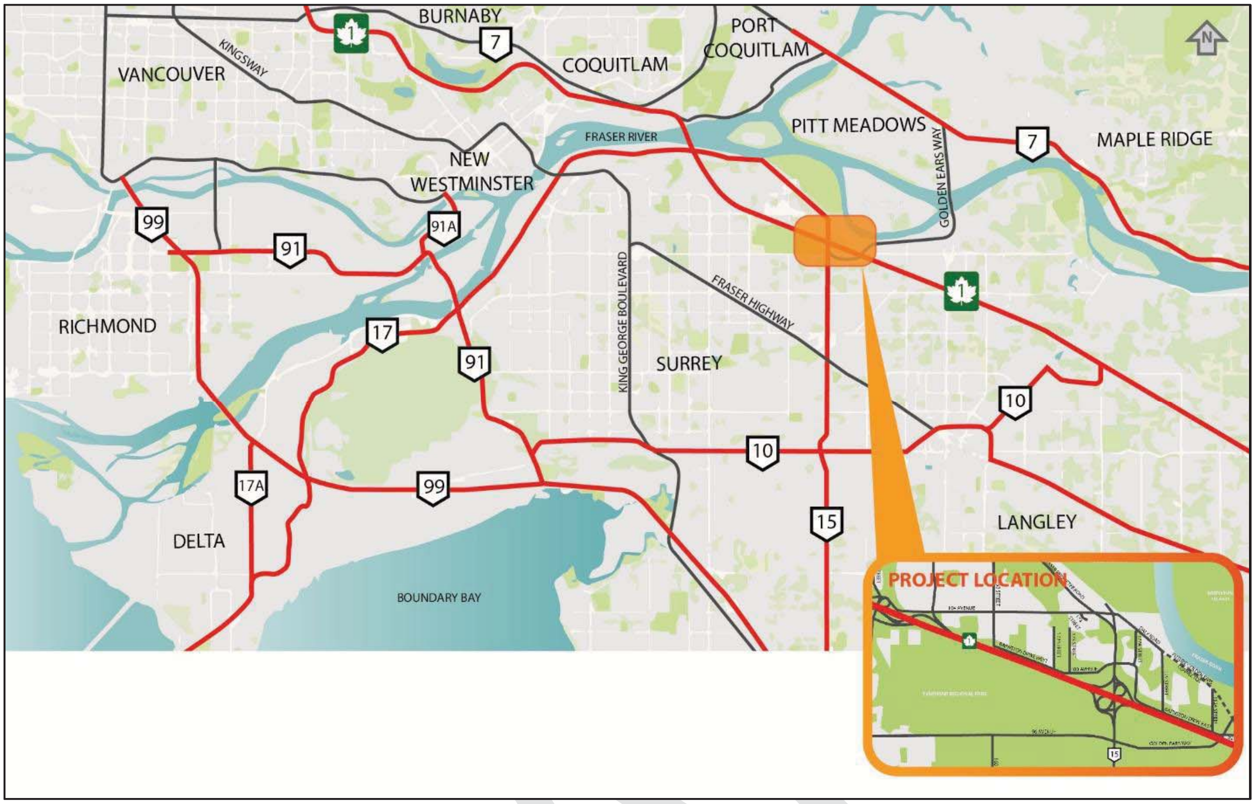

Figure 1-1: Project Location

2 EXISTING CONDITIONS

2.1 Adjacent Road Network

2.1.1 Highway 1

Highway 1 is operated and maintained by the Ministry of Transportation and Infrastructure (MOTI). The study segment of Highway 1 runs in the east-west direction. Its main access to Abbey Ridge is provided at the 176 Street/Highway 15 Interchange. In 2013, the Port Mann Highway 1 Improvement Project was completed to provide an improved Fraser River crossing to connect with the Lower Mainland. Within the study area, Highway 1 currently has a divided eight-lane cross-section with three General Purpose (GP) lane and one High Occupancy Vehicle (HOV) lane in each direction. The current posted speed on Highway 1 is 100 km/h.

Anecdotally, traffic flows well on the study segment of Highway 1 following the recent widening. Due to the tolling of the new Port Mann Bridge, a considerable portion of Highway 1 westbound traffic would exit at the 176 Street/Highway 15 Interchange to travel to the existing Pattullo Bridge and Alex Fraser Bridge via SFPR in the AM peak, which are non-tolled alternatives to the Port Mann Bridge. In the PM peak, similar eastbound traffic pattern could be observed travelling between SFPR and Highway 1 via the 176 Street/Highway 15 Interchange.

2.1.2 Highway 17 SFPR

Highway 17 is commonly known as SFPR. It is an arterial roadway constructed as part of the MOTI's Gateway Program to improve traffic flows in the region, particularly south of the Fraser River. SPFR connects the BC Ferry Tsawwassen Ferry Terminal, Highway 99 in Delta, and Highway 1 in Surrey, as well as the major Fraser River crossings. The study segment of SFPR runs in the east-west direction and it is a four-lane divided roadway with two lanes in each direction. Its current posted speed in the vicinity of the study area is 80 km/h.

In Abbey Ridge, vehicular access to and from SFPR is provided at the 104 Avenue intersection, which is a four-legged at-grade intersection that is currently signalized. To the east of SFPR, 104 Avenue currently provides access to the Barnston Island Ferry Terminal.

2.1.3 176 Street/Highway 15

176 Street is also known as Highway 15, which is operated and maintained by the MOTI. Similar to the SFPR, the study segment of 176 Street/Highway 15 was recently constructed as a four-lane divided roadway as part of the Port Mann Highway 1 Improvement Project to connect SFPR with Highway 1. The posted speed limit on the study segment of 176 Street/Highway 15 is 60 km/h. Between 104 Avenue and the Highway 1 westbound off-ramp terminal, there is a steep uphill segment for the southbound traffic; in the opposing direction, the northbound traffic travels on a steep downhill segment towards the 104 Avenue intersection. A new Barnston Drive East overpass was also constructed maintain transportation connectivity in Abbey Ridge.

2.1.4 Arterial Roads

Golden Ears Way

Golden Ears Way is operated by the Greater Vancouver Transportation Authority (TransLink). It generally has a four-lane divided arterial roadway that runs between 176 Street/Highway 15 in Surrey and 210 Street in Maple Ridge, including the Golden Ears Bridge segment. In its eastern end in Maple Ridge, Golden Ears Way transitions into 128 Avenue east of 210 Street. In its western end in Surrey, Golden Ears Way transitions into 96 Avenue west of 176 Street/Highway 15. For the study segment within Abbey Ridge, Golden Ears Way generally runs in the east-west direction with a posted speed of 60 km/h.

An existing three-legged signalized intersection connects Golden Ears Way with 96 Avenue, which is another arterial roadway in Surrey. The proposed Golden Ears Connector is currently under constructions and it is expected to tie-in to Golden Ears Way as the north approach in late 2016 or early 2017.

Golden Ears Connector

The proposed Golden Ears Connector will be operated and maintained by the MOTI and/or TI Corp. It will provide a direct connection between SFPR and Golden Ears Way to improve the major road network connectivity without the need to rely on Highway 1. The proposed cross-section on the Golden Ears Connector will include a four-lane divided arterial template between SFPR and 179 Street, and a two-lane undivided rural template between 179 Street and Golden Ears Way.

Between SFPR and Golden Ears Way, there will be a number of at-grade and signalized intersections including the Canadian National (CN) Railway modal yard, 104 Avenue, 177A Street, and 179 Street. Key access to Abbey Ridge will be provided via 177A Street and 179 Street.

104 Avenue

104 Avenue is currently designated as an arterial roadway in the City. The study segment of 104 Avenue also provides access to the Barnston Island Ferry Terminal. To the east of SFPR, it generally has a two-lane rural cross-section. To the west of SFPR, it has a two-lane urban cross-section with curb and gutter on either side of 104 Avenue. The current posted speed limit is 50 km/h.

When the Golden Ears Connector is constructed, the existing 104 Avenue east of SFPR will be re-configured. Based on the technical memorandum prepared by Binnie for the Transportation Investment Corporation (TI Corp) on September 22, 2015, the future 104 Avenue will tie-in to the Golden Ears Connector as the north approach of a three-legged and signalized intersection. This study noted that the said configuration is contrary to the proposed alignment of Triggs Road to connect 104 Avenue with the Golden Ears Connector, which was deemed not feasible due to property constraints.

96 Avenue

96 Avenue runs in the east-west direction between Golden Ears Way and Langley. It currently intersects at Golden Ears Way to form a three-legged signalized intersection. When the Golden Ears Connector is constructed, it will form the west approach of this intersection and the vehicular traffic on 96 Avenue will be able to access SFPR without needing to detour to 176 Street/Highway 15 via Golden Ears Way based on the existing road network condition. In the vicinity of the study area, 96 Avenue has a four-

lane cross-section with two lanes in each direction. The current posted speed limit on 96 Avenue is 60 km/h.

2.1.5 Collector Roads

100 Avenue/Barnston Drive East

100 Avenue/Barnston Drive East is a two-lane undivided collector roadway that runs through Abbey Ridge between 168 Street and 96 Avenue. Within the study area, there is an existing left-turn lane provided for the eastbound movement onto 177A Street. In addition, there is a 1 km segment of Barnston Drive East within Abbey Ridge with bike lanes on both sides; however, pedestrian sidewalk is only provided on the north side of Barnston Drive East. The current speed limit was noted to be 50 km/h.

177A Street

Based on the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge, as shown in **Figure 2-1**, 177A Street is designated as a collector roadway within Abbey Ridge. It is a two-lane undivided roadway that runs between 100 Avenue/Barnston Drive East and the future Golden Ears Connector, which will form a three-legged signalized intersection at its tie-in with the latter roadway. At the intersection of Barnston Drive East and 177A Street, a traffic signal has also been proposed in the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge. There are sidewalks, curbs and gutters on both sides of 177A Street, with on-street parking permitted along the east side only. The current speed limit on 177A Street is 50 km/h.

The existing laning configurations and controls at the study intersections are shown in **Figure 2-2**.

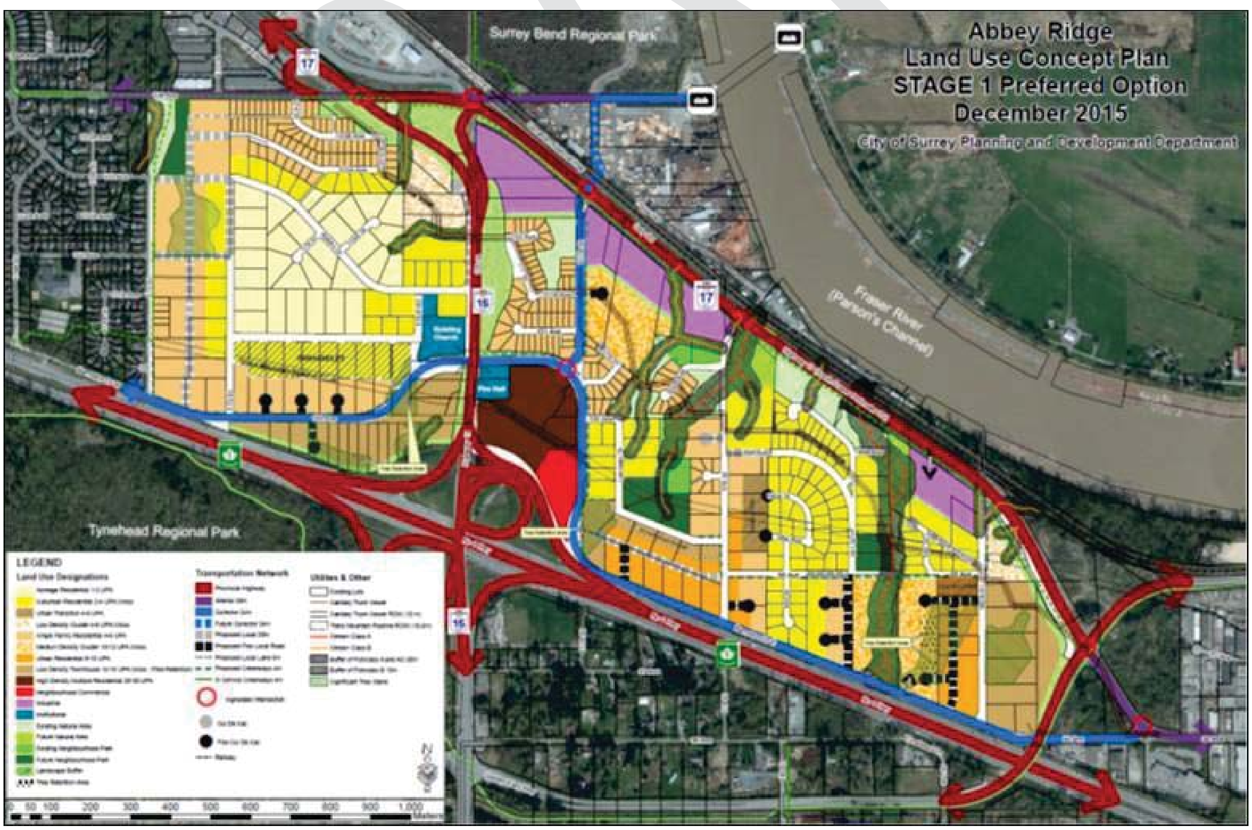

Figure 2-1: Abbey Ridge Land Use Concept Plan

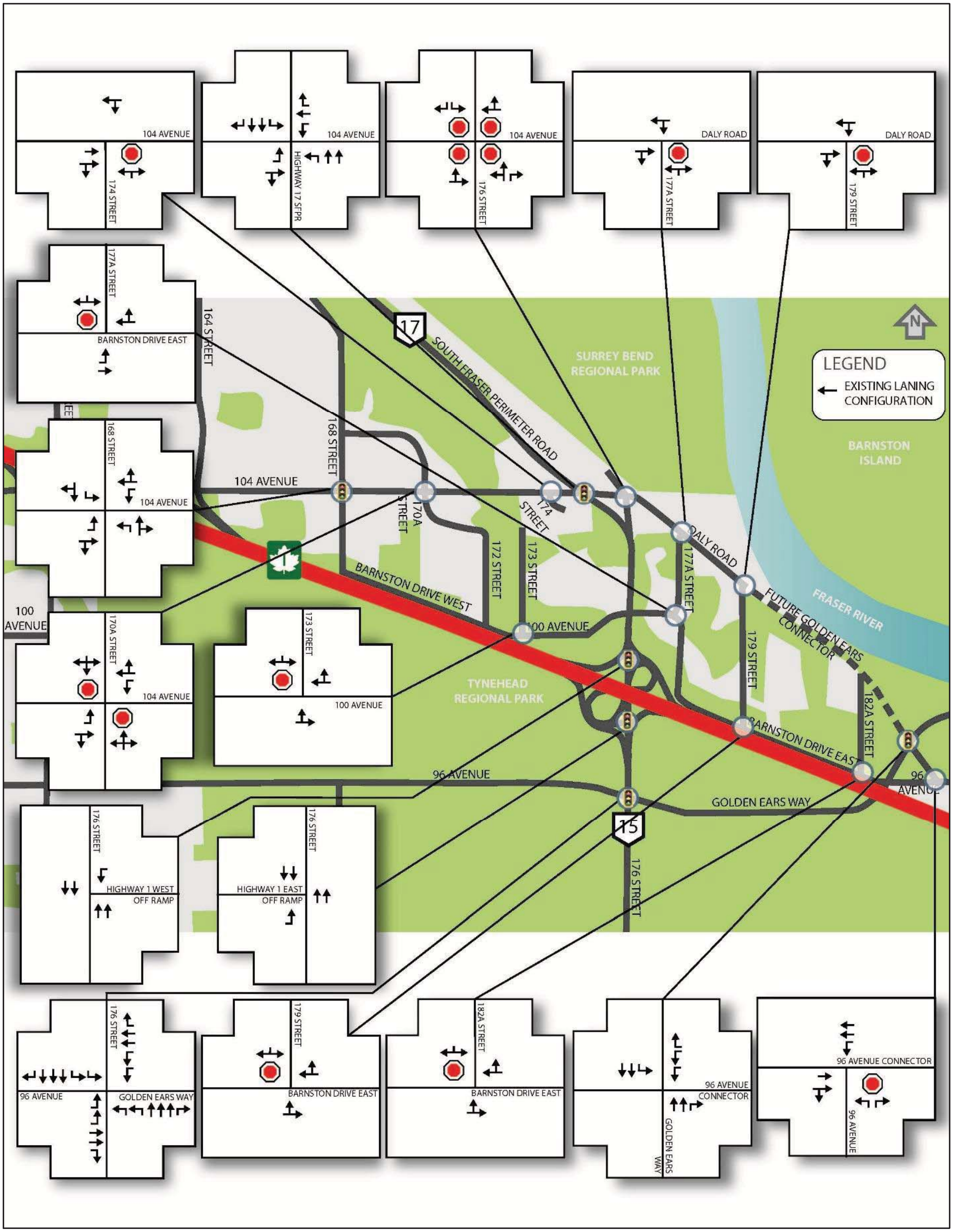

Figure 2-2: Existing Intersection Laning Configurations and Traffic Controls

2.2 Land Use

As per the information received from the City, the residential land uses in Abbey Ridge can generally be identified as different density zones based on the number of dwelling units per acre (UPA). The typical zones and their corresponding densities include the following:

- One-Acre Residential Zone (RA) 1-2 UPA
- Half-Acre Residential Zone (RH) 2-4 UPA
- Half-Acre Residential Gross Density Zone (RH-G) 2-4 UPA
- Single Family Residential Zone (RF) 4-6 UPA
- Single Family Residential Gross Density Zone (RF-G) 4-6 UPA
- Cluster Residential Zone (RC) 4-6 UPA
- Semi-Detached Residential Zone (RF-SD) 8-10 UPA
- Multiple Residential 10 Zone (RM-10) 10-15 UPA
- Multiple Residential 15 Zone (RM-15) 10-15 UPA
- Multiple Residential 23 Zone (RM-23) 10-15 UPA

Higher density zones, such as Multiple Residential 30 Zone (RM-30), were initially considered for Abbey Ridge. Based on the feedback received from the past public information meeting, they are no longer being considered in the LAP in order to be developed at densities that are deems appropriate by the City and the local communities.

2.3 Existing Intersection Configurations and Traffic Volumes

The existing traffic volumes on the study road network were gathered from a number of sources. Binnie received a technical memorandum from TI Corp on the planning of the Golden Ears Connector and the proposed modifications at the SFPR and 104 Avenue intersection. This memorandum was prepared by Parsons Corporation (then Delcan Corporation) on August 13, 2014.

In addition, Binnie retained TransTech Data Services Ltd. (TransTech) to perform additional turning movement counts at a number of intersections in Abbey Ridge that were not covered in the technical memorandum provided by TI Corp. Binnie staff also performed short turning movement counts at the Highway 15 and 96 Avenue/Golden Ears Way intersection to estimate the traffic volumes at this intersection. For the purpose of this assignment, the PM peak hour at the 104 Avenue and 170A intersection was selected to be between 14:30 and 15:30 to account for the traffic volumes generated by the nearby Pacific Academy.

As shown previously in **Figure 2-2**, the study intersections are listed below:

- 104 Avenue at 168 Street
- 104 Avenue at 170A Street
- 104 Avenue at 174 Street
- Highway 17 (SFPR) at 104 Avenue
- Highway 15 northbound off-ramp at 104 Avenue

- Highway 1 westbound off-ramp at 176 Street/Highway 15
- Highway 1 eastbound off-ramp at 176 Street/Highway 15
- Highway 15 at 96 Avenue/Golden Ears Way
- 100 Avenue at 173 Street
- Barnston Drive East at 177A Street
- Barnston Drive East at 179 Street
- Barnston Drive East at 182A Street
- 96 Avenue at 96 Avenue Connector
- Golden Ears Connector at 177A Street
- Golder Ears Connector at 179 Street
- Golden Ears Way at 96 Avenue Connector (and future Golden Ears Connector)

2.3.1 104 Avenue and 174 Street Intersection

The 104 Avenue and 174 Street junction is a three-legged intersection, with the stop-control placed on the south approach. The east approach has one shared left-turn/through lane. The west approach has two through lanes, with the curb lane accommodating shared through/right-turn movement at the Highway 17 and 104 Avenue intersection.

2.3.2 104 Avenue and 168 Street

The 104 Avenue and 168 Street junction is a four-legged signalized intersection. Each of the existing four approaches has one left-turn lane and one shared through/right-turn lane. The south approach has dedicated bicycle lanes on both sides of the road.

2.3.3 104 Avenue and 170A Street

The 104 Avenue and 170A Street junction is a four-legged intersection, with the stop-control placed on the north and south approaches. The east and west approaches each have a left-turn lane and a shared through/right-turn lane. The north and south approaches each have a shared left-turn/through/right-turn lane.

2.3.4 Highway 17 and 104 Avenue Intersection

The Highway 17 and 104 Avenue junction is a four-legged signalized intersection. The north approach has one left-turn lane, two through lanes ad a channelized right-turn lane. When the Golden Ears Connector is constructed, dual southbound left-turn lanes will be provided for traffic to travel from SFPR to the Golden Ears Connector. The south approach has one left-turn lane and two through lanes. Due to the geometry of the intersection, northbound right-turn movement is prohibited from the south approach onto 104 Avenue at the intersection. Instead, the northbound right-turn movement takes place further to the east via an off-ramp to 104 Avenue (and the future Golden Ears Connector).

On 104 Avenue, the east approach has one left-turn lane, one through lane and a right-turn lane, with the latter being channelized with an acceleration lane on SFPR. The west approach currently has one left-turn lane and one shared through/right-turn lane; however, when the Golden Ears Connector is constructed, the west approach will be re-configured to have one shared left-turn/through lane and one shared through/right-turn lane. Pedestrian crosswalks are provided on the east approach, west approach and south approach.

2.3.5 Highway 15 Northbound Off-Ramp and 104 Avenue Intersection

The Highway 15 northbound off-ramp and 104 Avenue junction is currently a four-legged all-way-stop-controlled (AWSC) intersection. The north approach has one shared left-turn/right-turn lane, which provides access to the CN Railway modal yard. The south approach has a shared left-turn/through lane and a right-turn lane with channelization. On 104 Avenue, the east approach currently has one shared through/right-turn lane and the west approach has one shared left-turn/through lane. When the Golden Ears Connector is constructed, the east and west approaches will be widened to an urban four-lane cross-section.

2.3.6 Highway 1 Westbound Off-Ramp and 176 Street Intersection

The Highway 1 westbound off-ramp and 176 Street junction is a three-legged signalized intersection. The north approach has two through lanes and since this intersection is operated under a partial signal, the southbound traffic is not required to stop. The south approach has two through lanes and traffic is required to stop at the traffic signal to allow the westbound left-turn movement to proceed onto 176 Street/Highway 15. The east approach is the off-ramp from Highway 1 and it has one left-turn lane and a channelized right-turn lane with an acceleration lane on 176 Street/Highway 15. The northbound and southbound traffic accessing Highway 1 westbound is not required to traverse through the signalized intersection under the existing on-ramp configurations.

2.3.7 Highway 1 Eastbound Off-Ramp and 176 Street Intersection

The Highway 1 eastbound off-ramp and 176 Street junction is a three-legged signalized intersection. The north approach has two through lanes and the south approach also has two through lanes. The west approach has one left-turn lane and one channelized right-turn with an acceleration lane on 176 Street/Highway 15. The northbound and southbound traffic accessing Highway 1 eastbound is not required to traverse through the signalized intersections under the existing on-ramp configurations.

2.3.8 Highway 15 and 96 Avenue/Golden Ears Way Intersection

The Highway 15 and 96 Avenue/Golden Ears Way junction is a four-legged signalized intersection operated by TransLink. The north approach has two left-turn lanes, two through lanes and one shared through/right-turn lane with channelization. The south approach has two left-turn lanes, three through lanes and one channelized right-turn lane. The east approach has two left-turn lanes, two through lanes and one channelized right-turn lane. The west approach has two left-turn lanes, two through lanes and one channelized right-turn lane.

2.3.9 100 Avenue and 173 Street Intersection

The 100 Avenue and 173 Street junction is a three-legged intersection with the stop-control placed on the north approach. The east approach has one shared through/right-turn lane and the west approach has one shared left-turn/through lane. The north approach has one shared left-turn/right-turn lane. There is no existing crosswalk on any of the approaches.

2.3.10 Barnston Drive East and 177A Street Intersection

The Barnston Drive East and 177A Street junction is a three-legged intersection with the stop-control placed on the north approach. The east approach has one shared through/right-turn lane. The west approach has one left-turn lane and one through lane. The north approach has one shared left-turn/right-turn lane. Although new pedestrian sidewalks were constructed on both sides of Barnston Drive, there is no existing crosswalk on any of the approaches.

2.3.11 Barnston Drive East and 179 Street Intersection

The Barnston Drive East and 179 Street junction is a three-legged intersection with the stop-control placed on the north approach. The east approach has one shared through/right-turn lane and the west approach has one shared left-turn/through lane. The north approach has one shared left-turn/right-turn lane. Similar to the adjacent intersections on 100 Avenue/Barnston Drive East, there is no existing crosswalk on any of the approaches.

2.3.12 Barnston Drive East and 182A Street Intersection

The Barnston Drive East and 182A Street junction is a three-legged intersection with the stop-control placed on the north approach. The east approach has one through and a right-turn lane. The west approach has one shared left-turn/through lane. The north approach has one shared left-turn/right-turn lane. There is an existing crosswalk on the north approach for pedestrians to cross 182A Street.

2.3.13 96 Avenue and 96 Avenue Connector Intersection

The 96 Avenue and 96 Avenue Connector junction is a three-legged intersection with the stop control placed on the south approach. For the purpose of this study, the 96 Avenue Connector is considered to be running in the east-west direction. The east approach has one left-turn lane and two through lanes. The west approach has one through lane and a shared through/right-turn lane. The south approach has one left-turn lane and one right-turn lane.

2.3.14 Golden Ears Way and 96 Avenue Connector Intersection

The Golden Ears Way and 96 Avenue Connector junction is a currently a three-legged signalized intersection. For the purpose of this study, the Golden Ears Way is considered to be running in the east-west direction. The east approach has one left-turn lane and two through lanes. The west approach has two through lanes and a channelized right-turn lane. The south approach has two left-turn lanes and a channelized right-turn lane.

When the proposed Golden Ears Connector is constructed, an eastbound left-turn lane and a westbound right-turn lane will be provided for the Golden Ears Way traffic to access Golden Ears Connector. On the south approach (96 Avenue Connector), a northbound left-turn lane and two through lanes will be provided. On the newly constructed north approach (Golden Ears Connector), a left-turn lane, one through lane and one channelized right-turn lane will be provided for the southbound traffic.

The existing (balanced) traffic volumes for the AM peak hour and PM peak hour are summarized in **Figure 2-3**.

2.4 Pedestrians

The Highway 1 and SFPR segments within the Abbey Ridge study area do not have sidewalks to accommodate pedestrian traffic. In general pedestrians are not permitted on these two highways due to their MOTI classifications. On the other hand, the 176 Street/Highway 15 segment between Barnston Drive and 96 Avenue has a sidewalk provided on the east side. Pedestrian crosswalks are currently provided on all four approaches at the Highway 15 and 96 Avenue/Golden Ears Way intersection.

Along 100 Avenue and Barnston Drive East, pedestrian sidewalk is generally provided on the north side. In the vicinity of the new multi-family residential development on Barnston Drive East, a pedestrian sidewalk is also provided on the south side of Barnston Drive East. Furthermore, aside from 177A Street, pedestrian sidewalk is generally lacking on 173 Street, 179 Street and 182A Street. On 104 Avenue, sidewalks are provided along the south side east of 170A Street and along the north side west side of 170A street. There is an existing special crosswalk on the east approach of the 104 Avenue and 170A Street intersection.

When the proposed Golden Ears Connector is constructed, pedestrian traffic will be accommodated on a multi-use pathway that runs along the south side between SFPR and Golden Ears Way. Along Golden Ears Way, a multi-use pathway is also provided along the south side between 176 Street/Highway 15 and Telegraph Trail. On 96 Avenue Connector, pedestrian sidewalks are currently provided on both sides of the roadway.

2.5 Cyclists

The City has a number of regional and community cycling routes and multi-use pathways based on the information published on its website. Along SFPR and 176 Street/Highway 15, except for the current interchange at Highway 1, there are shoulder bicycle lanes to accommodate cyclists. Along Barnston Drive East between the 176 Street/Highway 15 underpass and Lyncean Drive, approximately from 173 Street to Lyncean Drive, there are shoulder bicycle lanes are also provided for cyclists. In addition to the existing multi-use pathway along the south side of Golden Ears Way, cyclists are permitted to travel on the paved shoulders in both eastbound and westbound directions.

When the Golden Ears Connector is constructed, cyclists will be accommodated on a multi-use pathway on the south side between SFPR and Golden Ears Way. A new connection will also be constructed between Golden Ears Connector and 104 Avenue between the Highway 15 northbound off-ramp and 177A Street. It is expected that a multi-use pathway will be constructed along this new roadway to allow cyclists to access the Barnston Island Ferry Terminal and the Surrey Bend Regional Park.

Cyclists are not permitted on Highway 1 because it is an expressway facility. There are existing cyclist restriction signs posted and cyclists must use the regional and community cycling routes to safely travel to other parts of Surrey.

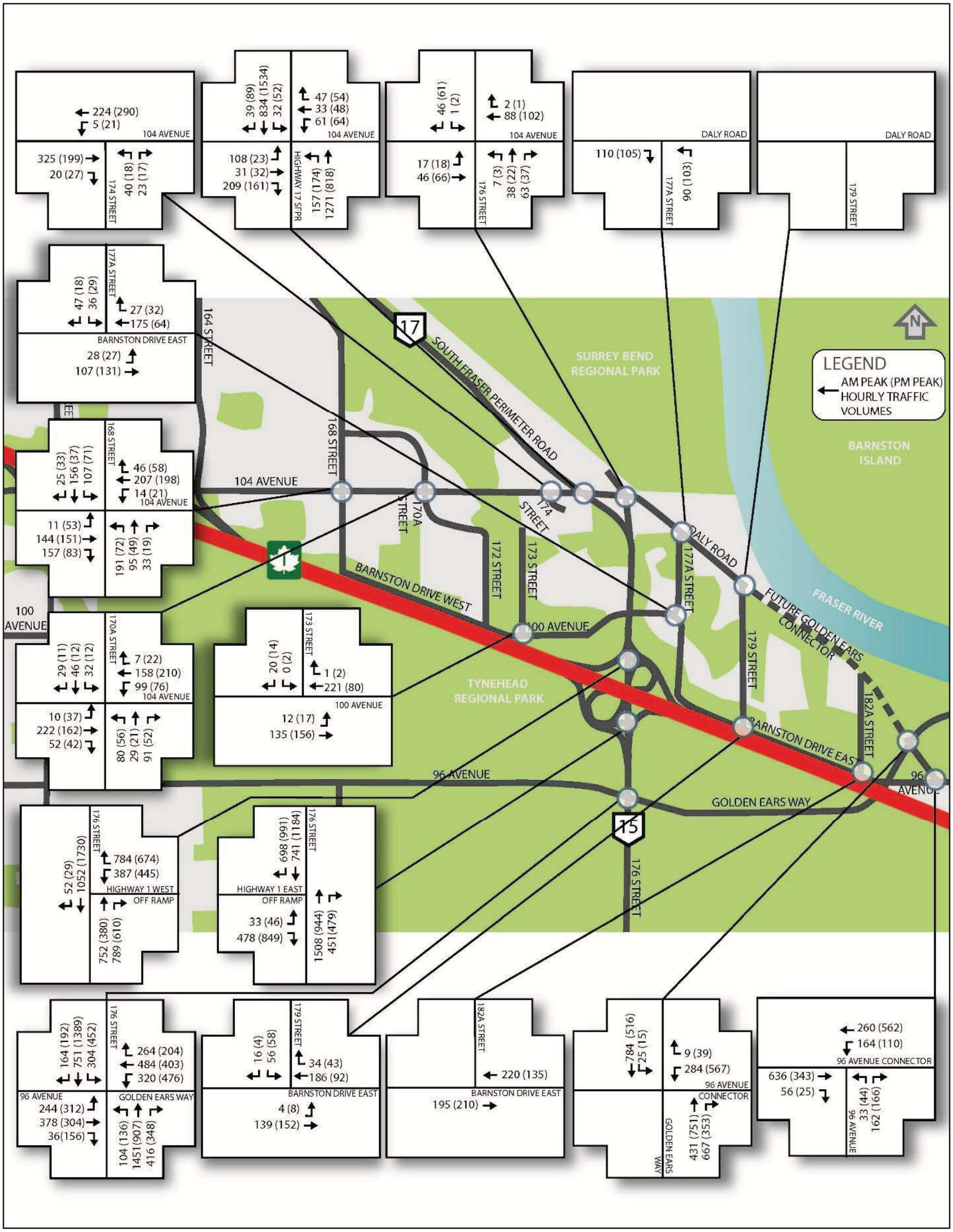

Figure 2-3: 2016 Existing and Balanced Traffic Volumes

2.6 Transit Services

Existing transit services in Surrey are provided by TransLink. According to the information published on TransLink's website, there is currently no transit service operating within Abbey Ridge. At the Abbey Ridge public information meeting hosted by the City in October 2015, over 30% of the feedback received from the public would like to see better transit services in Abbey Ridge to support the anticipated population growth.

3 ABBEY RIDGE LAND USE PLAN CONCEPT

3.1 Growth Areas

The City's planning department provided the forecast build-out dwelling unit and population scenario for the purpose of this study. The number of dwelling units considers both primary residents and secondary suites in Abbey Ridge to ensure that the forecast trip generation estimates will better represent the future conditions in the study area, given that most of the future residential developments in Abbey Ridge may be single-family homes with potential to accommodate secondary suites. For the purpose of this study, it was agreed between the City and Binnie that the more conservative unit forecast will be used for a robust evaluation.

The following sections outline Binnie's understanding of the various growth areas in Abbey Ridge to estimate the number of vehicle trips that may be generated by the future population within the study area and the potential impacts to the adjacent transportation infrastructures.

3.1.1 Limited Growth Potential Areas

Within Abbey Ridge, the limited growth potential areas are not expected to see significant new residential developments. These areas were generally noted to be along 177A Street and 99A Avenue/181 Street. It is anticipated that the primary traffic growth will be generated by the remaining 81 units at the multi-family residential development on the south side of Barnston Drive East across from 177A Street. In addition, approximately 23 additional secondary suites are anticipated in this growth area.

3.1.2 Long-Term Growth Potential Areas

The long-term growth potential areas within Abbey Ridge are expected to be developed in the westernmost and easternmost areas in Abbey Ridge. In addition, there are a number of areas along 100 Avenue/Barnston Drive East that may be developed further as well to accommodate the majority of forecast population growth in Abbey Ridge.

Based on the information provided by the City, this study assumes that just over 1,000 single-family residential dwelling units may be constructed in the long-term growth potential areas, and approximately 150 multi-family residential units will also be developed. In addition, the City projected that 768 secondary suites may reside in Abbey Ridge given the number of new single-family homes that are expected to be built in these areas.

3.1.3 Infill Potential Suburban Growth Areas

The infill growth areas are expected to see a small number of new dwelling units being developed to maximize the growth potential in Abbey Ridge. Based on the latest information provided by the City, this study assumes that 61 single-family homes and another 52 secondary suites will occupy these infill growth potential areas.

3.1.4 Other Growth Area

In addition to the forecast residential growth, this study anticipates that new industrial properties will be developed along the south side of the Golden Ears Connector when it is completed. In addition, a small neighbourhood commercial area has also been considered in the vehicle trip generation forecast for Abbey Ridge.

The forecast growth areas were provided by the City, and they are shown in **Figure 3-1**.

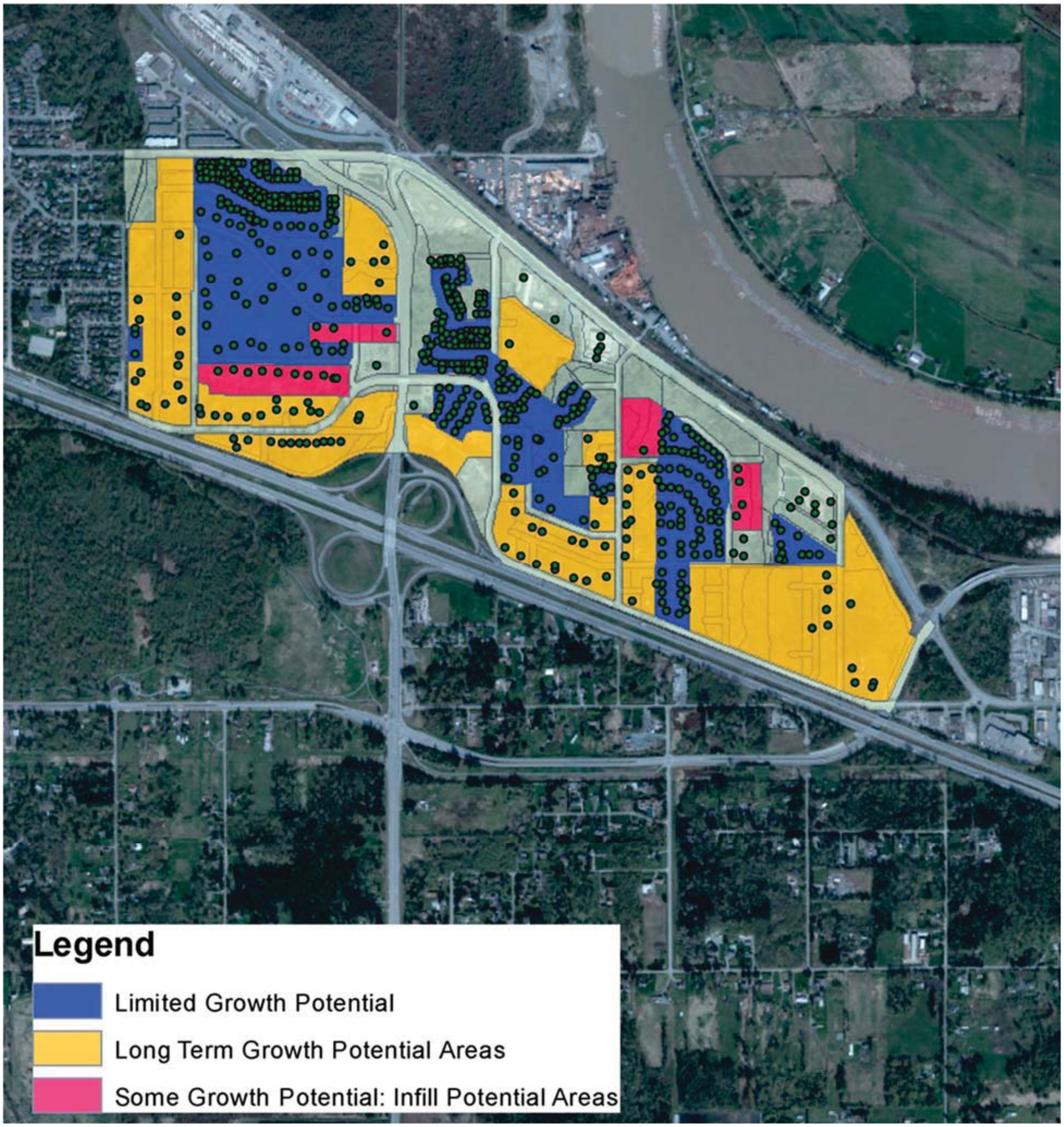

Figure 3-1: Forecast Growth Areas in Abbey Ridge

3.2 Trip Generation

The forecast trip generation for the proposed Abbey Ridge neighbourhood is estimated based on the rates published in the Institute of Transportation Engineers' (ITE) *Trip Generation, 8th Edition*.

The Single-Family Detached Homes land use (ITE Ref. 210) is chosen to represent the vast majority of developments in Abbey Ridge. The trip generation rates published under this land use were gathered throughout North America and they typically represent vehicle-dependent neighbourhoods such as Abbey Ridge. For the purpose of this study, this land use is also chosen to represent the vehicle trip generation patterns of the secondary suites assuming that no new transit service is being introduced to Abbey Ridge, which is a conservative estimate.

The Multi-Family Residential Townhouse land use (ITE Ref. 231) is chosen to represent the forecast multi-family residential developments in Abbey Ridge. They are expected to be developed in the limited growth and long-term growth potential areas.

For the industrial properties along Golden Ears Way, their trip generation rates are expected to be consistent with the Industrial Park land use (ITE Ref. 130) since their exact development proposals are not known at this point. This study assumes that most of the site generated trips from these industrial properties will be distributed onto the Golden Ears Connector.

Lastly, based on the information obtained from the City's online mapping system, the proposed neighbourhood commercial is anticipated to be 7,500 sq. ft. in size and its trip generation rates are expected to be consistent with the ITE land use Ref. 820.

Based on the selected ITE reference land use codes, the forecast site generated traffic volumes in the overall Abbey Ridge are summarized in **Table 3-1** for the AM peak and PM peak. In summary, Abbey Ridge is expected to see an additional 1,696 vehicle trips during the AM peak hour, with 482 inbound trips and 1,214 outbound trips. During the PM peak hour, an additional 2,240 vehicle trips are expected to be generated by the future Abbey Ridge population, with 1,358 inbound trips and 882 outbound trips.

3.2.1 Pass-by Trips

According to ITE, pass-by trips are defined as site trips diverted from existing vehicle trips in the surrounding road network, which are mainly associated with commercial developments, i.e. coffee shops or grocery stores.

Based on the information received from the City, the commercial generated vehicle trips are expected to account for just 1.2% of the total site generated vehicle trips during the PM peak hour. In the AM peak, the commercial generated vehicle trips account for even less; therefore, this study assumes that there will be no pass-by trip in Abbey Ridge as any necessary transportation improvements will likely be driven by the trip generation demands from the future primary and secondary residential units within the study area.

Table 3-1: Forecast Site Generated Traffic

Growth Areas	Description	Size	Unit	ITE Ref.	Avg. Trip Ends per Unit	Generated Trip Ends	% Entering	% Exiting	Vehicle Entering	Vehicle Exiting
AM Peak Hour										
Limited Growth Area	Single-Family Detached	2	Dwelling Units	210	0.75	2	25	75	1	2
	Multi-Family Residential	81	Dwelling Units	231	0.67	55	25	75	14	41
	Projected Secondary Suites	23	Dwelling Units	210	0.75	18	25	75	5	14
Long Term Growth Area	Single-Family Detached*	1,007	Dwelling Units	210	0.75	756	25	75	189	567
	Multi-Family Residential	151	Dwelling Units	231	0.67	102	25	75	26	76
	Projected Secondary Suites	768	Dwelling Units	210	0.75	576	25	75	144	432
Infill Potential Area	Single-Family Detached	61	Dwelling Units	210	0.75	46	25	75	12	35
	Projected Secondary Suites	52	Dwelling Units	210	0.75	39	25	75	10	29
Industrial Area	Industrial Park	11	Acres	130	8.55	91	83	17	76	15
Commercial Area	Neighbourhood Commercial	7,500	1,000 sq. ft.	820	1.00	8	61	39	5	3
								AM Total:	482	1,214
PM Peak Hour										
Limited Growth Area	Single-Family Detached	2	Dwelling Units	210	1.01	3	63	37	2	1
	Multi-Family Residential	81	Dwelling Units	231	0.78	64	58	42	37	27
	Projected Secondary Suites	23	Dwelling Units	210	1.01	24	63	37	15	9
Long Term Growth Area	Single-Family Detached*	1,007	Dwelling Units	210	1.01	1,018	63	37	641	377
	Multi-Family Residential	151	Dwelling Units	231	0.78	118	58	42	68	50
	Projected Secondary Suites	768	Dwelling Units	210	1.01	776	63	37	489	287
Infill Potential Area	Single-Family Detached	61	Dwelling Units	210	1.01	62	63	37	39	23
	Projected Secondary Suites	52	Dwelling Units	210	1.01	53	63	37	33	20
Industrial Area	Industrial Park	11	Acres	130	8.84	94	21	79	20	74
Commercial Area	Neighbourhood Commercial	7,500	1,000 sq. ft.	820	3.73	28	49	51	14	14
								PM Total:	1,358	882

*Based on the latest planning forecast statistics provided by the City of Surrey on August 4, 2016.

3.3 Trip Distribution

The trip distribution for the site generated traffic in Abbey Ridge is estimated based on a number of considerations.

Initially, the existing inbound and outbound traffic patterns were reviewed based on the various turning movement count data. Based on the observations made, it was generally found that the study traffic patterns depend greatly on the MOTI highways to access Abbey Ridge. Therefore, this study assumes that similar traffic patterns may persist in the future when the highway corridors continue to be improved as per the MOTI's ten year transportation plan, which has been outlined in a document titled *B.C. on the Move*.

Secondly, the forecast population growths in Abbey Ridge are expected to cause various levels of traffic increases depending on the number of new dwelling units and secondary suites projected in each growth potential areas. For the purpose of this study, Binnie assumes that there will be three major trip generation areas within Abbey Ridge. The first area is assumed to be on the west side of 176 Street/Highway 15, the second area is assumed to be between 176 Street/Highway 15 and 179 Street, and the third area is assumed to be east of 179 Street up to the easternmost boundary of Abbey Ridge. Based on these considerations, the first and third areas are expected to be the key vehicle trip generators within the study area based on the forecast population growths. **Figure 3-2** summarizes the assumed growth areas used to estimate the vehicle trip distribution.

Thirdly, the trip distribution assumes that the local traffic will access the major highways and arterial corridors via the closest travel paths based on typical driver behaviours. The future residents in the area west of 176 Street/Highway 15 may be evenly split on accessing Highway 1 westbound via the 160 Street Interchange and the 176 Street/Highway 15 Interchange. If the local traffic is travelling towards Highway 1 in the eastbound direction, it will likely be distributed onto the 176 Street/Highway 15 Interchange.

As noted in **Section 3.2**, this study assumes that the vehicle trip generation from the proposed industrial developments will be focused along the new Golden Ears Connector. For the purpose of this study, the vehicle trips related to the employment opportunities will be distributed onto 177A Street and 179 Street at Golden Ears Connector. This approach is anticipated to be conservative as the vehicle trips generated by the industrial properties are expected to access those sites via local driveways along Golden Ears Connector.

Lastly, the proposed vehicle trip distribution was loosely compared with the forecast traffic volumes summarized in the technical memorandum prepared by Parsons Corporation in 2014 on the Golden Ears Connector and SFPR. Parsons Corporation prepared a regional traffic forecast as part of the Port Mann Highway 1 Improvement Project and the traffic patterns considered a number of regional transportation improvements, including the Golden Ears Connector; however, as discussed with the City at the start of this study, regional traffic forecast models were not deemed to be required for this study.

Figure 3-2: Assumed Abbey Ridge Growth Areas

Based on these considerations, the estimated 2016 traffic volumes in Abbey Ridge with the completion of Golden Ears Connector are shown in **Figure 3-3**. The site generated traffic volumes for the build-out of Abbey Ridge are shown in **Figure 3-4**.

Figure 3-3: 2016 Forecast Volumes with Golden Ears Connector Adjustment

Figure 3-4: Estimated Site Generated Traffic Volumes at Build-Out of Abbey Ridge

4 TRAFFIC ANALYSIS

4.1 Methodologies

The traffic operation analysis in this report is performed using the Synchro 8 software suite for unsignalized and signalized intersections, which is generally based on the Highway Capacity Manual (HCM) 2010 methodologies. For this study, the signal timing plans are optimized based on typical clearance intervals and minimum green time as per MOTI and ITE standards.

The traffic operations for the background condition and the 2031 horizon year scenarios are evaluated to estimate the volume-to-capacity (v/c) ratios, approach delays, level-of-services (LOS), and 95th percentile queue lengths at the study intersections. The 2031 horizon year was chosen for this study assuming that Abbey Ridge has reached build-out stage by then, and the timeline is also consistent with the regional traffic forecast performed for the Port Mann Highway 1 Improvement Project.

When reviewing the traffic analysis results, a v/c ratio at or above 1.0 typically indicates that traffic volumes exceed the intersection capacity. Delay, in terms of seconds, represents the wait time experienced by a driver on the approach to the intersection. LOS is a grading system on intersection operation based on the calculated delay as shown in **Table 4-1** for a signalized intersection and **Table 4-2** for an unsignalized intersection. LOS A means that the intersection experiences little to no delay whereas a LOS F indicates significant delay is present.

For the purpose of this report, the study threshold for the v/c ratio is 0.85. The target LOS for the overall intersection and individual turning movements is LOS D; therefore, the assumed approach delay thresholds are 55 s for a signalized intersection and 35 s for an unsignalized intersection.

Table 4-1: HCM LOS Criteria for Signalized Intersection

Level of Service	Average Control Delay (s/veh)
A	0 - 10
B	> 10 - 20
C	> 20 - 35
D	> 35 - 55
E	> 55 - 80
F	> 80

Table 4-2: HCM LOS Criteria for Unsignalized Intersection

Level of Service	Average Control Delay (s/veh)
A	0 - 10
B	> 10 - 15
C	> 15 - 25
D	> 25 - 35
E	> 35 - 50
F	> 50

4.2 Existing Traffic Operations

The existing traffic operations in Abbey Ridge is evaluated based on the balanced background traffic volumes shown in **Figure 2-3**. The traffic analysis is performed based on the existing intersection configurations and controls, and assuming that the Golden Ears Connector is not in place. For the purpose of this study, Golden Ears Way is considered to be running in the east-west direction at the Golden Ears Way and 96 Avenue Connector intersection, while the south approach is the 96 Avenue Connector.

4.2.1 AM Peak Hour

The SFPR and 104 Avenue intersection was found to be operating at LOS D. Its maximum v/c ratio was estimated to be 0.79 in the northbound through movement along SFPR; however, the existing 104 Avenue westbound left-turn movement is operating at LOS E with a v/c ratio of 0.49.

Following the Port Mann Highway 1 Improvement Project, the existing ramp terminal intersections on 176 Street/Highway 15 were found to be operating at LOS A. The westbound left-turn and eastbound left-turn movements at these two intersections were found to be operating at LOS C.

The existing 96 Avenue and 96 Avenue Connector intersection is operating at LOS A. Under the existing stop-control, the northbound left-turn movement was found to be operating at LOS E with a v/c ratio of 0.26. The northbound right-turn movement was found to be operating at LOS B. Further to the west, the existing Golden Ears Way and 96 Avenue Connector intersection is operating at LOS A. The remaining study intersections within Abbey Ridge were found to be operating within the target thresholds.

4.2.2 PM Peak Hour

The SFPR and 104 Avenue intersection is operating at LOS D with a number of turning movements operating above the study thresholds. The eastbound through/right-turn movement is currently operating at LOS E while the westbound left-turn movement was found to be operating at LOS F. In addition, the northbound left-turn and southbound left-turn movements are both operating at LOS E as well. The southbound through movement is operating at LOS F with a v/c ratio of 1.14.

The two existing Highway 1 ramp terminal intersections on 176 Street/Highway 15 were found to be operating at LOS A. The Highway 15 and 96 Avenue/Golden Ears Way intersection was found to be operating at LOS D with the westbound left, northbound left and southbound left-turning movements found to be operating at LOS E.

The existing 96 Avenue and 96 Avenue Connector intersection is operating at LOS A in the PM peak with all of its turning movements operating within the study thresholds. The existing Golden Ears Way and 96 Avenue Connector intersection is operating at LOS B. The remaining study intersections within Abbey Ridge were found to be operating within the target thresholds.

The existing traffic analysis results for the AM peak and PM peak scenarios are summarized in **Figure 4-1** and **Figure 4-2** respectively.

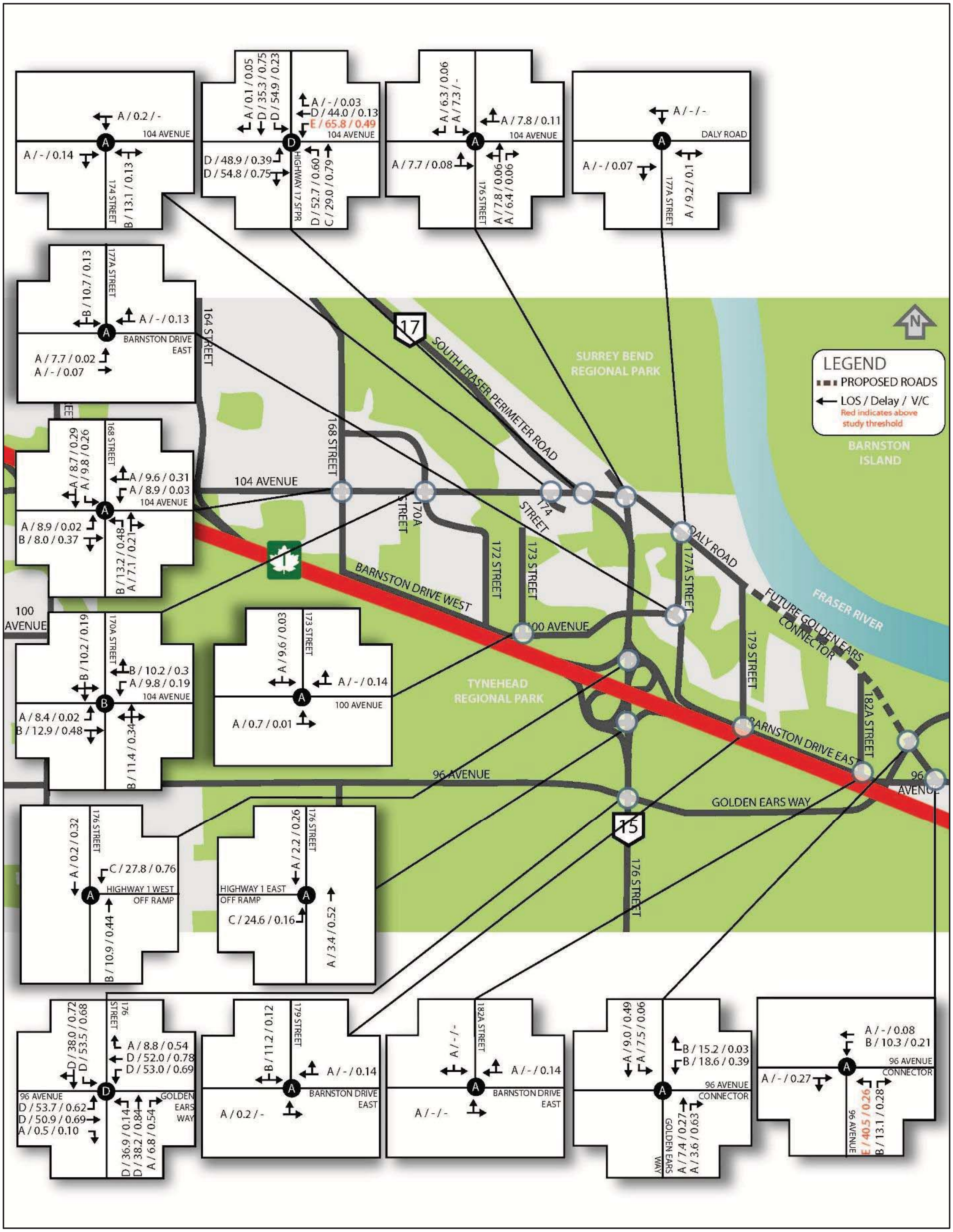

Figure 4-1: 2016 Existing AM Peak Traffic Operations

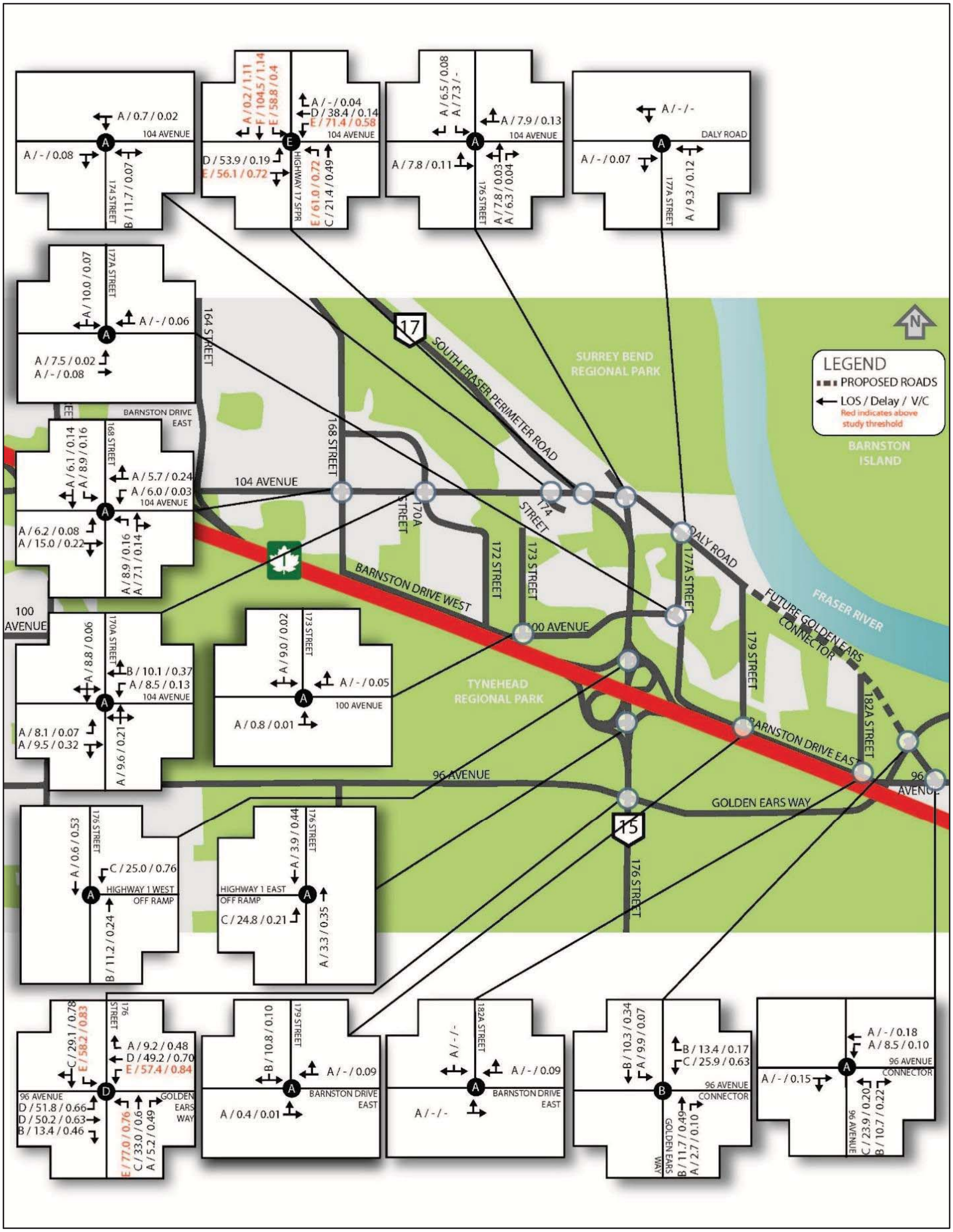

Figure 4-2: 2016 Existing PM Peak Traffic Operations

4.3 2031 Horizon Year Traffic Condition

For the local road network within Abbey Ridge, Binnie did not consider any background growth since the City has provided forecast population growth data for the build-out stage; therefore, the traffic growths in Abbey Ridge are generally expected to be incurred by the trip generation forecast based on our assumptions outlined in **Section 3.2**.

The future Golden Ears Connector is expected to be fully operational by the 2031 horizon year. In addition, the following intersections are expected to be signalized in the future based on the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge shown in **Figure 2-1** in this study:

- Highway 15 northbound off-ramp at 104 Avenue
- Barnston Drive East at 177A Street
- 96 Avenue at 96 Avenue Connector
- Golden Ears Connector at 177A Street
- Golder Ears Connector at 179 Street

It is noted that the Highway 15 northbound off-ramp intersection, 177A Street intersection and 179 Street intersection will be signalized as part of the Golden Ears Connector Project by TI Corp/MOTI. **Figure 4-3** shows the proposed laning configurations at these intersections.

The forecast 2031 horizon year combined traffic volumes are shown in Error! Reference source not found.**4**. They were derived by combining the 2016 adjusted background traffic volumes, as shown in **Figure 3-3**, with the forecast site generated traffic volumes shown in **Figure 3-4**.

The 2031 horizon year traffic volumes were compared with the forecast traffic volumes prepared by Associated Engineering Ltd. (AE) for the Golden Ears Connector Project. In a document titled *Golden Ears Connector (GEC) Traffic Engineering Analysis Report* dated March 2014, the projected 2031 AM and PM peak hour traffic volumes were shown in Appendix A, Drawing No: 20132409-00-SK121. Based on Binnie's review and the field observations conducted, the current westbound through traffic on Golden Ears Way making the westbound right-turn movement to access the SFPR via Highway 15 was not noted to be significant; and vice versa, the southbound left-turn movement traffic at the Highway 15 and 96 Avenue/Golden Ears Way intersection heading towards Golden Ears Way was not noted to be significant either. These observations were contrary to the forecast traffic pattern changes made in the AE's report, which were likely based on the regional traffic model. Based on the current assumptions made in this report, it is expected that a considerable proportion of background and site generated traffic volumes may continue to use Highway 1 to travel to their destinations via 176 Street/Highway 15.

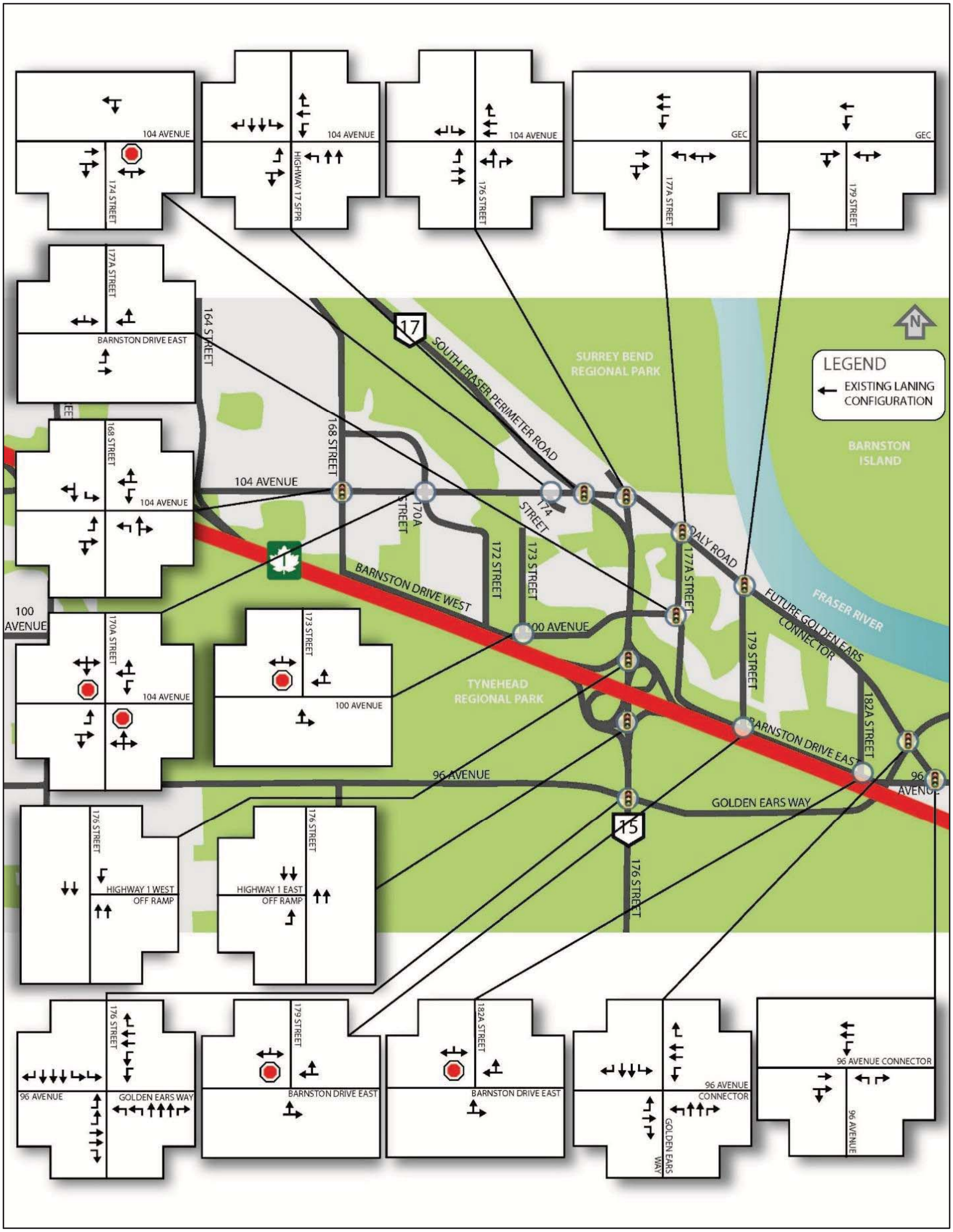

Figure 4-3: 2031 Horizon Year Laning Configurations

Figure 4-4: 2031 Horizon Year Combined Volumes

4.3.1 AM Peak Hour

The SFPR and 104 Avenue intersection is expected to operate at LOS F with the maximum v/c ratio of 1.28 for the eastbound movements. A number of other turning movements at this intersection are also expected to operate at LOS F.

The intersection at Highway 15 and 96 Avenue/Golden Ears Way is expected to operate at LOS D. Its eastbound left-turn, westbound left-turn and southbound left-turn movements are expected to operate at LOS E with v/c ratios less than 1.0; therefore, the delays are expected to be caused by these movement having protected-only phases to proceed through the intersection.

In general, the study intersections within Abbey Ridge are expected to operate within the study thresholds during the AM peak hour. The 104 Avenue and 168 Street intersection is expected to operate at LOS B. The 104 Avenue and 170A Street is anticipated to operate at LOS D; however, the northbound movement may deteriorate to LOS F with a v/c ratio of 1.04 due to the increase in egress traffic from Abbey Ridge. The 179 Street and 182A Street intersections on Barnston Drive East are expected to operate acceptably under the existing stop-control.

4.3.2 PM Peak Hour

The SFPR and 104 Avenue intersection is expected to operate at LOS F. A number of turning movement are expected to operate well above capacities as their v/c ratios well exceed 1.0. The poor eastbound movements and northbound left-turn movement may force the local Abbey Ridge traffic to seek alternate routes to travel through the neighbourhood.

The intersection at Highway 15 and 96 Avenue/Golden Ears Way is expected to operate at LOS D. A number of left-turn movements are expected to operate at LOS E but with v/c ratios less than 1.0. The southbound through movement is expected to operate at LOS C with a v/c ratio of 0.86.

Within Abbey Ridge, the study intersections are expected to operate within the study thresholds. The 104 Avenue and 168 Street intersection is expected to operate at LOS A. Its highest v/c ratio was estimated to be 0.61 for the eastbound shared through/right-turn movement. The 104 Avenue and 170A Street is anticipated to operate at LOS B; however, the northbound movement may deteriorate to LOS E with a v/c ratio of 0.78 due to the increase in egress traffic from Abbey Ridge. The 179 Street and 182A Street intersections on Barnston Drive East are expected to operate acceptably under the existing stop-control in the PM peak.

The 2031 horizon year traffic analysis results for the AM peak and PM peak scenarios are summarized in **Figure 4-5** and **Figure 4-6** respectively.

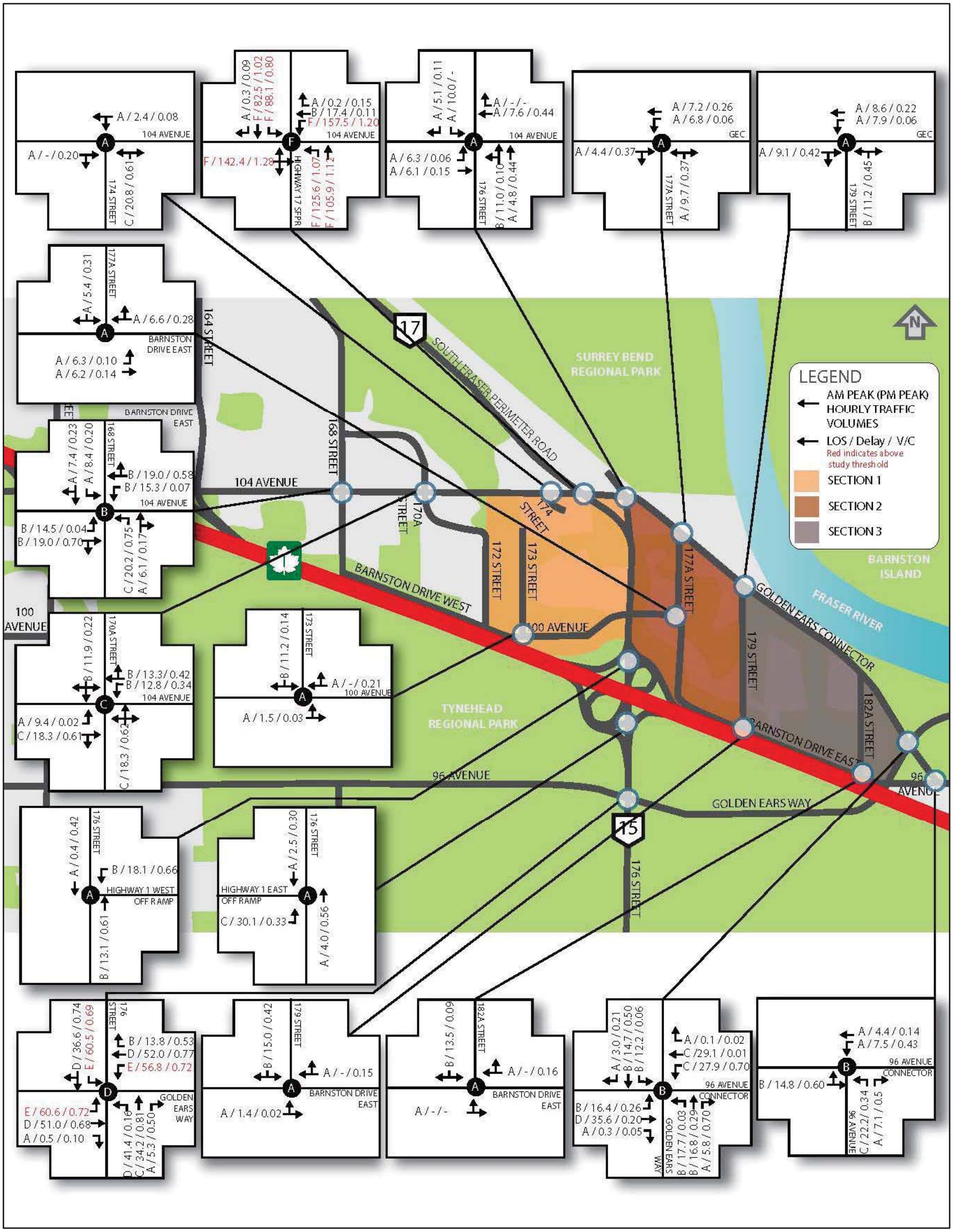

Figure 4-5: 2031 Horizon Year AM Peak Traffic Operations

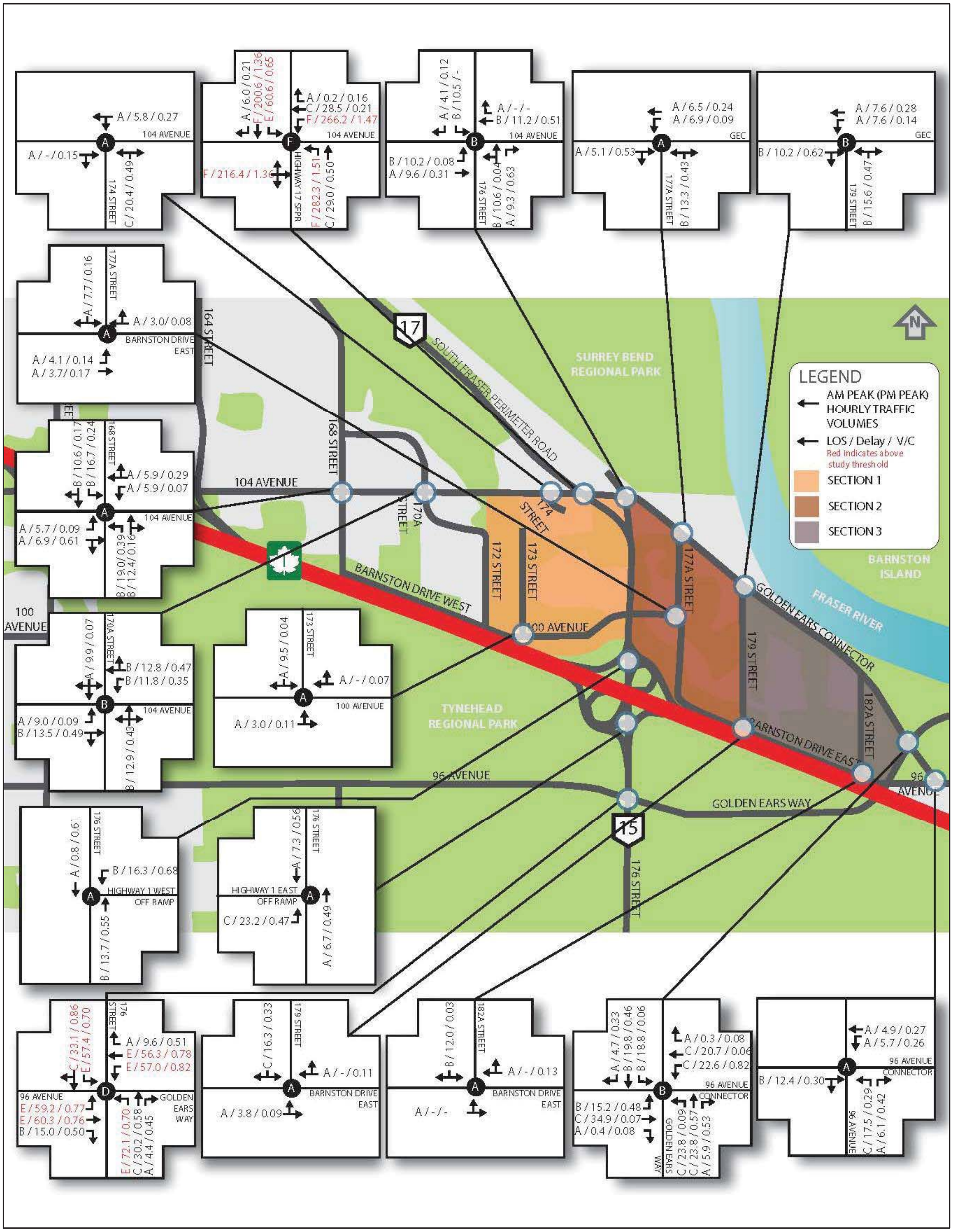

Figure 4-6: 2031 Horizon Year PM Peak Traffic Operations

4.4 2031 Horizon Year Traffic Condition – Sensitivity Analysis

The sensitivity traffic analysis was performed based on scenarios discussed with the City. Based on the forecast traffic analysis performed with the baseline assumptions, the SFPR and 104 Avenue intersection is anticipated to operate with considerable congestions; as a result, drivers may rely more on the municipal roadways to travel between Abbey Ridge and their destinations assuming that the SFPR and 104 Avenue junction remains as an at-grade signalized intersection. These assumptions are expected to place more traffic demands on 104 Avenue, Barnston Drive East and 96 Avenue; therefore, the traffic analysis results are considered to be conservative for planning the local road network improvements. **Figure 4-7** shows the redistributed volumes for this sensitivity analysis.

4.4.1 AM Peak Hour

Based on the reduced forecast traffic demands, the SFPR and 104 Avenue intersection is expected to operate at LOS E; a number of turning movements are expected to operate poorly still.

The intersection at Highway 15 and 96 Avenue/Golden Ears Way is expected to operate at LOS D. A number of left-turn movements are expected to operate at LOS E with v/c ratios less than 1.0.

The study intersections within Abbey Ridge are generally expected to operate within the study thresholds under the sensitivity analysis scenario. The 104 Avenue and 168 Street intersection is expected to operate at LOS B based on its existing laning configuration. The 104 Avenue and 170A Street is anticipated to operate at LOS F based on the existing stop-controls on 170A Street. In the eastern part of Abbey Ridge, the 179 Street and 182A Street intersections on Barnston Drive East are expected to operate acceptably under the existing stop-control.

4.4.2 PM Peak Hour

The SFPR and 104 Avenue intersection is still expected to operate at LOS F under the sensitivity analysis scenario. A number of turning movements are expected to operate poorly, particularly the left-turn movements.

The intersection at Highway 15 and 96 Avenue/Golden Ears Way is expected to operate at LOS D. A number of left-turn movements are expected to operate at LOS E but with v/c ratios less than the study threshold.

The Future Golden Ears Connector/96 Avenue and 96 Avenue Connector intersection is expected to operate at LOS C. Its northbound left-turn movement is expected to operate at LOS C but with a v/c ratio of 0.87. The 104 Avenue and 170A Street is anticipated to operate at LOS C based on the existing stop-controls on 170A Street, and the northbound movements are expected to operate at LOS F. In the eastern part of Abbey Ridge, the 179 Street and 182A Street intersections on Barnston Drive East are expected to operate acceptably under the existing stop-control.

The 2031 horizon year sensitivity analysis results for the AM peak and PM peak scenarios are summarized in **Figure 4-8** and **Figure 4-9** respectively.

Figure 4-7: 2031 Horizon Year Sensitivity Analysis Combined Volumes

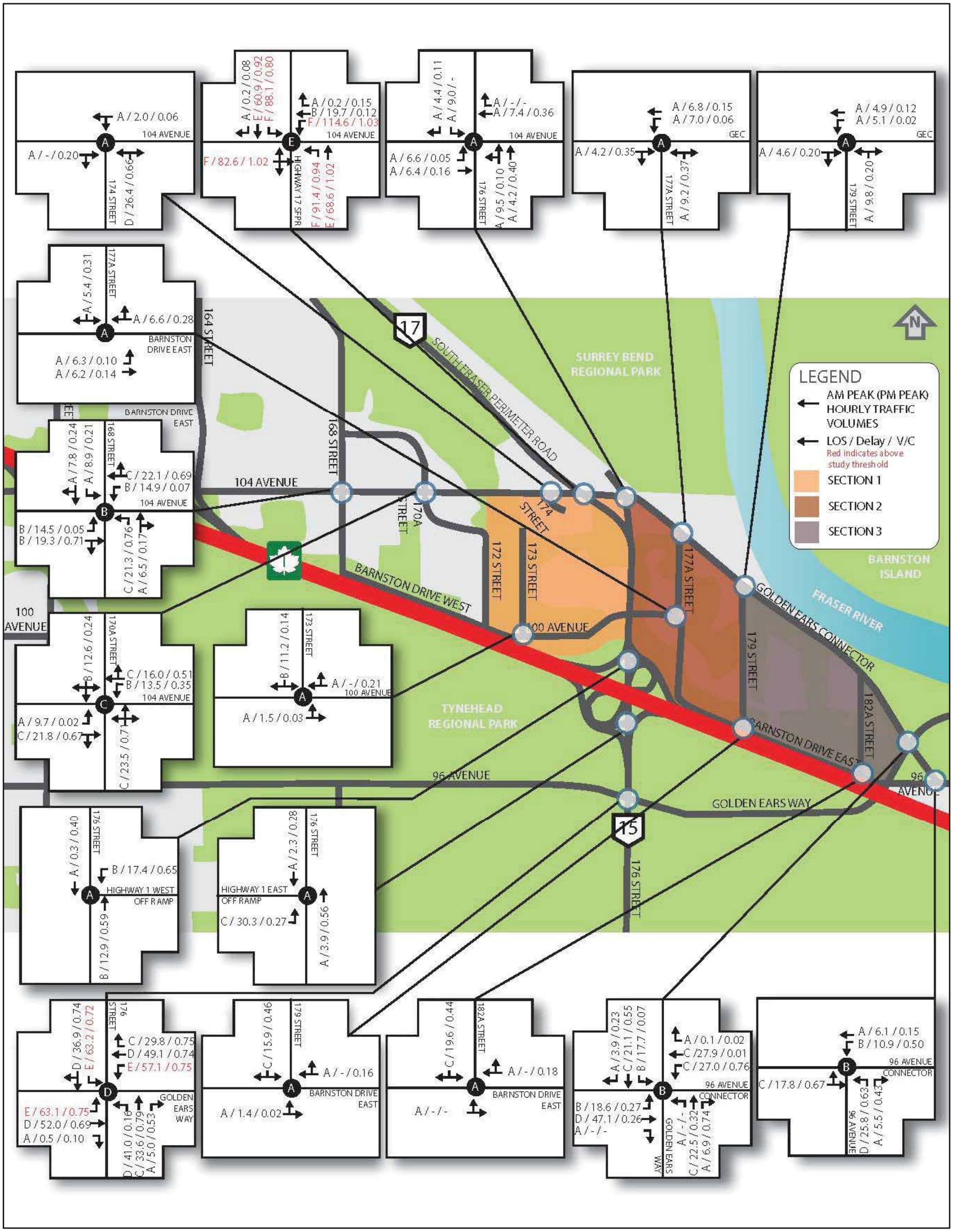

Figure 4-8: 2031 Horizon Year Sensitivity Analysis AM Peak Traffic Operations

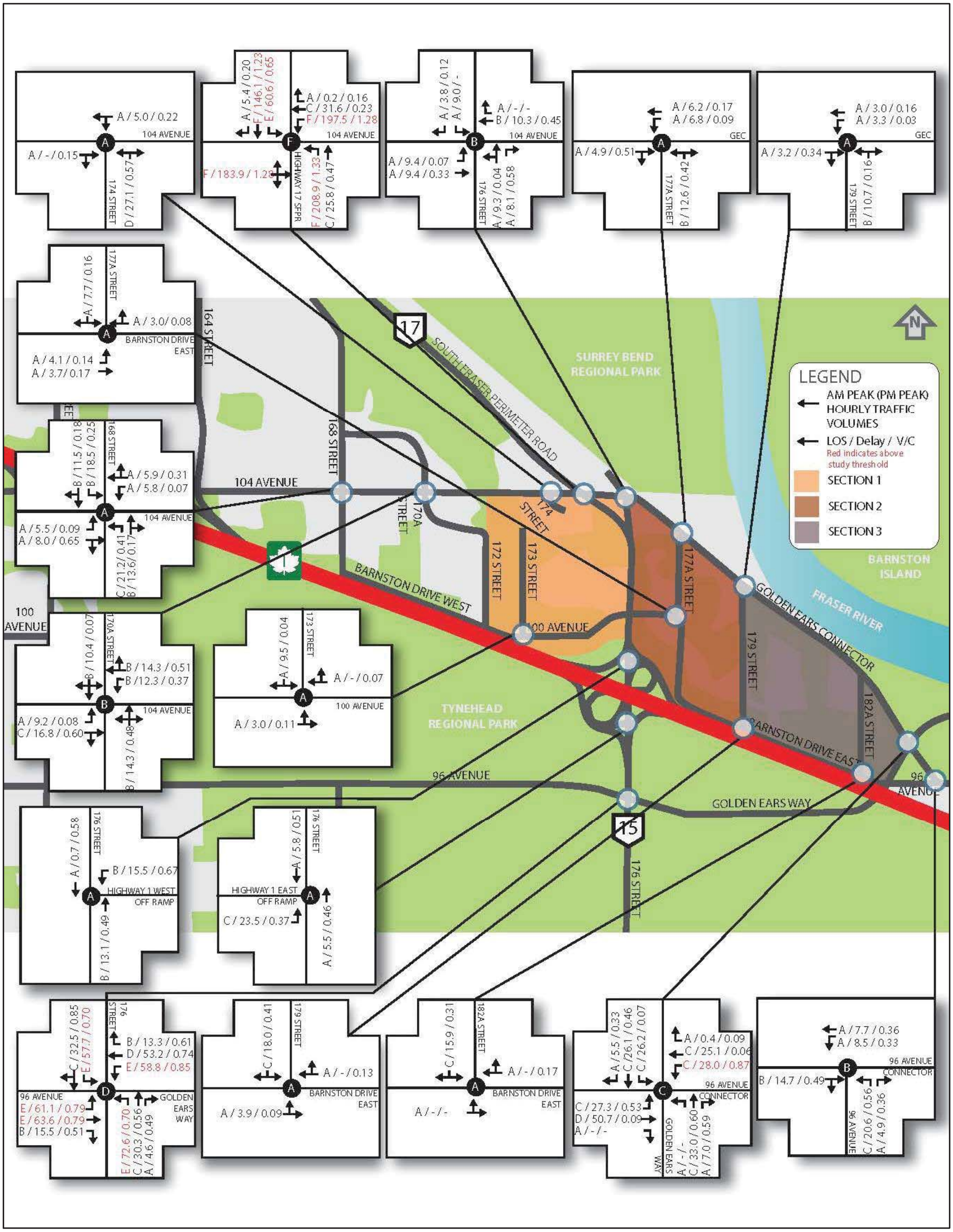

Figure 4-9: 2031 Horizon Year Sensitivity Analysis PM Peak Traffic Operations

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The purpose of this road network evaluation is to confirm the transportation servicing plan developed in the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge by the City, and recommend necessary transportation infrastructure updates required within Abbey Ridge and outside of the LAP area.

The forecast population growth in Abbey Ridge is expected to include 2,232 dwelling units consisting of new single-family homes, multi-family homes and secondary suites. Along Golden Ears Connector, new industrial properties are also expected to be developed to create job opportunities in Abbey Ridge. For the purpose of this study, Binnie divided the study area into three key growth areas to estimate the vehicle trip generation based on planning information provided by the City.

A summary of the study findings are as follows:

- Abbey Ridge is currently lacking transit services and during one of the public information meeting with the local residents and stakeholders, improvements in transit services were identified as a key requirements to support the forecast population growth within the study area.
- The future population in Abbey Ridge is expected to generate 1,696 vehicle trips onto the study road network during the AM peak hour, with 482 inbound trips and 1,214 outbound trips.
- The future population in Abbey Ridge is expected to generate 2,240 vehicle trips onto the study road network during the PM peak hour, with 1,358 inbound trips and 882 outbound trips.
- The existing SFPR and 104 Avenue intersection is already operating above the study thresholds and with poor safety records. It will require capacity improvements to support the growing local and regional traffic demands.
- The existing Highway 15 and 96 Avenue/Golden Ears Way intersection is already operating with several turning movements operating above study thresholds. Its traffic operations should be monitored in order to provide capacity improvements when required to support the growing local and regional traffic demands.
- Due to the high through traffic flows on the 96 Avenue Connector travelling to and from the adjacent Port Kells Industrial Area, the existing left-turn egress movement from 96 Avenue to 96 Avenue Connector was found to be operating at LOS E in the AM peak. This intersections is expected to be signalized based on the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge and once the improvement is provided, it is expected to operate acceptably in the 2031 horizon year.
- When the Golden Ears Connector is constructed, the existing Golden Ears Way and 96 Avenue Connector intersection will become a four-legged intersection. By the 2031 horizon year, capacity improvements may be required to accommodate the forecast northbound left-turn movement traffic volumes based on the sensitivity analysis results, which assumed that the SFPR and 104 Avenue junction would remain as an at-grade signalized intersection operating with considerable congestions.
- Due to the forecast increase in traffic demands on 104 Avenue, the existing two-way-stop-controlled (TWSC) intersection at 104 Avenue and 170A Street will need to be upgraded to an AWSC intersection.

- The existing signalized intersection at 104 Avenue and 168 Street is expected to operate acceptably in the 2031 horizon year without any capacity improvements.
- The proposed signalization of the five intersections listed in **Section 4.3** is expected to accommodate the forecast 2031 horizon year traffic volumes within the study operational thresholds.

5.2 Recommendations

The following recommendations were made based on the traffic operations analysis findings outlined in this study:

5.2.1 Transit Improvements

The City should liaise with TransLink to plan for the improvement of transit services in Abbey Ridge to reduce the dependencies on personal vehicles in the future.

5.2.2 Pedestrian and Cyclist Accommodations

The City should ensure that pedestrians and cyclists are well accommodated by the future road network in Abbey Ridge. As noted in **Section 5.2.4** below, it would be preferable to improve the pedestrian and cyclist accommodations along 104 Avenue to support the population growth in Section 1 of Abbey Ridge. Between Section 2 and Section 3 of Abbey Ridge, it would be preferable to provide a pedestrian sidewalk at least on the north side of Barnston Drive East, or a multi-use pathway to accommodate both pedestrians and cyclists. The proposed Golden Ears Connector is also expected to include a multi-use pathway; therefore, connections should be provided between the local road network and the Golden Ears Connector for pedestrians and cyclists.

5.2.3 Intersection Signalization

The following intersections should be signalized by the City and MOTI/TI Corp as per the Stage 1 Preferred Land Use Concept Plan for Abbey Ridge:

- Highway 15 northbound off-ramp at 104 Avenue
- Barnston Drive East at 177A Street
- 96 Avenue at 96 Avenue Connector
- Golden Ears Connector at 177A Street
- Golder Ears Connector at 179 Street

5.2.4 104 Avenue

The City should consider upgrading 104 Avenue with an urban two-lane arterial cross-section, complete with curb and gutters, sidewalks, bicycle lanes, and transit stops.

5.2.5 104 Avenue at 170A Street

The existing 104 Avenue and 170 Street intersection will need to be upgraded to an AWSC intersection.

5.2.6 SFPR and 104 Avenue Intersection

The City should liaise with the MOTI and TI Corp regarding the timing of the interchange improvement at this junction to replace the existing at-grade signalized intersection, which is currently operating above the desired thresholds and with safety issues.

5.2.7 Golden Ears Way and Golden Ears Connector/96 Avenue Connector Intersection

The City should liaise with TransLink to consider providing a second northbound left-turn lane for traffic turning from 96 Avenue Connector to Golden Ears Way. Secondly, the City should liaise with the MOTI and TI Corp to estimate the timing of the Highway 1 and 192 Street Interchange to provide improved access to the Port Kells Industrial Area, which may lessen the traffic demands on 96 Avenue.

5.2.8 Highway 15 and 96 Avenue/Golden Ears Way intersection

The City should liaise with TransLink, MOTI and TI Corp to continuously monitor the operational levels for the left-turn movements at this intersection and make adjustments to the signal timings as needed.

5.2.9 Accommodations for On-Street Parking for Secondary Suites

The City anticipates that there would be a number of secondary suites in Abbey Ridge when it reaches build-out stage. The proposed road network design and parking policy should be developed with that in mind such that on-street parking would not be an issue in the future that may hinder garbage collection and emergency response services.

6 CLOSING

We trust the City will find this road network evaluation adequate in showing the forecast traffic volumes in Abbey Ridge resulting from the anticipated population growth, and their potential impacts on the study road network. Should there be questions or comments on the information contained herein, please do not hesitate to contact the undersigned.

Prepared by:

DRAFT

Ava Li, EIT
Traffic Engineer

Reviewed by:

DRAFT

Jonathan Ho, P.Eng., PTOE
Traffic Services Division Manager

APPENDIX A

INTERSECTION TRAFFIC DATA

Vehicle Turning Movement Survey
With Classification

Major Route:	100th Avenue
Minor Route:	173rd Street
Municipality:	Surrey
Filename:	1-100th@173rd-May12,2016.xlsx
Location #:	1
Date:	May 12, 2016
Day-of-week:	Thursday
East/West Route:	100th Avenue
Intersection Type:	3-leg north approach
Signalized?:	No
Weather:	Clear and dry

Vehicle Classifications: Regular Vehicles, Heavy Trucks, Cyclists

This data is for All Vehicles Combined

Shift	Start	End	Duration
AM	7:00	9:00	2.00
MD			
PM	15:00	18:00	3.00
Total	**7:00**	**18:00**	**5.00**

Notes:
24-hour clock used for reporting (15-minute increments)
North Approach - southbound vehicles approaching intersection from the north
15x4 - 15 min volume (from maximum 15 minute period of movement/approach in peak hour period [*]) x 4
Pedestrians - N indicates pedestrians crossing north approach (east/west)

Comments:

Time	173rd								100th				100th										
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians			
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E
7:00	0		1	**1**					0	9		**9**		7	0	**7**	**17**			0		0	0
7:15	2		1	**3**					0	8		**8**		15	0	**15**	**26**			0		0	0
7:30	0		4	**4**					2	14		**16**		21	0	**21**	**41**			0		0	0
7:45	0		7	**7**					3	19		**22**		51	1	**52**	**81**	165	*	0		0	0
8:00	0		7	**7**					2	27		**29**		91	0	**91**	**127**	275	+	0		0	0
8:15	0		3	**3**					6	45		**51**		52	0	**52**	**106**	355	*	0		0	0
8:30	0		3	**3**					1	44		**45**		27	0	**27**	**75**	389	*	0		0	0
8:45	0		3	**3**					2	23		**25**		14	0	**14**	**42**	350		1		0	0
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total	2		29	**31**					16	189		**205**		278	1	**279**	**515**			1		0	0

n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
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n/a																							
n/a																							
n/a																							
n/a																							
Total																							

15:00	1		3	**4**					6	38		**44**		30	0	**30**	**78**		*	3		0	0
15:15	1		3	**4**					6	53		**59**		16	1	**17**	**80**		+	1		0	0
15:30	0		5	**5**					0	34		**34**		22	0	**22**	**61**		*	0		0	0
15:45	0		3	**3**					5	31		**36**		12	1	**13**	**52**	271	*	0		0	0
16:00	0		2	**2**					3	25		**28**		34	0	**34**	**64**	257		0		0	0
16:15	0		1	**1**					4	25		**29**		20	0	**20**	**50**	227		0		0	0
16:30	0		1	**1**					1	22		**23**		20	0	**20**	**44**	210		1		0	0
16:45	0		3	**3**					4	22		**26**		26	1	**27**	**56**	214		1		0	0
17:00	1		1	**2**					8	25		**33**		25	0	**25**	**60**	210		2		0	0
17:15	1		0	**1**					3	26		**29**		24	1	**25**	**55**	215		0		0	0
17:30	0		8	**8**					3	20		**23**		14	0	**14**	**45**	216		0		0	0
17:45	0		1	**1**					2	11		**13**		23	1	**24**	**38**	198		0		0	0
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total	4		31	**35**					45	332		**377**		266	5	**271**	**683**			8		0	0

Time	173rd								100th				100th												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
7:00	0		1	1					0	9		9		7	0	7	17			0		0	0	10	
7:15	2		1	3					0	8		8		15	0	15	26			0		0	0	17	
7:30	0		4	4					2	14		16		21	0	21	41			0		0	0	27	
7:45	0		7	7					3	19		22		51	1	52	81	165	*	0		0	0	62	116
8:00	0		7	7					2	27		29		91	0	91	127	275	+	0		0	0	100	206
8:15	0		3	3					6	45		51		52	0	52	106	355	*	0		0	0	61	250
8:30	0		3	3					1	44		45		27	0	27	75	389	*	0		0	0	47	270
8:45	0		3	3					2	23		25		14	0	14	42	350		1		0	0	26	234
n/a																									
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n/a																									
n/a																									
Total	2		29	**31**					16	189		**205**		278	1	**279**	515			1		0	0		324
Avg Hr	1		15	**16**					8	95		**103**		139	1	**140**	258			1		0	0		

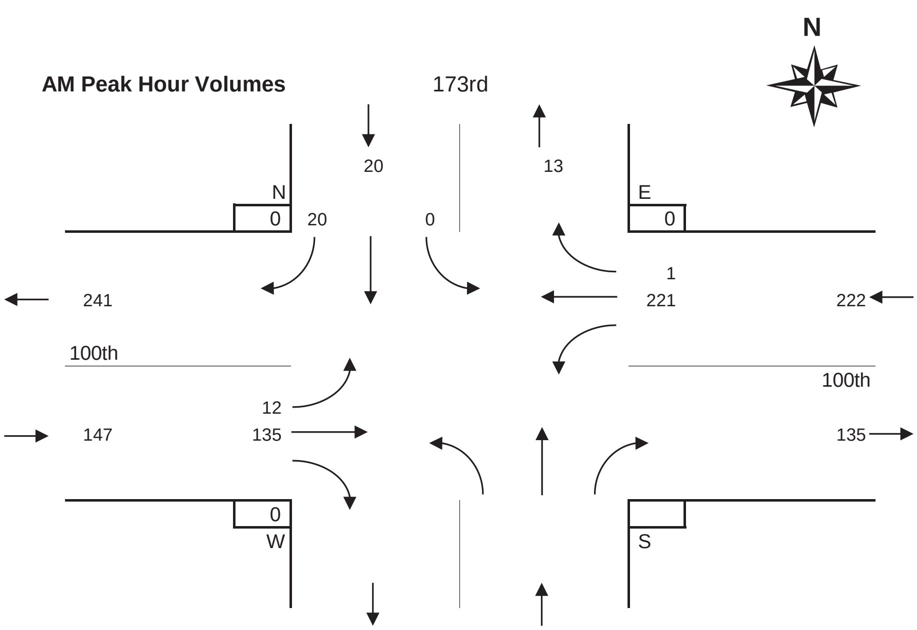
Peak hour of the intersection

Pk Hr	0		20	20					12	135		147		221	1	222	389	*		0		0	0		254
15x4	0		28	28					24	180		204		364	4	364	508	+		0		0	0		420
PHF	n/a		0.71	**0.71**					0.50	0.75		**0.72**		0.61	0.25	**0.61**	0.77			n/a		n/a	n/a		0.60

Peak hour of conflicting volumes for the intersection

Pk Hr	0		20	20					12	135		147		221	1	222	389	*		0		0	0		254
15x4	0		28	28					24	180		204		364	4	364	508	+		0		0	0		420
PHF	n/a		0.71	**0.71**					0.50	0.75		**0.72**		0.61	0.25	**0.61**	0.77			n/a		n/a	n/a		0.60

AM Peak Hour Volumes



MD Peak Period
All Vehicles Combined

100th Avenue @ 173rd Street
Thursday, May 12, 2016

Time	173rd								100th				100th												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
n/a																									
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n/a																									
n/a																									
Total																									
Avg Hr																									

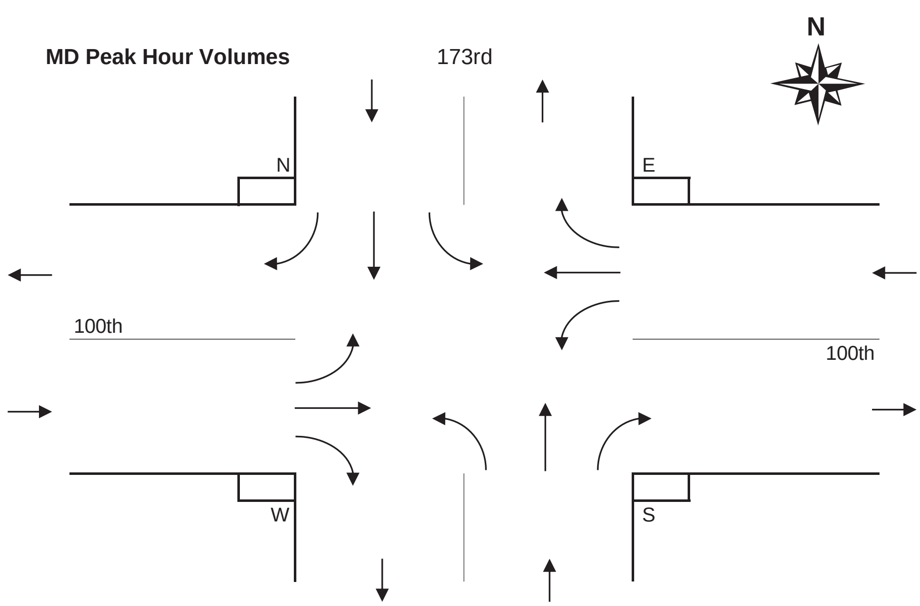
Peak hour of the intersection

Pk Hr																	*						
15x4																	+						
PHF																							

Peak hour of conflicting volumes for the intersection

Pk Hr																	*						
15x4																	+						
PHF																							

MD Peak Hour Volumes



PM Peak Period
All Vehicles Combined

100th Avenue @ 173rd Street
Thursday, May 12, 2016

Time	173rd								100th				100th												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
15:00	1		3	4					6	38		44		30	0	30	78		*	3		0	0	41	
15:15	1		3	4					6	53		59		16	1	17	80		+	1		0	0	56	
15:30	0		5	5					0	34		34		22	0	22	61		*	0		0	0	39	
15:45	0		3	3					5	31		36		12	1	13	52	271	*	0		0	0	34	170
16:00	0		2	2					3	25		28		34	0	34	64	257		0		0	0	39	168
16:15	0		1	1					4	25		29		20	0	20	50	227		0		0	0	26	138
16:30	0		1	1					1	22		23		20	0	20	44	210		1		0	0	23	122
16:45	0		3	3					4	22		26		26	1	27	56	214		1		0	0	34	122
17:00	1		1	2					8	25		33		25	0	25	60	210		2		0	0	34	117
17:15	1		0	1					3	26		29		24	1	25	55	215		0		0	0	29	120
17:30	0		8	8					3	20		23		14	0	14	45	216		0		0	0	28	125
17:45	0		1	1					2	11		13		23	1	24	38	198		0		0	0	27	118
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
Total	4		31	**35**					45	332		**377**		266	5	**271**	683			8		0	0		363
Avg Hr	1		10	**12**					15	111		**126**		89	2	**90**	228			3		0	0		

Peak hour of the intersection

	N Left	N Thru	N Right	N Total	S Left	S Thru	S Right	S Total	W Left	W Thru	W Right	W Total	E Left	E Thru	E Right	E Total	Total Volume		N	S	W	E	Conflict
Pk Hr	2		14	16					17	156		173		80	2	82	271	*	4		0	0	170
15x4	4		20	20					24	212		236		120	4	120	320	+	12		0	0	232
PHF	0.50		0.70	**0.80**					0.71	0.74		**0.73**		0.67	0.50	**0.68**	0.85		0.33		n/a	n/a	0.73

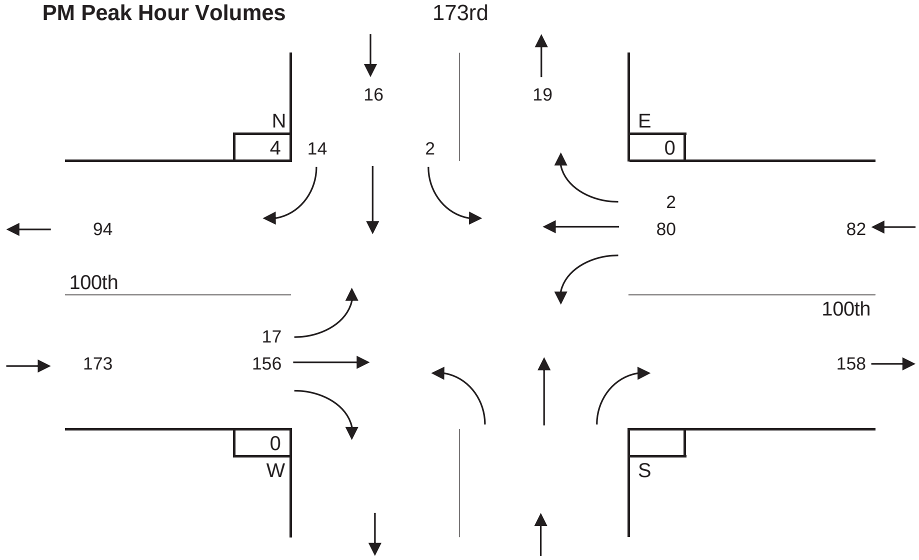
Peak hour of conflicting volumes for the intersection

	N Left	N Thru	N Right	N Total	S Left	S Thru	S Right	S Total	W Left	W Thru	W Right	W Total	E Left	E Thru	E Right	E Total	Total Volume		N	S	W	E	Conflict
Pk Hr	2		14	16					17	156		173		80	2	82	271	*	4		0	0	170
15x4	4		20	20					24	212		236		120	4	120	320	+	12		0	0	232
PHF	0.50		0.70	**0.80**					0.71	0.74		**0.73**		0.67	0.50	**0.68**	0.85		0.33		n/a	n/a	0.73

** Calculated peak hour occurs during the first or last hour of shift and therefore may be invalid. **

N

PM Peak Hour Volumes



Entire Survey Period

5 Hours

	173rd NORTH Approach				SOUTH Approach				100th WEST Approach				100th EAST Approach				Total Volume
	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total	6		60	**66**					61	521		**582**		544	6	**550**	1198
Avg Hr	1		12	**13**					12	104		**116**		109	1	**110**	240

Pedestrians			
N	S	W	E
9		0	0
2		0	0

AM Peak Period

2 Hours

	173rd NORTH Approach				SOUTH Approach				100th WEST Approach				100th EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Period	2		29	**31**					16	189		**205**		278	1	**279**	515
Avg Hr	1		15	**16**					8	95		**103**		139	1	**140**	258

Pedestrians			
N	S	W	E
1		0	0
1		0	0

MD Peak Period

Hours

	173rd NORTH Approach				SOUTH Approach				100th WEST Approach				100th EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total																	
Avg Hr																	

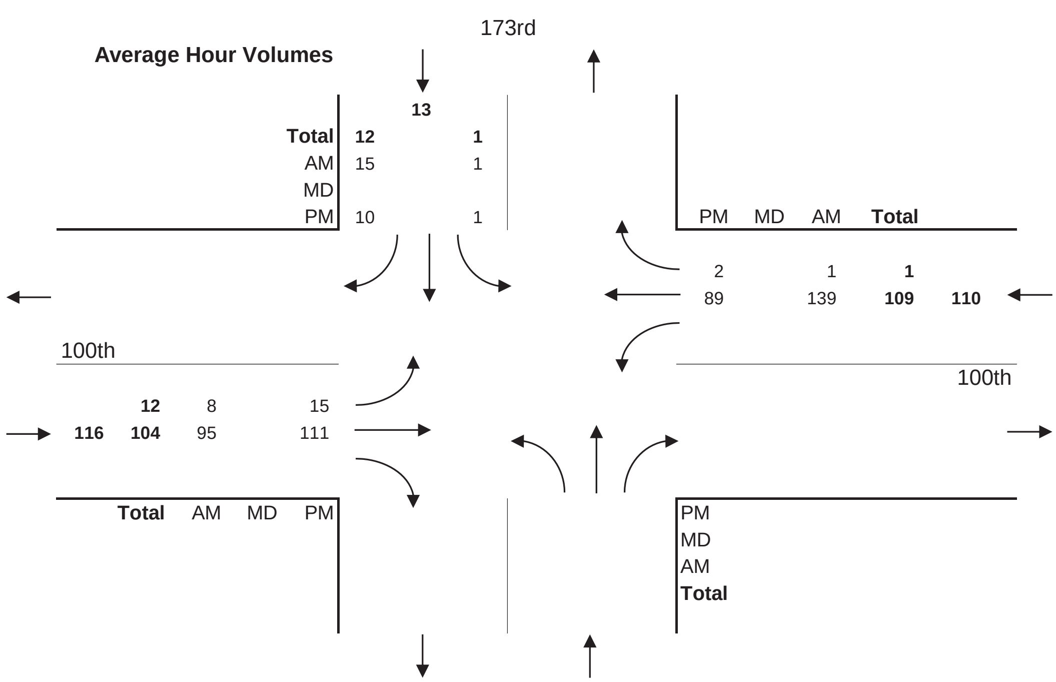
Pedestrians			
N	S	W	E

PM Peak Period

3 Hours

	173rd NORTH Approach				SOUTH Approach				100th WEST Approach				100th EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total	4		31	**35**					45	332		**377**		266	5	**271**	683
Avg Hr	1		10	**12**					15	111		**126**		89	2	**90**	228

Pedestrians			
N	S	W	E
8		0	0
3		0	0



Major Route:	104th Avenue
Minor Route:	174th Street
Municipality:	Surrey
Filename:	2-104th@174th-May12,2016.xlsx
Location #:	2
Date:	May 12, 2016
Day-of-week:	Thursday
East/West Route:	104th Avenue
Intersection Type:	3-leg south approach
Signalized?:	No
Weather:	Clear and dry

Vehicle Classifications: Regular Vehicles, Heavy Trucks, Cyclists

This data is for All Vehicles Combined

Shift	Start	End	Duration
AM	7:00	9:00	2.00
MD			
PM	15:00	18:00	3.00
Total	**7:00**	**18:00**	**5.00**

Notes: 24-hour clock used for reporting (15-minute increments)
North Approach - southbound vehicles approaching intersection from the north
15x4 - 15 min volume (from maximum 15 minute period of movement/approach in peak hour period [*]) x 4
Pedestrians - N indicates pedestrians crossing north approach (east/west)

Comments:

Time					174th				104th				104th										
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians			
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E
7:00					5		4	**9**		54	1	**55**	3	22		**25**	**89**				0	0	0
7:15					6		5	**11**		54	1	**55**	2	22		**24**	**90**				0	0	0
7:30					4		5	**9**		56	3	**59**	1	32		**33**	**101**				0	0	0
7:45					9		7	**16**		52	2	**54**	2	68		**70**	**140**	420	*		0	0	0
8:00					15		6	**21**		82	3	**85**	2	72		**74**	**180**	511	+		1	0	0
8:15					9		6	**15**		107	8	**115**	0	48		**48**	**178**	599	*		0	0	0
8:30					7		4	**11**		84	7	**91**	1	36		**37**	**139**	637	*		0	0	0
8:45					4		6	**10**		59	6	**65**	2	34		**36**	**111**	608			0	0	0
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total					59		43	**102**		548	31	**579**	13	334		**347**	**1028**				1	0	0

n/a																							
n/a																							
n/a																							
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n/a																							
n/a																							
n/a																							
n/a																							
Total																							

15:00					3		4	**7**		75	8	**83**	3	58		**61**	**151**				2	0	0
15:15					3		1	**4**		76	8	**84**	6	56		**62**	**150**				0	0	7
15:30					2		6	**8**		54	5	**59**	1	58		**59**	**126**				0	0	0
15:45					3		0	**3**		57	4	**61**	4	64		**68**	**132**	559			0	0	0
16:00					7		1	**8**		56	8	**64**	5	56		**61**	**133**	541			4	0	0
16:15					3		1	**4**		48	7	**55**	0	72		**72**	**131**	522			0	0	0
16:30					4		4	**8**		63	6	**69**	2	47		**49**	**126**	522			0	0	0
16:45					4		4	**8**		52	7	**59**	6	71		**77**	**144**	534			0	0	0
17:00					6		4	**10**		39	4	**43**	4	72		**76**	**129**	530	*		0	0	0
17:15					6		6	**12**		50	8	**58**	5	71		**76**	**146**	545	*		0	0	0
17:30					2		5	**7**		60	8	**68**	2	61		**63**	**138**	557	*		0	1	0
17:45					4		2	**6**		50	7	**57**	10	86		**96**	**159**	572	+		1	0	0
n/a																							
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n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total					47		38	**85**		680	80	**760**	48	772		**820**	**1665**				7	1	7

AM Peak Period
All Vehicles Combined

104th Avenue @ 174th Street
Thursday, May 12, 2016

Time					174th				104th				104th												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
7:00					5		4	9		54	1	55	3	22		25	89				0	0	0	63	
7:15					6		5	11		54	1	55	2	22		24	90				0	0	0	63	
7:30					4		5	9		56	3	59	1	32		33	101				0	0	0	65	
7:45					9		7	16		52	2	54	2	68		70	140	420	*		0	0	0	77	268
8:00					15		6	21		82	3	85	2	72		74	180	511	+		1	0	0	102	307
8:15					9		6	15		107	8	115	0	48		48	178	599	*		0	0	0	124	368
8:30					7		4	11		84	7	91	1	36		37	139	637	*		0	0	0	99	402
8:45					4		6	10		59	6	65	2	34		36	111	608			0	0	0	73	398
n/a																									
n/a																									
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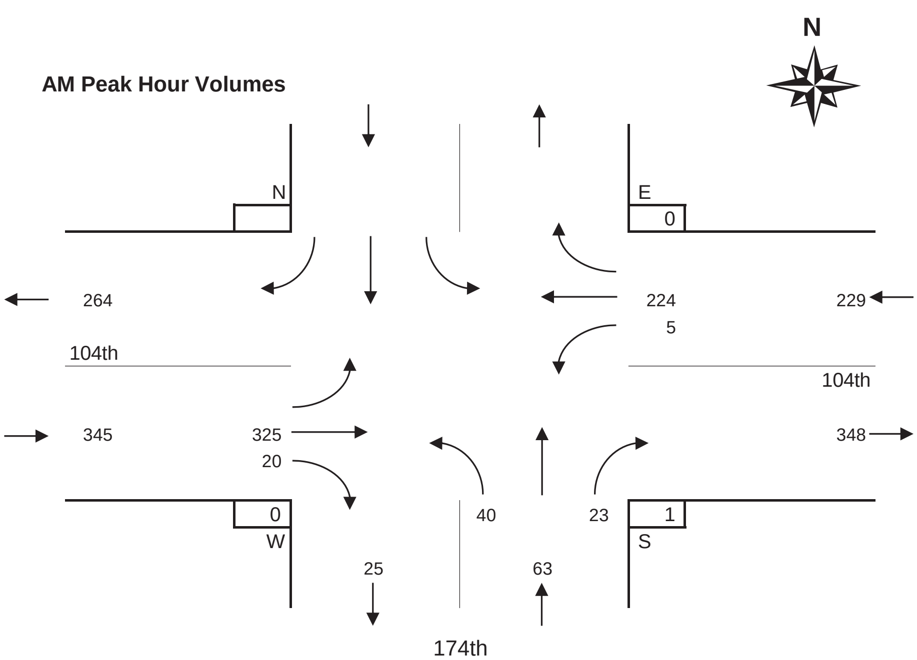
n/a																									
n/a																									
n/a																									
Total					59		43	**102**		548	31	**579**	13	334		**347**	1028				1	0	0		651
Avg Hr					30		22	**51**		274	16	**290**	7	167		**174**	514				1	0	0		

Peak hour of the intersection

Pk Hr					40		23	63		325	20	345	5	224		229	637		*		1	0	0		390
15x4					60		28	84		428	32	460	8	288		296	720		+		4	0	0		528
PHF					0.67		0.82	**0.75**		0.76	0.63	**0.75**	0.63	0.78		**0.77**	0.88				0.25	n/a	n/a		0.74

Peak hour of conflicting volumes for the intersection

Pk Hr					40		23	63		325	20	345	5	224		229	637		*		1	0	0		390
15x4					60		28	84		428	32	460	8	288		296	720		+		4	0	0		528
PHF					0.67		0.82	**0.75**		0.76	0.63	**0.75**	0.63	0.78		**0.77**	0.88				0.25	n/a	n/a		0.74



Time					174th				104th				104th												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
n/a																									
n/a																									
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n/a																									
n/a																									

Total																					
Avg Hr																					

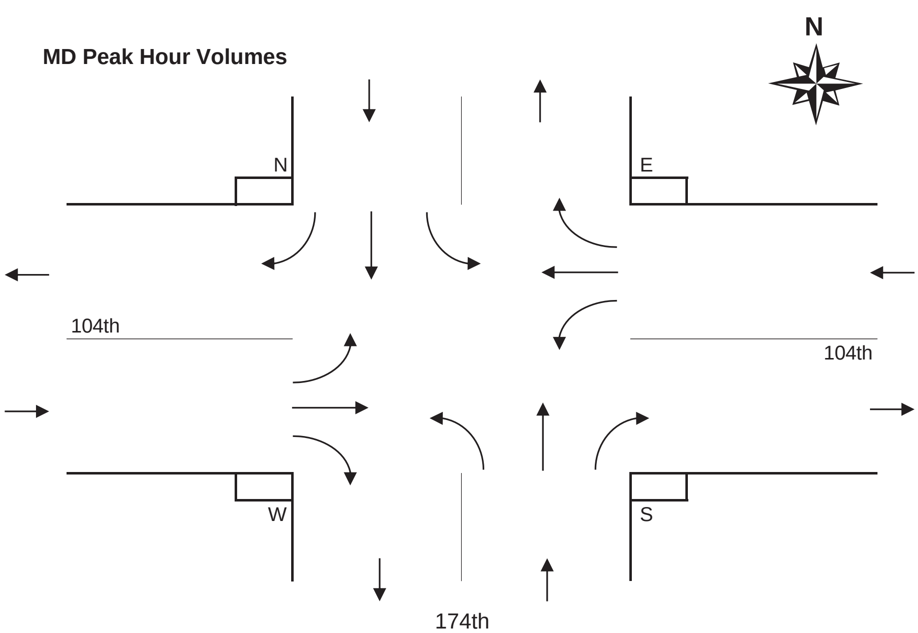
Peak hour of the intersection

Pk Hr																	*					
15x4																	+					
PHF																						

Peak hour of conflicting volumes for the intersection

Pk Hr																	*					
15x4																	+					
PHF																						

MD Peak Hour Volumes



PM Peak Period
All Vehicles Combined

104th Avenue @ 174th Street
Thursday, May 12, 2016

Time					174th				104th				104th												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
15:00					3		4	7		75	8	83	3	58		61	151				2	0	0	90	
15:15					3		1	4		76	8	84	6	56		62	150				0	0	7	93	
15:30					2		6	8		54	5	59	1	58		59	126				0	0	0	66	
15:45					3		0	3		57	4	61	4	64		68	132	559			0	0	0	68	317
16:00					7		1	8		56	8	64	5	56		61	133	541			4	0	0	76	303
16:15					3		1	4		48	7	55	0	72		72	131	522			0	0	0	75	285
16:30					4		4	8		63	6	69	2	47		49	126	522			0	0	0	75	294
16:45					4		4	8		52	7	59	6	71		77	144	534			0	0	0	75	301
17:00					6		4	10		39	4	43	4	72		76	129	530	*		0	0	0	78	303
17:15					6		6	12		50	8	58	5	71		76	146	545	*		0	0	0	77	305
17:30					2		5	7		60	8	68	2	61		63	138	557	*		0	1	0	75	305
17:45					4		2	6		50	7	57	10	86		96	159	572	+		1	0	0	90	320
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									

Total					47		38	**85**		680	80	**760**	48	772		**820**	1665				7	1	7		855
Avg Hr					16		13	**28**		227	27	**253**	16	257		**273**	555				2	0	2		

Peak hour of the intersection

Pk Hr					18		17	35		199	27	226	21	290		311	572	*			1	1	0		308
15x4					24		24	48		240	32	272	40	344		384	636	+			4	4	0		368
PHF					0.75		0.71	**0.73**		0.83	0.84	**0.83**	0.53	0.84		**0.81**	0.90				0.25	0.25	n/a		0.84

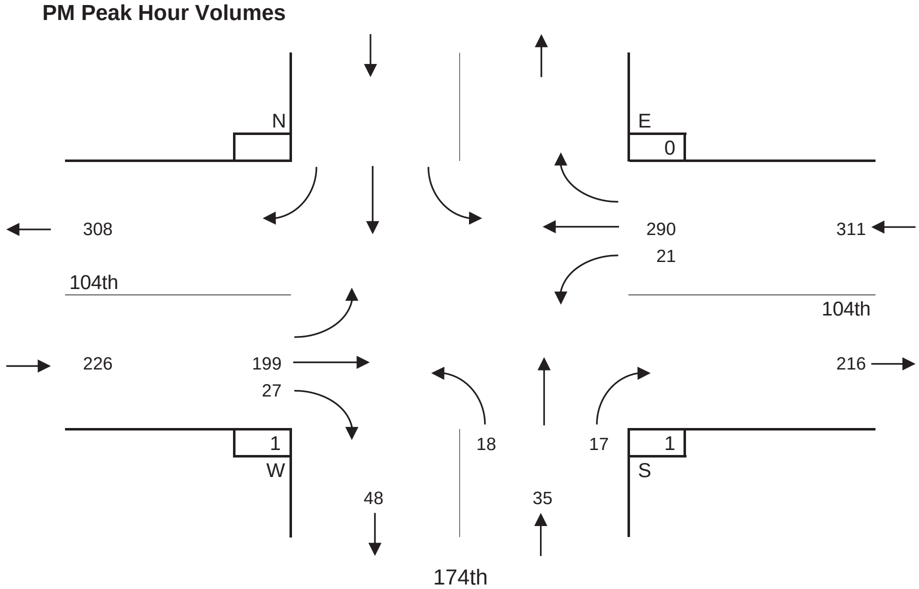
Peak hour of conflicting volumes for the intersection

Pk Hr					18		17	35		199	27	226	21	290		311	572	*			1	1	0		308
15x4					24		24	48		240	32	272	40	344		384	636	+			4	4	0		368
PHF					0.75		0.71	**0.73**		0.83	0.84	**0.83**	0.53	0.84		**0.81**	0.90				0.25	0.25	n/a		0.84

** Calculated peak hour occurs during the first or last hour of shift and therefore may be invalid. **

N

PM Peak Hour Volumes



Entire Survey Period

5 Hours

					174th				104th				104th				
	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total
	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Volume
Total					106		81	**187**		1228	111	**1339**	61	1106		**1167**	2693
Avg Hr					21		16	**37**		246	22	**268**	12	221		**233**	539

Pedestrians			
N	S	W	E
	8	1	7
	2	0	1

AM Peak Period

2 Hours

					174th				104th				104th				
	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Volume
Period					59		43	**102**		548	31	**579**	13	334		**347**	1028
Avg Hr					30		22	**51**		274	16	**290**	7	167		**174**	514

Pedestrians			
N	S	W	E
	1	0	0
	1	0	0

MD Peak Period

Hours

					174th				104th				104th				
	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Volume
Total																	
Avg Hr																	

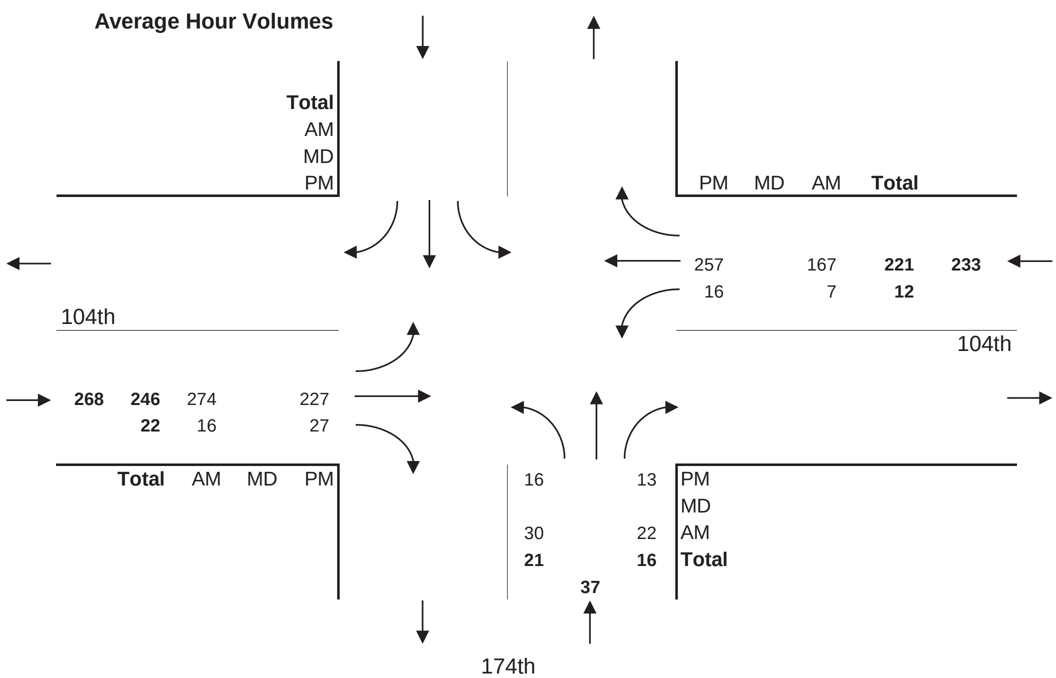
Pedestrians			
N	S	W	E

PM Peak Period

3 Hours

					174th				104th				104th				
	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Volume
Total					47		38	**85**		680	80	**760**	48	772		**820**	1665
Avg Hr					16		13	**28**		227	27	**253**	16	257		**273**	555

Pedestrians			
N	S	W	E
	7	1	7
	2	0	2



Vehicle Turning Movement Survey
With Classification

Major Route: Barnston Drive
Minor Route: 179th Street
Municipality: Surrey
Filename: 3-Barnston@179th-May12,2016.xlsx
Location #: 3

Date: May 12, 2016
Day-of-week: Thursday

East/West Route: Barnston Drive
Intersection Type: 3-leg north approach
Signalized?: No
Weather: Clear and dry

Vehicle Classifications: Regular Vehicles
Heavy Trucks
Cyclists

This data is for All Vehicles Combined

Shift	Start	End	Duration
AM	7:00	9:00	2.00
MD			
PM	15:00	18:00	3.00
Total	**7:00**	**18:00**	**5.00**

Notes: 24-hour clock used for reporting (15-minute increments)
North Approach - southbound vehicles approaching intersection from the north
15x4 - 15 min volume (from maximum 15 minute period of movement/approach in peak hour period [*]) x 4
Pedestrians - N indicates pedestrians crossing north approach (east/west)

Comments:

Time	179th								Barnston				Barnston										
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians			
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E
7:00	6		1	**7**					1	18		**19**		13	6	**19**	**45**			0		0	0
7:15	6		2	**8**					1	14		**15**		14	9	**23**	**46**			0		0	0
7:30	16		0	**16**					0	23		**23**		22	13	**35**	**74**		*	0		0	1
7:45	14		3	**17**					0	34		**34**		35	5	**40**	**91**	256	*	0		0	0
8:00	12		7	**19**					2	27		**29**		53	7	**60**	**108**	319	+	0		0	0
8:15	14		2	**16**					2	46		**48**		20	9	**29**	**93**	366	*	0		0	0
8:30	14		1	**15**					1	25		**26**		18	9	**27**	**68**	360		0		0	0
8:45	11		1	**12**					1	22		**23**		14	5	**19**	**54**	323		0		0	0
n/a																							
n/a																							
n/a																							
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n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total	93		17	**110**					8	209		**217**		189	63	**252**	**579**			0		0	1

n/a																							
n/a																							
n/a																							
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n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total																							

15:00	9		3	**12**					3	31		**34**		25	8	**33**	**79**			0		0	0
15:15	6		1	**7**					2	47		**49**		24	9	**33**	**89**		*	1		0	0
15:30	21		1	**22**					1	29		**30**		35	14	**49**	**101**		+	0		0	0
15:45	19		0	**19**					2	29		**31**		25	9	**34**	**84**	353	*	0		0	0
16:00	12		3	**15**					2	27		**29**		29	11	**40**	**84**	358	*	0		0	0
16:15	11		3	**14**					0	25		**25**		21	7	**28**	**67**	336		0		0	0
16:30	16		2	**18**					3	25		**28**		31	5	**36**	**82**	317		0		0	0
16:45	16		1	**17**					1	28		**29**		18	10	**28**	**74**	307		0		0	0
17:00	13		2	**15**					2	29		**31**		30	12	**42**	**88**	311		0		0	0
17:15	15		1	**16**					3	25		**28**		34	10	**44**	**88**	332		0		0	0
17:30	8		1	**9**					2	24		**26**		13	9	**22**	**57**	307		0		0	0
17:45	11		0	**11**					0	11		**11**		22	10	**32**	**54**	287		0		0	0
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total	157		18	**175**					21	330		**351**		307	114	**421**	**947**			1		0	0

AM Peak Period
All Vehicles Combined

Barnston Drive @ 179th Street
Thursday, May 12, 2016

Time	179th								Barnston				Barnston												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
7:00	6		1	7					1	18		19		13	6	19	45			0		0	0	26	
7:15	6		2	8					1	14		15		14	9	23	46			0		0	0	30	
7:30	16		0	16					0	23		23		22	13	35	74		*	0		0	1	51	
7:45	14		3	17					0	34		34		35	5	40	91	256	*	0		0	0	54	161
8:00	12		7	19					2	27		29		53	7	60	108	319	+	0		0	0	74	209
8:15	14		2	16					2	46		48		20	9	29	93	366	*	0		0	0	60	239
8:30	14		1	15					1	25		26		18	9	27	68	360		0		0	0	42	230
8:45	11		1	12					1	22		23		14	5	19	54	323		0		0	0	33	209
n/a																									
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n/a																									
n/a																									
Total	93		17	**110**					8	209		**217**		189	63	**252**	579			0		0	1		353
Avg Hr	47		9	**55**					4	105		**109**		95	32	**126**	290			0		0	1		

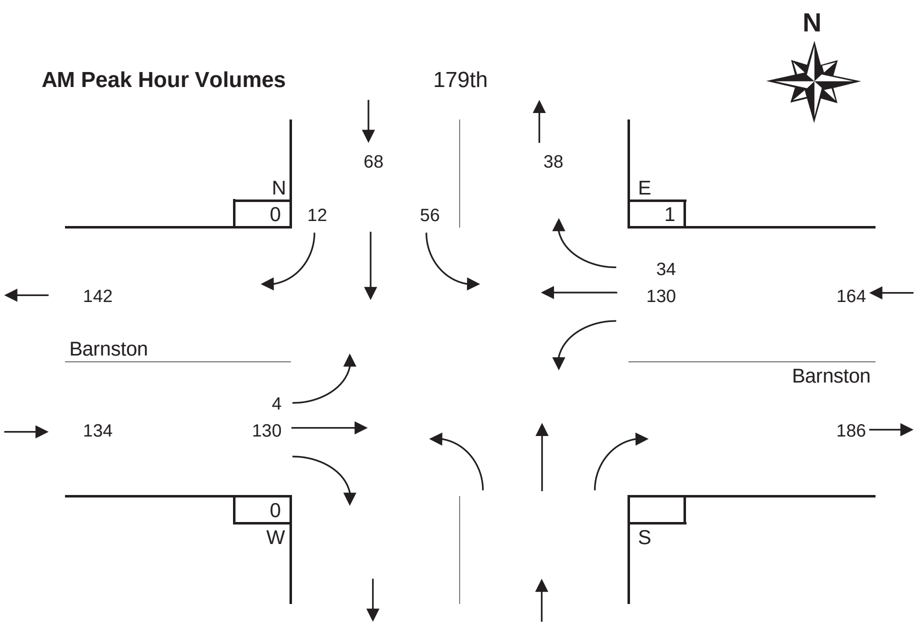
Peak hour of the intersection

	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour	N	S	W	E	Hr
Pk Hr	56		12	68					4	130		134		130	34	164	366	*	0		0	1	224
15x4	64		28	76					8	184		192		212	52	240	432	+	0		0	4	336
PHF	0.88		0.43	**0.89**					0.50	0.71		**0.70**		0.61	0.65	**0.68**	0.85		n/a		n/a	0.25	0.67

Peak hour of conflicting volumes for the intersection

	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour	N	S	W	E	Hr
Pk Hr	56		12	68					4	130		134		130	34	164	366	*	0		0	1	224
15x4	64		28	76					8	184		192		212	52	240	432	+	0		0	4	336
PHF	0.88		0.43	**0.89**					0.50	0.71		**0.70**		0.61	0.65	**0.68**	0.85		n/a		n/a	0.25	0.67

AM Peak Hour Volumes



Time	179th								Barnston				Barnston												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
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n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									

Total																						
Avg Hr																						

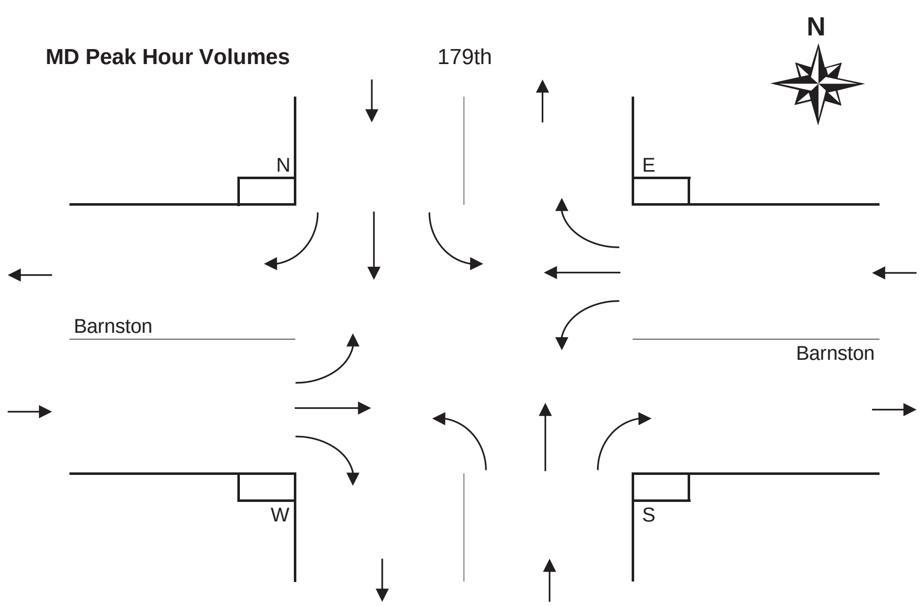
Peak hour of the intersection

Pk Hr																		*					
15x4																		+					
PHF																							

Peak hour of conflicting volumes for the intersection

Pk Hr																		*					
15x4																		+					
PHF																							

MD Peak Hour Volumes



Time	179th								Barnston				Barnston												
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
15:00	9		3	12					3	31		34		25	8	33	79			0		0	0	45	
15:15	6		1	7					2	47		49		24	9	33	89		*	1		0	0	53	
15:30	21		1	22					1	29		30		35	14	49	101		+	0		0	0	71	
15:45	19		0	19					2	29		31		25	9	34	84	353	*	0		0	0	55	224
16:00	12		3	15					2	27		29		29	11	40	84	358	*	0		0	0	54	233
16:15	11		3	14					0	25		25		21	7	28	67	336		0		0	0	39	219
16:30	16		2	18					3	25		28		31	5	36	82	317		0		0	0	55	203
16:45	16		1	17					1	28		29		18	10	28	74	307		0		0	0	45	193
17:00	13		2	15					2	29		31		30	12	42	88	311		0		0	0	57	196
17:15	15		1	16					3	25		28		34	10	44	88	332		0		0	0	62	219
17:30	8		1	9					2	24		26		13	9	22	57	307		0		0	0	32	196
17:45	11		0	11					0	11		11		22	10	32	54	287		0		0	0	43	194
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
Total	157		18	**175**					21	330		**351**		307	114	**421**	947			1		0	0		599
Avg Hr	52		6	**58**					7	110		**117**		102	38	**140**	316			0		0	0		

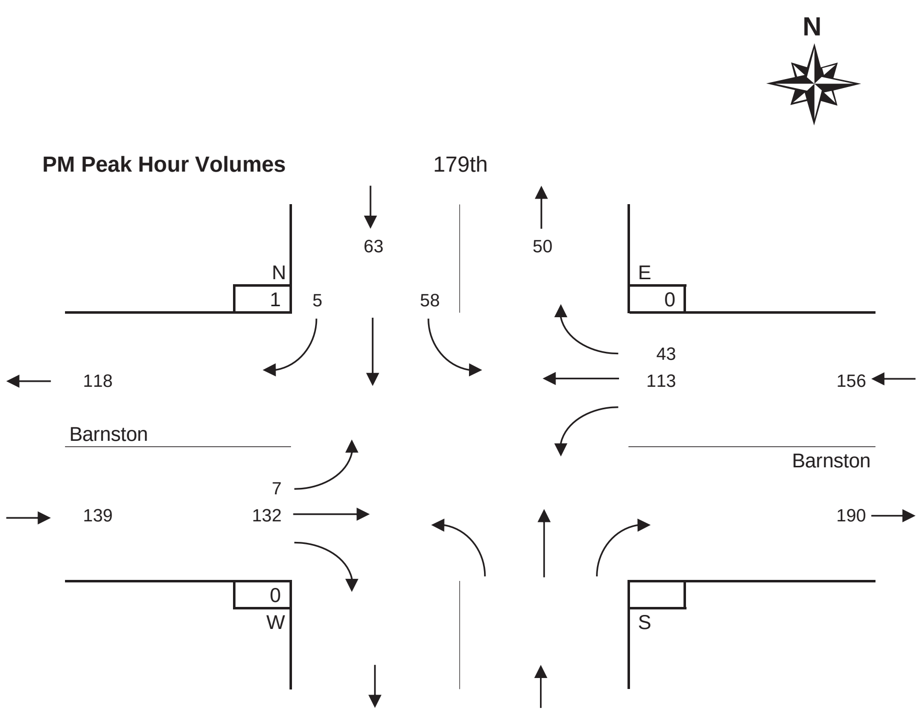
Peak hour of the intersection

Pk Hr	58		5	63					7	132		139		113	43	156	358	*	1		0	0		221
15x4	84		12	88					8	188		196		140	56	196	404	+	4		0	0		288
PHF	0.69		0.42	**0.72**					0.88	0.70		**0.71**		0.81	0.77	**0.80**	0.89		0.25		n/a	n/a		0.77

Peak hour of conflicting volumes for the intersection

Pk Hr	58		5	63					7	132		139		113	43	156	358	*	1		0	0		221
15x4	84		12	88					8	188		196		140	56	196	404	+	4		0	0		288
PHF	0.69		0.42	**0.72**					0.88	0.70		**0.71**		0.81	0.77	**0.80**	0.89		0.25		n/a	n/a		0.77

PM Peak Hour Volumes



Entire Survey Period

5 Hours

	179th NORTH Approach				SOUTH Approach				Barnston WEST Approach				Barnston EAST Approach				Total Volume
	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total	250		35	**285**					29	539		**568**		496	177	**673**	1526
Avg Hr	50		7	**57**					6	108		**114**		99	35	**135**	305

Pedestrians			
N	S	W	E
1		0	1
0		0	0

AM Peak Period

2 Hours

	179th NORTH Approach				SOUTH Approach				Barnston WEST Approach				Barnston EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Period	93		17	**110**					8	209		**217**		189	63	**252**	579
Avg Hr	47		9	**55**					4	105		**109**		95	32	**126**	290

Pedestrians			
N	S	W	E
0		0	1
0		0	1

MD Peak Period

Hours

	179th NORTH Approach				SOUTH Approach				Barnston WEST Approach				Barnston EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total																	
Avg Hr																	

Pedestrians			
N	S	W	E

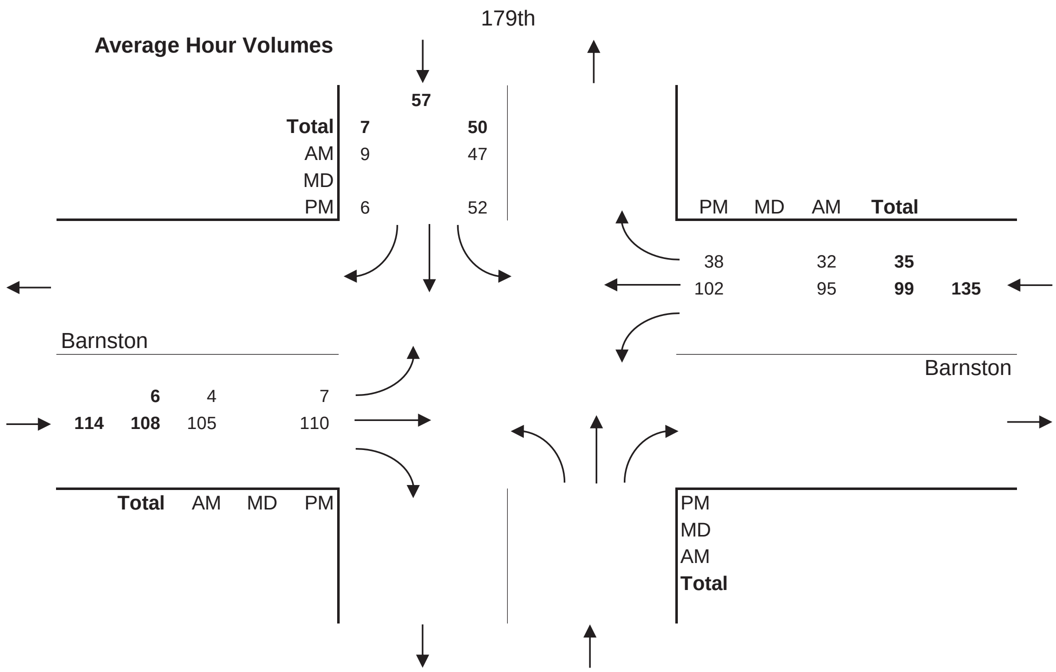
PM Peak Period

3 Hours

	179th NORTH Approach				SOUTH Approach				Barnston WEST Approach				Barnston EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total	157		18	**175**					21	330		**351**		307	114	**421**	947
Avg Hr	52		6	**58**					7	110		**117**		102	38	**140**	316

Pedestrians			
N	S	W	E
1		0	0
0		0	0

Average Hour Volumes



Vehicle Turning Movement Survey
With Classification

Major Route:	96th Connector
Minor Route:	96th Avenue
Municipality:	Surrey
Filename:	4-96thConnector@96th-May12,2016.xlsx
Location #:	4
Date:	May 12, 2016
Day-of-week:	Thursday
East/West Route:	96th Avenue
Intersection Type:	3-leg west approach
Signalized?:	No
Weather:	Clear and dry

Vehicle Classifications: Regular Vehicles
Heavy Trucks
Cyclists

This data is for All Vehicles Combined

Shift	Start	End	Duration
AM	7:00	9:00	2.00
MD			
PM	15:00	18:00	3.00
Total	**7:00**	**18:00**	**5.00**

Notes: 24-hour clock used for reporting (15-minute increments)
North Approach - southbound vehicles approaching intersection from the north
15x4 - 15 min volume (from maximum 15 minute period of movement/approach in peak hour period [*]) x 4
Pedestrians - N indicates pedestrians crossing north approach (east/west)

Comments:

Time	96th Connector				96th Connector				96th														
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians			
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E
7:00		94	7	**101**	21	49		**70**	3		15	**18**					**189**			0	0	0	
7:15		143	8	**151**	23	59		**82**	2		25	**27**					**260**		*	0	0	0	
7:30		151	9	**160**	30	64		**94**	6		28	**34**					**288**		*	0	0	0	
7:45		209	15	**224**	32	74		**106**	11		43	**54**					**384**	1121	+	0	0	0	
8:00		133	16	**149**	55	63		**118**	8		36	**44**					**311**	1243	*	0	0	0	
8:15		96	7	**103**	21	68		**89**	14		49	**63**					**255**	1238		0	0	0	
8:30		88	8	**96**	21	63		**84**	4		36	**40**					**220**	1170		0	0	0	
8:45		85	4	**89**	17	45		**62**	13		27	**40**					**191**	977		0	0	0	
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total		999	74	**1073**	220	485		**705**	61		259	**320**					**2098**			0	0	0	

n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total																							

15:00		74	6	**80**	28	182		**210**	12		27	**39**					**329**		*	0	0	0	
15:15		101	10	**111**	31	93		**124**	11		48	**59**					**294**		*	0	0	0	
15:30		89	9	**98**	48	164		**212**	12		57	**69**					**379**		+	0	0	0	
15:45		79	6	**85**	27	123		**150**	12		47	**59**					**294**	1296	*	0	0	0	
16:00		68	8	**76**	31	177		**208**	8		33	**41**					**325**	1292		0	0	1	
16:15		60	4	**64**	30	133		**163**	12		26	**38**					**265**	1263		0	0	0	
16:30		76	4	**80**	33	226		**259**	8		41	**49**					**388**	1272		0	0	0	
16:45		91	1	**92**	27	114		**141**	10		38	**48**					**281**	1259		0	0	0	
17:00		79	7	**86**	35	157		**192**	9		40	**49**					**327**	1261		0	0	0	
17:15		82	5	**87**	40	75		**115**	11		30	**41**					**243**	1239		0	0	0	
17:30		91	4	**95**	22	78		**100**	2		32	**34**					**229**	1080		0	0	0	
17:45		48	5	**53**	29	64		**93**	2		23	**25**					**171**	970		0	0	0	
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
n/a																							
Total		938	69	**1007**	381	1586		**1967**	109		442	**551**					**3525**			0	0	1	

Time Period Begins	96th Connector NORTH Approach Left	Thru	Right	Total	96th Connector SOUTH Approach Left	Thru	Right	Total	96th WEST Approach Left	Thru	Right	Total	EAST Approach Left	Thru	Right	Total	Total Volume 15-min	Hour	Peak	Pedestrians N	S	W	E	Conflict 15 min	Hr
7:00		94	7	101	21	49		70	3		15	18					189			0	0	0		137	
7:15		143	8	151	23	59		82	2		25	27					260		*	0	0	0		199	
7:30		151	9	160	30	64		94	6		28	34					288		*	0	0	0		218	
7:45		209	15	224	32	74		106	11		43	54					384	1121	+	0	0	0		299	853
8:00		133	16	149	55	63		118	8		36	44					311	1243	*	0	0	0		240	956
8:15		96	7	103	21	68		89	14		49	63					255	1238		0	0	0		173	930
8:30		88	8	96	21	63		84	4		36	40					220	1170		0	0	0		153	865
8:45		85	4	89	17	45		62	13		27	40					191	977		0	0	0		133	699
n/a																									
n/a																									
n/a																									
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n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
Total		999	74	**1073**	220	485		**705**	61		259	**320**					2098			0	0	0			1552
Avg Hr		500	37	**537**	110	243		**353**	31		130	**160**					1049			0	0	0			

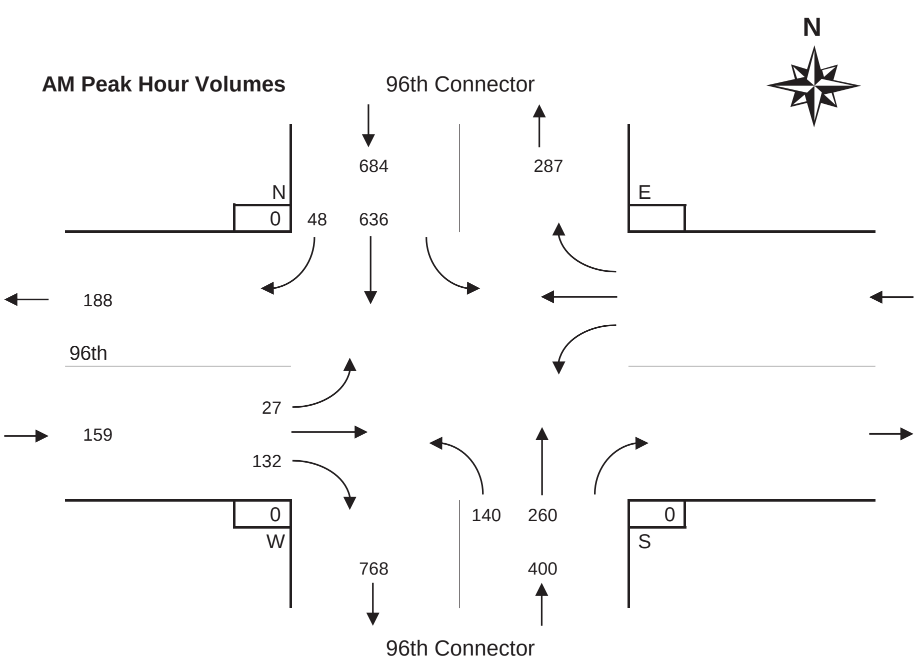
Peak hour of the intersection

	N Left	N Thru	N Right	N Total	S Left	S Thru	S Right	S Total	W Left	W Thru	W Right	W Total	E Left	E Thru	E Right	E Total	Total		Ped N	S	W	E	Conflict
Pk Hr		636	48	684	140	260		400	27		132	159					1243	*	0	0	0		956
15x4		836	64	896	220	296		472	44		172	216					1536	+	0	0	0		1292
PHF		0.76	0.75	**0.76**	0.64	0.88		**0.85**	0.61		0.77	**0.74**					0.81		n/a	n/a	n/a		0.74

Peak hour of conflicting volumes for the intersection

	N Left	N Thru	N Right	N Total	S Left	S Thru	S Right	S Total	W Left	W Thru	W Right	W Total	E Left	E Thru	E Right	E Total	Total		Ped N	S	W	E	Conflict
Pk Hr		636	48	684	140	260		400	27		132	159					1243	*	0	0	0		956
15x4		836	64	896	220	296		472	44		172	216					1536	+	0	0	0		1292
PHF		0.76	0.75	**0.76**	0.64	0.88		**0.85**	0.61		0.77	**0.74**					0.81		n/a	n/a	n/a		0.74

AM Peak Hour Volumes



MD Peak Period
All Vehicles Combined

96th Connector @ 96th Avenue
Thursday, May 12, 2016

Time	96th Connector				96th Connector				96th															
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
n/a																									
n/a																									
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n/a																									
n/a																									
n/a																									
n/a																									
n/a																									

Total																						
Avg Hr																					

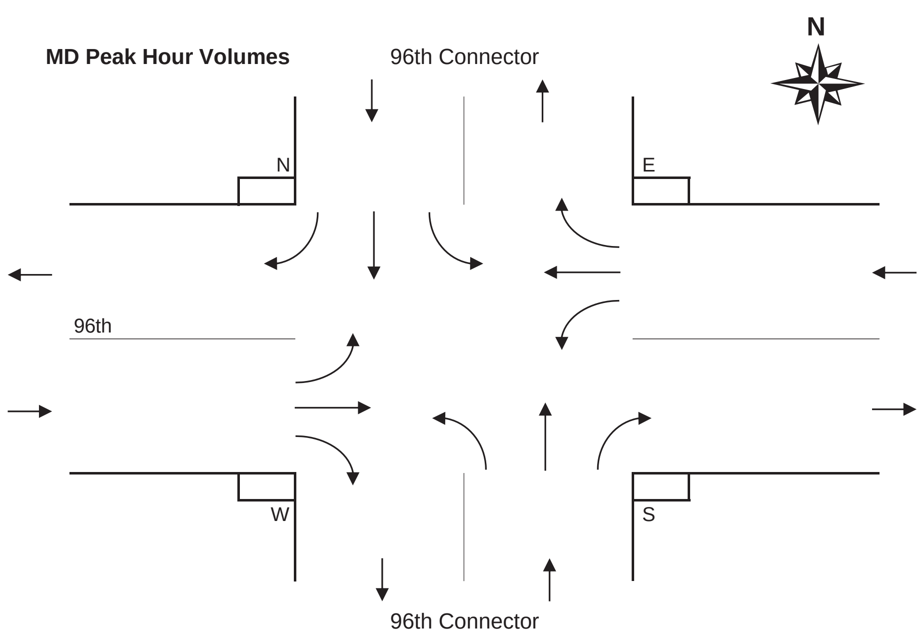
Peak hour of the intersection

Pk Hr																	*					
15x4																	+					
PHF																						

Peak hour of conflicting volumes for the intersection

Pk Hr																	*					
15x4																	+					
PHF																						

MD Peak Hour Volumes



PM Peak Period
All Vehicles Combined

96th Connector @ 96th Avenue
Thursday, May 12, 2016

Time	96th Connector				96th Connector				96th																
Period	NORTH Approach				SOUTH Approach				WEST Approach				EAST Approach				Total Volume		Peak	Pedestrians				Conflict	
Begins	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	15-min	Hour		N	S	W	E	15 min	Hr
15:00		74	6	80	28	182		210	12		27	39					329		*	0	0	0		209	
15:15		101	10	111	31	93		124	11		48	59					294		*	0	0	0		190	
15:30		89	9	98	48	164		212	12		57	69					379		+	0	0	0		221	
15:45		79	6	85	27	123		150	12		47	59					294	1296	*	0	0	0		170	790
16:00		68	8	76	31	177		208	8		33	41					325	1292		0	0	1		210	791
16:15		60	4	64	30	133		163	12		26	38					265	1263		0	0	0		159	760
16:30		76	4	80	33	226		259	8		41	49					388	1272		0	0	0		267	806
16:45		91	1	92	27	114		141	10		38	48					281	1259		0	0	0		157	793
17:00		79	7	86	35	157		192	9		40	49					327	1261		0	0	0		197	780
17:15		82	5	87	40	75		115	11		30	41					243	1239		0	0	0		157	778
17:30		91	4	95	22	78		100	2		32	34					229	1080		0	0	0		149	660
17:45		48	5	53	29	64		93	2		23	25					171	970		0	0	0		105	608
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									
n/a																									

Total		938	69	**1007**	381	1586		**1967**	109		442	**551**					3525			0	0	1			2028
Avg Hr		313	23	**336**	127	529		**656**	36		147	**184**					1175			0	0	0			

Peak hour of the intersection

Pk Hr		343	31	374	134	562		696	47		179	226					1296		*	0	0	0			741
15x4		404	40	444	192	728		848	48		228	276					1516		+	0	0	0			956
PHF		0.85	0.78	**0.84**	0.70	0.77		**0.82**	0.98		0.79	**0.82**					0.85			n/a	n/a	n/a			0.78

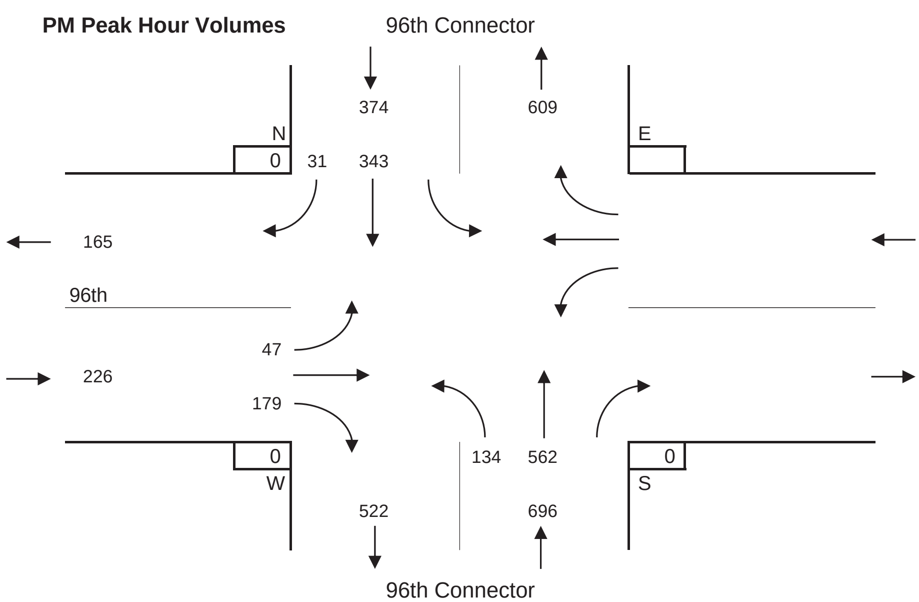
Peak hour of conflicting volumes for the intersection

Pk Hr		283	22	305	121	659		780	40		147	187					1272		*	0	0	1			806
15x4		316	32	340	132	904		1036	48		188	236					1552		+	0	0	4			1092
PHF		0.90	0.69	**0.90**	0.92	0.73		**0.75**	0.83		0.78	**0.79**					0.82			n/a	n/a	0.25			0.74

** Calculated peak hour occurs during the first or last hour of shift and therefore may be invalid. **

N

PM Peak Hour Volumes



Entire Survey Period

5 Hours

	96th Connector NORTH Approach				96th Connector SOUTH Approach				96th WEST Approach				EAST Approach				Total Volume
	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total		1937	143	**2080**	601	2071		**2672**	170		701	**871**					5623
Avg Hr		387	29	**416**	120	414		**534**	34		140	**174**					1125

Pedestrians			
N	S	W	E
0	0	1	
0	0	0	

AM Peak Period

2 Hours

	96th Connector NORTH Approach				96th Connector SOUTH Approach				96th WEST Approach				EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Period		999	74	**1073**	220	485		**705**	61		259	**320**					2098
Avg Hr		500	37	**537**	110	243		**353**	31		130	**160**					1049

Pedestrians			
N	S	W	E
0	0	0	
0	0	0	

MD Peak Period

Hours

	96th Connector NORTH Approach				96th Connector SOUTH Approach				96th WEST Approach				EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total																	
Avg Hr																	

Pedestrians			
N	S	W	E

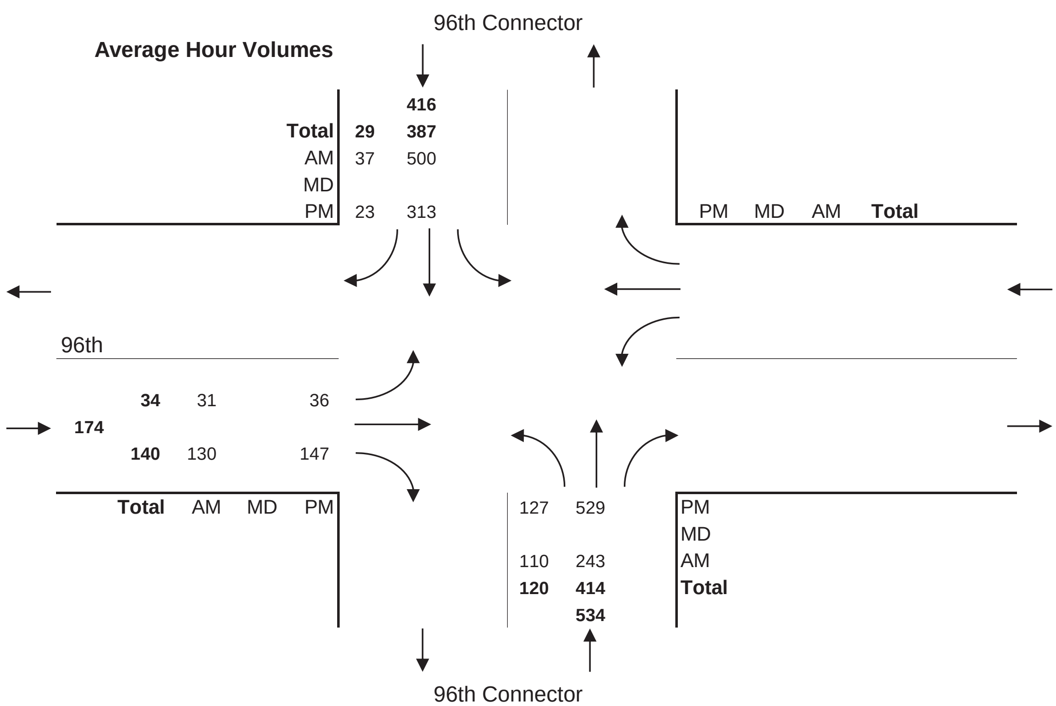
PM Peak Period

3 Hours

	96th Connector NORTH Approach				96th Connector SOUTH Approach				96th WEST Approach				EAST Approach				Total Volume
Totals	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	Left	Thru	Right	Total	
Total		938	69	**1007**	381	1586		**1967**	109		442	**551**					3525
Avg Hr		313	23	**336**	127	529		**656**	36		147	**184**					1175

Pedestrians			
N	S	W	E
0	0	1	
0	0	0	

Average Hour Volumes



ACKNOWLEDGEMENTS

The City of Surrey acknowledges the contribution and participation of the following individuals, organizations and staff members in the preparation of this Local Area Plan.

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Laura Hardiman, Project Engineer

Jeff Pang, Transportation Planner

Parks Recreation and Culture Department

Doug Merry, Parks Planner

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McElhanney Consulting Services Ltd

F.F. Binnie & Associates

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Abbey Ridge
Local Area Plan

Planning and Development &
Engineering Departments

City of Surrey
13450 104 Avenue
Surrey, British Columbia V3T 1V8

APPROVED BY COUNCIL FEBRUARY 2017

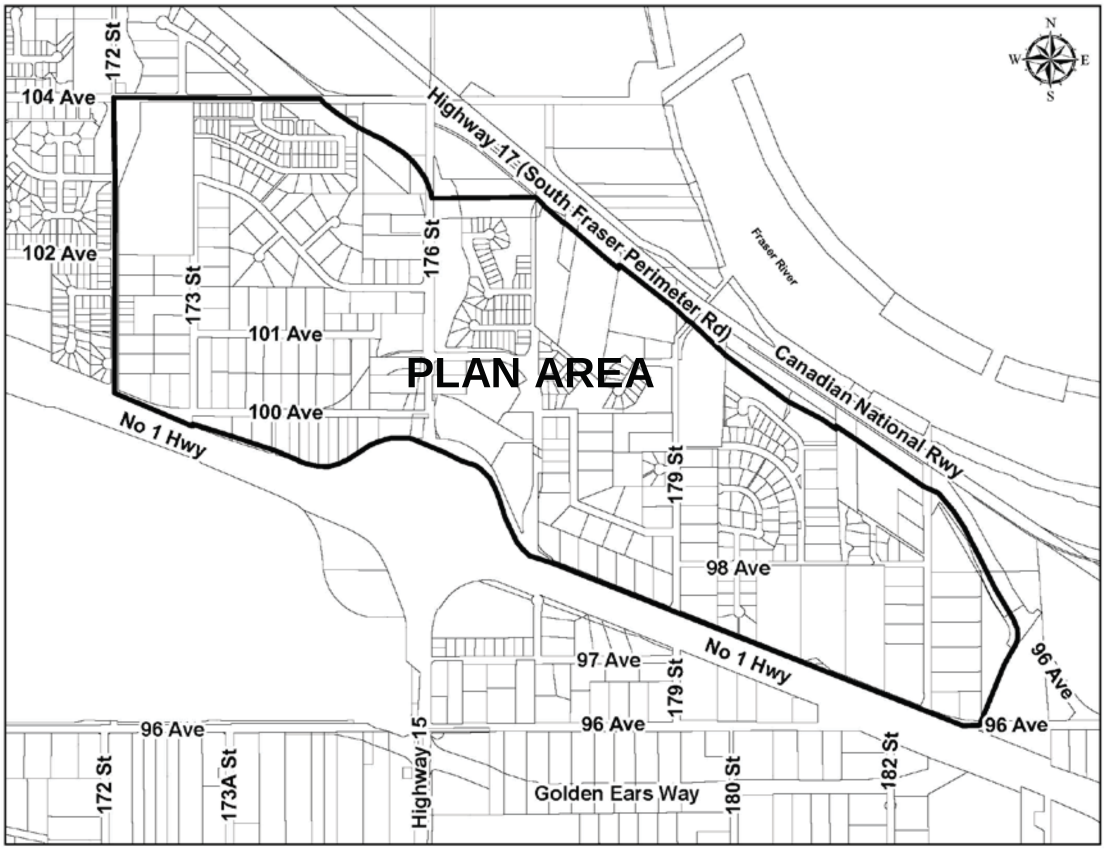
CITY OF SURREY

Proposed Amendment to Schedule F and G of the Zoning By-law

Proposed Amendments to
Surrey Zoning By-law, 1993, No. 12000, as amended

The following amendments are proposed to Surrey Zoning By-law, 1993, No. 12000, as amended:

1. Schedule F – Map of Neighbourhood Concept Plan and Infill Areas is amended by inserting Map 31 - Area XXX for Abbey Ridge, as follows:

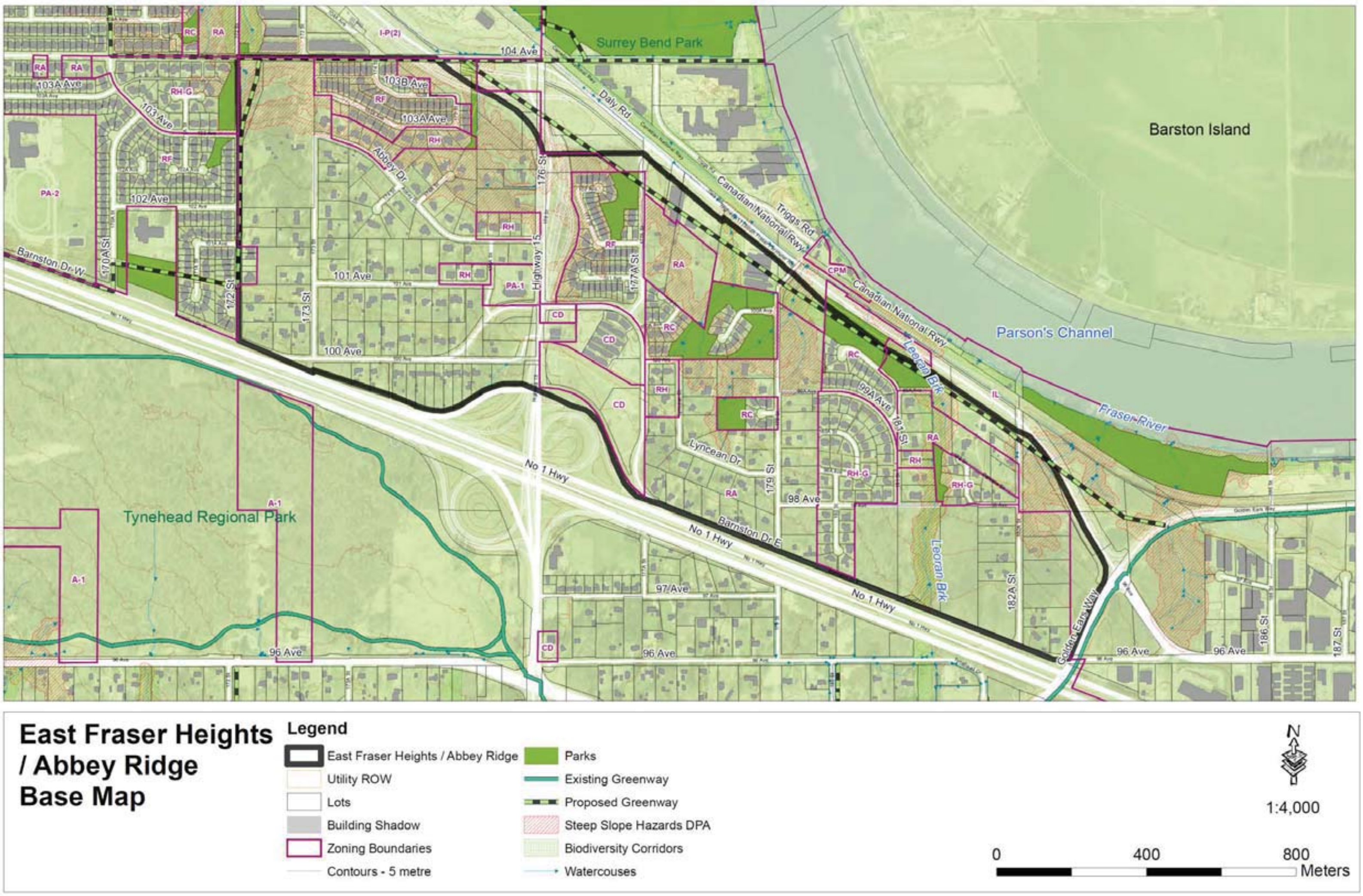


*The Abbey Ridge Local Area Plan, shown above as the "Plan Area", shall be considered to be an Area for the purpose of assessing and collecting Amenity Contributions.

2. Schedule G - Amenity Requirements for Areas in Schedule F of this Bylaw is amended by inserting a new Item 31 after Item 30, as follows:

Areas in Schedule F of this Bylaw		Uses	Contributions for the amenity categories of:				
			Police Protection	Fire Protection	Library Materials	Park, Pathway & Facility Development	Total
31.	Area XXXI	**Residential** ($ per *dwelling unit*)	$65.16	$281.46	$146.58	$1,480.00	$1,973.20
		Non-Residential ($ per acre)	$260.56	$1,125.83	N/A	N/A	$1,386.48

APPENDIX “III”



ABBEY RIDGE LOCAL AREA PLAN (LAP)
PUBLIC OPEN HOUSE – OCTOBER 18, 2016
COMMENT SHEET SUMMARY

Approximately 56 people attended the Abbey Ridge LAP Public Open House held on October 18, 2016 at Fraser Heights Secondary School. To date, the Planning & Development Department has received 9 completed feedback forms, representing comments from 6 properties within the Abbey Ridge LAP boundary, 1 property within 100 m of the boundary, and 2 properties outside these areas. Below is a summary of the comments received from the 9 properties. *Note: Numbers in brackets represent the survey number, NOT the frequency of the response.*

1. What features do you like about the Stage 2 Local Area Plan?

Parks and Greenspace – 3 responses

- It is good to see that green space and parks are forming a substantial part of the area. Please keep that high on the priority list. (4)
- Added community parks. (5)
- … increase in park area / bicycle paths / creek area reserve left natural. (7)

Low Density – 2 responses

- Low density (3)
- Low density (7)

Land Uses Proposed for 17770, 17780, and 17850 Daly Road (Solid Rock Properties) – 2 responses

- I like the "land uses" as proposed on Daly Road / Solid Rock. (8)
- Happy with the proposed land use for the properties on Daly Rd (17770, 17780, 17850) (9)

Access from 179 St to Golden Ears Way – 1 response

- Access from 179 St to Golden Ears Pkwy. (7)

Flex Road to Barnston Dr – 1 response

- Flex road from new townhouse area Barnston Drive direct. (7)

Other – 1 response

- I guess this is completely different than what I thought this evening was going to be about. Now, I would like to know if my taxes are going to go up simply because other residents have sold and developers are going to squeeze more lots into that original space. - Or - if the funds all come from the new developments themselves. Please email me with this answer and then I'll know how I like the plan. (1)

2. Are there any aspects of the Stage 2 Local Area Plan that are of concern to you? Please explain.

Traffic – 3 responses

- I think that residential lots 8-10 and also 10-12 make a big density in the area, it will be a lot of traffic and I don't like it. I think that Fraser Heights Area should be left for big family lots as is now. I think it will be very crowded and I don't like the idea. It will be crowded like in downtown. (2)
- Increased residential density will have an adverse effect on traffic through other areas of Fraser Heights and Port Kells as there is no direct access off 176th St/Hwy 17 to the residential streets. (4)
- Barnston East Road speedbumps should be incorporated to slow traffic to speed limits. Noise barrier on Barnston East to be upgraded to concrete & extended. (7)

Density Too High (Low Density Townhouse at Barnston Dr E and 177A St; Increased Density on 179 St) – 3 responses

- I think that residential lots 8-10 and also 10-12 make a big density in the area, it will be a lot of traffic and I don't like it. I think that Fraser Heights Area should be left for big family lots as is now. I think it will be very crowded and I don't like the idea. It will be crowded like in downtown. (2)
- Low density townhomes - Barnston East + 177A - highly oppose. Higher density on 179 than last town hall. I do not support the town homes. (3)
- Increased residential density will have an adverse effect on traffic through other areas of Fraser Heights and Port Kells as there is no direct access off 176th St/Hwy 17 to the residential streets. (4)

Community Pump Station at 177A St – 2 responses

- I don't like having the community pump station on East side of 177A Street. Why not on the west side? (8)
- Opposed to Community Pump Station on the east side of 177A St. There's lots of land that Surrey owns already that could be used for this P.S. (the West side!) (9)

No Elementary School – 1 response

- No provision for Elementary School site - townhouses, wow! No school K-7!!! You have to be kidding! (5)

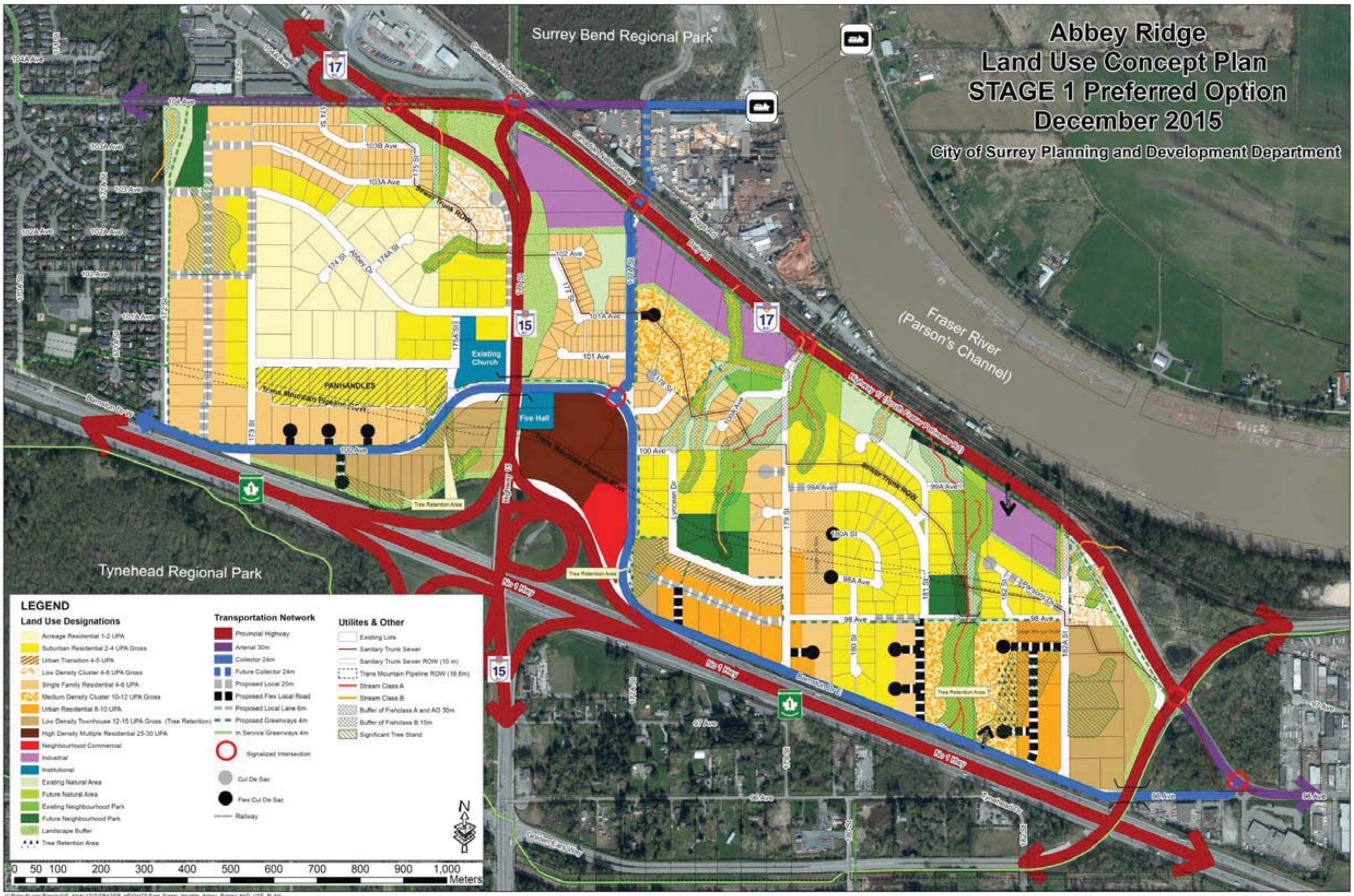
DCC Shortfall – 1 response

- Concerned about how the sewer DCC shortfall will be addressed. How come shortfalls aren't handled like windfalls/excess - in other words shared equally throughout Surrey (9)

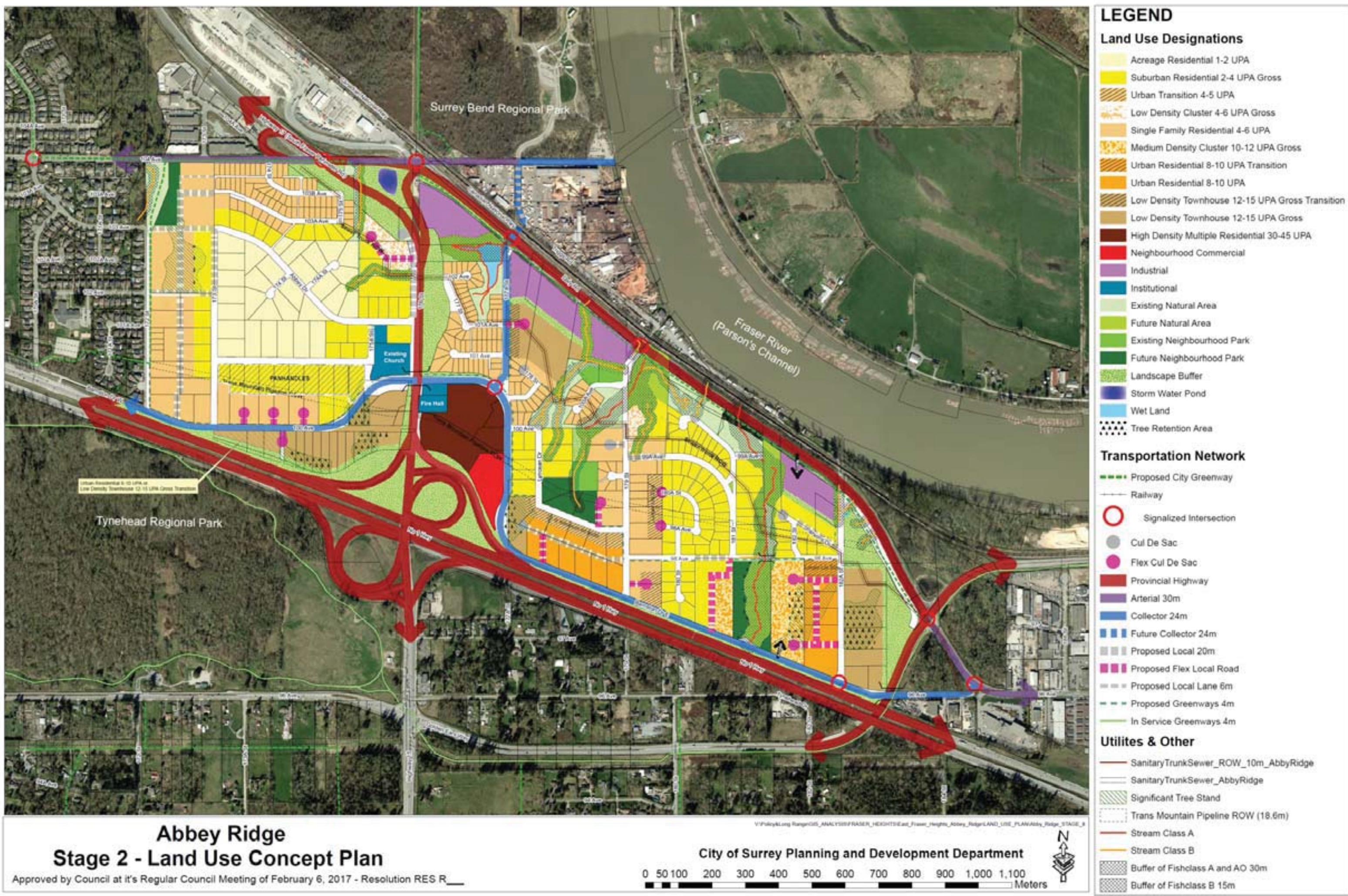
3. In general, do you support the Stage 2 Local Area Plan? Please check (✓) one:

I generally support the Local Area Plan.	3 responses	(33%)
I support the Local Area Plan but have concerns.	3 responses	(33%)
I generally support the Local Area Plan. I support the Local Area Plan but have concerns.	1 response	(11%)
I do not support the Local Area Plan.	1 response	(11%)
Blank	1 response	(11%)

APPENDIX "V"

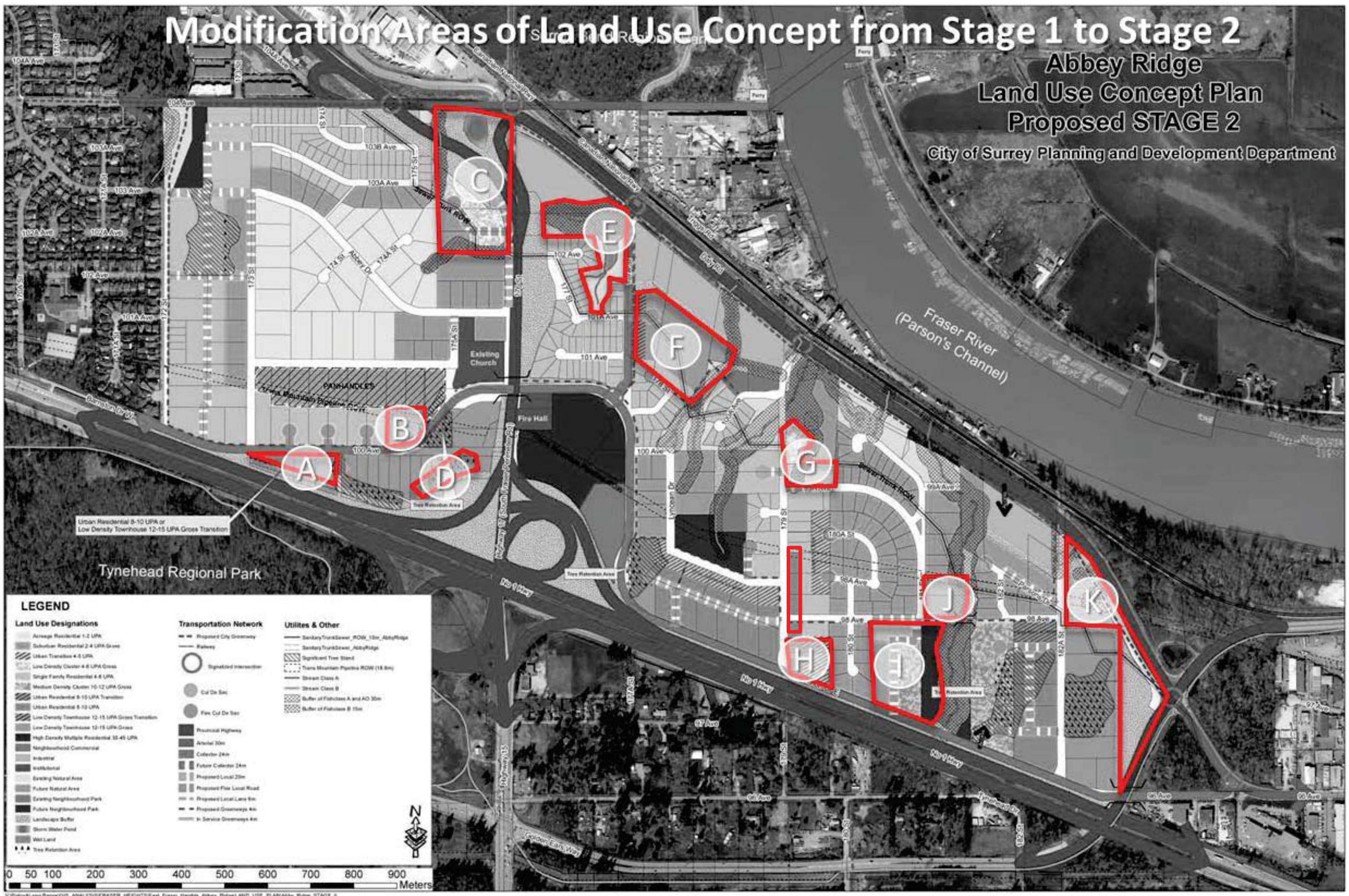

Abbey Ridge
Land Use Concept Plan
STAGE 1 Preferred Option
December 2015
City of Surrey Planning and Development Department
Surrey Bend Regional Park
Tynehead Regional Park
Fraser River
(Parson's Channel)
Existing Church
Fire Hall
PANHANDLES
Tree Retention Area
LEGEND
Land Use Designations
Acreage Residential 1-2 UPA
Suburban Residential 2-4 UPA Gross
Urban Transition 4-5 UPA
Low Density Cluster 4-6 UPA Gross
Single Family Residential 4-6 UPA
Medium Density Cluster 10-12 UPA Gross
Urban Residential 8-10 UPA
Low Density Townhouse 12-15 UPA Gross (Tree Retention)
High Density Multiple Residential 25-30 UPA
Neighbourhood Commercial
Industrial
Institutional
Existing Natural Area
Future Natural Area
Existing Neighbourhood Park
Future Neighbourhood Park
Landscape Buffer
Tree Retention Area
Transportation Network
Provincial Highway
Arterial 30m
Collector 24m
Future Collector 24m
Proposed Local 20m
Proposed Flex Local Road
Proposed Local Lane 6m
Proposed Greenways 4m
In Service Greenways 4m
Signalized Intersection
Cul De Sac
Flex Cul De Sac
Railway
Utilites & Other
Existing Lots
Sanitary Trunk Sewer
Sanitary Trunk Sewer ROW (10 m)
Trans Mountain Pipeline ROW (18.6m)
Stream Class A
Stream Class B
Buffer of Fishclass A and AO 30m
Buffer of Fishclass B 15m
Significant Tree Stand
N
0 50 100 200 300 400 500 600 700 800 900 1,000
Meters

APPENDIX “VI”



Surrey Bend Regional Park
Fraser River (Parson's Channel)
Tynehead Regional Park
Existing Church
Fire Hall
PANHANDLES
LEGEND
Land Use Designations
Acreage Residential 1-2 UPA
Suburban Residential 2-4 UPA Gross
Urban Transition 4-5 UPA
Low Density Cluster 4-6 UPA Gross
Single Family Residential 4-6 UPA
Medium Density Cluster 10-12 UPA Gross
Urban Residential 8-10 UPA Transition
Urban Residential 8-10 UPA
Low Density Townhouse 12-15 UPA Gross Transition
Low Density Townhouse 12-15 UPA Gross
High Density Multiple Residential 30-45 UPA
Neighbourhood Commercial
Industrial
Institutional
Existing Natural Area
Future Natural Area
Existing Neighbourhood Park
Future Neighbourhood Park
Landscape Buffer
Storm Water Pond
Wet Land
Tree Retention Area
Transportation Network
Proposed City Greenway
Railway
Signalized Intersection
Cul De Sac
Flex Cul De Sac
Provincial Highway
Arterial 30m
Collector 24m
Future Collector 24m
Proposed Local 20m
Proposed Flex Local Road
Proposed Local Lane 6m
Proposed Greenways 4m
In Service Greenways 4m
Utilites & Other
SanitaryTrunkSewer_ROW_10m_AbbyRidge
SanitaryTrunkSewer_AbbyRidge
Significant Tree Stand
Trans Mountain Pipeline ROW (18.6m)
Stream Class A
Stream Class B
Buffer of Fishclass A and AO 30m
Buffer of Fishclass B 15m
Abbey Ridge
Stage 2 - Land Use Concept Plan
Approved by Council at it's Regular Council Meeting of February 6, 2017 - Resolution RES R___
City of Surrey Planning and Development Department
0 50 100 200 300 400 500 600 700 800 900 1,000 1,100
Meters
N

APPENDIX "VII"



Proposed Modifications of Land Use Concept from Stage 1 to Stage 2

"Area A" – Low Density Townhouse with option for Urban Residential 8-10 UPA

Amendment permitting three Low Density Townhouse 12-15 Gross Density designated sites lots along 100 Avenue, which are encumbered by unique site constraints based on location and shape, to allow for the flexibility of lower density at the Urban Residential 8-10 UPA destination which would permit possibility of single family homes or Low Density Townhomes at time of development application.

"Area B" - Amendment from Single Family Residential 4-6 UPA to Suburban Residential 2-4 UPA

Amendment for reduced density is proposed for two lots north of 100 Ave, which are encumbered by the Trans Mountain Pipeline, and have limited urban site potential. The amendment proposed would reduce the density from Single Family Residential to Suburban Residential which can be more realistically established based on the unique site limitations the more urban Single Family homes would provide.

"Area C" - Addition of Flex Road and amendment from Low Density Cluster to Suburban Designation adjacent to Residential Acreages with 7.5 m landscaped buffer.

Amendment proposed to reduce density adjacent to Existing Acreage Residential areas from Low Density Cluster 4-6 UPA to Suburban Residential 2-4 UPA, and include a 7.5 meter wide landscaped buffer separating the Acreage residential and Suburban Residential Uses. Inclusion of a potential flex road location to service the site also provided.

"Area D" – Removal of Class B Ditch based on Environmental Study Findings

This amendment to remove a Class B Ditch is proposed to align with the findings of the Phoenix Environmental Study report recommendations, which concluded that there is not ditch located within this area.

"Area E" – Updated Mapping of Existing Water Courses and ponds

Amendment updates water course mapping based on the Phoenix Environmental Study results showing the current location of water bodies and A Class streams.

"Area F" – Amendment from Medium Density Cluster to a mix of Single Family, Low Density Townhouse Transition and Townhouse.

Amendment to the a Medium Density Cluster designation areas with alternation along transition areas to allow for a mix of Single Family Residential 4-6 UPA, and Low Density Townhouse Transition 12-15 UPA, and Low Density Townhouse. Amendment includes transition from existing Single Family Residential areas to the South, and provides a single family form transition of duplex of multifamily development along 77A St to buffer townhouses from existing single family homes.

"Area G" – Amendment from Suburban Residential to a mix of Low Density Cluster and Single Family Residential.

Amendment of two Suburban Residential sites to allow for an increase in density to Low Density Cluster and Single Family Residential. The designation changes provide for a single family road interface along the future 99A Avenue, and provide enhanced environmental protection for density bonus along streams.

"Area H" – Amendments from Single Family Residential and Urban Residential to Single Family Residential and Urban Transition Designation

Amendment to reduced density from Urban Residential to Single Family Residential and provided for an Urban Residential Transition designation from existing Suburban Residential lots.

"Area I" –Inclusion of Flex Road, and amendment of land use from a mix of Single family and Suburban to a mix of Suburban and Low Density Cluster

Amendment to include a flex road connection from 181 Street and 98 Avenue to Barnston Drive, providing for Medium Density Cluster designation interface (Multiple Family) adjacent to Park, and transition of lower density Suburban Residential.

"Area J" – Amendments from Neighbourhood Park to Suburban Residential to adjust Park location to south of 98 Avenue along Leoran Brook

Amendment to adjust the site from Future Neighbourhood Park to Surburban Residential, based on a new Park location provided adjacent to Leoran Brook south of 98 Avenue. This park location will provide for both Natural Area Protection but a small active park including future playground facility.

"Area K" – Two Ministry of Transportation owned lots amended from Low Density Cluster and Low Density Townhouse to Landscaped Buffer

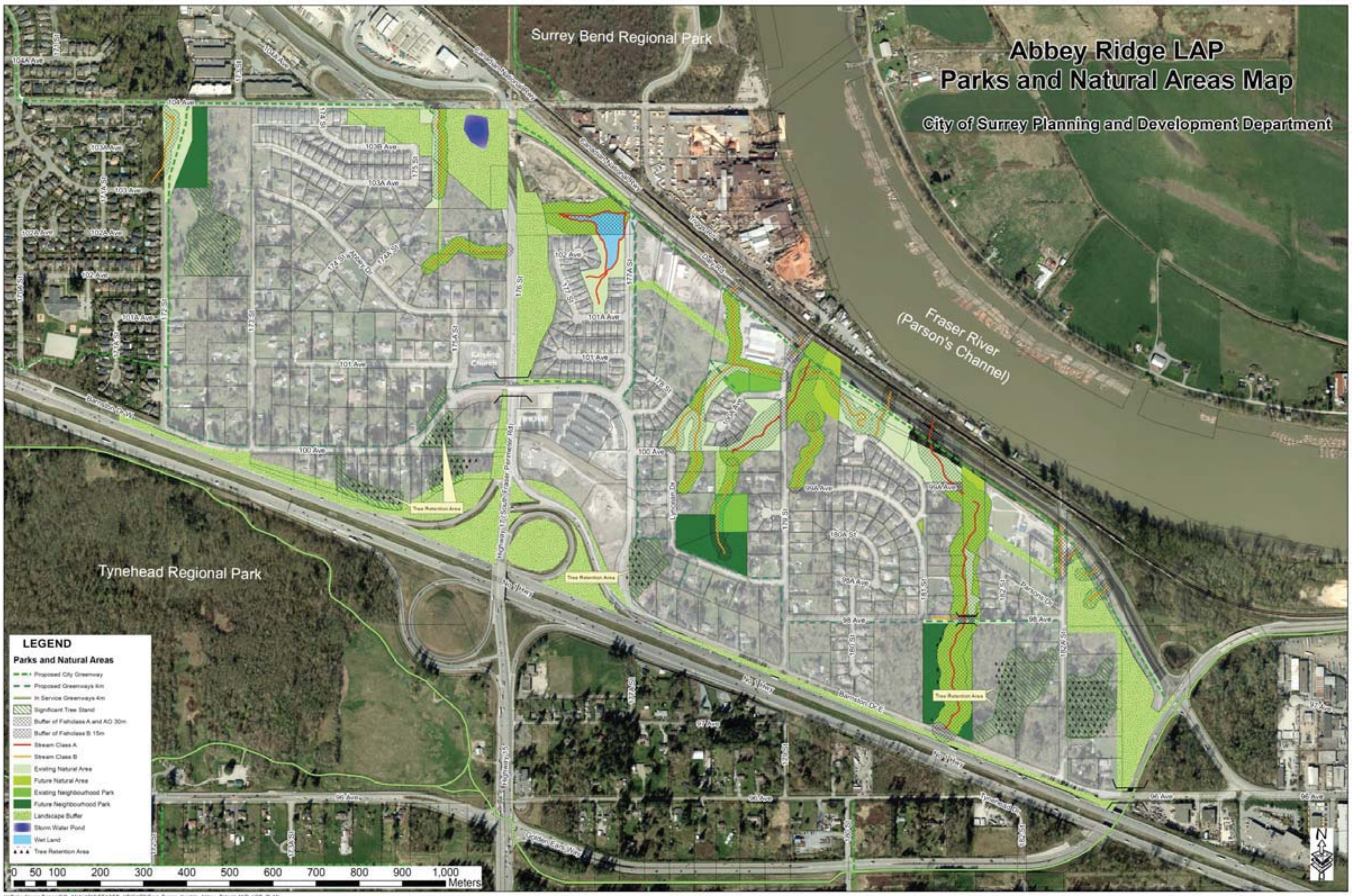
Two properties located in Area K are currently owned by the Ministry of Transportation as Road, and are currently not intended for any urban redevelopment. As such the site has been identified as Landscaped Buffer Areas as they provide separation from regional road network areas.

APPENDIX “VIII”

Abby Ridge Stage 2 - Land Use Plan Buildout Unit and Population Scenario December 2016

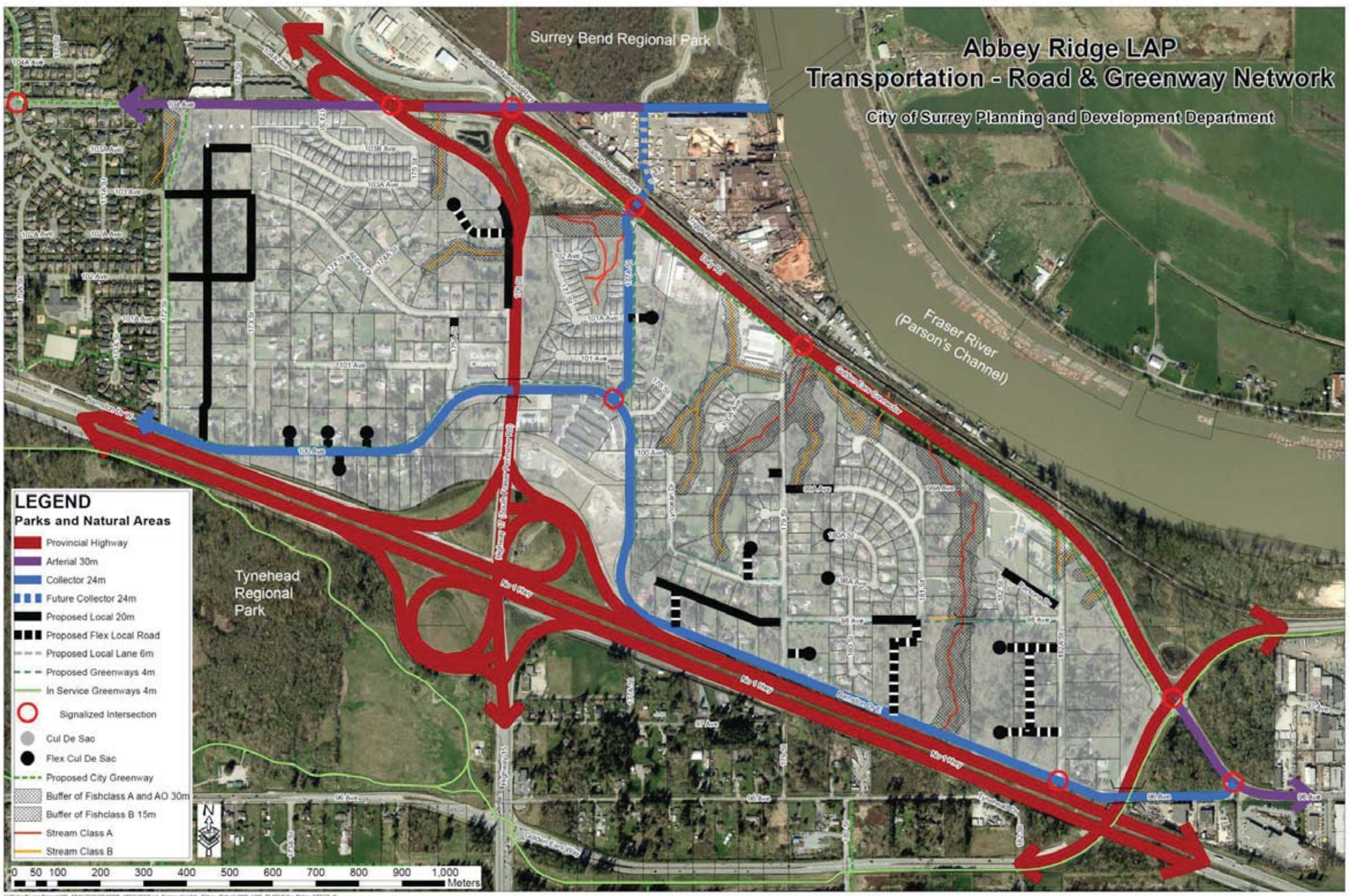
Land Use	Acres	Area %	Existing Units	Projected			Existing Population	Projected			Number of Existing Secondary Suites	Projected Secondary Suites	Existing Secondary Suite Population	Projected Secondary Suite Population	Possible Non-residential Floor Area	Projected Employment
				Low Units	Avg Units	High Units		Low Population	Avg Population	High Population						
Roads	90.9	21.3%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wet Land	1.6	0.4%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storm Water Pond	0.9	0.2%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landscape Buffer	25.9	6.1%	1	0	0	0	2	0	0	0	0	0	0	0	0	0
Existing Natural Area	16.0	3.8%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Natural Area	21.9	5.1%	2	0	0	0	6	0	0	0	0	0	0	0	0	0
Sanitary Trunk Sewer Buffer	4.6	1.1%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Neighbourhood Park	2.7	0.6%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Neighbourhood Park	7.8	1.8%	4	0	0	0	14	0	0	0	0	0	0	0	0	0
Industrial	16.1	3.8%	2	0	0	0	7	0	0	0	0	0	0	0	351,699	382
Institutional	4.7	1.1%	0	0	0	0	0	0	0	0	0	0	0	0	53,372	67
Neighbourhood Commercial	3.6	0.8%	0	56	56	56	0	152	152	152	0	0	0	0	7,265	10
Acreage Residential 1-2 UPA	30.9	7.2%	29	30	31	31	104	104	106	107	0	2	0	4	0	0
Suburban Residential 2-4 UPA Gross	65.0	15.2%	161	189	222	254	536	682	798	914	24	111	48	378	0	0
Urban Transition 4-5 UPA	6.2	1.5%	6	25	28	31	21	85	95	106	0	14	0	57	0	0
Low Density Cluster 4-6 UPA Gross	3.1	0.7%	4	12	15	18	12	41	50	59	1	5	2	19	0	0
Single Family Residential 4-6 UPA	62.3	14.6%	305	415	450	485	914	1,285	1,404	1,523	107	225	204	586	0	0
Urban Residential 8-10 UPA	13.9	3.3%	19	112	126	140	64	313	352	391	2	60	4	160	0	0
Urban Residential 8-10 UPA Transition	1.2	0.3%	2	9	10	11	7	25	28	31	0	5	0	11	0	0
Medium Density Cluster 10-12 UPA Gross	9.3	2.2%	0	93	102	111	0	252	277	302	0	50	0	109	0	0
Low Density Townhouse 12-15 UPA Gross	26.4	6.2%	22	312	354	396	75	1,046	1,188	1,329	0	0	0	0	0	0
Low Density Townhouse 12-15 UPA Gross Transition	0.9	0.2%	0	10	12	13	0	35	40	44	0	0	0	0	0	0
High Density Multiple Residential 25-30 UPA	11.2	2.6%	190	335	408	480	481	876	1,073	1,269	0	0	0	0	0	0
Total	**427.2**	100.0%	**747**	**1,598**	**1,813**	**2,027**	**2,242**	**4,896**	**5,563**	**6,229**	**134**	**472**	**258**	**1,326**	**412,336**	**459**

APPENDIX "IX"



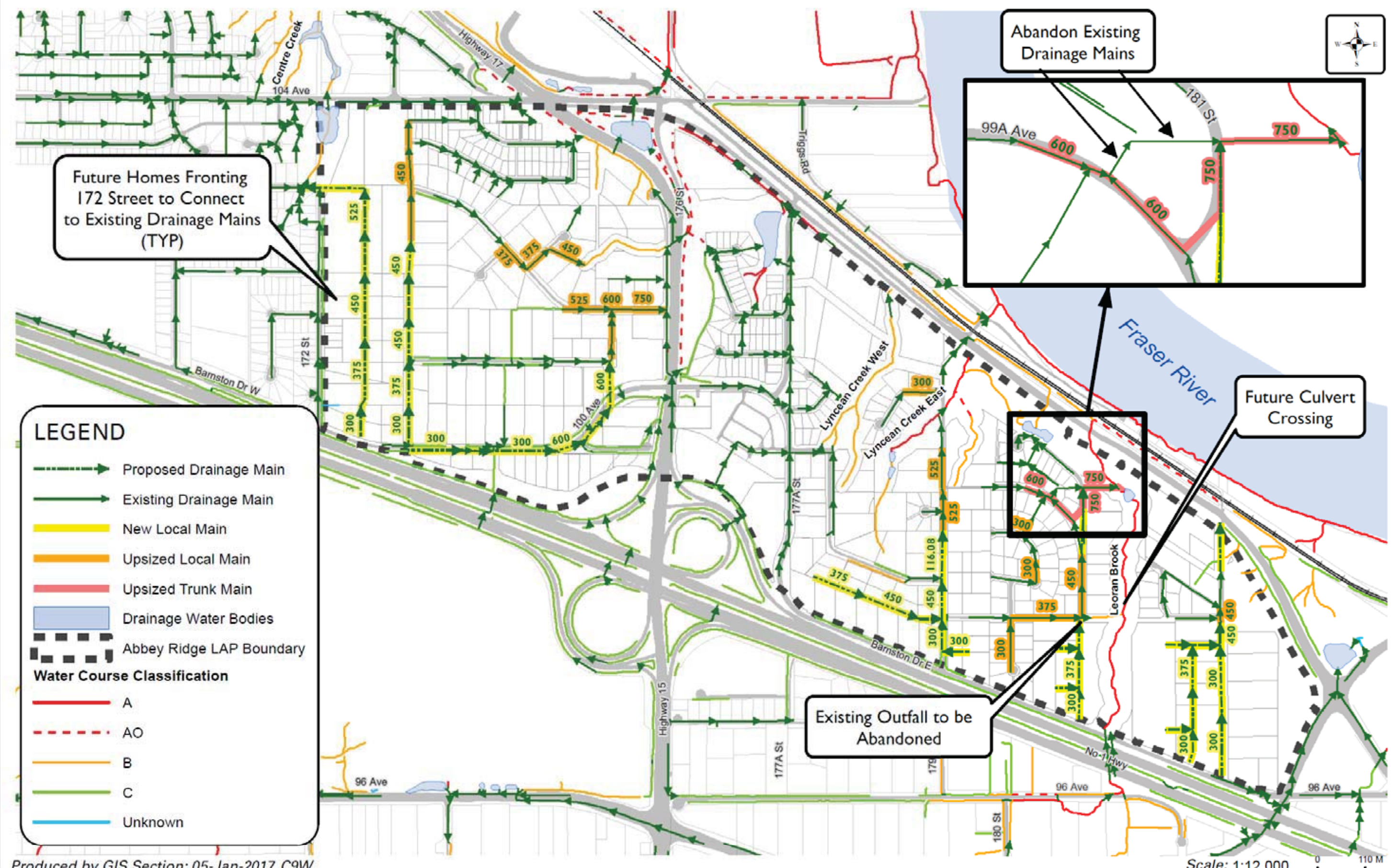
Abbey Ridge LAP
Parks and Natural Areas Map
City of Surrey Planning and Development Department
Surrey Bend Regional Park
Fraser River
(Parson's Channel)
Tynehead Regional Park
Tree Retention Area
LEGEND
Parks and Natural Areas
Proposed City Greenway
Proposed Greenways 4m
In Service Greenways 4m
Significant Tree Stand
Buffer of Fishclass A and AO 30m
Buffer of Fishclass B 15m
Stream Class A
Stream Class B
Existing Natural Area
Future Natural Area
Existing Neighbourhood Park
Future Neighbourhood Park
Landscape Buffer
Storm Water Pond
Wet Land
Tree Retention Area
0 50 100 200 300 400 500 600 700 800 900 1,000
Meters

APPENDIX “X”



Abbey Ridge LAP
Transportation - Road & Greenway Network
City of Surrey Planning and Development Department
Surrey Bend Regional Park
Fraser River
(Parson's Channel)
Tynehead
Regional
Park
LEGEND
Parks and Natural Areas
Provincial Highway
Arterial 30m
Collector 24m
Future Collector 24m
Proposed Local 20m
Proposed Flex Local Road
Proposed Local Lane 6m
Proposed Greenways 4m
In Service Greenways 4m
Signalized Intersection
Cul De Sac
Flex Cul De Sac
Proposed City Greenway
Buffer of Fishclass A and AO 30m
Buffer of Fishclass B 15m
Stream Class A
Stream Class B
0 50 100 200 300 400 500 600 700 800 900 1,000
Meters

APPENDIX "XI"



CITY OF SURREY
the future lives here.

Abbey Ridge Local Area Plan
Proposed Stormwater System
Servicing Plan

ENGINEERING
DEPARTMENT

Source:
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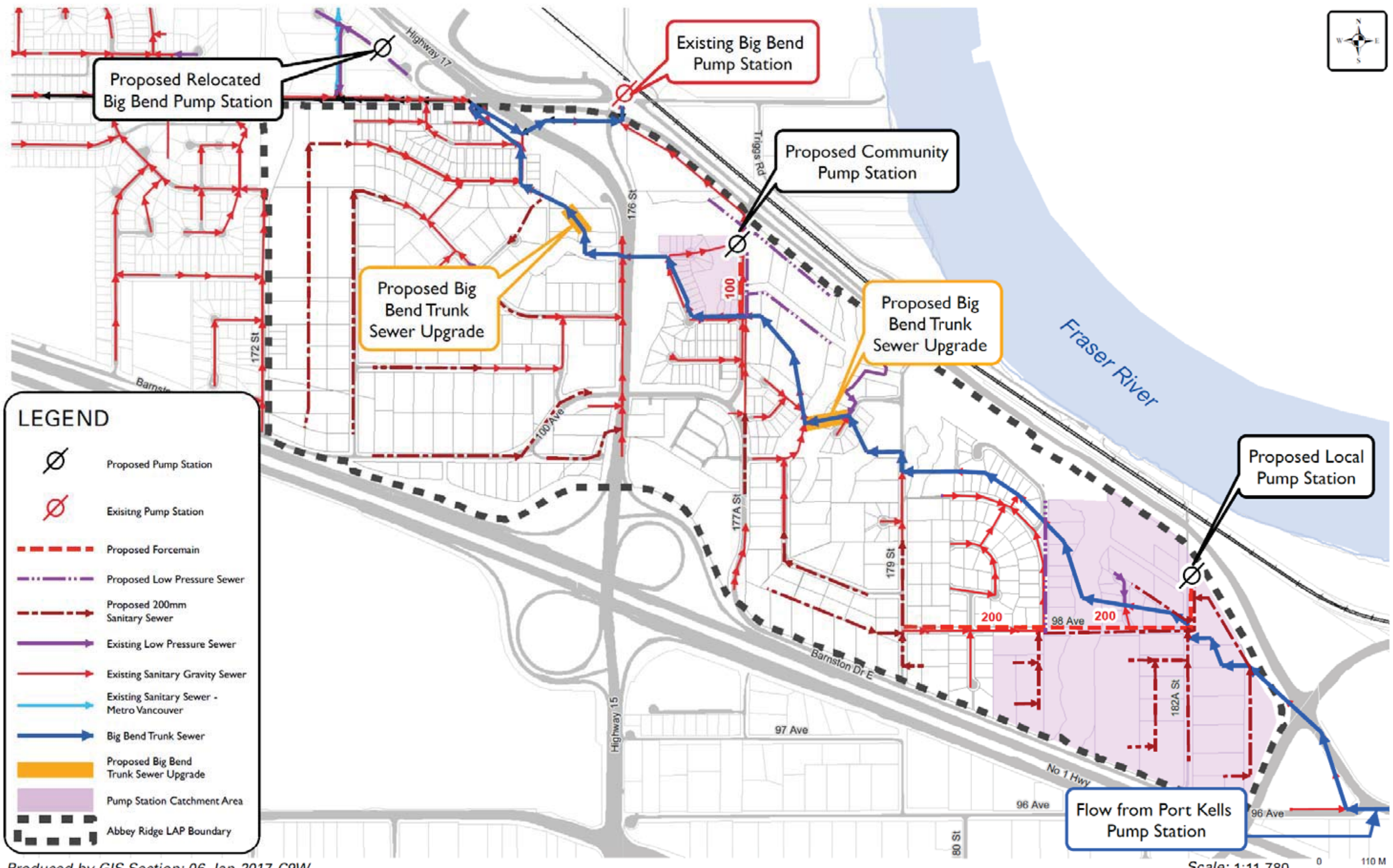
APPENDIX "XII"



CITY OF SURREY the future lives here.	Abbey Ridge Local Area Plan Proposed Sanitary Sewer System Servicing Plan	ENGINEERING DEPARTMENT

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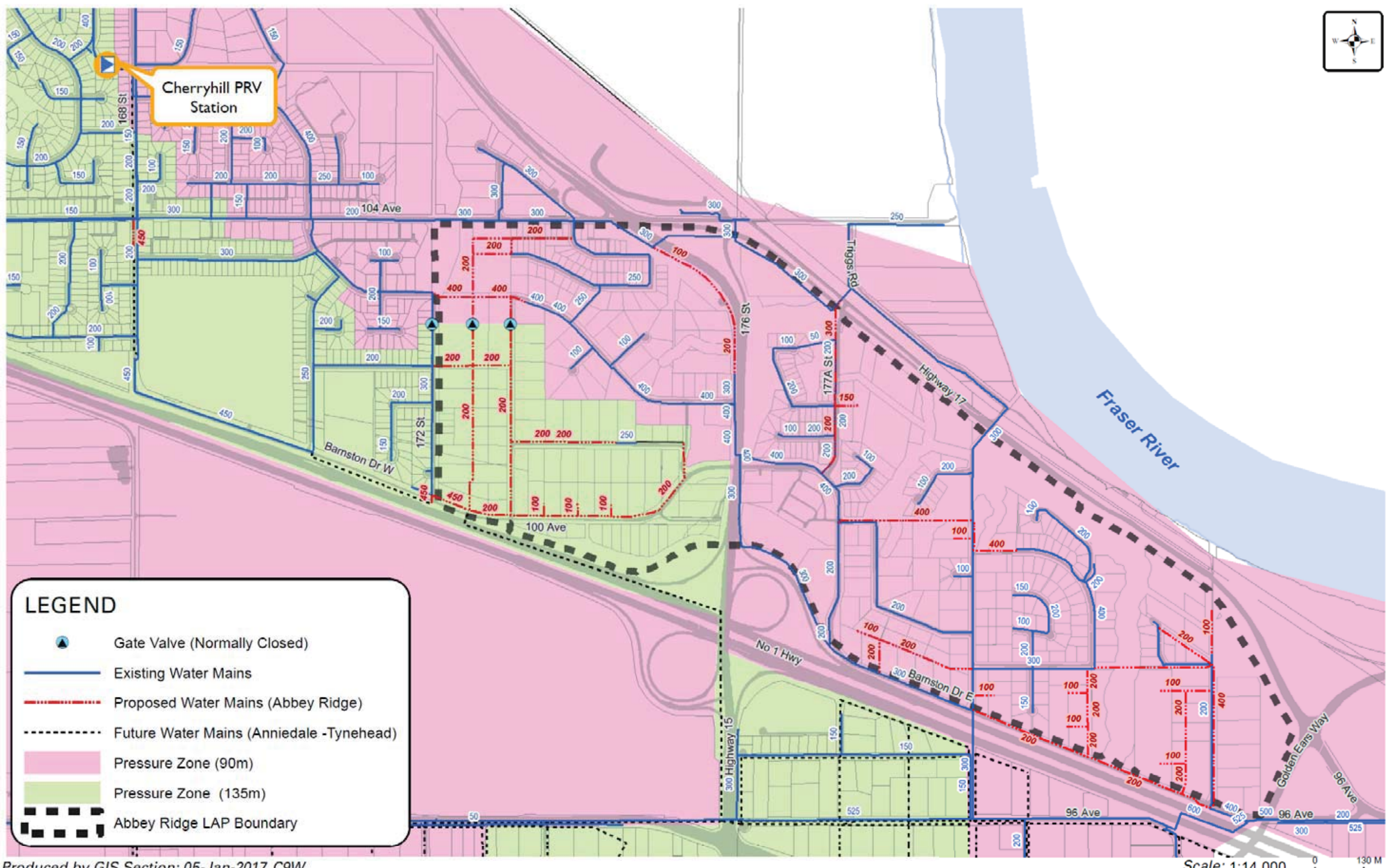
APPENDIX "XIII"



CITY OF SURREY
the future lives here.

Abbey Ridge Local Area Plan
Proposed Water System
Servicing Plan

ENGINEERING DEPARTMENT

The data provided is compiled from various sources and IS NOT warranted as to its accuracy or sufficiency by the City of Surrey.
This information is provided for information and convenience purposes only.
Lot sizes, Legal descriptions and encumbrances must be confirmed at the Land Title Office.

Source:
G:\MAPPING\GIS\Maps\CorporateReps\Other\AbbeyRidge\CW_wtrAbbeyRidgeLAP_APIII_AL.mxd