FERGUS CREEK INTEGRATED STORMWATER MANAGEMENT PLAN

PROJECT 4802-707-00

FOR

CITY OF SURREY

FINAL REPORT

2111-02276-0

Prepared By:

McElhanney Consulting Services Ltd.
13160 - 88 Avenue
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September 2010

McElhanney

September 29, 2010
Our File: 2111-02276-0

City of Surrey
14245 – 56 Avenue
Surrey, BC V3X 3A2

Attention: Ms. Jeannie Lee, M.A.Sc., P.Eng.
Project Engineer

Dear Jeannie:

Fergus Creek ISMP – Final Report

We are pleased to submit three (3) copies of the Fergus Creek ISMP report. As this ISMP has proceeded into areas not normally included in drainage planning we have approached the needs of the City and the Watershed in a new and innovative manner.

We recommend that a Watershed Vision be created to describe the future state of the Fergus Creek Watershed. The visioning process should be a part of future Neighbourhood Planning and Redevelopment Planning within the Fergus Creek Watershed. The vision can be used to create Signature Neighbourhoods that would benefit the City, its residents, and the environment within the watershed.

The ISMP recommends policy and procedural changes needed to implement the proposed stormwater management facilities and to incorporate these into multi-use facilities that would allow a wider range of facility use and financing options. The multi-use corridors can become an integral and signature feature for the new neighbourhood.

We thank you for the opportunity on working on this ISMP study and look forward to assisting you in its implementation. If you have any questions or comments, please do not hesitate to contact this office.

Yours very truly,

McELHANNEY CONSULTING SERVICES LTD.

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1.0 INTRODUCTION

The City of Surrey has engaged McElhanney Consulting Services Ltd. to prepare the Fergus Creek Integrated Stormwater Management Plan (**ISMP**). The purpose of the ISMP is to establish the framework that would allow the environmental features of the watershed to be maintained, or improved, while allowing for human uses and development within the watershed. The plan provides flexibility in meeting both the needs of the community and the environment while allowing development and redevelopment. As such, the ISMP is not just another Engineering Drainage Study. Rather it incorporates and balances the requirements of drainage, watershed uses, development and the environment.

This project is the result of the efforts by the City of Surrey and fulfills a regional commitment to develop watershed / landscape-based plans that integrate the engineering, planning, environmental and recreation perspectives.

An ISMP involves a continuum – where we are now (the starting point), where we wish to get to (the target), and how we get there over time (the strategy). Furthermore, the watershed / landscape-based approach involves planning with reference to watershed features to produce 'integrated solutions' that are affordable and achievable.

The watershed as identified on **Figure 1.1** depicts the developing portions of the Fergus Creek Watershed, that is, those portions of the watershed that are expected to redevelop from the existing land use to a higher density. Already numerous plans are in place or are in process. A short and possibly incomplete listing of these plans includes the following:

- Highway 99 Corridor,
- 24th Avenue Land Use Plan,
- Semiahmoo Town Centre Plan,
- King George Highway Corridor Plan, and
- Grandview Heights Land Use Plan.

1.1 SURREY ISMP PROCESS

An Integrated Stormwater Management Plan (ISMP) is a policy document that provides direction to land owners and local government to address community land use choices and determine best options to manage these in light to the natural resources present in the watershed while accommodating growth by:

- Regulating redevelopment of land;
- Setting goals to control runoff;
- Protecting existing streams and flood plains;
- Improving water quality along Fergus Creek and its tributaries;
- Improving riparian and terrestrial habitat;
- Introducing new park areas; and
- Providing opportunities for people to interact with nature.

The ISMP is a new process that provides an overview planning function for input into future Neighbourhood Concept Plans within the Fergus Creek Watershed. The ISMP examines how a watershed functions in terms of:

- The interaction of water resources and natural environments;
- Ensuring public safety;
- Providing erosion control; and
- Protection and enhancement of the natural environment. On a watershed basis this must include both aquatic and terrestrial environments.

The ISMP process will provide direction for redevelopment designs and assist in identifying municipal infrastructure needs over the next 30 years. The Fergus Creek ISMP can form the basis for establishing both the requirements within this watershed and for future ISMP’s that will be undertaken in the City. The form and function of future ISMP’s can be established through this precedent setting project.

The general process for developing ISMP’s within the GVRD has been established in the ISMP Template. Consideration was provided within the Template for customization so as to allow individual municipalities to tailor the process to unique local conditions. We propose to take advantage of the flexibility offered within the ISMP Template to provide

Plotted: December 13, 2007 , 10:20:14 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_1 - WATERSHED.dwg\FIGURE 1.1 - WATERSHED

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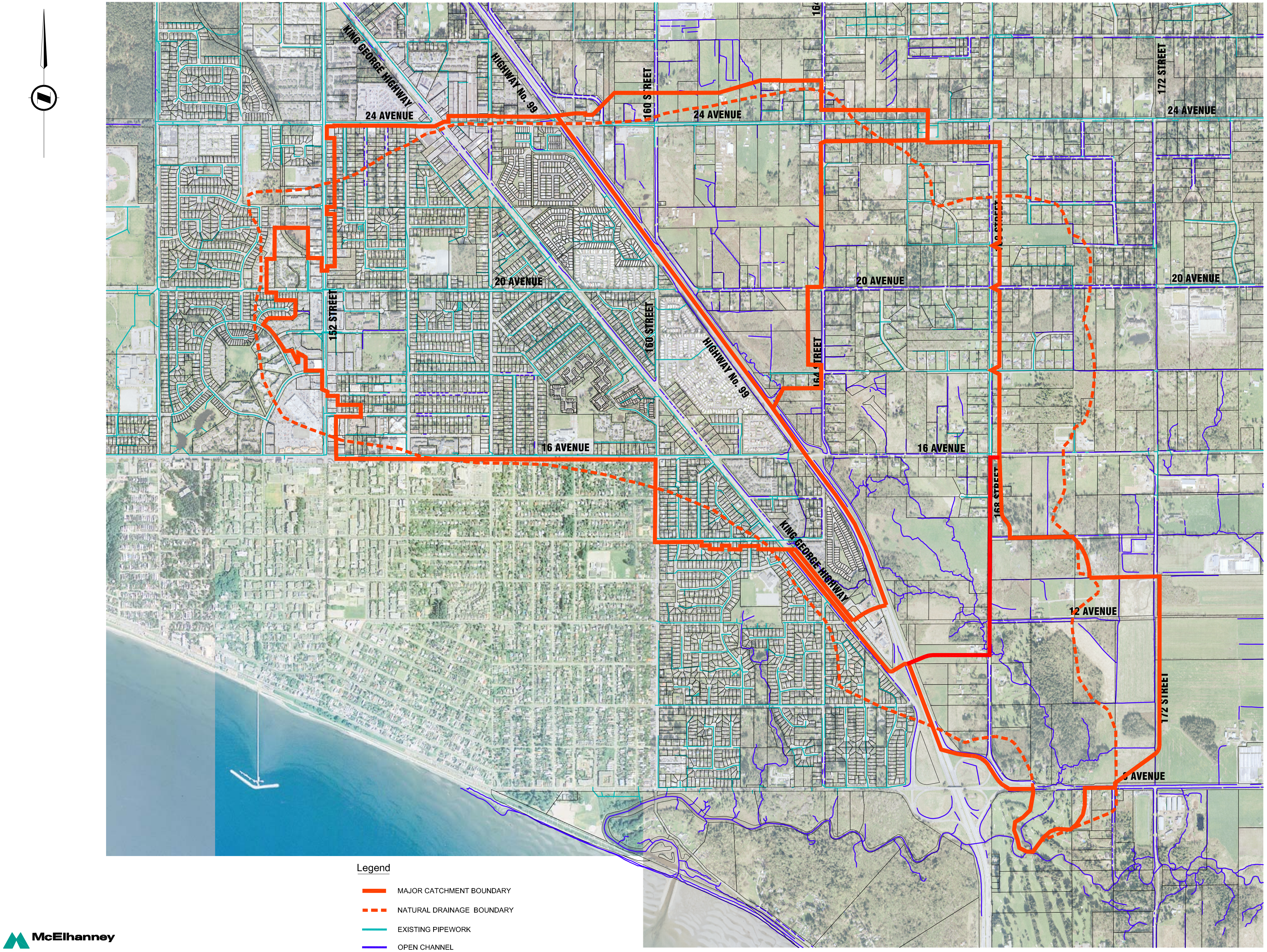

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FERGUS CREEK ISMP

Watershed

Figure 1.1

Surrey with a comprehensive plan for the Fergus Creek Watershed and with a process that is tailored specifically for the needs and aspirations of the City of Surrey.

Over the past decade, both drainage and land use planning has been ongoing within the Fergus Creek Watershed. A great wealth of engineering, planning and environmental information has been assembled and presented in the form of numerous reports. Some of the main issues that we have found in our review of the available material include comments from senior government agencies, issues of land use planning, and a lack of consensus among the many stakeholders with interest in the watershed.

One of the most significant questions regarding the Fergus Creek Watershed is “what will it become over the next 30 years?” Will it become a model for ‘sustainable watershed development and redevelopment’ complete with a stream corridor that is a ‘community resource’? Achieving this vision will require commitment and perseverance by the City to incrementally overcome the legacy of the 20th century, guided by a belief that “we can make it work”. The document provides a roadmap for the 30-year journey, one step at a time.

1.1.1 ISMP Goals and Objectives

The objectives of the Fergus Creek ISMP are to provide an integration of planning drainage and consensus development. The City of Surrey requires that the ISMP be based upon the criteria, framework and objectives as outlined in the GVRD ISMP Template. The City is free to select the most appropriate portions of the template upon which to base the ISMP.

The City has stated objectives for the Fergus Creek ISMP that have been expressed as:

- The ISMP establishes how the City, development community, regulatory agencies and citizens will grow and live within the Fergus Creek Watershed;
- The ISMP Identifies existing conditions within the watershed and project the conditions into the future with a 30 planning year horizon;
- The ISMP provides the City, regulators, the public, and developers with the information required to balance development, growth and the environment.

Specifically there the ISMP identifies potential negative impacts and mitigation strategies required to offset the impacts;

- The ISMP provides financial information required to support the plan;
- The ISMP provides enhancement opportunities for aquatic life and habitat; and
- The ISMP will enable orderly and cost effective development and re-development opportunities.

1.2 FERGUS CREEK WATERSHED

There are several land use plans identified within the Fergus Creek Watershed, including the Official Community Plan. Execution of each land use plan and applications for revised zoning places more demand upon the existing drainage systems within the watershed and upon Fergus Creek itself. A summary of the approved land use plans has been prepared and are shown on **Figure 1.2**. While the various land uses comply with the Official Community Plan for the City of Surrey, the details of environmental protection, engineering services and recreation have not been fully documented. These would normally be prepared as part of the planning process. The ISMP is intended to provide the guidance needed to prepare the more detailed implementation plans and designs for Neighbourhoods and individual developments.

Three distinct areas can be identified: the rural areas east of the BC Hydro Transmission line R.O.W. (BC Hydro R.O.W. indicated by the buffer & habitat areas within the Highway #99 Corridor Land Use Plan); the built up areas west of Highway 99; and the developing strip located between the BC Hydro R.O.W. and Highway 99. The planning for each of these distinct areas has been ongoing and is presently at a different level of detail.

1.2.1 Rural Areas

The rural areas have been included within Grandview Heights Neighbourhood Concept Plan Area 2, which is being planned concurrently with the creation of the ISMP for Fergus Creek. This parallel process allows watershed criteria and values to be established and entrenched within the NCP prior to redevelopment of the rural area. Typical views of the rural areas can be seen on **Figure 1.3**. The area is composed

Plotted: December 13, 2007 , 14:25:13 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_2 - LAND USE.dwg\FIGURE 1.2 - LANDUSE

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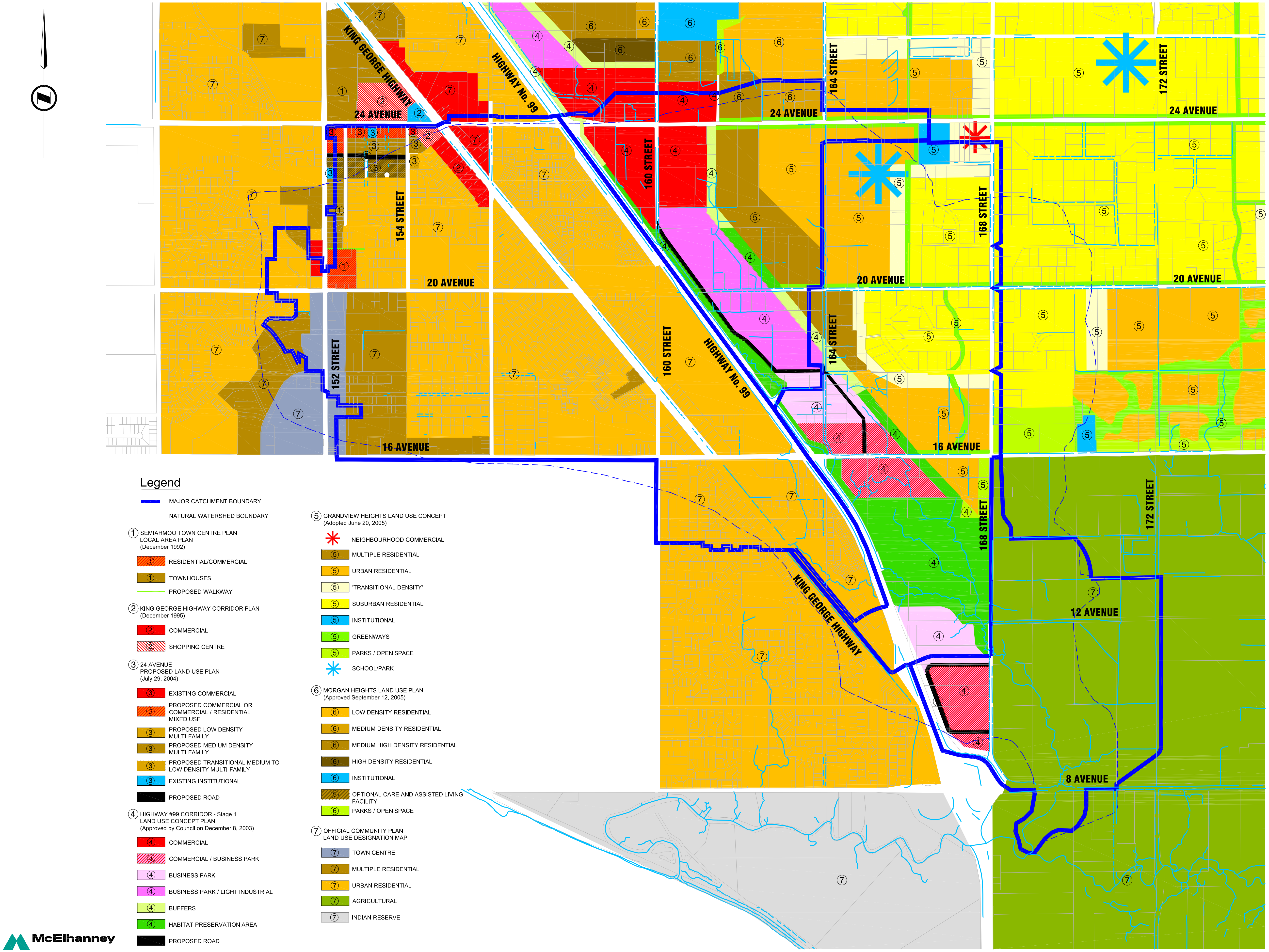

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FERGUS CREEK ISMP
Land Use Designations
Figure 1.2

primarily of rural housing developments with limited impervious surfaces. The current drainage system within the area is defined by roadways and ditches created during forest harvesting and land subdivision.

1.2.2 Highway 99 Corridor

The Highway 99 corridor is undergoing redevelopment following the approval of the Highway 99 Corridor Plan. The Plan calls for the area to be redeveloped with commercial, business park and light industrial land uses. The redevelopment will alter the nature of this portion of the watershed. Mitigation strategies have been established for this area as part of the planning process to manage the changes from landforms shown on **Figure 1.4** to commercial/industrial.

1.2.3 Existing Developments

The area west of King George Highway has undergone the greatest changes to date with near full development as shown on **Figure 1.5**. This portion of the watershed will redevelop with increased density of housing and increased business and commercial land uses. These changes will result in increased impervious surfaces.

1.3 IDENTIFIED DRAINAGE ISSUES

The changes initiated by development, whether for urban housing and business or agriculture can be identified through examination of the natural and existing watershed boundaries as shown on **Figure 1.1**. Since there have been significant alterations of the natural drainage boundaries and the drainage system, even in the rural areas, it is reasonable to assume that the streams have been impacted and are not now in their natural hydrologic regime.

The drainage and runoff conveyance systems within the Fergus Creek Watershed have been studied and assessed in considerable detail in previous studies. The previous studies include:

- Fergus Creek Drainage Study, October 1996, New East Consulting.
- Fergus Creek Master Drainage Plan Update, September 12, 2001.

- Grandview Heights Highway #99 Corridor Servicing Study.
- Preliminary Water Quality & Quantity Management Plan, First Pro South Surrey Commercial Development: 24th Avenue and 160th Street, Surrey, BC, October 15, 2004, Jacques Whitford.

A number of drainage system capacity deficiencies have been identified by the previous studies and have been shown on **Figure 1.6**. The deficiencies have been defined as a lack of discharge capacity that could result in flooding and risk to property and the public. It is this risk that must be reduced to safeguard the people living in, or visiting, the City of Surrey.

The upland urban area drainage systems have been assessed in detail as part of this study and the results are available in the previously noted documents. A series of drainage system upgrades have been previously proposed to reduce the risks of flooding and to address issues within the watershed as shown on **Figure 1.7**. These upgrades should be incorporated into future development or capital projects.

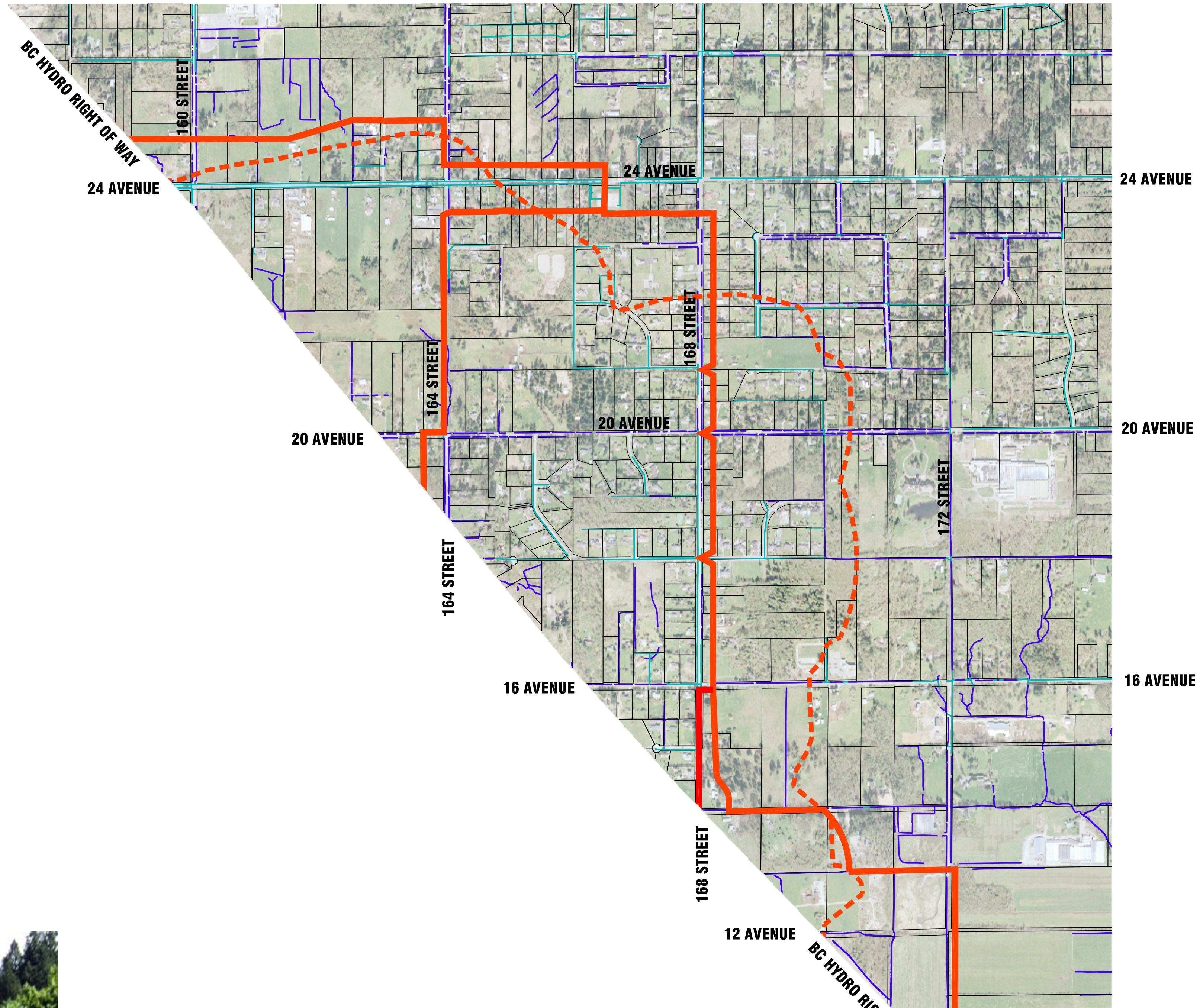
The analysis of the ISMP will focus upon Fergus Creek and its existing and future condition. This does not imply that the urban areas will not be a part of the future planning and of the ISMP, but merely that a substantial number of previous analyses exist and that a duplication of effort is not productive in preparing the ISMP.

1.4 SURFICIAL GEOLOGY

The surficial geology of the Fergus Creek watershed was reviewed and information extracted from soil maps (Luttmerding, 1981) and surveys published by Ministry of Environment. This information is presented on **Figure 1.8**. The primary surficial geological material noted within the watershed is a Capilano Sediment type Cd as described below with some portions of the area underlain by the Vachon drift.

Capilano Sediments (Cb.d.e) are raised marine, deltaic, and fluvial deposits

- Cd, marine and glaciomarine stony (including till-like deposits) to stone less silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30 m thick, containing marine shells.



Legend

- ▬ MAJOR CATCHMENT BOUNDARY
- - - - NATURAL DRAINAGE BOUNDARY
- ▬ EXISTING PIPEWORK
- ▬ OPEN CHANNEL

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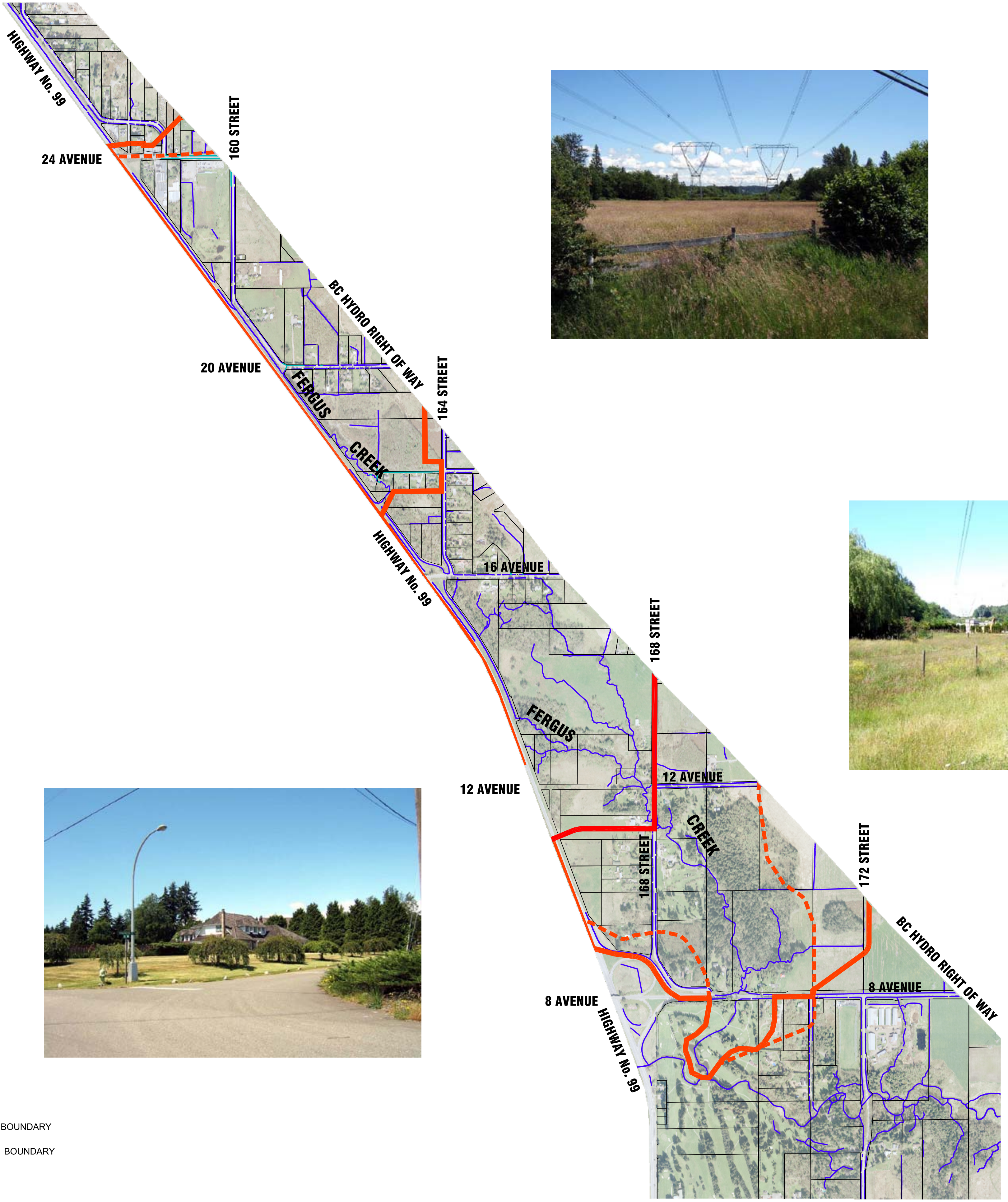
FERGUS CREEK ISMP
Rural Areas
Figure 1.3

Plotted: December 13, 2007 , 14:29:11 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_3 - RURAL AREAS.dwg\FIGURE 1.3 - RURAL AREAS



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- MAJOR CATCHMENT BOUNDARY
- NATURAL DRAINAGE BOUNDARY
- EXISTING PIPEWORK
- OPEN CHANNEL

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FERGUS CREEK ISMP

Highway 99 Corridor

Figure 1.4

Plotted: December 13, 2007 , 14:33:41 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_4 - HIGHWAY 99 CORRIDOR.dwg\FIGURE 1.4 - HWY 99 CORRIDOR

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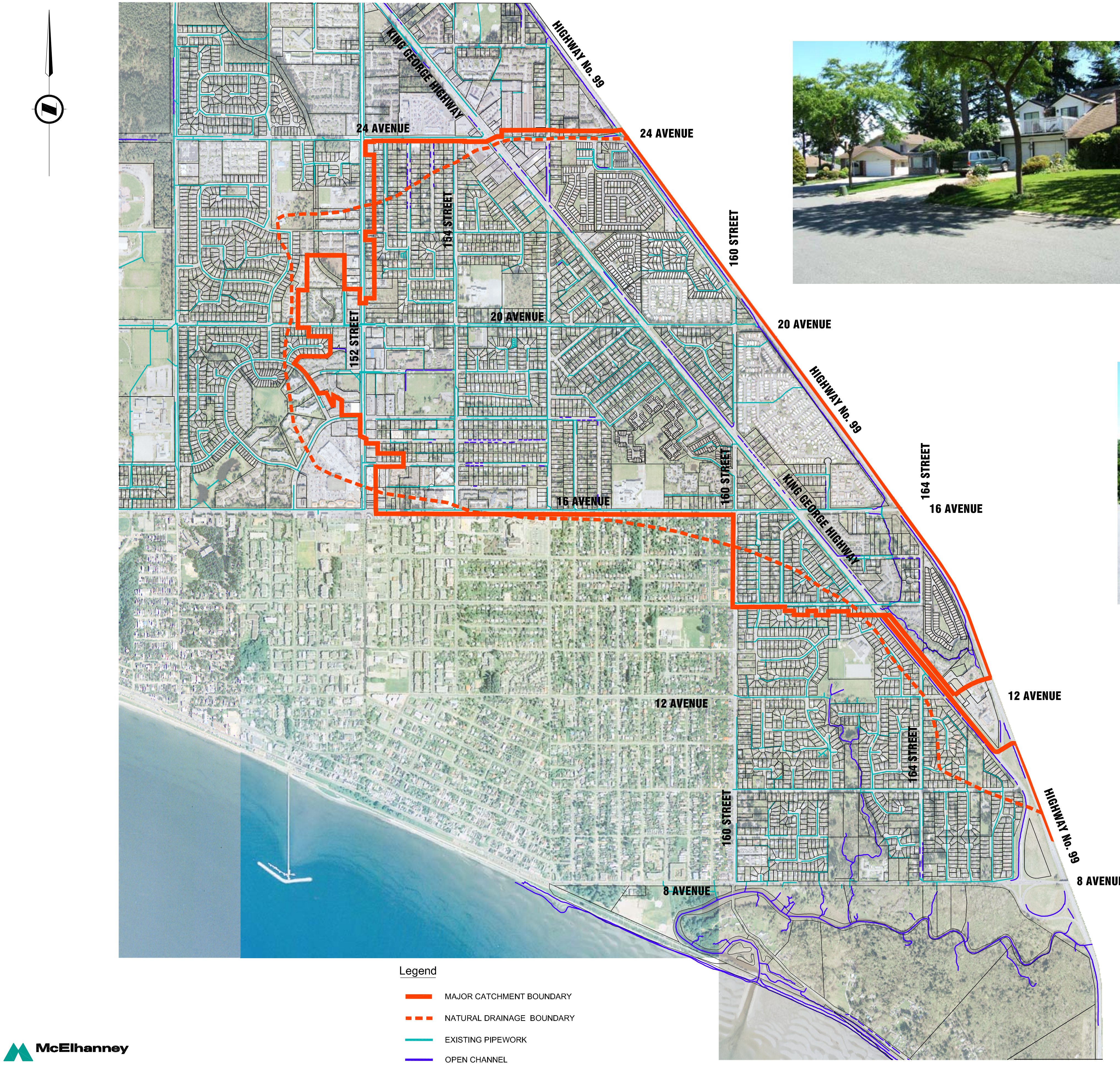

Legend

▬	MAJOR CATCHMENT BOUNDARY
- - -	NATURAL DRAINAGE BOUNDARY
▬	EXISTING PIPEWORK
▬	OPEN CHANNEL

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Existing Suburban Development

Figure 1.5

Plotted: December 13, 2007 , 14:41:54 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_5 - Existing Suburban Development.dwg\FIGURE 1.5 - EX SUBURBAN DEV

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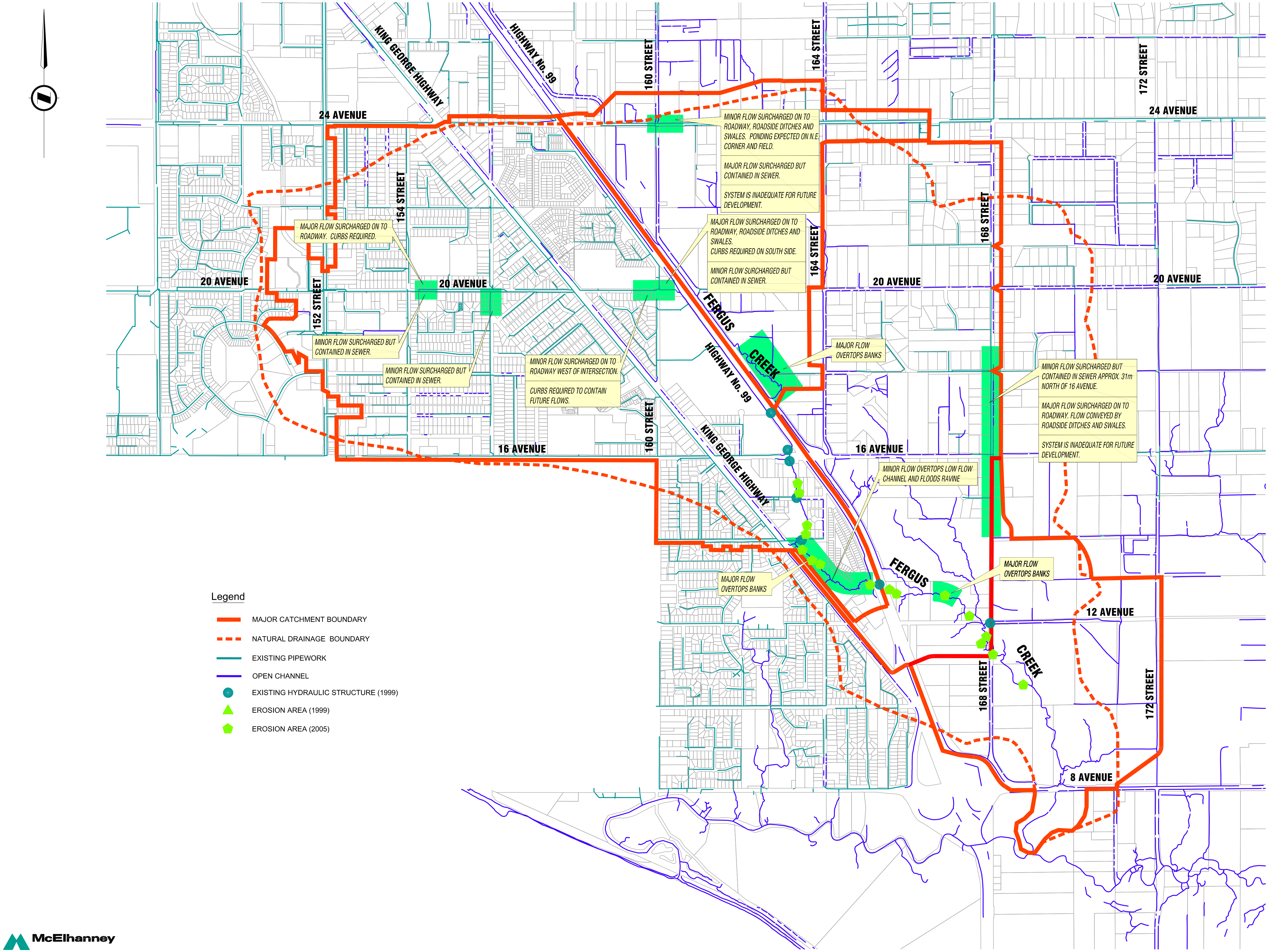

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Drainage System Deficiencies

Figure 1.6

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Plotted: December 13, 2007 , 14:45:09 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_6 - DRAINAGE DEFICIENCIES.dwg\FIGURE 1.6 - DRAINAGE DEFICIENCIES

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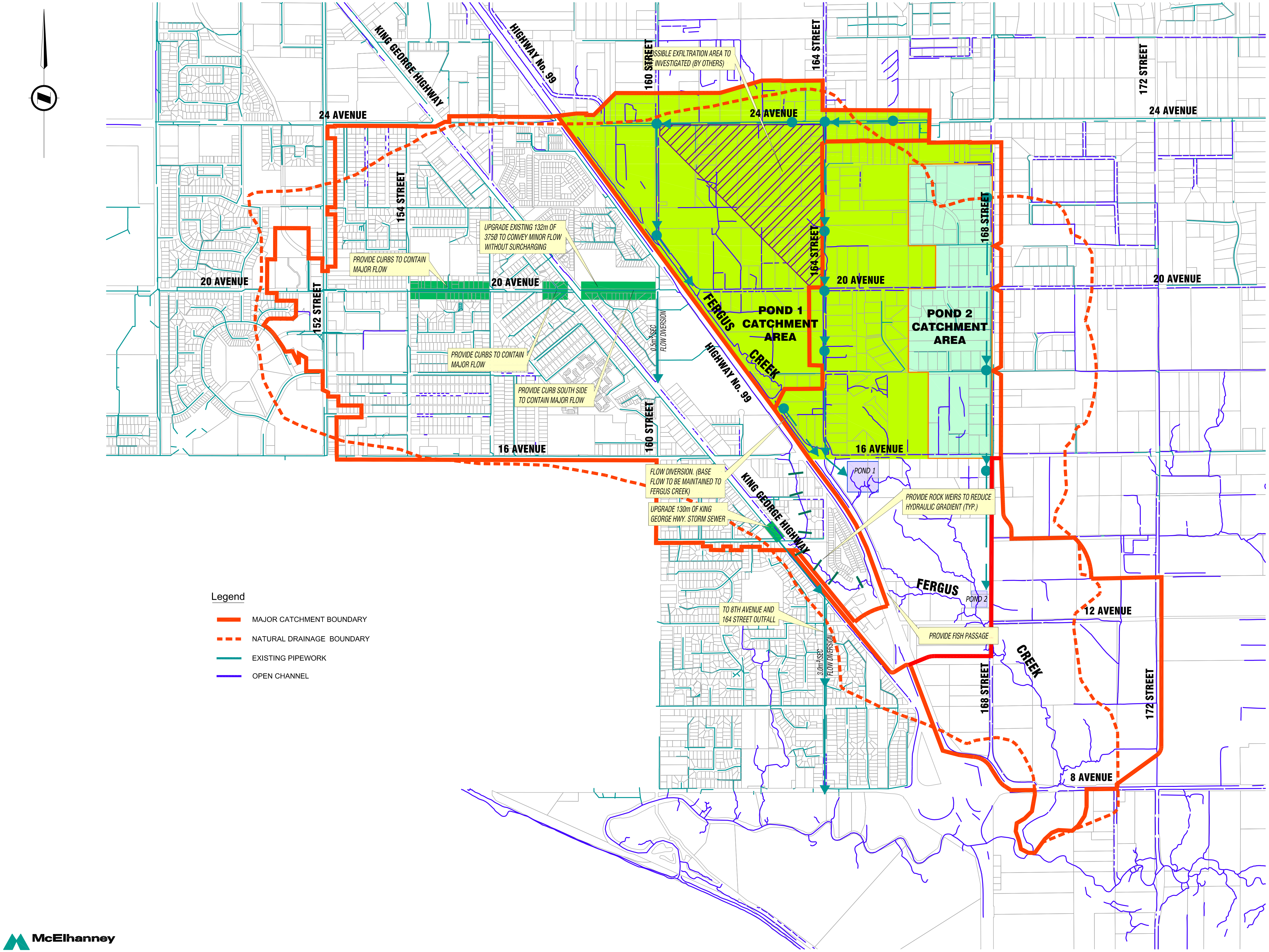

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Proposed Upgrades

Figure 1.7

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Plotted: December 13, 2007 , 14:46:40 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_7 - PROPOSED UPGRADES.dwg\FIGURE 1.7 - PROPOSED UPGRADES

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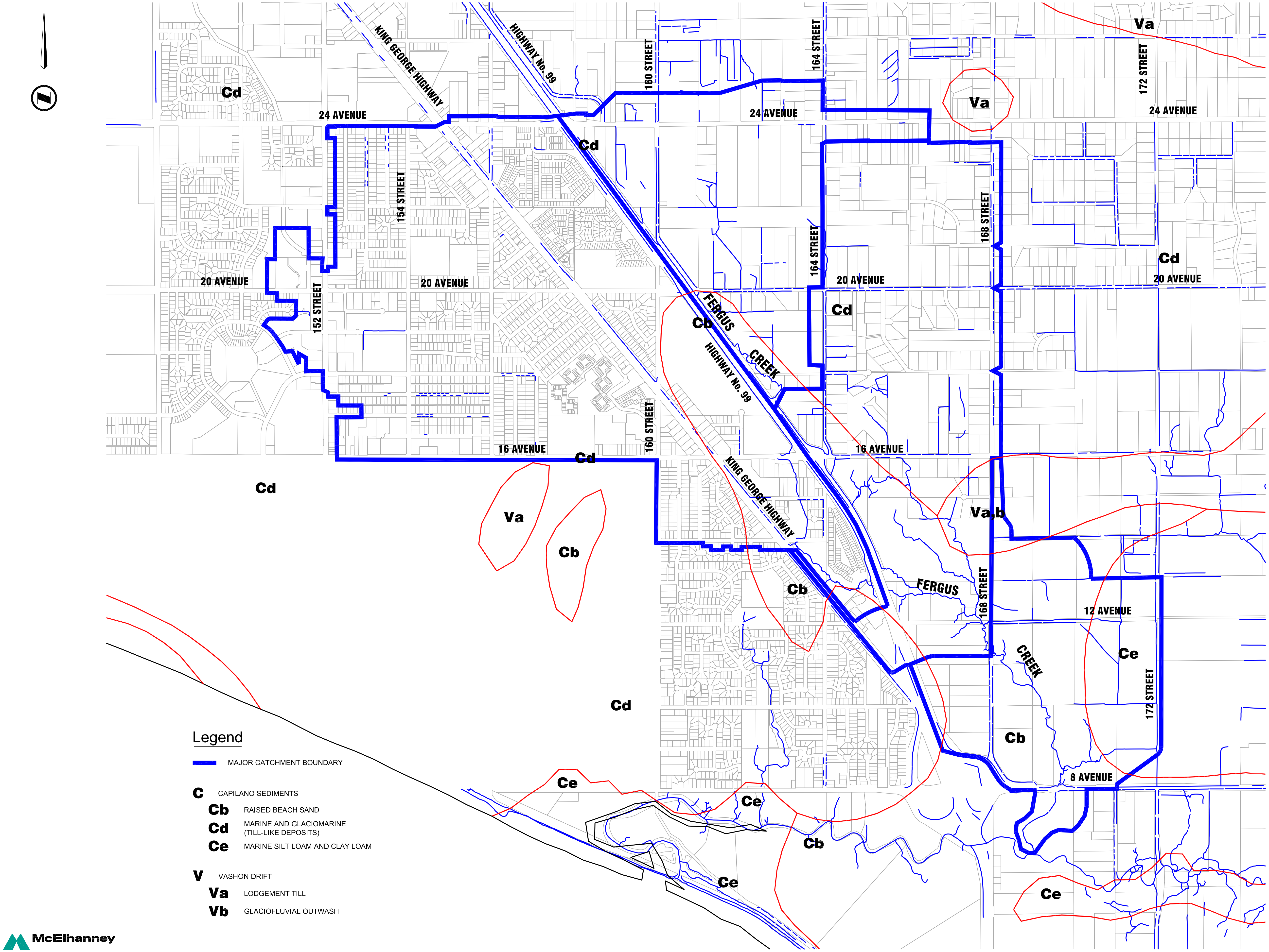

FERGUS CREEK ISMP

Surficial Geology

Figure 1.8

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Plotted: December 13, 2007 , 14:47:36 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_8 - SURFICIAL GEOLOGY.dwg\FIGURE 1.8 - SURFICIAL GEOLOGY

- Cb, raised beach medium to coarse sand 1 to 5 m thick containing fossil marine shell casts;
- Ce, mainly marine silt loam to clay loam with minor sand, silt, and stony glaciomarine material, up to 60+m thick.

The Vashon Drift (Va,b) is comprised of till and glaciofluvial deposits:

- The Va, lodgement till with sandy loam matrix, up to 10 m thick, overlain in many places by gravely ablation till up to 3 m thick.
- The Vb, glaciofluvial sandy gravel and gravely sand outwash and ice-contact deposits

1.5 SURFACE SOILS

Examination of surficial soils is critical to understanding the hydrology of an area. The soils develop as a result of combined physical characteristics of the geological materials, topography and climate. As the surficial soils are often much modified over time by these factors and their physical characteristics will be altered from those of the original geological materials. A brief description of the soil formation processes and the soil types that are present within the Fergus Creek Watershed are included below. This is included to provide a basic understanding of the soil formation processes and can be considered a primer on soil formation. Our past experience leads us to believe that these processes and the resulting soil properties are not well understood by many practitioners in the area of water resources.

1.5.1 Soil Formation

Surface soils are the product of the environmental factors under which they have developed and are developing. These factors include the mineral parent materials plus topographic, climatic and biological influences. The climatic and biological factors are the normal forces of change acting in soil development. The surface soils found within the Fergus Creek Watershed have been highly disturbed from their original state of the mid 19th Century. First logging, followed by farming and most recently urban development has had an impact upon the soils and their ongoing formation processes.

The parent materials of lower Fraser valley soils are of marine origin of glaciomarine silt loams and clay loams including till-like deposits. Elevation and subsequent erosion developed a variety of drainage conditions and upon these primary characters was imposed the effect of a humid and temperate climate.

On the upland the large but unevenly distributed rainfall, together with moderately high temperatures and long growing season, combined to produce luxuriant forest vegetation. Originally the upland supported a heavy forest of Douglas Fir and Western hemlock. In swampy places and where seepage occurred, the Western red cedar was abundant.

The zonal soils have developed under the influence of a coniferous forest. The effect, of a coniferous forest on the soil is normally toward the development of the Podsolic Order of Soil. A major factor in soil genesis is the midsummer drought in July and August, which brings about dehydration and chemical precipitation processes, an upward movement of water and a slight decrease in the acidity of the soil. Chemical precipitation centres in the formation of numerous iron concretions, which have the appearance of small rusty gravel, in the first foot or more of the soil horizon. The pellets of iron oxide thus formed absorb and hold substantial amounts of other minerals.

The presence of comparatively large amounts of essential minerals in these soils shows that solubility of salts and bases must be slow. The upward movement of water during the dry period may also be the reason for the lack of any marked downward movement of minerals and their accumulation in the lower part of the soil horizon. The change in the reaction of the surface soil under well drained conditions from slightly below pH 6.0 in wet seasons to slightly above pH 6.0 in dry seasons may be due to the upward movement of minerals in the dry season.

Although the trees shed a large amount of organic material the accumulation on the ground is seldom more than one or two inches thick. Decomposition is very rapid, but only a very small amount of organic matter becomes intermixed with the mineral soil below.

The colours of the zonal soils beneath the layer of forest litter range from reddish brown to yellowish brown. The reddish brown colour, probably due to unhydrated iron oxide (hematite) is most distinct in the Whatcom series when exposed during cultivation or excavation. The entire weathered layer or solum of the azonal soils seldom extends beyond a depth of two or two and a half feet. Below this layer the parent materials are generally grey, mottled with grey or rusty brown, or bluish grey depending on whether the drainage is good, restricted or poor.

Since the onset of urban development there has been a pattern of removal of large contiguous portions of the organic soil horizon combined with the replacement of the native vegetation with species more desirable in an urban setting. The long term soil genesis under these conditions will ultimately result in soil types that are far different than those found in the mid 19th Century.

1.5.2 Fergus Creek Watershed Soils

The surficial soils of the Fergus Creek Watershed, as shown on **Figure 1.9**, are dominated by three soils commonly named Bose, Sunshine and Heron. These names are typically used to aid in describing the soil type without undue use of the more rigorous system established in the Canadian System of Soil Classification (CSSC). Use of the CSSC descriptors and review of the underlying soil formation processes will allow us to more fully understand the physical properties of the soils. Typical soil lithography, or soil horizons, of the soils documented to occur within the Fergus Creek Watershed are shown on **Figure 1.10**. The often-missed information is the correlation of the common soil name with the more precise soil descriptor that defines the sequence and depths of the soil layers, or more precisely named soil horizons. Of particular importance are the chemical and physical characteristics that are associated with the soil horizons. For example a Gleysol is a soil that has experienced extended durations of saturation under anoxic conditions.

Bose

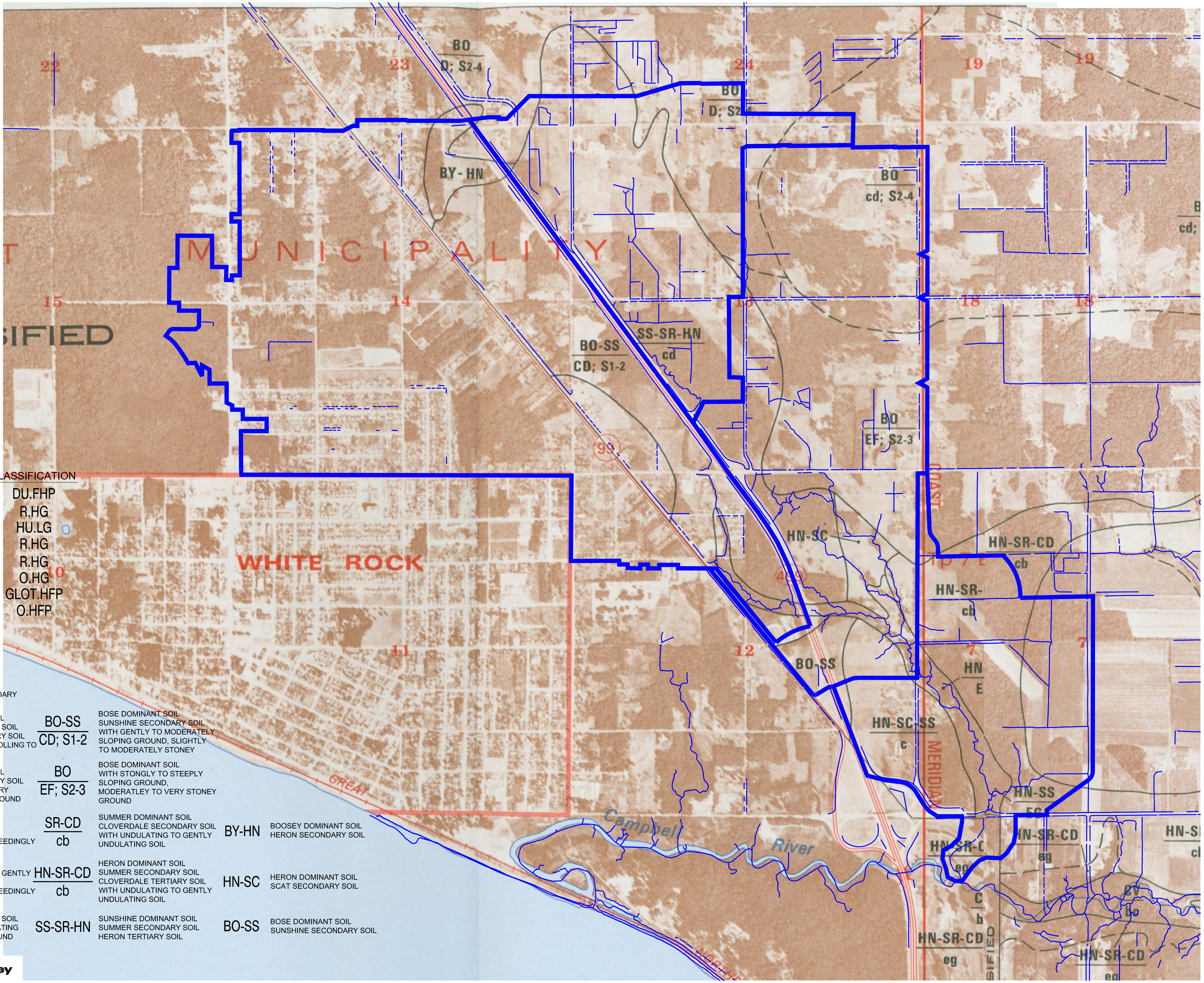
The Bose Soil is classified as a Duric Ferro-Humic Podzol (DU.FHP) with a common horizon sequence of LFH or 0, Ae, Bhf, Bf or Bfg, BCc, and C. They have a strongly cemented duric horizon (Bhf) that usually has an abrupt upper boundary to an overlying podzolic B horizon and a diffuse lower boundary at least 50 cm below surface. Cementation is usually strongest near the upper boundary, which occurs commonly at a depth of 40-80 cm from the mineral surface. Usually the color of a duric horizon differs little from that of the parent material and the structure is massive or very coarse platy. Moist clods at least 3 cm thick usually cannot be broken in the hands. Air-dry clods of the material do not slake when immersed in water. They may have an Ah horizon and mottles indicative of gleying in some part of the control section. Bose soils would tend to be well drained but may have some resistance to flow resulting from the cemented Bf horizon that would in turn gley the upper Ae horizon.

Sunshine

The Sunshine soil series is defined as an Orthic Humo-Ferric Podzol (O.HFP) with the typical soil horizons sequencing of a leaf litter LFH, a lightly collared eluviated Ae, a podzolic Bf with an accumulation of material, elevated iron content, and is coarser than clay, and overly a BC and C parent material. The Bf horizon may be cemented but not as strongly as in the Duric soils. The Sunshine soils would tend to be well drained but may have some resistance to flow resulting from the cemented Bf horizon.

Heron R.HG

Heron soils series, as with the sunshine Soils are part of the Great Group of Humic Gleysol and have a dark-coloured A horizon in addition to the general properties of soils of the Gleysolic order. The Heron Soils are of the further differentiated from the Sunshine Soils and defined as a Rego Humic Gleysols (R.HG.). These soils are characterized as having a common horizon sequence: LFH or 0, Ah, Cg. These soils have the general properties specified for the Gleysolic order and the Humic Gleysol great group. They differ from the Orthic Humic Gleysols in that they lack a B horizon at least 10 cm thick. Typically, they have a well-developed Ah horizon overlying a gleyed C horizon. This soil description would also apply to the Boosey, and Carvalth soils. The Humic Gleysols are typical of solids that have developed in extended periods of saturation and exhibit poor vertical drainage through the soil horizons.



MAP SYMBOL	SOIL NAME	CLASSIFICATION
BO	BOSE	DU.FHP
BY	BOOSEY	R.HG
CD	CLOVERDALE	HU.LG
CV	CARVOLTH	R.HG
HN	HERON	R.HG
SC	SCAT	O.HG
SR	SUMMER	GLOT.HFP
SS	SUNSHINE	O.HFP

Legend

▬ MAJOR CATCHMENT BOUNDARY

HN-SR-CD eg	HERON DOMINANT SOIL SUMMER SECONDARY SOIL CLOVERDALE TERTIARY SOIL WITH MODERATELY ROLLING TO HILLY GROUND
HN-SS EG	HERON DOMINANT SOIL SUNSHINE SECONDARY SOIL WITH STONGLY TO VERY STEEPLY SLOPING GROUND
BO D; S2-4	BOSE DOMINANT SOIL WITH MODERATELY SLOPING GROUND, MODERATLEY TO EXCEEDINGLY STONEY GROUND
BO cd; S2-4	BOSE DOMINANT SOIL WITH UNDULATING TO GENTLY ROLLING GROUND, MODERATLEY TO EXCEEDINGLY STONEY GROUND
CV bc	CARVOLTH DOMINANT SOIL WITH GENTLY UNDULATING TO UNDULATING GROUND
BO-SS CD; S1-2	BOSE DOMINANT SOIL SUNSHINE SECONDARY SOIL WITH GENTLY TO MODERATELY SLOPING GROUND, SLIGHTLY TO MODERATELY STONEY
BO EF; S2-3	BOSE DOMINANT SOIL WITH STONGLY TO STEEPLY SLOPING GROUND, MODERATLEY TO VERY STONEY GROUND
SR-CD cb	SUMMER DOMINANT SOIL CLOVERDALE SECONDARY SOIL WITH UNDULATING TO GENTLY UNDULATING SOIL
HN-SR-CD cb	HERON DOMINANT SOIL SUMMER SECONDARY SOIL CLOVERDALE TERTIARY SOIL WITH UNDULATING TO GENTLY UNDULATING SOIL
SS-SR-HN	SUNSHINE DOMINANT SOIL SUMMER SECONDARY SOIL HERON TERTIARY SOIL
BY-HN	BOOSEY DOMINANT SOIL HERON SECONDARY SOIL
HN-SC	HERON DOMINANT SOIL SCAT SECONDARY SOIL
BO-SS	BOSE DOMINANT SOIL SUNSHINE SECONDARY SOIL

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FERGUS CREEK ISMP

Soils

Figure 1.9

Plotted: December 13, 2007 , 14:49:33 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 1_9 - SOILS.dwg\FIGURE 1.9 - SOILS

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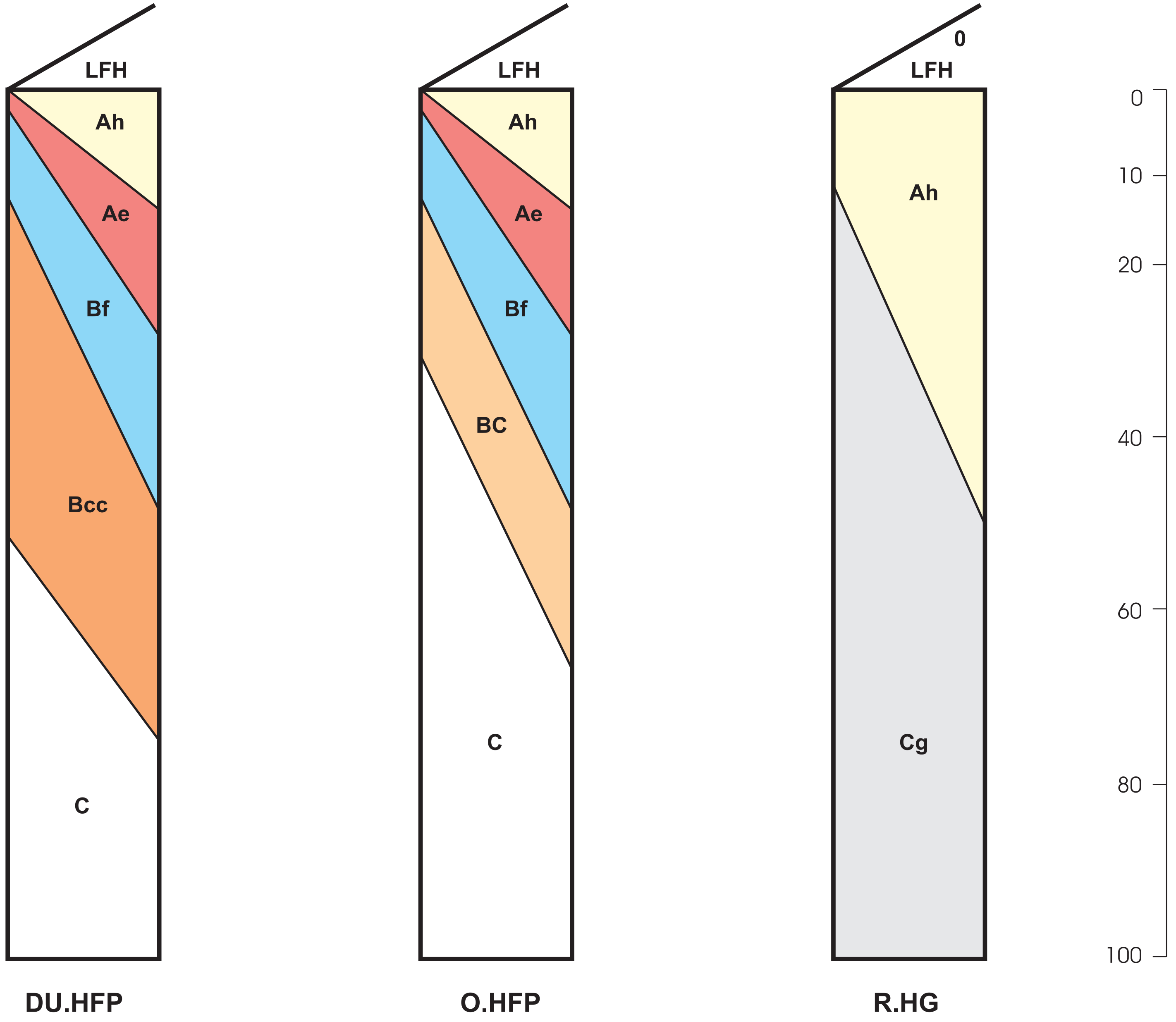
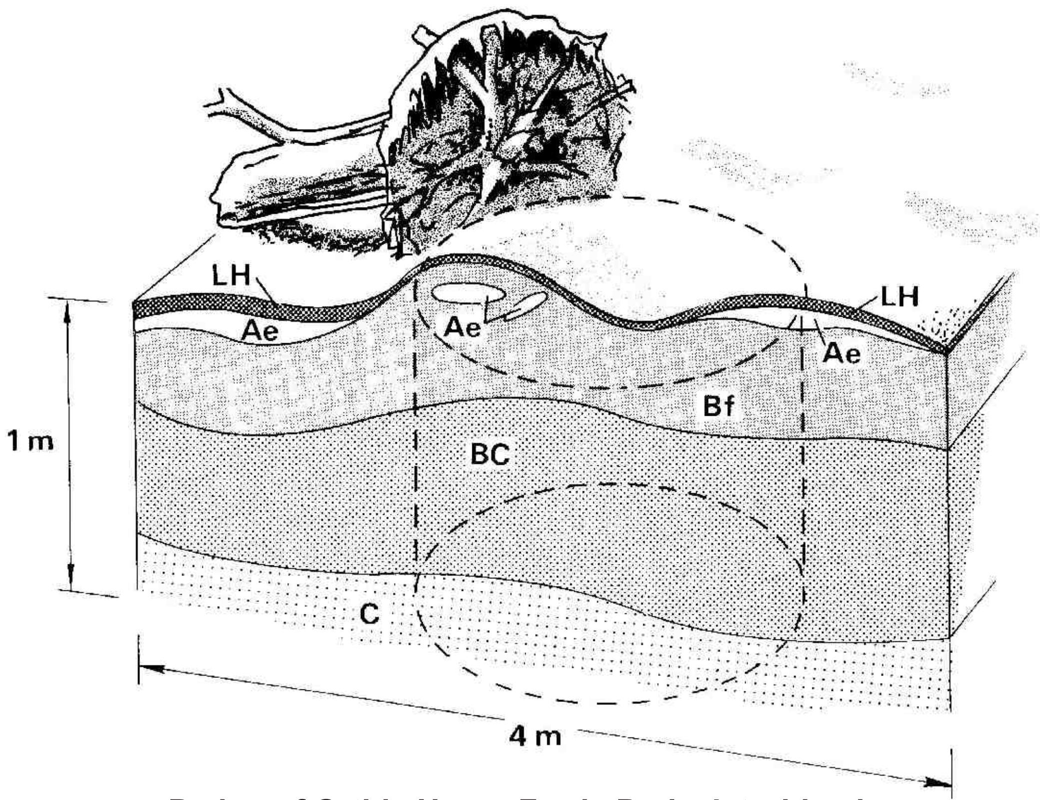


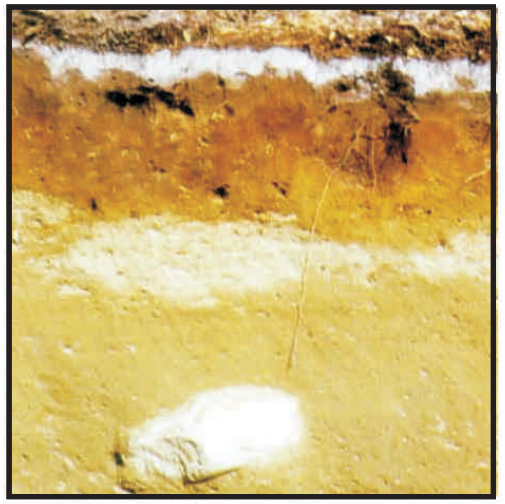


Pedon of Orthic Humo-Ferric Podzol, turbic phase, in hummocky terrain due to blowdown of trees.

LEGEND

DU.HFP	**Duric Humo-Ferric Podzol**	Duric Humo-Ferric Podzols usually have L, F, and H horizons. They may have an Ah horizon and mottles indicative of gleying in some part of the control section. A strongly cemented duric horizon (Bcc) with cementation occurring in the upper boundary at a depth typically from 40-80 cm.
O.HFP	**Orthic Humo-Ferric Podzol**	Orthic Humo-Ferric Podzols usually have L, F, and H horizons and an Ae horizon, and they may have an Ah horizon. They may have mottles indicative of gleying at some depth within the control section. They have a podzolic B horizon at least 10 cm thick and parts of the Bf horizon may be cemented.
R.HG	**Rego Humic Gleysol**	These soils have the properties that indicate prolonged periods of intermittent or continous saturation with water and reducing conditions. Typically they have a well-developed Ah horizon overlaying gleyed C horizon.

Orthic Humic Gleysol



Orthic Ferro-Humic Podzol

McElhanney

FERGUS CREEK ISMP
Soil Profile
Figure 1.10

Summary

The northern portion of the Fergus Creek watershed predominately consists of Bose Sunshine Soils whereas the southern portion consists of the Heron Soils series. Given this underlying geological composition we would anticipate moderate to low infiltration rates throughout the Fergus Creek watershed. Although the Bose and Sunshine Soils tend to be well drained, the underlying Bf horizon layer would tend to dictate infiltration rates of the sub soils. The Gleysolic order of the Heron Soils also leads to the assumption of low infiltration rates in the south portion of the watershed. As part of this study field testing have been performed to determine infiltration rates.

2.0 SPECIAL ISSUES

Creation of the Fergus Creek ISMP must result in more than just another drainage study that acknowledges the aquatic environment. This is where the vision of the future watershed begins to form and where the direction of future endeavours is established. We must recognize the need to provide balance in satisfying the needs for the environment, development and flood protection.

The creation of the Fergus Creek ISMP recognizes the changing values of society in the increased importance of the environment and recreation within the City. These expectations also call for the creation of a more sustainable City that provides advancement in the liveability of urban areas. The ISMP has the potential to provide value to the City and future generations.

The beginnings of this theme were stated with the Official Community Plan (OCP) for the City of Surrey. Selected portions of the OCP have been extracted and included here to provide a general background and a reason for the unique direction that this ISMP process has taken.

2.1 SURREY OCP

The planning and development process is about managing growth in the City of Surrey. The ISMP supports the growth process while safeguarding the environmental values and allowing recreational opportunities to be created. The OCP has the following to say about managing growth.

Efficient land use allows the City to continue growing while preserving open space and agricultural areas. A compact form of development contains future growth within planned areas, provides new opportunities for housing, business and mobility, and allows more efficient use of City utilities, amenities and finances. The City will strengthen the *nodal development pattern of City Centre, Town Centres, Neighbourhood Centres and Workplace Areas as the framework for future growth.*

Planning the future development and redevelopment within the City can have a dramatic impact upon the economic sustainability of the City. Considerations of the economy and costs must be given when creating a vision of the future of the Fergus Creek Watershed. The OCP has the following to say about economic sustainability

The Official Community Plan is committed to the concept of a complete city. A complete city builds upon a strong and sustainable local economy, and balances it with a high quality residential environment. A strong local economy provides livelihood for residents in terms of jobs, consumer goods and services, and business and investment opportunities. A strong local economy is also important for the fiscal health and functioning of the City in providing the public infrastructure, amenities, facilities and services that contribute to the quality of life in our City. A strong local economy and quality living are dependent upon the City developing a positive and attractive image and character that will enhance growth and investment, as more people and businesses perceive Surrey as a desirable location to live, do business, and invest.

Ensuring that a well rounded community is created from the existing mixture of land uses within the Fergus Creek Watershed is an essential outcome of the planning of future development and redevelopment within the City. The OCP has the following to say about complete communities

Complete communities have a wide range of housing choice, opportunities for employment, business and investment opportunities, recreation, relaxation and a full range of services and leisure activities. In building complete communities, towns and neighbourhoods will be planned to accentuate their own distinct identity. Complete communities are liveable and energy efficient. Neighbourhoods will be designed to be a safe and attractive environment for residents to walk and cycle to a variety of places and activities close to home.

Natural areas are of tremendous value to the City. This can be seen in the large tracts of green space that have been set aside in this City of Parks. The Fergus Creek Watershed must become a part of the overall fabric of the City, complete with its contribution of protected natural areas. The OCP has the following to say about preservation of natural areas

Natural areas are to be preserved, protected and used where appropriate for park and recreational purposes. Measures are needed to reduce the impact of development on the natural environment.

The times are changing as are the expectations of the residents of the City of Surrey. To accommodate the changes there is a need to look at development with a new perspective and to accommodate new visions for the future. A part of the future will include more compact development footprint to maintain affordability of housing and business in the City of Surrey. The OCP has the following to say about growth within compact urban areas

The City encourages growth and forms of development that effectively utilize land and City resources, creating new opportunities to grow in ways that can enhance the qualities of our neighbourhoods and communities.

The Surrey OCP is a forward looking document providing direction in shaping the vision of the future City.

2.2 FERGUS CREEK WATERSHED VISION

The Fergus Creek ISMP must take inspiration from the OCP and look beyond the simple drainage issues and the sum of environmental values. The ISMP must provide information to allow the planners of the City to establish a vision of the City within future Neighbourhood Plans and Redevelopment Plans within the Fergus Creek Watershed.

The reasons that require the ISMP to look into the future vision of the watershed are simple. The form of the development within the watershed directly impacts the environmental values contained of the Fergus Creek Watershed. Therefore, the future form of development within the watershed directly impacts creating a protection and mitigation plan. The successful mitigation plan is contingent upon understanding the vision of the watershed, or sufficient contingencies must be built into the plan to allow for unanticipated development forms.

The form of development and the potential vision of the watershed can be created through examination of the development form of other similar areas within the City of Surrey. A number of example existing land uses and their build form are described in **Table 2.1** and depicted in the referenced figures that follow.

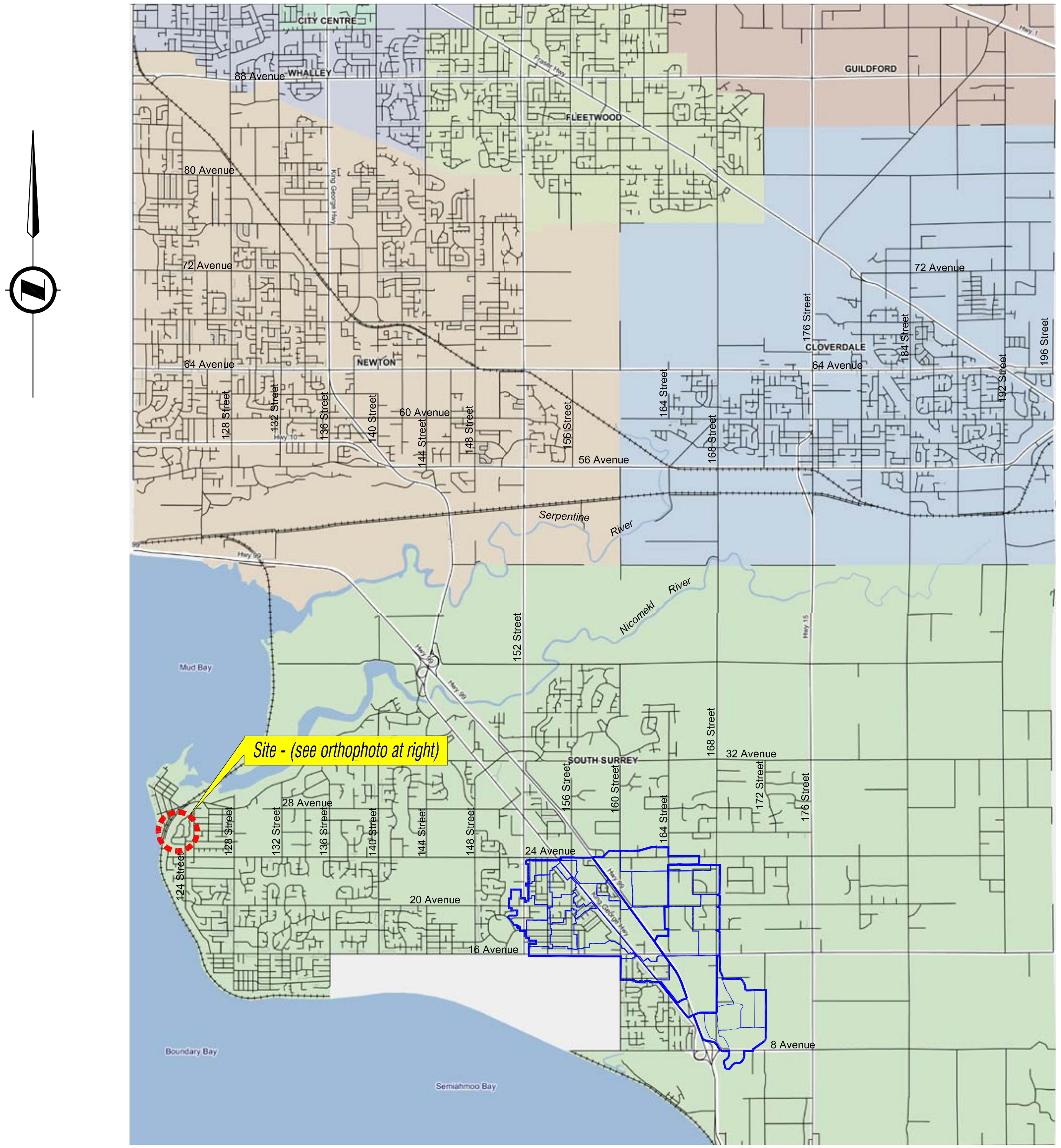
One important item to note is that in almost every case the number of residential units permitted under the zoning was not achieved in the built form. This factor would have an impact if the potential economics of development relies upon the densities implied by the zoning.

Three general types of redevelopment will be occurring within the Fergus Creek Watershed. These include:

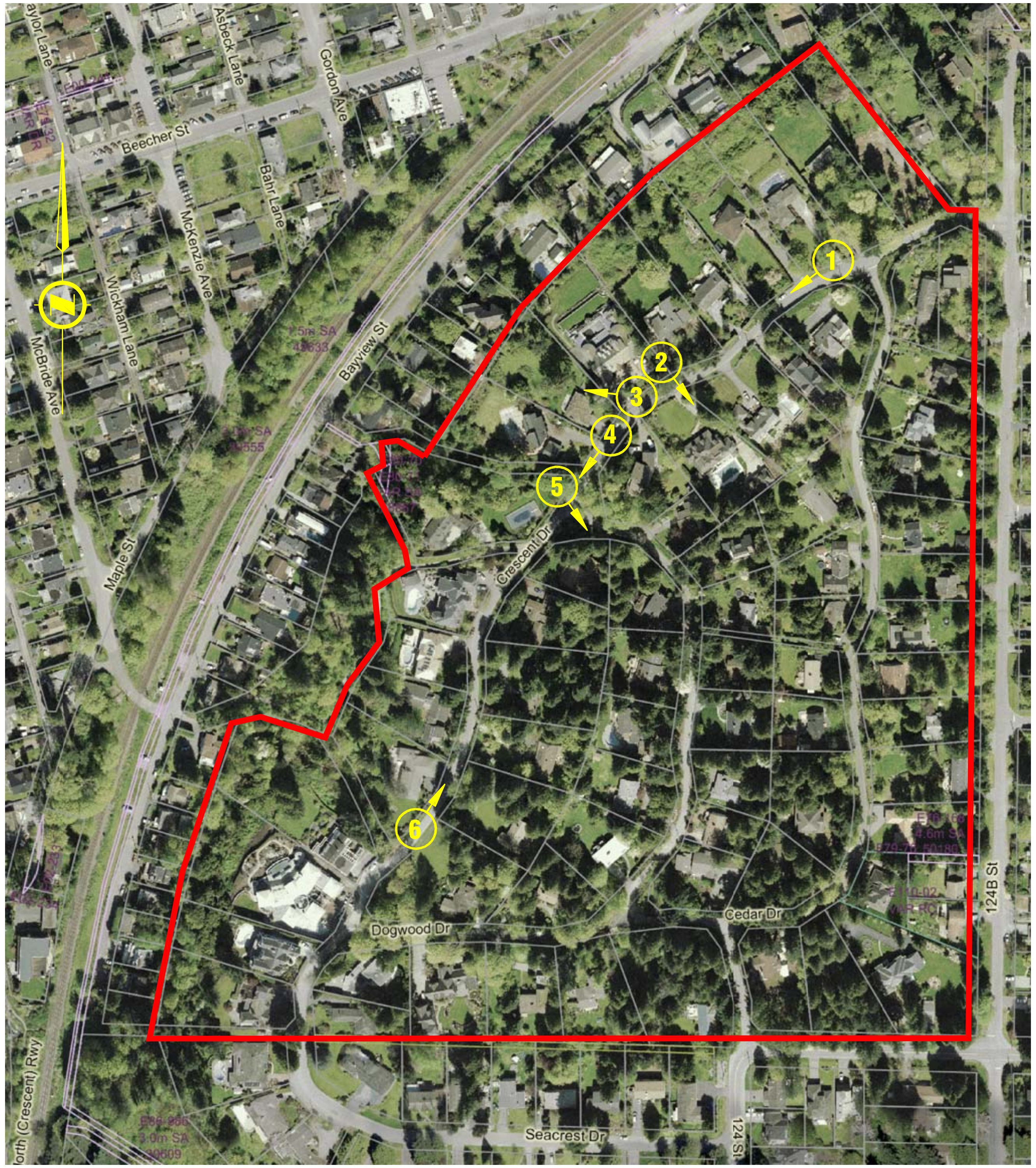
1. Redevelopment of the rural areas east of the BC Hydro R-O-W,
2. Redevelopment of the urban areas west of Highway 99, and
3. Ultimately the redevelopment of the Highway 99 Corridor.

The **Figures 2.1** through **2.17** depict examples of possible redevelopment in the rural areas in Grandview Heights.

SURREY
CITY OF PARKS



Location Plan



Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 2
Percent Impervious: 35
Housing Type: Detached
Figure 2.1 - Location

McElhanney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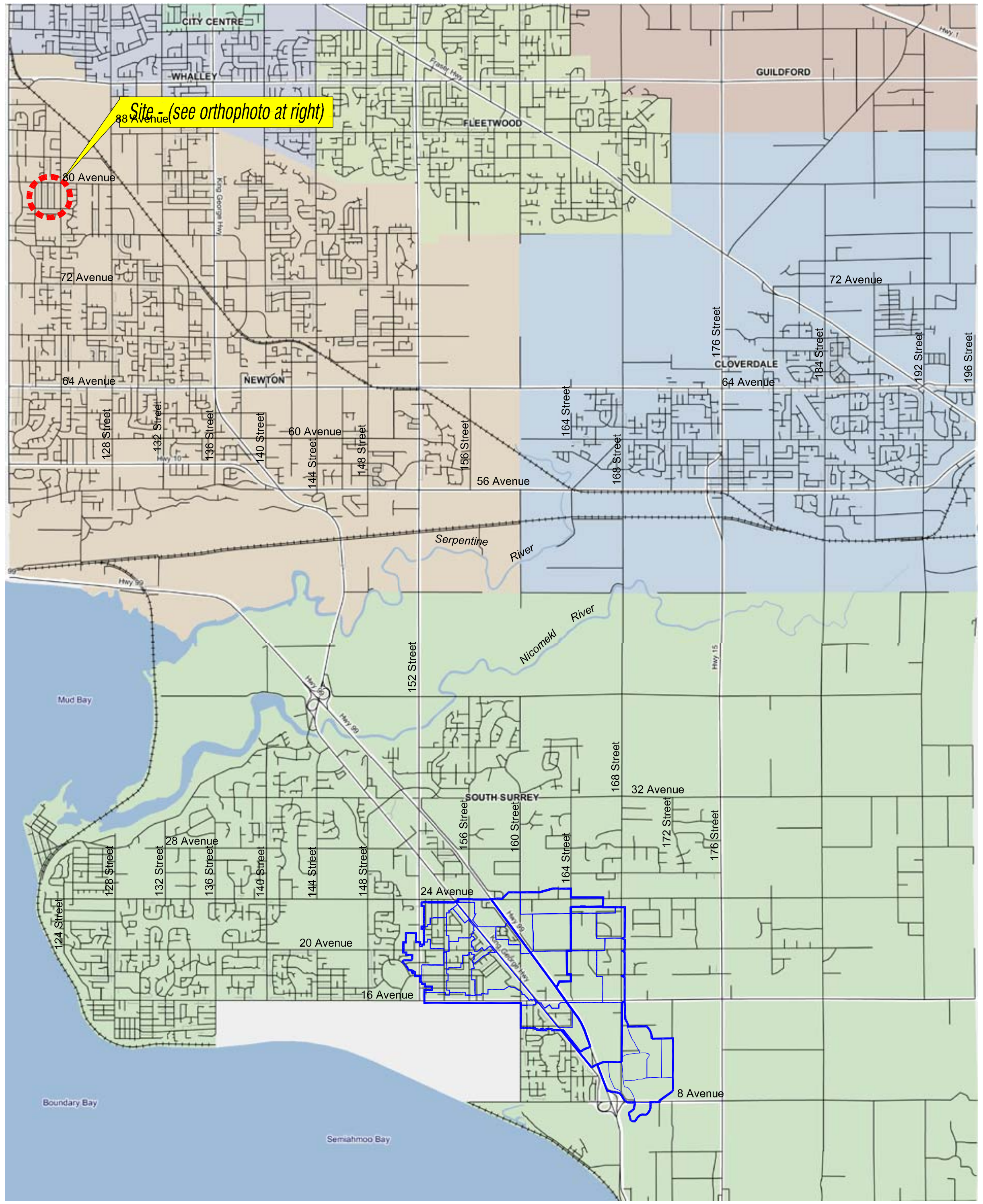
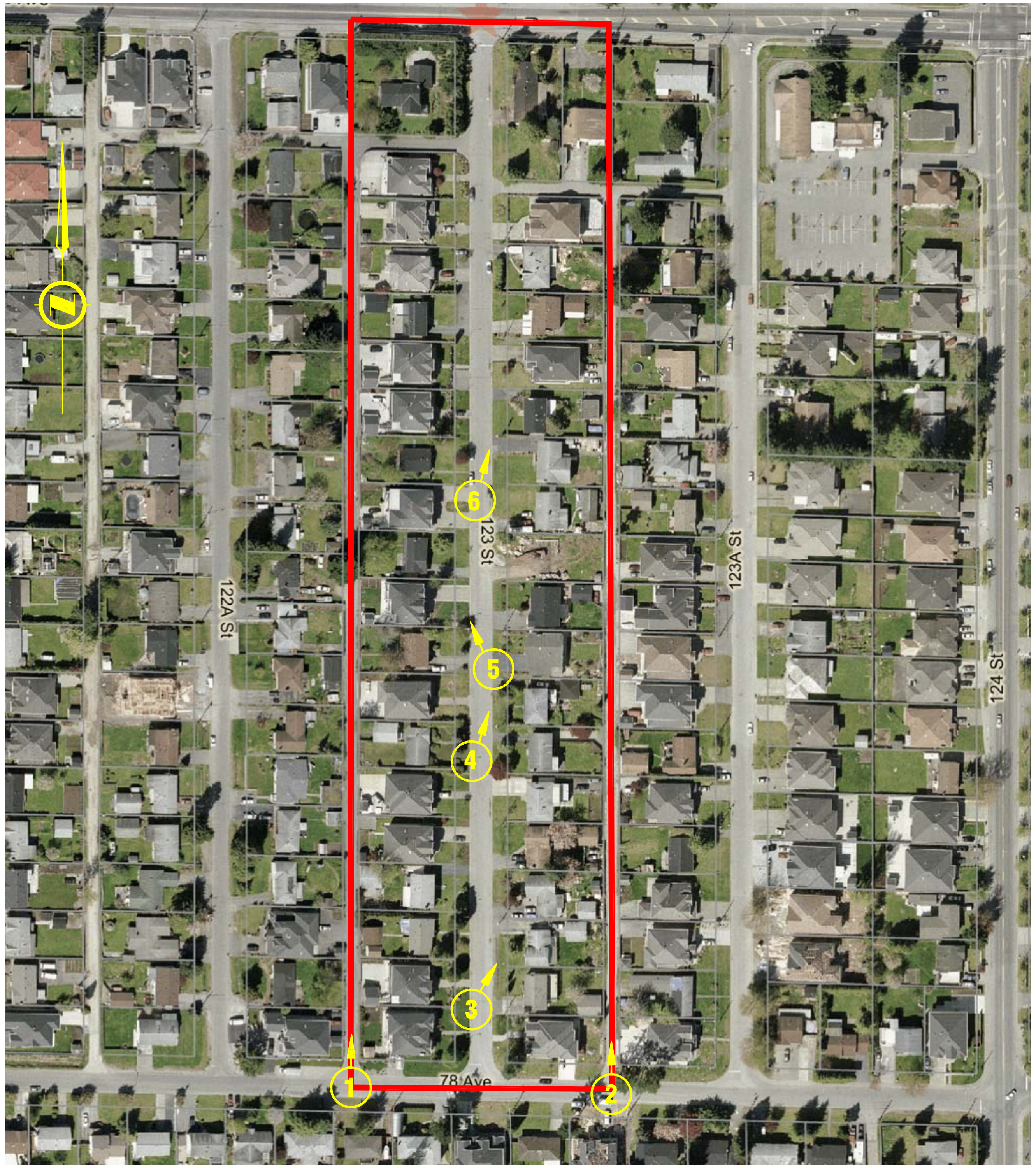
FERGUS CREEK ISMP
Units per Acre: 2
Percent Impervious: 35
Housing Type: Detached

Figure 2.1 - Photos



Location Plan



Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 4
Percent Impervious: 60
Housing Type: Detached
Figure 2.2 - Location

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McElhanney

FERGUS CREEK ISMP

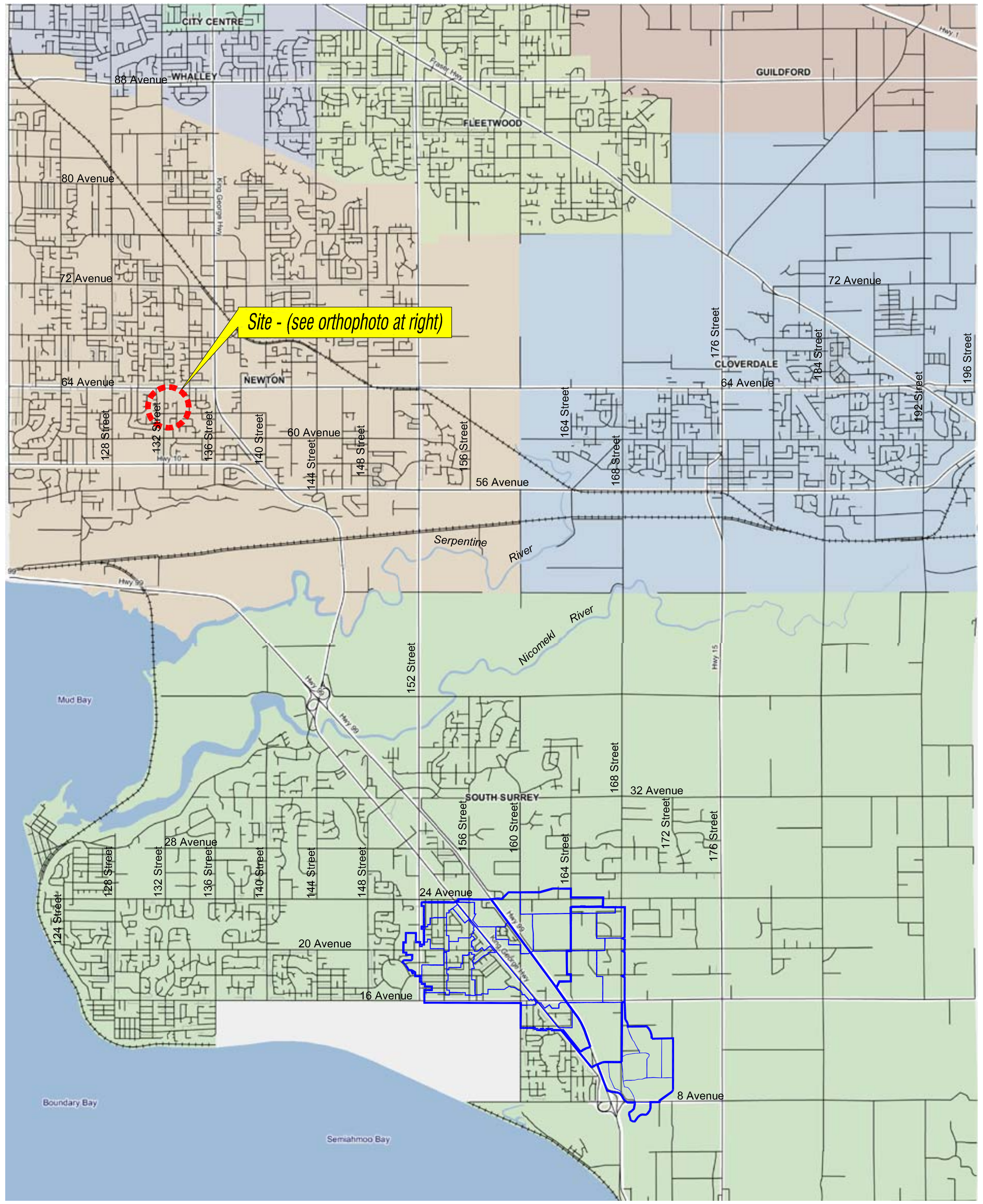
Units per Acre: 4

Percent Impervious: 60

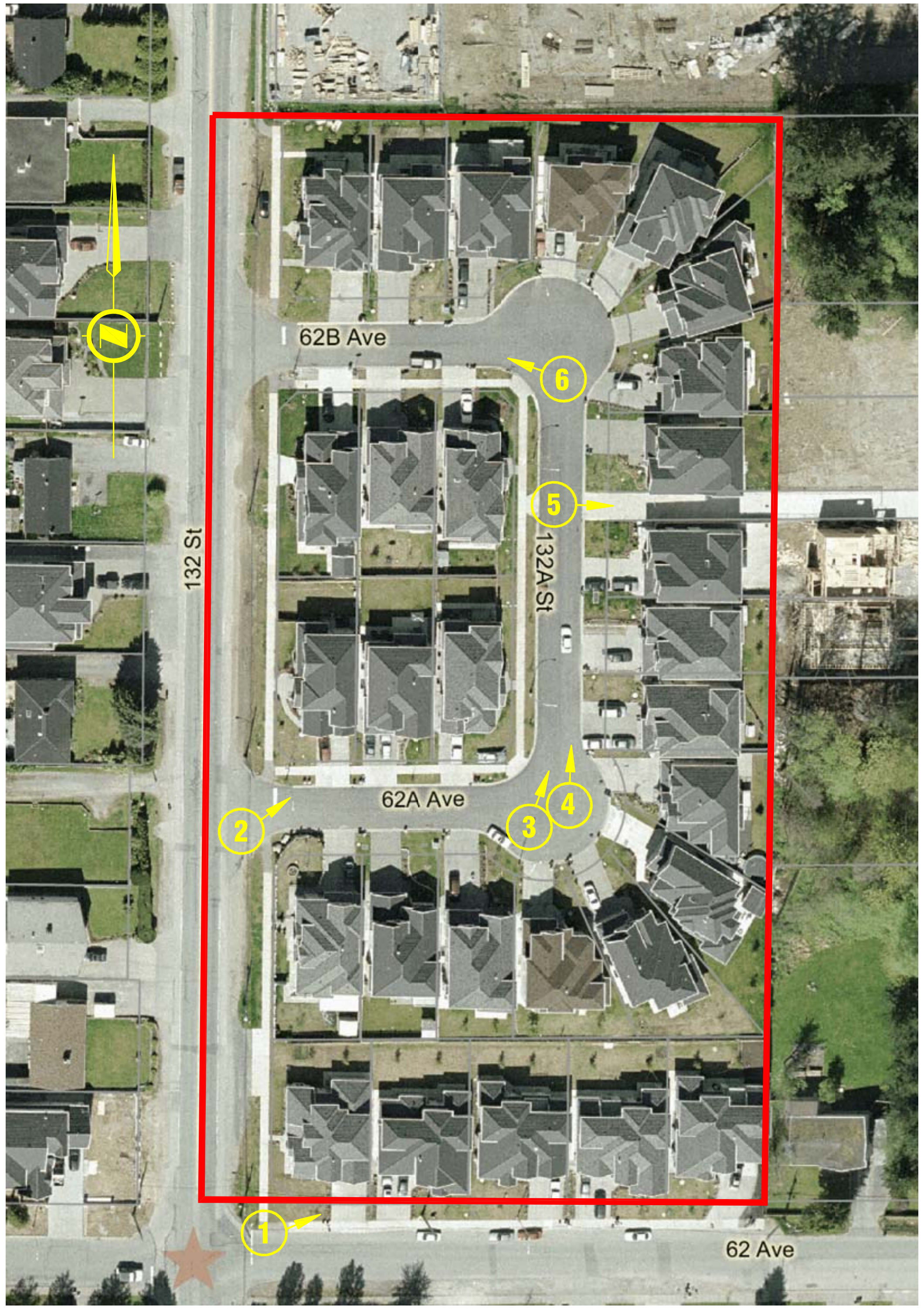
Housing Type: Detached

Figure 2.2 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 6
Percent Impervious: 70
Housing Type: Detached
Figure 2.3 - Location

McElhanney

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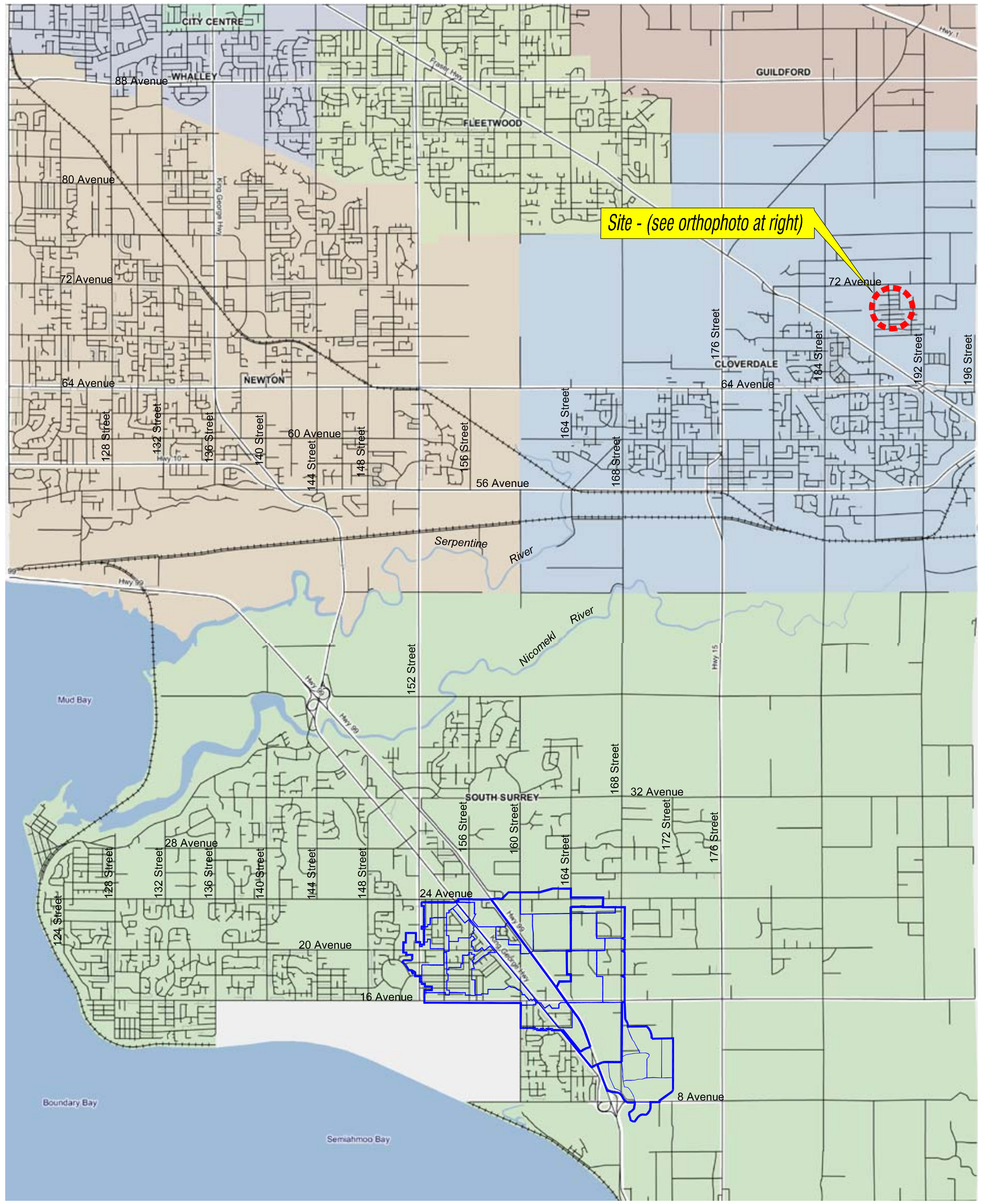
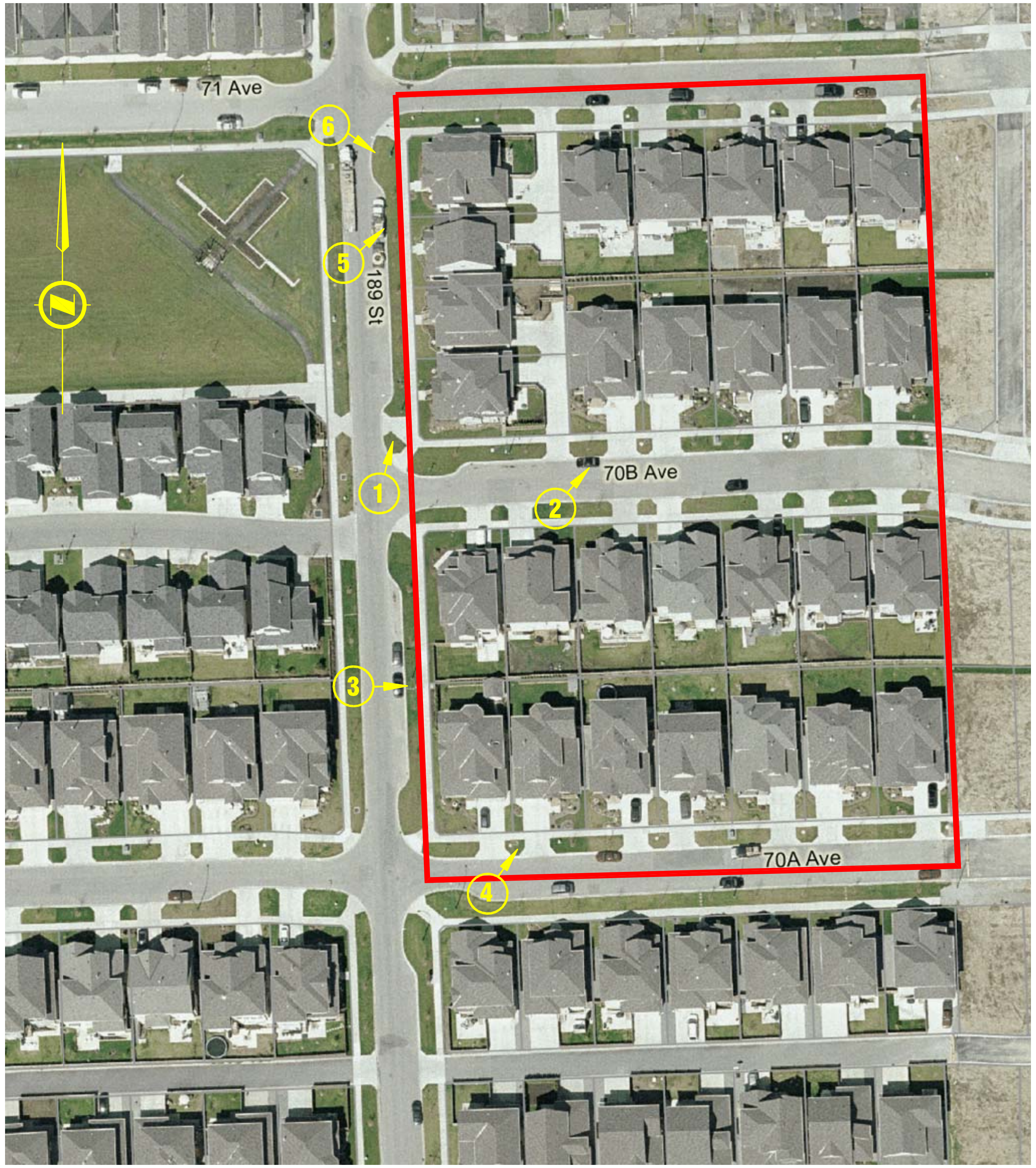
FERGUS CREEK ISMP
Units per Acre: 6
Percent Impervious: 70
Housing Type: Detached
Figure 2.3 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 8
Percent Impervious: 60
Housing Type: Detached
Figure 2.4 - Location

McElhanney

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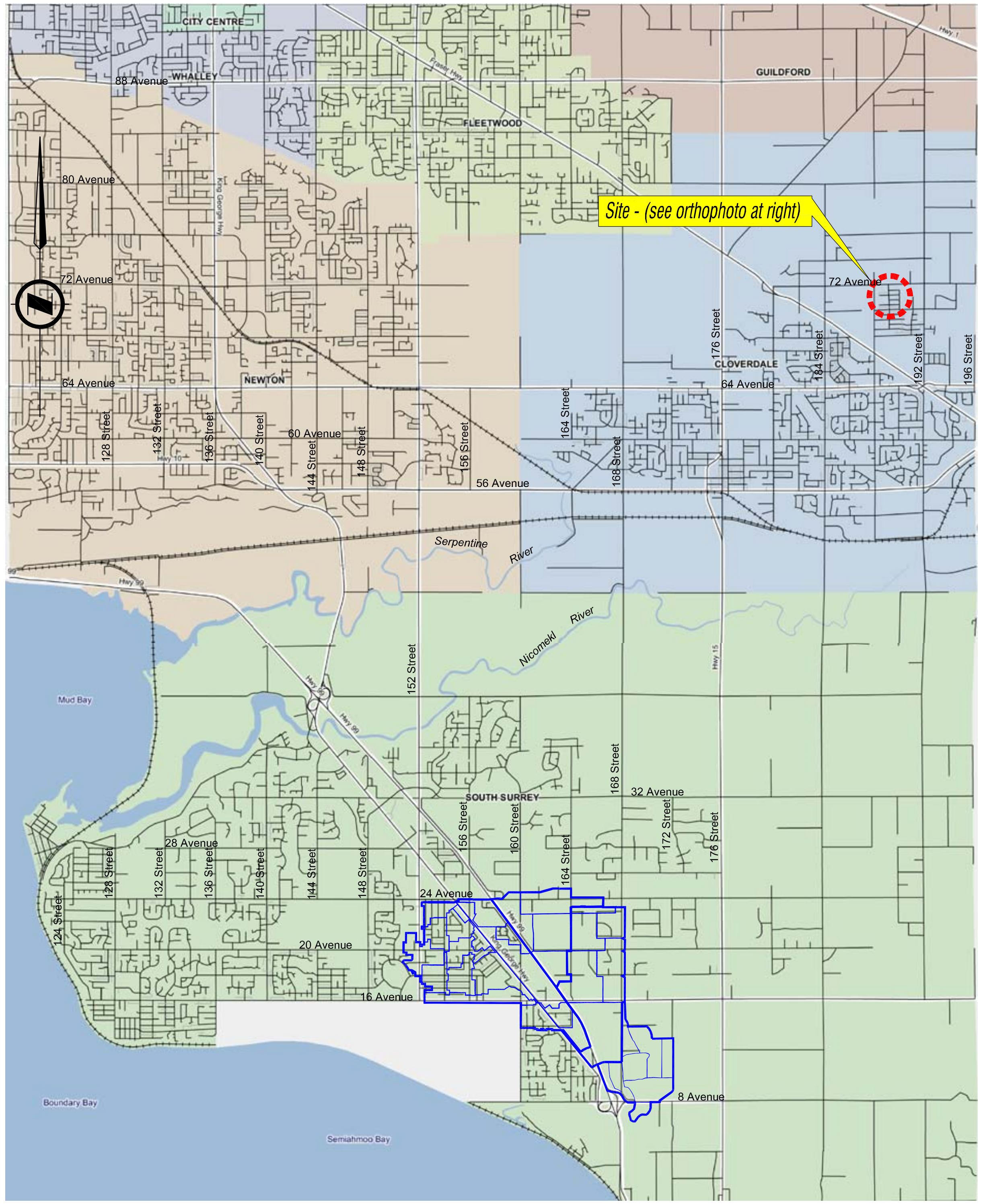
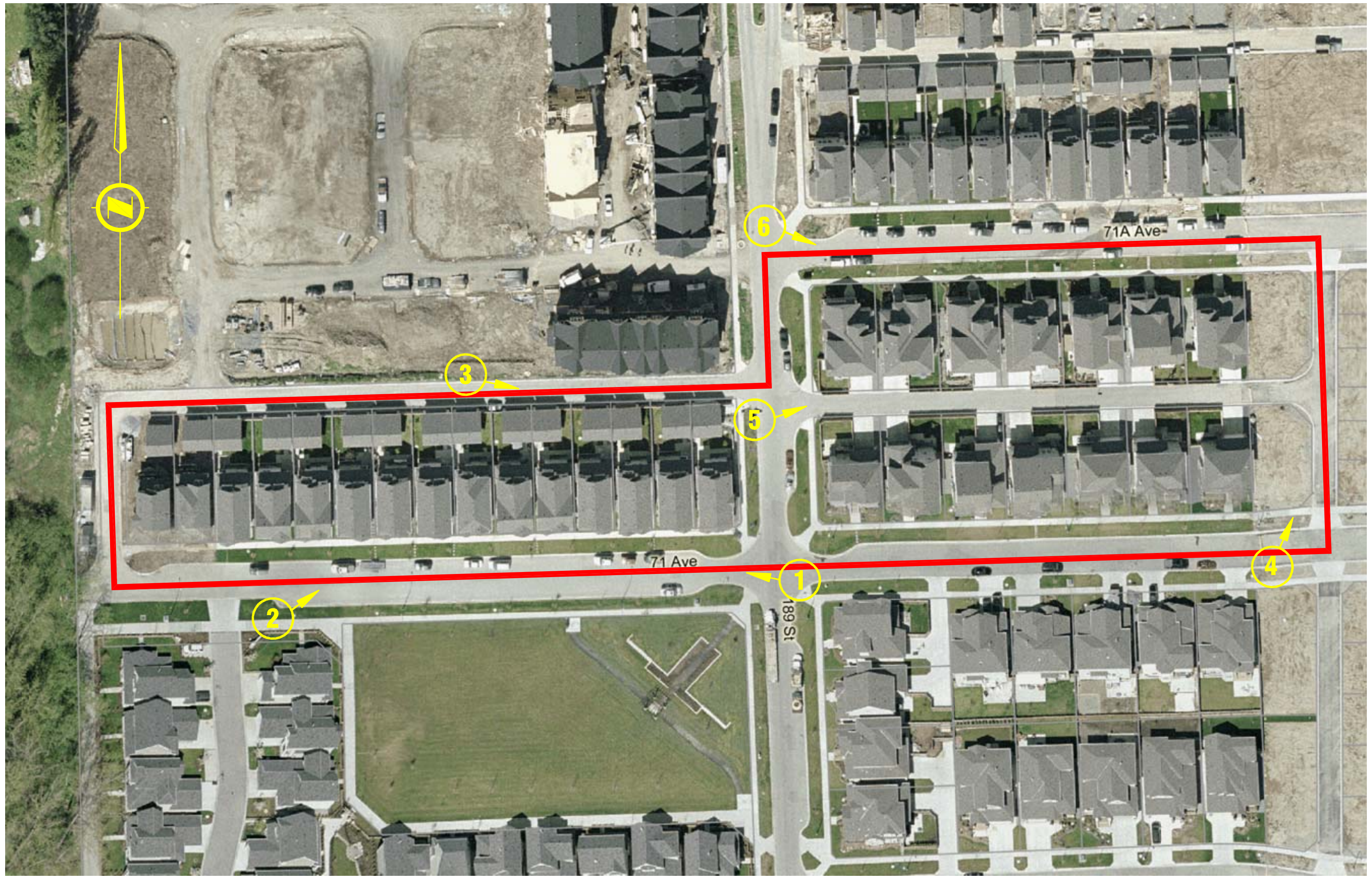
FERGUS CREEK ISMP
Units per Acre: 8
Percent Impervious: 60
Housing Type: Detached
Figure 2.4 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan and Photo Locations

McElhanney

FERGUS CREEK ISMP
Units per Acre: 10
Percent Impervious: 70
Housing Type: Detached
Figure 2.5 - Location

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FERGUS CREEK ISMP

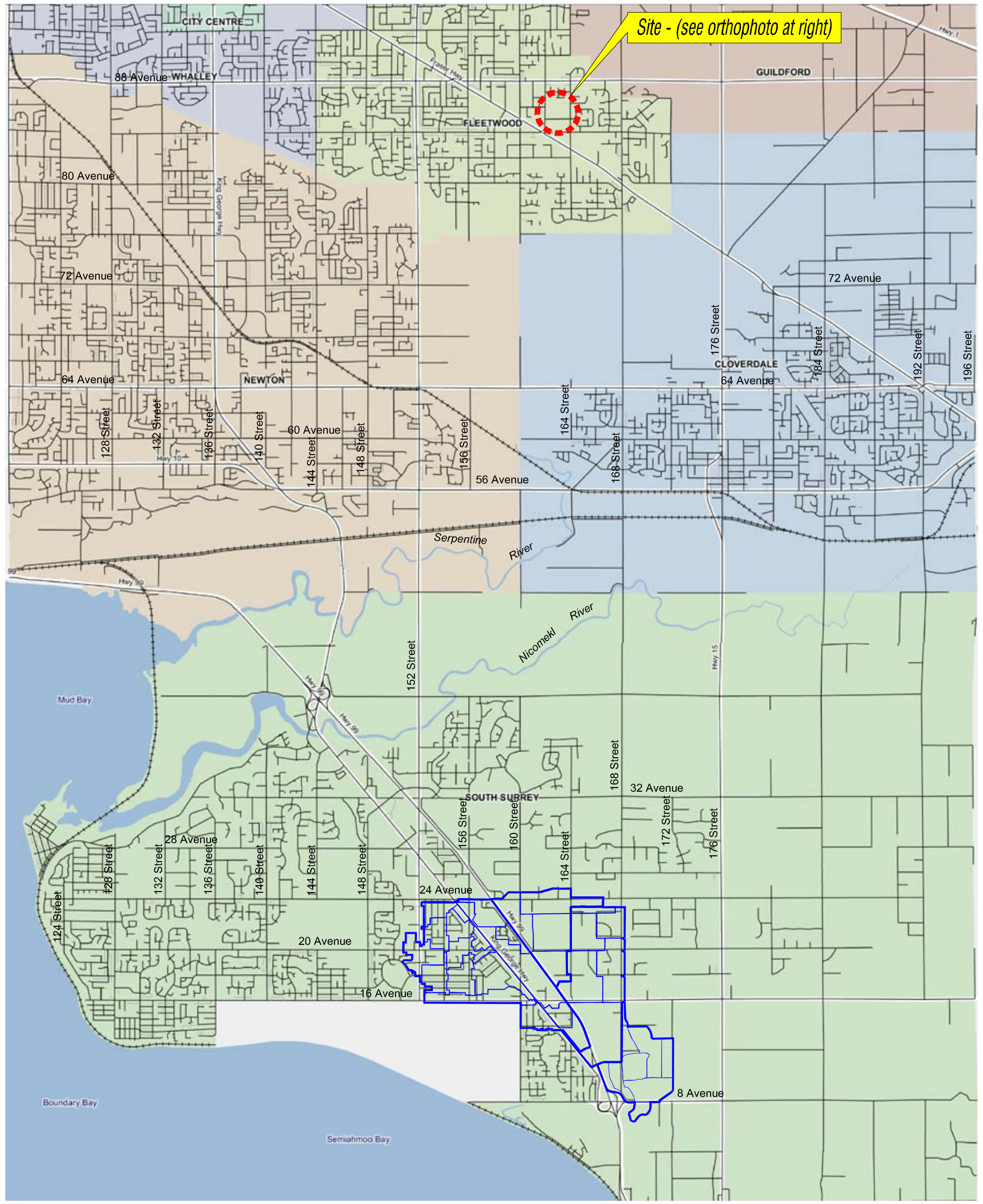
Units per Acre: 10

Percent Impervious: 70

Housing Type: Detached

Figure 2.5 - Photos

SURREY
CITY OF PARKS



Location Plan

Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 10
Percent Impervious: 70
Housing Type: Multi-Family
Figure 2.6 - Location

McElhanney

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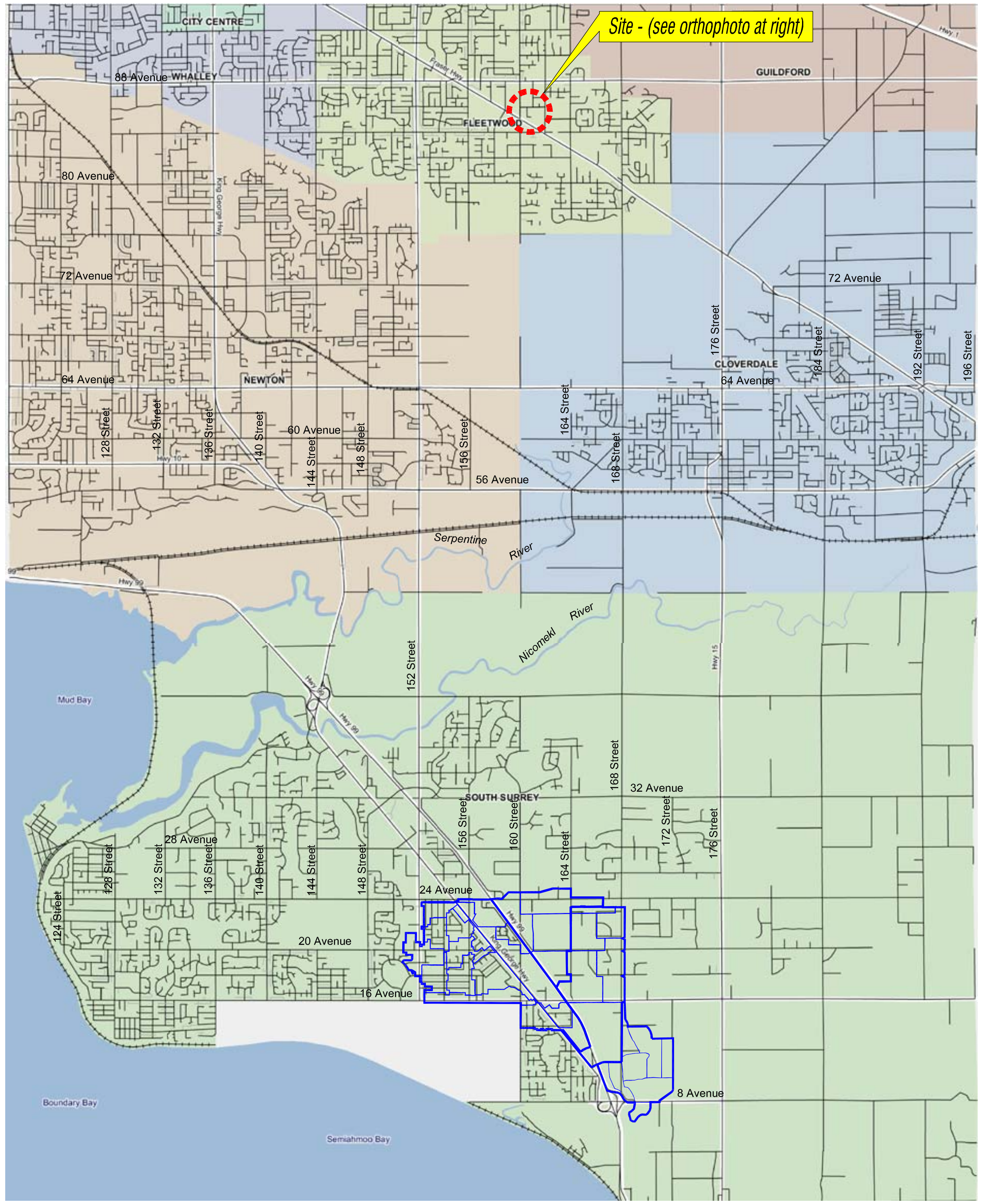
FERGUS CREEK ISMP
Units per Acre: 10
Percent Impervious: 70
Housing Type: Multi-Family
Figure 2.6 - Photos



Location Plan

Site Plan and Photo Locations

FERGUS CREEK ISMP

Units per Acre: 12

Percent Impervious: 75

Housing Type: Multi-Family

Figure 2.7 - Location

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McElhanney

FERGUS CREEK ISMP

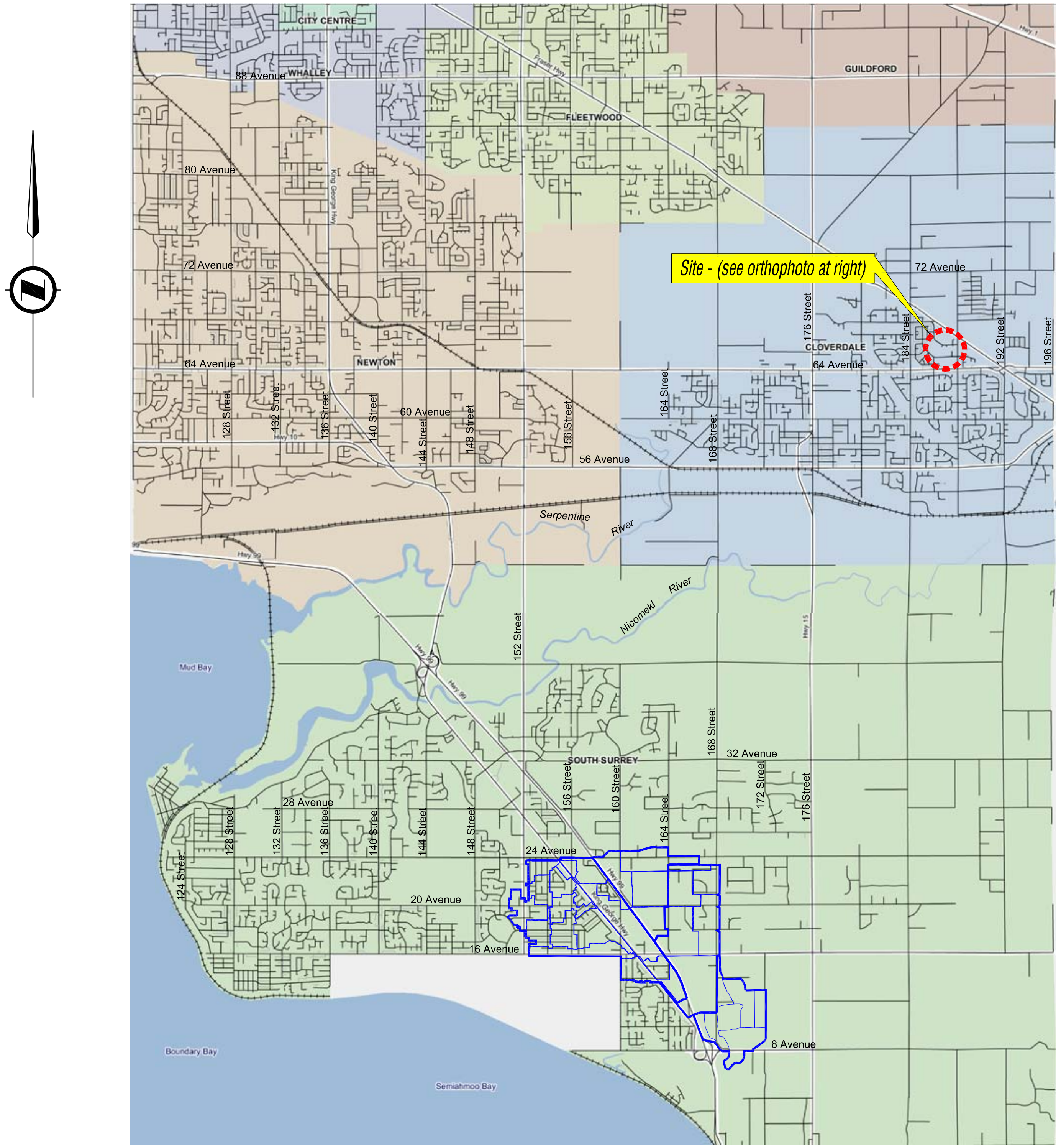
Units per Acre: 12

Percent Impervious: 75

Housing Type: Multi-Family

Figure 2.7 - Photos

SURREY
CITY OF PARKS



Location Plan

Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 14
Percent Impervious: 75
Housing Type: Multi-Family
Figure 2.8 - Location

McElhanney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FERGUS CREEK ISMP

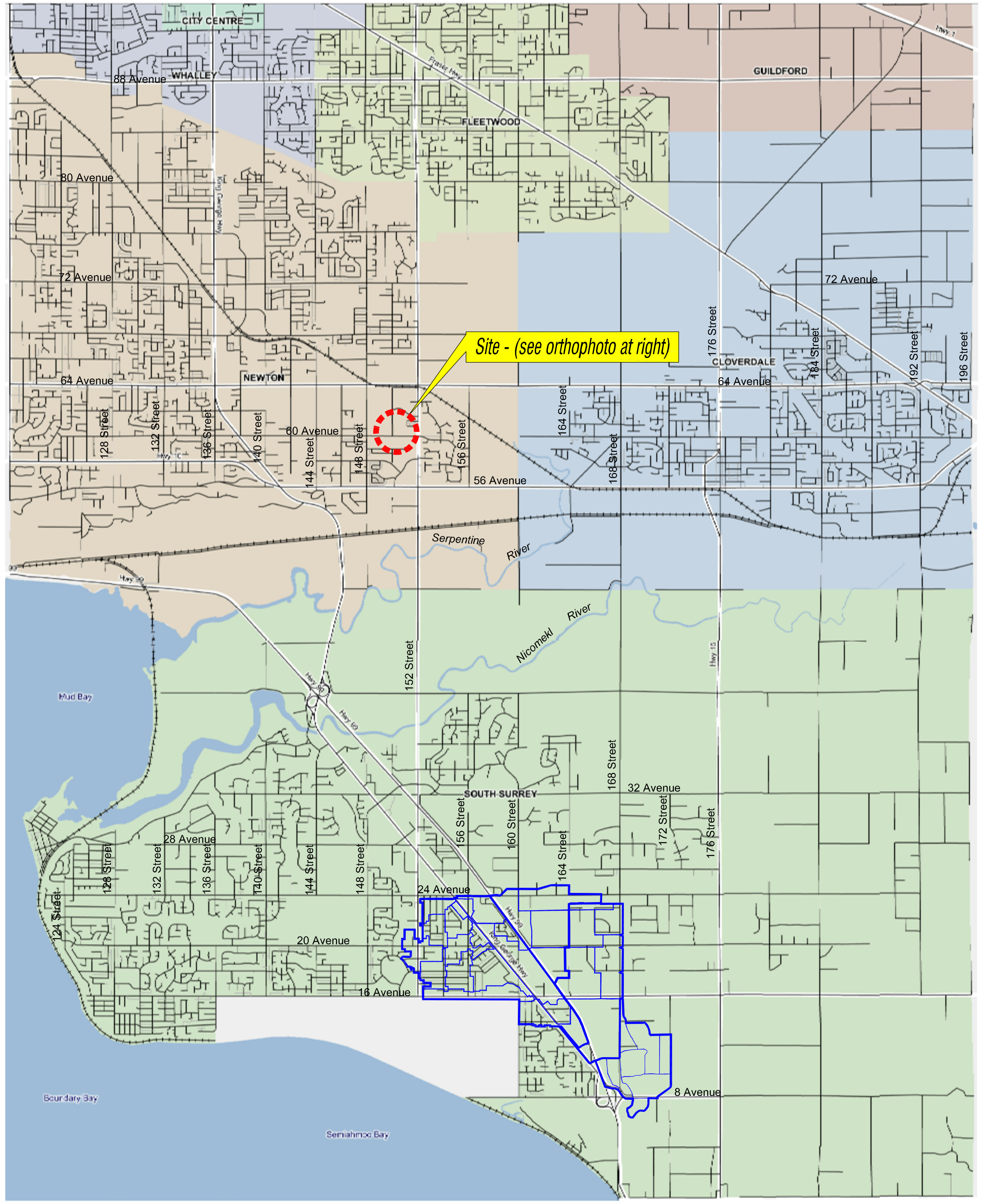
Units per Acre: 14

Percent Impervious: 75

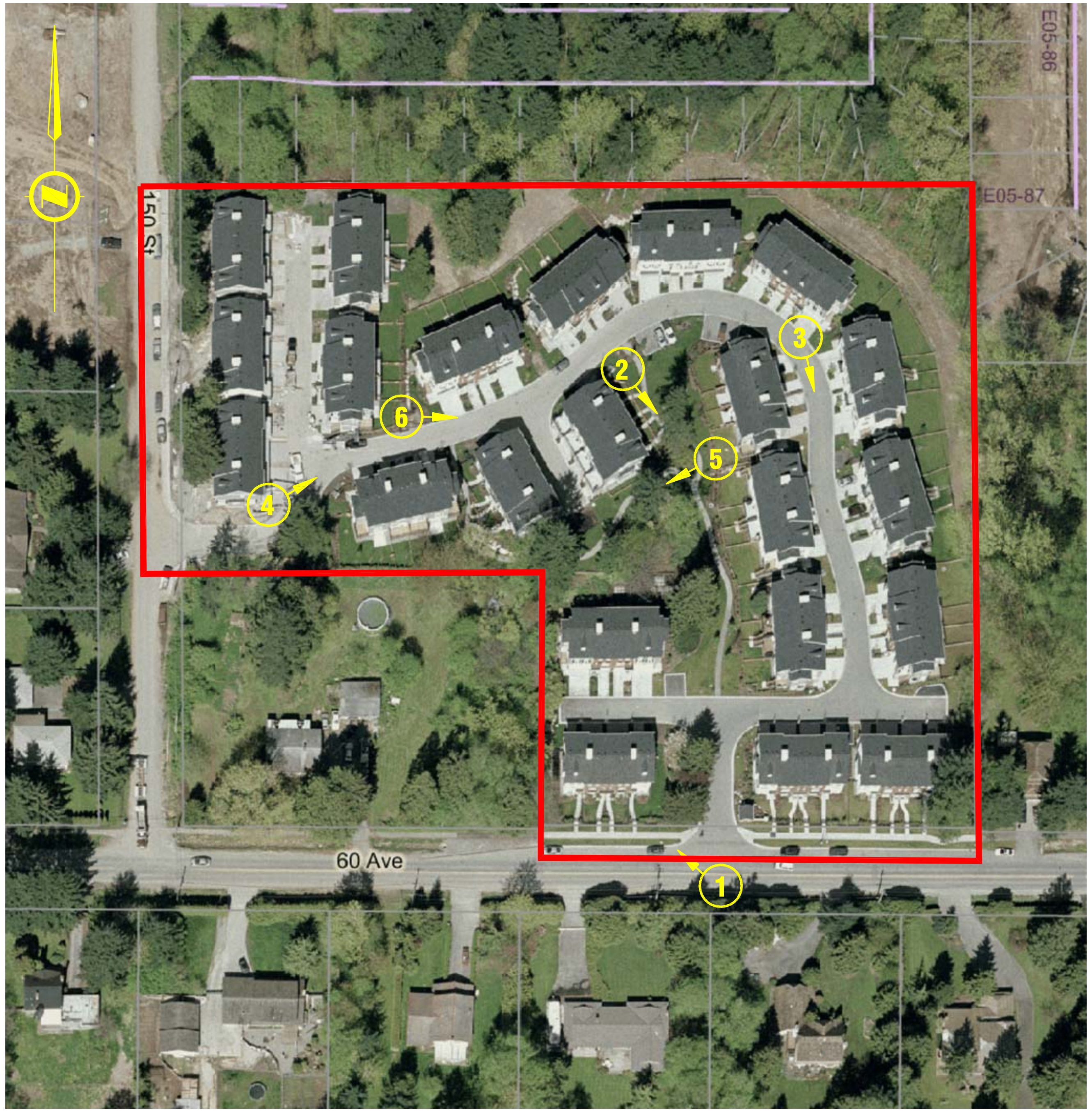
Housing Type: Multi-Family

Figure 2.8 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 14
Percent Impervious: 55
Housing Type: Multi-Family
Figure 2.9 - Location

McElhanney

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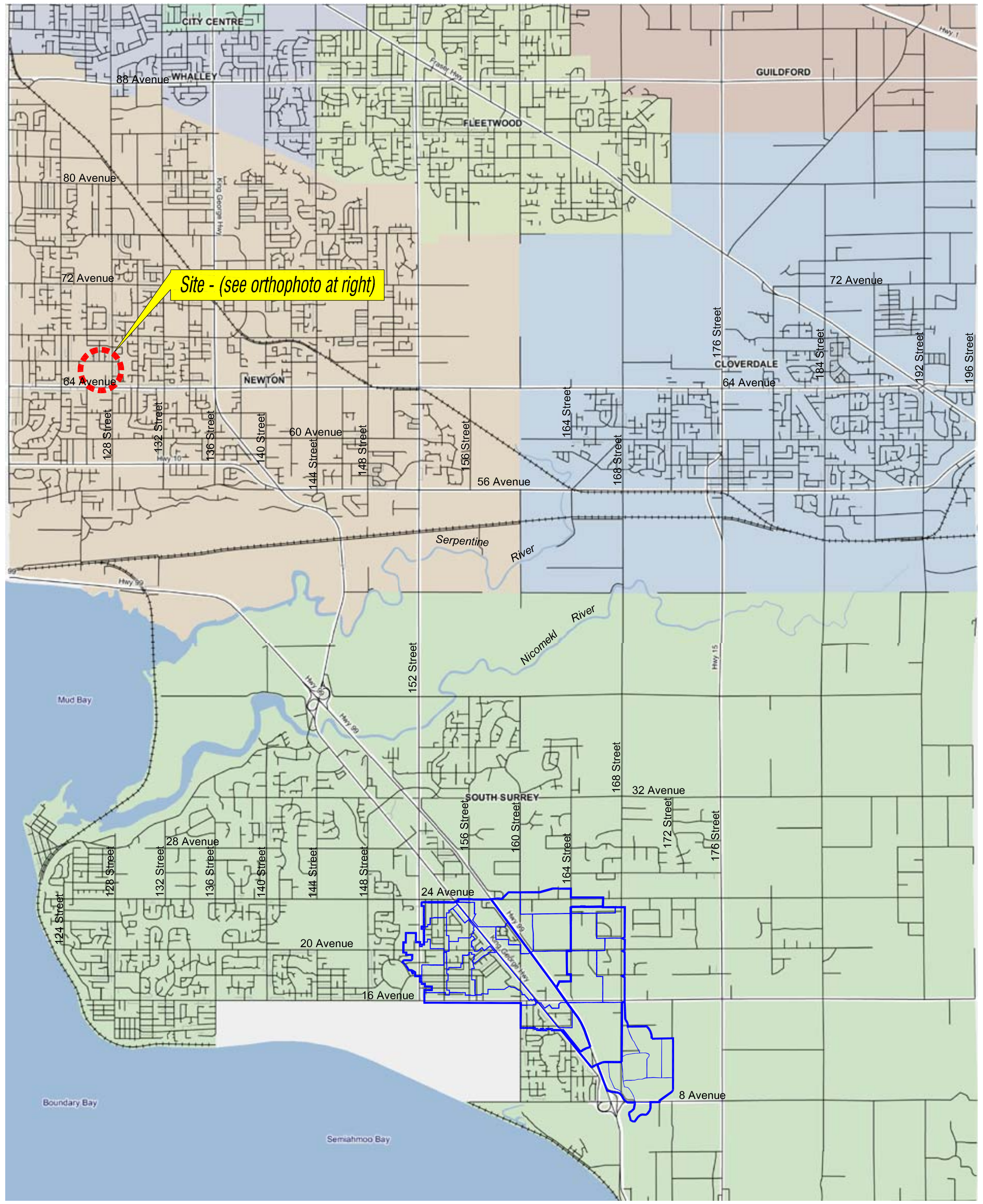
FERGUS CREEK ISMP
Units per Acre: 14
Percent Impervious: 55
Housing Type: Multi-Family
Figure 2.9 - Photos

SURREY
CITY OF PARKS



Location Plan

Site Plan and Photo Locations

FERGUS CREEK ISMP
Units per Acre: 20
Percent Impervious: 80
Housing Type: Multi-Family
Figure 2.10 - Location

McElhanney

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FERGUS CREEK ISMP

Units per Acre: 20

Percent Impervious: 80

Housing Type: Multi-Family

Figure 2.10 - Photos

Location Plan

Site Plan

FERGUS CREEK ISMP
Units per Acre:18
Percent Impervious: 40
Housing Type: Multi-Family
Figure 2.11 - Location

SURREY
CITY OF PARKS


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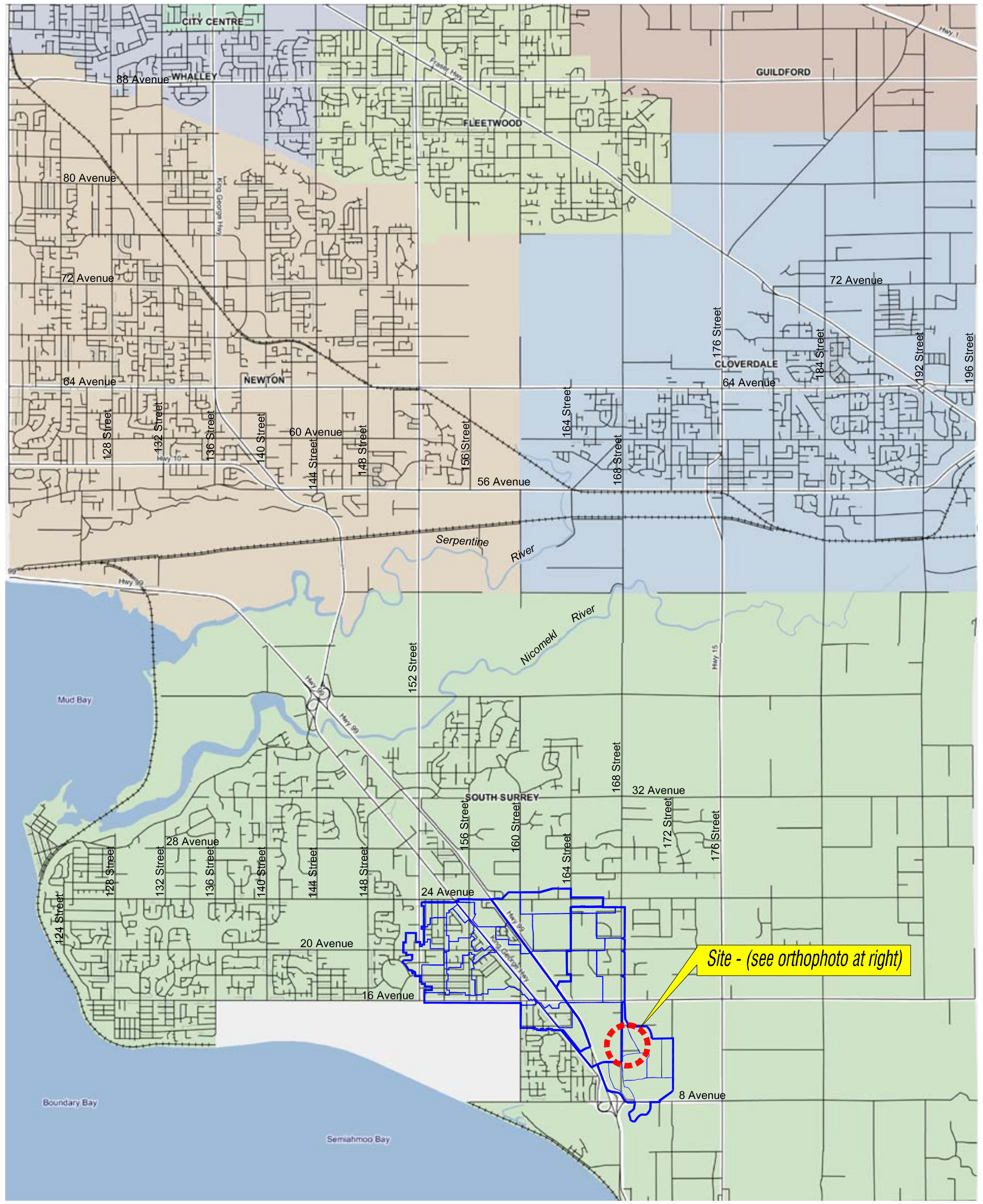
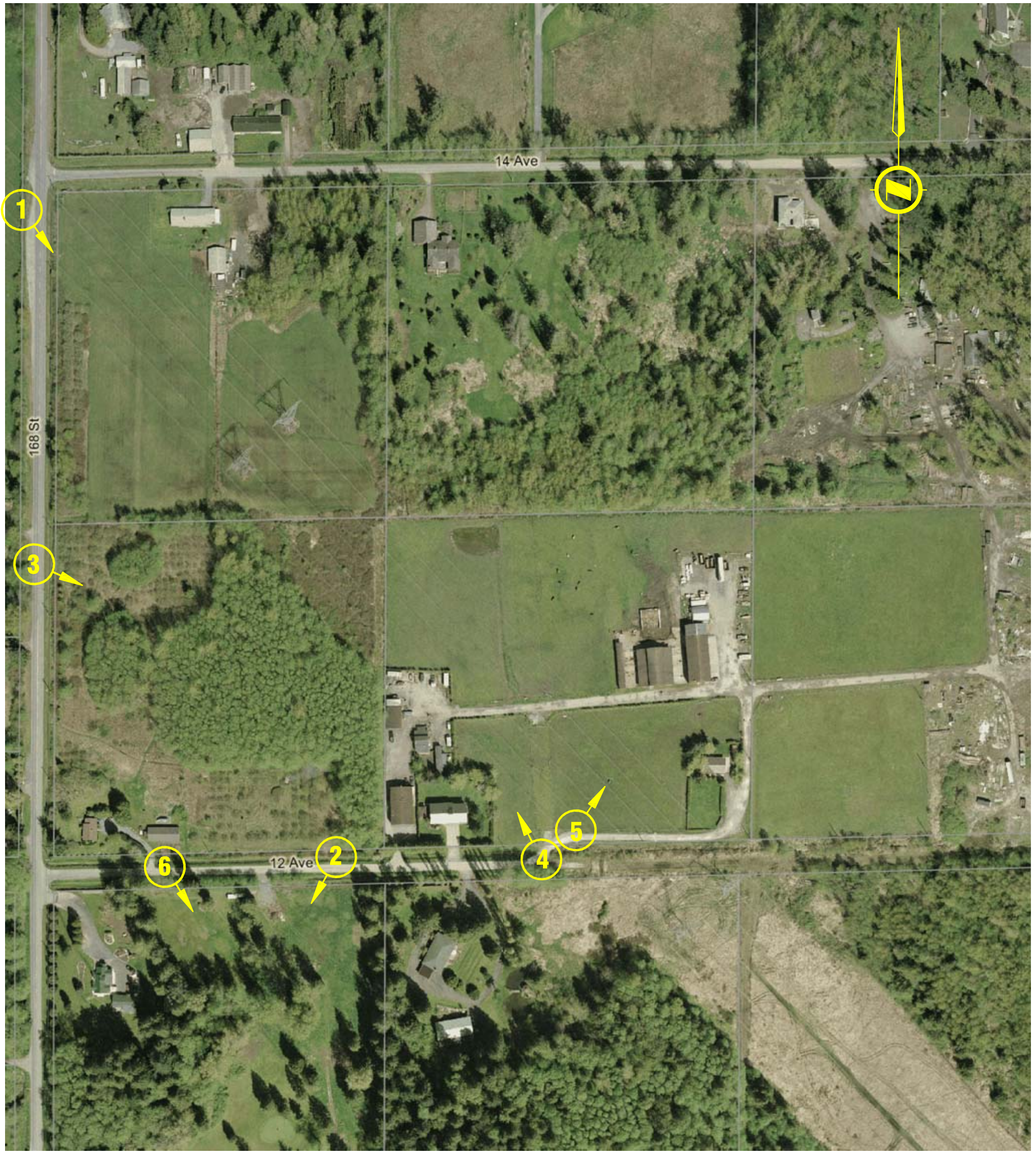
McElhanney

FERGUS CREEK ISMP
Units per Acre: 18
Percent Impervious: 40
Housing Type: Multi-Family
Figure 2.11 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan

FERGUS CREEK ISMP
Units per Acre: N/A
Percent Impervious: 2
Agricultural
Figure 2.12 - Location

McElhanney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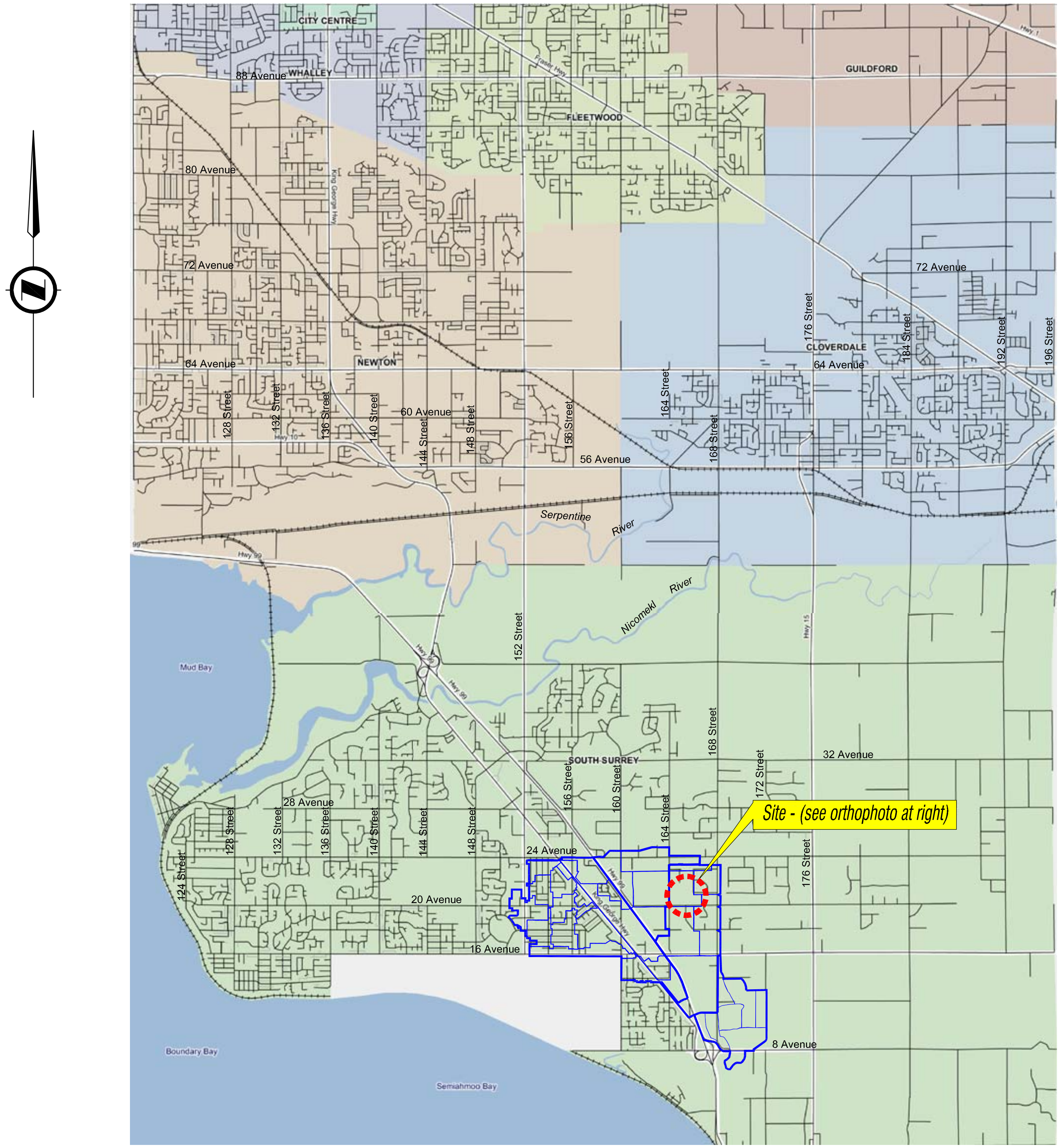
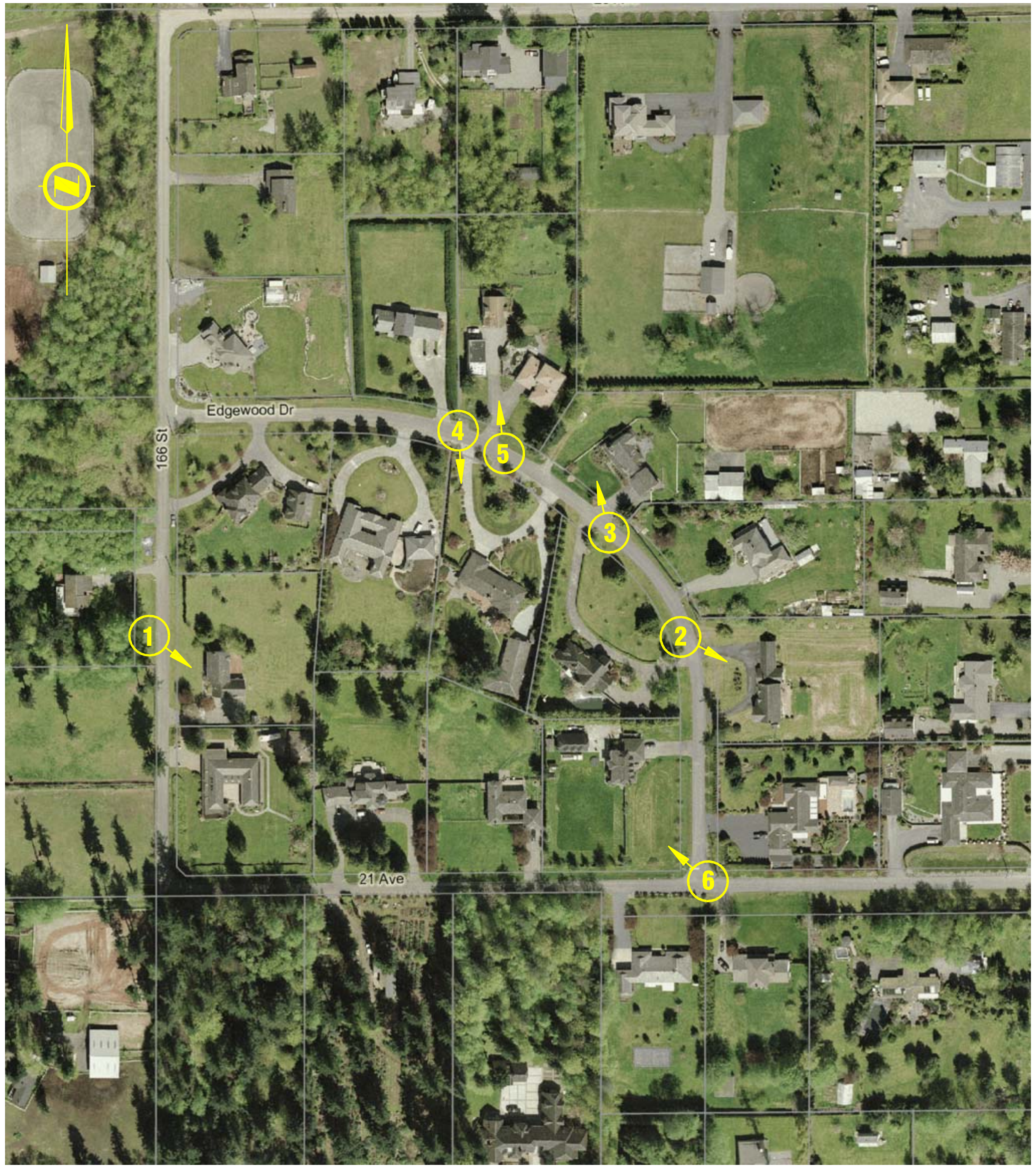
McElhanney

FERGUS CREEK ISMP
Units per Acre: N/A
Percent Impervious: 2
Agricultural
Figure 2.12 - Photos



Location Plan



Site Plan

FERGUS CREEK ISMP

Units per Acre: 1

Percent Impervious: 15

Rural Residential

Figure 2.13 - Location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FERGUS CREEK ISMP

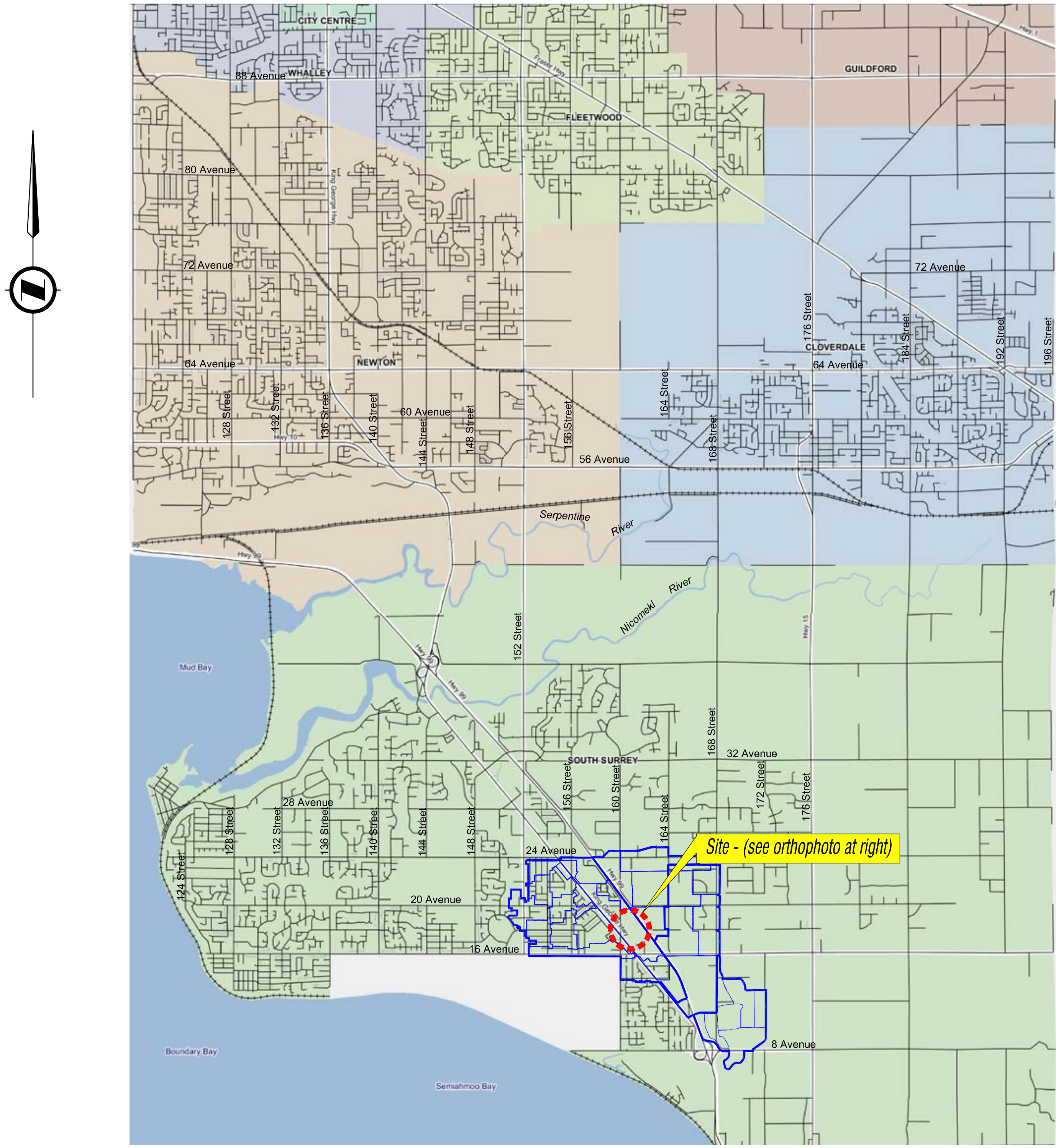
Units per Acre: 1

Percent Impervious: 15

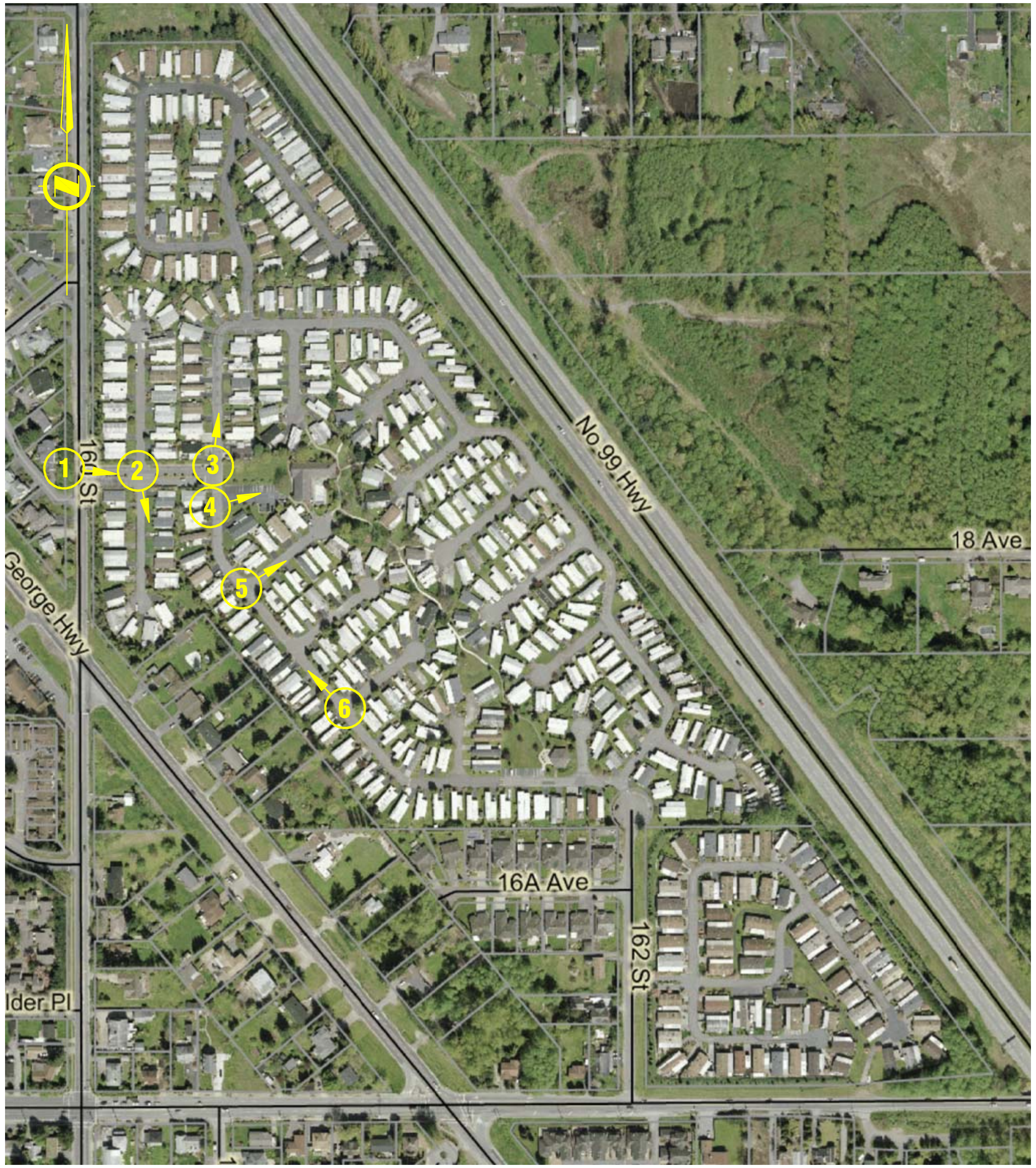
Rural Residential

Figure 2.13 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan

FERGUS CREEK ISMP
Units per Acre: 8
Percent Impervious: 80
Trailer Park
Figure 2.14 - Location

McElhanney

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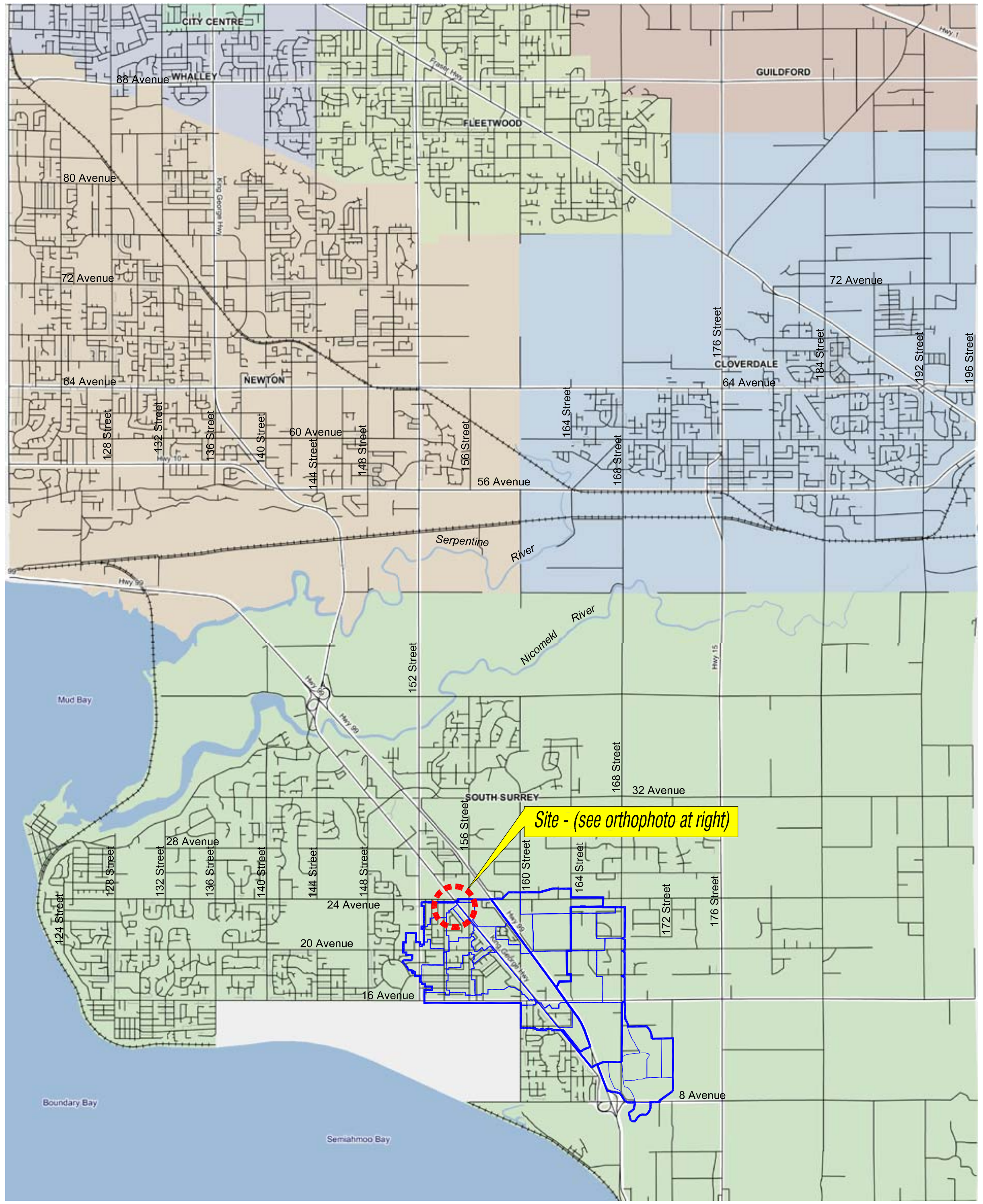
FERGUS CREEK ISMP

Units per Acre: 8

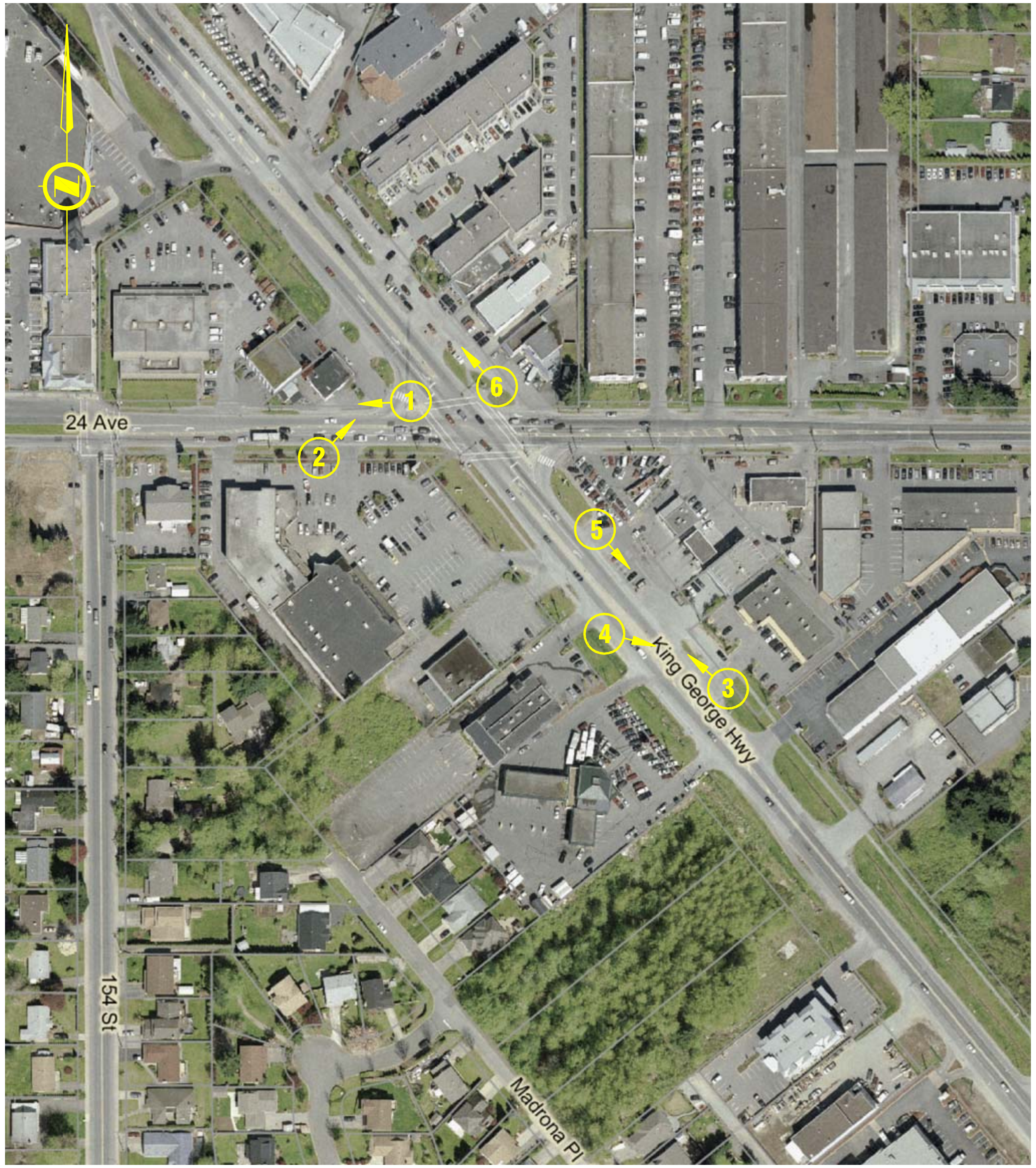
Percent Impervious: 80

Trailer Park

Figure 2.14 - Photos



Location Plan



Site Plan

FERGUS CREEK ISMP

Units per Acre: N/A

Percent Impervious: 95

Commercial

Figure 2.15 - Location

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FERGUS CREEK ISMP

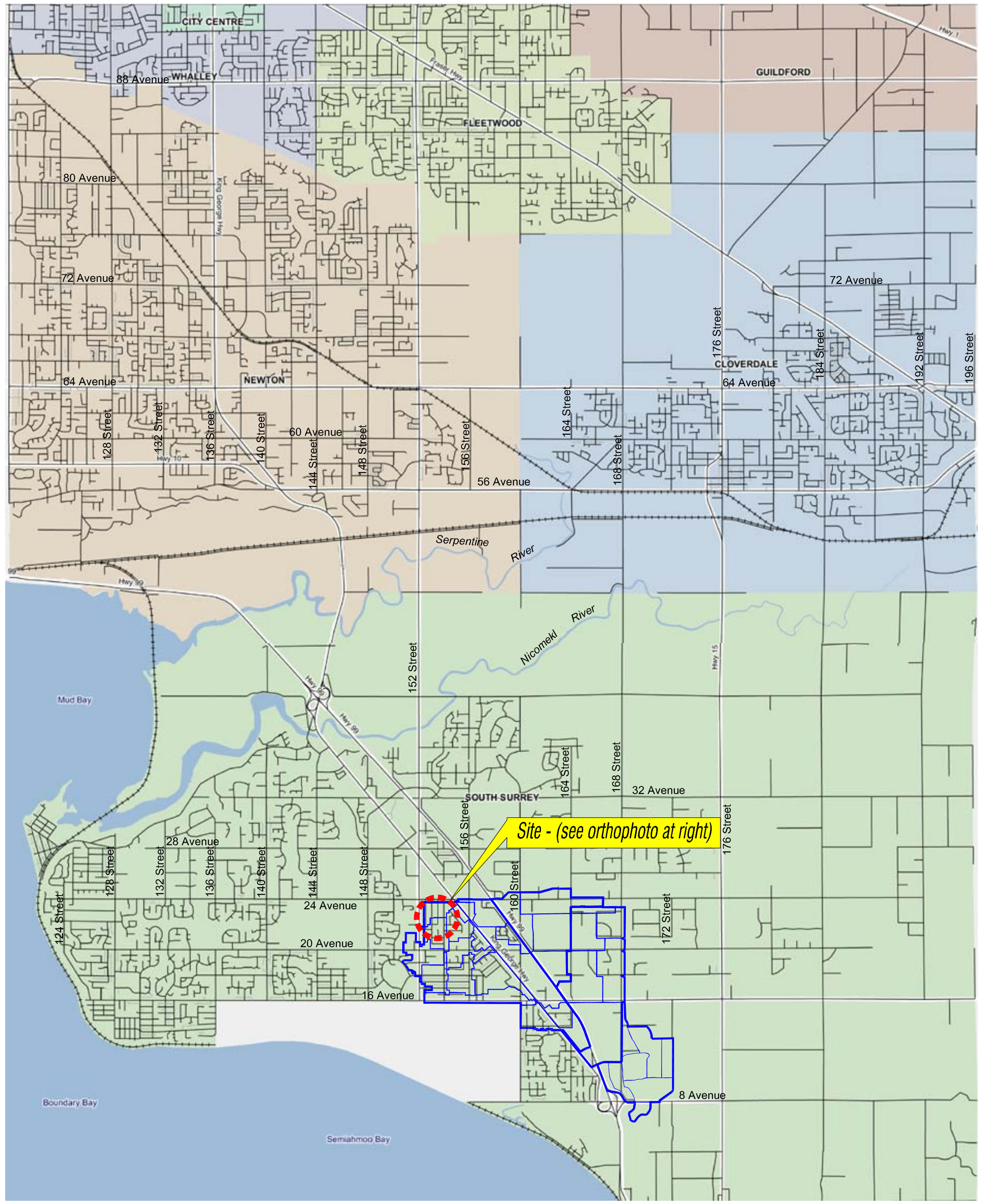
Units per Acre: N/A

Percent Impervious: 95

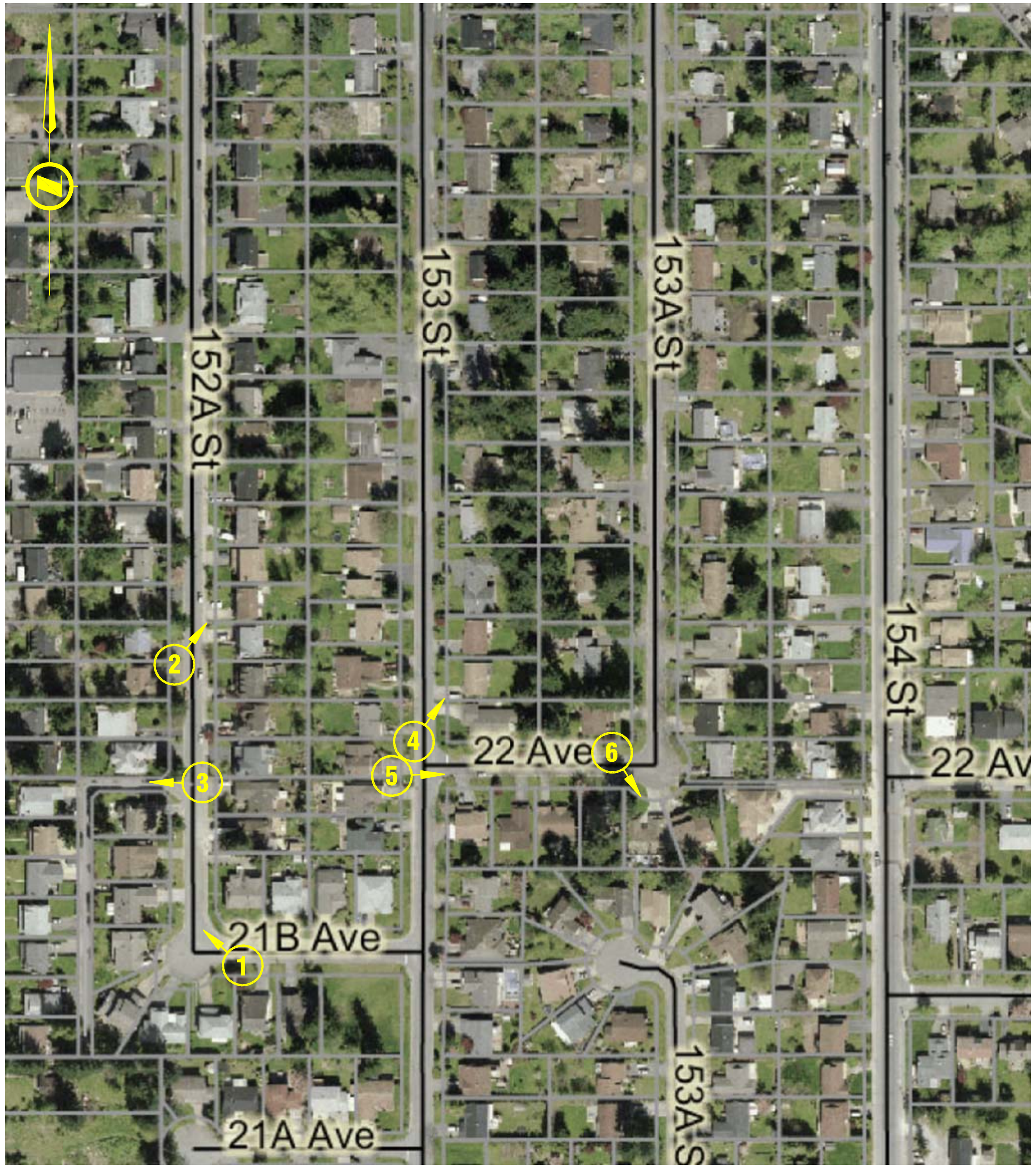
Commercial

Figure 2.15 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan

FERGUS CREEK ISMP
Units per Acre: 4
Percent Impervious: 60
Detached
Figure 2.16 - Location

McElhanney

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FERGUS CREEK ISMP

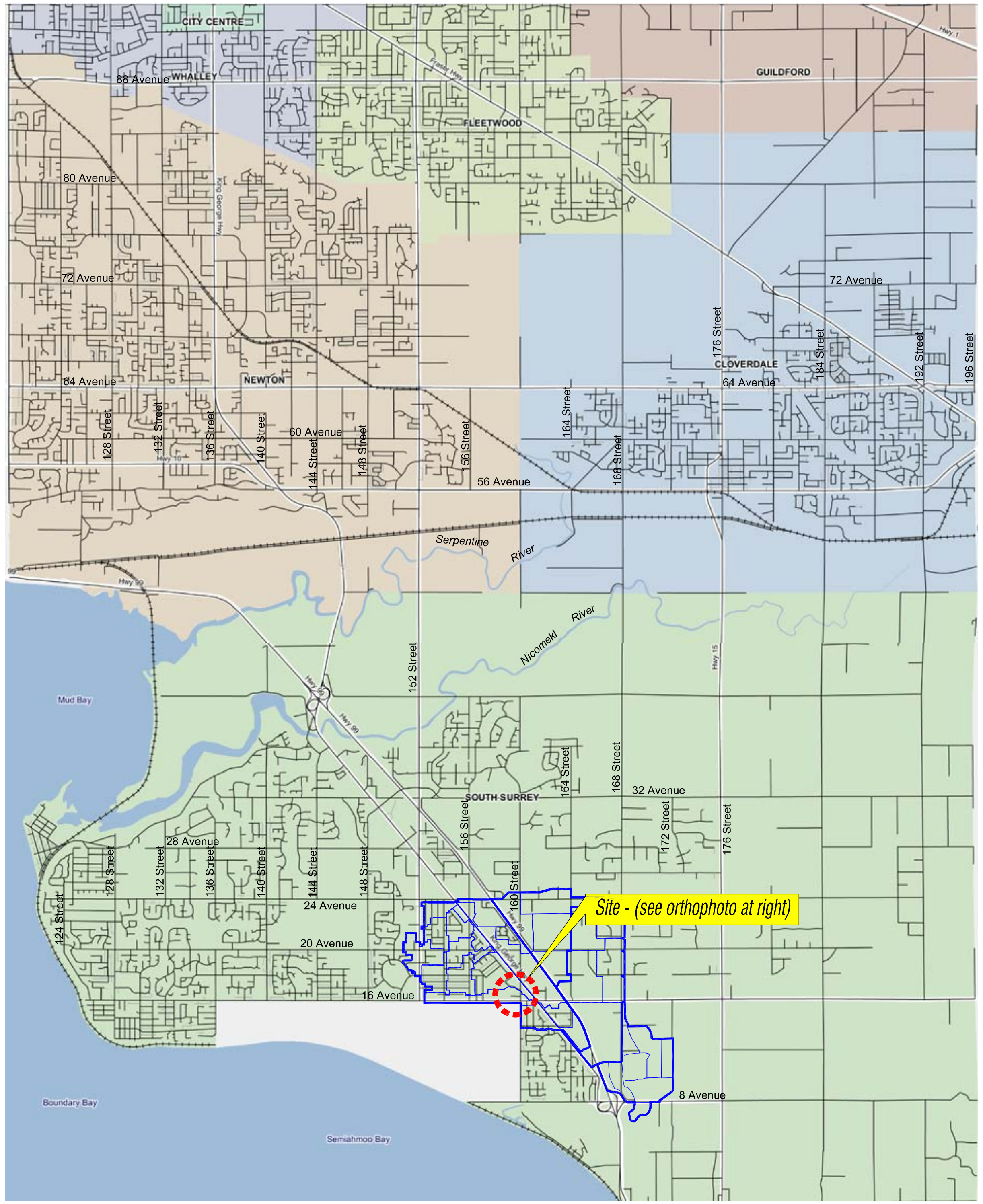
Units per Acre: 4

Percent Impervious: 60

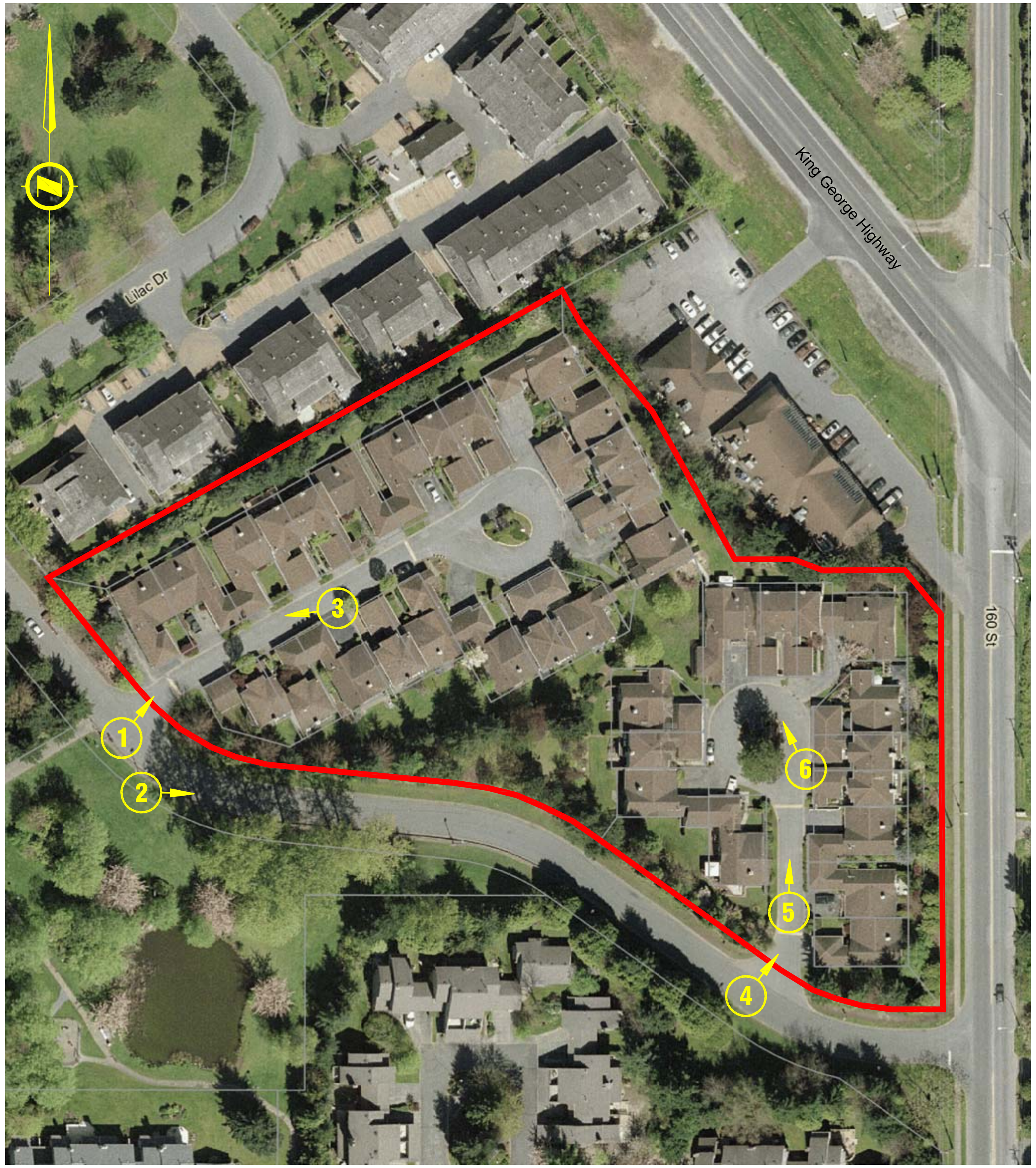
Detached

Figure 2.16 - Photos

SURREY
CITY OF PARKS



Location Plan



Site Plan

FERGUS CREEK ISMP
Units per Acre: 9
Percent Impervious: 60
Multi-Family
Figure 2.17 - Location

McElhanney

TABLE 2.1 Land Use Examples

Figure	In or Out of Fergus Creek Watershed	Land Use	Percent Impervious	Residential Density Units per Acre	Land Use Zone Designation
Figure 2.1 - Location	Out	Detached	35	2	RH
Figure 2.1 - Photos	Out	Detached	35	2	
Figure 2.2 - Location	Out	Detached	60	4	RF
Figure 2.2 - Photos	Out	Detached	60	4	
Figure 2.3 - Location	Out	Detached	70	6	RF-12
Figure 2.3 - Photos	Out	Detached	70	6	
Figure 2.4 - Location	Out	Detached	60	8	RF-12C
Figure 2.4 - Photos	Out	Detached	60	8	
Figure 2.5 - Location	Out	Detached	70	10	RF-9C and RF-12C
Figure 2.5 - Photos	Out	Detached	70	10	
Figure 2.6 - Location	Out	Multi-family	70	10	RM-15
Figure 2.6 - Photos	Out	Multi-family	70	10	
Figure 2.7 - Location	Out	Multi-family	75	12	RM-15
Figure 2.7 - Photos	Out	Multi-family	75	12	
Figure 2.8 - Location	Out	Multi-family	75	14	RM-15
Figure 2.8 - Photos	Out	Multi-family	75	14	
Figure 2.9 - Location	Out	Multi-family	55	14	RM-15
Figure 2.9 - Photos	Out	Multi-family	55	14	
Figure 2.10 - Location	Out	Multi-family	80	20	RM-30
Figure 2.10 - Photos	Out	Multi-family	80	20	
Figure 2.11 - Location	Out	Multi-family	40	18	N/A
Figure 2.11 - Photos	Out	Multi-family	40	18	
Figure 2.12 - Location	In	Agricultural	2	N/A	A-1
Figure 2.12 - Photos	In	Agricultural	2	N/A	
Figure 2.13 - Location	In	Rural Residential	15	1	RA
Figure 2.13 - Photos	In	Rural Residential	15	1	
Figure 2.14 - Location	In	Trailer Park	80	8	RM-M
Figure 2.14 - Photos	In	Trailer Park	80	8	
Figure 2.15 - Location	In	Commercial	95	N/A	C-8 and CHI
Figure 2.15 - Photos	In	Commercial	95	N/A	
Figure 2.16 - Location	In	Detached	60	4	RF
Figure 2.16 - Photos	In	Detached	60	4	
Figure 2.17 - Location	In	Multi-family	60	9	RM-15
Figure 2.17 - Photos	In	Multi-family	60	9	

As second item of note is the variability of the imperviousness in the examples. This is directly related to the relative proportion of hard surfaces that would produce stormwater runoff. There are important differences in the examples shown. **Figure 2.8** and **Figure 2.9** have dramatically different imperviousness from similar density and Land Use Zones. The primary difference is in the number of floors of the housing units and the location of the parking spaces.

The level of imperviousness is linked to the number of housing units, whether single family or multi-family. This can be seen when comparing a range of development types and particularly when looking at **Figure 2.5** and **Figure 2.6**. As shown, the percent imperviousness is similar both development irrespective of housing type.

A very different type of development is shown on **Figure 2.11** that combines different building layouts but limits the amount of parking available. While this appears to be a good example creating less of an environmental impact, the basic form is very different than that allowed in the City at this time.

These series of figures offer a view of the possibilities for creating a vision of the future Fergus Creek Watershed. We must ask ourselves two questions:

1. How will the existing rural areas develop?
2. How will the existing developed areas redevelop?

The answers to these questions form the basis of the Fergus Creek Watershed Vision and allow the City to create a fabric of rules and policies to preserve and enhance the Fergus Creek Watershed in accordance with the requirements outlined within the OCP. While the Fergus Creek ISMP cannot create a vision of the watershed we can identify the need to do so and provide information that can be used in the process. We recommend the vision for the Fergus Creek Watershed be created as part of the development and redevelopment planning that will include preparation of the Grandview Heights 2 Neighbourhood Development Plan and any redevelopment plans for the existing urban areas.

The redevelopment of the urban areas west of Highway 99 would take on a different form compared to existing development densities. For example, it is reasonable to assume that existing, subdivided single family lots with older dwelling will eventually be replaced with new homes that are closer to the maximum FAR. Some of the existing single family homes will be replaces with larger buildings as shown on **Figure 2.18** and that will result in an increased degree of imperviousness within the watershed.

A method of reducing the final imperviousness within the existing urban areas would be to convert some of the paved surfaces to landscaped pervious areas. One view of how this can be accomplished in areas with lanes is shown on **Figure 2.19**. Over the time line of the redevelopment process, the rear lane could become a landscape feature that would benefit the neighbourhood and provide a reduction in the impervious area.

Another method of reducing the imperviousness in the single family portions of the existing urban areas would be to use porous pavement. An example of methods of replacing portions of the impervious areas with porous pavement is included in **Figure 2.20**.

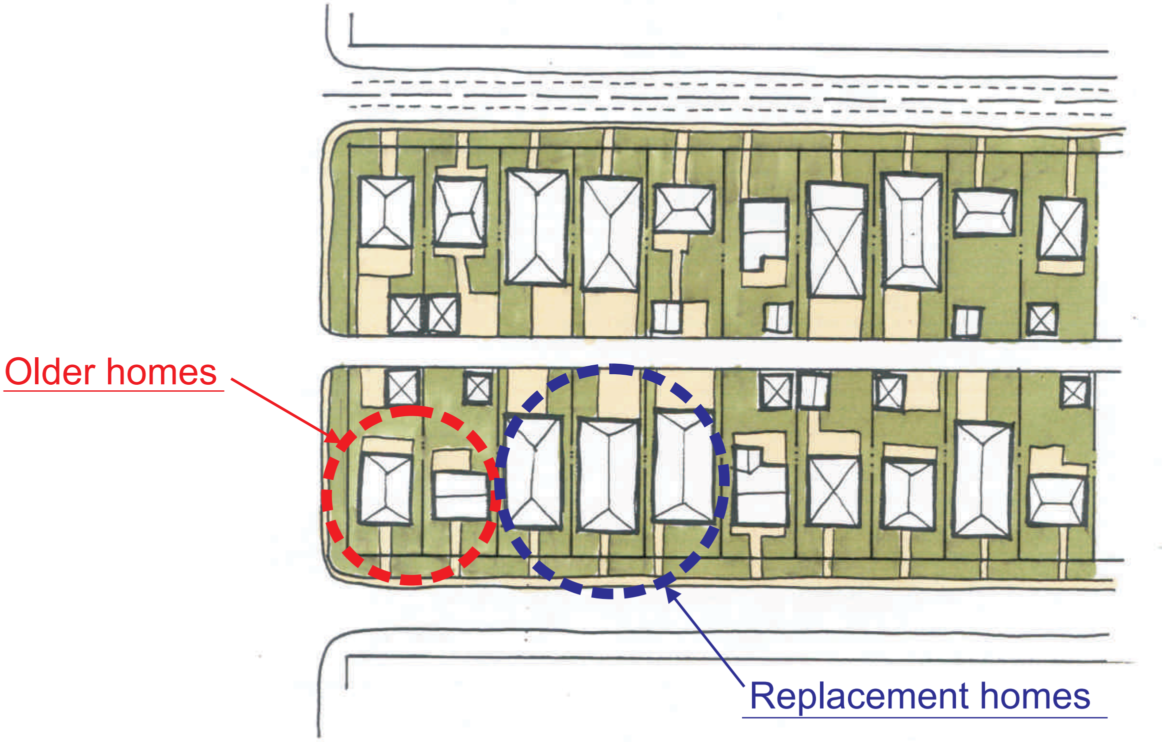
A further approach to reducing the imperviousness within the single family portions of the urban area would be to modify the street cross section. As shown on **Figure 2.21**, this process would likely to move the parking areas onto private property while not resulting in a net reduction in the impervious area. Although the RF Zone does not currently require that access be from the lane (assumes a non-arterial road condition), this arrangement may provide a tool to maintain the net impervious area via modification of the fronting road cross section. Access would have to be shifted to the rear lane and could only be realistically obtained as a requirement of rezoning or subdivision undertaken by the land owner. We anticipate the number of parking spots will have a significant impact upon the total hard surface area in the single family developments.

In reviewing the potential for consolidation and redevelopment of single family housing into multi-family dwellings we can anticipate that planning of the form and function of the individual developments will have an impact upon the amount of impervious surface area. A possible layout of a consolidated parcel with a large open landscape area can be seen on **Figure 2.22**. While this may not be an ideal layout, the question of the planning of landscaped areas into the development must be addressed so as to promote less paving and more aesthetically pleasing surroundings.

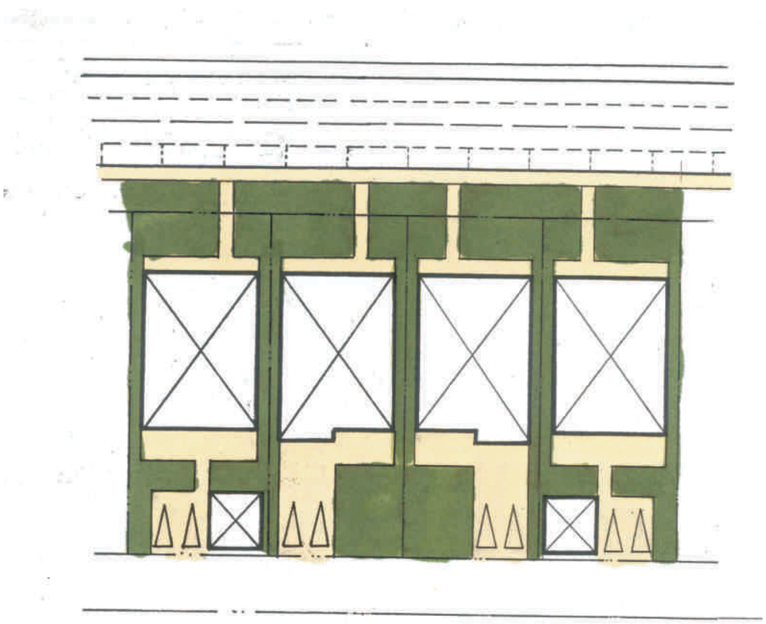
The information presented here can be used in developing a vision for the Fergus Creek Watershed that encompasses both the rural areas and the existing urban areas.

2.3 LEVEL OF DETAIL

The analysis that was completed during the preparation of the Fergus Creek ISMP was at a planning level, particularly with respect to future development form and function. As no detailed ground surveys and land use planning were undertaken for the ISMP, a detailed analysis of the infrastructure must be performed as a part of the next steps in the development, or redevelopment, process within the watershed. During the detailed design of future developments additional analyses will be required to confirm the location, operation, size and capacity and of all required municipal infrastructure.



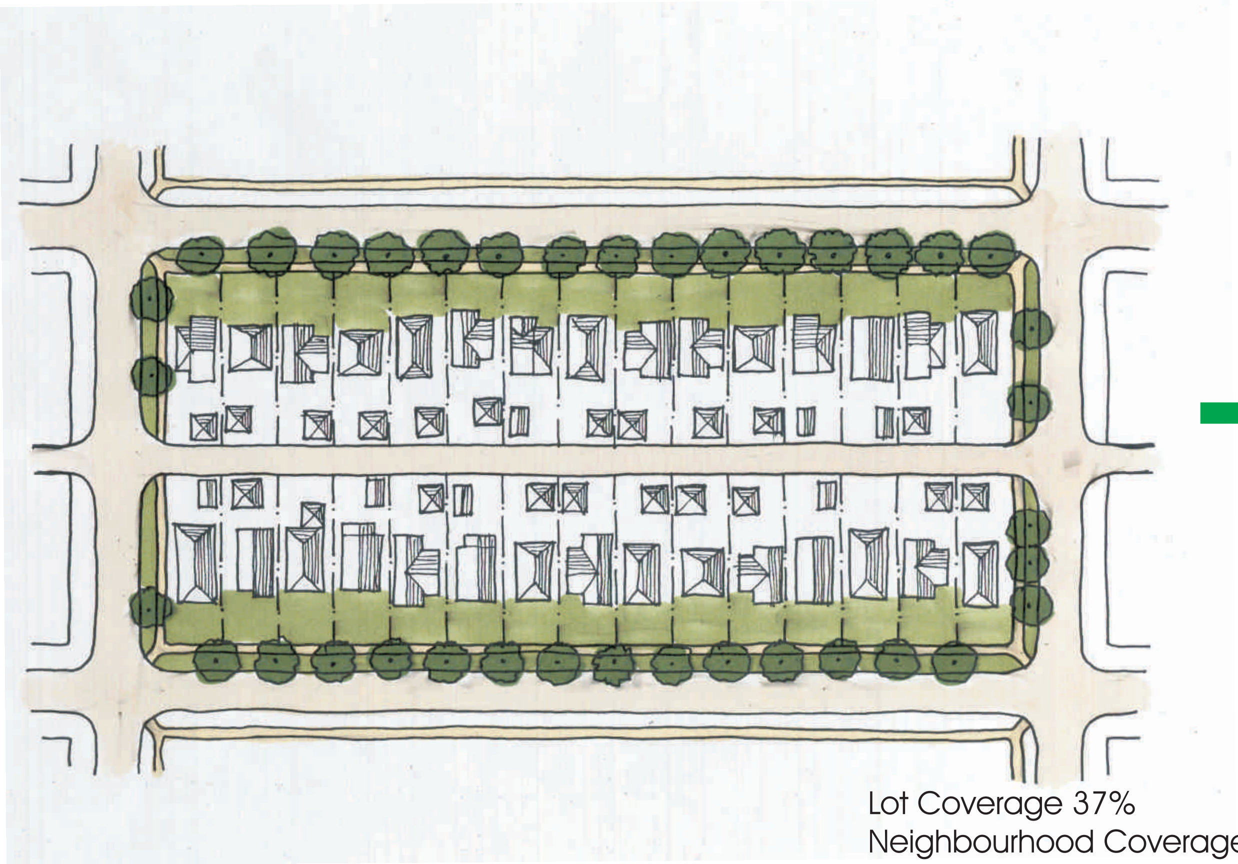
Existing Lot Coverage
Lot Coverage approx. 61%;
Road Coverage approx. 72%
Overall Coverage approx. 64%



Possible Lot Coverage
Lot Coverage approx. 65% (Building 45%);
Road Coverage approx. 72%
Overall Coverage approx. 67%

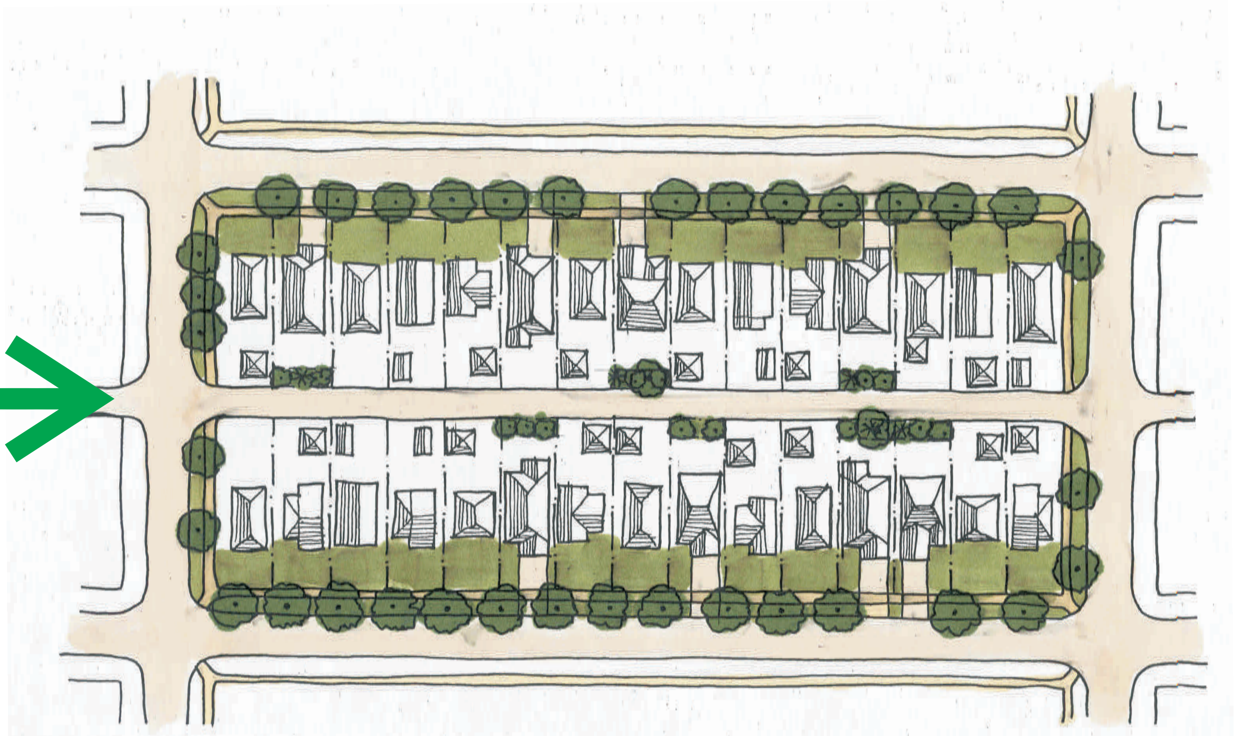
Building Reconstruction
Figure 2.18

SURREY
CITY OF PARKS



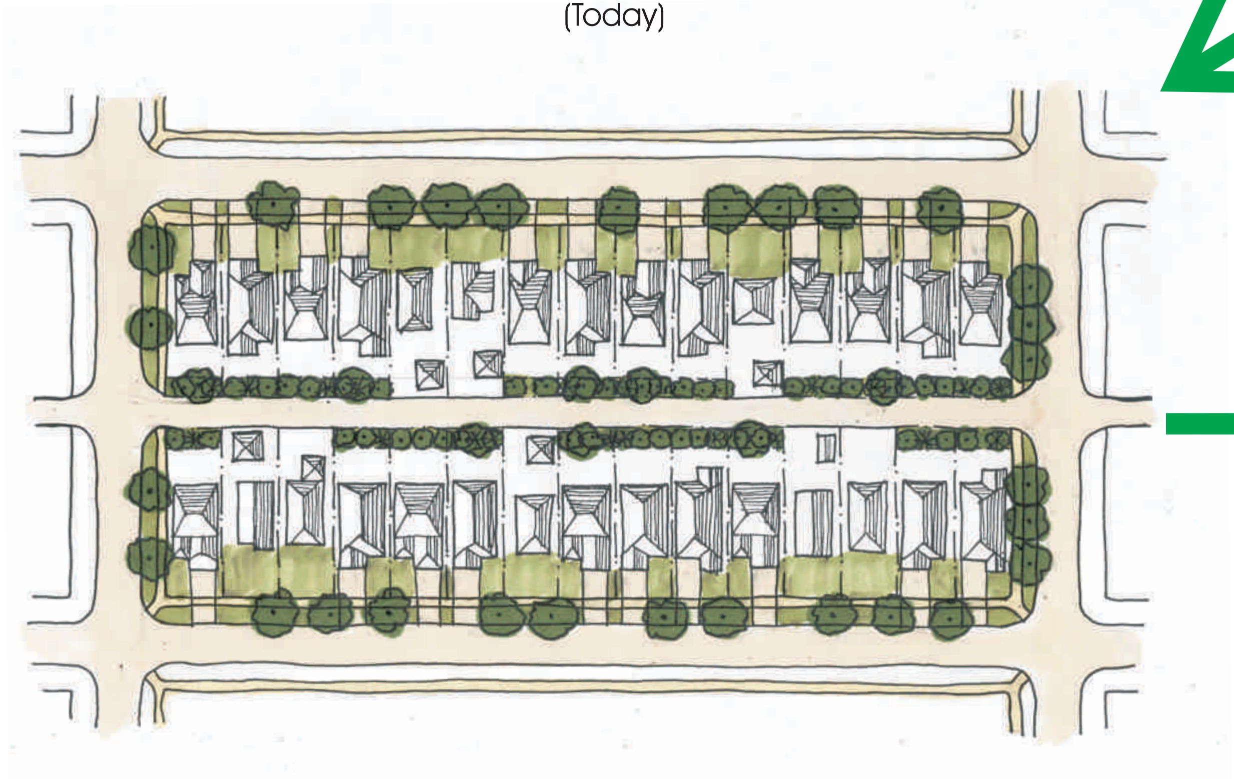
Lot Coverage 37%
Neighbourhood Coverage 42%

Existing Single Family Neighbourhood
(Today)



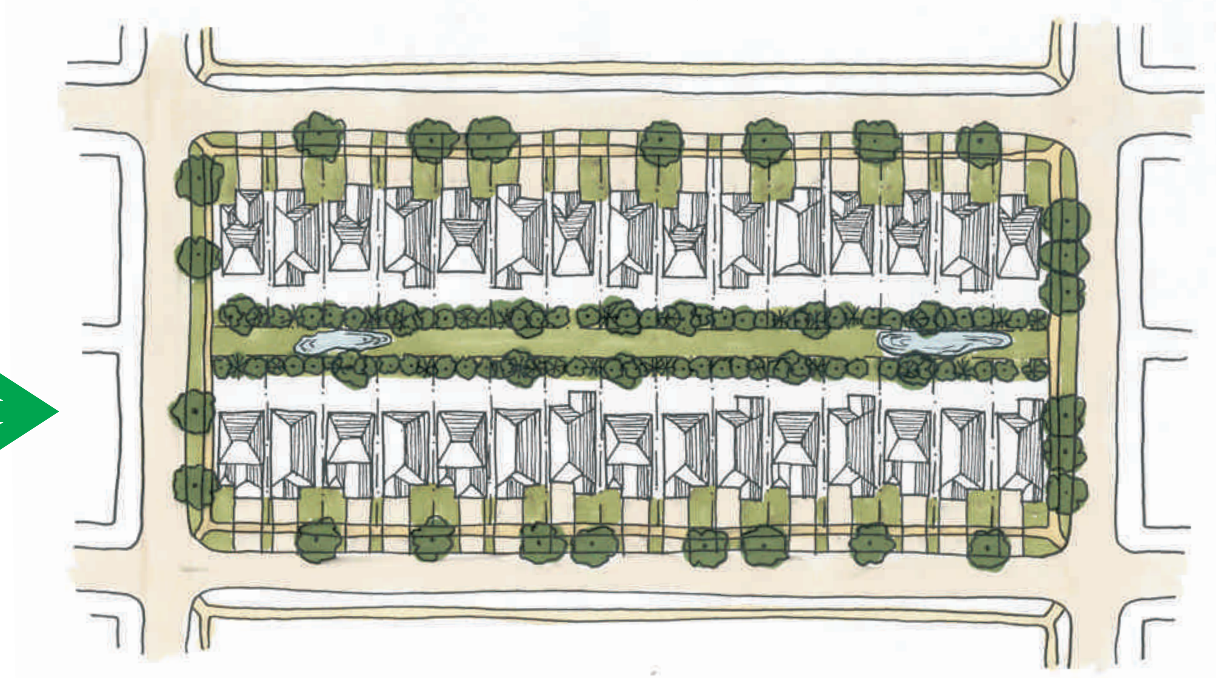
Lot Coverage 39%
Neighbourhood Coverage 44%

Partially Redeveloped Single Family Neighbourhood
(in 5 to 10 Years)



Lot Coverage 44%
Neighbourhood Coverage 48%

Partially Redeveloped Single Family Neighbourhood
(in 25 to 30 Years)



Lot Coverage 46%
Neighbourhood Coverage 43%

Fully Redeveloped Single Family Neighbourhood
(in 50 Years)

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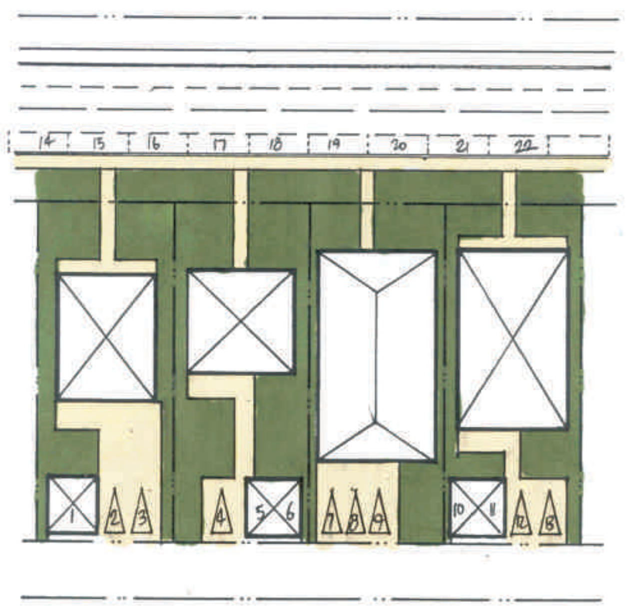
FERGUS CREEK ISMP

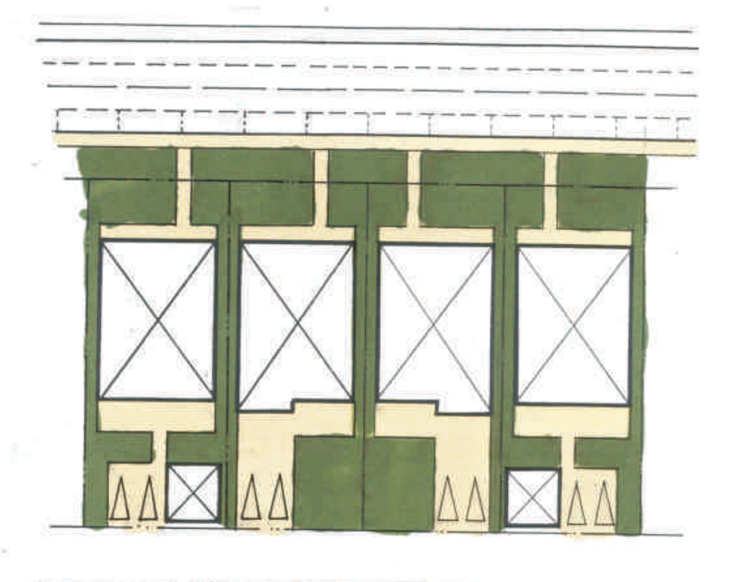
Potential Single Family Redevelopment

Figure 2.19

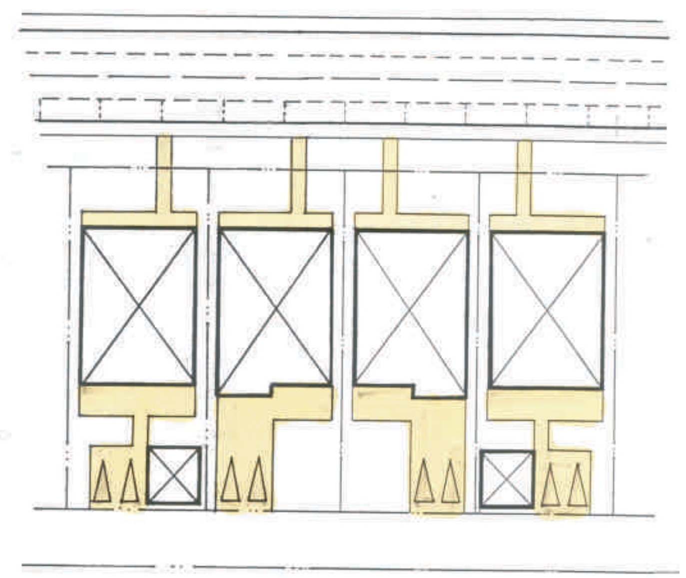
SURREY
CITY OF PARKS



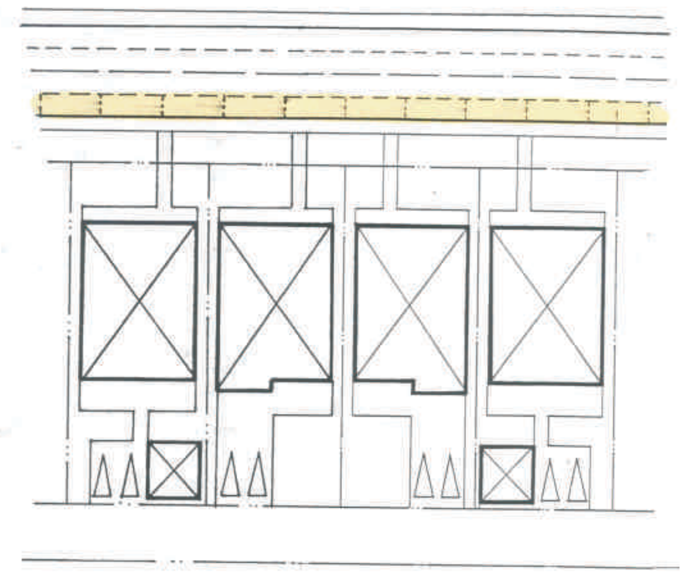
Existing Lots
Lot Coverage approx. 61%
Road Coverage approx. 72%
Overall Coverage approx. 64%



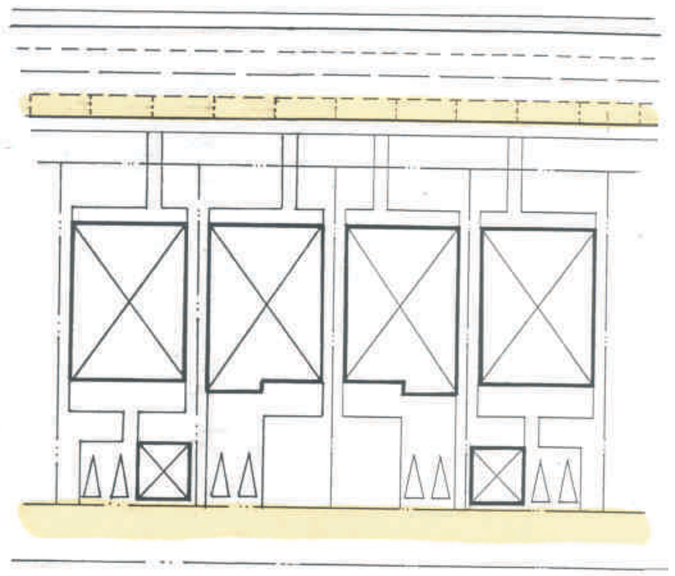
Possible Lots
Lot Coverage approx. 65%
(Building 45%);
Road Coverage approx. 72%
Overall Coverage approx. 67%



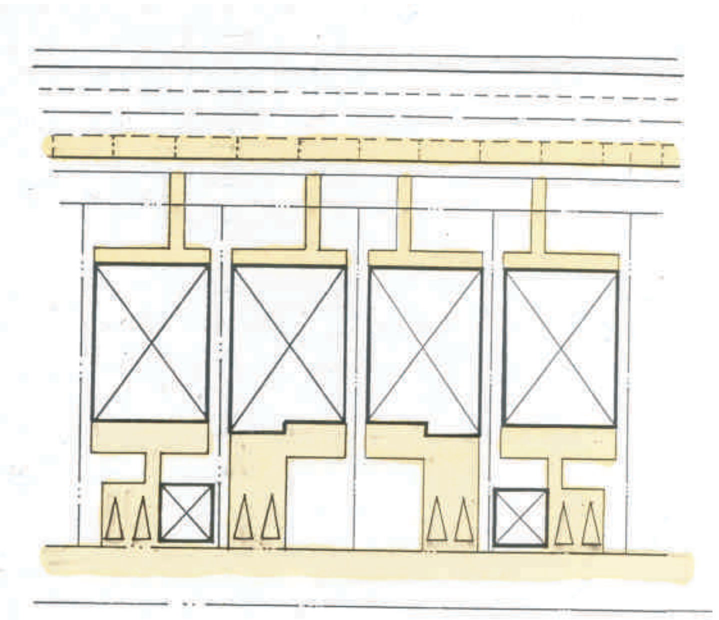
Driveways & Walks Porous
Lot Coverage approx. 45%;
Road Coverage approx. 72%
Overall Coverage approx. 52%



Parking Lanes Porous
Lot Coverage approx. 65%;
Road Coverage approx. 53%
Overall Coverage approx. 62%



Parking Lanes & Lanes Porous
Lot Coverage approx. 65%;
Road Coverage approx. 30%
Overall Coverage approx. 56%

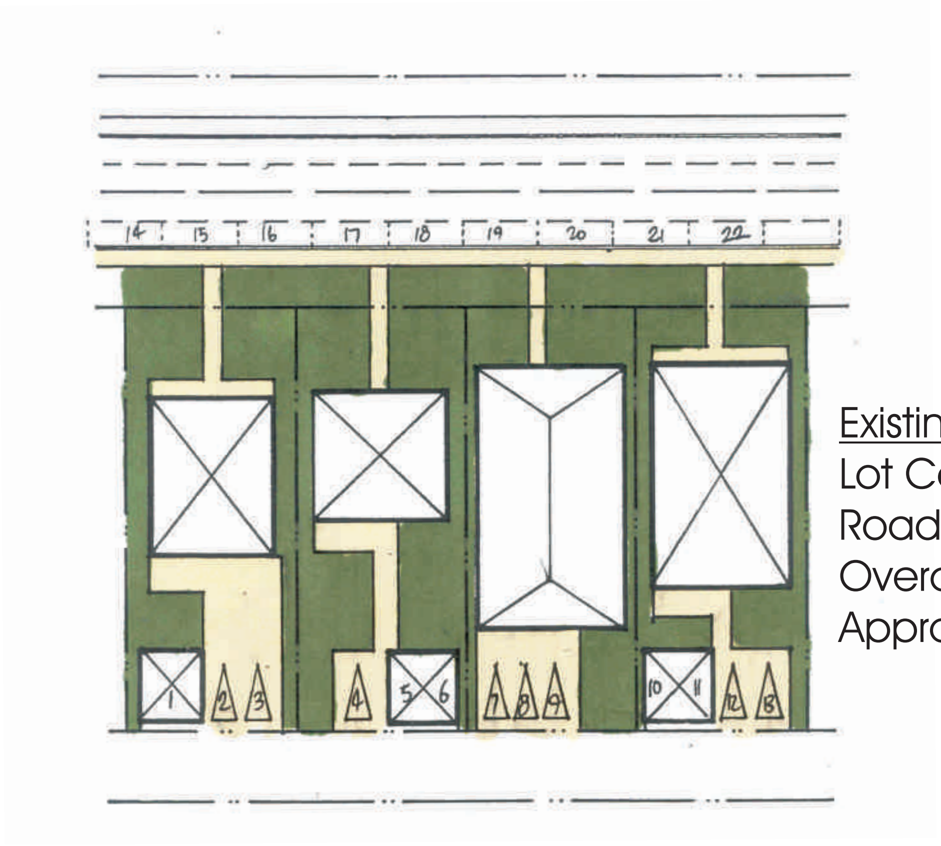


Driveways, Walks, Parking Lanes & Lanes Porous
Lot Coverage approx. 45%;
Road Coverage approx. 30%
Overall Coverage approx. 41%

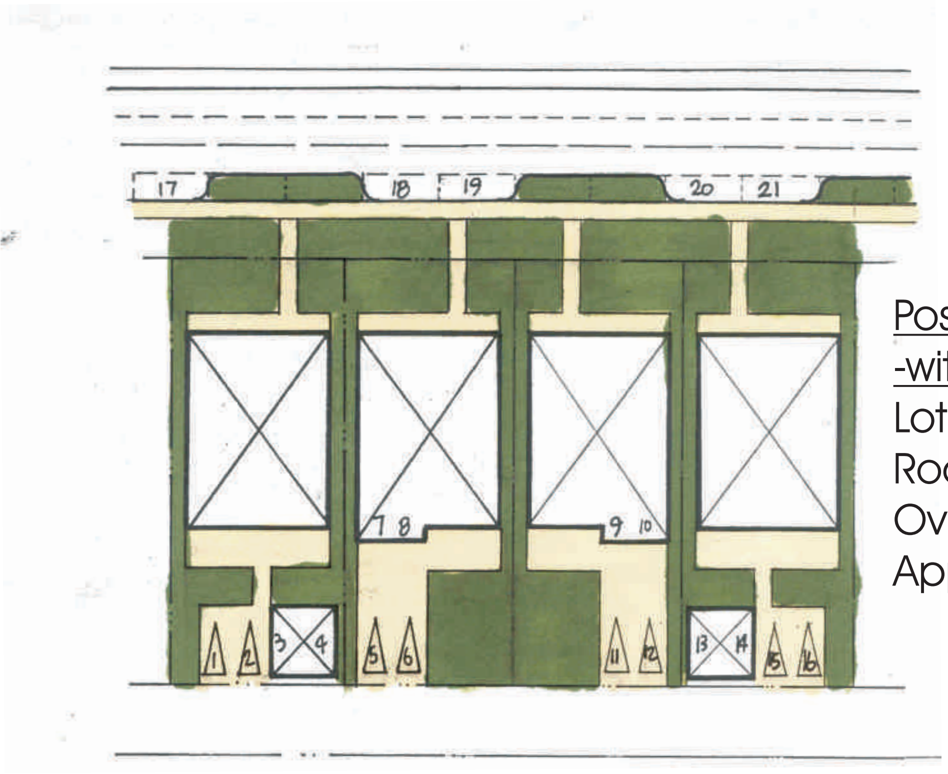
McElhanney

FERGUS CREEK ISMP
Lots with Porous Pavement
Figure 2.20

SURREY
CITY OF PARKS



Existing Lots
Lot Coverage approx. 61%;
Road Coverage approx. 72%
Overall Coverage approx. 64%
Approx. 5.5 parking stalls/lot



Possible Lots
-with Parking Lane Infill
Lot Coverage approx. 65%;
Road Coverage approx. 64%
Overall Coverage approx. 65%
Approx. 5.25 parking stalls/lot

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FERGUS CREEK ISMP

Modified Street Standards

Figure 2.21

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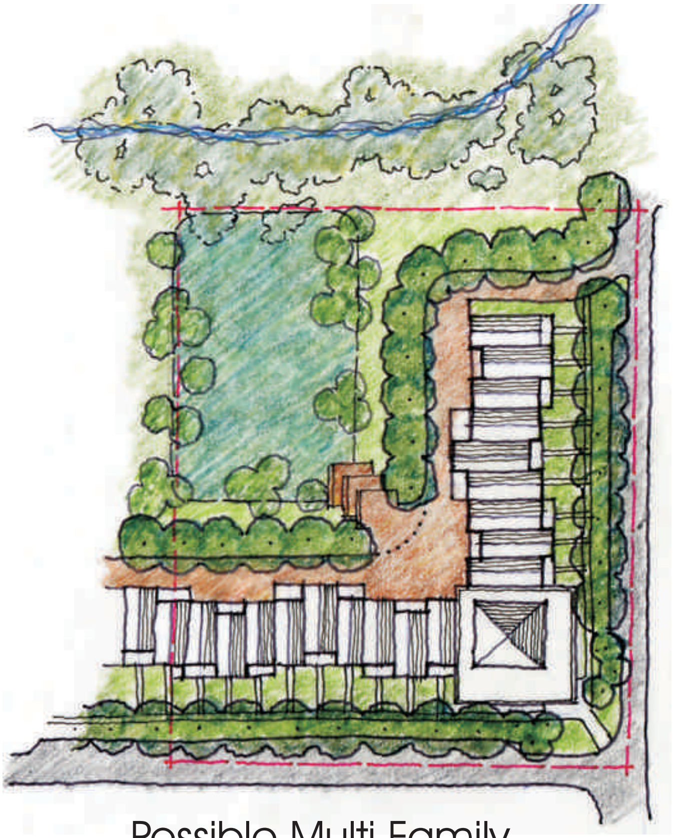
Existing Single Family

Existing Development
35 people/ha in 14 homes
Neighbourhood Imperviousness 42%



Possible Multi Family

New / Redevelopment
65 people/ha in 26 homes
Neighbourhood Imperviousness 45%
- can be reduced to 31% with porous pavements in parking and access.

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FERGUS CREEK ISMP

Possible Multi-Family Redevelopment

Figure 2.22

3.0 STORMWATER MANAGEMENT

Existing storm drainage of the watershed can be subdivided into two portions. The western portion of the watershed has a pipe network system. The eastern portion of the watershed consists of open channels and ditches. Each poses a difficult systemic drainage problem. Detailed review may be required and subject to funding availability.

As a result of development process the imperviousness area in the watershed will increase. This would cause the runoff volumes and discharges to increase and surface evaporation and infiltration capabilities to decrease. As the discharges increase, so do the volumes of runoff and the duration of peak flows. Low flow volumes and duration of base flows will also decrease. Since these factors are critical to the health of the stream and habitat conditions mitigating measures are required to the availability of aquatic habitat associated with the watershed.

An alternative to the traditional engineering analysis methodologies is an approach that examines the amount of time that the discharge within the stream exceeds certain threshold values. As the threshold values are difficult to define, a range of values can be examined concurrently to develop an understanding of the impacts on the stream caused by changes within the watershed.

The control of runoff volume has substantial environmental benefits for streams and is highly favoured by regulatory agencies. Hence, volume control is a watershed practice that should be implemented. The value of the volume controls must be balanced by the effectiveness of such measures.

3.1 AGENCY INPUTS

This ISMP addresses several issues and concerns identified by regulatory agencies. DFO in particular, has identified issues regarding several items that have been included in previous drainage studies or plans. The outstanding questions that have been address within this ISMP relate to the following:

- The proposed diversion works as a means of last resort to solve the erosion problems along Fergus Creek;
- The on-stream detention ponds upstream of Highway 99 are considered unacceptable and discouraged; and
- DFO requires the implementation of urban stormwater management BMP's in new developments and areas undergoing redevelopment.

3.2 TRADITIONAL METHODOLOGIES

The lower reaches of Fergus Creek have experienced instances of flooding outside the banks of the stream. The City is cognizant of the issues relating to maintaining the predevelopment discharge rates within the stream for up to the 1 in 100 year return period flood event. A part of the stormwater management system will include detention facilities that would limit the post development discharge rates to predevelopment rates. This criterion would prevent increases to both the flood magnitudes and their associated damages.

3.2.1 Stormwater Detention

The traditional stormwater management methodology intended to mitigate stream flooding and erosion is the construction of stormwater detention facilities. It is assumed that by restricting the post development discharge rates to some proportion of predevelopment rates stream erosion and, therefore, stream impacts would be mitigated. Detention also provides a reduction in downstream flooding or the increase in flood protection for specific design criteria.

To create a starting point for discussion within the ISMP a preliminary assessment has been undertaken to determine the minimum stormwater detention that would be required to meet the City of Surrey design criteria. Traditional techniques have been used for determining the size of detention facilities. Analysis of the existing or pre-development drainage conditions and of the anticipated future conditions as outlined by the future land use and street layout was carried out using the SWMHYMO model. SWMHYMO, as with its predecessors OTTHYMO-89 (Wisner, Sabourin and Alperin, 1989), HYMO

(Williams and Hann, 1973), and OTTHYMO-83 (Wisner, P'ng, 1983), is a complex hydrologic model used for the simulation and management of stormwater runoff in either small or large rural and urban areas. The model was developed to specifically address dual drainage systems encompassing both the minor (pipe) and major (overland) components.

Based on easily acquired watershed information, SWMHYMO can use single rainfall events (observed or synthetic) simulate the transformation of rainfall into surface runoff. Computed hydrographs can be routed through pipes, channels or stormwater control ponds and reservoirs. In urban areas, the effective capture rates of catchbasins and the effects of surface storage in street low points can also be simulated.

The hydrologic and hydraulic principles, which are incorporated in SWMHYMO, have been applied, tested and calibrated over many years. It is the amalgamation of these principles, which makes SWMHYMO such a useful and flexible tool. The SWMHYMO computer program is a stable modelling system that has provided a suitable analysis tool for this project.

The City of Surrey places the Fergus Creek Watershed within the area that is subject to both the Surrey Municipal and the Whiterock rainfall recording stations. The City has predefined design storms for use when modelling the operation of the drainage systems. We have selected the Surrey Municipal Gauge design storms for use in this study.

The SWMMHYMO model was used to calculate pre-development or existing runoff hydrographs using modified SCS curve numbers for predominantly rural catchments and to calculate runoff from pervious areas where the directly connected impervious ratios for suburban lands was estimated to be 0.25 or less. For this analysis, a CN of 78 and an initial abstraction (Ia) of 2 mm were selected for impervious surfaces and 7 mm for pervious surfaces.

Hydrographs from future development catchments were calculated using the generally accepted default values contained within the standard hydrograph routines. In this case, user input includes the ratio of impervious area to total area and the approximate weighted ground slope for each of the subcatchments.

The traditional detention system of ponds for the previously undeveloped areas of the Fergus Creek Watershed are shown on **Figure 3.1**. The objective was also to reduce the potential for flooding in the downstream reaches of Fergus Creek for up to a 1 in 100 year return period rainfall event. The size and potential cost of these facilities is shown in **Table 3.1**. We recommend that an area comprising 5% of the watershed be set aside for these, or future detention facilities within the Fergus Creek Watershed.

Table 3.1 Traditional Stormwater Detention Ponds

Pond	Catchment Area (ha)	Pond Area (ha)	Excavation Volume (m3)	Construction Cost ($)	Land Cost ($)	Cost ($)
1	103.48	5.02	100,000	5,502,000	9,920,000	15,422,000
2	38.03	1.42	28,000	1,542,000	2,806,000	4,348,000
3	20.33	0.79	16,000	879,000	1,561,000	2,440,000
4	26.77	1.29	26,000	1,429,000	2,549,000	3,978,000
5	39.66	1.61	32,000	1,761,000	3,181,000	4,942,000
6	28.91	0.91	18,000	991,000	1,798,000	2,789,000
7	15.27	0.60	12,000	660,000	1,186,000	1,846,000
8	25.73	1.01	20,000	1,101,000	1,996,000	3,097,000
Total	298.18	12.65	252,000	13,865,000	24,997,000	38,862,000

Land cost $800,000 per acre
Excavation and disposal cost $50 / m^3
Landscaping cost $10/$m^2$

These detention facilities would be constructed only in those areas that require a new drainage system discharging to Fergus Creek or its tributaries. These costs do not include an allowance for creation of detention within the existing urban areas west of King George Highway or within the Highway 99 corridor.

One significant issue that has been reported in other jurisdictions is the increase in stream erosion following development, even with the implementation of stormwater detention. Given the high cost of the facilities and the potential for a systemic failure to meet the objectives a further assessment was undertaken.

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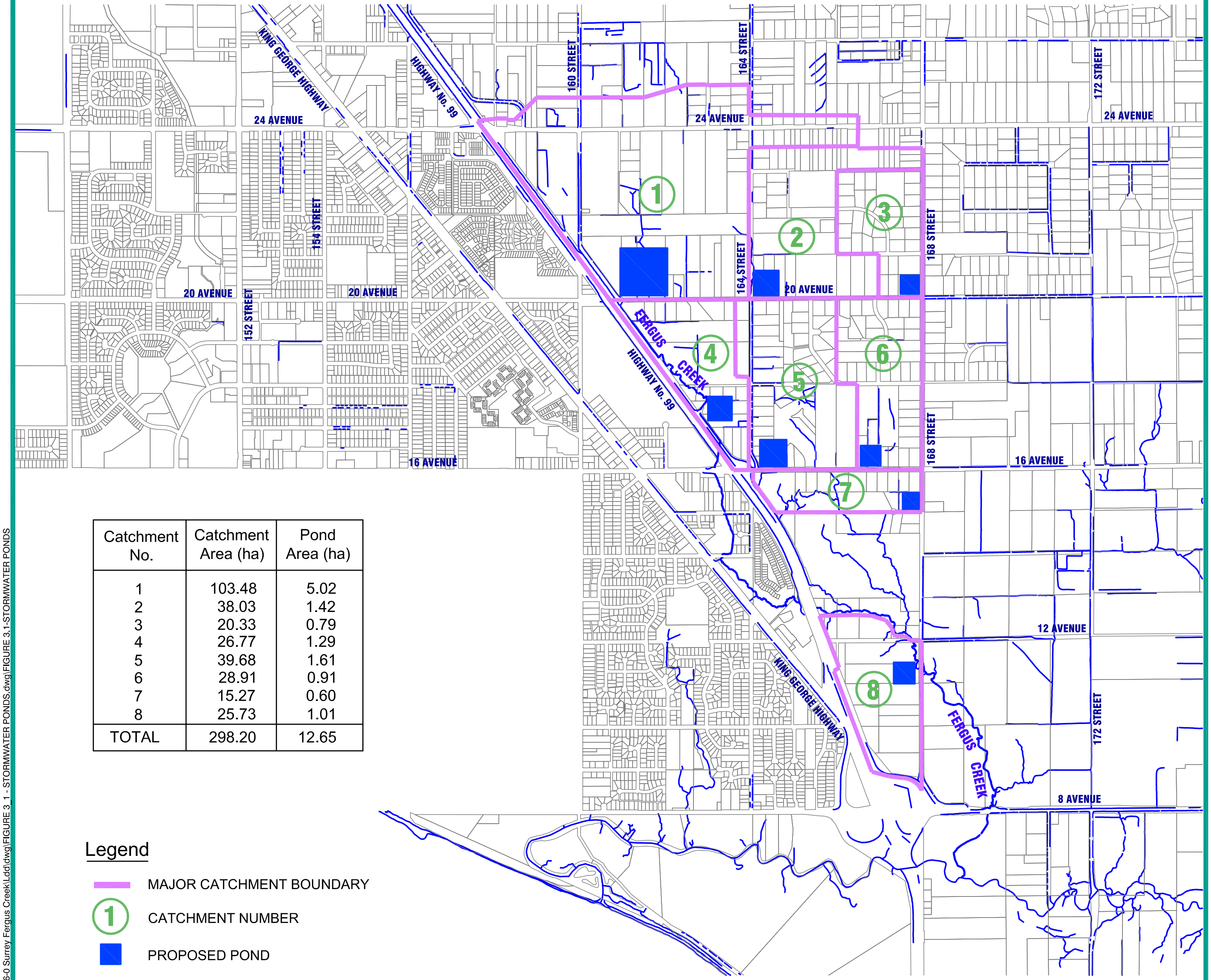


Catchment No.	Catchment Area (ha)	Pond Area (ha)
1	103.48	5.02
2	38.03	1.42
3	20.33	0.79
4	26.77	1.29
5	39.68	1.61
6	28.91	0.91
7	15.27	0.60
8	25.73	1.01
TOTAL	298.20	12.65

Legend

▬	MAJOR CATCHMENT BOUNDARY
①	CATCHMENT NUMBER
■	PROPOSED POND

Plotted: September 16, 2010 , 10:07:22 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 3_1 - STORMWATER PONDS.dwg\FIGURE 3.1-STORMWATER PONDS

McElhanney

FERGUS CREEK ISMP
Drainage Analysis
Stormwater Ponds
Figure 3.1

3.3 GUIDEBOOK REQUIREMENTS

Traditional stormwater management strategies in Surrey and other lower mainland communities employ stormwater detention facilities that collect stormwater during a rain event and release it at a reduced rate into a downstream watercourse once the rain event is completed. This approach is referred to as “rate control” as it seeks to control the quantity of water that reaches watercourses.

The rate of rainfall infiltration is dependent on the permeability of the ground. In natural environments, where the ground is relatively permeable and a high rate of infiltration is possible, rain which does not infiltrate travels overland to watercourses. In urban environments, which are typified by a high percentage of impermeable surfaces, the probability of watercourse damage or flooding is magnified. Stormwater detention facilities were believed to help ameliorate the impact of large rainfall events; however, their overall effectiveness is limited by the intensity and duration of rain events and by the size of the detention pond. That is, a detention pond, no matter how great its storage capacity, can be filled during an especially intense and/or long rain event, necessitating the downstream release of water which has the potential to cause harm.

An alternative approach of volume control in urban environments is to replicate the rainwater infiltration capacity of the natural environment by increasing the amount and quality of permeable surfaces. Implementation of this approach in the recent past has focused on limiting the surface coverage of development sites (including residential and commercial) or by introducing more permeable surfaces into typically hard, impermeable surfaces. An example of the later is using paving stones or permeable pavement in the construction of driveways or parking lots. While these techniques have had reasonable success the recent trend towards higher density single and multiple family developments in response to higher land and development costs and the implementation of municipal plans can limit their effectiveness depending on the sensitivity of site design to maintaining permeable surfaces.

In addition to the above noted detention systems, several guides have been proposed with the aim to reduce the impacts of urban development on streams. For the Fergus Creek Watershed there are three Guides that would be applicable, these being:

1. Stormwater Planning, A Guidebook for British Columbia, (2002);
2. The GVRD Stormwater Source Control Guidelines, 2005; and
3. Urban Stormwater Guidelines And Best Management Practices For Protection Of Fish And Fish Habitat, Draft Discussion Document, Revision 4.

The **Guidebook** for BC suggests that retaining one half of a mean annual 24 hour rainfall event, or 30 mm, falling onto impervious surfaces would mitigate environmental impacts. Within the Fergus Creek Watershed and an ultimate development pattern comprised of 70% imperviousness over the 298 ha of undeveloped land this would imply a need to provide a retention volume of 63,000 m^3 for all the potentially impervious surfaces. Recent construction costs indicate the provision of retention in underground facilities on both private properties and within the municipal Rights-of-Way would cost on average $400 per m^3 of volume, not including the associated piping. This would add a watershed cost of approximately $25,000,000 to the cost of the stormwater management system. The combined costs of providing detention ponds and Guidebook retention BMP's within the eastern portion of the watershed would be $63,862,000 ($38,862,000 plus $25,000,000) or as expressed on a per area basis $213,000 per ha ($86,000 per acre).

The **GVRD Guide** increases the retention volume to 70 mm over the impervious surfaces to mitigate environmental impacts. Within the Fergus Creek Watershed this would imply a need to provide a retention volume of 146,000 m^3 for all the potentially impervious surfaces at a cost of $58,000,000, not including the associated piping, in addition to the other stormwater management system costs. The combined costs of providing detention ponds and retention GVRD Guide BMP's within the eastern portion of the watershed would be $96,862,000 ($38,862,000 plus $58,000,000) or as expressed on a per area basis $323,000 per ha ($130,000 per acre).

The total estimated costs of the traditional detention and retention BMP's is summarized in **Table 3.2**. The costs compare the differences between the application of the Guidebook to those for the GVRD Guide.

TABLE 3.2 Detention and Retention System Cost

	Total Cost		Cost Per Acre	
Traditional Detention	$38,862,000	$38,862,000	$52,000	$52,000
Guidebook Retention BMP's	$25,000,000	-	$34,000	-
GVRD Guide Retention BMP's	-	$58,000,000	-	$78,000
Total with Guidebook	$63,862,000	N/A	$86,000	-
Total with GVRD Guide	-	$96,862,000	-	$130,000

Note: Guidebook and Guide costs include storage only; the costs do not include associated connection and overflow piping for the systems.

As can be seen, applying the GVRD Guide would yield the highest total cost and the highest cost per acre within the rural areas of the Fergus Creek Watershed. These costs do not include existing areas west of King George Highway or the Highway 99 Corridor.

The **DFO Guide** provides the guidance for the design of stormwater mitigation systems in that the previously assumed retention values can be re-evaluated. The DFO Guide indicates that the hydrologic designs of these systems should follow the following rules:

- Pre-development rates of runoff from developed and undeveloped sites will be modelled using public-domain hydrological analysis programs with continuous simulation (e.g., HSPF or SWMM) or third-party programs based on these models. The model shall be calibrated in saturated and non-saturated conditions using 6 months continuous flow data.
- Single event models are acceptable for preliminary sizing of BMP's, conveyance systems and post-development conditions if representative multiple event scenarios are modelled.

One should note carefully that the use of the volume of a mean annual storm represents the practice of using a design storm and should only be used for preliminary sizing purposes.

For design of the mitigation systems the use of continuous simulations is suggested. As DFO is the senior approving agency their recommended design methodologies have been utilized in the analysis for the Fergus Creek ISMP. This process takes the City of Surrey beyond the guidebook requirements originally envisioned in the ISMP Template and in the Provincial Guidebook. This also allows the City to explore the requirements associated with the fundamental requirements of DFO for stream health and environmental protection.

3.4 BEYOND THE GUIDEBOOK METHODOLOGY

During the course of preparing this ISMP, the need to go beyond the traditional methodologies has been recognized. The two reasons being the combined cost of the detention and retention facilities combined with published reports indicating the failure of such facilities to achieve their design objectives. The potential costs alone create a need to further evaluate the systems, their need and their performance in meeting the objectives of the various stakeholders and agencies.

The methodology chosen to analyse stormwater runoff and environmental impact mitigation for the Fergus Creek Watershed is one of continuous simulation. This approach allows a probabilistic analysis of runoff in the study area. The probabilities attached to various events, or put another way, their return periods, are correctly determined so as to properly carry out any associated risk analysis. The probabilities are determined by frequency analyses of the simulation results in exactly the same way as if there were recorded streamflow data available.

A primary benefit of continuous simulation is that the frequency of various conditions can be estimated more easily than when alternate approaches are used. For example, the occurrence of a given runoff flow rate depends not only on the rainfall volume and distribution, but also on antecedent conditions such as rainfall and soil moisture. Any drainage system, whether natural or manmade, is extremely sensitive to conditions prior to any actual and specific rainfall event. A period of relatively low intensity, but high volume, rainfall, may fill, or at least partially fill, the system soil and surface storage and detention facilities. The drainage system would react quite differently under these conditions than if the watershed were presumed to be dry for analytical purposes.

An additional benefit to continuous modelling is that it allows for duration analyses. This is useful as it allows us to demonstrate the ability of the proposed systems to mimic the natural hydrologic cycle in terms of both duration and volume of runoff.

Long term (1963 to 1999) continuous precipitation records were used to simulate the response of the Fergus Creek watershed under different operational conditions, and to establish the stream discharges and flow characteristics. Through such operational studies, it is possible to have a better understanding of the watershed's response to extended wet weather conditions (multiple events) and combined probability of rainfall and antecedent conditions.

3.4.1 Computer Model

The computer simulation analysis of this study utilized the QHM computer model that has been developed from the QUALHYMO computer model. We should point out that the QUALHYMO model is being incorporated into the Water Balance Model and will be available in for general release in mid 2007. This will allow any user to undertake simulations such as those described and used in developing the Fergus Creek ISMP.

The original QAULHYMO model was developed in 1983 during the creation of a methodology for analysis of stormwater detention ponds for water quality control, funded by a grant from the Ontario Ministry of the Environment. QHM can be used as a general tool for simulating rainfall runoff; however, it is most suited to planning level analyses in basins where the land surface is developing from a rural, or undeveloped state, to an urban land use.

The basic structure for QHM is new, but several concepts have been retained from two earlier models, QUALHYMO and HYMO. HYMO, created in 1973 by J.R. Williams, has proven to be a very popular model for use in stormwater quantity management studies. HYMO in its original form is a single event runoff model using a United States Soil Conservation Service (SCS) loss procedure, and is most suitable for use in simulation of direct runoff from rural areas. HYMO employs a concept in code structure that has proven to be excellent for practical applications; basic hydrologic functions (such as runoff generation and routing) are represented by a series of specific "commands" which correspond to distinct subroutines within the model.

QHM uses the basic input structure developed by Williams for HYMO. The HYMO input structure was chosen partly due to the wide experience with HYMO and, more recently, OTTHYMO models, and also reflects the effectiveness of this concept for use in studies where a simple, flexible, and rapid data input method is desirable. QHM is distinct from HYMO and OTTHYMO in its ability to simulate the generation and routing of pollutants, and in its orientation towards continuous simulation.

3.4.2 Model Verification

Fergus Creek model parameters were developed through a calibration or verification process. As there are no long term discharge records for Fergus Creek, a proxy stream was selected to establish appropriate model operation. The streams used included the Salmon River at 72 Avenue with a watershed of 49 km^2 and West Creek near Fort Langley with a watershed area of 11.4 km^2 as shown on **Figure 3.2**.

Critical factors such as the annual flood frequency or maximum discharge rates were established, as were the annual runoff volumes. The shapes of individual runoff event hydrographs were used to further modify the computer model parameters to assure reasonable operation through a number of runoff events with a wide rage of discharge magnitude. To account for rainfall variations across the Fraser Valley, the precipitation records for the Surrey Municipal Hall were increased to match the average annual values observed for the proxy watersheds as shown on **Figure 3.3**.

The flood frequency analysis as measured in L/s/ha of watershed area of the surrogate streams are indicated in **Table 3.3**. The measure of L/s/ha creates a uniform measure upon which the values for different watersheds can be compared.

Table 3.3 Flood Frequency

Return Period (years)	Discharge (L/s per hectare)	
	Salmon River	West Creek

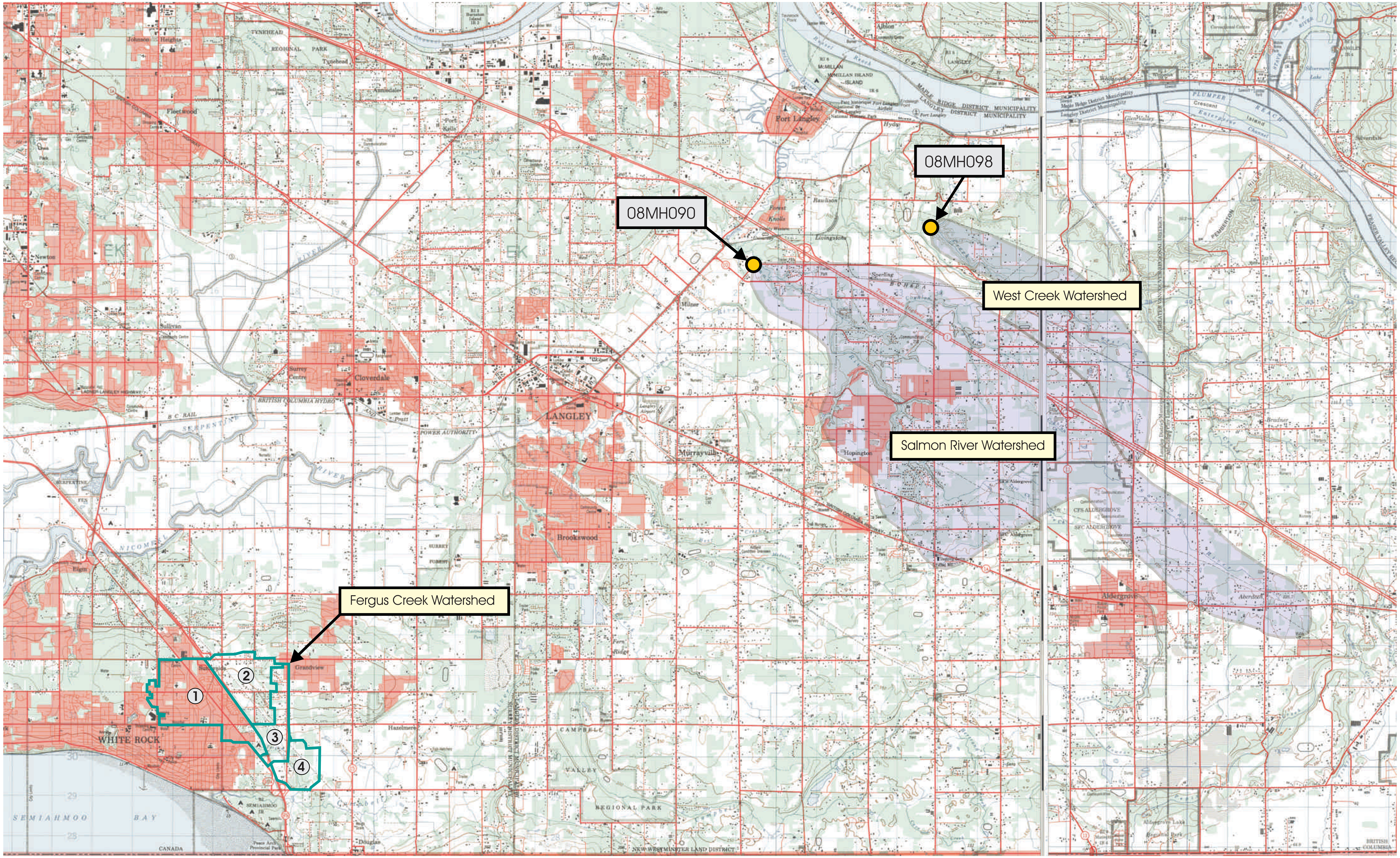
200	19.2	23.3
100	16.8	21.0
50	14.7	18.8
25	12.6	16.6
10	10.0	13.7
5	8.1	11.5
3	6.8	9.7
2	5.6	8.1

The annual volumes of stream discharge and rainfall for the period of record where both were measured are shown in **Table 3.4**. The rainfall amounts as shown are the Surrey Municipal gauge increased by a factor of 1.33 to account the increase in rainfall volumes that occurs at the watershed locations.

Table 3.4 Rainfall and Runoff

	Station	08MH090		08MH098	
Year	Rainfall (m^3/ha)	Runoff (m^3/ha)	Discharge Coefficient (Discharge/Rainfall)	Runoff (m^3/ha)	Discharge Coefficient (Discharge/Rainfall)
1963	10,833	8,946	0.83	-	-
1964	9,700	-	-	-	-
1965	12,415	-	-	14,910	1.20
1966	16,059	-	-	14,717	0.92
1967	18,241	-	-	-	-
1968	19,507	-	-	-	-
1969	14,583	-	-	-	-
1970	13,768	7,208	0.52	-	-
1971	18,011	12,486	0.69	16,875	0.94
1972	18,716	12,807	0.68	16,543	0.88
1973	14,892	-	-	8,963	0.60
1974	12,745	9,911	0.78	13,223	1.04
1975	15,881	10,748	0.68	14,413	0.91
1976	16,327	8,882	0.54	9,544	0.58
1977	14,763	7,530	0.51	8,659	0.59
1978	11,288	6,410	0.57	6,999	0.62
1979	-	6,758	0.98	8,769	1.27
1980	-	9,590	0.77	12,365	1.00
1981	-	10,491	0.95	13,278	1.20
1982	-	9,525	1.05	11,840	1.31
1983	17,585	9,203	0.52	-	-
1984	19,363	10,555	0.55	-	-
1985	11,987	5,644	0.47	6,639	0.55
1986	16,047	8,946	0.56	10,235	0.64
1987	13,065	6,500	0.50	6,971	0.53
1988	17,995	9,396	0.52	11,259	0.63
1989	15,361	9,332	0.61	11,148	0.73
1990	17,195	11,649	0.68	12,836	0.75
1991	13,284	9,268	0.70	9,903	0.75
1992	13,268	7,981	0.60	8,576	0.65
1993	10,864	6,436	0.59	7,137	0.66
1994	11,847	8,817	0.74	10,678	0.90
1995	13,584	10,169	0.75	11,674	0.86
1996	17,168	10,619	0.62	10,761	0.63
1997	21,587	13,580	0.63	-	-
1998	15,733	9,654	0.61	11,591	0.74
1999	11,053	11,585	1.05	-	-

Note: - Denotes missing or incomplete data



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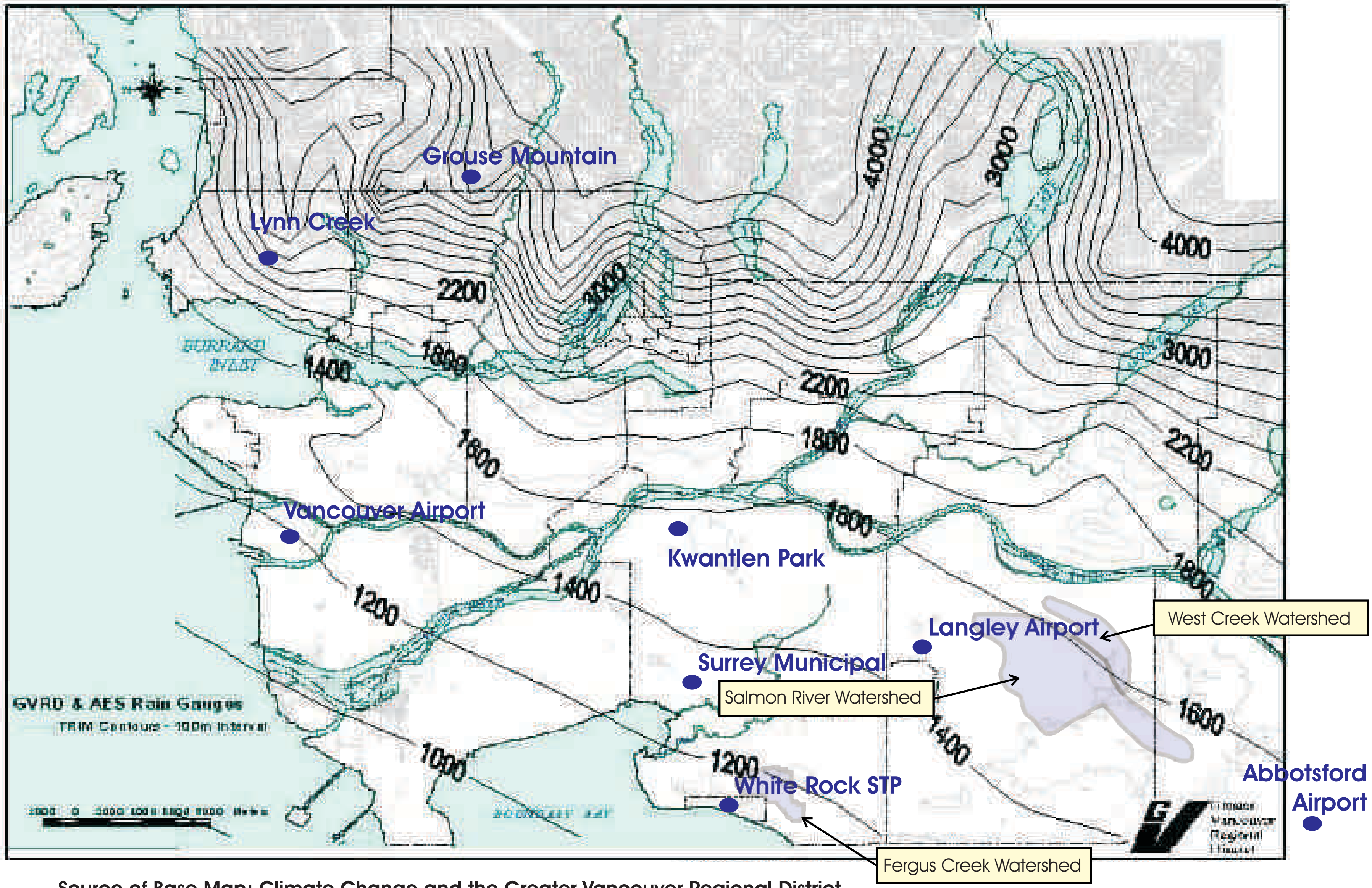
FERGUS CREEK ISMP

Watershed Location

Figure 3.2

GVRD Mean Annual Precipitation 1961-90



Source of Base Map: Climate Change and the Greater Vancouver Regional District
Environment Canada,June 22, 2000

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FERGUS CREEK ISMP
Annual Precipitation
Figure 3.3

Typically not all of the rainfall that falls on the watershed will eventually discharge in the stream. There may be inaccuracies in the measurements but the trend indicates that at least 50% of the rainfall will reach the stream. The losses would go to deep groundwater that do not return to the stream, to evaporation from the surface of vegetation, transpiration from plants following infiltration into the ground and plant uptake.

The watershed parameters that provided the best fit for frequency and annual volumes are presented in **Table 3.5**.

Table 3.5 Pre-Development Catchment Parameters

Catchment	Area (ha)	Impervious	Time to Peak		Initial Abstraction		Soil Storage		
			Impervious (hrs)	Pervious (hrs)	Impervious (mm)	Pervious (mm)	Minimum (mm)	Maximum (mm)	Decay (1/mm)
1	328.3	0.68	1.5	1.5	2.5	6.0	16.0	150.0	0.01
2	125.1	0.31	1.5	1.8	2.5	6.0	16.0	150.0	0.01
3	206.9	0.31	1.7	1.7	2.5	6.0	16.0	150.0	0.01
4	122.2	0.14	1.6	1.6	2.5	6.0	16.0	150.0	0.01

The QHM computer model utilizes additional soil moisture parameters; these are shown in **Table 3.6**.

Table 3.6 Additional Soil Data

Minimum Base Flow	0.025
Base Flow Depletion Factor	1
Starting Soil Moisture (mm)	20
Soil Moisture at Wilting Point (mm)	16
Soil Moisture at Field Capacity (mm)	150
Base Recession Constant	0.00001
Base Flow Reduction Factor	0.15

The actual recorded rainfall recorded at the Surrey Municipal Hall was used in assessing the hydrology of the Fergus Creek Watershed. The predevelopment discharge rates in selected stream reaches are shown on **Figure 3.4**. Also shown are the stream cross sections along the stream.

3.4.3 Post Development Hydrology

The changes in the watershed from the existing conditions to final development will primarily be a result of increased imperviousness with a corresponding reduction in the time to peak of the catchment runoff. These post development modelling parameters are shown in **Table 3.7**.

Table 3.7 Post-Development Catchment Parameters

Catchment	Area (ha)	Impervious	Time to Peak	
			Impervious (hrs)	Pervious (hrs)
1	328.3	0.70	1.0	1.0
2	125.1	0.66	0.8	1.0
3	206.9	0.70	1.0	1.0
4	122.2	0.30	1.0	1.0

The changes in catchment parameters will result in an increase in both the volumes and rates of runoff unless these are mitigated as a part of the development and redevelopment process.

3.4.4 Volume Reduction Analysis Methodology

The volume reduction can be analysed if one can envision how they will physically operate and then apply modelling techniques to simulate their operation. Their operation can be envisioned as is shown on **Figure 3.5**. It is essentially a storage system with a number of discharges. There are two places in the model where the BMP's can be input, these are associated with the catchment parameters and/or a storage function.

Changing the catchment parameters can provide analysis of volume reduction methods or BMP's. Low impact development items falling into this category consist of augmented or enhanced surface conditions that include:

- Increased top soil depth
- Soil porosity or moisture holding capacity
- Surface infiltration rates
- Vegetation and ground cover

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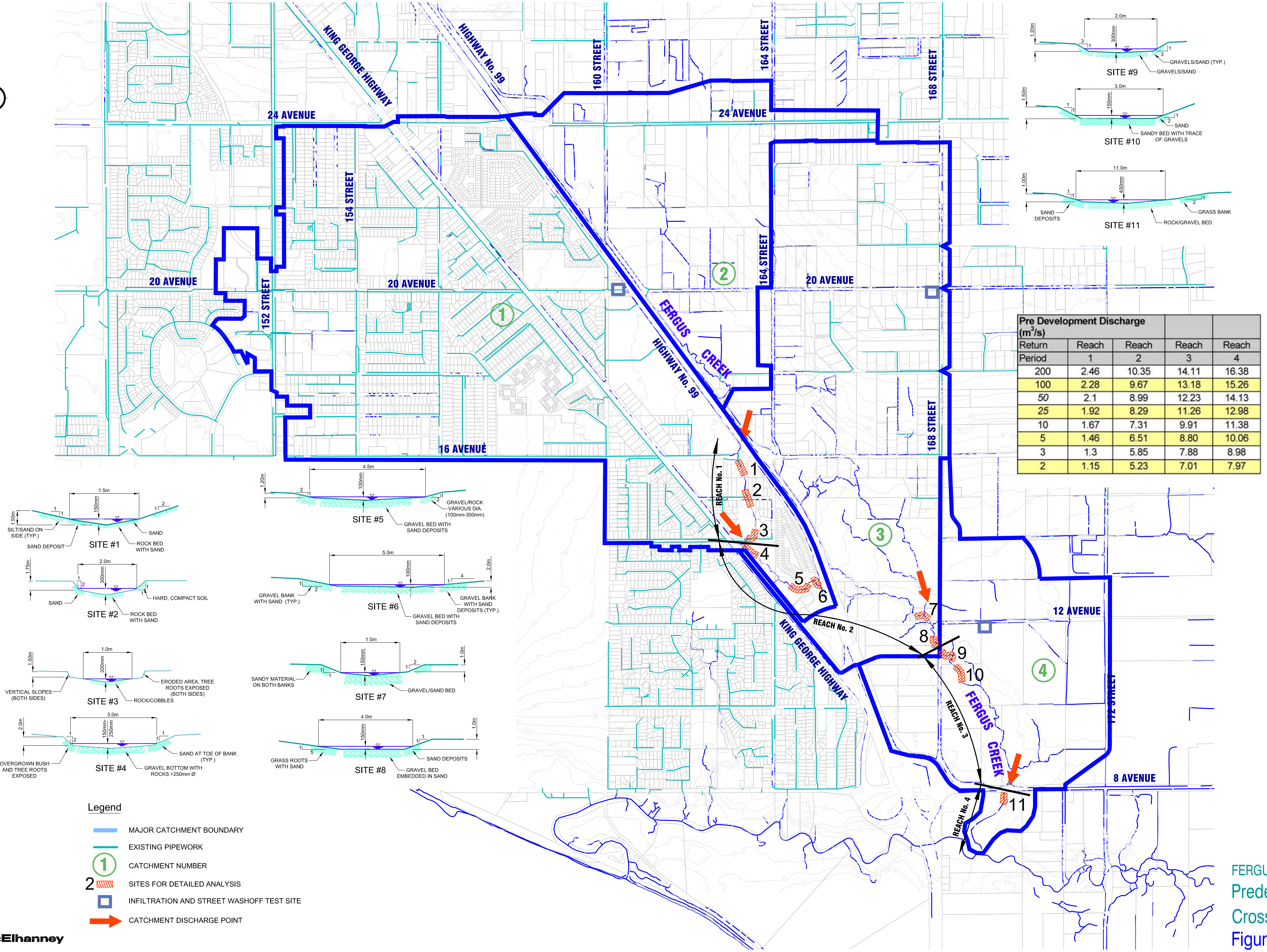

Pre Development Discharge (m^3/s)				
Return Period	Reach 1	Reach 2	Reach 3	Reach 4
200	2.46	10.35	14.11	16.38
100	2.28	9.67	13.18	15.26
50	2.1	8.99	12.23	14.13
25	1.92	8.29	11.26	12.98
10	1.67	7.31	9.91	11.38
5	1.46	6.51	8.80	10.06
3	1.3	5.85	7.88	8.98
2	1.15	5.23	7.01	7.97

Legend

▬	MAJOR CATCHMENT BOUNDARY
—	EXISTING PIPEWORK
①	CATCHMENT NUMBER
2 ▨	SITES FOR DETAILED ANALYSIS
□	INFILTRATION AND STREET WASHOFF TEST SITE
➡	CATCHMENT DISCHARGE POINT

McElhanney

FERGUS CREEK ISMP

Predevelopment Discharge and Cross Section Locations

Figure 3.4

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Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Lcd\dwg\FIGURE 3_4 - PREDEV DISCHARGE.dwg\FIGURE 3.4 - PREDEV DISCHARGE

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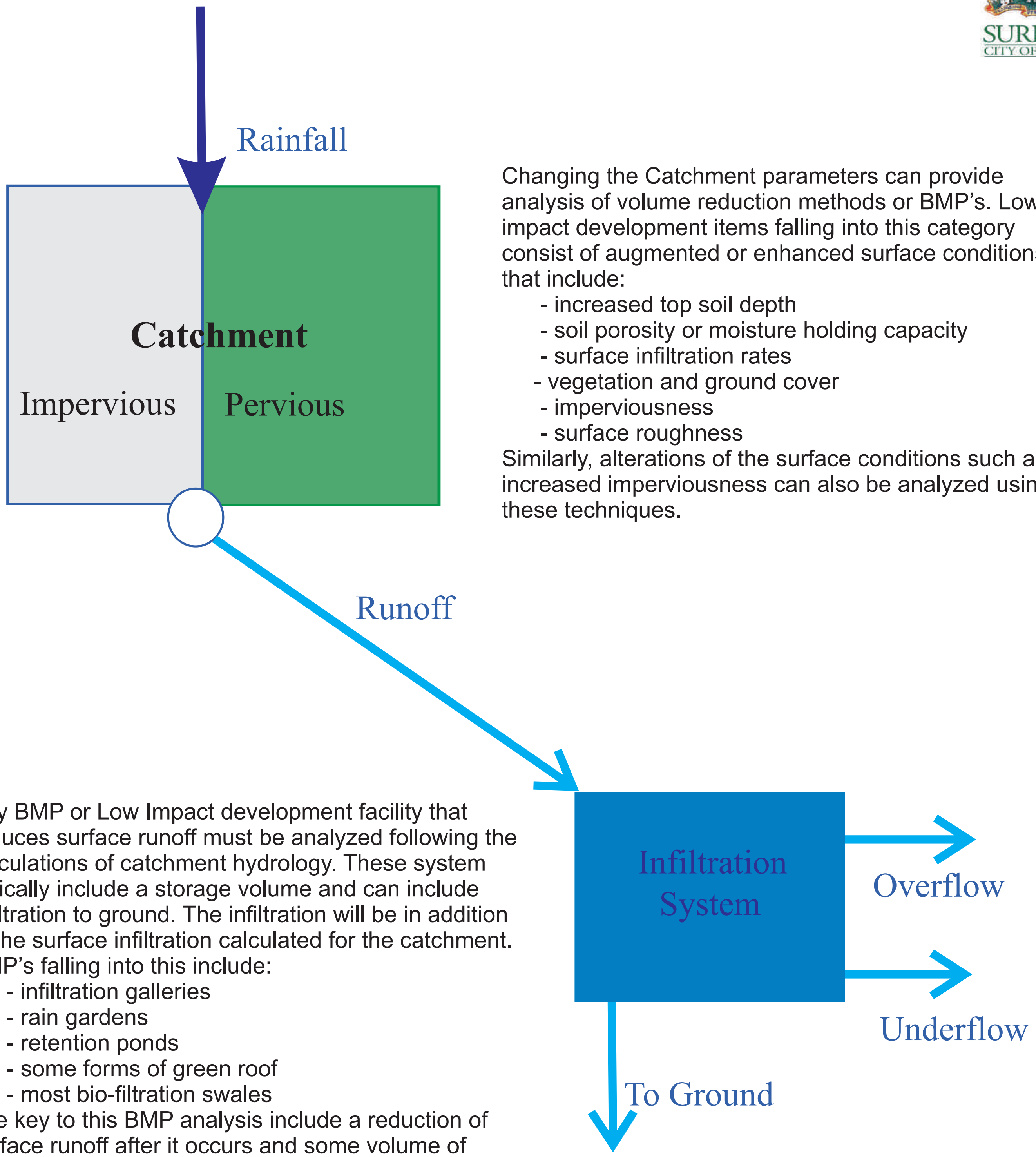

Changing the Catchment parameters can provide analysis of volume reduction methods or BMP’s. Low impact development items falling into this category consist of augmented or enhanced surface conditions that include:

- increased top soil depth
- soil porosity or moisture holding capacity
- surface infiltration rates
- vegetation and ground cover
- imperviousness
- surface roughness

Similarly, alterations of the surface conditions such as increased imperviousness can also be analyzed using these techniques.

Any BMP or Low Impact development facility that reduces surface runoff must be analyzed following the calculations of catchment hydrology. These system typically include a storage volume and can include infiltration to ground. The infiltration will be in addition to the surface infiltration calculated for the catchment. BMP’s falling into this include:

- infiltration galleries
- rain gardens
- retention ponds
- some forms of green roof
- most bio-filtration swales

The key to this BMP analysis include a reduction of surface runoff after it occurs and some volume of stored water.

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FERGUS CREEK ISMP
BMP System Modelling
Figure 3.5

- Imperviousness
- Surface roughness

Similarly, alterations of the surface conditions such as increased imperviousness can also be analyzed using these techniques.

Any BMP or Low Impact development facility that reduces surface runoff must be analyzed following the calculations of catchment hydrology. These systems typically include a storage volume and can include infiltration to ground. The infiltration will be in addition to the surface infiltration calculated for the catchment. BMP's falling into this includes:

- Infiltration galleries
- Rain gardens
- Retention ponds
- Some forms of green roof
- Most bio-filtration swales

The key to this BMP analysis includes a reduction of surface runoff after it occurs and some volume of stored water. The infiltration system captures runoff from a portion of the catchment and stores the runoff as it infiltrates it to ground. The runoff can go to three different outflow paths. The primary discharge is through infiltration to ground. An overflow is obviously needed, as there will always be some storm events that will more than fill the storage capacity of the system. We have also included an underflow system to augment stream baseflows and to enhance the system operation. This is an important function and will be further described in later sections of this report.

3.4.5 Discharge Exceedence Methodology

A critical factor in the health of a stream is the duration of flow or, as viewed slightly differently, the amount of time that the discharge would exceed critical values. While there are a number of critical discharge values for any specific stream reach an assessment can be undertaken to compare a range of values. In this manner the effects of altered hydrologic regimes can be evaluated along with a range of possible mitigation options. To allow a comparison of stream sections though out the main stem of Fergus Creek a range of common discharge values has been established to allow the results to be compared across the system.

The watershed simulations using the QHM model included the period commencing in 1963 and ending with 1999 rainfall data from the Surrey Municipal Hall rainfall recording station as reported by Environment Canada. The hourly records were used to estimate the discharge rates for the various catchments within the watershed for both the predevelopment or existing conditions and the ultimate development conditions as foreseen in the Fergus Creek watershed. The volume reduction BMP’s used to limit the changes to the hydrologic cycle of the watershed were modelled using a multiple outflow storage device. Various sizing and operating criteria were evaluated as a part of the analysis. The variables for the infiltration system included:

- The surface area and resulting infiltration discharge rates,
- The volume of storage in the infiltration systems, and
- The low flow, or underflow, discharge rates from the facilities.

The evaluation of the system operation and performance of the volume reduction BMP’s was undertaken through the use of both flow exceedence and potential erosion in the streams within the Fergus Creek Watershed.

3.4.6 Erosion Analysis Methodology

Two key observations relating to stormwater runoff can be made. Note that these reflect runoff, rather than rainfall.

1. For only a relatively small amount of time are there stream discharges of a large magnitude. In fact, only rarely, and for only a few hours every other year does the discharge reach the magnitude of a 1 in 2 year return period runoff event.
2. The vast majority volume of runoff must, therefore, come from events that are much smaller than a 1 in 2 year return period runoff event.
3. Chronic stream erosion problems must be associated with discharges that are smaller in magnitude than the 1 in 2 year return period event.

These observations have great impacts upon the approach that is required to control the rates and volumes of runoff and for the control of erosion. The conclusion is that in order to control the volume of runoff, effort must be expended in controlling the small discharge rates. These are the rates that do not cause flooding, however they must, by default, result in a vast majority of the sediment transport (erosion) that occurs within the watershed.

One can also conclude that if the volume of runoff is reduced, there may only be a relatively small corresponding reduction in discharge rates. In fact, volume reduction may not significantly reduce flood discharges.

A further conclusion is that the 1 in 2 year return period discharge must not be considered to be a “safe” discharge, or in other words it should not be used as the basis for the design of stable streams.

Several quantitative indicators can be utilized in assessing the potential for erosion or sediment accumulation within the Fergus Creek Watershed. The methodology selected for analysis of the Fergus Creek watershed is based upon shear stress as applied to the streambed and stream banks over time. This is a measure of the energy available to cause erosion in the stream.

An “Impulse” can be defined as a measure of the potential for erosion (MNR 1982). It is defined as a force applied to a surface over a period of time; in this case, shear stress applied to the bed and submerged banks of the stream over the period of the simulation. The amount of shear stress and the duration for which it acts are dependent upon: the discharge in the stream; the depth of flow; and, the stream slope. The surface over which the shear stress is applied is dependent upon the depth of flow and length of channel (Chow 1959).

The equations used in calculating the shear stress include:

$\tau = \sigma Rs$, where
τ = shear stress (Pascals or Newtons / m^2)
σ = unit weight of water (1000kg / m^3)
R = hydraulic radius of flow (m), and
s = slope of channel (m / m)

The Impulse is calculated as:

$I = \tau PT$, where
I = Impulse (kg-seconds / m)
τ = shear stress (Pascals / m^2)
P = wetted perimeter (m)
T = time (seconds)

The Impulse is a measure of the energy available to cause erosion, not an absolute measure of erosion. It might be argued that a critical or minimum shear stress is required to initiate sediment movement. We have selected a typical critical stream velocity based upon the soil types found at the typical stream selected locations.

Comparing the Impulse values in a channel for existing and post-development flow conditions can provide an indication of erosion potential of a streambed over a specified time.

3.4.7 Water Quality Analysis Methodology

It has often been assumed that stormwater is uncontaminated, and therefore it has usually been discharged to the nearest watercourse without further concern. In recent years, however, it has been recognized that direct discharge of stormwater can have detrimental effects on the receiving water caused by the quality of the run-off, as well as the rate of discharge. This new awareness is leading the regulatory agencies in a process that will result in the implementation of water quality objectives for stormwater. While this may be some time in the future, this project offers an opportunity to review the implications and the possible impacts of meeting water quality based design objectives.

The current design guidelines for the City and Province do not specifically address issues other than those associated with construction sediment control. The guidelines as provided by senior levels of government attempt to address this issue.

The potential for significant input of pollutants from urban run-off to the receiving water is now generally recognized. The run-off becomes contaminated through contact with street litter, eroded swales, deicing chemicals, animal droppings, traffic residues, fertilizers, biocides, atmospheric dust fall and other substances. Major pollutants of street run-off have been found to be in the form of suspended settleable solids along with organic matter, algal nutrients, coliform bacteria, heavy metals, and pesticides.

Settleable solids resulting from erosion may be considered to be the largest single source of receiving water pollution. A major source of sediment is from land undergoing urbanization. Land under construction can have erosion rates from 50 to 500 times the rate of undeveloped farmland. In contrast, a stable post-development watershed generated much less sediment due to erosion.

The sediment facility loadings will affect the operation of, and the maintenance costs for, the sedimentation facilities. The loadings will determine the clean-out timing of the facilities. The loading of sedimentation facilities will vary greatly depending on the state of the catchment, the development staging and the sediment control practices implemented within the catchment. Sediment yields for different land use conditions are shown in **Table 3.8**, (Ports, 1975) (MMM, 1985).

Table 3.8 Sediment Yield

Type of Land Use	Sediment Yield (tonnes/ha/yr)
Natural Forest	0.66
Agricultural	0.11 to 2.2
Urban Construction	1.8 - 73.5
Stable Watershed	0.039 to 0.367
Urban Areas	0.10 to 0.61

As can be seen from the sediment yield data, it is critical to implement on-site sediment controls during construction. Every effort must be made to reduce the loading to a stormwater management and volume control facilities. If the loading to the facility is increased as a result of construction activities, the result will be an increased sediment load and possible early failure, or at minimum and increase in the maintenance requirements.

The water quality characteristics are dynamic in time (that is, they change over time). Typically, the term chronic is used with respect to long-term average water quality conditions, and the term acute is used with respect to short-term high intensity (shock loads) with respect to water quality conditions. Chronic conditions are average conditions over long time periods, generally a year, while acute conditions refer to shorter periods of time, in the order of a number of hours or days.

In assessing the significance of the level of any particular contaminant, with respect to water quality, it is important to note that average long-term concentrations of the contaminant may well be acceptable, while there will be periods of time when the contaminant's concentration is many times higher, possibly exceeding acceptable levels.

The distinction between long term (chronic) and short term (acute) contaminant loadings is particularly important. For most contaminants, the non-urbanized watershed area contributes greater chronic (long term) loads, while the storm sewers produce greater acute (short term) high concentration loadings. Storm sewers are the major contributors of short-term acute pollutant loadings. Loadings of organic matter and nutrients are significant. The primary concern with the acute loadings is the potential for short-term degradation of water quality to a degree sufficient to pose a public health risk and damage the aquatic environment.

Constituents in the run-off must also be considered and include silts which will cover the facility during inundation and appear in the lake as turbidity. Other components in run-off include nutrients such as phosphorous and nitrogen which along with sunlight form an ideal mixture for the growth of aquatic weeds and algae in the lake. This will result in possible unsightly conditions and odour problems. The runoff water will also contain salts and potentially have an acidity level, pH, which can damage the vegetation. The impact of hazardous spills must be considered regardless of their source. Spills could occur on the streets that drain into the pond. Oil and fuel are just two of the types of hazardous materials that could enter the drainage system and necessitate the need for emergency action.

Floating materials and trash will enter the lake and form an unsightly situation. The most common methods to handle these situations are source control, clean-out at the entrance to the lake or clean-up of the lake after accumulations occur.

As a part of the Fergus Creek ISMP we have undertaken to utilize the continuous simulation data files while adding the water quality components to quantify the build-up and wash-off of sediment and first order decay contaminants from the catchment. While the model was not calibrated, it can provide useful information regarding the operation of the stormwater management systems. The model parameters were adjusted to provide the annual loadings based upon literature values. As more data becomes available further optimization of the model parameters can be undertaken.

The establishment of water quality objectives must be undertaken in a pragmatic manner, which will allow the optimization of system performance for the removal of sediment and other deleterious substances from stormwater runoff. The ISMP provides direction as to goals and objectives for the future Neighbourhood and Redevelopment Planning processes. The future planning processes will establish a set of tools that will be used to evaluate environmental impacts, to design mitigation measures in a cost-effective and understandable manner. These tools must be analytical rather than relying upon inference. The tools will then be capable of providing repeatable and verifiable results that tie the engineering to environmental factors.

Engineers must understand the concepts implicit in the tools. The concepts must be easy to analyze and the results must be quantifiable and reproducible. The use of the tools MUST measure mitigation effectiveness. This will allow mitigation systems to be analyzed and will allow comparison of alternative measures in order to arrive at a cost-effective solution to the problem of preserving stream health in the face of increased urban development in the City.

Establishing an effective water quality and quantity monitoring program will be essential in verifying the success of the ISMP. The monitoring requirements will be documented in terms of location, costs, and physical parameters to be recorded. As with all monitoring programs we anticipate that a limited number of physical parameters can actually be recorded and that spot checks of other parameters will suffice in establishing both a baseline and for verification of system performance.

3.5 BEYOND THE GUIDEBOOK ANALYSIS

The analysis of the works required to mitigate the impacts of development within the Fergus Creek Watershed have proceeded upon the basis of four scenarios. These represent the predevelopment condition, the post development condition without mitigation works, post development with mitigation works that meet the criteria of the "Guidebook", and an alternative mitigation case.

1. Predevelopment Case represents the watershed in accordance with the Design Criteria Manual of the City of Surrey. This watershed is essentially in its current state with a mixture of urban and rural development. This watershed condition is provides the base case upon which all others are compared.

2. Post Development condition without mitigation provides a view of the potential impacts to development would be if mitigation were not included in future planning and development within the Fergus Creek Watershed. This case represents the extreme to provide a comparison for both the predevelopment condition and the mitigated development condition of the watershed.

3. The "Guidebook" scenario represents a developed watershed where one half of the mean annual storm must be retained on site. For storms that exceed this volume the discharges are detained in a series of ponds to prevent increases downstream flooding. (One unintended consequence to implementing the full Guidebook requirement was to significantly reduce the baseflows in the stream.)

4. An alternative mitigation case has been developed to eliminate the unintended reduction in base flows and to provide a more balanced approach.

3.5.1 Sediment Characteristics

Additional soils testing was undertaken to establish the particle distribution of the sediment and grit found on the streets in the southern portions of Surrey. The test results are a part of the geotechnical report included in **Appendix A** and the results are summarized in **Table 3.9**. The particle size distribution of street sediment samples exhibits a degree of coarseness that was not anticipated. The relative proportion of silts and clays was much less than typically found in reported values of Total Suspended Sediment (TSS) for storm runoff collected from pipes and streams. We believe this is due in part to a substantial bed load that is the materials carried along the invert of a pipe or bed of a stream that would not be included in samples taken from higher in the water column. Further we believe that these samples are representative of the materials that would be washed into Fergus Creek from the roadways.

Table 3.9 Street Sediment Particle Size Distribution

Test Number	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	6.6	85.5	5.3	2.6
2	2.9	82.6	11.2	3.3
3	3.1	59.0	30.6	7.3

An average value of sediment particle size distribution was used in the analysis of the sediment wash-off within this ISMP process.

3.5.2 Infiltration Testing

The variations within the sizing and performance of individual volume reduction systems is based upon initial field testing if infiltration capacity at three representative locations within the watershed. The full test report is included in **Appendix A**. The test results indicate a relatively small infiltration rate that varies across the watershed. The range of infiltration rate varies from a low of 0.8 mm/hr to a high of 2.4 mm/hr with an average of 1.7 mm/hr. The rates were applied to the catchments based upon proximity between the test location and the catchment. The infiltration rates while low represent values typically found within the clays and silts underlying the surficial soils of the Fergus Creek Watershed.

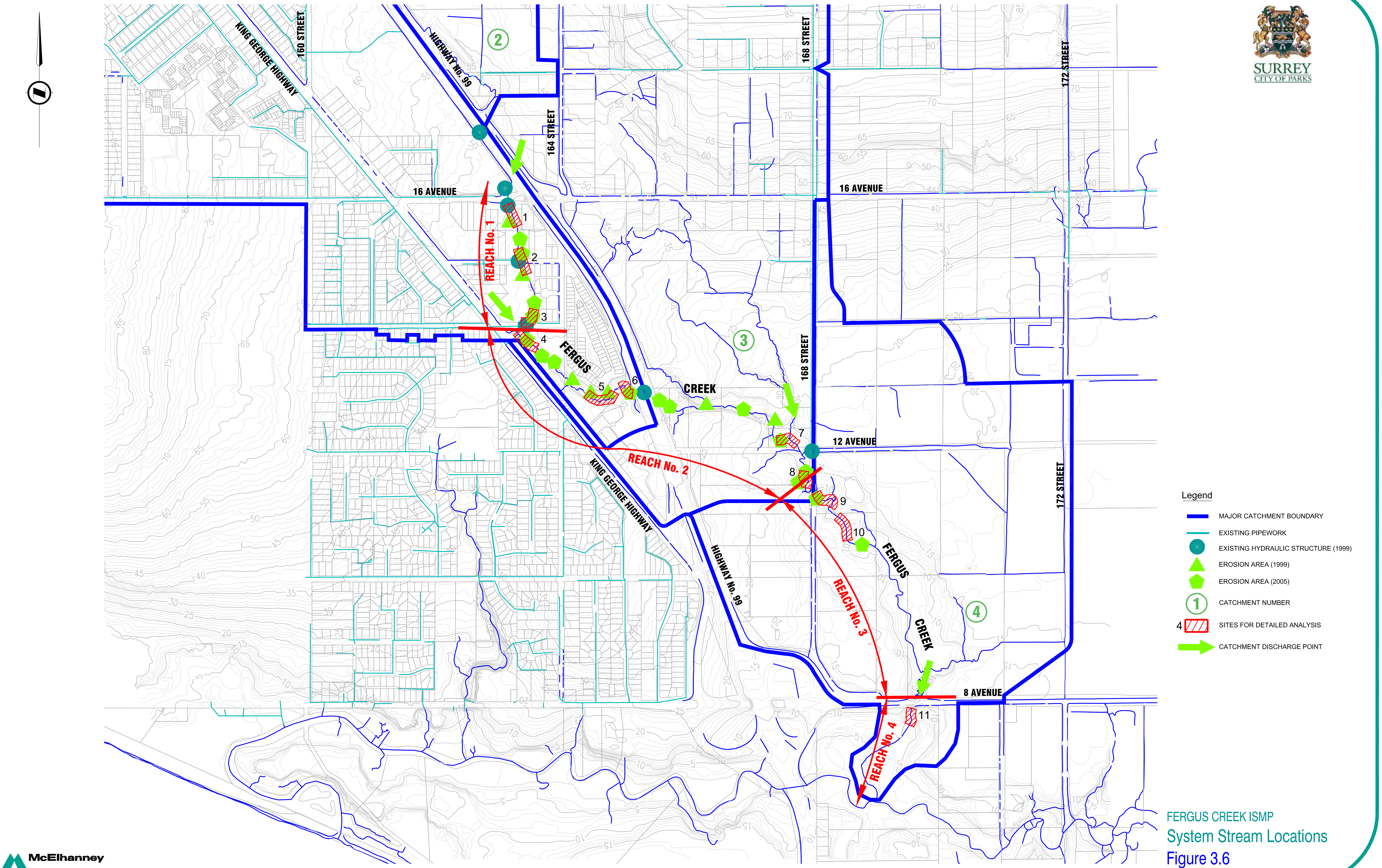
3.5.3 Results

The results of the analysis for the mitigation works have been distilled into their essence to allow easy assimilation and understanding. The numerical results have been converted to a series of charts to allow easy comparison of the four watershed conditions described above. These series of charts have then been presented for each of the analyses completed; stream flow Exceedence, potential stream erosion and water quality. The results are described below.

1. Streamflow Exceedence

The main stem of Fergus Creek was divided into four stream reaches as shown on **Figure 3.6**. These reaches were selected for the assessment of flow exceedence for each of the watershed conditions. The summary of stream flow discharge exceedence is shown on **Figure 3.7** for each of the four (4) stream reaches.

The charts for each of the four reaches indicate a similar impact as the watershed develops from the existing condition to the full development condition if no mitigation efforts are made. The impact is an increase in the amount of time that any given stream discharge is exceeded. An example would be the discharge of 1 m^3/s through reach 1. The blue line for predevelopment and the red line for post development without mitigation indicate these results. For the 1 m^3/s under predevelopment conditions the discharge is exceeded for a total of approximately 100 hours over the 30 year period of analysis. The same 1.0 m^3/s with unmitigated post development conditions would be exceeded by 900 hours. This represents a very significant impact to the stream in having nearly a 10 fold increase in the time that the flows would exceed this typical value of 1.0 m^3/s. The overall magnitude of the discharge increases from a maximum of 2.0 m^3/s to 4.0 m^3/s. This increase in the maximum discharges is significant. As is clear the unmitigated development would increase the discharge rates and the amount of time for which these rates occur within the stream.



Legend

- ▬ MAJOR CATCHMENT BOUNDARY
- ─ EXISTING PIPEWORK
- ● EXISTING HYDRAULIC STRUCTURE (1999)
- ▲ EROSION AREA (1999)
- ⬟ EROSION AREA (2005)
- ① CATCHMENT NUMBER
- 4 ▨ SITES FOR DETAILED ANALYSIS
- ➡ CATCHMENT DISCHARGE POINT

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FERGUS CREEK ISMP
System Stream Locations
Figure 3.6

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Plotted: December 13, 2007 , 15:27:36 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 3_6 - SYSTEM STREAM LOCATIONS.dwg\FIGURE 3.6 - SYSTEM STREAM LOCATIONS

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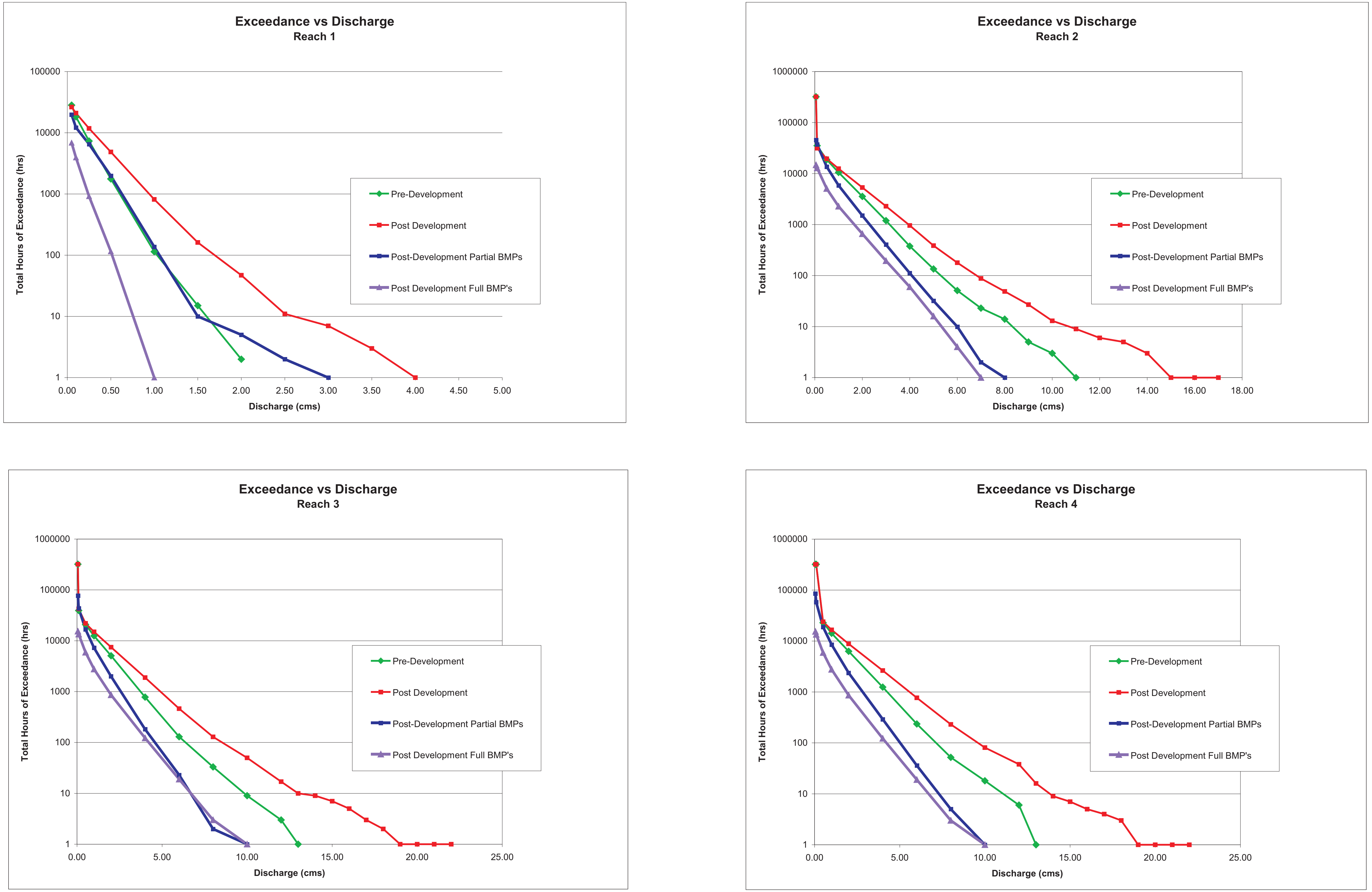
CITY OF PARKS



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FERGUS CREEK ISMP

Exceedance Analysis

Figure 3.7

A similar pattern of increases in discharge exceedence occurs for each reach if development does not include mitigation measures designed to maintain the predevelopment hydrologic regime.

The first set of mitigation measures was to impose the “Guidebook” retention of one half of the mean annual storm on site. We have interpreted this requirement as one that would occur on a daily basis. That is, for any rainfall in any 24 hour period, no surface runoff would be allowed until the rainfall total exceeded 30 mm. For this initial volume of rainfall that is retained on site, it must be discharged to ground and thus become groundwater that would eventually reach the stream through movement through the soil subsurface.

In every reach the results of imposing the “Guidebook” criteria are similar. These are shown by the lines to the far left on each of the **Figure 3.7** charts. The results indicate both good and bad post development impacts on the stream. The good impacts would result in a decrease in the overall magnitude of discharges and their exceedence. The bad impact is that the base flow would also be reduced significantly. The example of reach1 indicates the discharge of 0.01 m^3/s would have the exceedence decreased from 378,000 hours, or essentially the entire 38 year period of record, to approximately 90,000 hours. This lack of base flow would have a significant and negative impact upon the stream. Similar reductions in base flow would occur in each of the stream reaches. We believe that this impact, while unintended, indicates a need to modify the “Guidebook” criteria when attempting to mitigate impacts caused by urban development.

A series of alternative mitigation measures were developed and tested through use of the established models and methodologies. These measures will be discussed in detail in the following **Section 3.6**. The results of implementing the alternative mitigation measures can be seen as the fourth line on each four of the charts on **Figure 3.7**. These are labelled as “Post Development Partial BMP’s”. The results for each of the four reaches indicates the flow exceedence of base flows has would be maintained at near predevelopment values while there would be a significant reduction in the exceedence values for larger discharge rates and that the maximum discharges would also be reduced. Several benefits accrue from implementing this set of BMP's with the greatest benefit being the maintaining a more natural hydrology while reducing the magnitude of large flood discharges throughout the length Fergus Creek.

2. Potential Stream Erosion

The discharge points for each of the catchments within the watershed were located at culvert crossings of roadways as shown on **Figure 3.6**. These points were selected for the assessment of potential erosion. The crossings were surveyed to determine the stream cross-section, physical condition. A field reconnaissance included a review of the soil materials observed in the bed and banks of the stream at each of the crossings.

Typical stream cross sections were then evaluated to provide an estimate of the tractive forces that would be applied to the stream section for a range of discharge values. These tractive forces were combined with the continuous simulation estimates of discharge to determine the "Total Impulse" at each site for each of the four development conditions as described previously. The results yield a single "Total Impulse" value for each site for each of the four development conditions. The "Total Impulse" values have been plotted on a series of charts as shown on **Figure 3.8**. The results can be compared at a glance with the predevelopment condition being in green and shown on the far left of the chart for each site. Following to the right on each chart are the "total Impulse" for the conditions of post development with no mitigation, post development with partial BMP's and on the right the value for the "Guidebook" criteria.

As can be seen in each case the unmitigated development would result in an increase in the potential for stream erosion. Both of the mitigation options would result in a reduction in the potential erosion from existing conditions while the "Guidebook" option would almost eliminate erosion. While an initial reaction to reduced stream erosion may be that a greater reduction may be most desirable we must urge caution.

Stream erosion is a natural process as there must be a method of carrying the sediment washed off the watershed. If stream erosion were halted entirely the results would include stream bed aggregation, or a buildup of sediment on the existing stream bed.

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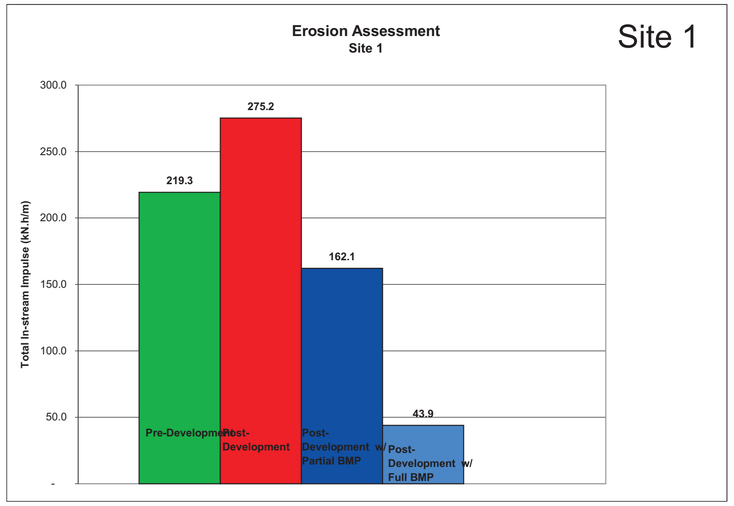

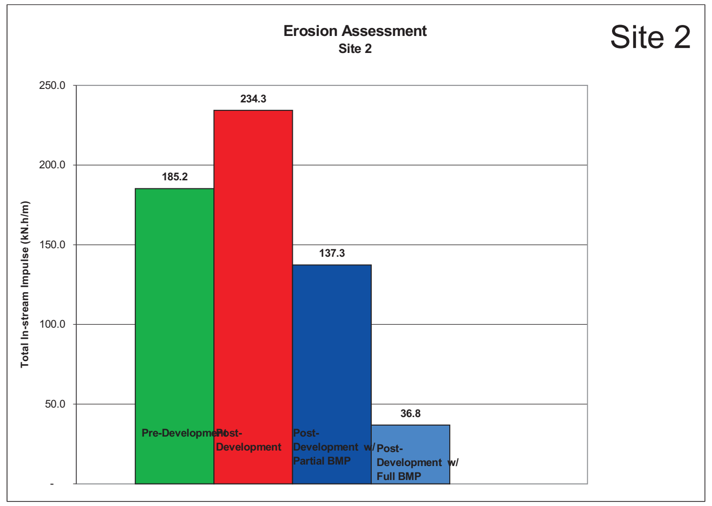

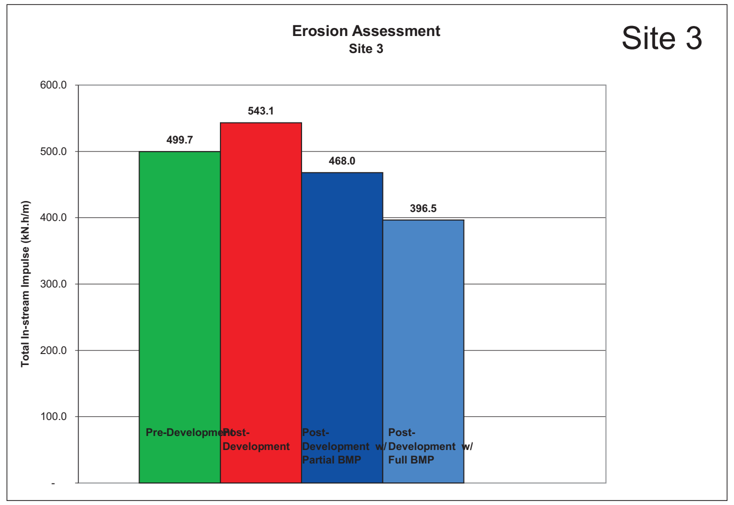

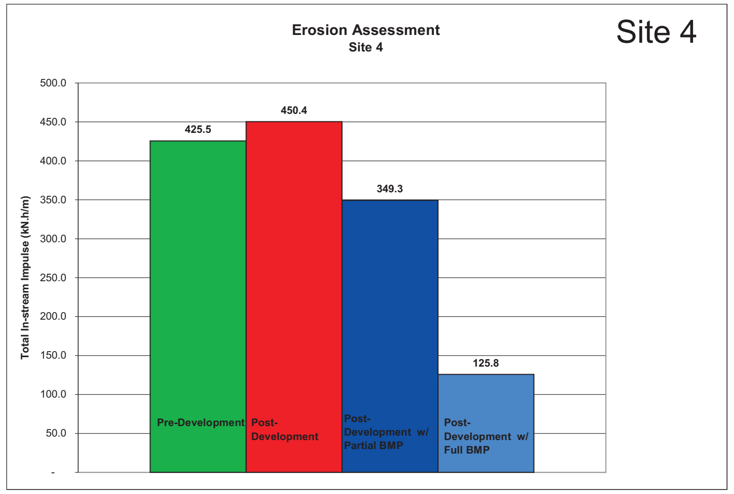

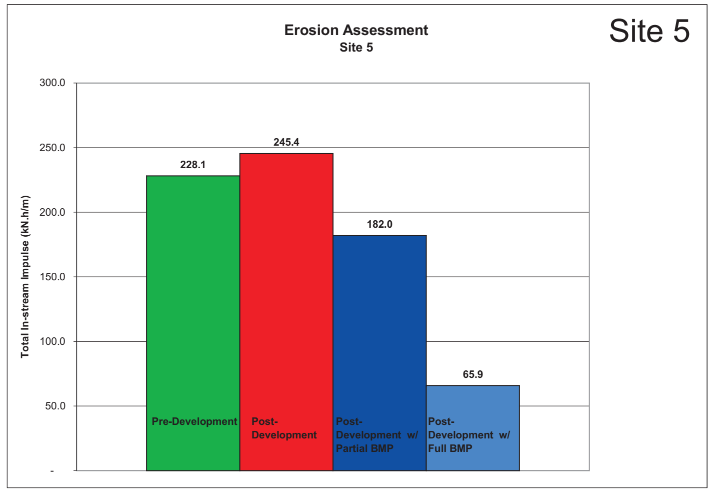

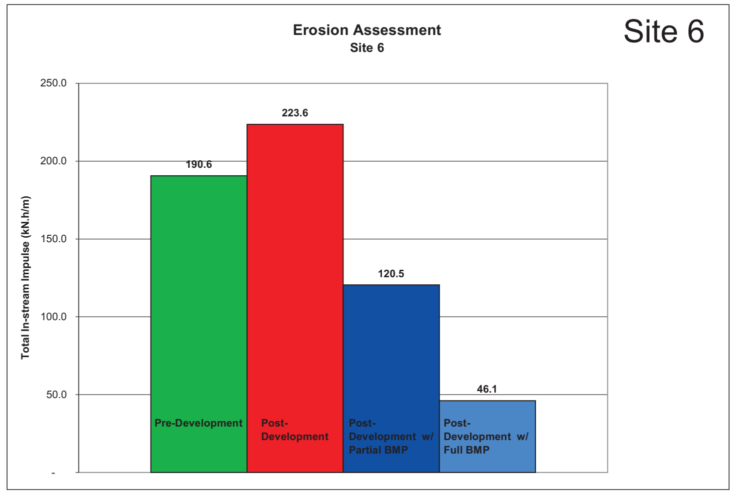

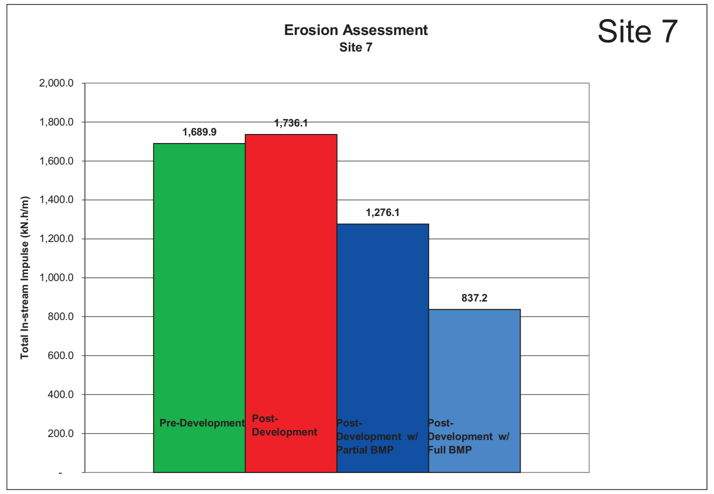

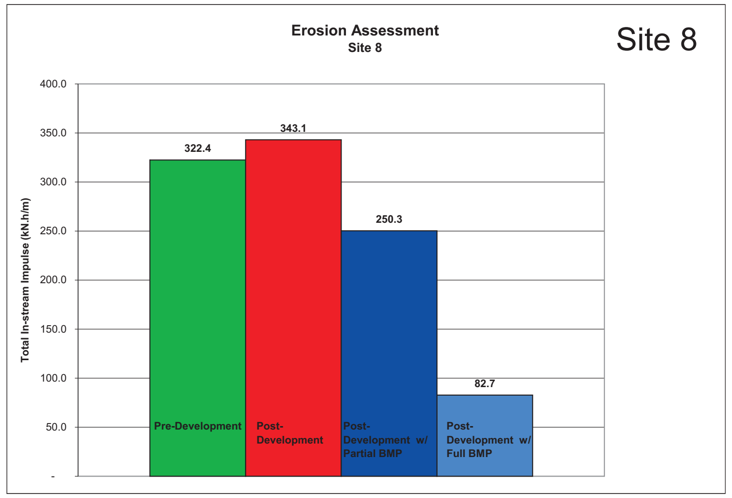

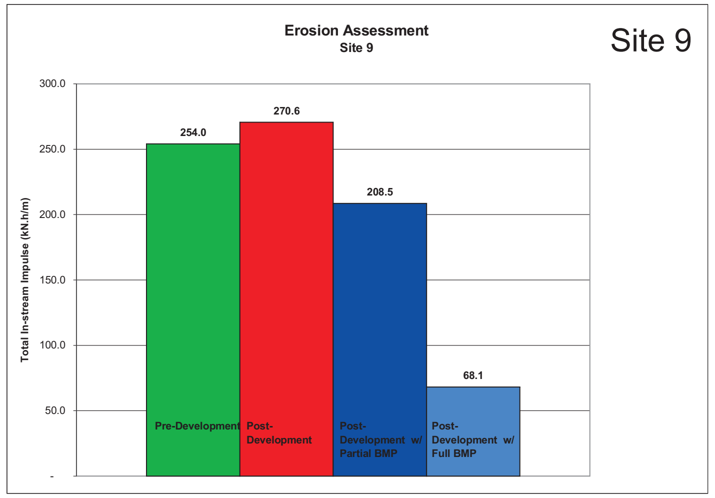

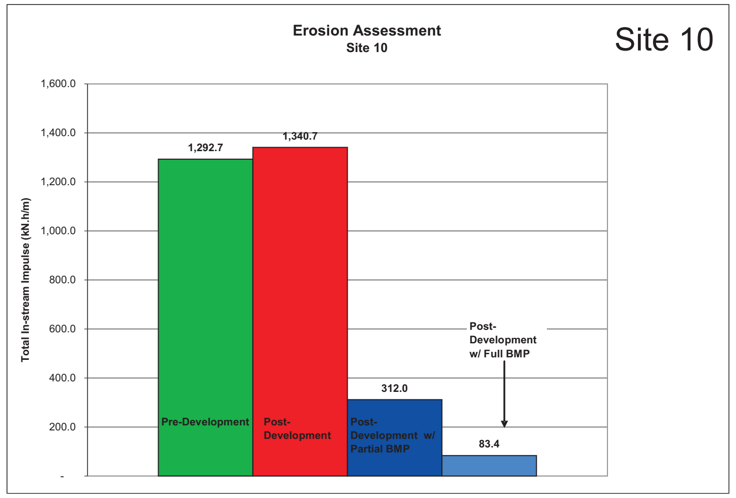

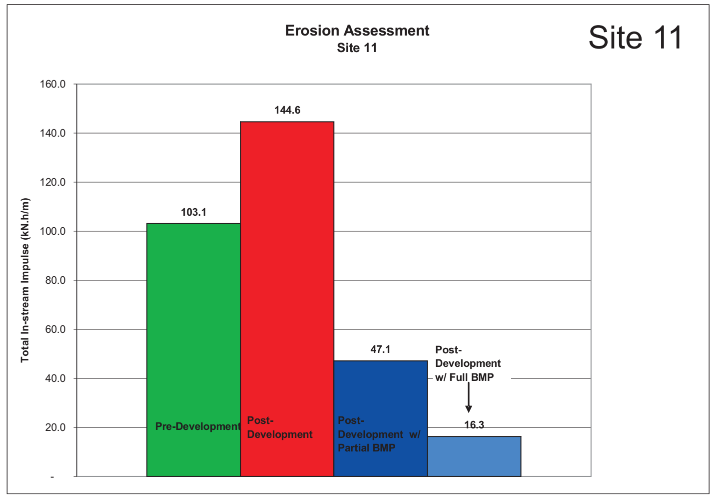

🟩 Pre-development

🟥 Post-development

🟦 Post-development with Partial BMP

🟦 Post-development with Full BMP

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FERGUS CREEK ISMP

Erosion Analysis

Figure 3.8

Accumulation of sediment can be as detrimental as excessive erosion. There must be a balance in the potential erosion and a match to predevelopment levels should be the target so as to maintain the stream regime.

In this case, the development case indicated by the partial BMP development condition would best meet the requirements to reduce existing stream erosion while not going overly far in reducing the streams capability to convey sediment.

3. Water Quality

The main stem of Fergus Creek was divided into four stream reaches as shown on **Figure 3.6**. These reaches were selected for the assessment of sediment entering the stream from the watershed for each of the watershed conditions. Normal sediment loading from a stable urban watershed is in the range of from 0.10 to 0.61 tonnes per year per hectare of watershed as indicated in **Table 3.8**. It is, therefore normal and expected that the stream will convey some sediment on a regular basis. The basis of geomorphology and of river regime theory agrees that sediment transport in a stream is a natural occurrence and should not be disrupted without anticipating some consequence. The stream has been impacted by urban development, forest clearing, and other man induced occurrences and has experienced unquantified impacts as the state of the Creek in its natural form is unknown.

The summary of stream water quality assessment is shown on **Figure 3.9** for each of the four (4) stream reaches. The analysis for the four reaches indicates that unmitigated development would result in an increase in the quantity of sediment washing into the stream. It further indicates that there can be a dramatic reduction with the implementation of runoff volume reduction techniques in the form of the BMP's as envisioned in the following sections of this document.

3.6 RECOMMENDED MITIGATION MEASURES

As discussed in the previous sections we have assessed three post development states of the Fergus Creek Watershed. These have included:

1. Fully developed without mitigation,
2. Fully developed with “Guidebook” rainfall controls, and
3. Fully developed with selected runoff control BMP’s.

As discussed previously in this report the first two watershed conditions can not be recommended for implementation as development progresses. This leaves the third condition as being the most desirable state of the future Fergus Creek Watershed.

The main components of the development mitigation process within the Fergus Creek Watershed will include runoff reduction infrastructure that includes a storage component. The combination of runoff volume reduction and storage will result in decreased flood peaks, stream erosion and sediment within the stream while enhancing the duration of base. The mitigation measures, or built infrastructure have been established on a catchment basis within the Fergus Creek Watershed.

The mitigation measures recommended for redevelopment within the Fergus Creek Watershed include:

1. Roof Leader Disconnection,
2. Top soil preservation and augmentation, and
3. Implementation of infiltration infrastructure.

The implementation of these systems is a departure from standard engineering practices within the City of Surrey. A discussion of the processes required for their implementation is provided in **Section 6.3**.

3.6.1 Roof Leader Disconnection

The City of Surrey has included roof leader disconnection for single family detached buildings in the design criteria and Development Control Bylaw for the City. The disconnection of roof leaders for other building types has not yet been mandated in the Development Control Bylaw there has not been a corresponding restriction placed into the Building Bylaw. Observations within recent developments indicate a tendency of allowing connection of roof leaders to be directly connected to the storm sewer system by those enforcing the regulations of the Building Bylaw. We recommend that

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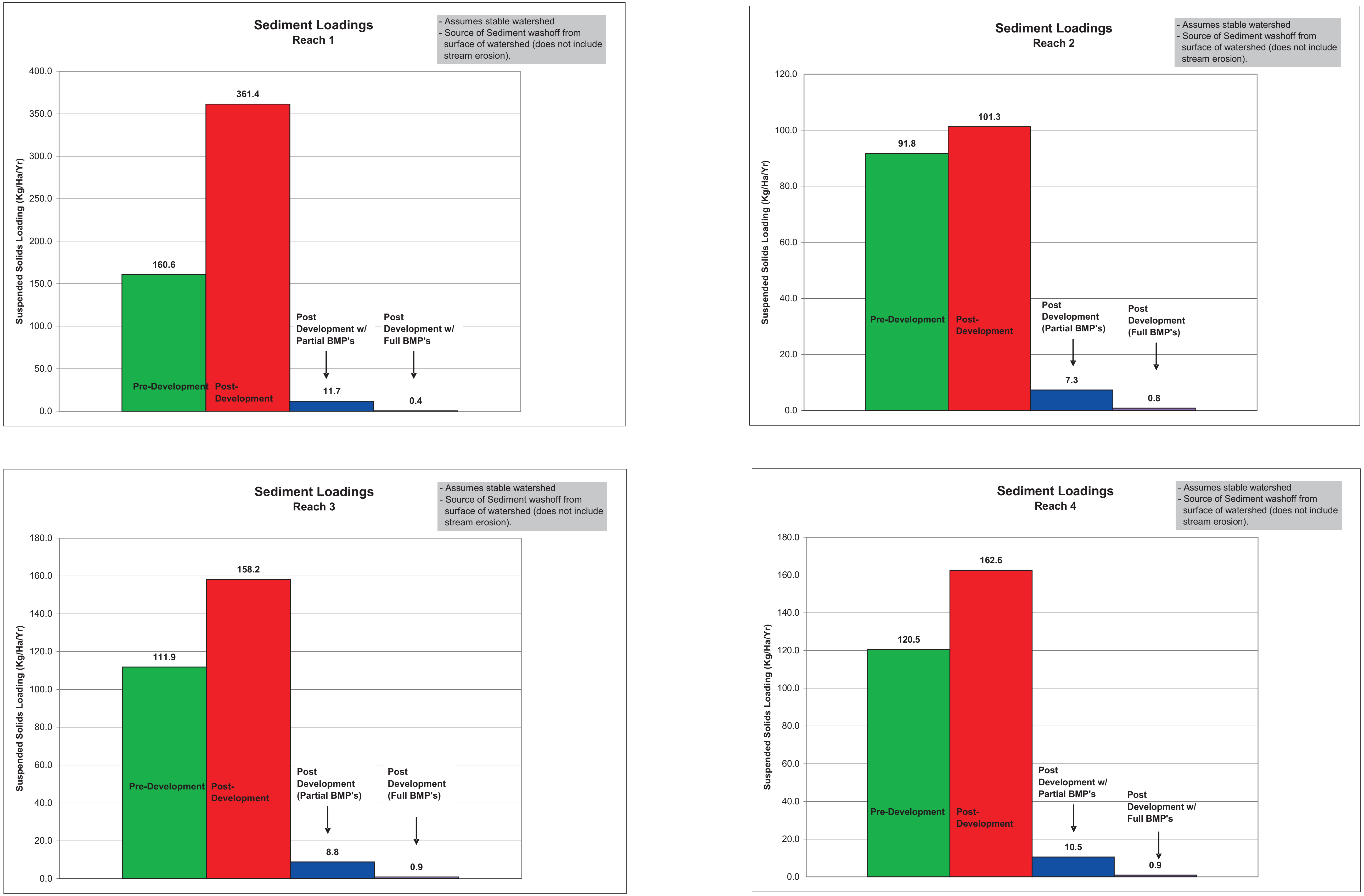

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FERGUS CREEK ISMP
Sediment Analysis
Figure 3.9

consistency be brought to the two bylaws by introducing a requirement for roof leader separation in the Building Bylaw.

The mitigation systems as assessed within the ISMP have assumed that all single family detached homes would have disconnected roof leaders in accordance with the Development Control Bylaw. The remaining portions of the watershed would not include disconnection due to the current difficulty in implementing full disconnection. The other impervious portions of the watershed are often difficult to disconnect from the storm sewer drainage system. The municipal roadways, multi-family, commercial and industrial areas typically do not have sufficient pervious area upon which to direct the runoff onto. In these instances we have assumed that these areas would be connected to the drainage system and that infiltration, or volume reduction, systems would be constructed to reduce the volumes of stormwater runoff.

3.6.2 Top Soil

The analysis of the watershed indicates that the single most effective system that can reduce stormwater runoff is an enhanced top soil layer on the pervious areas. The common soil types typically have a poor top soil layer. Often it is limited to a leaf litter or a poorly configured ploughed layer composed primarily of the underlying mineral soils.

As development and redevelopment occurs the most typical practice is to strip off the materials that can not be used for backfill. The material is then collected and hauled away as a waste product. The useable top soil should be retained on site and amended to provide a valuable plant growth media. The City of Surrey Parks Department has published soil specifications that can be used to guide the soil augmentation process.

The soil depth assumed to be present following redevelopment within the Fergus Creek Watershed is a minimum of 150 mm in depth over the entire pervious area. Where this is not possible additional depth will be required over other portions of the watershed as compensation.

The top soil proposed for the watershed can be augmented with the addition of absorbent landscapes components that can include:

- Tree cover density,
- Increased top soil depth,
- Porous pavement,
- Green Roof – Typical, and
- Some infiltration swales – without free water storage.

3.6.3 Infiltration Systems

The most prevalent form of volume reduction involves the construction of infiltration systems. These would be considered to complement the top soil, rather than to replace the need for a substantial top soil layer on the pervious surfaces in the watershed. The most typical configurations would involve some form of capture of surface runoff and a storage component while infiltration to ground occurs. These systems would have multiple purposes in that they would provide volume reduction through infiltration, detention to reduce downstream discharge rates and slow release of stored water to augment base flow in the streams. Systems can include:

- Rain gardens
- Infiltration swales with storage
- Surface or subsurface storage
- Infiltration ponds
- Underground galleries.

The components of the infiltration systems that are critical to the operation within the Fergus Creek Watershed include an area of 5% of the watershed, distributed over the watershed and located within both private property and public R-O-W's and parks. The storage component of the systems would be equivalent to 300 mm of clear depth over the infiltration surface area. The volume equates to 150 m^3 per ha spread out over the area of the infiltration systems. It is critical to note that the infiltration area as calculated does not have built in safety factors or allowances for possible degradation of performance over time. Estimated costs for the runoff retention system storage is approximately $60,000 per ha ($24,000 per acre), a considerable savings over the traditional and Guideline criteria of between $86,000 and $130,000 per ha as shown in **Table 3.2**.

An advantage observed during the course of the assessment is the potential to extend the duration of base flows in Fergus Creek if an underflow is utilized. The underflow for each of the four watershed catchments shown on **Figure 3.2** has been established. The discharge rates would be for storage volumes that do not exceed the infiltration system capacity. The underflow rates are shown in **Table 3.10**.

Table 3.10 System Underflow Rates

Catchment	Underflow Rate (L/s/ha)
1	0.122
2	0.719
3	0.435
4	0.736
Overflow rates exceed these values.	

We recommend that a safety factor of 2 be carried forward for potential application as part of an adaptive management system change for future implementation. The safety factor should apply to both the volume and the surface area of the infiltration systems. This safety factor is subject to review and can be adjusted following review of performance data such as results from monitoring programs. The constructed systems can be expanded, enhanced, or be added to other areas of the watershed if the monitoring programs indicate a shortfall in performance. Additional discussion on implementing the facilities is included in **Section 6.3**. Discussion of establishing the area required to apply the potential safety factors is included in **Section 4.0**.

The constructed underground facilities can be installed at the time of redevelopment where land subdivision occurs. The systems can be located on private lots of either single family or multi-family land use or within the municipal road Rights-of-Way (R-O-W's). Systems that have proven to be successful within the City of Surrey on private properties are shown in **Figure 3.10** for single family properties and on **Figure 3.11** for multi-family properties.

The facilities constructed within the road ROW can have a number of different configurations however most of the available line assignments have been used. This leaves a problem of fitting another piece of infrastructure within the width of the R-O-W. One infiltration system used in Etobicoke can be used in this application. The installations have been monitored for performance and maintenance requirements with no problems being identified in the available published reports. The system is shown on **Figure 3.12**. Alternative R-O-W cross sections with two potential infiltration system configurations are shown on **Figure 3.13** with details being shown on **Figure 3.14**. The in street systems can be constructed as demonstrated in other locals.

The water quality improvements that have been included in the analysis of the mitigation works in the Fergus Creek Watershed have utilized two processes. The first being removal as the volume of runoff is decreased and secondly through a sedimentation process in the stormwater management facilities. The systems that have proven to be the most cost effective in removing sediment from runoff have been surface basins that have been configured specifically for sediment removal. These can be in the form of constructed wetlands where the combination of pond configuration and vegetation are optimized to provide the maximum sediment removal. A typical pond layout is shown on **Figure 3.15** and can be adapted through the application of accepted design principals.

The vegetation used in the ponds and in the swales previously identified on **Figure 3.14** is critical in the successful implementation of the natural treatment systems. Care must be taken in specifying the appropriate vegetation giving consideration to the duration of wetness and inundation anticipated during the operation of the facilities. A preliminary list of suitable vegetation is provided on **Figure 3.16**.

As with all systems the proper planning and design is essential in their successful long term operation. The next steps in the Fergus Creek Watershed will be the creation of Neighbourhood Concept Plans for the rural areas and Redevelopment Plans for the urban areas. These plans will establish the types of infrastructure to implement and provide additional details as to their design requirements.

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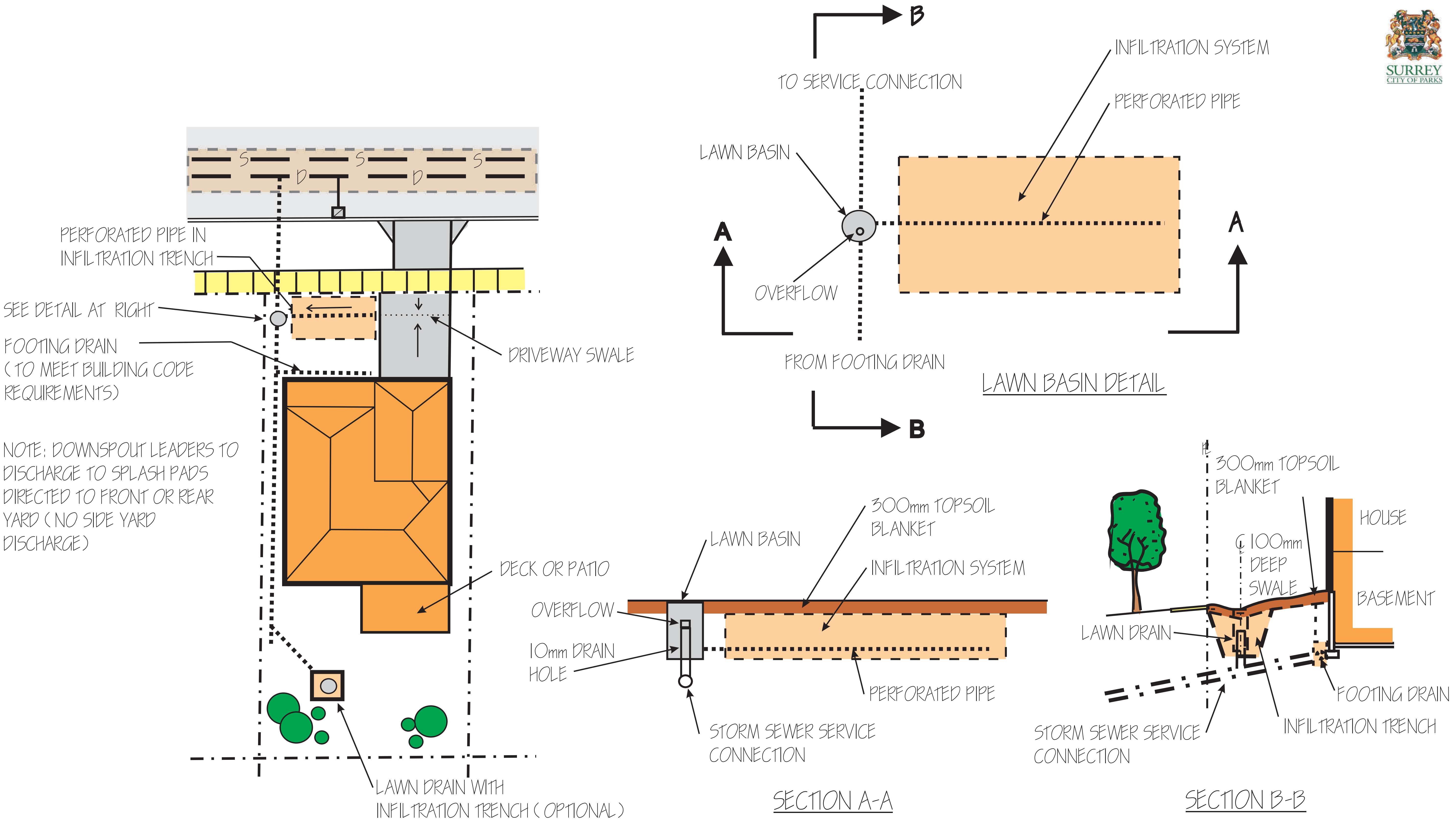

Note: CONCEPT ONLY. Final configuration to be confirmed during detailed design.

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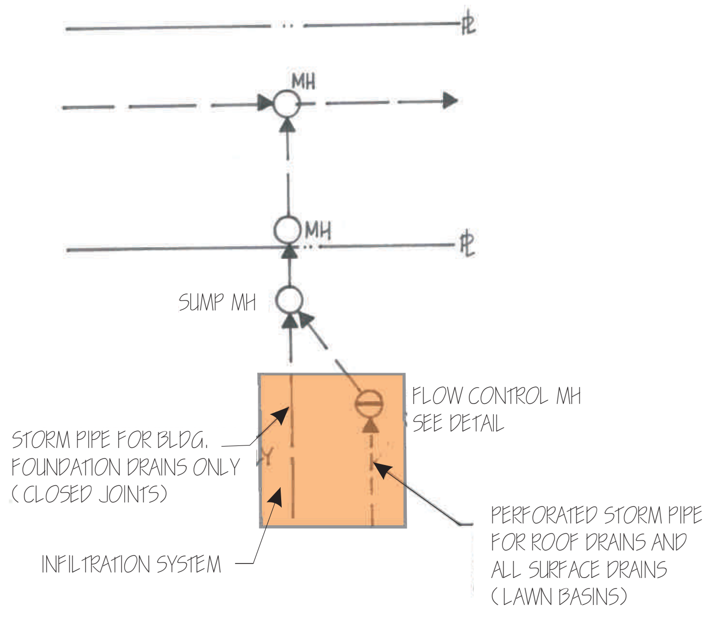
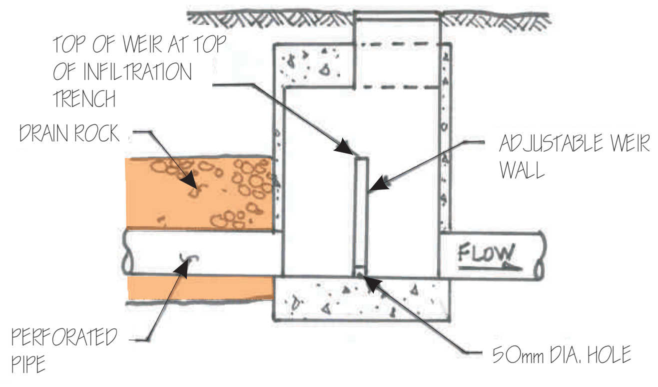
FERGUS CREEK ISMP
Private Infiltration System
Figure 3.10

Site 65% impervious
Infiltration Area is 5% of site area
Final Site Layout to be established at detailed design

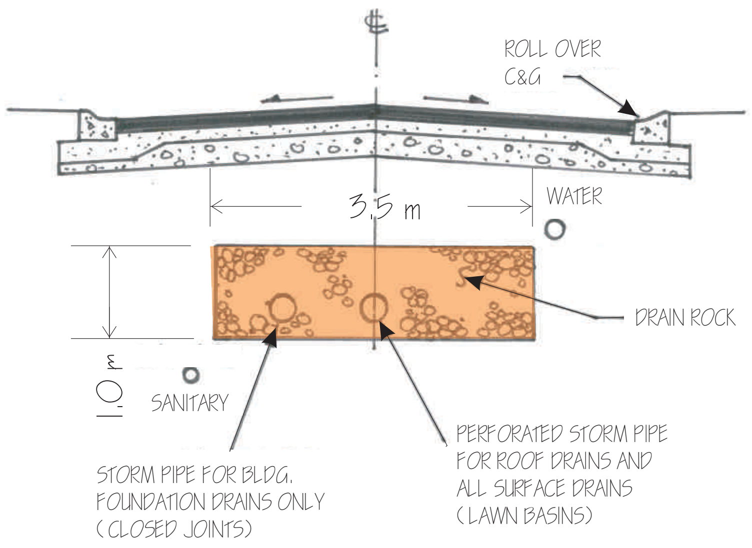
TYPICAL PLAN



PLAN DETAIL



FLOW CONTROL MANHOLE



TYPICAL SECTION

Typical surface area of the infiltration system will be 5% of the total site area.

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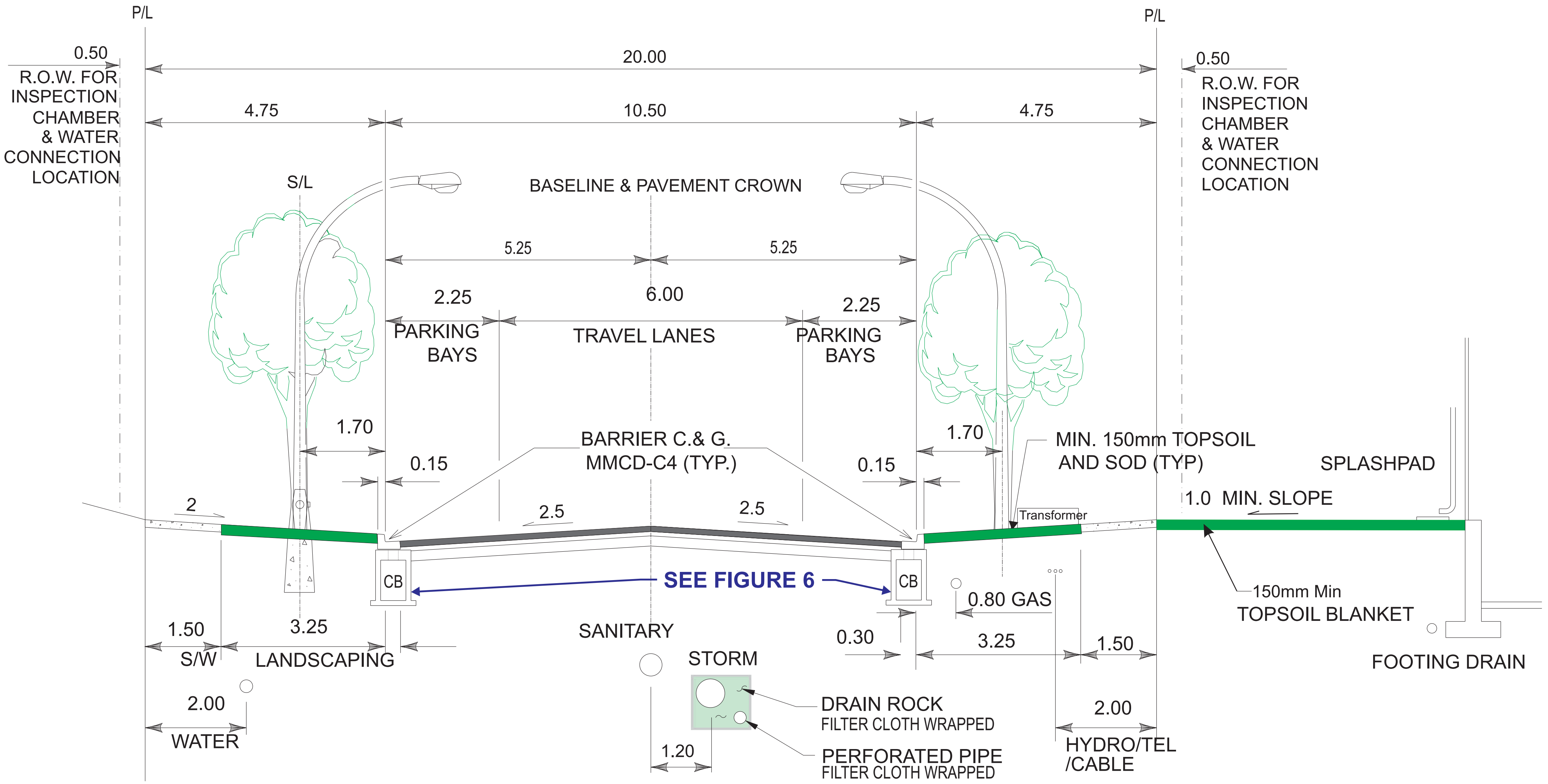
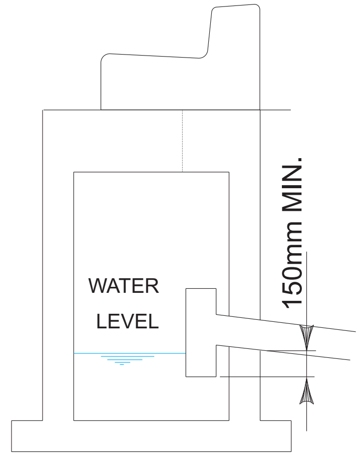
FERGUS CREEK ISMP

Multi-Family Site Infiltration System

Figure 3.11

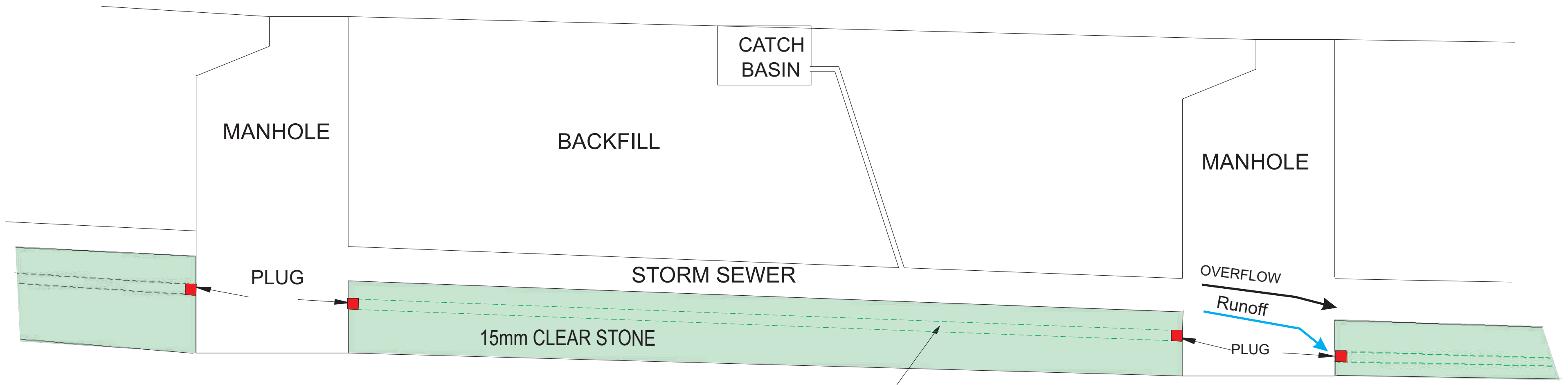


BMP STREET TYPICAL CROSS SECTION



TYPICAL OIL / GRIT TRAPPING CATCHBASIN

SEE FIGURE 6



TYPICAL PROFILE

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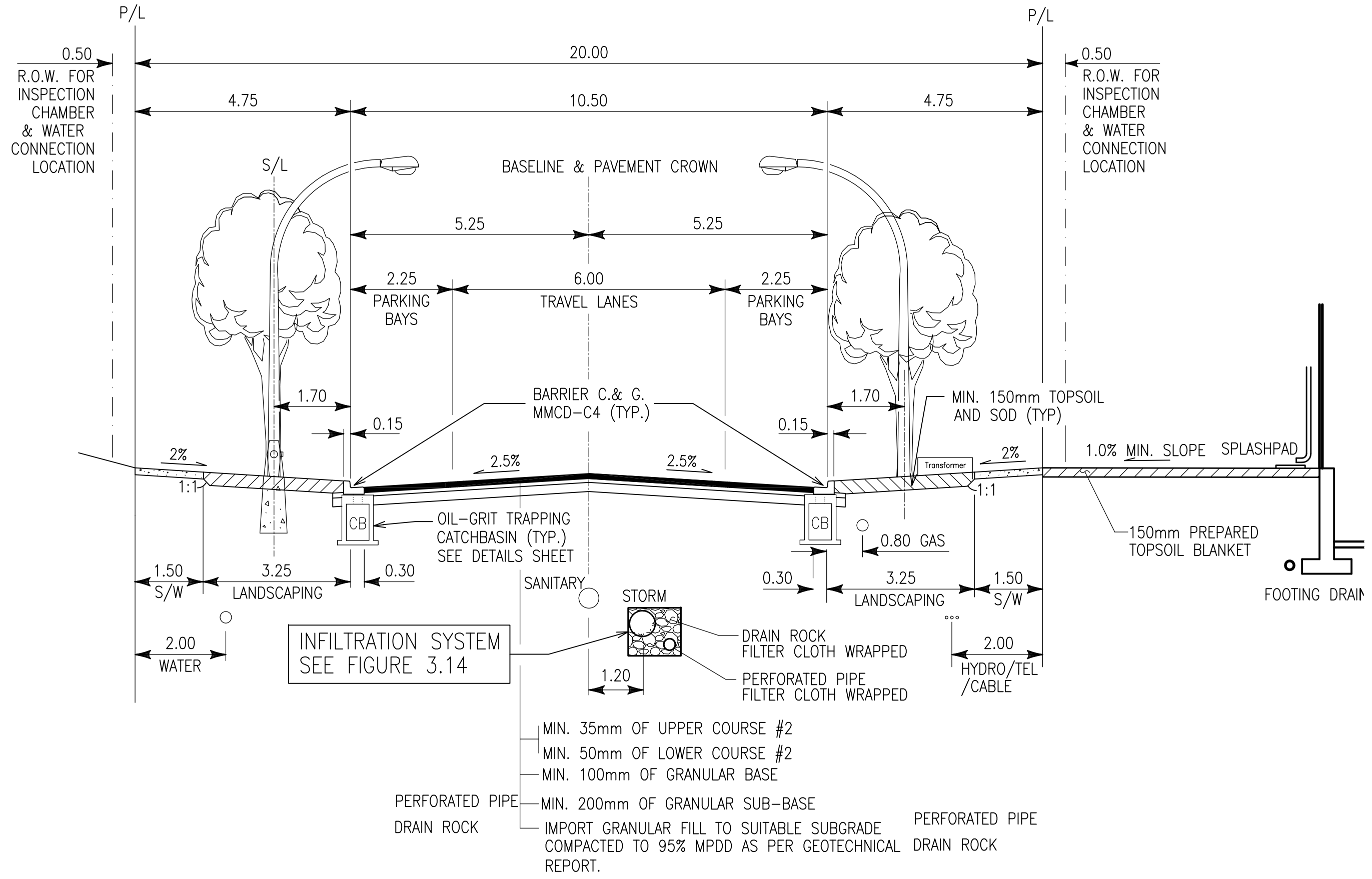
FERGUS CREEK ISMP

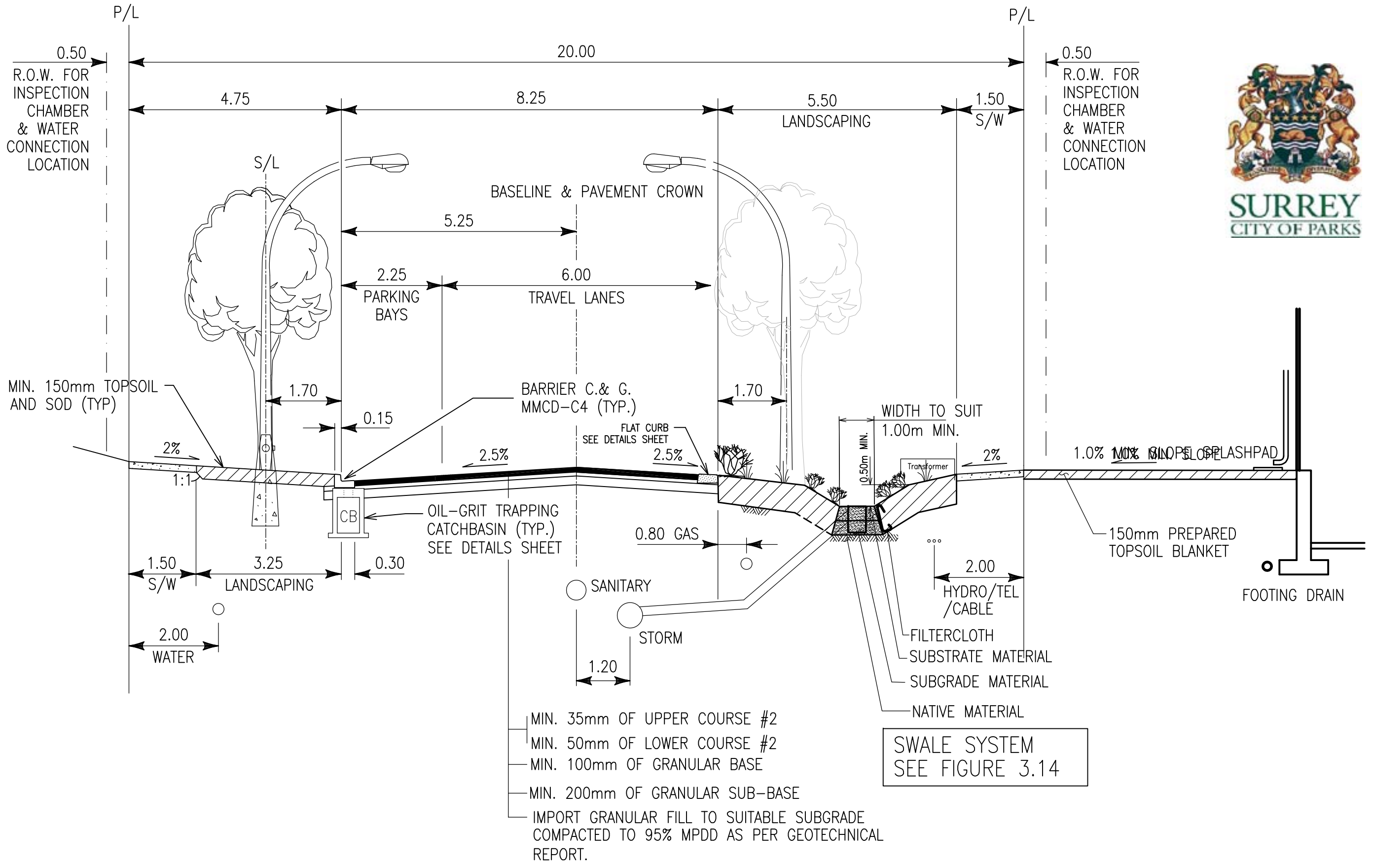
In Street Infiltration System

Figure 3.12



20.0m ROW: STREET BMP CROSS SECTION

Standard Surrey Cross Section with Addition of Infiltration System



20.0m ROW: GREEN STREET CROSS SECTION - for Rear Access Developments

Standard Surrey Cross Section with Swale System Replacing Sidewalk and One Parking Lane

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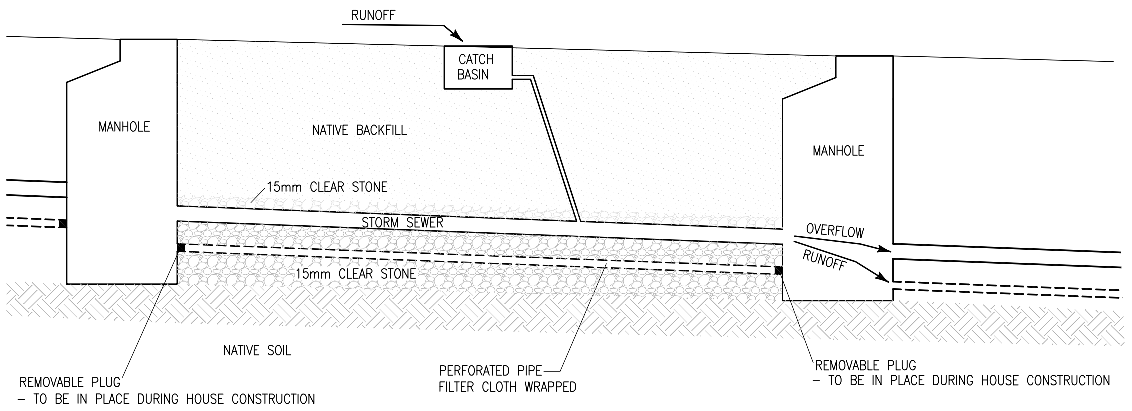
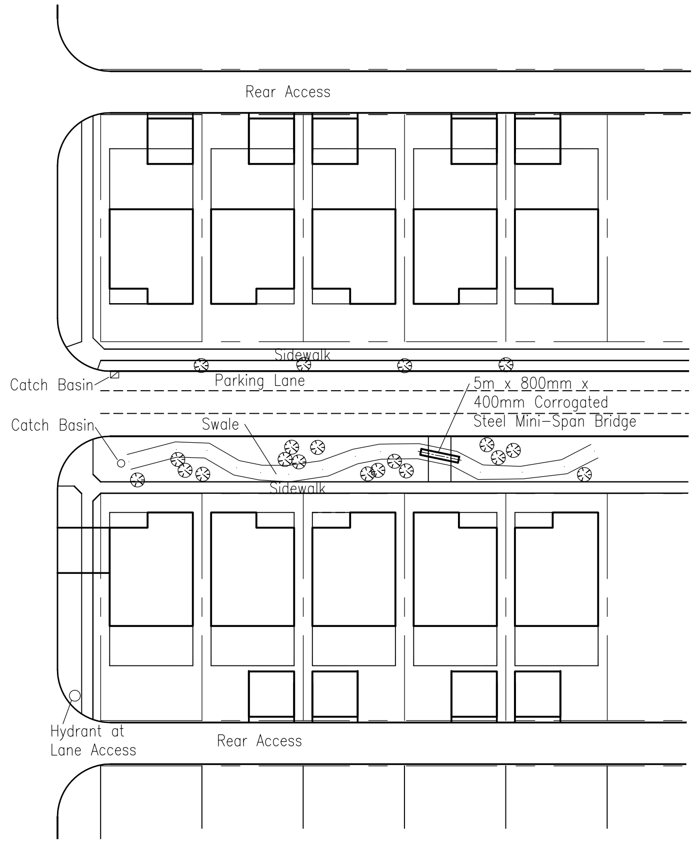
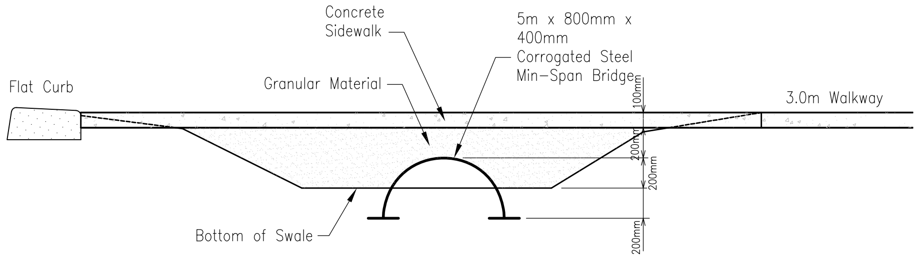


TYPICAL STORM SEWER PROFILE

Note: REAR ACCESS LOTS ONLY



20.0m ROW: GREEN STREET PLAN



ELEVATION MINI-SPAN BRIDGE

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FERGUS CREEK ISMP

20.0m ROW: BMP

Figure 3.13

Plotted: December 13, 2007 , 15:29:43 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 3_13 -20m ROW BMP.DWG\FIG 3.13 20m ROW_BMP

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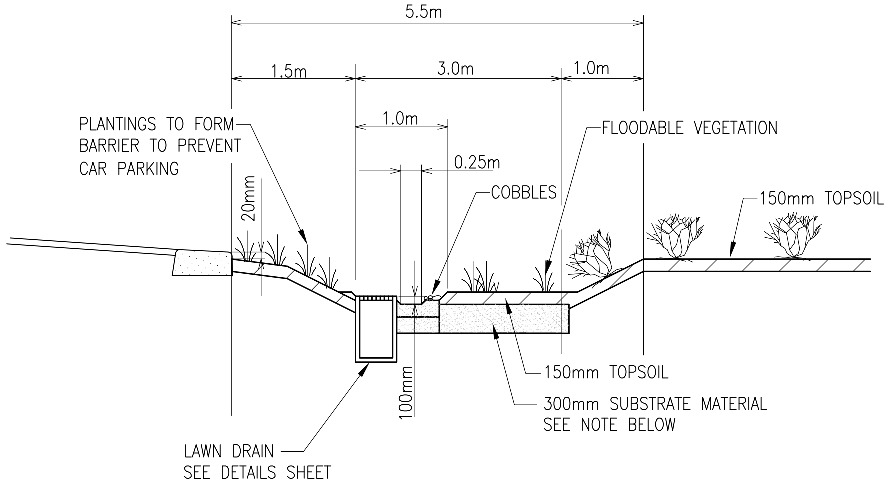
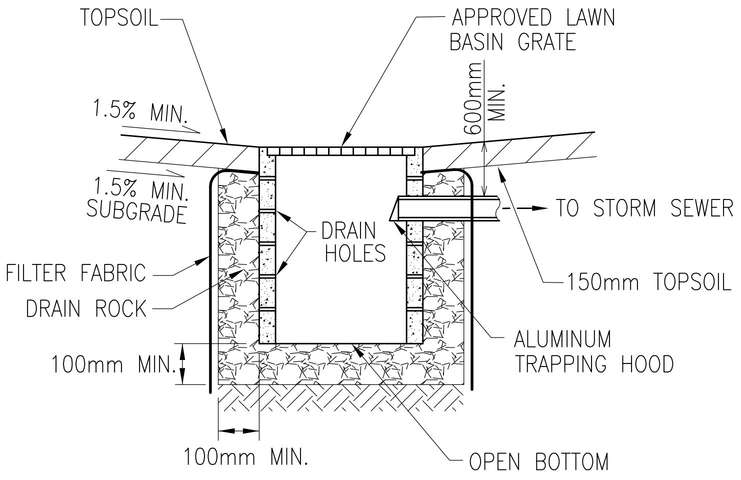
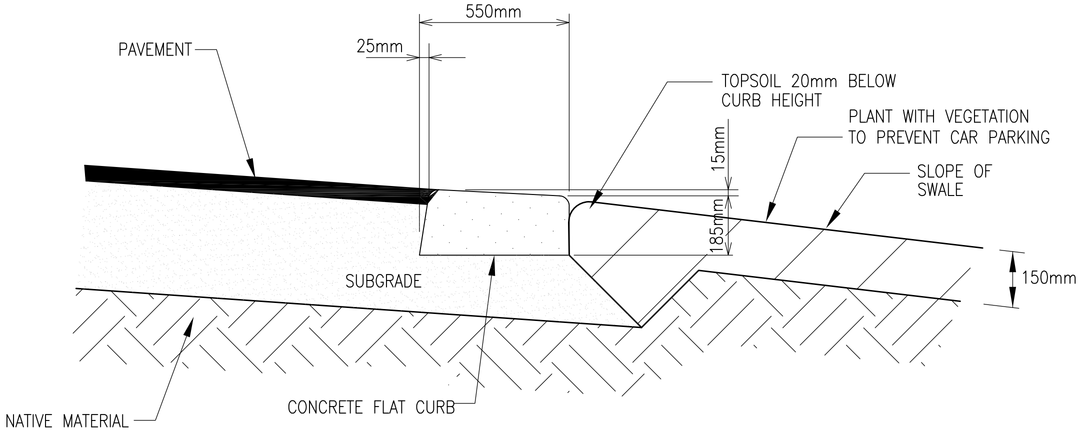


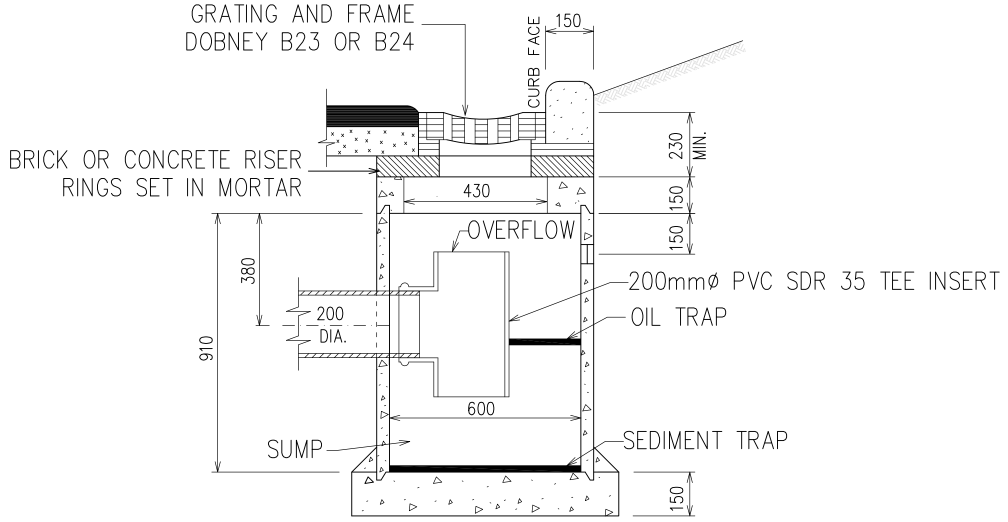
TYPICAL SWALE DETAIL



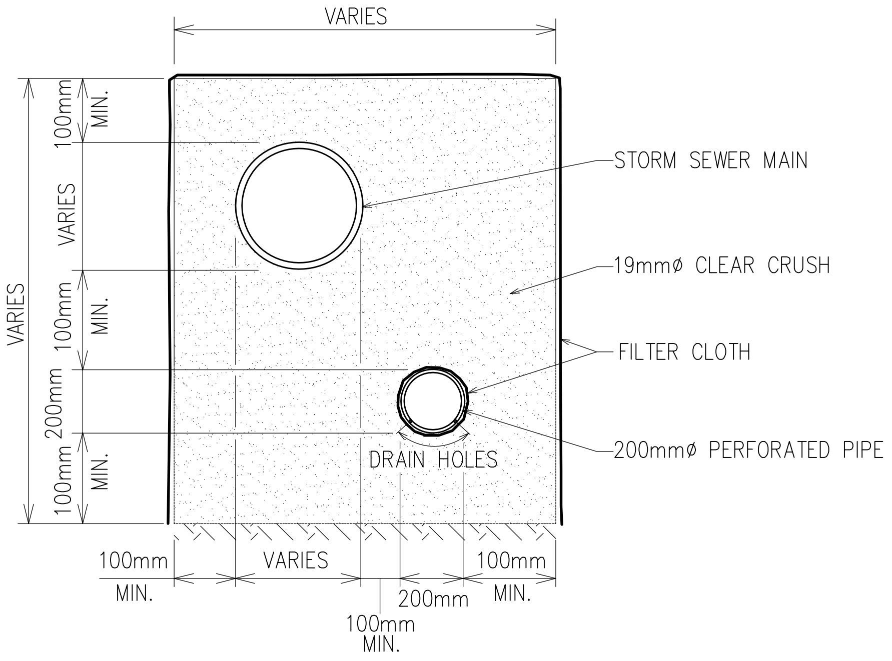
LAWN DRAIN DETAIL



CURB DETAIL



TYPICAL OIL-GRIT
TRAPPING CATCH BASIN



IN STREET INFILTRATION SYSTEM

SUBSTRATE MIX SPECIFICATION

40% COARSE SAND
15% PEA GRAVEL
15% $\frac{3}{4}$" ROUND
15% $1\frac{1}{2}$" ROUND
15% 3" ROUND

NOTE: ADD JUST ENOUGH SAND TO FILL ALL INTERSTIAL SPACES OF THE SUBGRADE MIX.
MAXIMUM DESIGN WATER VELOCITY NOT TO BE GREATER THAN 0.5m/s.

FERGUS CREEK ISMP
Road BMP Details
Figure 3.14

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Plotted: December 13, 2007 , 15:30:46 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 3_14 - ROAD BMP DETAILS.dwg\FIGURE 3.14 - ROAD BMP DETAILS

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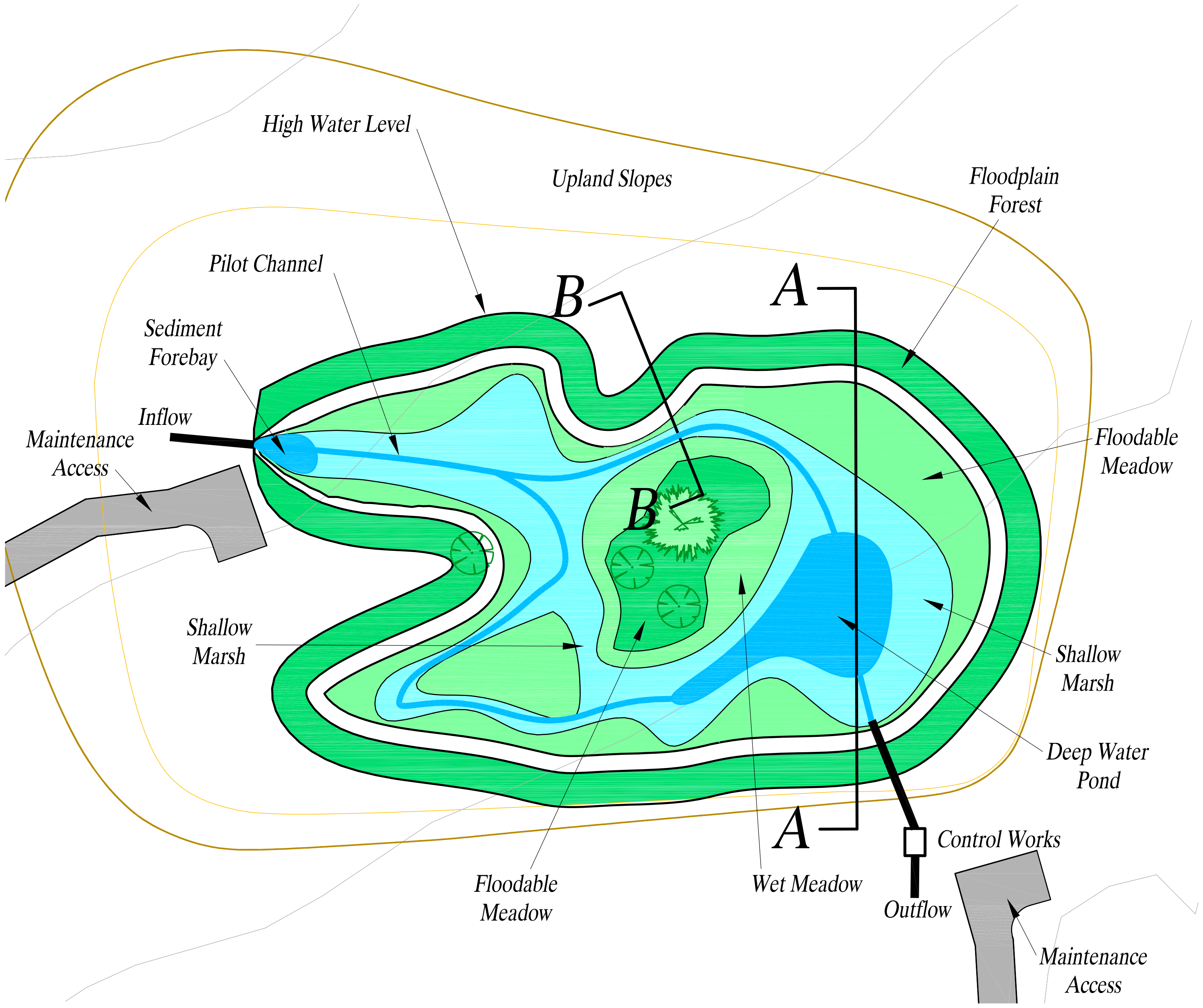
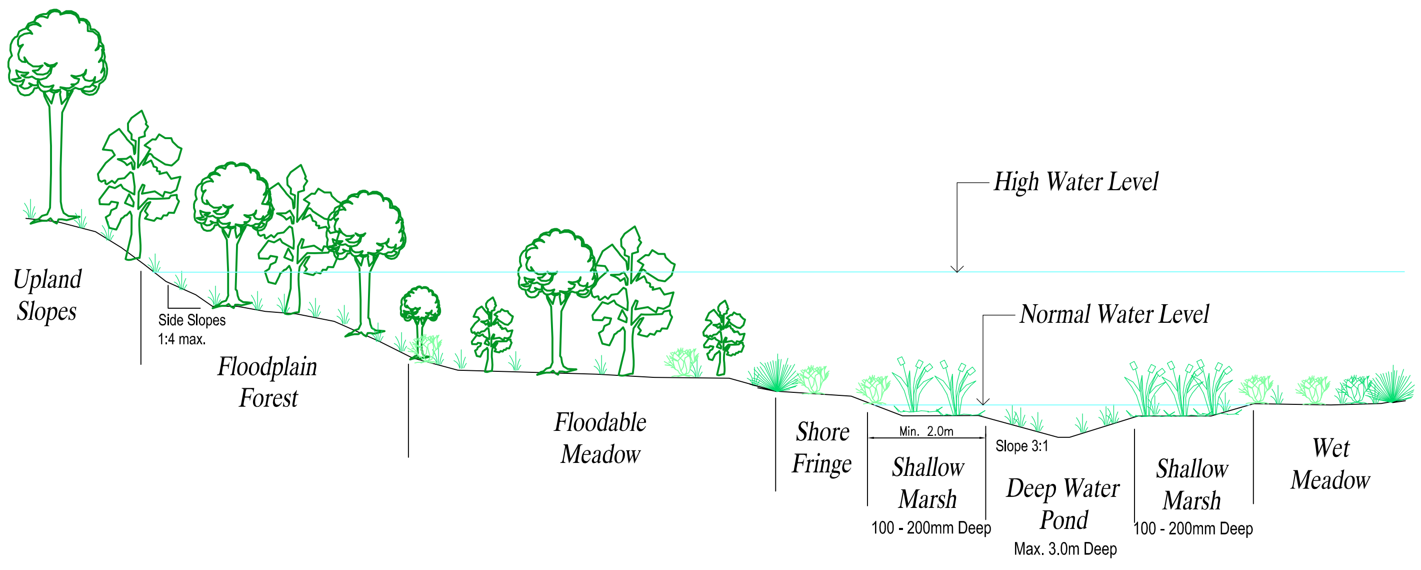
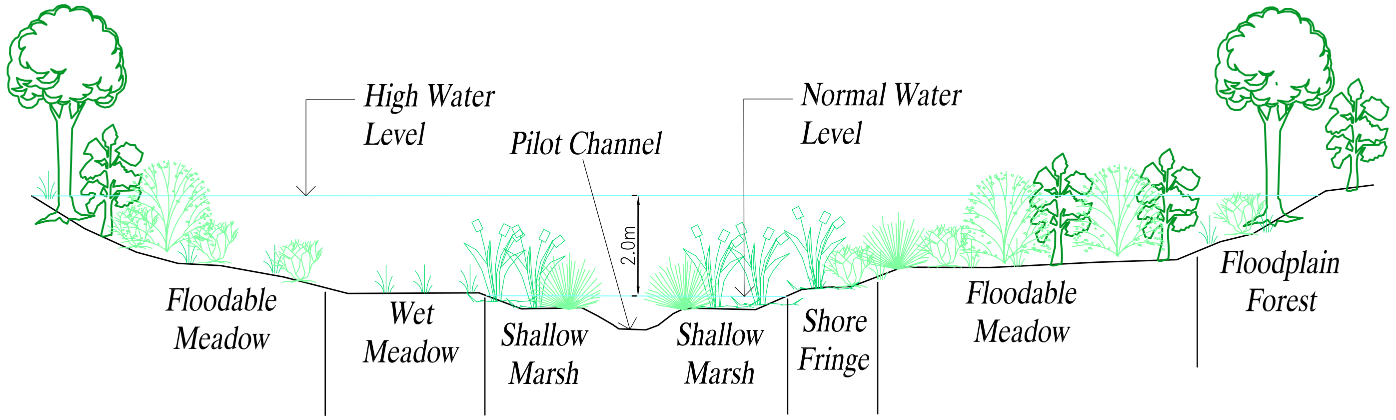


Typical Pond



Section A - A



Section B - B

Plotted: December 13, 2007 , 15:31:48 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 3_15 - BIOFILTRATION POND DETAILS.dwg\FIGURE 3.15-BIOFILTRATION POND DETAILS

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FERGUS CREEK ISMP
Biofiltration Pond Details
Figure 3.15

This is only a partial list for plants suitable for use in swales. Consultants are encouraged and expected to expand on this list for planting designed to suit site conditions; address CPTED concerns; provide wildlife habitat value and sustainability goals for maintenance. Consultants design the swales to control and direct surface run-off. The swale planting must be attractive and easy to maintain.

Trees
Abies procera – Noble fir
Acer circinatum – vine maple
Crataegus douglasii – black hawthorne
Chaemcyparis nootkatensis pendula – weeping yellow cypress
Fraxinus latifolia – Oregon ash
Malus fusca – crabapple
Physocarpus capitatus – ninebark
Picea sitchensis – Sitka spruce
Populus tremuloides – Quaking aspen
Rhamnus purshiana – Cascara
Sambucus cerulean – blue elderberry
Sambucus racemosa – red berry elder
Taxodium distichum – swamp cypress
Thuja plicata – Western red cedar
Tsuga heterphylla – Western hemlock

Shrubs
Amelanchier almifolia – Serviceberry
Cornus stolonifera – red osier dogwood
Cornus sericea – redtwig dogwood
Gaultheria shallon – salal
Holodiscus discolor – Oceanspray
Mahonia aquifolium – Oregon grape
Mahonia nervosa – Low Oregon grape
Rosa spp. – e.g. flower carpet rose; bald hip rose ; Nootka rose
Spirea douglassii – hardhack
Spirea japonica – Japanese spirea
Symphoricarpus albus – snowberry
Vaccinium parviflorum – red huckleberry
Vaccinium ovatum – evergreen huckleberry
Ribes sanguineum – red flowering currant

Perennials & Groundcovers
Acorus calamus – sweet flag
Adiantum pedatum – maidenhair fern
Anaphalis margaritacea – Pearly everlasting
Arctostaphylos uva ursii – kinnickinnick
Astilbe spp. – false spirea
Carex mertensii – Merten's sedge
Cornus unalaschkensis – Bunchberry
Fragaria chiloensis – Beach strawberry
(wildlife habitat, evergreen, full sun to partial shade, dry soil)
Hemerocallis spp. – daylily
Iris versicolor – blue flag iris
Linum perenne – Wild blue flax
Maianthemum dilatatum – False lily-of-the-valley
Polystichum munitum – Western sword fern
Sedum 'Brilliant' – stonecrop
Vancouveria hexandra – Inside-out flower

Plants for Wet Areas (Floodable Vegetation)
Typha latifolia – cattail
Saggitaria latifolia – arrowhead
Scirpus microcarpus – small-flowering bulrush
Carex obnupta – slough sedge
Salix lasiandrapacific – willow
Physocarpus capitus – pacific ninebark
Cornus stolonifera – red-osier dogwood

Note: City of Surrey Parks Dept. to provide recommendations for medium and small trees for use in street boulevards.

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FERGUS CREEK ISMP
Draft Plant List
Figure 3.16

4.0 LIVEABILITY

Two very different special issues have arisen during the course of completing the Fergus Creek ISMP. Those associated with the engineering requirements and others that could be used to ease engineering decisions in the future while providing a more diverse landscape. The diverse landscape can be utilized for a host of purposes and can become part of a multi-use system that can enhance the future neighbourhoods. These enhancements can be established in such a way so as to create “Signature” neighbourhoods that are unique and friendlier to the residents.

4.1 RECREATION

Recreation opportunities within the Fergus Creek Watershed need not be limited to formal playgrounds and team sports. There is a need to include activities for individuals where a more passive participation is possible.

The recreation goal and strategies apply not only to the stream corridor and its tributaries but also across the entire watershed and all of its components. Integration of stormwater, environmental and recreational goals utilizing a “basin-wide” approach is a key component of this ISMP. Although some of the recreation strategies and possible action items may not have immediately apparent direct linkages to improved watershed health, this report provides supporting documentation and tools that substantiate many indirect benefits.

The roles of stormwater management in short and long term community liveability cross many traditional boundaries. Viewing “recreation” as more than swing sets and ball diamonds, within this context, is crucial. Healthy community environments maximize the utility of stormwater in terms of ecological integrity and in terms of social activities such as recreation and stewardship.

4.1.1 Connect People to the Watershed

This is one of the central themes that were identified by the Steering Committee in order to promote the long term, ongoing proprietary interest in Fergus Creek as an urban watershed. Key points to note with respect to this central theme are highlighted next:

- The consulting and City staff share an understanding, after dozens of collective years of planning and managing stormwater in an urban setting, of the requirements for stormwater management and impact mitigation.
- The individual and community awareness of Fergus Creek is typically very low with notable exceptions being concerned citizens who seek to maintain and to enhance Fergus Creek.
- In connecting people to the watershed, awareness will grow. Awareness of Fergus Creek (via education, stewardship, increased physical and visual access etc) will lead to an understanding of the watershed issues, which will in turn lead to more responsible personal care and commitment to an improved environment, across the basin.
- Enhancing pedestrian and cycle safety in the catchment area (typically at the time of infrastructure improvement and redevelopment) will mitigate the impact of vehicles on the watershed. The intent of this plan is to remove physical and policy barriers to efficient and safe cycling and develop an urban tree strategy that will eventually result in contiguous tree canopies over pedestrian and cycle routes.

4.1.2 Provide Stream Education

There is a single, all encompassing strategy supporting this goal - Provide Environmental Education Opportunities. Integrating stormwater management with environment and “social” values has not, until recently, been a typical stormwater management outcome. Furthermore, other ISMP’s have not explicitly integrated recreation and public art, although many of them have included stewardship considerations. In that sense, the Fergus Creek ISMP can break new ground.

Given the above frame-of-reference, this document is intended to provide the community, Council and staff with insight, inspiration that will facilitate the integration of stormwater planning into a more liveable community fabric by incorporating recreation values and strategies.

In order to create and implement a strategy, programs are required to create and enhance historic and environmental education opportunities across the watershed. One of the possible actions is to implement a public art program that traces all sections of Fergus Creek and its tributaries that includes two and three dimensional art installations, performance art and participatory community gatherings. Associated actions to achieve the desired outcome include:

- Develop a watershed understanding through demarcation of the watershed and its sub catchments by creating built and planted gateways, public art and education strategies; ongoing stormwater, creek and tributary markings/signage/art.
- Integrate signage and interpretive panels with ongoing city street and park signage works. Every crossing of Fergus Creek and its tributaries should be signed in an obvious, artful way. Information about the impact of damaging landscape maintenance and dumping practices and inappropriate dog behaviour should be posted utilizing “user friendly” techniques.
- Utilize the Fergus Creek corridor as a walking watershed education tour. Emphasis on the future would involve students of all ages in as many of the changes to the public realm within the Fergus Creek Watershed as possible. Programs should strive to integrate the landscape, geologic and First Nation’s history in the interpretation theme along Fergus Creek and its tributaries. A watershed brochure outlining the history and growth trend of the watershed and its recreational values would serve to enhance educational efforts.

4.2 LAND DEVELOPMENT PLANNING

Planning of future neighbourhoods will incorporate the multitude of needs for infrastructure, recreation, and the environment. These planning processes are required to provide the City with a vision of the future neighbourhoods and with a process to achieve the visions. The processes would include the Neighbourhood Concept Plans for the rural areas, and redevelopment planning for the urban portions of the Watershed.

4.2.1 Green Corridors

Despite the design and implementation difficulties, the concept of replicating natural infiltration processes has considerable merit. A new strategy to increase and/or improve permeable surfaces and infiltration rates in urban environments is the creation of large-scale green corridors. Besides obvious environmental benefits, the corridors can result in cost savings for developers (and ultimately homebuyers) and municipal governments as their effectiveness at controlling rainfall volumes make the traditional detention pond redundant. At minimum, a green corridor can be cost neutral compared to the costs associated with a detention facility. Green corridors can be designed as multi purpose facilities that include pedestrian and cycling trails as well as recreation and open spaces, which contribute to a neighbourhood's liveability and amenity.

The combination of environmental and liveability benefits can significantly enhance a neighbourhood's character and appeal and establish it as a preferred and highly desirable neighbourhood to reside in. It can also serve as a "showcase" example of a cutting edge sustainable neighbourhood that guides the conceptualization and development of other neighbourhoods, both within and outside a municipality.

As noted above, a green corridor can be designed and developed as a multi-purpose facility to secure environmental and liveability benefits. Typical environmental benefits include maintenance of natural rainwater mitigation processes (i.e., infiltration) and provision of wildlife habitat, while typical recreation benefits include opportunities for walking, running and cycling and informal games for a full range of age groups and physical abilities

The stormwater management and mitigation assessment has indicated a need to carry a safety factor forward to deal with potential shortfalls in the operation and performance of the stormwater reduction infrastructure. We have recommended in **Section 3.6.3**, a safety factor of 2 that would require setting aside a 10% portion of the watershed that could be used for these purposes to augment and replace the proposed facilities. This would be over and above that area normally set aside for stormwater management ponds used to control the rates of discharge to the streams as recommended in **Section 3.2.1**.

The areas set aside for possible use in the mitigation of stormwater impacts can be used in a multitude of ways and for many users. These areas should be viewed as green space that can be used for amenities in the watershed. Contiguous green spaces would provide the greatest flexibility for future use for stormwater mitigation, recreation, environmental, or other joint use. To provide the greatest benefit a plan for the future neighbourhoods that include contiguous green spaces would provide the greatest potential benefits. We have developed two concepts of contiguous and linked green spaces for the rural portions of the watershed.

Our purpose is to create green, unoccupied areas within future urban areas that could be used for stormwater infiltration/storage/conveyance/compensation purposes. Some of the areas would likely be disturbed with construction when targets cannot be met within the future developments or road R-O-W's. These could then become facilities with multi-use on the surface and a drainage component below ground.

The location of the greenways has been driven by several factors as described below:

1. **Proximity to roadways**

The green street alternatives that have been provided to the City for review have not been approved or adopted within the watershed. As there is some uncertainty regarding this, we need another option for providing runoff volume control for streets and other City owned lands. The greenways will therefore need to be located near streets to allow stormwater to be directed to the greenways.

The greenways will need to connect infrastructure across the road system network. The drainage and the pathways will need to connect across the road pattern to provide linkages between roadways.

The drainage component of the greenway will include both surficial and subsurface features. On the surface will be shallow streams and water quality improvement facilities. The underground systems will utilize infiltration systems and conveyance where required.

Construction of the drainage features will require disruption of the surface; these should be located away from, or adjacent to, the treed areas and other habitat that will be protected. We anticipate pathways will be suitable on the drainage portions of the greenways.

Greenways must have a longitudinal slope, but should not be located along the steepest slopes.

Greenways should not parallel roadways to allow better efficiency of use and linkages between drainage systems.

2. Acquisition

Acquisition of greenway lands will be problematic. We have attempted to place the greenways on a multitude of properties so that no single property owner would be required to loose development opportunities. That is why the layout is consistently located along the property lines of adjacent properties. This will minimize future problems with development layout and acquisition.

Greenways should not parallel the road system. This allows maximum use opportunities while minimizing acquisition issues.

A system of funding the acquisition must be developed and put into place

3. Habitat

The greenways will also provide habitat for wildlife, serve as a food source, provide linkage and passage between other larger habitat areas. The size and width of the greenways should be sufficient to allow both human and wildlife use.

4. Dispersal

The greenways need to be dispersed across the neighbourhood. This will allow easier linkages for drainage infrastructure and pathways and wildlife corridors. They should not have ends without connections to other portions of roadway or greenway.

The greenways are dispersed and included in the planning at an early stage. This process is different than that which would locate retention ponds at the low points in the watershed. The low points of this Neighbourhood / watershed are also the locations of the highest proposed population densities and are therefore the most valuable. The greenways provide a method of distributing the drainage component throughout the neighbourhood in smaller individual components. This should allow easier integration into the planning and provide easier acquisition during implementation.

5. Multiple Usage

The greenway system must allow for a multiple of uses.

4.2.2 Linked Green Spaces

The linking of larger green spaces can provide numerous benefits for the neighbourhood. The contiguous corridors can provide linkages to the large green spaces located centrally throughout the watershed as shown on **Figure 4.1**. These can be integrated into the habitat preservation areas that will be discussed in **Section 5**.

4.2.3 Green Corridors

The green corridors could become the prime feature of a new neighbourhood. These corridors can be used to link neighbourhood features and provide a focus for life in the developing areas. Creation of the linkages can become a “Signature” feature of the new neighbourhood as shown on **Figure 4.2**.

4.2.4 Greenway Characteristics

Attainment of stormwater management objectives requires the availability of sufficient area to allow for the infiltration of rainwater generated from roads, dwellings, driveways and other hard surfaces located in a neighbourhood. Typical stormwater management infrastructure to be accommodated includes infiltration galleries and a surface water system (consisting of a stream/swale and water quality ponds) to convey excess water and/or to maintain downstream base flows. Landscaping with native shrubs and trees and grassed surfaces are also important to replicating a natural environment. The multi-purpose recreational trail should be a minimum 4.0 metre wide to safely accommodate pedestrians and cyclists. The trail should have a hard surface to ensure for safe and easy use. As shown on **Figure 4.3**, a green corridor should be a minimum 40 metres wide to accommodate all required environmental and recreational infrastructure.

The greenway corridor can be sited in two alternative locations: 1) between two residential development areas (either single or multiple residential); or, 2) between a public road and a residential development area (again, either single or multiple residential). In the first option, adjacent dwellings back onto both sides of the greenway enhancing their appeal and character and affording residents quick and easy access to the amenity. This design also enhances neighbourhood surveillance opportunities, a cornerstone of crime prevention design strategies (i.e., CEPTED). This design orientation also has some drawbacks, such as limited access opportunities for maintenance equipment and vehicles, as well as increased design and construction costs for adjacent dwellings as a result of higher visual standards to the rear of dwellings that municipal approval authorities often require. Municipal authorities may also require low fencing between private yards and the corridor to improve resident surveillance; homeowners may instead want a full height fence for safety and security reasons. It is also possible the adjacent residents could use the greenway to dispose of yard waste.

In the second alternative, only one back of dwelling units backs on to the corridor. These dwellings and their residents continue to benefit from their close proximity to the green corridor and surveillance opportunities can be improved from passing automotive traffic passing. Proximity to a roadway also improves access for maintenance vehicles

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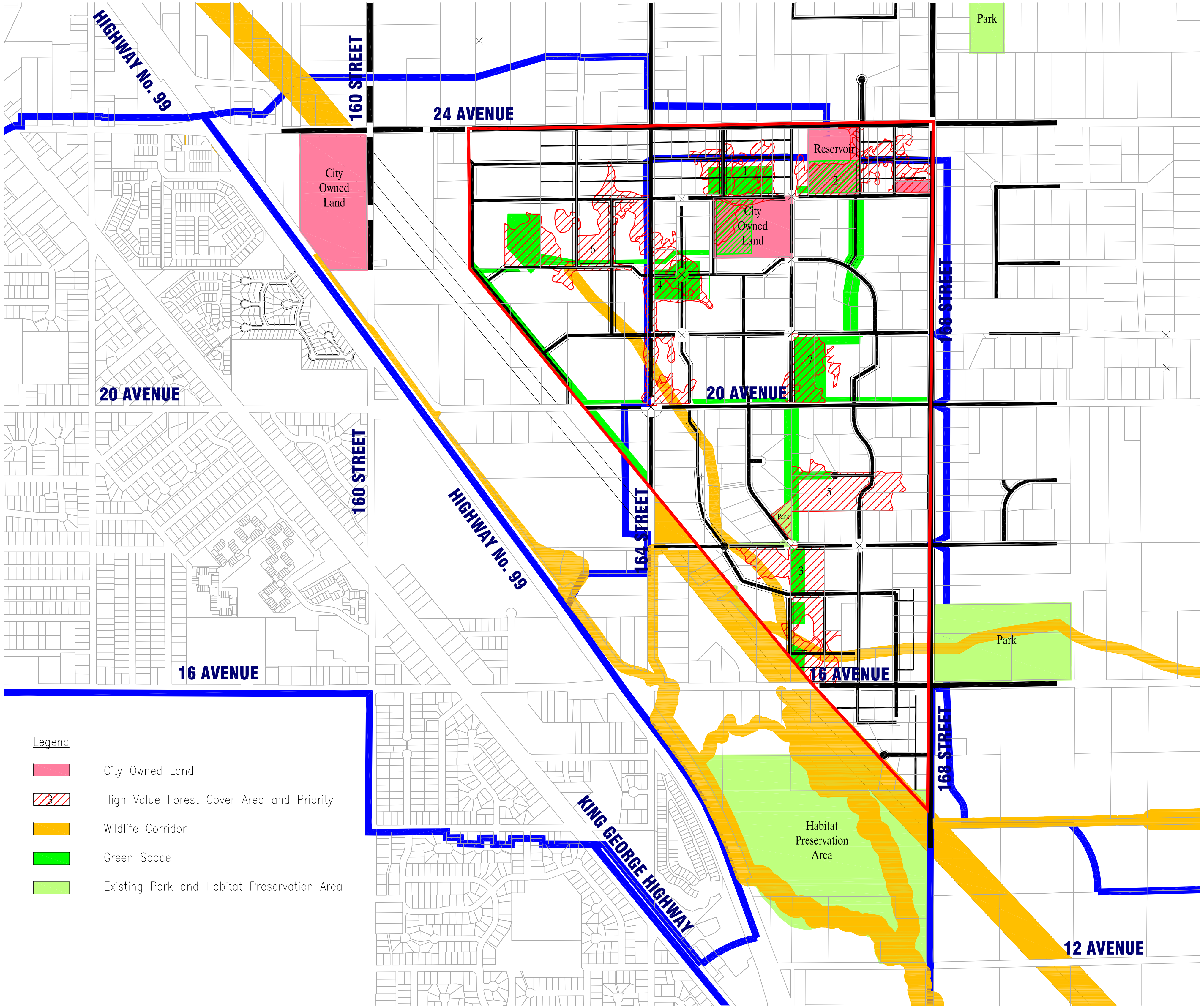


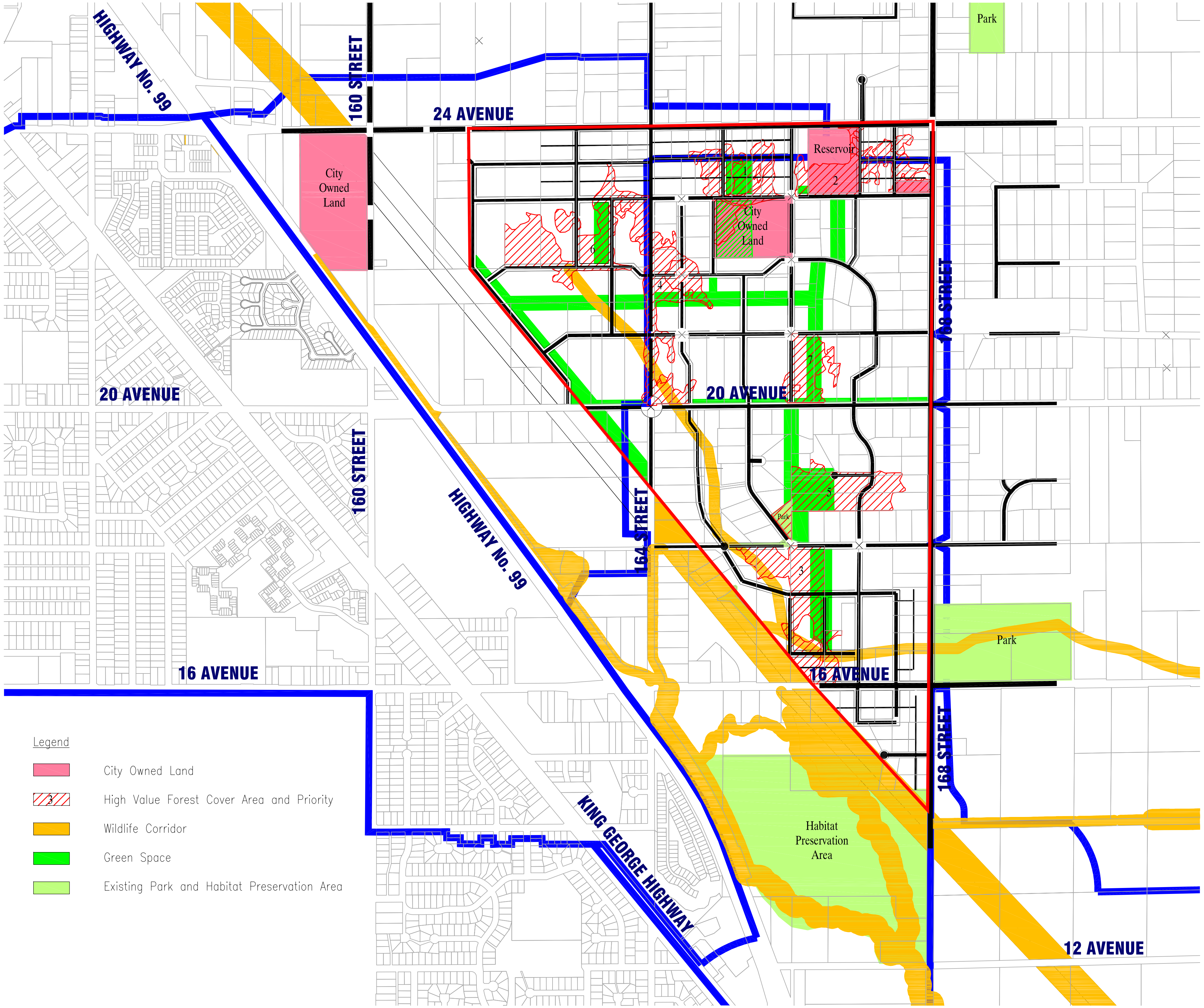
FERGUS CREEK ISMP

Green System - Alternative 1

Figure 4.1

McElhanney

Plotted: December 13, 2007 , 15:33:48 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 4.1 - GREEN SYSTEM ALT 1.dwg\FIG 4.1 - GREEN SYSTEM ALT 1



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FERGUS CREEK ISMP

Green System - Alternative 2

Figure 4.2

Plotted: December 13, 2007 , 15:34:44 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 4.2 - GREEN SYSTEM ALT 2.dwg\FIG 4.2 - GREEN SYSTEM ALT 2

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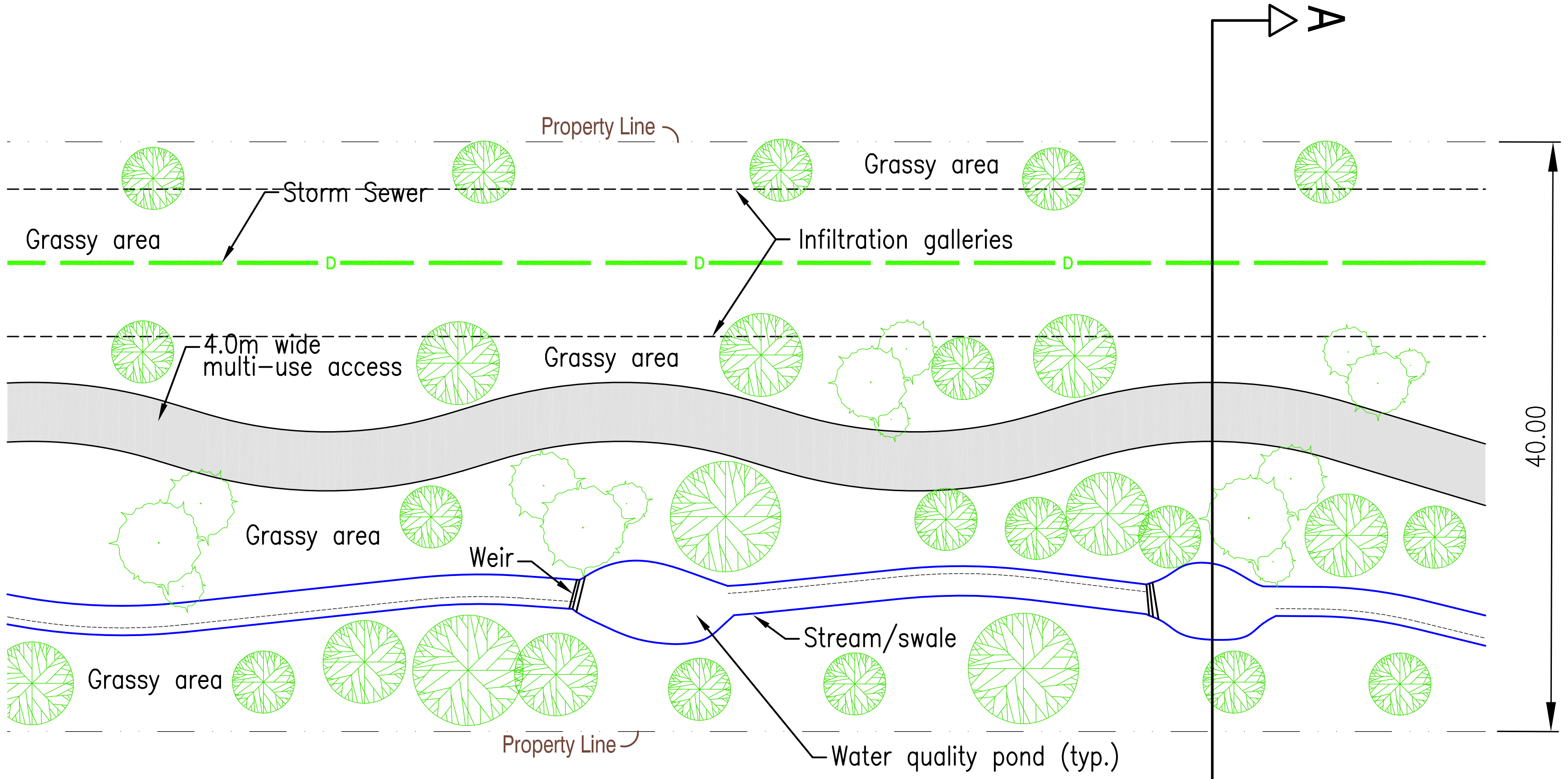

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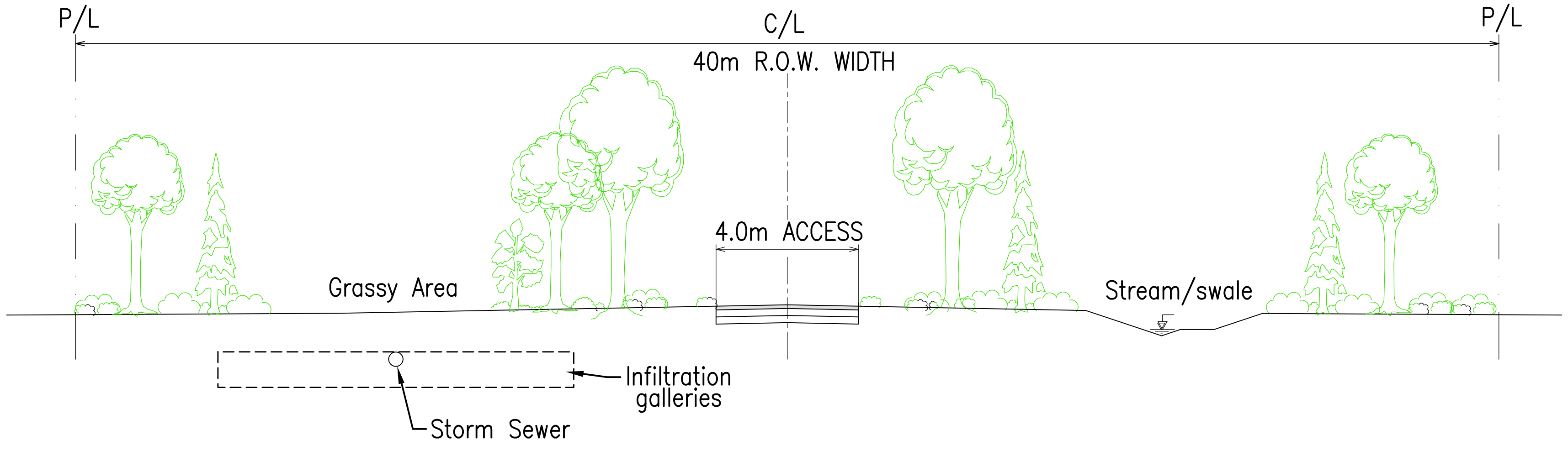

TYPICAL SECTION AA

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Plotted: December 13, 2007 , 15:35:33 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 4_3 - 40m Multiuse Corridor.dwg\40m MULTI-USE CORRIDOR

McElhanney

FERGUS CREEK ISMP

40m Multi-Use Corridor

Figure 4.3

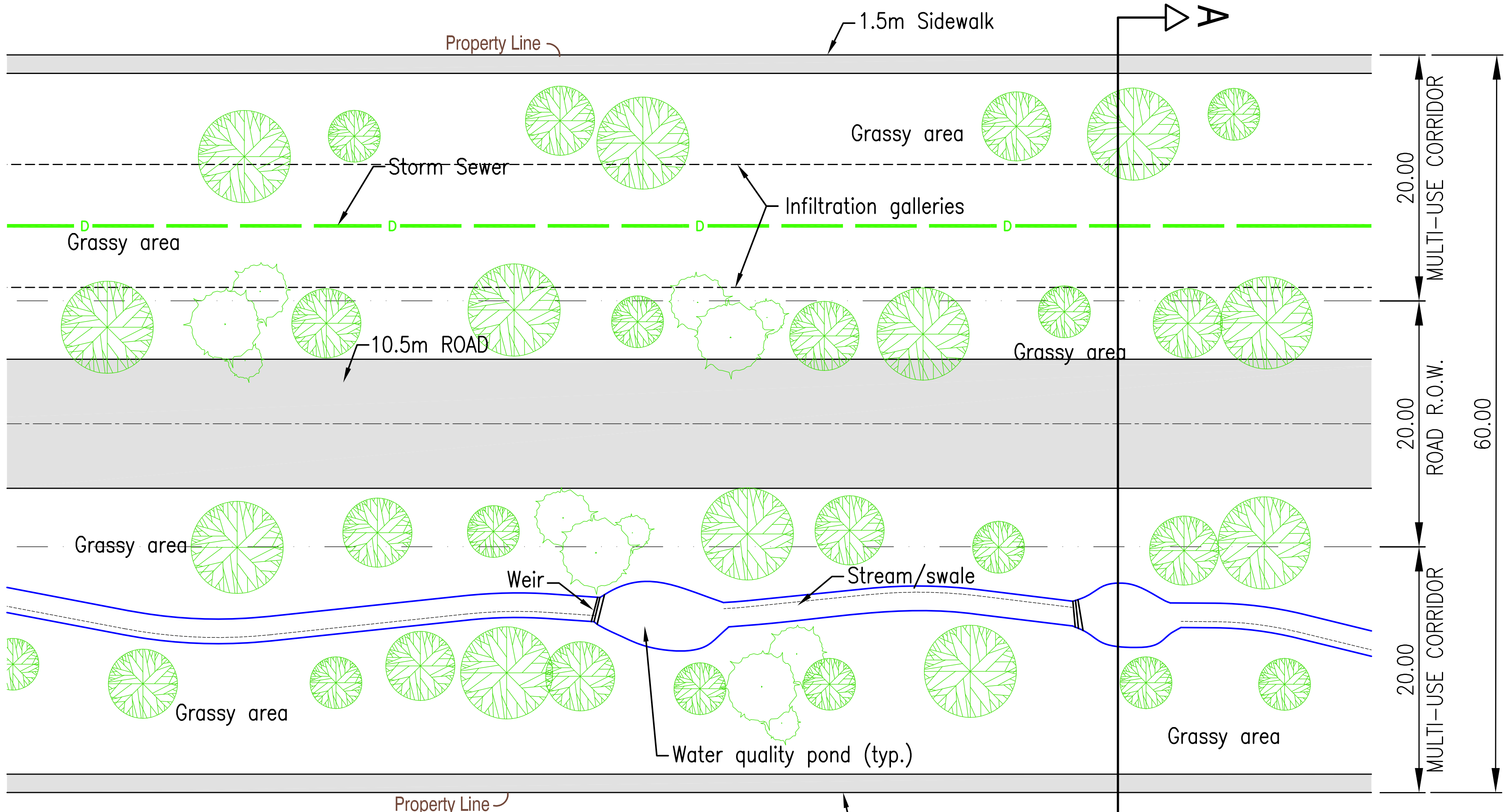
and equipment. The other drawbacks noted above would also be applicable with this alternative.

The basic greenway corridor can be modified to incorporate roadways. To ensure that the primary environmental and recreational functions are not impacted, the total width of the green corridor should be increased to 60 metres. Adjacent dwellings could either back onto or front the corridor. Single residential dwellings that front onto the corridor would have their primary access from rear lanes. While this design can contribute to the aesthetics of the corridor it can also result in parking problems for the fronting dwellings, suggesting that limits on the number of fronting dwellings should be limited.

Within the corridor there are several possible combinations for the location of roadways, sidewalks, infiltration galleries and surface watercourses. For example, the roadway can be located in the center of the greenway separating the infiltration galleries and the watercourse (see **Figure 4.4**). Alternatively, the roadway can be split so that separate directional lanes border stormwater management infrastructure (see **Figure 4.5**). Although these alternatives show dual sidewalks instead of a multi-use path it is possible to introduce one into the design.

As each of the green corridor design alternatives presented here provide effective stormwater management and recreation and amenity opportunities all three should be available for implementation when envisioning the desired physical and visual experience of a new neighbourhood. They provide considerable flexibility in the location and design of the corridors resulting in improved opportunities to shape neighbourhood form, design and character. This is in sharp contrast to neighbourhoods that employ stormwater detention ponds that are simply located at the bottom of individual catchment areas and do not necessarily provide these opportunities. Regardless of the corridor design and location, it will be necessary to consider appropriate design and architectural responses (i.e., building orientation, fencing, façade treatments, setbacks, CEPTED) as well as to ensure safe and efficient access.

The green corridors can also have a positive effect on the timing of development in a neighbourhood. In a neighbourhood employing standard detention ponds for stormwater



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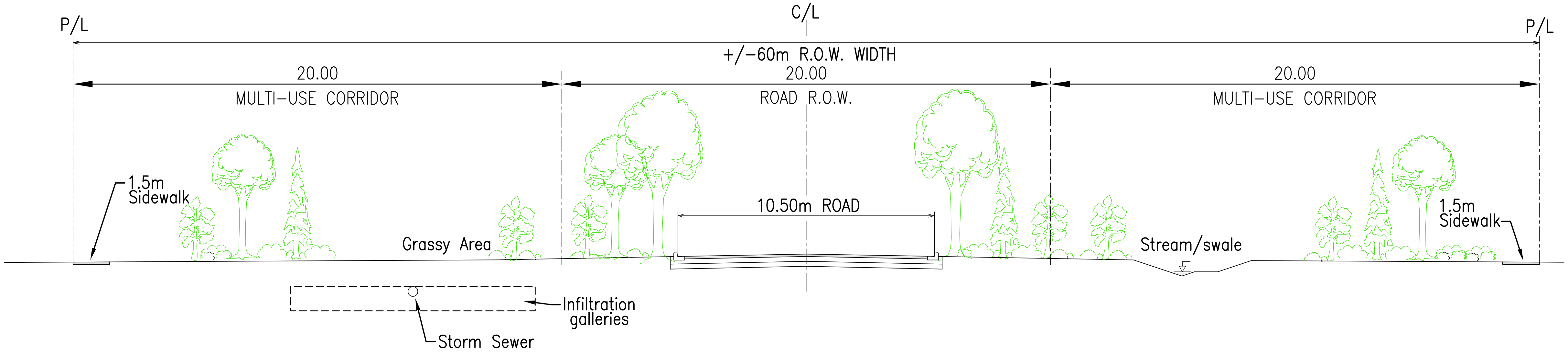

TYPICAL SECTION AA

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FERGUS CREEK ISMP

60m Grand Boulevard

Figure 4.4

Plotted: December 13, 2007 , 15:36:55 Filename: M:\Proj\2111-02276-0 Surrey Fergus Creek\Ldd\dwg\FIGURE 4_4 - 60m Grand Boulevard.dwg\60m - Grand Boulevard

management control the ponds must be secured and constructed before upstream development can occur. This can represent a significant up-front cost depending on the size of the required detention facility (which is a function of catchment area) that can have considerable influence on the timing of development. The location of development within a neighbourhood can also be affected if it consists of several catchment areas and it is assumed that development will focus on areas with lower costs, such as where a detention facility has been provided. In contrast to this, green corridors offer greater flexibility in the timing and location of development because the ultimate corridor does not have to be provided prior to development activities and can instead be expanded as development occurs.

4.2.5 Signature Neighbourhood Features

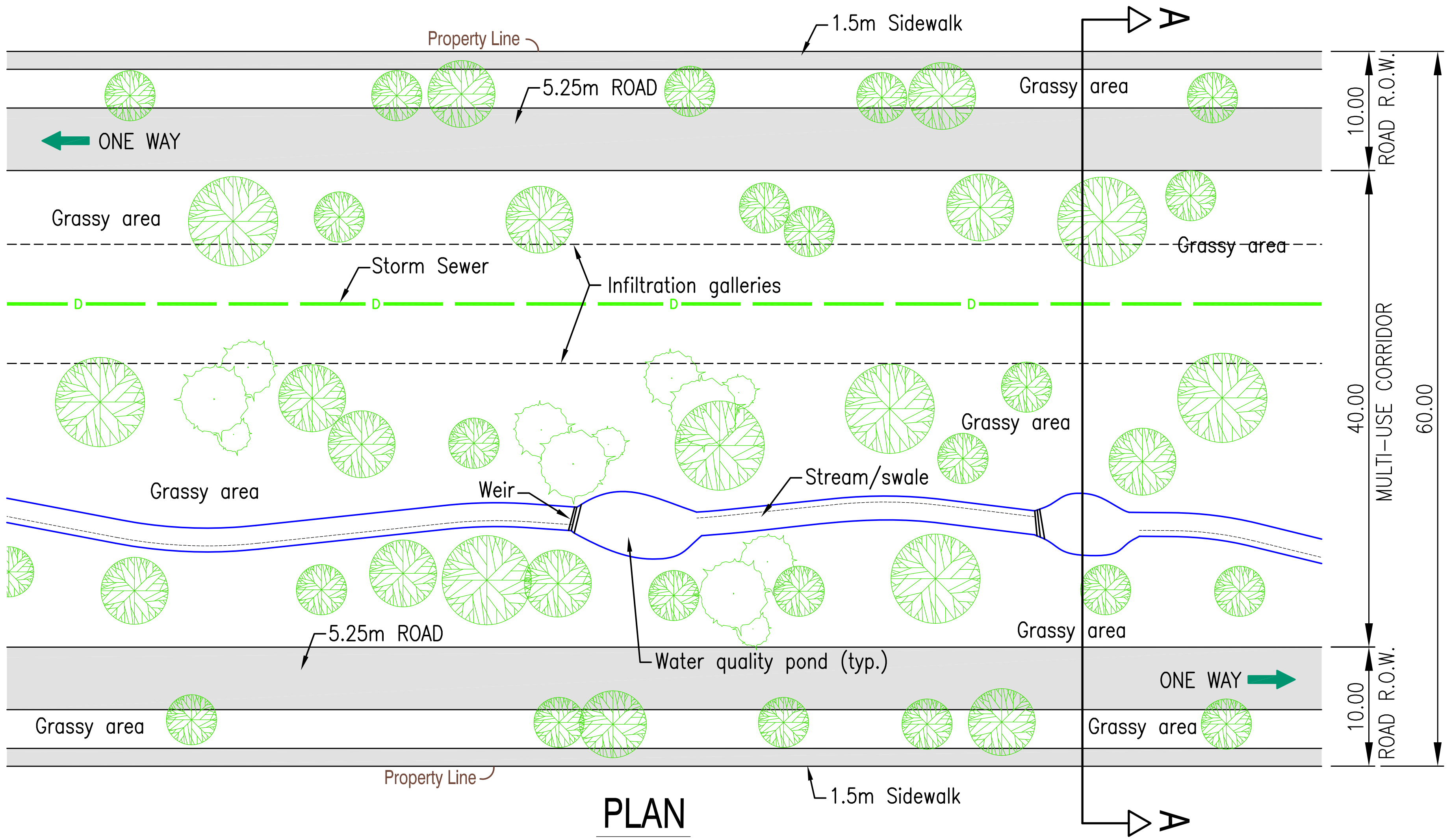
As noted above the green corridors present an opportunity to enhance not only the drainage system but also the environmental values and aesthetics of future neighbourhoods and the recreation opportunities within the Fergus Creek Watershed.

The ultimate locations of the green corridors and their function will be refined during the preparation of the Neighbourhood Concept Plans for the rural area. Consideration should be given to creating similar features within the redevelopment areas of the existing urban areas of the Fergus Creek Watershed.

These contiguous greenways have the potential to be a truly exciting and valuable asset to the City of Surrey and future residents as the watershed redevelops and the population expands.

4.2.6 Land Acquisition

The total land area required to develop a neighbourhood green corridor system is directly related to the factors which affect the volume of stormwater, including soil conditions, infiltration rates, intensity and duration of rainfall events, type and density of land uses and surface permeability rates.



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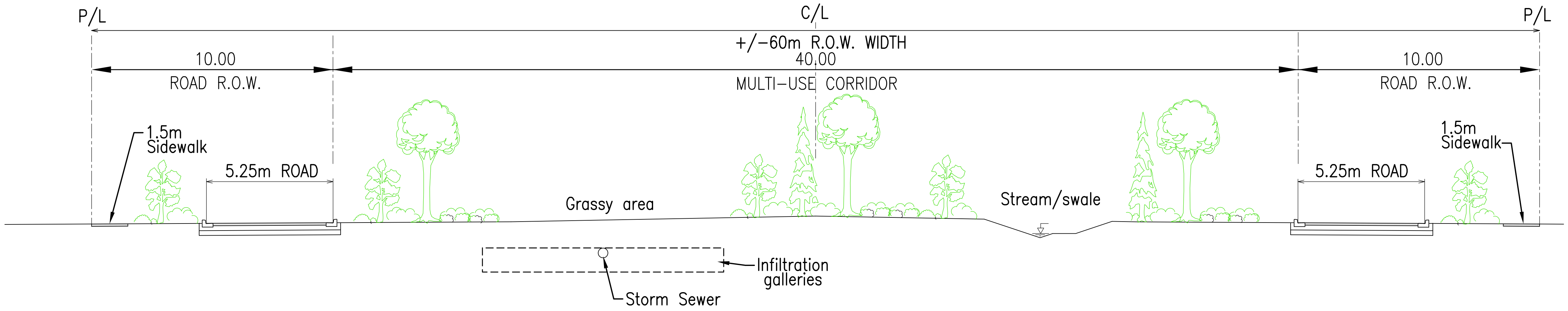


TYPICAL SECTION AA

N.T.S.

FERGUS CREEK ISMP

60m Grand Boulevard - Divided

Figure 4.5

In order to simplify a complex interaction of variables a working target of 10% of a neighbourhood can be used to estimate the land area needed for green corridors. The amount of land required is clearly substantial as will be acquisition and construction costs, which raises important questions regarding financial responsibility. As with the funding of other municipal infrastructure and facilities, the City of Surrey seeks an acquisition and funding strategy that is equitable and achievable. Equitability is achieved when costs are shared by the city and the development industry, as well as between developers (i.e., the first developer in a new neighbourhood pays the same as the last developer). An acquisition and funding system is considered achievable when the system does not function as a disincentive to development. It is also important that an acquisition and funding strategy is consistent with current municipal regulatory and financial frameworks.

As green corridors are, by definition, multi purpose facilities combining engineering and recreation infrastructure it can be reasonably argued that existing funding sources can be used for their acquisition and development. Therefore, there are three possible funding sources that can be considered: 5% parkland dedication, development cost charges (DCCs) and special levies. The 5% parkland requirement can be collected as cash-in-lieu, rather than as a land dedication. The charge is only applicable to subdivisions where more than three lots are created but it cannot be applied against multiple residential development which accounts for a significant and growing portion of new and future development. In effect, multiple residential developments could benefit from the stormwater management and recreational infrastructure provided in the green corridors without contributing the same level of funding as would a comparable single family residential. This imbalance could be addressed by adjusting multiple residential development cost charge rates and/or special levies. Presently, the city has a park acquisition and drainage development cost charge, which can be used for the acquisition and construction of drainage facilities. Development cost charges collected in a particular neighbourhood could be used to finance the acquisition and development of a green corridor. The city has the ability to adjust the parkland and drainage development cost charge rates for development within a specific neighbourhood. This strategy has been used in the Campbell Heights and Highway 99 Corridor areas to fund industrial development.

In the event that the combination of 5% parkland charges and development cost charges are insufficient to fund green corridor acquisition and development a special levy can be used to cover anticipated shortfalls. The city presently employs a special levy in the form of a NCP Amenity Charge to fund neighbourhood park and facility development. A special levy could be applied to both single and multiple residential developments, but at different rates to reflect different rates of utilization as is the case with development cost charges. A levy in addition to development cost charges may not be well received by the development industry so it would be necessary to make a clear economic case in favour of multi purpose green corridors instead of separate detention ponds and park facilities. An economic assessment of green corridors should acknowledge the potentially lower upfront costs and the reduced impacts on the timing, pace and location of development.

Regardless the method used to fund the green corridors, there is the likely scenario where development has been initiated within a neighbourhood but insufficient funds for acquisition and construction have been collected. In these situations where development cost charges are the primary method to fund infrastructure the first developer(s) in a neighbourhood would be responsible for the upfront capital costs and development cost rebates or credits and/or frontender or development works agreements would be available to recover costs. The city could also provide funding situation.

4.2.7 Redevelopment Planning

The need for careful planning of the infrastructure needs within the rural portions of the Fergus Creek Watershed have been identified with some considerable detail. There also exists a need to undertake the next planning steps for the urban portions of the watershed. This effort is required to assure the implementation of the stormwater mitigation methodologies as those areas redevelop. It is equally critical to stream health that the existing developed areas implement stormwater runoff volume control in a consistent manner to meet the overall ISMP objectives.

Redevelopment planning should be undertaken prior to further redevelopment within the existing urban development areas of the Fergus Creek Watershed

5.0 THE ENVIRONMENT

The Fergus Creek Watershed has been reviewed and evaluated as part of the ISMP process. A substantial level of effort has been expended to identify the environmental values within the watershed and to provide direction in the preparation of the ISMP. A full copy of the Environmental Review is included in **Appendix B** of this report. Following are excerpts from the Environmental Review.

As part of the planning process for the Fergus Creek Integrated Stormwater Management Plan in south Surrey, ENKON Environmental Limited (ENKON) was retained to inventory fish, wildlife and vegetation resources and identify any environmentally sensitive areas within the watershed. This report describes the results of environmental surveys conducted in 2005 and 2006.

- ENKON reviewed a number of relevant environmental reports for the Fergus Creek watershed including:
- .Environmental Review of the Grandview Heights Neighbourhood Concept Plan Area 2 (ENKON 2006);
- General Environmental Review for the Grandview Heights Plan Area prepared by Envirowest (May 2005);
- Environmental Impact Assessment Report for Grandview Heights #1 NCP Phase 2 prepared by Phoenix Environmental Services Ltd (2005);
- General Habitat Management Principles Developed by Envirowest (January 2004) for the Highway 99 Corridor; and
- Fergus Creek Stream Assessment conducted by Gartner Lee (2001).

5.1 ENVIRONMENTAL INVENTORIES

A total of 5 biological surveys were conducted during the summer/fall of 2005 and the spring of 2006 (**Table 5.1**) within the Fergus Creek Watershed.

Table 5.1 Fish and Wildlife Surveys Conducted within the Fergus Creek Watershed during 2005/2006

Survey Conducted	Date
Raptor surveys to identify habitat use by federally and provincially listed bird species	July 6, 2005 December 8 and 12, 2005 January 23-24, 2006
Small Mammal live trapping to identify habitat use by federally and provincially listed small mammals	August 3 , 2005 March 13, 2006
Reptile and Amphibian surveys to identify habitat use by federally and provincially listed reptiles and amphibians	July 6, 2005 August 3-5, 2005 February 22, 2006
Watercourse Classification surveys to confirm the City of Surrey mapping and to identify enhancement opportunities	July 06, 2005 September 26, 2005 October 02, 2006
Water Quality Sampling during the low summer flow period to assess the health of the Fergus Creek watershed	September 26, 2005

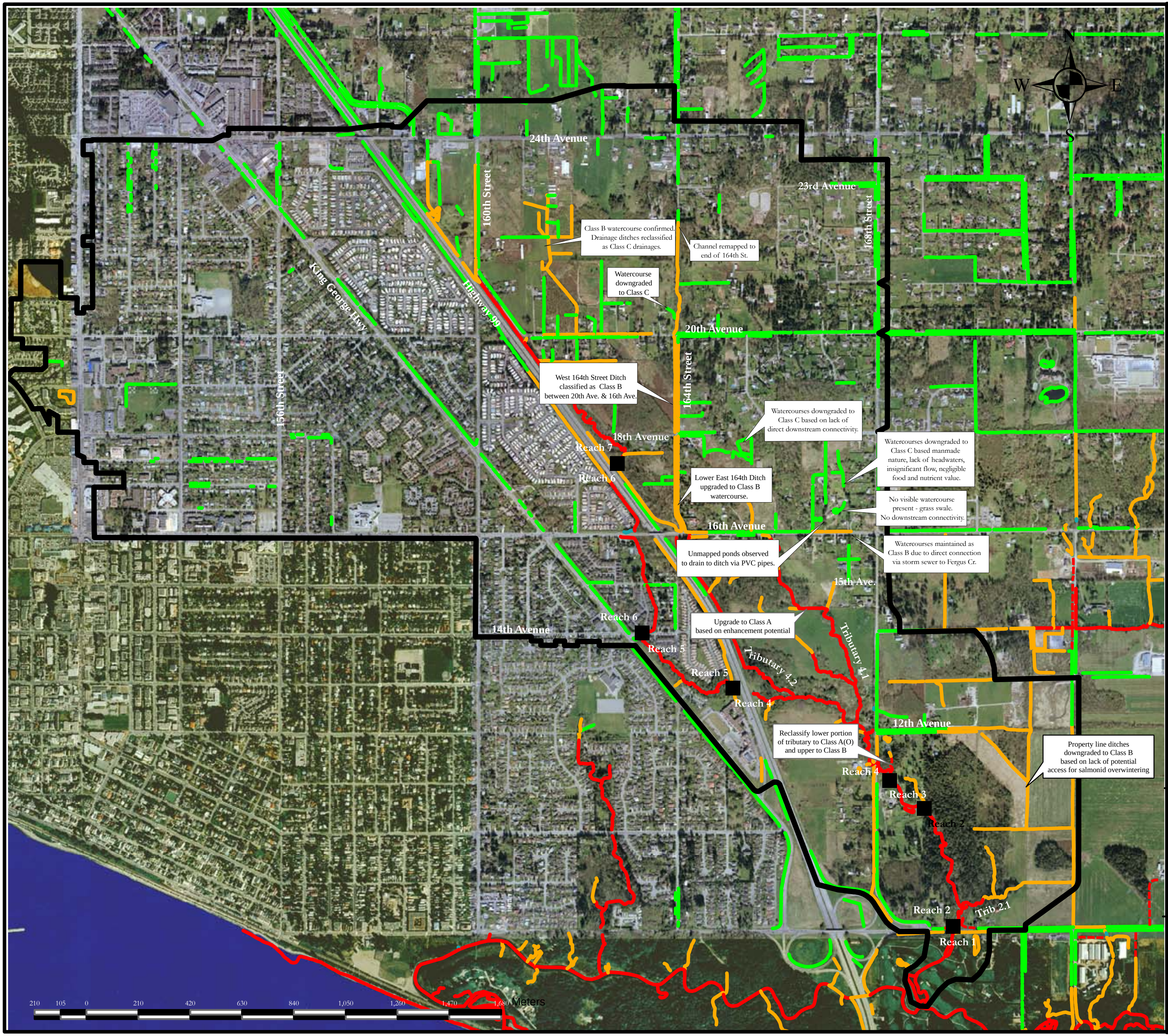
5.2 FISHERIES RESOURCES

5.2.1 Watercourse Classification

Watercourse classifications were assessed based on the City of Surrey's watercourse classifications as available from digital datasets for fish stream classifications received April 2006.

Six Class A or Class A(O) watercourses were identified within the Fergus Creek as shown on **Figure 5.1**. Field verification has allowed a revision of the classification that has been previously reported by the City of Surrey.

1. The Fergus Creek mainstem from its confluence with the Little Campbell River to just north of 20th Avenue;



Class B watercourse confirmed. Drainage ditches reclassified as Class C drainages.

Channel remapped to end of 164th St.

Watercourse downgraded to Class C

West 164th Street Ditch classified as Class B between 20th Ave. & 16th Ave.

Watercourses downgraded to Class C based on lack of direct downstream connectivity.

Watercourses downgraded to Class C based manmade nature, lack of headwaters, insignificant flow, negligible food and nutrient value.

Lower East 164th Ditch upgraded to Class B watercourse.

No visible watercourse present - grass swale. No downstream connectivity.

Unmapped ponds observed to drain to ditch via PVC pipes.

Watercourses maintained as Class B due to direct connection via storm sewer to Fergus Cr.

Upgrade to Class A based on enhancement potential

Reclassify lower portion of tributary to Class A(O) and upper to Class B

Property line ditches downgraded to Class B based on lack of potential access for salmonid overwintering

Proposed WaterCourse Re-Classification Area

Figure 5.1

McElhanney Consulting Services

Legend:

▭ Fergus Creek Watershed

City of Surrey Watercourse Classification

🟥 Class A
- - Class A(O)
🟧 Class B
🟩 Class C
🟦 Unclassified

Scale 1:20000

Map created December 2006

Prepared by:
ENKON
Environmental Ltd.

2. A significant tributary (Trib 4.2) from its confluence with the Fergus Creek mainstem immediately east from the Highway 99 culvert crossing to 16th Avenue;
3. Two tributary branches (Trib 4.1) immediately west of 168th Street between 12th and 16th Avenues;
4. A small tributary branch east of 168th Street and below 12th Avenue;
5. The lowermost portion of a tributary channel with its confluence from the east within Reach 2, immediately north of 8th Avenue;
6. A network of property line drainage ditches in the vicinity of the BC Hydro right-of-way to the east of 168th Street, between 8th and 14th Avenues.

Numerous Class B watercourses were also identified within the Fergus Creek watershed including the most significant one being Reach 7 of the Fergus Creek mainstem. Other important Class B watercourses include portions of Tributary 4.1 and 4.2 in Reach 4 of the Fergus Creek mainstem and Tributary 2.1 in lower Fergus Creek. The remaining watercourses within the Fergus Creek watershed are Class C watercourses characteristic of roadside ditches or man-made ditches to drain individual properties. In many cases, the watercourses are void of riparian vegetation due to adjacent roadways or manicured lawns/developed properties.

ENKON conducted field assessment/verification of Class A and significant Class B watercourses and associated tributaries to confirm or reclassify these drainages. Based on field assessments and discussions with Fisheries and Oceans Canada, several watercourses were reclassified due to observations of significant flow, direct downstream connectivity or seasonally significant hydrologic contributions to downstream resources. At the request of Fisheries and Oceans Canada, no “downgrading” of watercourses from Class B to Class C has been recommended; rather, future development planning will require detailed assessments for site specific changes to watercourse classifications for the purposes of assessing stream classification and appropriate setback criteria. The proposed reclassifications are intended as an overview classification for overview planning purposes.

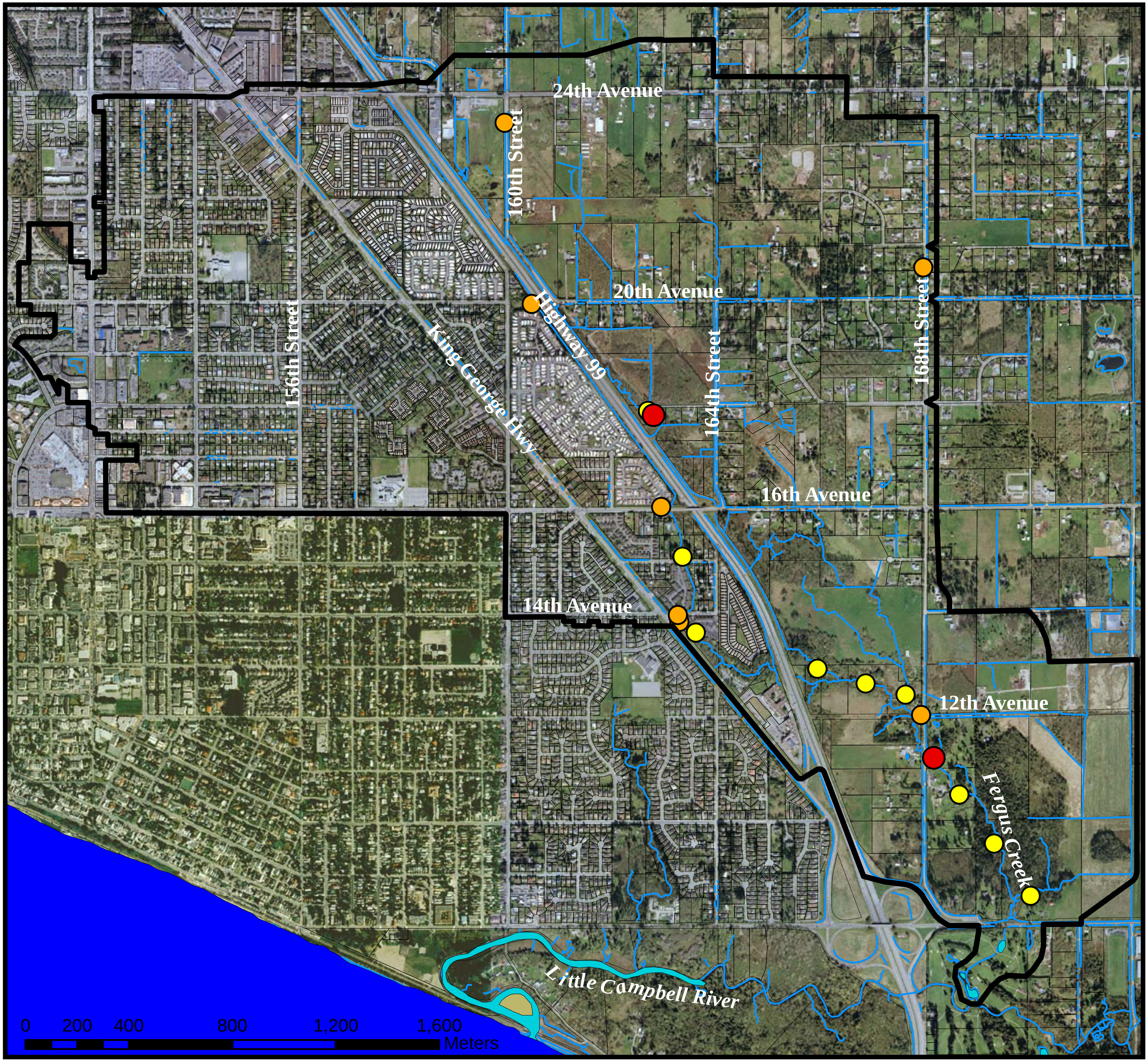
For preliminary planning purposes, the City of Surrey directed ENKON to assess streamside protection and enhancement areas (i.e. setbacks) for Class A/B watercourses following an adaptation of the Simple Assessment Methodology of the Riparian Areas Regulations (RAR).

Based on the GIS based analysis and resulting average widths for existing or potential vegetation, all Class A and B watercourses within the Fergus Creek watershed fall within Categories 1 and 2, with an average width greater than 15m. For vegetation category 1 the resulting SPEA widths for fish-bearing and non-fish bearing watercourses are identical. Based on field assessments, all Class A and B watercourses were classified based on evidence of fluvial scour and assumed flow conditions for periods greater than 6 months per year. Given the vegetation categories and the permanent flow conditions, the resulting SPEA width for all Class A and B watercourses assessed for the Fergus Creek watershed are 30m from top-of-bank. Class B tributaries assumed to exhibit non-permanent flow status were those constructed as east-west draining property line drainage ditches with no significant mapped headwaters. Based on potential vegetation categories of 1 and 2, non-permanent non fish bearing Class B watercourses result in a minimum 15m SPEA width.

Although Class C watercourses were not evaluated, it is anticipated that detailed assessments would be completed for each Class C watercourse during the development application phase of individual sites, to confirm the watercourse classification and determine the appropriate streamside protection and enhancement area. The preliminary SPEA widths utilized in this report do not preclude the potential for a developer of a site to negotiate different SPEA’s in consultation with the Department of Fisheries and Oceans and the City of Surrey or if new legislation is implemented in the future.

5.2.2 Water Quality and Benthic Sampling

Water quality and benthic field investigations have been competed at a number of locations as shown on **Figure 5.2**. Field verification of the physical condition of the stream provides information not previously available.



Benthic Invertebrate & Water Quality Sampling Sites

Figure 5.2

McElhanney Consulting Services Ltd.

Legend

- ▬ Watershed Boundary
- 🔴 Benthic Samples
- 🟡 Instream WQ Sites
- 🟠 Stormwater WQ Sites
- ─ Watercourse

Scale 1:20000

Map created: December 2006

Prepared by:
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Water quality data including temperature, conductivity, turbidity, pH and dissolved oxygen was collected during dry-weather baseflow conditions (September 26, 2005) at all major storm sewer outlets, creek reaches and tributaries (Figure 6). All measurements except turbidity were made with a Horiba U-10 water tester. Turbidity was measured with a LaMotte 2020 Turbidimeter. The Horiba U-10 underwent span calibration before the crew went into the field. The Turbidimeter was calibrated in the field at the beginning of the sampling day.

Based on the one time sample, Tributary 4.1 had marginal water quality due to elevated turbidity. Reach 6 had poor water quality due to low dissolved oxygen levels. The 16th Avenue stormwater outfall had poor water quality due to low dissolved oxygen levels and elevated turbidity, while the 160th street at 24th Avenue stormwater outfall had marginal water quality due to dissolved oxygen level <8.0 mg/L but >6.0 mg/L (Table 13). All other sampling locations had acceptable levels of dissolved oxygen, pH, turbidity, conductivity and temperature.

The B-IBI scores for the Fergus Creek sites ranged from poor (18 at F1) to very poor (14 at F2) (Table 12). A B-IBI score of 18 would be typical of a watershed with approximately 55% TIA, and a score of 14 would be typical of a watershed with TIA approaching 70% (EVS Environmental Consultants 2000). The actual TIA of the watershed above site F1 is 58%; thus, the B-IBI score corresponds well with the TIA. However, the TIA above site F2 is only 43%. The B-IBI score suggests a significantly more degraded benthic invertebrate community than would be expected at this site based on TIA.

Dillon (2005) cautions against relying on B-IBI scores based on a single sampling event, especially for watercourses such as those in Surrey where baseline (i.e., pre-impact ‘healthy’ stream) conditions vary from those of the reference watercourses used to calibrate the B-IBI stream condition ratings. They point out that although fewer pollution sensitive (intolerant) taxa were found at F2 than at F1, higher numbers of intolerant individuals were present at the downstream (F2) site.

There are additional reasons for using caution when interpreting the B-IBI scores. The Dillon (2005) samples were collected in April, whereas the GVRD’s B-IBI guide (EVS

Environmental Consultants 2003) specifies sampling should occur between August and late September. The spring rather than late summer sampling time might have resulted in fewer or different species being present due to differences in adult emergence and/or breeding times. It is possible as well that some species could not be identified in April because the larvae were small and/or underdeveloped. For example, it is possible that a greater number of mayfly species than the one (Baetis tricaudatus) listed by Dillon (2005) were present but not identified because the larvae were too small for accurate identification. However, the presence of unidentified early-stage larvae would not account for the absence of caddisflies at F2 and stoneflies at both sites.

5.3 TERRESTRIAL RESOURCES

5.3.1 Vegetation Resources

The Fergus Creek watershed study area lies within the Coastal Western Hemlock Biogeoclimatic Dry Maritime Subzone (CWHdm). Forests of the study area consist of a mosaic of coniferous and deciduous species. The tree layer is formed of a mixture of deciduous species including bigleaf maple (Acer macrophyllum), black cottonwood (Populus balsamifera), paper birch (Betula papyrifera) and red alder (Alnus rubra) with coniferous species including Douglas-fir (Pseudotsuga menziesii), western red cedar (Thuja plicata), mountain hemlock (Tsuga mertensiana) and Sitka spruce (Picea sitchensis) comprising the largest component of the tree canopy cover.

Salal (Gaultheria shallon), Indian plum (Oemleria cerasiformis), red elderberry (Sambucus nigra), Oregon grape (Mahonia nervosa), vine maple (Acer circinatum) and trailing blackberry (Rubus ursinus) are common components of the shrub layer. The herb layer of these forests is composed primarily of ferns with abundant sword fern (Polystichum munitum). Spiny wood fern (Dryopteris expansa) and licorice fern (Polypodium glycyrrhiza) are present in the wetter sites and bracken fern (Pteridium aquilinum) is common in drier sites.

Seven important stands of wildlife tree patches were identified by ENKON as part of the Grandview Heights Neighbourhood Concept Plan Area 2 environmental review which likely contain a number of significant trees according to the City of Surrey Tree Bylaw. Additional important tree patches likely exist in lower Fergus Creek north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99.

5.3.2 Important Wildlife Tree Patches

Factors such as overall forest cover, forest size, shape and degree of fragmentation all affect the viability of habitat for wildlife species. Optimal wildlife tree patch size is generally relevant to the species or suite of species you are trying to protect or manage for, however, there is a minimum of natural cover necessary to maintain a threshold of ecosystem function. Guidelines from Environment Canada (2004) suggest that patches of between 0.5 and 20 ha will support very few to no native interior forest species and will be dominated by edge species such as open area and shrub species, introduced or exotic species, and avian predators. Significant tree cover has been identified and is shown on **Figure 5.3**.

As part of the environmental review for the Grandview Heights Neighbourhood Concept Plan Area 2, seven important stands of wildlife tree patches were identified ranging in size from 2.0-5.4 hectares and ranked on a scale of 0-10 (10 being the highest) in terms of habitat value and priority for protection. The results show Stand No. 1 (between 23rd and 24th Avenue and between 164th and 165th Street) as the most valuable in terms of natural, mature forest habitat. Stand No. 2 (between 23rd and 24th Avenue, and between 166th and 168th Street) was second most significant, while Stand No. 7 (between 20th and 21st Avenue, and between 166th and 167th Street) had the lowest relative amount of habitat value among the seven important wildlife tree patches. The largest of the patches were Stand No's 3, 4 and 6 (ranked 4.5, 4.8, 5.4 ha, respectively).

Although ENKON did not survey stands of wildlife tree patches within the remainder of the Fergus Creek watershed, there are likely important stands of wildlife tree patches in the lower watershed north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99. Field reconnaissance and Orthophoto interpretation suggest that the mature coniferous stands located along Fergus Creek Reach 2 may be important wildlife tree patches.

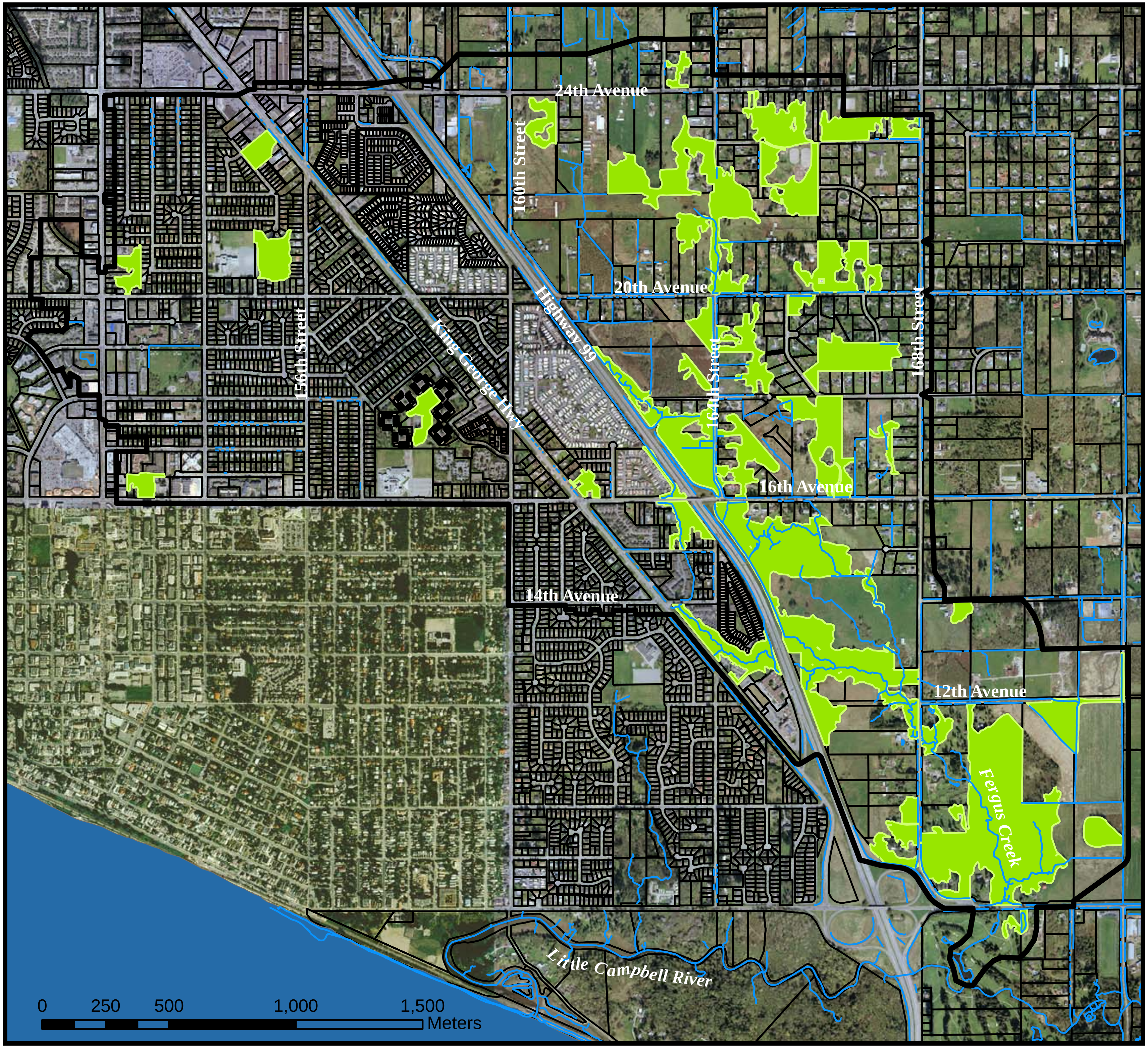
Although, in general, small urban patches of habitat do not function very well as natural ecosystems, ENKON's survey results determined that the higher ranking significant patches were fairly representative of the natural vegetation community within this biogeoclimatic subzone. Avian species diversity was moderate relative to the expected species composition which would normally occur in less disturbed habitats and included many interior forest species. Their value, although small, appears high, possibly due to their proximity to the riparian areas within the balance of the watershed. These patches of forest offer recreational wildlife viewing, aesthetic quality, environmental services such as oxygen and nutrient recycling, noise buffering, and most importantly, habitat for the remaining persistent wildlife species in the area. If these patches are fragmented further by development, or become completely isolated from other patches of moderate to higher quality patches or green spaces, they will eventually cease to function as wildlife refuges, breeding sites or foraging areas.

In addition to recommending that most or all of the significant patches are retained, ENKON recommends that landscape planning for stormwater features include a system of connecting or enhancing areas to maintain green links to these stands of forest and ensure the quality of health is maintained or enhanced. Forest patches should be within 2 km of one another. Without a system of corridors or green spaces for wildlife and plants to distribute themselves throughout the forested networks, the native species will not persist.

5.3.3 Wildlife Resources

Raptors

The only diurnal raptor species observed during the 2005/2006 field program were a breeding pair of Cooper's hawks (Accipiter cooperii) in a forested area behind the Meridian Par 3 Golf Course and a breeding pair of red-tailed hawks (Buteo jamaicensis)



Important Wildlife Tree Patches

Figure 5.3

McElhanney Consulting Services Ltd.

Legend

- ▬ Watershed Boundary
- — Watercourse
- 🟩 Significant Tree Patches

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON Environmental Ltd.

above 20th Avenue, west of 168th St. Both pairs were regularly observed displaying nesting behaviour.

Both the blue-listed short-eared owl and barn owl were detected at separate locations in the southern area of Fergus Creek watershed. Both observations were of individual birds in flight and responding to call playback.

There were also several detections of both barred owls (Strix varia) in 2005 and 2006, and great horned owls (Bubo virginianus) in 2006 at the call points within Plan Area 2. These data and other anecdotal information provided by local residents suggest these birds are common in the watershed.

Small Mammals

The only small mammal live-trapped within the Fergus Creek watershed was the ubiquitous deer mouse (Peromyscus maniculatus). One live and one dead coast mole (Scapanus orarius) were found in the riparian area between the north and south extensions of 164th Street, north of 20th Avenue.

Other Mammals

Other mammals that have the potential to occur within the Fergus Creek watershed include black-tailed deer (Odocoileus hemionus), coyote (Canis latrans), raccoon (Procyon lotor), opossum (Didelphis virginiana), striped skunk (Mephitis mephitis), Douglas squirrel (Tamiasciurus douglasii) and two introduced species including eastern cottontail rabbit (Sylvilagus floridanus) and eastern grey squirrel (Sciurus carolinensis).

Amphibians

Pacific tree frogs (Hyla regilla) were the only amphibian detected during ENKON’s surveys and were heard on many occasions within forest and shrub habitats of the Fergus Creek watershed. Other amphibians which have not been detected but are likely to occur in the watershed are red-legged frog (Rana aurora), ensatina (Ensatina eschscholtzi), northwestern salamander (Ambystoma gracile), long-toed salamander

(Ambystoma macrodactylum), western red-backed salamander (Plethodon vehiculum), rough-skinned newts (Taricha granulosa), Pacific treefrog (Hyla regilla) and western toad (Bufo boreas).

5.3.4 Federally and Provincially Listed Species

The B.C. Conservation Data Centre (CDC) lists 20 bird species in the Chilliwack Forest District as threatened or vulnerable (Appendix B). The Species at Risk Act (SARA) lists 23 bird species from British Columbia in Schedule 1, 2 or 3. Of these species, the land within and adjacent to the Fergus Creek watershed area contains suitable breeding habitat for 4 listed species including barn owl, short-eared owl, western screech-owl and band-tailed pigeon. Of these, the barn owl and short-eared owl were observed during ENKON's 2006 avian surveys. Suitable breeding and foraging habitat is available for these species in all open grassy agricultural areas and the BC Hydro right-of-way. The great blue heron was not observed during ENKON's surveys; however, there is suitable habitat (groups of mature, large deciduous and coniferous trees) within the watershed.

Due to the colonial nesting habits of great blue heron and the historical locations of their rookery sites, it is unlikely they will nest within the Fergus Creek watershed or surrounding lands. Other listed species might occasionally rest or forage within the watershed but they are not likely to nest there.

With regard to rare vertebrate wildlife species, there has been one capture of the red-listed Pacific water shrew and the blue-listed Trowbridge's shrew at Fergus Creek, 150 metres north of 8th Avenue (September 1992), and three captures of Trowbridge's shrew in two tributaries to the Little Campbell River downstream of the Fergus Creek confluence (June 2004). Pacific water shrew is federally identified as Threatened (Schedule 1 of the Species at Risk Act). Suitable habitat for both these rare species exist in the watershed, however, none were detected during ENKON's surveys.

The provincially blue-listed red-legged frog (Rana aurora) and the federal species of concern the western toad, have the potential to occur at or adjacent to permanent streams or ephemeral ponds within the Fergus Creek watershed, and at several wet forested sites such as the mixed older mature forest patch located northeast of the riparian right-of-way corridor at 164th St above 20th Ave. Neither species were detected during ENKON's surveys.

None of the 46 plant species listed as blue- or red-listed in the CDC Tracking List were observed during vegetation surveys, however, there have not been structured vegetation surveys conducted to confirm their presence or absence in the Fergus Creek Watershed. The local observations of blue-listed Henderson's checker-mallow (Sidalcea hendersonii), western pearlwort (Sagina decumbens), and field dodder (Cuscuta pentagona) recorded in the Rare Elements Occurrence Report were observed within the Fergus Creek Watershed before 1990.

5.4 HABITAT PRESERVATION AREAS

The City of Surrey's 2004 Highway 99 Corridor Local Area Plan outlines three environmental preservation areas as shown on **Figure 5.4**, including:

1. A "linear habitat feature" adjacent to Highway 99, extending approximately between the 12 Avenue and 23 Avenue right-of-ways including the upper section of Fergus Creek. This feature includes Reach 7 of the Fergus Creek mainstem which consists of mainly fines substrate (i.e. clay with some gravel and cobbles). The upper half of the reach is ditched along Highway 99 and fisheries values have been assessed as medium for rearing and low for spawning, although the culvert under Highway 99 limits fish access. The lower portion of Reach 7 has a well defined riparian vegetation zone useful for a variety of wildlife species;
2. Two sections of proposed fisheries "food and nutrient" features to be developed within the BC Hydro right-of-way. This portion of the BC Hydro ROW is comprised primarily of field habitat with no forested areas and as such has limited wildlife values; and
3. A large "block" of habitat comprising the Fergus Creek ravine and most of the critical wildlife habitat located generally south of 16th Avenue. The existing habitat of this area consists of 5 vegetation types including old field, pole-sapling,

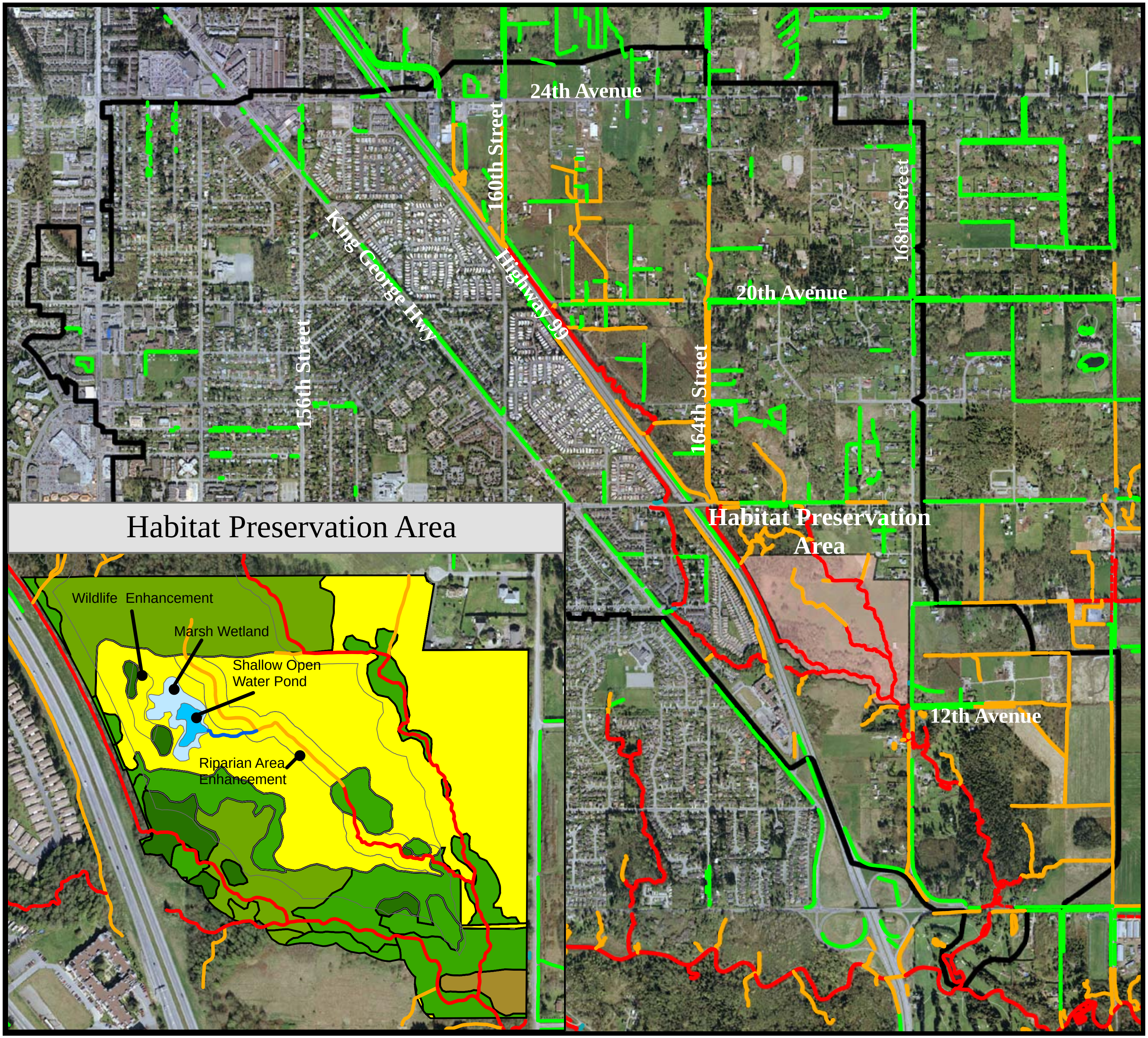
deciduous, coniferous and mixed forests. Tributaries 4.1 and 4.2 are also within this area.

5.5 ENVIRONMENTALLY SENSITIVE AREAS

As indicated in the previous discussions and in keeping with the City's by-laws, plans and policies, areas which were identified as environmentally sensitive include:

1. High suitability habitat for the following listed species; Great blue heron, barn owl, short-eared owl, western screech-owl, band-tailed pigeon, Pacific water shrew, Trowbridge's shrew, western toad and red-legged frog.
2. Seven important wildlife tree patches identified in the Grandview Heights Neighbourhood Plan Area 2 Environmental Review (ENKON 2006), in particular those ranking relatively high in Plan Area 2 such as Stands No. 1 and No. 2. Stand No. 1 is a moderate sized but dynamic and old patch of natural forest, with significant diversity and productivity of native species. Stand No. 2 includes a narrow riparian area, an old patch of structurally diverse forest in the north end with wet depressions and vernal pools, a mix of several stages, a range of native vegetation species, and a raptor nest.

   Although ENKON did not survey stands of wildlife tree patches within the remainder of the Fergus Creek watershed, there are likely important stands of wildlife tree patches in the lower watershed north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99.
3. Wildlife movement corridors which provide access to important habitats such as a movement corridor along Fergus Creek mainstem/tributaries and a potential corridor along the "Height of Land" from the northwest corner of Grandview Heights Neighbourhood Plan Area 2 to the southeast and connecting to Dart's Hill Garden and Redwood Park. Much of the "Height-of-Land" potential wildlife movement corridor is treed and passes through portions of 3 significant stands of trees (Stands No. 3, 4 and 6) as well as patches of mature to old forest and riparian areas. A third wildlife movement corridor exists along the BC Hydro right-of-way running along the western border of Grandview Heights Neighbourhood Concept Plan Area 2 connecting to the Little Campbell River. A fourth corridor



Proposed Habitat Preservation Area

Figure 5.4

McElhanney Consulting Services Ltd

Legend

▬ Watershed Boundary
🟥 Enhancement Area

Watercourse Classification

▬ Class A
╍ Class A(O)
▬ Class B
▬ Class C
▬ Unclassified

Preservation Area Inset

▭ Marsh Area
🟦 Pond Area
▬ Connector Channel

N
W E
S

Scale 1:20000

Map created December 2006

Prepared by: ENKON Environmental Ltd.

exists east from the BC Hydro ROW between 16th and 12th .Avenues to Sam Hill Creek which eventually flows into the Little Campbell River just north of 8th Avenue;

4. The proposed “Habitat Preservation Area” located south of 16th Avenue, east of Highway 99 and west of 168th Street. This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew; and
5. The Fergus Creek mainstem and all other Class A and B tributaries and associated riparian habitat that provide significant rearing/spawning habitat and/or food and nutrient contributions to downstream fish populations. Any Class C watercourses that are assessed as “fish habitat” during the development application phase.

5.6 POTENTIAL ENHANCEMENT OPPORTUNITIES

ENKON identified a number of potential opportunities to enhance both fish and wildlife habitat within the Fergus Creek watershed, as shown on **Figure 5.5**. Where possible, the enhancement opportunities were prioritized as follows:

5.6.1 Fish Habitat

1. Fish Access Improvements
2. Baseflow/Water Quality Enhancement
3. Riparian Enhancement
4. Erosion Control
5. Instream Habitat Enhancement

5.6.2 Wildlife Habitat

1. Watercourse Road Crossings
2. Forest Retention
3. Wildlife Stewardship

5.6.3 Wildlife Movement Corridors

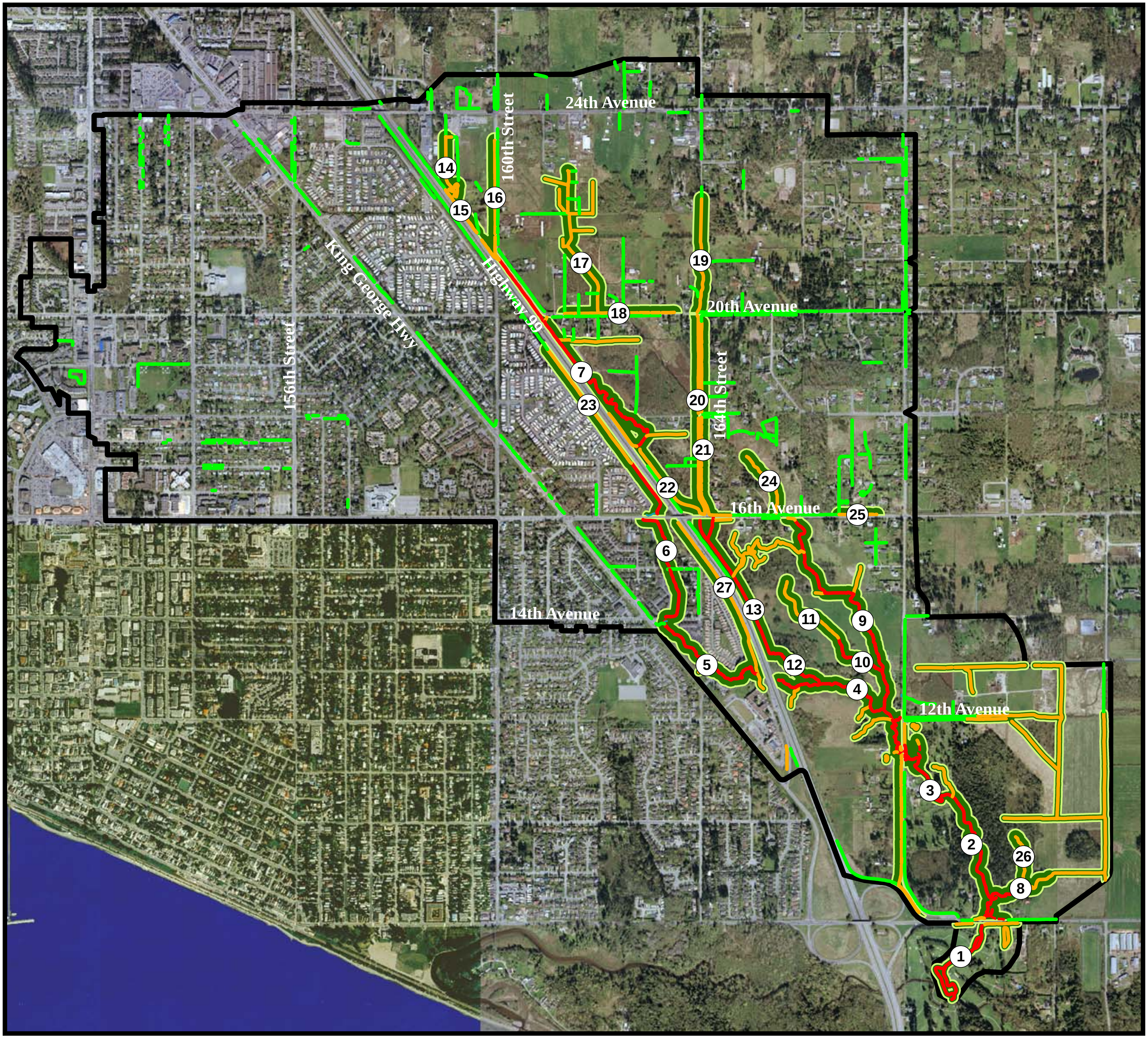
Determination of optimal wildlife movement corridor width is complicated by factors such as the difference in habitat values in the available linear landscape, the differing needs of plant and animals using the corridor, the influence of disturbances from outside the corridor and the long-term management and stability of the corridor within the surrounding urban matrix. Some species such as black-tailed deer and coyotes prefer corridors and riparian areas to move through the landscape, but will occasionally move into the open. Other smaller animals such as frogs and birds may be entirely dependent on wildlife corridors for cover while moving within their range.

Terrestrial corridors designed to facilitate species movement should be a minimum of 50 to 100 m in width to facilitate movement for common generalist species, depending on habitat quality, while stream corridor widths of at least 75 m are recommended to support breeding birds. Vegetation composition should be representative of the natural vegetation for the region. A corridor of 30 m in width will support 90% of natural streamside plant species diversity.

Four wildlife movement corridors were identified including the Fergus Creek as shown on **Figure 5.6**, mainstem/tributaries and associated riparian habitat, the “Height-of-Land” from the northwest corner of Plan Area 2 to the southeast and connecting to Dart’s Hill Garden and Redwood Parks, the BC Hydro ROW along the western boundary of Plan Area 2 connecting to the Little Campbell River and east from the BC Hydro ROW between 16th and 12th Avenues to Sam Hill Creek which eventually flows into the Little Campbell River just north of 8th Avenue.

5.7 PROPOSED GUIDELINES

ENKON has recommended a number of “Best Management Objectives and Development Guidelines” to provide some guidance to the City of Surrey during the development or redevelopment of the Fergus Creek watershed to ensure that critical vegetation, fish and wildlife habitat is maintained. Although it is likely that not all of the objectives/guidelines can be followed due to density requirements, road/servicing



Streamside Protection & Enhancement Area Setbacks

Figure 5.5

McElhanney Consulting Services Ltd.

Legend

③ Table 9 & 10 ID's

Watercourse Classification

Class A

Class A(O)

Class B

Class C

Unclassified

🟩 SPEA Setbacks

Watershed Boundary

Scale - 1:20,000

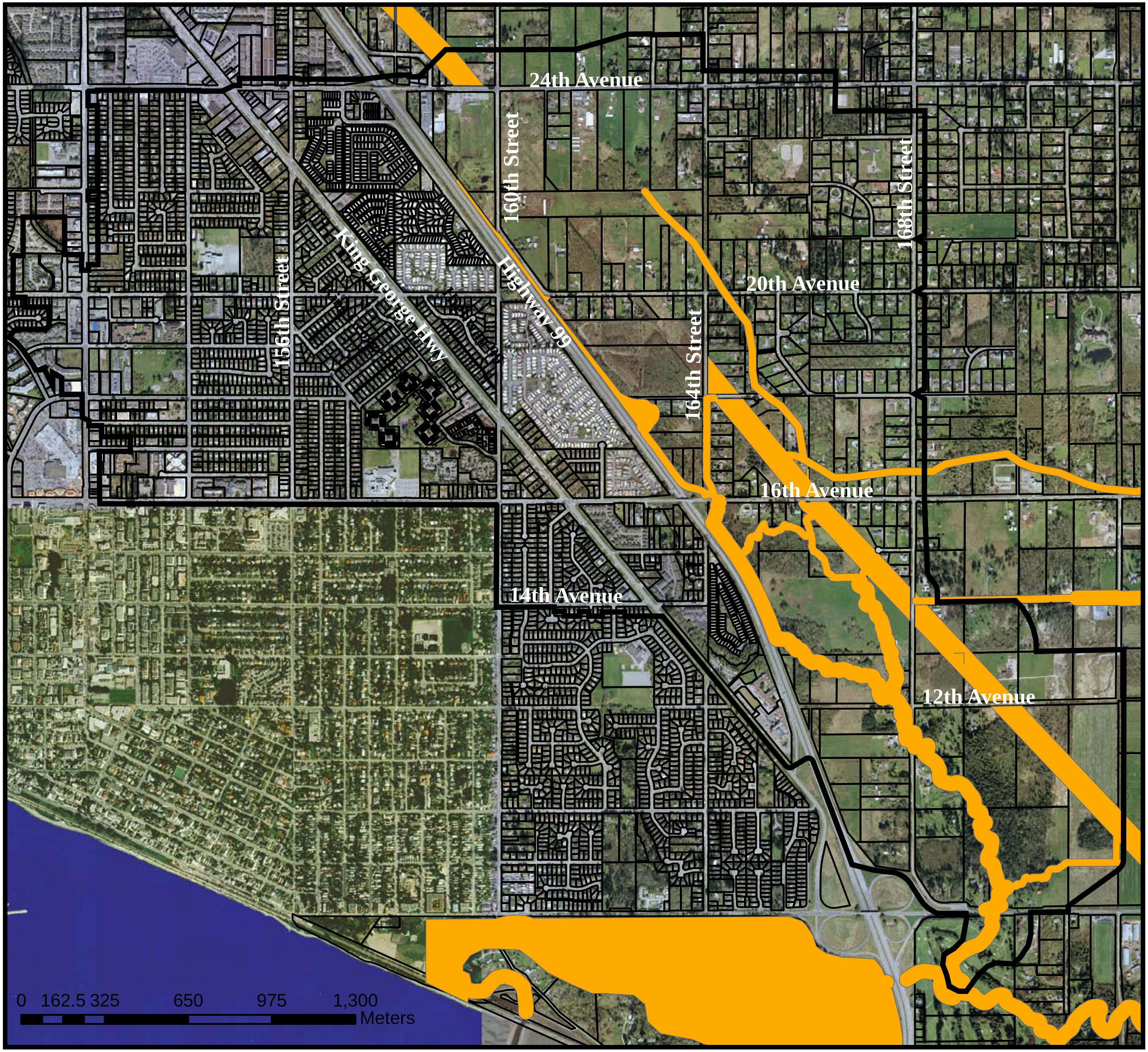
Map Created December 2006

Prepared by:
ENKON
Environmental Ltd.

Wildlife Movement Corridors within Fergus Creek Watershed

Figure 5.6

McElhanney Consulting Services Ltd.



Legend

- ▭ Watershed Boundary
- 🟧 Wildlife Corridors

Scale 1:20000

Map created:
September 2006

Prepared by:
ENKON
Environmental Ltd.

networks and commercial/industrial developments, an attempt should be made to incorporate as many as possible. Best Management Objectives and Development Guidelines were provided in the following areas:

1. Environmentally Sensitive Areas
    - Important Wildlife Tree Patches
    - Wildlife Movement Corridors
    - Habitat Preservation Areas
    - Multi-Use Greenways
    - Federally and Provincially Listed Species
    - Fish Habitat
2. Development or Re-Development Areas
    - Raptors
    - Small Mammals
    - Amphibians and Reptiles
    - General Wildlife

5.8 ENVIRONMENTAL RECOMMENDATIONS

The following recommendations are provided to the City of Surrey and developers to protect environmentally sensitive areas and provide development guidelines during the build out of the Fergus Creek watershed.

5.8.1 City Initiatives

- Where possible, retain all or portions (>0.5 hectares) of important Wildlife Tree Patches including Stands No. 1, 2 and 4 to provide refuge, food and breeding areas for various federally and provincially listed wildlife species including Pacific water shrew, Trowbridge’s shrew, red-legged frog and western toad. In addition, retain all or portions of important Wildlife Tree Patches including Stands No. 1, 2 and 7 to provide refuge, food and breeding areas for the western screech-owl and band-tailed pigeon.

Forested areas within the lower Fergus Creek watershed should be assessed for their importance to wildlife and ranked with the tree patches within Plan Area 2 to determine which tree patches should be given priority for protection.

- Provide wildlife movement corridors to maintain genetic diversity of wildlife species. Wildlife movement corridors can include riparian habitat areas, treed areas along residential lots, multi-use greenways, the Fergus Creek mainstem/tributaries and associated riparian areas, the “Height-of-Land” from the northwest corner of Plan Area 2, the BC Hydro ROW and the east-west connection to Sam Hill Creek.
- Purchase the lands that contain the proposed “Habitat Preservation Area” located south of 16th Avenue, east of Highway 99 and west of 168th Street. This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew.
- Protect high suitability habitat for other federal and provincial species at risk including field habitat and old buildings for barn and short-eared owls.
- Protect and enhance Class A/B watercourses including their associated streamside protection and enhancement areas.
- Conduct a structured vegetation inventory (spring and summer) to focus on the detection of rare plants and plant communities. If found, protect these areas and provide a suitable buffer to maintain their integrity.

5.8.2 Developer Initiatives

- If clearing is to be conducted during the active bird breeding season, March 1 to August 1, conduct a bird nest survey to ensure that active nests are protected during the breeding season.

- Conduct fish habitat assessments of all Class C watercourses prior to development of each site to ensure that watercourses and their function are accurately classified and appropriate streamside and enhancement areas are protected where applicable.

- Stormwater management for each development site should follow the recommendations of the Fergus Creek Integrated Stormwater Management Plan.

- Review the above report sections: 4.0 Protection Plans, 5.0 Best Management Objectives and Development Guidelines, and 6.0 Enhancement Opportunities, to ensure the effective protection of ecosystem integrity and environmental values and concerns.

6.0 THE PLAN

6.1 CREATING A SUSTAINABLE WATERSHED

Integrated stormwater management planning has the potential to achieve significant benefits for urban environments. Liveability may be enhanced as the quality of natural environment is improved, higher levels of sustainability are achieved through the design and development of our cities, and a wider range of lifestyle choices are available than was previously evident, improved aesthetics.

Realization of these benefits is only possible when integrated stormwater management planning assumes a long-term perspective on growth and change as well as ensuring that plans and strategies coincide and recognize the pace and timing of development and redevelopment cycles. In North America a complete development/redevelopment cycle can occur within a relatively short period of 30 to 50 years if a modest annual redevelopment rate of 2% occurs.

Planning for a 30 to 50 year horizon is understandably challenging because of the number of variables involved and the inability to anticipate changes in personal attitudes, economic and market conditions, technology and politics. It is further complicated by the nature of redevelopment: it will be piecemeal, geographically random, and relatively slow paced. Therefore, the use of proscriptive planning strategies and detailed, focused goals and objectives to guide redevelopment will probably be ineffective. Alternatively, the adherence to general visions and flexible supporting goals and objectives and perhaps performance standards should be employed.

In terms of alternative stormwater management it would be necessary to develop runoff stormwater volume controls requirements (or performance targets) for potential future redevelopment scenarios that are differentiated by the form and density of development. Volume control standards and funding mechanisms would also be needed to meet these requirements. For example, targets for the provision of parks/open spaces or the alternative street designs.

6.2 ADAPTIVE MANAGEMENT

We can see the effect of better scientific knowledge shaping the direction of stormwater management. Further advances can be expected to continue and these will create a need to revise the approaches and methodologies that will be developed in the ISMP. It is, therefore, critical that the ISMP include provisions for change that are driven by advances in knowledge. A process of "Adaptive Management" will be incorporated into the Drainage Plan to provide flexibility in meeting future requirements. The process should be one that encourages change rather than one that is reactive and restrictive.

Adaptive management is defined as performance monitoring with consequences. The goal is to learn from experience. In the urban context, this means improve land development practices over time. Through a Performance Evaluation Plan, the objective is to establish the 'rules of adaptive management' that are understood and supported by all stakeholders, and that answers these questions:

- What needs to be monitored?
- What are the performance objectives / targets?
- Who will monitor performance?
- How will monitoring results:
  - Define better watershed management, stormwater management and land development practices.
  - Lead to changes in development standards and regulations?

6.2.1 Performance Evaluation Plan

A proposed action item arising from this ISMP is to form an inter-jurisdictional Fergus Creek Watershed Assessment Steering Committee (Steering Committee), and give it the mandate to:

- Develop the Performance Evaluation Plan.
- Establish and/or refine achievable Performance Objectives / Targets.

- Oversee implementation of a comprehensive and inter-jurisdictional Performance Monitoring Program that has effectiveness, compliance and validation components.
- Evaluate what the monitoring results mean in comparison with performance objectives / targets.
- Identify whether specific watershed management, stormwater management and land development practices need to be changed.
- Consult stakeholders for feedback / input.
- Recommend how to implement specific changes in watershed management, stormwater management and land development practices.
- Prepare Annual State-of-the Watershed Reports.

6.2.2 Desired Outcomes

The adaptive management framework provides a feedback process allowing for long term modification and successful implementation of the Fergus Creek ISMP. If the Fergus Creek Performance Evaluation Plan is clearly understood and widely supported, it would:

- Establish watershed based performance standards for the receiving stream of interest (e.g. a comprehensive modeling and monitoring study of watershed in accordance with the City of Surrey). This would yield greater confidence that performance standards will meet the management objectives;
- Provide staff with insights and knowledge regarding the effectiveness of each stormwater control system (i.e. stormwater management facilities, infiltration practices, water quality inlets, etc.);
- Encourage landowners and developers to carry out development projects in a sustainable manner and based on up-to-date information on watershed;
- Provide staff and government agencies with tools and procedure to fine tune not only design guidelines but also operating and maintenance manual.

6.2.3 Three Types of Monitoring

The proposed Fergus Creek Performance Evaluation Plan would be comprehensive because it would ultimately encompass three types of monitoring:

- Effectiveness Monitoring – Determines the extent to which the completed actions have achieved the management objectives (for example, monitor the volume and frequency of overflow from an on-site facility and compare with the performance targets).
- Compliance Monitoring – Identifies whether or not the implementing parties have completed the actions they agreed to complete in the planning phase (for example, confirm that developers are incorporating properly sized on-site storage and infiltration facilities).
- Validation Monitoring – Measures the extent to which completion of the objectives (actions) has been successful at achieving the goal (for example, monitor annual watershed runoff volume and compare with the performance objective established for runoff volume reduction).

6.2.4 Application of Effectiveness Monitoring at Three Scales

Based on discussions with staff and inputs from stakeholders it is agreed that effectiveness monitoring has the highest priority. Preceding subsections also indicate that there is the need to establish a Performance Evaluation Plan for the watershed. Once the plan is established detailed guidelines with respect to a monitoring program will be available.

At this time it is recommended that any monitoring program should provide sufficient tools so that staff can assess the performance of employed mitigation and/or enhancement activities within the watershed. Specifically, the performance assessment for this watershed should encompass both watershed-based and technology-based assessments.

Watershed-based assessment provides ways to identify achievements in terms of watershed goals and objectives. This type of assessment is critical, subjective and sometimes qualitative. Monitoring activities for this type of assessment are:

- Site reconnaissance before and after stormwater controls are in place. Depending on specific objectives one can determine if proposed measures are appropriate or require improvement or enhancement; and
- Record keeping so that the baseline conditions are modified in the future.

Technology-based assessments are used to evaluate the effectiveness of various stormwater controls (i.e. Stormwater Management Facilities, infiltration measures, etc.) To attain the above assessments a detailed monitoring program should be established to assist the Fergus Creek Watershed Assessment Steering Committee in defining an appropriate monitoring program. Examples of both types of assessment are included below for reference purposes.

Watershed-Based Assessment

Table 6.1 below presents examples of performance goals for watershed-based assessments.

Table 6.1 – Examples of Objectives & Criteria Associated with Performance Goals

Category	Goal
Hydraulics	▪ Improve flow characteristics upstream and/or downstream of the stormwater control **What is the change in the downstream flow rate from baseline conditions?** a. Statistical difference in downstream flow rate distribution
Hydrology	▪ Flood mitigation, improve runoff characteristics (peak shaving) **What is the peak outflow rate during various runoff events?** a. Outflow rate distribution
Water Quality	▪ Reduce downstream pollutant loads and concentrations of pollutants **What is the change in water quality from baseline conditions?** a. Statistical difference in downstream in water quality concentrations b. Statistical difference in downstream in pollutant loads

Treatment	▪ Achieves desired pollutant concentration in outflow **What degree of treatment is provided under typical operating conditions?** a. Statistical difference in influent and effluent concentrations b. Percent difference in event influent and effluent concentrations **How does effectiveness vary from pollutant to pollutant?** a. Statistical difference in percent differences of influent/effluent concentrations **How does effectiveness vary with various input concentrations?** a. Distribution of influent and effluent concentrations of pollutants of concern **How does effectiveness vary with storm characteristics?** a. Percent difference for pollutants of concern with rainfall total **How do design variables affect performance?** a. Distribution of influent and effluent concentrations of pollutants of concern
Source Control	▪ Removal of litter and debris **How much litter and debris is collected in areas with clean neighborhood programs?** a. Mass of collected litter and debris
Regulatory	▪ Compliance with approvals / permits **What is the change in water quality from baseline conditions?** a. Statistical difference in downstream in water quality concentrations ▪ Meet municipal, provincial, or federal water quality criteria **How does downstream water quality compare to criteria?** a. Statistical difference of downstream concentrations and a standard or objective b. Percent exceedance
Implementation Feasibility	▪ Ability to function as designed **How does the control's efficiency, performance, and effectiveness compare to other controls?** a. Statistical difference in effluent quality b. Statistical difference in percent difference in influent and effluent quality
Cost	▪ Capital, operation, and maintenance costs **What are the life cycle costs (labor and materials)?** a. Annual operating and maintenance costs
Aesthetic	▪ Improve appearance of site **What is the public's perception of the amount of trash or erosion present downstream?** a. Visual appearance
Maintenance	• Operate within maintenance, and repair schedule and requirements **How does effectiveness vary with different operational and maintenance approaches?** • a. Statistical difference in percent different and effluent levels • Ability of system to be retrofitted, modified or expanded
Longevity	▪ Long-term functionality **Does effectiveness improve, decay, or remain stable over time?** a. Statistical difference percent difference for different time periods b. Trend of effluent levels

Resources	▪ Improve downstream aquatic environment/erosion control **What is the change in the biological community from baseline conditions?** a. Change in macroinvertebrate species and populations ▪ Improve wildlife habitat **What is the change in the downstream flow rate?** a. Statistical difference in downstream flow rate distribution ▪ Multiple use functionality **How does downstream water quality compare to criteria for various designated uses?** a. Percent exceedance
Safety, Risk and Liability	▪ Function without significant risk or liability **Does the facility drain within the allotted period of time?** a. Standing water levels over time ▪ Ability to function with minimal environmental risk downstream **Is there stream bank erosion in downstream areas?** a. Loss of material
Public Perception	▪ Information is available to clarify public understanding of runoff quality, quantity and impacts on receiving waters **What public events has the program participated in?** a. Number of events

Technology-Based Assessment

While watershed-based performance assessment provides an overview of the health of the watershed, the technology-based performance assessment illustrates achievements of specific goals and stormwater management controls. Steps involved in this type of assessment are:

- Step 1: Establish goals. Typical goals consists of one or more of the following:
  - Overbank and extreme flood control goals;
  - Channel protection goals; and
  - Water quality control goals.
- Step 2: Quantify desired level of control. Each goal established in the preceding step should be supported by specific numerical criteria about the receiving water and/or control technology. Often, a technology-based level of control is used because of a desire to apply criteria uniformly throughout a jurisdiction or watershed. Levels of control can then be subdivided into:
  - Level of control for large, infrequent storms;
  - Recharge level of control; and

  - Channel protection level of control.
- Step 3: Select design precipitation. This step identifies commonly used information and evaluations for determining design precipitation conditions for the large, infrequent storms controlled by overbank flood volume (OFV) or extreme flood volume (EFV), and the smaller storms used to establish the recharge volume (RV), water quality volume (WQV), and channel protection volume (CPV).
- Step 4: Determine Rainfall-Runoff Relationships. This can be done using various simulation models for representing complex rainfall-runoff relationships within the watershed.
- Step 5: Define capture volumes and release rates. This should be based on the "need" of the watershed.
- Step 6: Monitor the "control" (after the installation) for a predetermined period to evaluate its effectiveness compared with quantities established in Step 5.

6.2.5 Be Strategic When Collecting Data

Data collection is expensive. Thus, the level of investment necessary to support the Fergus Creek Adaptive Management Plan needs to be strategic. This means asking three questions:

- Why do we need the data?
- How will the data be applied?
- What problems will the data help solve?

The impacts of changes in land use are generally understood. The purpose of data collection is to help us look forward, not backwards, by improving our understanding of what we can do to improve watershed conditions.

6.2.6 Integration with Neighbourhood and Redevelopment Plans

The neighbourhood scale is the appropriate scale for setting 30-year performance targets, and overlaying a program for effectiveness monitoring. As the City of Surrey develops and implements Neighbourhood and Redevelopment Plans over time, integration of an adaptive management strategy would provide a feedback loop on what is achievable under neighbourhood-specific land use, soil and rainfall conditions.

The adaptive management program is not envisioned as being an all encompassing data acquisition program for Fergus Creek Watershed, rather it intended to be a selective and targeted program to obtain a limited but critical set of data to identify the success or failure of the ISMP. If successful, limited future changes will be required. If unsuccessful, interventions can be undertaken in a timely manner.

6.3 IMPLEMENTATION OF DEVELOPMENT MITIGATION

Implementation of the stormwater management systems will require a change in the administrative processes, department responsibilities and design criteria as established within the City of Surrey. We are providing this information regarding the “mechanics of implementation” of the stormwater management systems within the Fergus Creek Watershed. The implementation of the systems will be commenced during the planning stages where the vision of the future watershed is created. This combined with modified criteria and processes within the development, redevelopment and building permit procedures are required to implement the stormwater management strategy within the Fergus Creek watershed.

The on-lot systems will be integral in the requirements of the watershed and must be constructed to create an effective environmental mitigation program to offset any future impacts to the aquatic and terrestrial habitat. The systems must be constructed in the newly redeveloping areas to the east and within the redeveloping urban area to the west. AS the systems within the road Rights-of-Way will be constructed as part of the redevelopment process, there is less concern that they will be left out of future planning and construction.

The primary item of concern is the implementation of on-lot systems. As the lots will form approximately two thirds (⅔) of the watershed it is critical that the on-lot systems be designed and constructed in accordance with the objectives of the ISMP. These are the infiltration systems and the enhanced depth, placement, and quality requirements of topsoil for stormwater runoff volume reduction. Specifically the questions included:

- Who would be responsible for constructing the facilities?
- Who would ensure their installation conforms to design?

A number of construction sequences can be envisioned with responsibility being taken by a number of different individuals or firms; these are items discussed below in a section describing the on-lot infiltration systems. Following this information will be a section on enhanced topsoil placement, which will include a discussion on administrative modifications to the development and building process that might be applied to assure construction of the designs. The selection of the overall design, construction and compliance process will require input and acceptance by a number of City departments and developers for new subdivisions within the study area.

6.3.1 On-Lot Infiltration Systems

There are two separate issues regarding construction responsibility and they hinge upon the timing of construction of the on-lot infiltration systems. We anticipate the construction of the facilities will occur in a logical progression as individual site locations become available for unencumbered construction. We see the site access and protection of the systems from physical damage or uncontrolled runoff of silt-laden water as being the most significant issues facing the construction of these systems.

House Builder Installation

We would like to point out the difficulty in providing a final design for each on-lot facility at the time of subdivision design. When the subdivision is designed, we establish the municipal infrastructure requirements and the locations of servicing ties to the individual properties. At that time in the subdivision design process, the individual building footprint for any given lot is unknown to the municipal design team and the “Engineer of Record”.

Given the flexibility of locating the building footprint within the building envelope, it is not possible to assign a specific location for the on lot infiltration systems. It would logically follow that the final layout of the on-lot infiltration systems should be completed as part of the building design. Only at that time would there be assurance that no conflicts would occur between the building footprint and the on-lot infiltration system. It may be possible for the City to revise the building envelope to include an allowance for the on-lot infiltration system.

We must assume that the design standards and criteria would be established as part of the watershed planning process. Further, only qualified individuals would be allowed to undertake the design, inspection and certification of the installations. These qualified individuals may not be the “Engineer of Record” taking responsibility for the subdivision.

Developer Installation

As an alternative to this, it would be possible for the developer and “Engineer of Record” to undertake the design and installation of the systems following the construction of the buildings. However, this would create problems with scheduling and access to the properties along with building occupancy and the building inspection process of the City. While the scheduling of this alternative is attractive, there would be many conflicts that we believe would make this unworkable. A variation of this process would see the developer passing the responsibility for the design and construction of the physical works to the builder and/or owner as a part of the sales agreement. This could be a seamless process that would be invisible to the City who would have an agreement with, and bonding from, the Developer for the works. A legal agreement between the developer and the builder / home owner would pass along the overall responsibility but the process would not relieve the developer of contractual obligations with the City. In this case the “Engineer of Record” who undertook responsibility for the subdivision may undertake the design, inspection and certification of the installations. However, any qualified individual could take the responsibility for design, inspection and certification of the installations.

Developer Installation with Restrictive Covenants

A second alternative would be to undertake the design and installation of the system prior to the building design and place encumbrances upon the lots to avoid damage to the systems and to provide separation between the systems and the building footprint. In this case the “Engineer of Record” for the subdivision would undertake the design, inspection and certification of the installations. There would be a need for on-going inspections during building construction to verify whether there had been any damage to the systems or whether silt had been deposited in them. A final inspection following landscaping and hook up would allow certification of installation.

Move Systems Off-Lot

A third alternative would be to move the infiltration system for the lots to locations within the road right-of-way. The space beneath the sidewalks is available for these systems. We must point out that this configuration would not replace the street infiltration systems; rather it would replace the on-lot systems. The construction of these systems could then be undertaken at the time of the construction of the roadway immediately prior to the installation of the sidewalks. The final connection of these systems would be done as part of the final landscaping of the lots and could be controlled by either the City or the Developer. In this case the “Engineer of Record” who undertook responsibility for the subdivision would undertake the design, inspection and certification of the installations. With the facilities located within the street right-of-way, the City would be acquiring the responsibility for maintenance and operation of the systems.

A variation of this alternative would see a consolidated infiltration system located centrally in the lower reaches of the watershed. This system, if considered, would occupy a land area larger than that envisioned by the original NCP for the detention ponds. Therefore none of the cost-saving advantages of utilizing on-site distributed systems would result. This variation cannot be considered to be viable and should be eliminated from further consideration.

6.3.2 Enhanced Topsoil Installation

A second component of the runoff volume control system is the enhanced topsoil that would be applied to all pervious surfaces in the development area. The pervious surfaces requiring the topsoil would include municipal rights-of-way, parks and private properties created as part of the subdivision process.

Observations of installations in other development areas has provided verification that there have been instances of non compliance with the design requirements and other installations where the depth specified in the civil design fell short of the specified depth. The objective of the City for topsoil placement would be to have all installations comply with the subdivision design specifications.

As with the installation of the infiltration systems, the most logical time to place the topsoil would be following the construction of buildings. This timing corresponds to standard practice in use today. To meet the design specifications, a formal grading check should be made at two milestones: the first when the subgrade has been prepared prior to placement of the topsoil and the second following its placement but prior to seeding or sodding.

Traditionally the building contractor is responsible for installation of the topsoil and vegetation on each lot. This has expanded somewhat to include the boulevard areas because of the disruptions caused during the building construction, which follows street construction. In many instances, finishing the swales specified in the municipal designs has been added to the builder's responsibility. There is a need to verify that the final grades are achieved and that the specified depth of topsoil is installed for both the lot and the boulevard.

6.3.3 Implementation Process

Two processes have been envisioned that would minimize the magnitude of the alterations to the City's internal processes. The first would be to modify the existing process whereby the home builder would take the responsibility for constructing the on-lot systems. This is essentially an extension of the existing building permit and inspection system to include the on-lot stormwater management systems. The second is a modification of the system to reduce the alteration of the City's processes by charging the developer with the responsibility and by providing them the means to execute the designs and construction of the systems.

Modified Traditional Approach

A modification of the traditional approach would include the creation of a specification or sketch of the requirements for each lot and associated boulevard area that would form part of the building permit package. This could be prepared by the “Engineer of Record” and would be provided to the City for inclusion in the building permit file. We envision distribution of the information to the builder / home owner along with the building permit to ensure that he is aware of the requirements. Compliance can be verified and certified by a qualified person at the two milestones as indicated above. A further visual check can be made when the City’s Municipal Inspector verifies the integrity of the sidewalks and curbs prior to issuing occupancy permits. We must assume that the City’s Municipal Inspector would have a copy of the information package supplied through the building permit process. Compliance can be guaranteed with the use of a refundable deposit or bonding from the builder with the process being administered through the City Municipal Inspector or the building permit process.

The administrative requirements could include:

- Preparation of a specification package for each lot by the “Engineer of Record”;
- Inclusion of the specification package with the building permit file;
- Distribution of the specification package to the Municipal Inspector;
- Submission to the City of a compliance certification by a qualified individual;
- Visual inspection by the Municipal Inspector; and
- Bonding or deposits administered by the City through either the Building Permit process or Municipal Inspector.

Inclusion of Developers

Bringing the developer into the process could be justified through a requirement to implement all the components of the land development and site designs. While the developer is responsible for all aspects of the subdivision outside of the lots, he has at present no legal responsibility for on-lot construction. Any change to this must involve revision to his contractual relationship with the purchaser of the lot and building contractor.

In this instance the developer would be required to enter into a modified sales agreement with the purchaser of the lots. We must assume that the developer would require a deposit or bonding that would pass the financial responsibility for non compliance to the purchaser of the lot and hence on to the building contractor. This process would be transparent to the City as only the City's agreements with the developer would be relevant to the City.

To ease the verification process and to assure the City that the topsoil has been placed in accordance with the subdivision design and watershed requirements, a process will be required.

The administrative process could include:

- Preparation of a specification package for each lot by the "Engineer of Record";
- Inclusion of the specification package with the sales agreement for each lot;
- Submission of the specification package the City for distribution to the Municipal Inspector and for inclusion in the building permit file;
- Submission to the City of the compliance certification by a qualified individual;
- Visual inspection by the Municipal Inspector; and
- Bonding or deposits administered by the developer through the sales agreement.

To provide the City with reasonable assurance of construction and operation of the systems, there needs to be a change in the administrative processes for this area. We have outlined two processes that can be implemented through cooperation between the City and the developers. To take this process forward to implementing the enhanced stormwater management system in the Fergus Creek Watershed, the City and the development community will be required to reach an understanding of the processes and agreement as to their implementation.

6.4 MAINTENANCE OF SYSTEMS

Questions have arisen in respect to the level of maintenance and operational requirements of the stormwater management infiltration systems. Specifically, the questions included:

- Who would be operating the facilities?
- Who maintains them?
- What level of effort ($) is needed to maintain them?

6.4.1 Construction

The construction of the facilities will occur in a logical progression. There is a different timing of construction requirement for those systems on private property and for those within the road right-of-way.

The facilities on private property must remain isolated from construction activities and the potential sediment wash-off during construction and until the contributing area has stabilized from an erosion perspective. From a timing standpoint and for ease of construction, it would be most feasible to construct these facilities following the construction of the buildings, as part of the final lot grading and clean up. This timetable would allow the facilities to be brought into service as the ground surface is stabilized with vegetation and other surface finishes. It would be possible to construct the facilities prior to building construction but there would be a risk of physical damage and a risk of damage from unintended inflow of sediment laden water during the construction of the buildings and landscaping.

The facilities located within the road rights-of-way would be constructed at the same time as the storm sewer. At the time of construction they would be capped to prevent possible inflow of sediment-laden waters from construction. It is vital that construction sediment be excluded from these systems. For this reason, they must remain blocked off until all portions of the catchment upstream of them are fully developed and the ground surfaces are fully vegetated and stable.

In summary, the facilities must be isolated from surface runoff until the catchment area has a stable and non-eroding surface comprised of the final surface treatments such as pavement, sidewalks, buildings and vegetation.

6.4.2 Maintenance

The maintenance of the facilities would fall under the owner of the systems, whether within private property or within the road Rights-Of-Way. On private property the homeowner or strata corporation would maintain the facility. The City would maintain facilities within the road rights-of-way.

The cost of maintenance should be minimal and should be limited to periodic inspections. We have estimated an annual sediment load to each facility as 0.4 kg per square metre based upon published sediment yield from stable urban watersheds of 100 kg/ha/year. This would be equivalent to a depth of less than 1 mm of sediment accumulation per year within the facilities. This sediment accumulation would provide the facilities with useful life spans of more than 50 years. We believe that the 50 year life expectancy will be equivalent to the building cycle of development and redevelopment of the properties and roadways. In future, as these are rebuilt, the facilities will also need to be replaced.

We must emphasize again, that it is critical that the facilities be isolated from construction activities and runoff that has a high sediment load. High sediment loadings will greatly increase the accumulation of sediment in the facilities and reduce their useful life, thus increasing the total maintenance costs.

7.0 CONCLUSIONS

An Integrated Stormwater Management Plan (ISMP) is a policy document that provides direction to land owners and local government to address community land use choices and determine best options to manage these in light to the natural resources present in the watershed.

The purpose of the Fergus Creek ISMP is to establish the framework to allow the environmental features of the watershed to be maintained, or improved, while allowing for human uses and development within the watershed. The ISMP provides flexibility in meeting both the needs of the community and the environment while allowing development and redevelopment.

The objectives of the Fergus Creek ISMP are to provide an integration of planning drainage and consensus development. The City of Surrey requires that the ISMP be based upon the criteria, framework and objectives as outlined in the GVRD ISMP Template. The City has selected the most appropriate portions of the template upon which to base the ISMP.

7.1 WATERSHED VISION

The future form of development within the watershed directly impacts creating a protection and mitigation plan. The successful mitigation plan is contingent upon understanding the vision of the watershed, or sufficient contingencies must be built into the plan to allow for unanticipated development forms.

Each of the land use plans and applications for revised zoning places more demand upon the existing drainage systems within the watershed and upon Fergus Creek itself. While the various land uses comply with the Official Community Plan for the City of Surrey, the details of environmental protection, engineering services and recreation have not been fully documented. These would normally be prepared as part of the planning process. The ISMP is intended to provide the guidance needed to prepare the more detailed implementation plans and designs for Neighbourhoods and individual developments.

We recommend the vision for the Fergus Creek Watershed be created as part of the development and redevelopment planning that will include preparation of the Grandview Heights 2 Neighbourhood Development Plan and any redevelopment plans for the existing urban areas.

7.2 ENGINEERING

A number of drainage system capacity deficiencies with the Fergus Creek watershed have been identified by previous studies. The deficiencies have been defined as a lack of discharge capacity that could result in flooding and risk to property and the public. These deficiencies should be further reviewed and resolved by incorporating upgrades into future development works or capital project.

As the development proceeds there will be increases in the impervious area in the watershed, the runoff volumes and rates increase while both the surface evaporation and deep infiltration decrease. As the flood discharges increase, so do the volumes of runoff and the duration of peak flood flow. With the increases in volumes and peak discharges there also comes a decrease in the low flow volumes and duration of base flows. Critical to the health of the stream and to the availability of aquatic habitat is the duration of flow within the stream. Unless the impacts are mitigated, the aquatic environment will be adversely impacted.

An alternative to the traditional engineering analysis methodologies is an approach that would examine the amount of time that the discharge within the stream exceeds certain threshold values. A range of values was examined to develop an understanding of the impacts of the stream caused by changes within the watershed.

The control of runoff volume has been identified as having substantial environmental benefits for streams and is highly favoured by regulatory agencies as a watershed practice that should be implemented. The value of the volume controls must be balanced by the effectiveness of such measures. The impact of the volume reduction techniques has upon the duration of flow or the exceedence of threshold discharges must also be compared to provide assurance that the impacts are understood.

While the Guidebook has become the standard applied to new developments but we have identified a need to go “Beyond the Guidebook”. The needs have been driven by both a lack of effectiveness of the methodologies in mitigating environmental impacts and the costs associated with the components mandated by applying those Guidebook methodologies.

During the course of preparing this ISMP, the need to go beyond the traditional methodologies has been recognized. The two reasons being the combined cost of the detention and retention facilities combined with published reports indicating the failure of such facilities to achieve their design objectives. The potential costs alone create a need to further evaluate the systems, their need and their performance in meeting the objectives of the various stakeholders and agencies.

The methodology chosen to analyse stormwater runoff and environmental impact mitigation for the Fergus Creek Watershed is one of continuous simulation in accordance to the most recent draft of the DFO Land Development Guideline.

The lower reaches of Fergus Creek have experienced instances of flooding outside the banks of the stream. The City is cognizant of the issues relating to maintaining the predevelopment discharge rates within the stream for up to the 1 in 100 year return period flood event. A part of the stormwater management system will include detention facilities that would limit the post development discharge rates for to predevelopment rates. This criterion would prevent increases to both the flood magnitudes and their associated damages.

The main components of the development mitigation process within the Fergus Creek Watershed will include runoff reduction infrastructure that includes a storage component. These include infiltration galleries, rain gardens, retention ponds, and bio-filtration swales located within private property, the dedicated road ROW and greenways and multi-use corridors. The use of an underflow has shown to enhance the infiltration system by augmenting stream base flows. This combination of runoff volume reduction and storage will result in decreased flood peaks, stream erosion and sediment within the stream while enhancing the duration of base flows. The mitigation measures recommended for redevelopment within the Fergus Creek Watershed include:

1. Roof Leader Disconnection,
2. Top soil preservation and augmentation, and
3. Implementation of infiltration infrastructure.

7.3 ENVIRONMENT

The following recommendations are provided to the City of Surrey and developers to protect environmentally sensitive areas and provide development guidelines during the build out of the Fergus Creek watershed.

- Retain all or portions (>0.5 hectares) of important Wildlife Tree Patches including Stands No. 1, 2 and 4 to provide refuge, food and breeding areas for various federally and provincially listed wildlife species including Pacific water shrew, Trowbridge's shrew, red-legged frog and western toad. In addition, retain all or portions of important Wildlife Tree Patches including Stands No. 1, 2 and 7 to provide refuge, food and breeding areas for the western screech-owl and band-tailed pigeon.

  Forested areas within the lower Fergus Creek watershed should be assessed for their importance to wildlife and ranked with the tree patches within Plan Area 2 to determine which tree patches should be given priority for protection.

- Where possible, provide wildlife movement corridors to maintain genetic diversity of wildlife species. Wildlife movement corridors can include riparian habitat areas, treed areas along residential lots, multi-use greenways, the Fergus Creek mainstem/tributaries and associated riparian areas, the "Height-of-Land" from the northwest corner of Plan Area 2, the BC Hydro ROW and the east-west connection to Sam Hill Creek.

- Purchase the lands that contain the proposed “Habitat Preservation Area” located south of 16th Avenue, east of Highway 99 and west of 168th Street. This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew.

- Protect high suitability habitat for other federal and provincial species at risk including field habitat and old buildings for barn and short-eared owls.

- Protect and enhance Class A/B watercourses including their associated streamside protection and enhancement areas.

- Conduct a structured vegetation inventory (spring and summer) to focus on the detection of rare plants and plant communities. If found, protect these areas and provide a suitable buffer to maintain their integrity.

- If clearing is to be conducted during the active bird breeding season, March 1 to August 1, conduct a bird nest survey to ensure that active nests are protected during the breeding season.

- Conduct fish habitat assessments of all Class C watercourses prior to development of each site to ensure that watercourses and their function are accurately classified and appropriate streamside and enhancement areas are protected where applicable.

- Stormwater management for each development site should follow the recommendations of the Fergus Creek Integrated Stormwater Management Plan.

- Review the above report sections: 4.0 Protection Plans, 5.0 Best Management Objectives and Development Guidelines, and 6.0 Enhancement Opportunities, to ensure the effective protection of ecosystem integrity and environmental values and concerns.

7.4 THE PLAN

Integrated stormwater management planning has the potential to achieve significant benefits for urban environments. Liveability may be enhanced as the quality of natural environment is improved, higher levels of sustainability are achieved through the design and development of our cities, and a wider range of lifestyle choices are available than was previously evident, improved aesthetics.

Realization of these benefits is only possible when integrated stormwater management planning assumes a long-term perspective on growth and change as well as ensuring that plans and strategies coincide and recognize the pace and timing of development and redevelopment cycles. In North America a complete development/redevelopment cycle can occur within a relatively short period of 30 to 50 years if a modest annual redevelopment rate of 2% occurs.

Planning for a 30 to 50 year horizon is understandably challenging because of the number of variables involved and the inability to anticipate changes in personal attitudes, economic and market conditions, technology and politics. It is further complicated by the nature of redevelopment: it will be piecemeal, geographically random, and relatively slow paced. Therefore, the use of proscriptive planning strategies and detailed, focused goals and objectives to guide redevelopment will probably be ineffective. Alternatively, the adherence to general visions and flexible supporting goals and objectives and perhaps performance standards should be employed.

An adaptive management framework provides a feedback process allowing for long term modification and successful implementation of the Fergus Creek ISMP. As part of this process, an inter-jurisdictional Fergus Creek Watershed Assessment Steering Committee would be formed tasked with establishing a performance evaluation plan. This plan would identify and establish performance objectives and targets and utilize a monitoring program to define better stormwater and development practices leading to changes in development standards and regulations. This would ultimately establish watershed-based performance standards through comprehensive modelling and monitoring study of the watershed. Furthermore, development can be carried out using up-to-date watershed data and information allowing the ability to fine-tune design guidelines over time.

7.5 IMPLEMENTATION

The implementation of the recommended stormwater management systems is a departure from standard engineering practices within the City of Surrey. Implementation of the systems will require a change in the administrative processes, department responsibilities and design criteria as established within the City of Surrey. We have provided information regarding the “mechanics of implementation” of the stormwater management systems within the Fergus Creek Watershed. The implementation of the systems will be commenced during the planning stages where the vision of the future watershed is created. This combined with modified criteria and processes within the development, redevelopment and building permit procedures are required to implement the stormwater management strategy within the Fergus Creek watershed.

7.6 SIGNATURE NEIGHBOURHOODS

Two very different special issues have arisen during the course of completing the Fergus Creek ISMP. Those associated with the engineering requirements and others that could be used to ease engineering decisions in future while providing a more diverse landscape. The diverse landscape can be utilized for a host of purposes and can become part of a multi-use system that can enhance the future neighbourhoods. These enhancements can be established in such a way so as to create “Signature” neighbourhoods that are unique and friendlier to the residents.

The green corridors present an opportunity to enhance not only the drainage system but also the environmental values and aesthetics of future neighbourhoods and the recreation opportunities within the Fergus Creek Watershed.

The ultimate locations of the green corridors and their function will be refined during the preparation of the Neighbourhood Concept Plans for the rural area. Consideration should be given to creating similar features within the redevelopment areas of the existing urban areas of the Fergus Creek Watershed.

These contiguous greenways have the potential to be a truly exciting and valuable asset to the City of Surrey and future residents as the watershed redevelops and the population expands.

The need for careful planning of the infrastructure needs within the rural portions of the Fergus Creek Watershed have been identified with some considerable detail. There also exists a need to undertake the next planning steps for the urban portions of the watershed. This effort is required to assure the implementation of the stormwater mitigation methodologies as those areas redevelops. It is equally critical to stream health that the existing developed areas implement stormwater runoff volume control in a consistent manner to meet the overall ISMP objectives.

Redevelopment planning should be undertaken prior to further redevelopment within the existing urban development areas of the Fergus Creek Watershed.

8.0 CORPORATE AUTHORIZATION

McElhanney Consulting Services Ltd. prepared this report for the City of Surrey, Engineering Department. The material in this report reflects the best judgement of McElhanney Consulting Services Ltd. in the light of the information available at the time of preparation. Any use of, or reliance placed upon, the material contained in this report by third parties, or decisions based upon this report are the sole responsibility of those third parties. McElhanney Consulting Services Ltd. accepts no responsibility for damages suffered by any third parties as a result of decisions made, or actions taken, based upon information contained within this report.

APPENDIX A

GEOTECHNICAL INVESTIGATIONS

Trow

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Via Facsimile: (604) 596-8853 and courier

Attention: J.M.K. (Jim) Dumont, P. Eng., P. Ag.

Infiltration Test Report
Fergus Creek Area, South Surrey, BC

Dear Sir:

Introduction

As requested, Trow Associates Inc. (Trow) has conducted infiltration testing for the storm water management study within the Fergus Creek area in South Surrey. The work was carried out in accordance with the Trow proposal (ref. 05Z-0689) dated August 2, 2005 and included review of surficial geology, infiltration testing, gradation analysis of street wash off materials and preparation of this letter report.

Review of Surficial Geology

According to the Geological Survey of Canada Surficial Geology Maps, majority of the Fergus Creek catchment area is underlain by Capilano sediments with a small portion near the east central end by Vashon drift, as shown on the attached Site Plan (Drawing No. 051-01466-01). The Capilano sediments typically consist of marine and glacial marine deposits, comprising raised beach sand, till-like deposits and silty clayey loam. As shown on the Site Plan, about three quarter of the study area is underlain by marine and glacial marine till-like deposits. The Vashion drift typically consists of lodgement and minor flow till, lenses and interbeds of substratified glacial fluvial sand and gravel, and lenses and interbeds of glacial laminated stoney silt.

A data search of Trow's files of previous projects within or in the vicinity of the subject study area has also been carried out and most of previous Trow's projects were located along or to the west of King George Highway. The near surface native soils were found to consist generally of dense silty sand to sandy silt till-like soils, consistent with the soil descriptions of the aforementioned surficial geology maps.

Infiltration Testing

The field work was conducted on October 4th, 2005 and consisted of excavating a relatively shallow test pit (1.4 m) at three different selected sites in the general Fergus Creek area using a mini-backhoe. Each site was located within municipal rights-of-way.

The sites with the inferred soil conditions from the surficial geology maps were located as follows and as shown on the attached Site Plan (Dwg. No. 051-01466-01).

Site No. 1	20th Avenue & 168th Street, near SW corner (Till-Like Soil)
Site No. 2	12th Avenue, about 200m east of 168th Street (Raised Beach Sand)
Site No. 3	20th Avenue, north side about 25m west of King George Highway (Till-Like Soil)

The soil conditions at each test pit were logged by a geotechnical engineer from our office and samples returned to our laboratory for moisture content determinations. The test pit logs are presented on the three log sheets following the Site Plan.

Upon completion of test pit excavation at each location, a percolation test was conducted at the bottom of each test pit by hand excavating a 12 inch by 12 inch by 6 to 12 inch deep hole. The tests were performed within the till-like soils varying from stiff to hard clayey silt to very dense silty sand and were in general accordance with BC Ministry of Health's Percolation Test Procedure. After a 10 to 15 minute pre-soak, the water level was brought to a 6 inch mark from the bottom of the hole and the time required for the water level to drop to the 5 inch mark was recorded. The test pits were backfilled with the excavated materials upon completion of the percolation test.

The measured percolation rates are presented on the test pit log sheets and are summarized as follows:

Percolation Test	**Soil**	**Measured Rate (min/inch)**	**Factored Infiltration Rate (m/s)**
Site #1	Hard Clayey Silt Till-Like	105	6.71×10^{-7}
Site #2	Stiff Clayey Silt	150	4.7×10^{-7}
Site #3	Very Dense Silty Sand Till-Like	More than 5 hours (extrapolated)	2.35×10^{-7}

It can be seen from the above test results that the native subsoils have a very low percolation rate, generally more than 4min/mm, and may be classified as practically imperious, as the calculated factored infiltration rates approach hydraulic conductivity requirements for permanent clay liners (1×10^{-7} m/s). As such, it may not be practical to design a storm water infiltration system as most of the surface runoff is expected to flow on top of the native subsoils with very little infiltration.

Preliminary calculations for a stormwater soak-away system based on this field test data indicate that conventional infiltration systems would likely not meet generally accepted maximum standing water criterion of 24 hours.

Gradation Analysis of Street Wash Off Materials

In addition to infiltration testing, it is understood that the mechanical properties of street wash-off materials are also of interest in this study. As such, a sample of street sweepings was obtained from nearby accumulations of runoff debris at each of the three infiltration testing sites. A soil grain size analysis, including hydrometer analysis of fines (silt and clay sizes) was performed on each of these samples. The grain size/hydrometer results are presented on the three graphs following the test pit logs and the particle size distributions based on ASTM Standard are summarized as follows:

Test No.	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	6.6	85.5	5.3	2.6
2	2.9	82.6	11.2	3.3
3	3.1	59.0	30.6	7.3

Closure

Please note that this letter report was prepared for the exclusive use of The City of Surrey, McElhanney Consulting Services Ltd. and their designated consultants or agents, and may not be used by other parties without the written consent of Trow.

Trow's "Interpretation and Use of Study and Report Instructions" is attached. These instructions form an integral part of this report and should be included with any copies of this report.

If you have any questions, please do not hesitate to contact the undersigned.

Yours truly,

TROW ASSOCIATES INC.

W. W. LAU

James Lau, P.Eng.
Senior Associate

Reviewed by:

James Wetherill, P. Eng.
Senior Associate

Attachments: Site Plan
Test Pit Logs (3)
Grain Size / Hydrometer Analysis (3)
Interpretation and Use of Study and Report

Trow

LOG OF TEST PIT NO. 051-1466-TP1

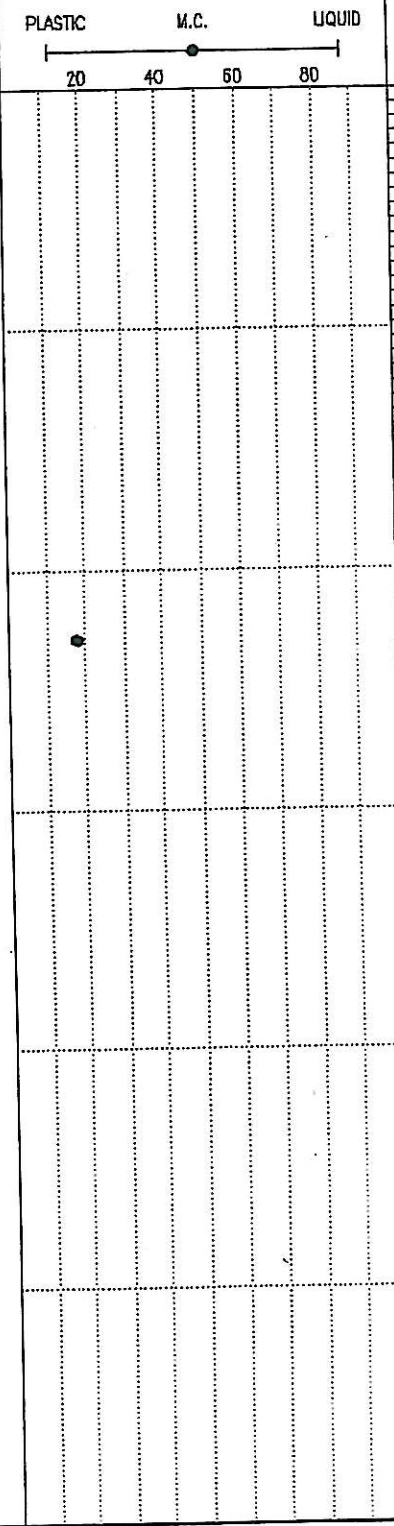
JOB NUMBER: 051-01466
CLIENT: McElhanney Consulting Engineers
SITE LOCATION: 168th Street & 20th Avenue (SW Corner)
Surrey, B.C.

SAMPLE TYPE ■ GRAB ▨ SHELBY TUBE ☒ SPLIT SPOON ☰ ENVIRONMENTAL ▯ NO RECOVERY ▯ CORE

ELEVATION:

DEPTH OF SOIL LAYER	SAMPLE TYPE	SAMPLE NO	Soil Description	Moisture Content (%)
0.0			FILL: silty Topsoil (dark brown) some sand, roots, occasional gravel/cobble damp below 0.3 m	
0.8			sandy SILT/silty SAND (mottled grey-brown) firm/compact, damp	
0.9	■	G-1	clayey SILT (brown) occasional gravel some silty Sand seams hard (till-like)	18
1.4			End of Test Pit PERCOLATION TEST RESULTS Pre-soak 10 minutes Trial #1 70 min. to drop from 6" to 5" Trial #2 105 min. to drop from 6" to 5" Test conducted at bottom of test pit.	

DEPTH(m): 0.0, 1.0, 2.0, 3.0



DEPTH(ft): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0

LOGGED BY: LSC
TRANSCRIBED BY: LSC
COMPLETION DATE: 10/04/05
EQUIPMENT: Mini Backhoe
Trow Associates Inc. (Burnaby, B.C.)
COORDINATES: N 0 0' 0" W 0 0' 0"

LOG OF TEST PIT . 051-1466-TP2

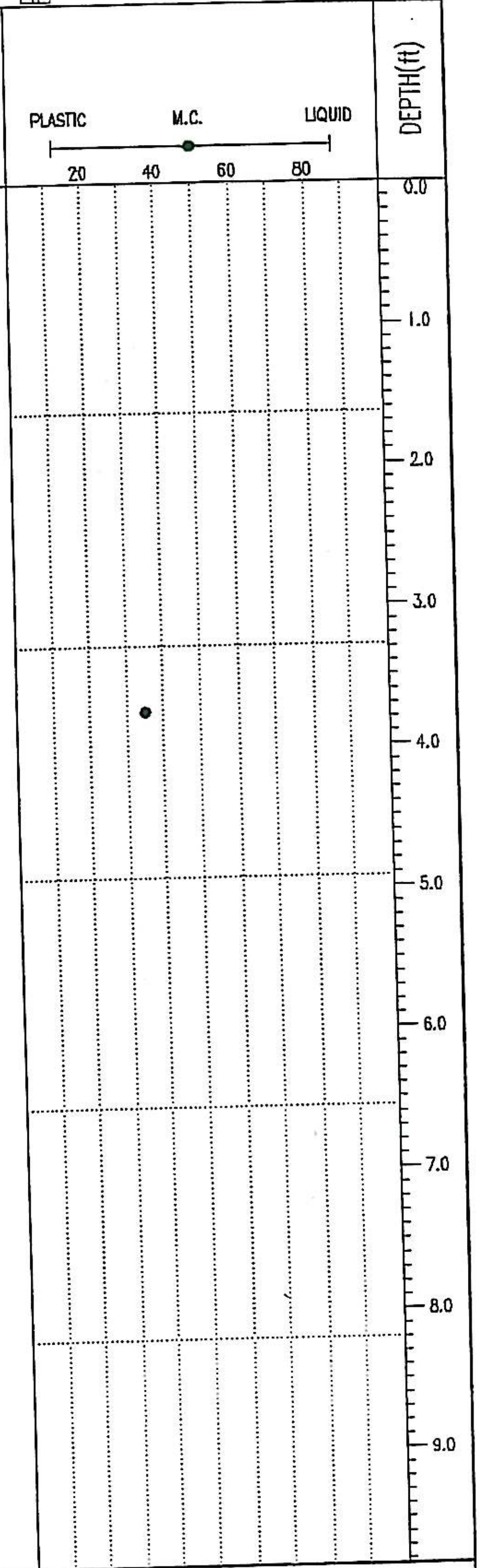
JOB NUMBER: 051-01466
CLIENT: McElhanney Consulting Engineers
SITE LOCATION: 168th Street & 12th Avenue (200 m East)
Surrey, B.C.

SAMPLE TYPE ■ GRAB ◩ SHELBY TUBE ☒ SPLIT SPOON ☰ ENVIRONMENTAL ▯ NO RECOVERY ▮ CORE

ELEVATION:

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	DEPTH OF SOIL LAYER	Soil Description	SOIL SYMBOL	Moisture Content (%)
0.0				FILL: clayey Silt (brown) occasional gravel, cobble stiff, moist		
			0.6	clayey TOPSOIL, some roots (dark brown)		
			0.7	sandy SILT/silty fine SAND (mottled) occasional root to 0.8 m firm/compact, damp		
1.0						
	■	G-2	1.1	clayey SILT (brown) occasional root (decayed) stiff, damp		35
			1.4	End of Test Pit		
2.0						
3.0						

PERCOLATION TEST RESULTS
Pre-soak 13 minutes
Trial #1 150 min. to drop from 6" to 5"
Test conducted at bottom of test pit.



LOGGED BY: LSC
TRANSCRIBED BY: LSC
COMPLETION DATE: 10/04/05
EQUIPMENT: Mini Backhoe
COORDINATES: N 0 0' 0" W 0 0' 0"
Trow Associates Inc. (Burnaby, B.C.)

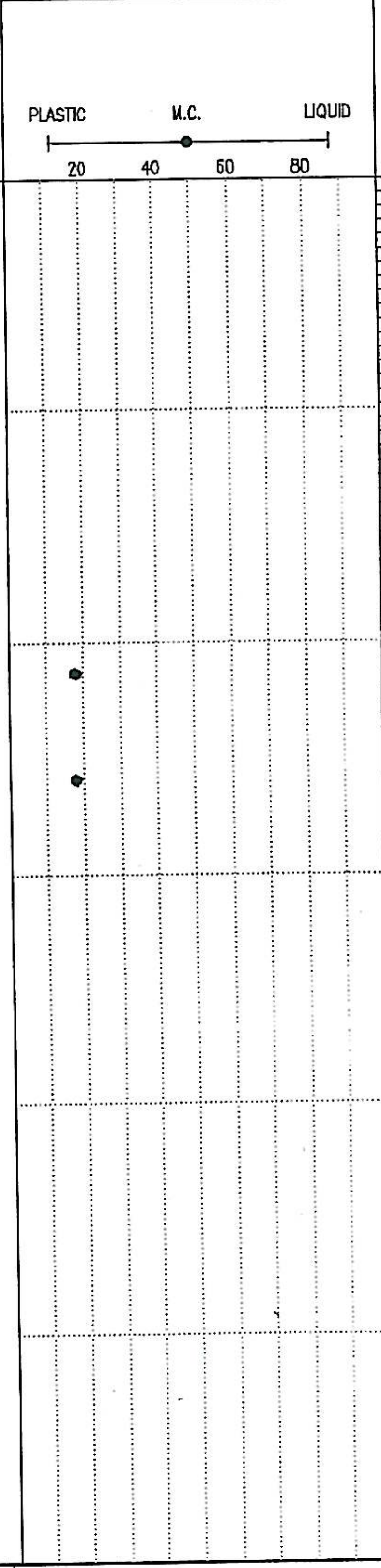
LOG OF TEST PIT NO. 051-1466-TP3

Trow

JOB NUMBER: 051-01466
CLIENT: McElhanney Consulting Engineers
SITE LOCATION: King George Hwy & 20th Avenue(NW Corner)
Surrey, B.C.

SAMPLE TYPE ■ GRAB ▧ SHELBY TUBE ☒ SPLIT SPOON ☰ ENVIRONMENTAL ▯ NO RECOVERY ▯ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	DEPTH OF SOIL LAYER	Soil Description	SOIL SYMBOL	Moisture Content (%)	DEPTH(ft)
				ELEVATION:			
0.0				FILL: 50 mm Sand & Gravel (grey) 200 mm silty Sand & Gravel (mulch)	▩		0.0
			0.3	FILL: Sand & Gravel (3" minus), trace silt	▩		1.0
							2.0
				75 mm clear crushed gravel at 0.8 m			
			0.8	clayey SILT (brown) occasional gravel, sand seams hard, till-like	▥		3.0
1.0	■	G-3				18	
			1.1	silty Sand, wet to saturated very dense (till-like)	▥		4.0
	■	G-4				18	
			1.4	End of Test Pit PERCOLATION TEST RESULTS Pre-soak 11 minutes Trial #1 120 min. to drop from 6" to 5.63" (Extrapolates to 5+ hrs. to drop 1") Test conducted at bottom of test pit.			5.0
							6.0
2.0							7.0
							8.0
							9.0
3.0							



LOGGED BY: LSC	TRANSCRIBED BY: LSC	COMPLETION DATE: 10/04/05	EQUIPMENT: Mini Backhoe
Trow Associates Inc. (Burnaby, B.C.)		COORDINATES: N 0 0' 0" W 0 0' 0"	Page 1 of 1

Trow

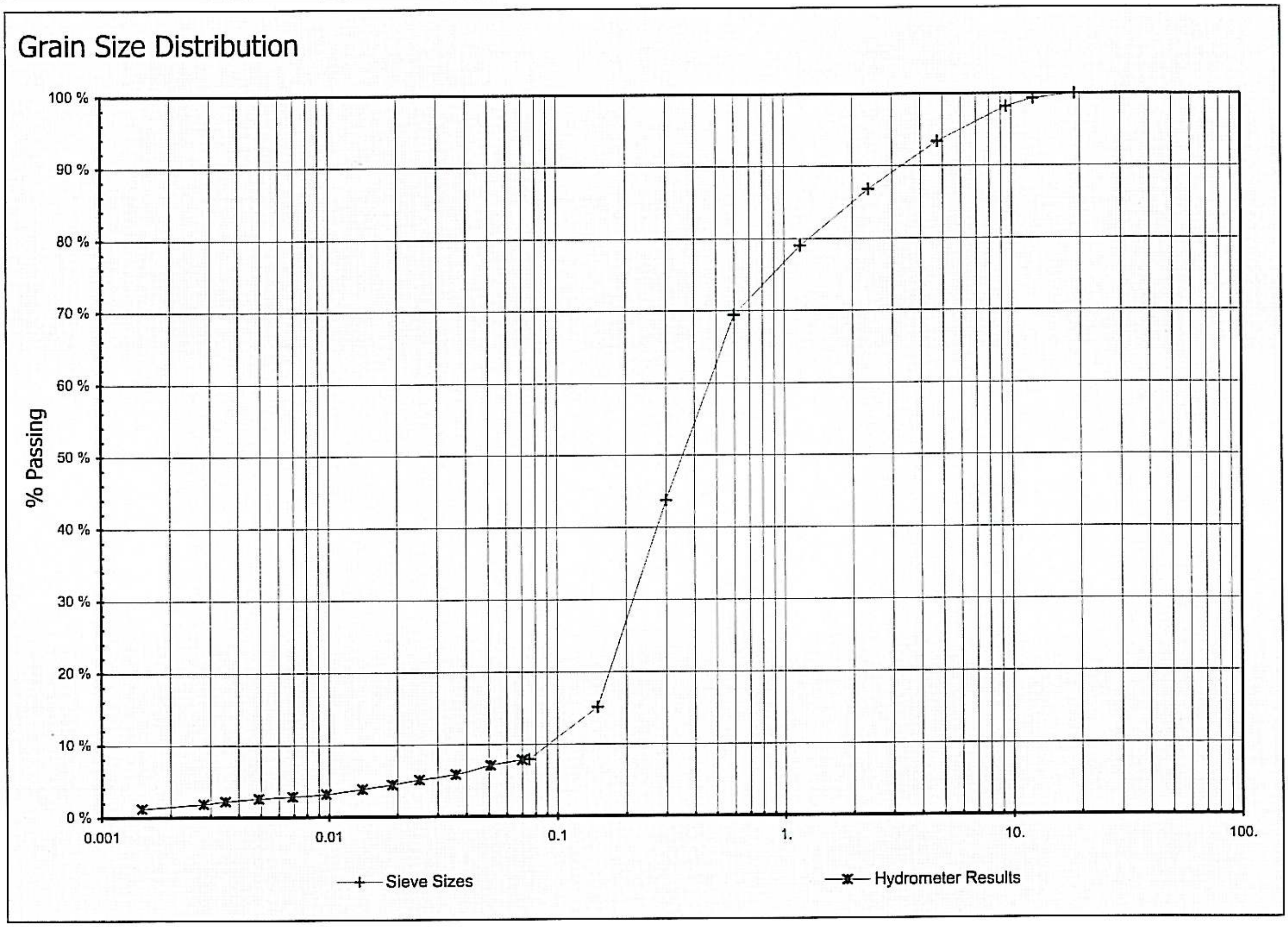
Hydrometer Analysis

Contact: MCELHANNEY CONSULTING SERVICES LTD.
Address: 13160 - 88th AVENUE
SURREY, BC
V3W 3K3
Project: INFILTRATION TESTING - FERGUS CREEK AREA

Project Number: 051-01466
Client Ref. No.:
Report Date: October 28, 2005
Cc:

Test No: Sieve Test No. 1
Specifications: N/A
Source: 168 St & 20 Ave, Surrey
Sample Type: Street Sweeping - Site #1

Date Sampled: October 13, 2005
Date Tested: October 27, 2005



Hydrometer	
Fines	
Diameter (mm)	Percent Passing
0.070	7.8%
0.051	7.1%
0.036	5.8%
0.025	5.1%
0.019	4.5%
0.014	3.9%
0.010	3.2%
0.007	2.9%
0.005	2.6%
0.004	2.3%
0.003	1.9%
0.002	1.3%

Sieve Testing	
Diameter (mm)	Percent Passing
37.5	
25.0	
19.0	100.0%
12.5	99.3%
9.5	98.2%
4.75	93.4%
2.36	86.8%
1.18	79.0%
0.600	69.4%
0.300	43.8%
0.150	15.1%
0.075	7.9%

Soil Properties

Plasticity

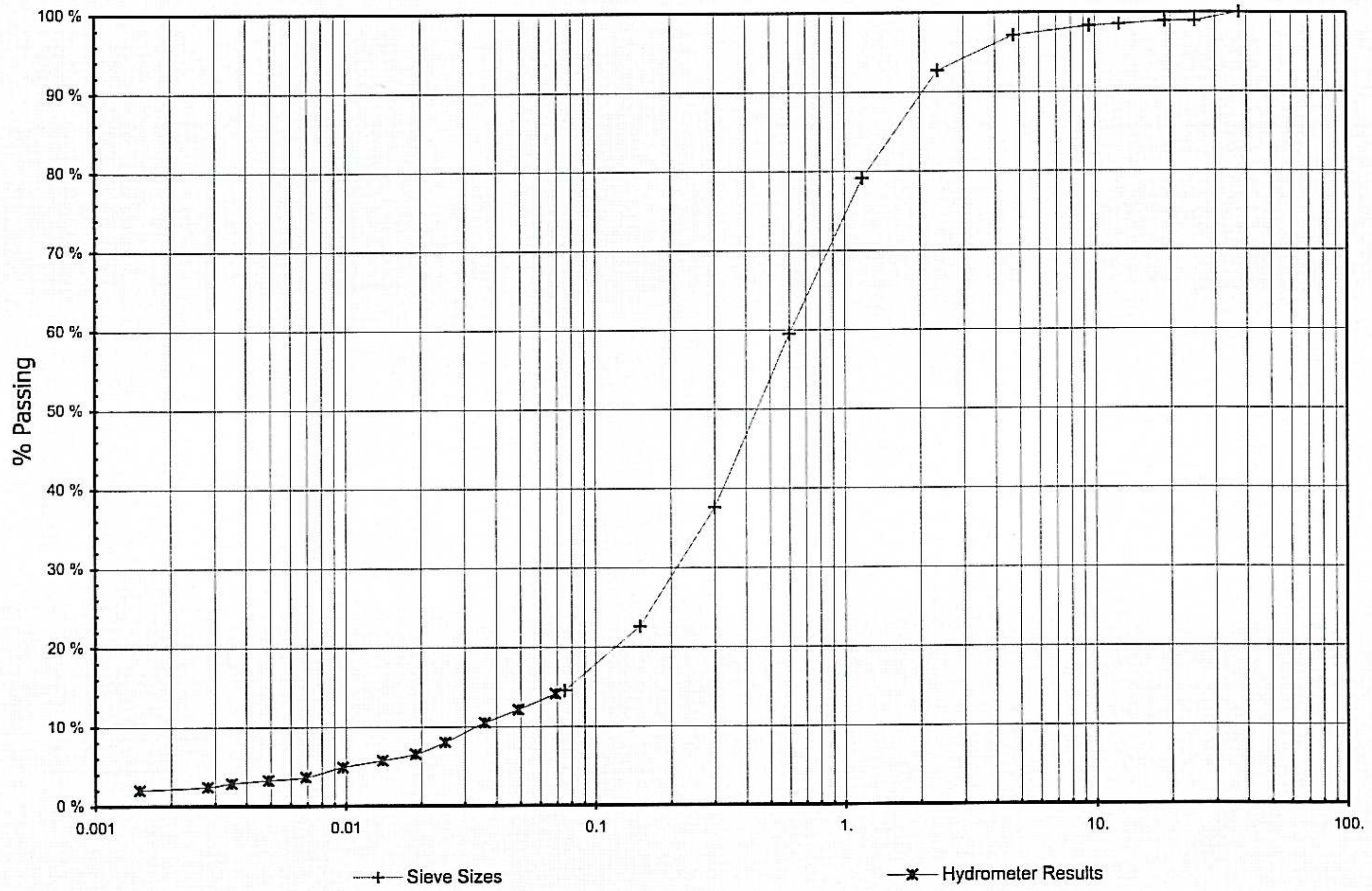
Plastic Limit=
Liquid Limit=
Plasticity Index =

Trow

Hydrometer Analysis

Contact:	MCELHANNEY CONSULTING SERVICES LTD.	Project Number:	051-01466
Address:	13160 - 88th AVENUE SURREY, BC V3W 3K3	Client Ref. No.:	
		Report Date:	October 26, 2005
		Cc:	
Project:	INFILTRATION TESTING - FERGUS CREEK AREA		
Test No:	Sieve Test No. 2	Date Sampled:	October 13, 2005
Specifications:	N/A	Date Tested:	October 19, 2005
Source:	168 St. & 12 Ave., Surrey		
Sample Type:	Street Sweepings - Site #2		

Grain Size Distribution



Hydrometer	
Fines	
Diameter (mm)	Percent Passing
0.069	14.1%
0.049	12.1%
0.036	10.5%
0.025	8.0%
0.019	6.5%
0.014	5.7%
0.010	4.9%
0.007	3.7%
0.005	3.3%
0.004	2.9%
0.003	2.4%
0.002	2.0%

Sieve Testing	
Diameter (mm)	Percent Passing
37.5	100.0%
25.0	98.9%
19.0	98.9%
12.5	98.5%
9.5	98.3%
4.75	97.1%
2.36	92.7%
1.18	79.1%
0.600	59.5%
0.300	37.6%
0.150	22.6%
0.075	14.5%

Soil Properties

Plasticity

Plastic Limit=
Liquid Limit=
Plasticity Index =

Trow

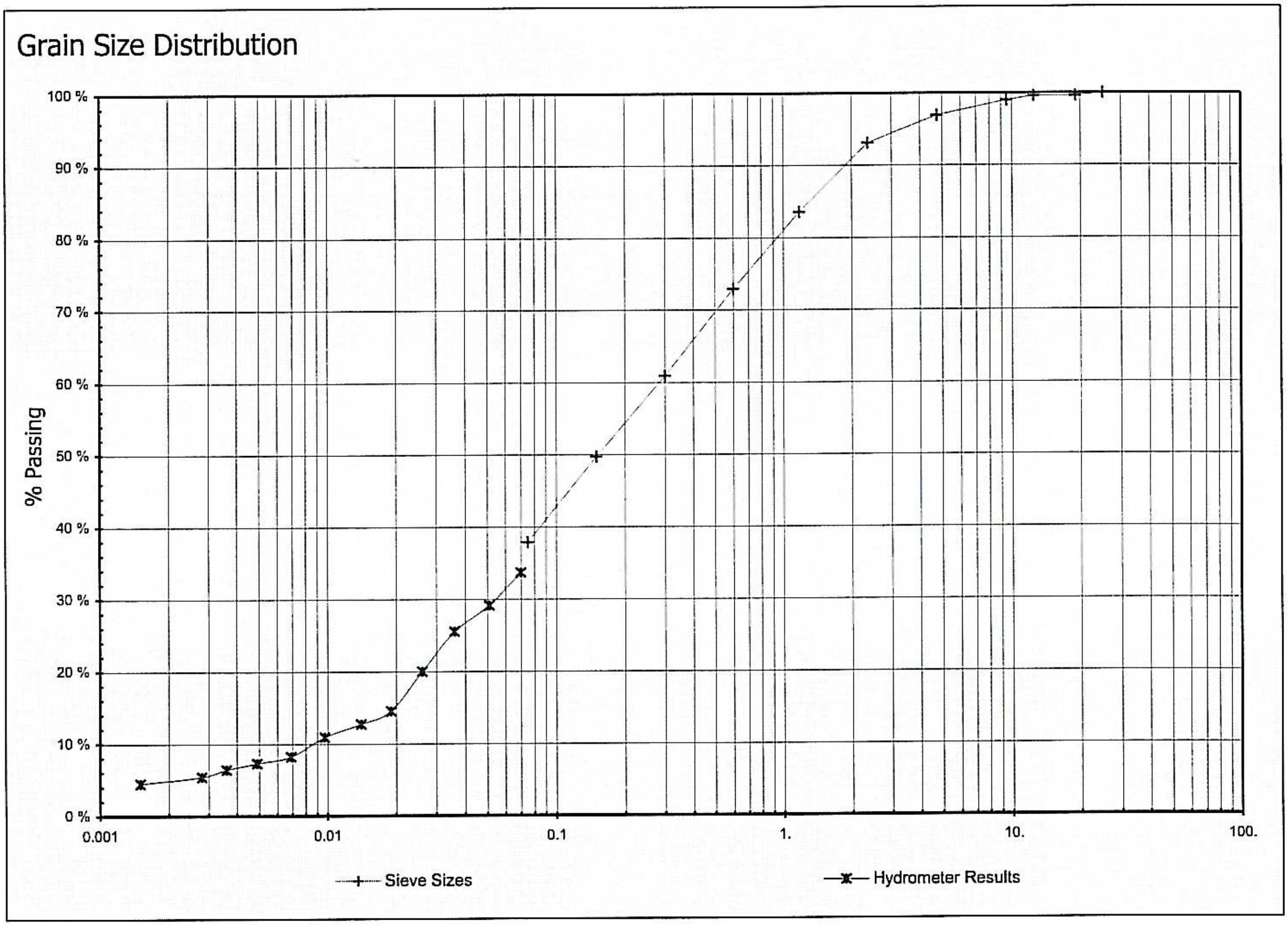
Hydrometer Analysis

Contact: MCELHANNEY CONSULTING SERVICES LTD.
Address: 13160 - 88th AVENUE
SURREY, BC
V3W 3K3
Project: INFILTRATION TESTING - FERGUS CREEK AREA

Project Number: 051-01466
Client Ref. No.:
Report Date: October 26, 2005
Cc:

Test No: Sieve Test No. 3
Specifications: N/A
Source: King George Hwy & 20 Ave, Surrey
Sample Type: Street Sweepings - Site #3

Date Sampled: October 13, 2005
Date Tested: October 19, 2005


Grain Size Distribution

Hydrometer

Fines

Diameter (mm)	Percent Passing
0.070	33.7%
0.051	29.1%
0.036	25.5%
0.026	20.0%
0.019	14.5%
0.014	12.7%
0.010	10.9%
0.007	8.2%
0.005	7.3%
0.004	6.4%
0.003	5.4%
0.002	4.5%

Sieve Testing

Diameter (mm)	Percent Passing
37.5	
25.0	100.0%
19.0	99.6%
12.5	99.6%
9.5	99.0%
4.75	96.9%
2.36	93.1%
1.18	83.6%
0.600	72.9%
0.300	60.9%
0.150	49.7%
0.075	37.9%

Soil Properties

Plasticity

Plastic Limit=
Liquid Limit=
Plasticity Index =

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request.

Interpretation and Use of Study and Report

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering consulting practices in this area. No other warranty, expressed or implied, is made. Engineering studies and reports do not include environmental consulting unless specifically stated in the engineering report.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF THE REPORT

The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

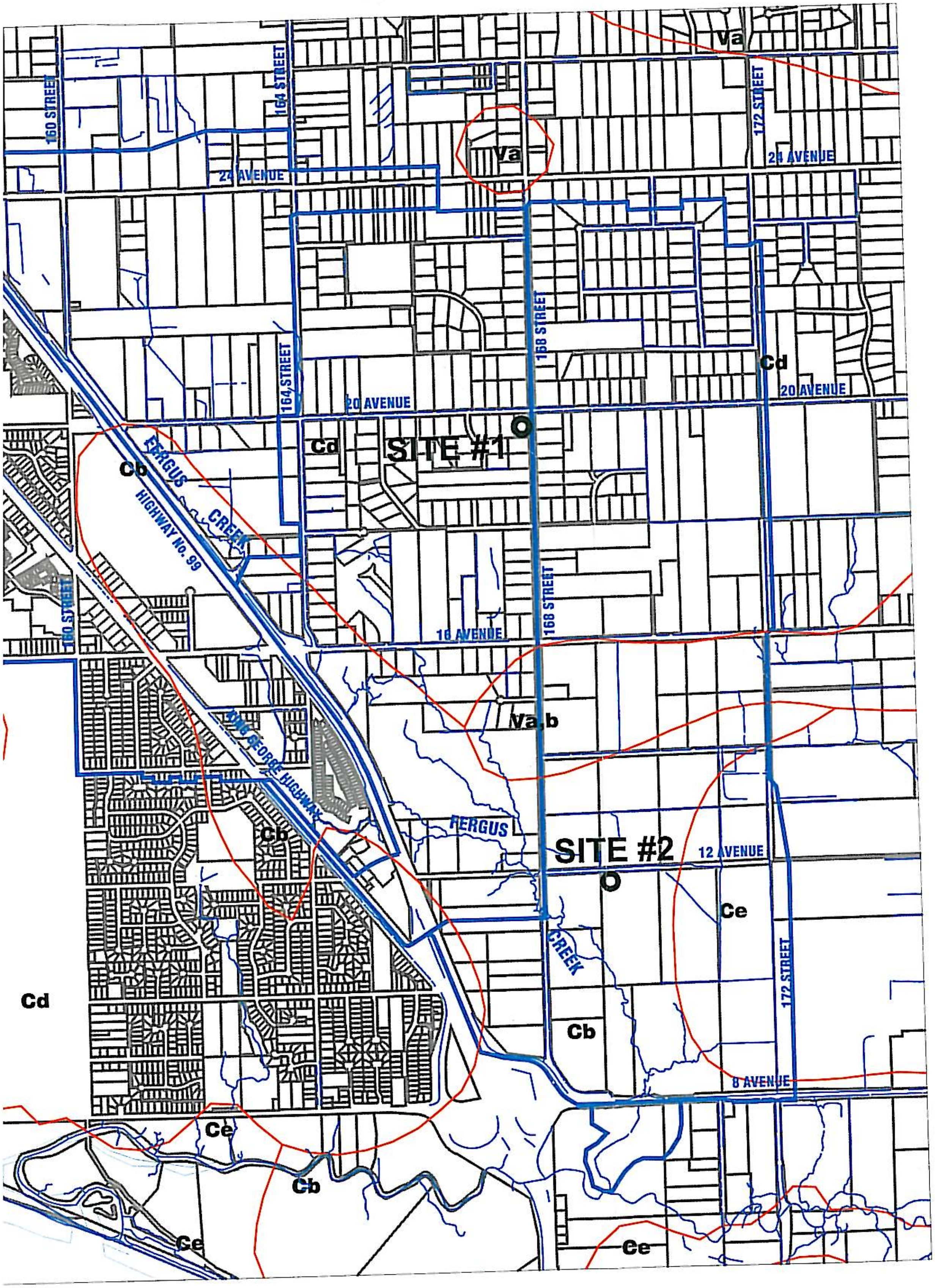
The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report, or any portion thereof, available to any party without our written permission. Any use which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting from unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT

a. Nature and Exactness of Descriptions: Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations, or building envelope descriptions, utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. 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. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b. Reliance on Provided information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. To avoid misunderstandings, Trow should be retained to work with the other design professionals to explain relevant engineering findings and to review their plans, drawings, and specifications relative to engineering issues pertaining to consulting services provided by Trow. Further, Trow should be retained to provide field reviews during the construction, consistent with building codes guidelines and generally accepted practices. Where applicable, the field services recommended for the project are the minimum necessary to ascertain that the Contractor's work is being carried out in general conformity with Trow's recommendations. Any reduction from the level of services normally recommended will result in Trow providing qualified opinions regarding adequacy of the work.



TS

DATE

CLIENT
McELHANNEY CONSULTING SERVICES LTD.

PROJECT
INFILTRATION TESTING
FERGUS CREEK AREA, SOUTH SURREY, B.C.

TITLE:
SITE PLAN

PROJECT NO. 051-01466
DFTR. MG
DSGN. LC
CHK. JL
DATE OCT. 11/05
SCALE: 1:20,000
DWG. NO. 051-01466-01

APPENDIX B

ENVIRONMENTAL REVIEW

Fergus Creek Integrated Stormwater Management Plan

Environmental Review
Surrey, BC

Prepared for:

McElhanney Consulting Services Ltd.
13160 – 88th Avenue
Surrey, BC
V3W 3K3

Prepared by:

ENKON ENVIRONMENTAL LIMITED
Suite 201 – 2430 King George Highway
Surrey, BC
V4P 1H8

Phone (604)-536-2947
Fax (604)-536-2948

e-mail: enkon@telus.net
web page: www.enkon.com

Project No.: 1051-031

December, 2006

Executive Summary

As part of the planning process for the Fergus Creek Integrated Stormwater Management Plan in south Surrey, ENKON Environmental Limited (ENKON) was retained to inventory fish, wildlife and vegetation resources and identify any environmentally sensitive areas within the watershed. This report describes the results of environmental surveys conducted in 2005 and 2006.

ENKON reviewed a number of relevant environmental reports for the Fergus Creek watershed including:

- Environmental Review of the Grandview Heights Neighbourhood Concept Plan Area 2 (ENKON 2006);
- General Environmental Review for the Grandview Heights Plan Area prepared by Envirowest (May 2005);
- Environmental Impact Assessment Report for Grandview Heights #1 NCP Phase 2 prepared by Phoenix Environmental Services Ltd (2005);
- General Habitat Management Principles Developed by Envirowest (January 2004) for the Highway 99 Corridor; and
- Fergus Creek Stream Assessment conducted by Gartner Lee (2001).

ENVIRONMENTAL INVENTORIES

A total of 5 biological surveys were conducted during the summer/fall of 2005 and the spring of 2006 (Table 1) within the Fergus Creek Watershed.

Table 1 Fish and Wildlife Surveys Conducted within the Fergus Creek Watershed during 2005/2006

Survey Conducted	Date
Raptor surveys to identify habitat use by federally and provincially listed bird species	July 6, 2005 December 8 and 12, 2005 January 23-24, 2006
Small Mammal live trapping to identify habitat use by federally and provincially listed small mammals	August 3 , 2005 March 13, 2006
Reptile and Amphibian surveys to identify habitat use by federally and provincially listed reptiles and amphibians	July 6, 2005 August 3-5, 2005 February 22, 2006

Survey Conducted	**Date**
Watercourse Classification surveys to confirm the City of Surrey mapping and to identify enhancement opportunities	July 06, 2005 September 26, 2005 October 02, 2006
Water Quality Sampling during the low summer flow period to assess the health of the Fergus Creek watershed	September 26, 2005

TERRESTRIAL RESOURCES

Vegetation Resources

The Fergus Creek watershed study area lies within the Coastal Western Hemlock Biogeoclimatic Dry Maritime Subzone (CWHdm). Forests of the study area consist of a mosaic of coniferous and deciduous species. The tree layer is formed of a mixture of deciduous species including bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera*), paper birch (*Betula papyrifera*) and red alder (*Alnus rubra*) with coniferous species including Douglas-fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), mountain hemlock (*Tsuga mertensiana*) and Sitka spruce (*Picea sitchensis*) comprising the largest component of the tree canopy cover.

Salal (*Gaultheria shallon)*, Indian plum (*Oemleria cerasiformis*), red elderberry (*Sambucus nigra*), Oregon grape (*Mahonia nervosa*), vine maple (*Acer circinatum*) and trailing blackberry (*Rubus ursinus*) are common components of the shrub layer. The herb layer of these forests is composed primarily of ferns with abundant sword fern (*Polystichum munitum*). Spiny wood fern (*Dryopteris expansa*) and licorice fern (*Polypodium glycyrrhiza*) are present in the wetter sites and bracken fern (*Pteridium aquilinum*) is common in drier sites.

Seven important stands of wildlife tree patches were identified by ENKON as part of the Grandview Heights Neighbourhood Concept Plan Area 2 environmental review which likely contain a number of significant trees according to the City of Surrey Tree Bylaw. Additional important tree patches likely exist in lower Fergus Creek north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99.

WILDLIFE RESOURCES

Raptors

The only diurnal raptor species observed during the 2005/2006 field program were a breeding pair of Cooper's hawks (*Accipiter cooperii*) in a forested area behind the Meridian Par 3 Golf Course and a breeding pair of red-tailed hawks (*Buteo jamaicensis*) above 20th Avenue, west of 168th St. Both pairs were regularly observed displaying nesting behaviour.

Both the blue-listed short-eared owl and barn owl were detected at separate locations in the southern area of Fergus Creek watershed. Both observations were of individual birds in flight and responding to call playback.

There were also several detections of both barred owls (*Strix varia)* in 2005 and 2006, and great horned owls (*Bubo virginianus)* in 2006 at the call points within Plan Area 2. These data and other anecdotal information provided by local residents suggest these birds are common in the watershed.

Small Mammals

The only small mammal live-trapped within the Fergus Creek watershed was the ubiquitous deer mouse (*Peromyscus maniculatus*). One live and one dead coast mole (*Scapanus orarius*) were found in the riparian area between the north and south extensions of 164th Street, north of 20th Avenue.

Other Mammals

Other mammals that have the potential to occur within the Fergus Creek watershed include black-tailed deer (*Odocoileus hemionus)*, coyote (*Canis latrans)*, raccoon *(Procyon lotor)*, opossum *(Didelphis virginiana),* striped skunk *(Mephitis mephitis)*, Douglas squirrel (*Tamiasciurus douglasii)* and two introduced species including eastern cottontail rabbit (*Sylvilagus floridanus*) and eastern grey squirrel (*Sciurus carolinensis*).

Amphibians

Pacific treefrogs (*Hyla regilla*) were the only amphibian detected during ENKON's surveys and were heard on many occasions within forest and shrub habitats of the Fergus Creek watershed. Other amphibians which have not been detected but are likely to occur in the watershed are red-legged frog (*Rana aurora*), ensatina *(Ensatina eschscholtzi)*, northwestern salamander *(Ambystoma gracile)*, long-toed salamander (*Ambystoma macrodactylum*), western red-backed salamander *(Plethodon vehiculum),* rough-skinned newts *(Taricha granulosa),* Pacific treefrog (*Hyla regilla*) and western toad (*Bufo boreas*).

Federally and Provincially Listed Species

The B.C. Conservation Data Centre (CDC) lists 20 bird species in the Chilliwack Forest District as threatened or vulnerable (Appendix B). The *Species at Risk Act* (SARA) lists 23 bird species from British Columbia in Schedule 1, 2 or 3. Of these species, the land within and adjacent to the Fergus Creek watershed area contains suitable breeding habitat for 4 listed species including barn owl, short-eared owl, western screech-owl and band-tailed pigeon. Of these, the barn owl and short-eared owl were observed during ENKON's 2006 avian surveys. Suitable breeding and foraging habitat is available for these species in all open grassy agricultural areas and the BC Hydro right-of-way. The great blue heron was not observed during ENKON's surveys; however, there is suitable habitat (groups of mature, large deciduous and coniferous trees) within the watershed.

Due to the colonial nesting habits of great blue heron and the historical locations of their rookery sites, it is unlikely they will nest within the Fergus Creek watershed or surrounding lands. Other listed species might occasionally rest or forage within the watershed but they are not likely to nest there.

With regard to rare vertebrate wildlife species, there has been one capture of the red-listed Pacific water shrew and the blue-listed Trowbridge's shrew at Fergus Creek, 150 metres north of 8th Avenue (September 1992), and three captures of Trowbridge's shrew in two tributaries to the Little Campbell River downstream of the Fergus Creek confluence (June 2004). Pacific water shrew is federally identified as Threatened (Schedule 1 of the *Species at Risk Act*). Suitable habitat for both these rare species exist in the watershed, however, none were detected during ENKON's surveys.

The provincially blue-listed red-legged frog *(Rana aurora)* and the federal species of concern the western toad, have the potential to occur at or adjacent to permanent streams or ephemeral ponds within the Fergus Creek watershed, and at several wet forested sites such as the mixed older mature forest patch located northeast of the riparian right-of-way corridor at 164th St above 20th Ave. Neither species were detected during ENKON's surveys.

None of the 46 plant species listed as blue- or red-listed in the CDC Tracking List were observed during vegetation surveys, however, there have not been structured vegetation surveys conducted to confirm their presence or absence in the Fergus Creek atershed. The local observations of blue-listed Henderson's checker-mallow (*Sidalcea hendersonii*), western pearlwort (*Sagina decumbens*), and field dodder (*Cuscuta pentagona*) recorded in the Rare Elements Occurrence Report were observed within the Fergus Creek Watershed before 1990.

Important Wildlife Tree Patches

Factors such as overall forest cover, forest size, shape and degree of fragmentation all affect the viability of habitat for wildlife species. Optimal wildlife tree patch size is generally relevant to the species or suite of species you are trying to protect or manage for, however, there is a minimum of natural cover necessary to maintain a threshold of ecosystem function. Guidelines from Environment Canada (2004) suggest that patches of between 0.5 and 20 ha will support very few to no native interior forest species and will be dominated by edge species such as open area and shrub species, introduced or exotic species, and avian predators.

As part of the environmental review for the Grandview Heights Neighbourhood Concept Plan Area 2, seven important stands of wildlife tree patches were identified ranging in size from 2.0-5.4 hectares and ranked on a scale of 0-10 (10 being the highest) in terms of habitat value and priority for protection. The results show Stand No. 1 (between 23rd and 24th Avenue and between 164th and 165th Street) as the most valuable in terms of natural, mature forest habitat. Stand No. 2 (between 23rd and 24th Avenue, and between 166th and 168th Street) was second most significant, while Stand No. 7 (between 20th and 21st Avenue, and between 166th and 167th Street) had the lowest relative amount of habitat value among the seven important wildlife tree patches. The largest of the patches were Stand No's 3, 4 and 6 (ranked 4.5, 4.8, 5.4 ha, respectively).

Although ENKON did not survey stands of wildlife tree patches within the remainder of the Fergus Creek watershed, there are likely important stands of wildlife tree patches in the lower watershed north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99. Field reconnaissance and Orthophoto interpretation suggest that the mature coniferous stands located along Fergus Creek Reach 2 may be important wildlife tree patches.

Although, in general, small urban patches of habitat do not function very well as natural ecosystems, ENKON's survey results determined that the higher ranking significant patches were fairly representative of the natural vegetation community within this biogeoclimatic subzone. Avian species diversity was moderate relative to the expected species composition which would normally occur in less disturbed habitats and included many interior forest species. Their value, although small, appears high, possibly due to their proximity to the riparian areas within the balance of the watershed. These patches of forest offer recreational wildlife viewing, aesthetic quality, environmental services such as oxygen and nutrient recycling, noise buffering, and most importantly, habitat for the remaining persistent wildlife species in the area. If these patches are fragmented further by development, or become completely isolated from other patches of moderate to higher quality patches or green spaces, they will eventually cease to function as wildlife refuges, breeding sites or foraging areas.

In addition to recommending that most or all of the significant patches are retained, ENKON recommends that landscape planning for stormwater features include a system of connecting or enhancing areas to maintain green links to these stands of forest and ensure the quality of health is maintained or enhanced. Forest patches should be within 2 km of one another. Without a system of corridors or green spaces for wildlife and plants to distribute themselves throughout the forested networks, the native species will not persist.

Wildlife Movement Corridors

Determination of optimal wildlife movement corridor width is complicated by factors such as the difference in habitat values in the available linear landscape, the differing needs of plant and animals using the corridor, the influence of disturbances from outside the corridor and the long-term management and stability of the corridor within the surrounding urban matrix. Some species such as black-tailed deer and coyotes prefer corridors and riparian areas to move through the landscape, but will occasionally move into the open. Other smaller animals such as frogs and birds may be entirely dependent on wildlife corridors for cover while moving within their range.

Terrestrial corridors designed to facilitate species movement should be a minimum of 50 to 100 m in width to facilitate movement for common generalist species, depending on habitat quality, while stream corridor widths of at least 75 m are recommended to support breeding birds. Vegetation composition should be representative of the natural vegetation for the region. A corridor of 30 m in width will support 90% of natural streamside plant species diversity.

Four wildlife movement corridors were identified including the Fergus Creek mainstem/tributaries and associated riparian habitat, the "Height-of-Land" from the northwest corner of Plan Area 2 to the southeast and connecting to Dart's Hill Garden and Redwood Parks, the BC Hydro ROW along the western boundary of Plan Area 2 connecting to the Little Campbell River and east from the BC Hydro ROW between 16th and 12th Avenues to Sam Hill Creek which eventually flows into the Little Campbell River just north of 8th Avenue.

FISHERIES RESOURCES

Watercourse Classification

Watercourse classifications were assessed based on the City of Surrey's watercourse classifications as available from digital datasets for fish stream classifications received April 2006.

Six Class A or Class A(O) watercourses were identified within the Fergus Creek:

1. The Fergus Creek mainstem from its confluence with the Little Campbell River to just north of 20th Avenue;
2. A significant tributary (Trib 4.2) from its confluence with the Fergus Creek mainstem immediately east from the Highway 99 culvert crossing to 16th Avenue;
3. Two tributary branches (Trib 4.1) immediately west of 168th Street between 12th and 16th Avenues;
4. A small tributary branch east of 168th Street and below 12th Avenue;
5. The lowermost portion of a tributary channel with its confluence from the east within Reach 2, immediately north of 8th Avenue;
6. A network of property line drainage ditches in the vicinity of the BC Hydro right-of-way to the east of 168th Street, between 8th and 14th Avenues.

Numerous Class B watercourses were also identified within the Fergus Creek watershed including the most significant one being Reach 7 of the Fergus Creek mainstem. Other important Class B watercourses include portions of Tributary 4.1 and 4.2 in Reach 4 of the Fergus Creek mainstem and Tributary 2.1 in lower Fergus Creek. The remaining watercourses within the Fergus Creek watershed are Class C watercourses characteristic of roadside ditches or man-made ditches to drain individual properties. In many cases, the watercourses are void of riparian vegetation due to adjacent roadways or manicured lawns/developed properties.

ENKON conducted field assessment/verification of Class A and significant Class B watercourses and associated tributaries to confirm or reclassify these drainages. Based on field assessments and discussions with Fisheries and Oceans Canada, several watercourses were reclassified due to observations of significant flow, direct downstream connectivity or seasonally significant hydrologic contributions to downstream resources. At the request of Fisheries and Oceans Canada, no "downgrading" of watercourses from Class B to Class C has been recommended; rather, future development planning will require detailed assessments for site specific changes to watercourse classifications for the purposes of assessing stream classification and appropriate setback criteria. The proposed reclassifications are intended as an overview classification for overview planning purposes.

For preliminary planning purposes, the City of Surrey directed ENKON to assess streamside protection and enhancement areas (i.e. setbacks) for Class A/B watercourses following an adaptation of the Simple Assessment Methodology of the Riparian Areas Regulations (RAR).

Based on the GIS based analysis and resulting average widths for existing or potential vegetation, all Class A and B watercourses within the Fergus Creek watershed fall within Categories 1 and 2, with an average width greater than 15m. For vegetation category 1 the resulting SPEA widths for fish-bearing and non-fish bearing watercourses are identical. Based on field assessments, all Class A and B watercourses were classified based on evidence of fluvial scour and assumed flow conditions for periods greater than 6 months per year. Given the vegetation categories and the permanent flow conditions, the resulting SPEA width for all Class A and B watercourses assessed for the Fergus Creek watershed are 30m from top-of-bank. Class B tributaries assumed to exhibit non-permanent flow status were those constructed as east-west draining property line drainage ditches with no significant mapped headwaters. Based on potential vegetation categories of 1 and 2, non-permanent non fish bearing Class B watercourses result in a minimum 15m SPEA width.

Although Class C watercourses were not evaluated, it is anticipated that detailed assessments would be completed for each Class C watercourse during the development application phase of individual sites, to confirm the watercourse classification and determine the appropriate streamside protection and enhancement area. The preliminary SPEA widths utilized in this report do not preclude the potential for a developer of a site to negotiate different SPEA's in consultation with the Department of Fisheries and Oceans and the City of Surrey or if new legislation is implemented in the future.

HABITAT PRESERVATION AREAS

The City of Surrey's 2004 Highway 99 Corridor Local Area Plan outlines three environmental preservation areas including:

1. A "linear habitat feature" adjacent to Highway 99, extending approximately between the 12 Avenue and 23 Avenue right-of-ways including the upper section of Fergus Creek. This feature includes Reach 7 of the Fergus Creek mainstem which consists of mainly fines substrate (i.e. clay with some gravel and cobbles). The upper half of the reach is ditched along Highway 99 and fisheries values have been assessed as medium for rearing and low for spawning, although the culvert

under Highway 99 limits fish access. The lower portion of Reach 7 has a well defined riparian vegetation zone useful for a variety of wildlife species;

2. Two sections of proposed fisheries "food and nutrient" features to be developed within the BC Hydro right-of-way. This portion of the BC Hydro ROW is comprised primarily of field habitat with no forested areas and as such has limited wildlife values; and

3. A large "block" of habitat comprising the Fergus Creek ravine and most of the critical wildlife habitat located generally south of 16th Avenue. The existing habitat of this area consists of 5 vegetation types including old field, pole-sapling, deciduous, coniferous and mixed forests. Tributaries 4.1 and 4.2 are also within this area.

ENVIRONMENTALLY SENSITIVE AREAS

As indicated in the previous discussions and in keeping with the City's by-laws, plans and policies, areas which were identified as environmentally sensitive include:

1. High suitability habitat for the following listed species; Great blue heron, barn owl, short-eared owl, western screech-owl, band-tailed pigeon, Pacific water shrew, Trowbridge's shrew, western toad and red-legged frog.
2. Seven important wildlife tree patches identified in the Grandview Heights Neighbourhood Plan Area 2 Environmental Review (ENKON 2006), in particular those ranking relatively high in Plan Area 2 such as Stands No. 1 and No. 2. Stand No. 1 is a moderate sized but dynamic and old patch of natural forest, with significant diversity and productivity of native species. Stand No. 2 includes a narrow riparian area, an old patch of structurally diverse forest in the north end with wet depressions and vernal pools, a mix of seral stages, a range of native vegetation species, and a raptor nest.

   Although ENKON did not survey stands of wildlife tree patches within the remainder of the Fergus Creek watershed, there are likely important stands of wildlife tree patches in the lower watershed north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99.
3. Wildlife movement corridors which provide access to important habitats such as a movement corridor along Fergus Creek mainstem/tributaries and a potential corridor along the "Height of Land" from the northwest corner of Grandview Heights Neighbourhood Plan Area 2 to the southeast and connecting to Dart's Hill Garden and Redwood Park. Much of the "Height-of-Land" potential wildlife movement corridor is treed and passes through portions of 3 significant stands of trees (Stands No. 3, 4 and 6) as well as patches of mature to old forest and riparian areas. A third wildlife movement corridor exists along the BC Hydro right-of-way running along the western border of Grandview Heights Neighbourhood Concept Plan Area 2 connecting to the Little Campbell River. A fourth corridor exists east from the BC Hydro ROW between 16th and 12th

Avenues to Sam Hill Creek which eventually flows into the Little Campbell River just north of 8th Avenue;

4. The proposed "Habitat Preservation Area" located south of 16th Avenue, east of Highway 99 and west of 168th Street. This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew; and
5. The Fergus Creek mainstem and all other Class A and B tributaries and associated riparian habitat that provide significant rearing/spawning habitat and/or food and nutrient contributions to downstream fish populations. Any Class C watercourses that are assessed as "fish habitat" during the development application phase.

POTENTIAL FISH AND WILDLIFE ENHANCEMENT OPPORTUNITIES

ENKON identified a number of potential opportunities to enhance both fish and wildlife habitat within the Fergus Creek watershed. Where possible, the enhancement opportunities were prioritized as follows:

Fish Habitat

1. Fish Access Improvements
2. Baseflow/Water Quality Enhancement
3. Riparian Enhancement
4. Erosion Control
5. Instream Habitat Enhancement

Wildlife Habitat

1. Watercourse Road Crossings
2. Forest Retention
3. Wildlife Stewardship

PROPOSED BEST MANAGEMENT OBJECTIVES AND DEVELOPMENT GUIDELINES

ENKON has recommended a number of "Best Management Objectives and Development Guidelines" to provide some guidance to the City of Surrey during the development or re-development of the Fergus Creek watershed to ensure that critical vegetation, fish and wildlife habitat is maintained. Although it is likely that not all of the objectives/guidelines can be followed due to density requirements, road/servicing networks and commercial/industrial developments, an attempt should be made to incorporate as many as possible. Best Management Objectives and Development Guidelines were provided in the following areas:

1. Environmentally Sensitive Areas

- Important Wildlife Tree Patches
- Wildlife Movement Corridors
- Habitat Preservation Areas
- Multi-Use Greenways
- Federally and Provincially Listed Species
- Fish Habitat

2. Development or Re-Development Areas
    - Raptors
    - Small Mammals
    - Amphibians and Reptiles
    - General Wildlife

RECOMMENDATIONS

The following recommendations are provided to the City of Surrey and developers to protect environmentally sensitive areas and provide development guidelines during the build out of the Fergus Creek watershed.

City Initiatives

- Where possible, retain all or portions (>0.5 hectares) of important Wildlife Tree Patches including Stands No. 1, 2 and 4 to provide refuge, food and breeding areas for various federally and provincially listed wildlife species including Pacific water shrew, Trowbridge's shrew, red-legged frog and western toad. In addition, retain all or portions of important Wildlife Tree Patches including Stands No. 1, 2 and 7 to provide refuge, food and breeding areas for the western screech-owl and band-tailed pigeon.

  Forested areas within the lower Fergus Creek watershed should be assessed for their importance to wildlife and ranked with the tree patches within Plan Area 2 to determine which tree patches should be given priority for protection.
- Where possible, provide wildlife movement corridors to maintain genetic diversity of wildlife species. Wildlife movement corridors can include riparian habitat areas, treed areas along residential lots, multi-use greenways, the Fergus Creek mainstem/tributaries and associated riparian areas, the "Height-of-Land" from the northwest corner of Plan Area 2, the BC Hydro ROW and the east-west connection to Sam Hill Creek.
- Purchase the lands that contain the proposed "Habitat Preservation Area" located south of 16th Avenue, east of Highway 99 and west of 168th Street. This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew.

- Protect high suitability habitat for other federal and provincial species at risk including field habitat and old buildings for barn and short-eared owls.
- Protect and enhance Class A/B watercourses including their associated streamside protection and enhancement areas.
- Conduct a structured vegetation inventory (spring and summer) to focus on the detection of rare plants and plant communities. If found, protect these areas and provide a suitable buffer to maintain their integrity.

Developer Initiatives

- If clearing is to be conducted during the active bird breeding season, March 1 to August 1, conduct a bird nest survey to ensure that active nests are protected during the breeding season.
- Conduct fish habitat assessments of all Class C watercourses prior to development of each site to ensure that watercourses and their function are accurately classified and appropriate streamside and enhancement areas are protected where applicable.
- Stormwater management for each development site should follow the recommendations of the Fergus Creek Integrated Stormwater Management Plan.
- Review the above report sections: 4.0 Protection Plans, 5.0 Best Management Objectives and Development Guidelines, and 6.0 Enhancement Opportunities, to ensure the effective protection of ecosystem integrity and environmental values and concerns.

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1.0 INTRODUCTION

1.1 Background

As part of the development of the Fergus Creek Integrated Stormwater Management Plan, in south Surrey, ENKON Environmental Limited (ENKON) was retained by the City of Surrey to provide the environmental component of the plan. This report describes the results of environmental surveys conducted in 2005 and 2006.

Integrated watershed planning is grounded in an understanding of the full range of human and ecological uses of the watershed and it ensures that management decisions are made within the context of the entire watershed recognizing the connectivity of its components. An integrated watershed plan is a comprehensive management process that should ultimately lead to the implementation of measures that collectively address potential impacts of future development on the watershed.

Fergus Creek is located in south-central Surrey (Figure 1). The headwaters originate at Highway 99 and 20th Avenue and the creek meanders to the southeast for approximately 4 km prior to discharging into the Little Campbell River near Highway 99 and 8th Avenue (Figure 2). The upper half of the creek flows through residential areas and has been altered through ditching and nearby development. Downstream of the Highway 99 crossing to 168th Street, sections of the creek that flow through 2 golf courses have been channelized, rip-rapped and excavated to form a pond. Previous researchers have divided the creek into 7 reaches with tributaries flowing into the mainstem in reaches 2, 4 and 7.

1.1.1 Previous Environmental Studies

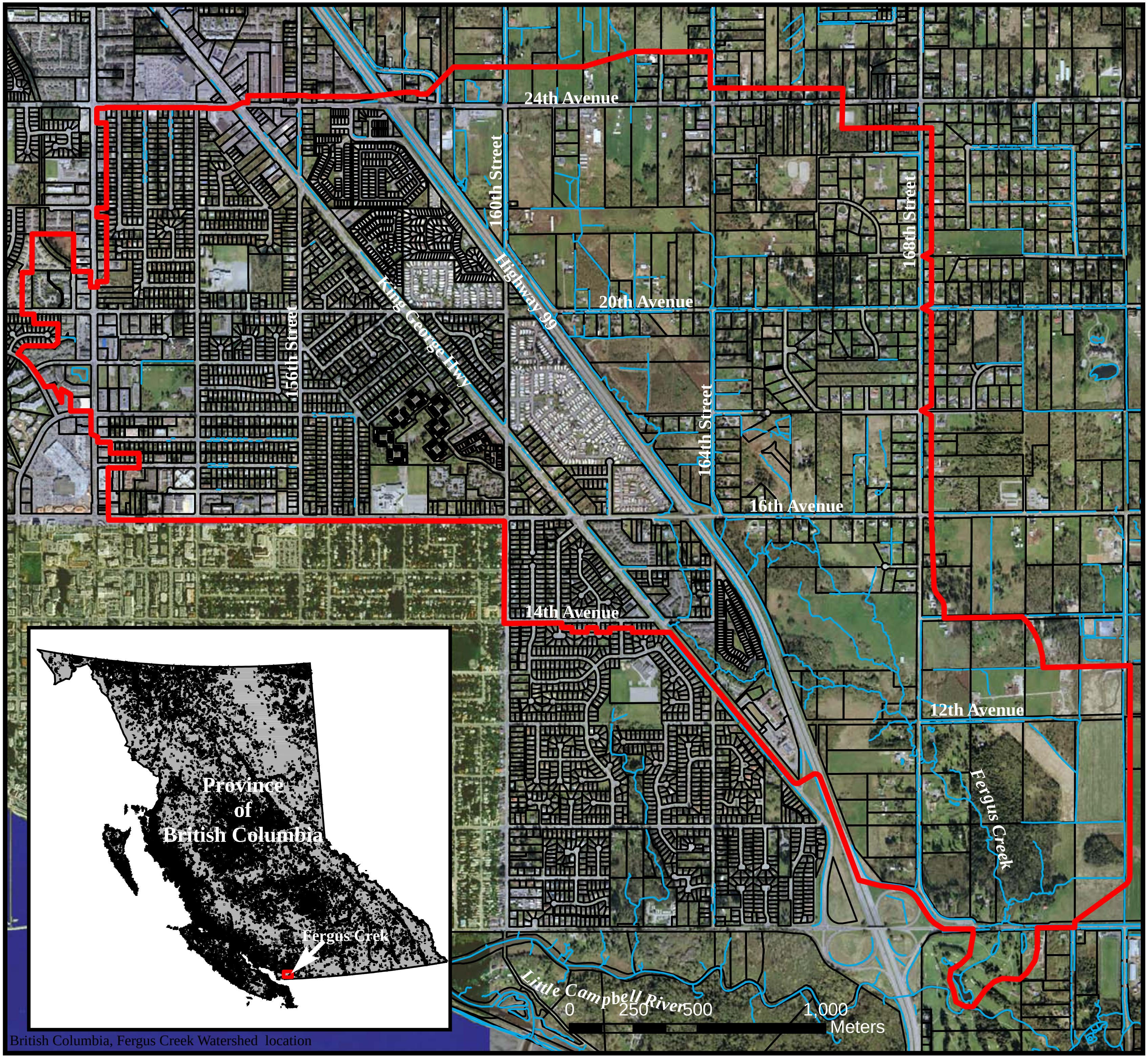
1.1.1.1 Grandview Heights Land Use Plan

(City of Surrey, June 2005)

The Grandview Heights Land Use Plan area is bordered by the BC Hydro Right-of-Way to the west, 28th Avenue to the north, 186th street to the east and 16th avenue to the south.

In June 2005, the City of Surrey prepared the Grandview Heights Land Use Plan concept, which envisaged Grandview Heights as a complete community with a mix of residential densities, small commercial nodes, community facilities, schools, parks, pathways, trees and protected areas (City of Surrey, June 2005).

The pastoral ambiance of Grandview Heights will be maintained through the retention, wherever possible, of watercourses, trees, and vegetation of environmental significance; through respect for the adjacent Agricultural Land Reserve (ALR) by the implementation of significant buffers; through protection of key view corridors of the mountains and the ocean; and through the retention of lower residential densities throughout the central area.



Fergus Creek Watershed Study Location

Figure 1

McElhanney Consulting Services Ltd.

Legend

🟥 Watershed Boundary

— Watershed Course

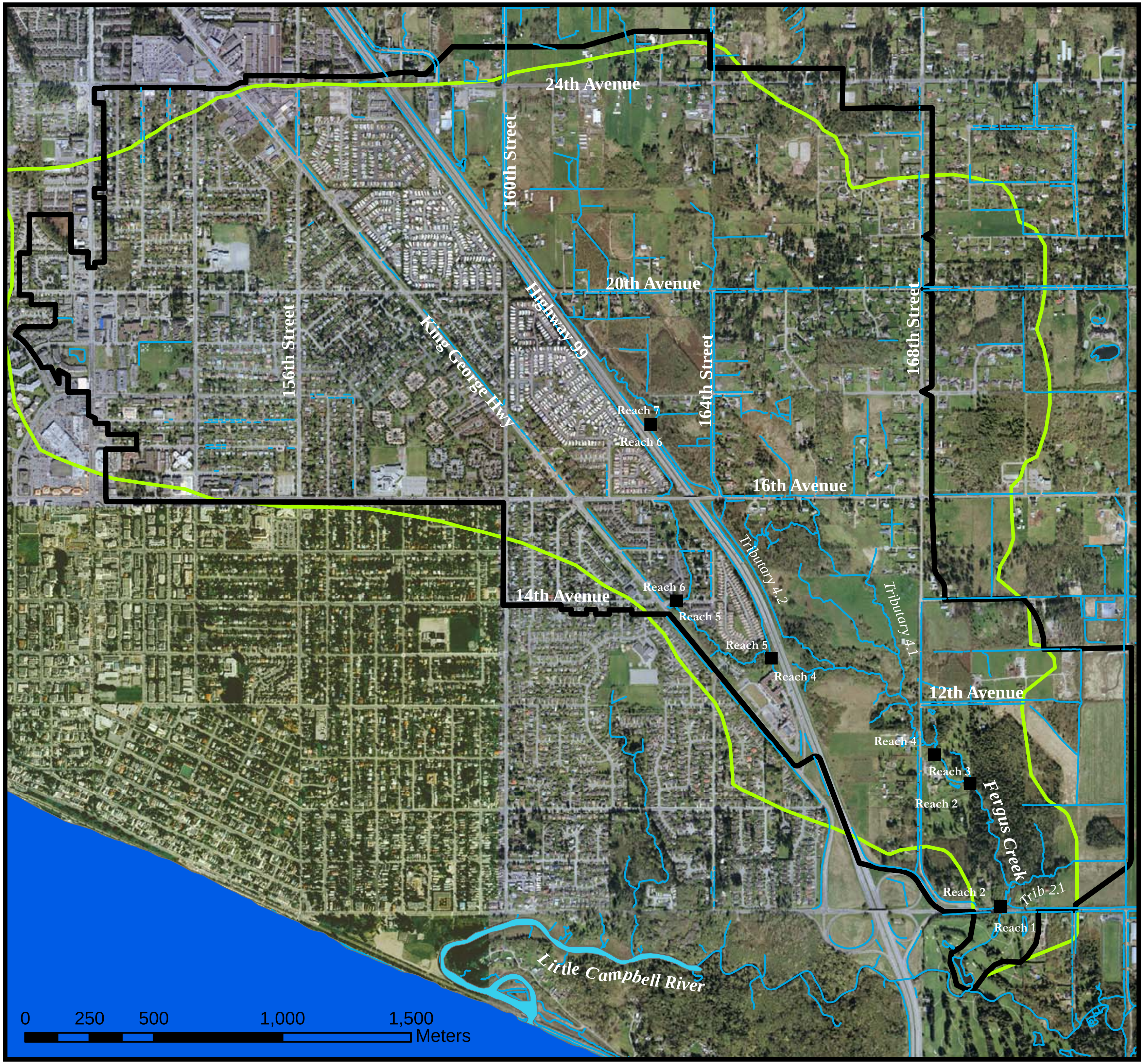
Inset Map

☐ Study location

Scale 1:20000

Map created September 2006

Prepared by: ENKON Environmental Ltd.



Fergus Creek Watershed Boundary

Figure 2

McElhanney Consulting Services Ltd.

Legend

- ■ Reach Breaks
- ━ Watershed Boundary
- ━ Historic (Natural) Watershed
- ─ Watercourse

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Scale 1:20000

Map created: December 2006

Prepared by:
ENKON Environmental Ltd.

A modified grid road system combined with greenways will enable residents to walk or cycle to all of the schools, parks, services and main facilities. The projected population at full build-out, subject to detailed planning and preparation of Neighbourhood Concept Plans under the proposed General Land Use Plan, is expected to be between 20,670 and 32,870 people.

General Environmental Resources

Environmental resource information was identified as part of the general environmental review for the Grandview Heights Plan Area prepared by Envirowest (May 2005).

The Grandview Heights area is drained predominantly by man-made ditches located along roadsides and property boundaries. Relatively few natural channels occur, and are associated with the lower elevation lands near the boundaries of the study area and/or in association with larger undeveloped properties. Almost all of the area's watercourses are ephemeral (seasonally dry) in their upper reaches, although groundwater seepage maintains nominal flow at or near the area boundary. Watercourses of the study area are identified based on mapping provided by the City of Surrey. Verification of watercourses has not been verified with respect to actual presence, location and alignment. Additional (unmapped) watercourses may be present in the study area. Given the relatively small catchment areas and current low density of development in the area, watercourse channels tend to be stable with little or no evidence of problematic erosion within the study area. There are downstream drainage issues which may be associated with manmade watercourses and/or natural processes.

There are few surface water features in the Grandview Heights area, and those that do occur are predominantly man-made. No notable wetlands were observed in the limited field investigations, although wet meadow environments (poorly draining open areas) were recorded on relatively flat sites. Lakes and ponds are common throughout the area but appear to be features constructed to facilitate livestock watering, irrigation or aesthetic/landscaping purposes.

The contribution of groundwater to summertime baseflows in creeks at or beyond the study area boundary appears to be ecologically significant based on observations of flow during dry weather. Local residents in upland areas within the eastern portion of the study area have reported that seepage flow occurs throughout most of the year, causing localized drainage problems. This seepage is likely a reflection of the telluric flow condition. The soil conditions of the area do not support significant groundwater recharge zones (due to the low permeability of soils and subsoils). Static water levels in wells in the Grandview Heights area (reported by Halstead 1986) ranged from about 25 m below ground surface near the boundaries to about 50 m below ground surface at higher elevations in the area. Artesian-flowing wells (groundwater naturally rising to ground surface) occur to the north and south of the study area and no assessment has been made with respect to the source of the water (local or regional).

Fish Habitat

The City's map indicates that the extent of fish-bearing (Class A) watercourses is limited in the Grandview Heights area, consisting only of one short reach of Justin Brook along the northeast boundary of the area. This information has; however, not been verified. Fish access may, in fact, extend further upstream in Justin Brook and in other tributaries of Erickson Creek (along the northeast boundary of the study area) and Sam Hill Creek (along the southern boundary). Class B watercourses are also of relatively limited extent in the area.

Wildlife Habitat

Based on habitat types occurring in the Grandview Heights area, 182 species are considered to inhabit or potentially inhabit the area. These include 10 species of amphibians, 4 species of reptiles, 132 species of birds and 36 species of mammals. All of the amphibians, all of the reptiles, 64 species of birds and 32 species of mammals are considered to be resident or migratory breeders. The others are considered rare migrants and may only occasionally occur in the area. Non-native (introduced) wildlife include 2 species of amphibians, 4 species of birds and 6 species of mammals.

Species of Concern

Among the 182 wildlife species potentially inhabiting the Grandview Heights Plan Area, nine (9) are considered to be "of management concern". These include species with particular designations made by the federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and/or the B.C. Conservation Data Centre (Ministry of Sustainable Resource Management). For the purpose of this report, "species of management concern" include those with COSEWIC designations of "endangered", "threatened" and "special concern" (but do not include those designated as "not at risk") and those designated by the Conservation Data Centre as "red-listed" and "blue-listed" (but do not include those listed as "yellow-listed"). Further, species that are COSEWIC and/or CDC designated, but considered migrants only (i.e. do not breed in the area) are not considered "species of management concern" for this Plan Area. The 9 species that are considered to be of management concern are:

- Great blue heron (*Ardea herodias fannini*)*:* Special Concern, Blue-listed
- Western screech-owl (*Otus kennicottii kennicottii*)*:* Special Concern, Blue-listed
- Barn owl (*Tyto alba*)*:* Special Concern, Blue-listed
- Short-eared owl (*Asio flammeus*): Special Concern, Blue-listed
- Band-tailed pigeon (*Columba fasciata*)*:* Blue-listed
- Pacific water shrew (*Sorex bendirii*)*:* Threatened, Red-listed
- Trowbridge's shrew (*Sorex trowbridgii*)*:* Blue-listed
- Red-legged frog (*Rana aurora*)*:* Special Concern, Blue-listed
- Western toad (*Bufo boreas*)*:* Special Concern, Yellow listed

The Conservation Data Centre (CDC) provided an Element Occurrence Report (EOR) for rare wildlife and vegetation species within 10 km of the Grandview Heights area. This report identified two rare wildlife species as occurring in the Grandview Heights area. Pacific water shrew (*Sorex bendirii*) and Trowbridge's shrew (*Sorex trowbridgii*) were captured in lower Fergus Creek (150 m north of 8th Avenue) in 1992.

Environmentally Sensitive Areas

In general, the Grandview Heights Plan Area contains zones of high sensitivity interspersed amongst the broader area that has been designated medium. A designation of "high" was assigned to areas containing a relatively high number of important ecological features or processes, and/or areas highly susceptible to disturbance. In the Grandview Heights Plan Area, high designations were assigned to areas that correspond generally with the largest blocks of deciduous and coniferous woodland, as well as to the riparian areas. Among the high ESA areas, the three areas identified as significant wildlife habitat areas should be considered to be of the highest ecological value.

Recommendations

- Preserve all natural watercourses and use as integral components of any drainage plan. Maintain streamflow conditions at pre-development conditions. Detailed site surveys should be conducted to confirm the location of all known watercourses and the presence of any additional watercourses;
- Address groundwater recharge (and in some cases groundwater discharge) in site planning and development engineering. Substantial effort should be directed to mitigating the impacts of development on water infiltration to ground. Maintain, or where practical, enhance baseflows to watercourses;
- Assess the (fisheries) classification of all study area watercourses in detail which may involve fish sampling at various times of the year. Both the City of Surrey and Fisheries and Oceans Canada should review watercourse classifications (particularly where changes are proposed);
- Explore opportunities to restore and enhance disturbed watercourses. Retain or enhance some man-made watercourses, and incorporate into developments as ecological and/or aesthetic features;
- Determine the width of riparian setbacks in accordance with legislative requirements current at the time of development, or otherwise in consultation with the City of Surrey and Fisheries and Oceans Canada. Explore opportunities to restore and/or enhance riparian areas;
- Protect adequate habitat areas and enhance within smaller planning zones of the Grandview Heights plan area, to ensure the long-term viability of all resident wildlife species currently inhabiting those planning zones. Particular emphasis should be afforded to species of concern (i.e. red-listed, blue-listed, SARA listed species) that have been confirmed as present, or are considered to be probable inhabitants of the study area;

- Develop wildlife habitat management plans for smaller planning zones taking into account habitat diversity, linkages with habitat features within and beyond the boundaries of the study area, existing and proposed barriers, and boundaries. Habitat management plans should consider watercourses to be key elements, and should compliment other area planning objectives such as preservation of aesthetic features, provision of visual/sound buffers, and maintenance of view corridors;
- Land clearing should not be undertaken during the bird nesting season (generally March 1 through August 1of any year);
- Enclose habitat preservation areas (for fish and/or wildlife) with suitable fencing to prevent development impacts. For wildlife habitat areas adjacent to major roadways, the boundaries should either exclude wildlife movement (onto the roadway) or provide appropriately designed passage facilities to avoid road mortality. Install signage at minor road crossings to inform the public;
- Landscaping for habitat restoration should be based on appropriate assemblages of native plant species, and specific site characteristics such as slope, aspect and soil moisture. Native plant species will better support use by wildlife. Non-native species should be eradicated from natural habitat areas;
- Represent most of the broad vegetation types (preferably as a single, contiguous unit) within smaller planning zones (of the Grandview Heights plan area); and
- Retain trees throughout the Grandview Heights plan area to the greatest extent feasible, thereby supporting the area’s wildlife and maintaining the high aesthetic values associated with established woodlands.

1.1.1.2 Highway 99 Corridor Local Area Plan

(City of Surrey, Planning and Development Department, February 2004)

In February 2004, the City of Surrey Planning and Development Department completed the Highway 99 Corridor Local Area Plan. The Highway 99 Corridor is located in south-central Surrey, and includes the lands generally bounded by Highway 99 to the west, the B.C. Hydro Right-of-Way and 164 Street to the east, 8 Avenue to the south, and the southerly extent of the Rosemary Heights Business Park to the north. To the east of the corridor is the community of Grandview Heights, a largely suburban residential area characterized by single family homes on acreage lots.

Habitat Management Principles

A series of general habitat management principles were developed by ECL Envirowest (January 2004) for the Highway 99 Corridor, as presented below:

- Adhere to the guiding principles of the City of Surrey’s Official Community Plan with respect to the protection of natural areas;

- Adhere to the habitat management policies of DFO and, in particular, address DFO's guiding principle of "No Net Loss of Habitat Productivity" and other requirements of the Federal Fisheries Act;
- Acknowledge and address the confirmed or potential occurrence of wildlife in accordance with the Federal Species at Risk Act;
- Ensure that wildlife, in particular birds, are considered with respect to non-disturbance periods, as required in accordance with both the Provincial Wildlife Act and the Federal Migratory Bird Act;
- Develop a habitat management plan that maximizes habitat diversity within areas to be protected as wildlife habitat;
- Consider linkages with habitat features beyond the boundaries of the Highway 99 Corridor; and
- Consider high value fish habitat as a key component of the habitat management strategy.

Habitat Management Plan

The Highway 99 Corridor includes a variety of habitat features that support resident and migratory populations of fish and wildlife. The Plan Area includes over 40 ha (100 acres) of high value habitat area that will be preserved, enhanced and protected. High quality fish habitat forms the foundation of the habitat protection plan and is supplemented by a mix of upland habitat types that will maintain representation by all wildlife groups currently found in this area.

Fish Habitat

The most significant fish habitat feature within the Corridor is Fergus Creek. The main stem sections of Fergus Creek and several other tributary sections have been designated as Class A habitat in accordance with the City of Surrey's watercourse classification system. These watercourses are inhabited by fish species such as coho salmon and cutthroat trout. Class A habitats must be protected by a minimum setback area of 30 m from commercial and industrial developments, in accordance with DFO guidelines.

A network of Class B watercourses also drains the Highway 99 corridor. Fish do not inhabit these watercourses; however, the Class B watercourses do contribute ecologically to the Class A watercourses located downstream. In the past, DFO has not objected to the principle of developers eliminating Class B habitats on the condition that approved replacement habitats are provided within the same area. Through the planning process for the Highway 99 Corridor, DFO has indicated that it could apply the same principle to the Corridor provided the majority of the enhancement efforts occur within the Corridor area and the replacement habitat is of similar or increased functional value.

Wildlife Habitat

The Highway 99 Corridor contains six general habitat types that include mature riparian forest, mature deciduous forest, pole/sapling deciduous forest, field, rural/suburban developed, and golf course. These habitats reflect varying degrees of urban encroachment but to some degree each supports wildlife communities. A broad range of wildlife, including large and small mammal, raptor and songbird, reptile and amphibian species, currently utilizes the corridor area.

Primary objectives of the habitat management strategy are to preserve representative habitat types and wildlife species currently utilizing the Corridor area, and in particular, to preserve habitat for the provincially red-listed Pacific water shrew, also a threatened species listed in Schedule (1) of the Species at Risk Act (SARA).

Environmental Preservation Areas

To meet the objectives of the habitat management strategy, three general habitat features were recommended to be preserved or established including:

1. A "linear habitat feature" adjacent to Highway 99, extending approximately between the 12 Avenue and 23 Avenue right-of-ways including the upper section of Fergus Creek;
2. Two sections of proposed fisheries "food and nutrient" features to be developed within the BC Hydro right-of-way; and
3. A large "block" of habitat comprising the Fergus Creek ravine and most of the critical wildlife habitat located generally south of 16th Avenue.

The lands associated with the significant environmental features were to be acquired in conjunction with development as landowners/developers dedicate existing areas as fish habitat and additionally, some areas will be purchased by the City as part of the on-going park acquisition program.

1.1.1.3 Fergus Creek Master Drainage Plan Update

(New East Consulting Services, September 2001)

New East Consulting Services Ltd. was retained by the City of Surrey to update the Fergus Creek Drainage Study conducted in 1996. The new study incorporated a larger study boundary than its predecessor, covering an area of approximately 650 ha.

The purpose of the study was to support the development of all developable lands within the study boundary by reviewing the existing drainage infrastructure and making recommendations for future improvements. Other objectives included recommendations for the remediation of erosion sites within Fergus Creek, a verification of the capacity of the existing trunk storm sewer system, and the identification of opportunities to enhance the natural environment and fisheries habitat.

The services of Gartner Lee Limited were retained by New East Consulting Services Ltd. to examine Fergus Creek from an environmental standpoint. Gartner Lee conducted a stream assessment (identifying fisheries habitat, barriers for fish access, and erosion areas) and obtained physical data on creek cross-sections and hydraulic structures. Gartner Lee confirmed that Fergus Creek provides good habitat for salmonids. However access to potential habitat upstream of the Highway 99 south culvert is impeded as the outlet of the culvert is 200 to 300 mm above the downstream water level.

The Habitat and Enhancement branch of the federal Department of Fisheries and Oceans (DFO) were asked to provide comment on the Conceptual Plan. DFO expressed concerns regarding the diversion of water from Fergus Creek because of its potential to interfere with olfactory cues to migrating salmonids. DFO stated that diversion should be the alternative last resort for flood control and would prefer that more consideration be given to the replacement of the south culvert crossing of Highway 99. DFO was also concerned with the proposal for rock weirs within the reaches of Fergus Creek between 14 Avenue and the south crossing of Highway 99. DFO stated that the placement of such weirs may result in an overall loss of existing fish habitat.

1.1.1.4 Finding the Balance: Environmentally Sensitive Areas in Surrey

(Abs et al., 1990)

The main goal of the Environmentally Sensitive Areas study was to provide an extensive information base and effective management tools to assist municipal officials to protect and enhance environmental and heritage resources within the municipality.

The only environmentally sensitive area rated as “high” identified within the Fergus Creek watershed was lower Fergus Creek mainstem south of 16th Avenue. The remainder of the watershed was designated as “low” environmentally sensitive area.

1.1.1.5 Environmental Review of the Grandview Heights Neighbourhood Concept Plan Area 2

(Enkon Environmental Limited, 2006)

As part of the planning process for the Grandview Heights Land Use Plan Area in south Surrey, ENKON Environmental Limited (ENKON) was retained by the City of Surrey to inventory fish, wildlife and vegetation resources and identify any environmentally sensitive areas within the Grandview Heights Neighbourhood Concept Plan Area 2.

No “significant” trees defined and registered in the City of Surrey, Tree Protection By-law are located within Plan Area 2. Seven important stands of wildlife tree patches were identified which likely contain a number of significant trees. Two wildlife movement corridors were identified including along the “Height-of-Land” from the northwest corner of the plan area to the southeast and connecting to Dart’s Hill Garden/Redwood Parks and the BC Hydro ROW along the western boundary of Plan Area 2.

Plan Area 2 contains suitable breeding habitat for four listed bird species including the band-tailed pigeon, barn owl, short-eared owl and western screech-owl, although none were detected during ENKON's 2005 and 2006 surveys. High suitability habitat for Pacific water shrew exists within Wildlife Tree Patch No. 4 and for Trowbridge's shrew within Wildlife Tree Patches #1 and #2. The red-legged frog has the potential to occur within the mixed forest of Wildlife Tree Patch No. 4, while the western toad could potentially occur within the mature coniferous/mixed forest of Wildlife Tree Patches No. 1 and 2.

None of the 46 plant species listed as blue- or red-listed in the CDC Tracking List were observed during vegetation surveys, however, there have not been structured vegetation surveys conducted to confirm their presence or absence in Plan Area 2.

There are no Class A or A(O) and four Class B watercourses within Plan Area 2. ENKON recommended that a number of Class B/C watercourses be re-classified or re-mapped. For preliminary planning purposes, the City of Surrey directed ENKON to assess streamside protection and enhancement areas (i.e. setbacks) for Class B watercourse following an adaptation of the Simple Assessment Methodology of the Riparian Areas Regulations (RAR). Given the vegetation categories, the non-fish bearing status and the permanent flow conditions, the resulting SPEA widths for all Class B watercourses assessed for Plan Area 2 are 30m from top-of-bank. Although Class C watercourses were not evaluated, it is anticipated that detailed assessments would be conducted on each Class C watercourse during the development application phase of individual sites, to confirm the watercourse classification and determine the appropriate streamside protection and enhancement area. This preliminary assessment does not preclude the potential for a developer of a site to negotiate different SPEA's in consultation with the Department of Fisheries and Oceans and the City of Surrey or if new legislation is implemented in the future.

Environmentally sensitive areas included high suitability habitat for listed wildlife species, seven important stands of wildlife tree patches, two potential wildlife movement corridors and Class B watercourses.

ENKON recommended a number of potential fish and wildlife habitat enhancement opportunities and best management objectives and development guidelines to protect environmentally sensitive areas and guide future development in Plan Area 2.

1.2 Purpose

The purpose of the environmental assessments in the Fergus Creek watershed was to provide the environmental component of the overall Fergus Creek Integrated Stormwater Management Plan, and to identify fish, wildlife and vegetation resources and any environmentally sensitive areas within the watershed. The specific objectives of the "Information Review and Goals" phase of ENKON's work program were to compile environmental resource information on the Fergus Creek watershed, identify objectives and goals of the Integrated Stormwater Management Plan, and then identify data, criteria or objective gaps and potential sources to supplement gaps. Based on ENKON's review of the existing environmental information available from previous studies on Fergus

Creek, ENKON filled in data gaps "Data Collection and Analysis Phase" to meet the "minimum effort" requirement of the Greater Vancouver Regional District's Terms of Reference for ISMP. The results of ENKON's field surveys combined with existing information from previous researchers was used to identify constraints/opportunities for development and recommend mitigation/enhancement options to address existing and future development impacts on Fergus Creek.

There is a focus within this report on the Grandview Heights Neighbourhood Concept Plan Area 2 within the Fergus Creek watershed due to the fact that there has been considerably more information gathered to facilitate the planning process for the Grandview Heights Land Use Plan Area. Work required specifically within Plan Area 2 included:

- Surveys to verify watercourse locations and classifications according to the City of Surrey's Watercourse Classification System (COMOS);
- Small mammal, owl call playback and amphibian surveys to supplement the Fergus Creek Integrated Stormwater Management Plan environmental studies and determine the presence and/or potential of protected rare species of plants and animals;
- Vegetation surveys to identify significant trees, important wildlife tree patches and wildlife movement corridors;
- Identification of environmentally sensitive fish and wildlife habitat; and
- Recommendations for enhancement opportunities, best management practices and development guidelines to guide future development.

2.0 METHODOLOGY

2.1 Literature Review

Historical environmental studies of the Fergus Creek watershed that ENKON Environmental Limited reviewed included but were not limited to:

- Conservation Data Centre's (CDC) Rare Element Occurrence Report for the Fergus Creek watershed and the CDC Tracking Lists for rare vertebrates, plants and plant communities in the Chilliwack Forest District;
- Fergus Creek Master Drainage Plan Update (New East Consulting Services, 2001);
- Fergus Creek Master Drainage Plan (New East Consulting Services, 1996);
- Highway 99 Corridor, Local Area Plan. Planning and Development Department, City of Surrey, BC (City of Surrey. 2004);
- City of Surrey Finding the Balance: Environmentally Sensitive Areas Study (Abs et al., 1990);
- Department of Fisheries and Oceans/Ministry of Environment’s FISS database;
- Environmental Review of the Grandview Heights Neighbourhood Concept Plan Area 2 (ENKON Environmental Limited, 2006);
- Species and Ecosystems Explorer. 2006. Conservation Data Centre (CDC), Rare Element Occurrence Report and rare species list records;
- Fergus Creek Biophysical Assessment and Identification of Enhancement Opportunities (Envirowest 1994);
- General Environmental Review For The Grandview Heights Plan Area, Surrey, BC (Envirowest May 2005);
- Grandview Heights General Land Use Plan (City of Surrey, 2005)
- Environmental Impact Assessment Report Grandview Heights #1 NCP Phase 2. (Phoenix Environmental Services Ltd., 2005);
- Sensitive Habitat Inventory Mapping Project (Little Campbell River System, Surrey, 2002); and
- Information on Zoning, Land Use, Land Ownership, Topographic Maps, etc.

2.2 Terrestrial Resources

2.2.1 Vegetation

Vegetation sampling was conducted concurrently with wildlife surveys incorporating the "Intuitive Controlled Survey Method" used in the Pacific Northwest by the U.S. Bureau of Land Management. It is described as a method to "survey and manage" [rare] plant species and includes a comprehensive assessment of the habitats with the highest potential to support rare plant species.

The surveyors traversed the project area to record plants species in a representative cross section of all the major habitat types and topographic features. Surveys focused on the presence of target listed plant species while travelling between different survey areas. All vascular plant and major bryophyte species sighted were recorded.

Vegetation cover assessment was based on available orthophoto analysis. Vegetation types were classified based on dominant cover as dictated by colour, tone and texture interpreted from orthophotos. Six general habitat types were delineated which include:

1. Coniferous
2. Deciduous
3. Mixed
4. Pole-sapling
5. Field
6. Road/Rural/Suburban Developed

Areas classified as rural/suburban developed frequently include vegetated areas such as landscaped yards, ornamental tree cover and maintained lawns. Significant patches of tree cover were classified separately wherever possible; however, it should be noted that the rural/suburban developed classification will frequently include areas of permeable surfaces. Field areas are primarily large agricultural fields; however, within the rural areas to the west of highway 99, several sports fields were included within the classification of field despite their obvious differences.

2.3 Wildlife

A total of eight wildlife surveys were conducted during the summer and winter of 2005, and the spring of 2006 (Table 1) to assess the presence of federally and provincially listed species, various other species of raptors, small mammals, reptiles and amphibians.

Table 1 Wildlife Surveys Conducted within the Fergus Creek Watershed during 2005/2006

Survey Conducted	Date
Raptor surveys to identify habitat use by federally and provincially listed bird species	July 6, 2005 December 8 and 12, 2005 January 23 - 24, 2006
Small Mammal live trapping to identify habitat use by federally and provincially listed small mammals	August 3 - 5, 2005 March 13, 2006
Reptile and Amphibian surveys to identify habitat use by federally and provincially listed reptiles and amphibians	July 6, 2005 August 3 - 5, 2005 February 22, 2006

Wildlife inventories focused on those federally or provincially listed species that have the potential to occur within the Fergus Creek watershed. From environmental assessments already conducted in Grandview Heights, the Fergus Creek watershed area, Highway 99 corridor, and information derived from the Conservation Data Centre's (CDC) Rare Species Tracking List, Rare Element Occurrence Report, and Schedule 1 of the federal Species at Risk Act, the wildlife species of concern likely to occur within the Fergus Creek watershed are:

- Great blue heron (*Ardea herodias fannini*)*:* Special Concern, Blue-listed
- Western screech-owl (*Otus kennicottii kennicottii*)*:* Special Concern, Blue-listed
- Barn owl (*Tyto alba*)*:* Special Concern, Blue-listed
- Short-eared owl (*Asio flammeus*): Special Concern, Blue-listed
- Band-tailed pigeon (*Columba fasciata*)*:* Blue-listed
- Pacific water shrew (*Sorex bendirii*)*:* Threatened, Red-listed
- Trowbridge's shrew (*Sorex trowbridgii*)*:* Blue-listed
- Red-legged frog (*Rana aurora*)*:* Special Concern, Blue-listed
- Western toad (*Bufo boreas*)*:* Special Concern, Yellow listed

All wildlife surveys were conducted according to the respective provincial Resources Information Standards Committee (RISC) survey protocols including:

- Inventory Methods for Raptors: Standards for Components of British Columbia's Biodiversity No. 11 (Version 2.0).
- Inventory Methods for Colonial-Nesting Freshwater Birds: Standards for Components of British Columbia's Biodiversity No. 8 (Version 2.0).

- Inventory Methods for Pond-breeding Amphibians and Painted Turtle: Standards for Components of British Columbia's Biodiversity No. 37 (Version 2.0).
- Inventory Methods for Tailed Frogs and Pacific Giant Salamanders: Standards for Components of British Columbia's Biodiversity No. 39 (Version 2.0).
- Inventory Methods for Small Mammals: Shrews, Voles, Mice & Rats Standards for Components of British Columbia's Biodiversity, No. 31.
- Species Inventory Fundamentals: Standards for Components of British Columbia's Biodiversity No. 1 (Version 2.0).
- Vegetation Resources Inventory Ground Sampling Procedures Version 4.5.

Survey protocol was adjusted where appropriate to include the relevant provincial Best Management Practices including:

- Environmental Best Management Practices for Urban and Rural Land Development in British Columbia.
- Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia.
- Best Management Practices for Raptors in Urban and Rural Environments in British Columbia.

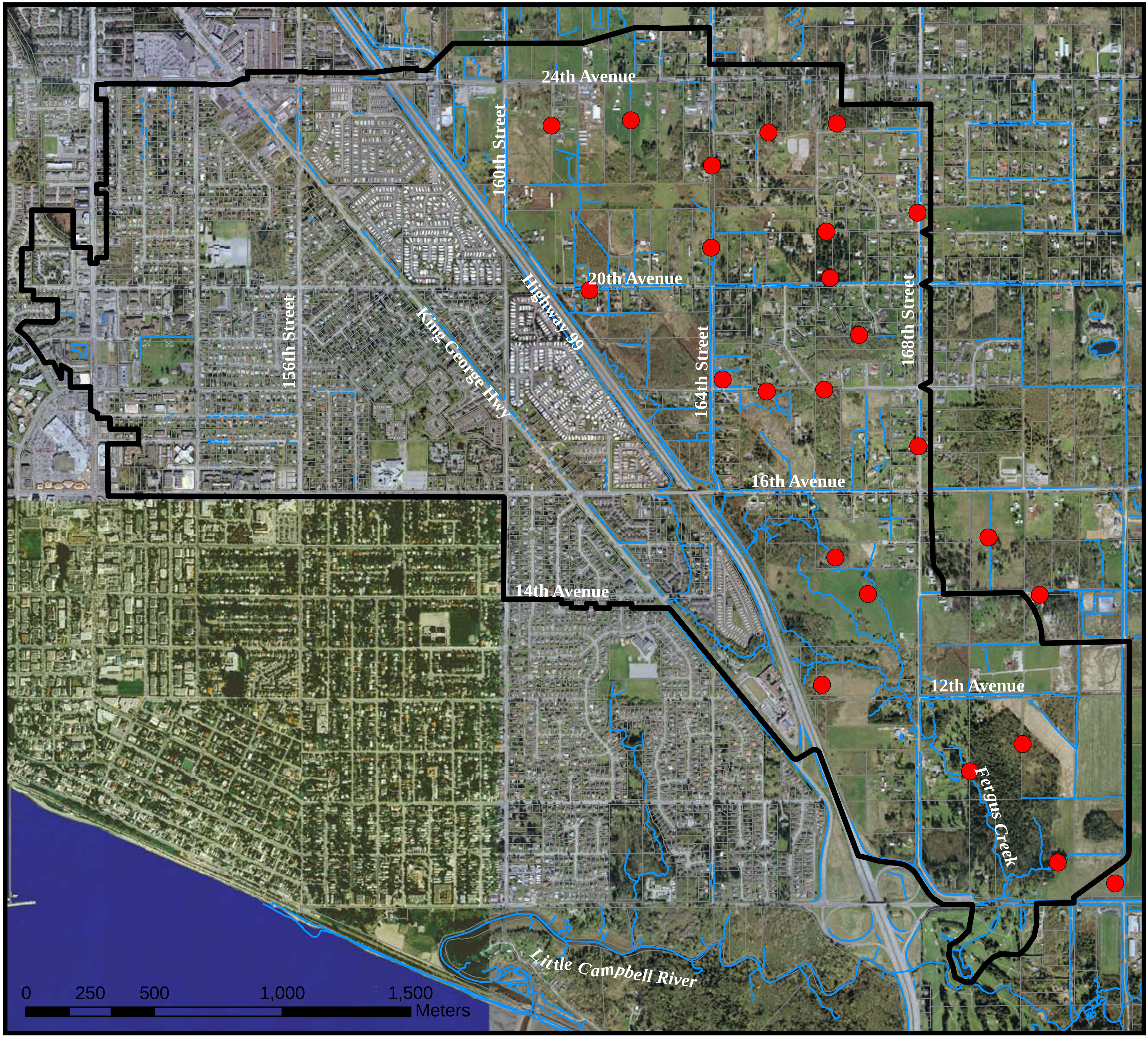
The following sections provide details of survey methodologies.

2.3.1 Bird Surveys

Raptors call to identify themselves, establish and defend territories and to attract mates. The call playback survey technique takes advantage of this by effectively putting an "intruder" into an already claimed territory. The response of the bird can be either behavioural (visual) and/or vocal allowing the observer to record the presence of the bird.

In July 2005, encounter (foot) surveys were conducted during daylight hours along Fergus Creek watershed’s established trails and within vegetated areas (Figure 3). The objective was to investigate the presence of breeding raptor and/or herons and locate nests, specifically species that are of federal and provincial concern: great blue heron (*Ardea herodias fannini*), barn owl (*Tyto alba*), short-eared owl (*Asio flammeus*), western screech-owl (*Ottus kennicotti kennicotti*), and band-tailed pigeon (*Columba fasciata*) (Appendix C and D). Survey transect routes were stratified with the study area to obtain data from representative habitats. Based on audio and visual observations, raptor species were classified as “present” or “not detected.” Observers scanned areas along transect routes for the presence of bird nests. Incidental observations of other bird species were also recorded.

Owl call playback surveys were conducted in during nocturnal hours in December, 2005 and January, 2006 along established roads, trails, forests and open fields to locate and



Nocturnal Raptor Call Playback Survey Locations

Figure 3

McElhanney Consulting Services Ltd.

Legend

▬ Watershed Boundary

● Owl Call Playback

— Watercourse

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON Environmental Ltd.

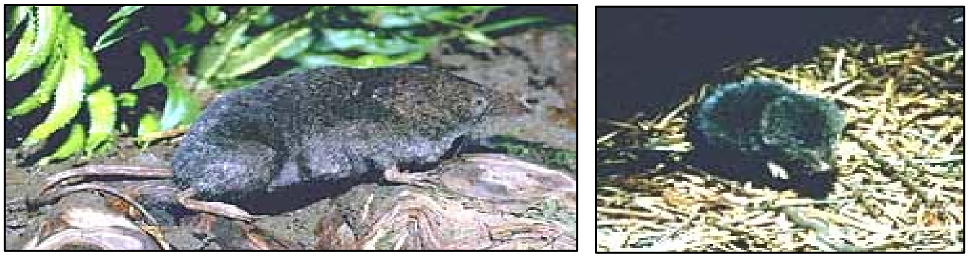
verify raptor use of the area. The surveys focussed on riparian and upland forested habitats, and open grassy areas. Target species of concern were the blue-listed western screech-owl, short-eared owl and barn owl (Photograph 1).

Photograph 1 Western Screech-Owl (*Otus kennicottii*), Barn Owl (*Tyto alba*) and Short-eared Owl (*Asio flammeus*) from left to right, respectively.

Call points were stratified whenever possible to obtain representative breeding and foraging habitat areas and to maximize an overview of the area. Based on response detections and visual and auditory observations, the occurrences of raptor species were classified as "present" or "not detected." Observers would arrive at a station, record the GPS location, general habitat conditions, incidental sightings of other wildlife and interference sounds such as dogs, traffic, etc., and any raptor sign such as prey remains, and whitewash (feces). Before broadcasting calls, observers would wait 2 minutes to allow disturbance to dissipate, to detect any unsolicited calls, and look for perched birds. Calls were played in the following order, 3 species at each station: western screech-owl, barn owl, and short-eared owl. Each species call was broadcast for 30 seconds at each of three 120 degree turns with 30 second listening intervals, followed by a 5 minute scan to detect the presence of owls. Responses by or detections of all raptor species were recorded.

2.3.2 Small Mammal Surveys

Permits to conduct small mammal trapping were obtained from the Ministry of Environment for the period of July 26 to August 31, 2005 and February 20 to March 15, 2006 (Appendix F) and focused on surveys of 2 provincially listed species (Appendix C) includng Pacific water shrew *(Sorex Bendirii*) and Trowbridge's shrew (*Sorex trowbridgii*) (Photograph 2).



Photograph 2 Pacific Water Shrew (*Sorex bendirii*) and Trowbridge's Shrew (*Sorex trowbridgii*) from left to right, respectively

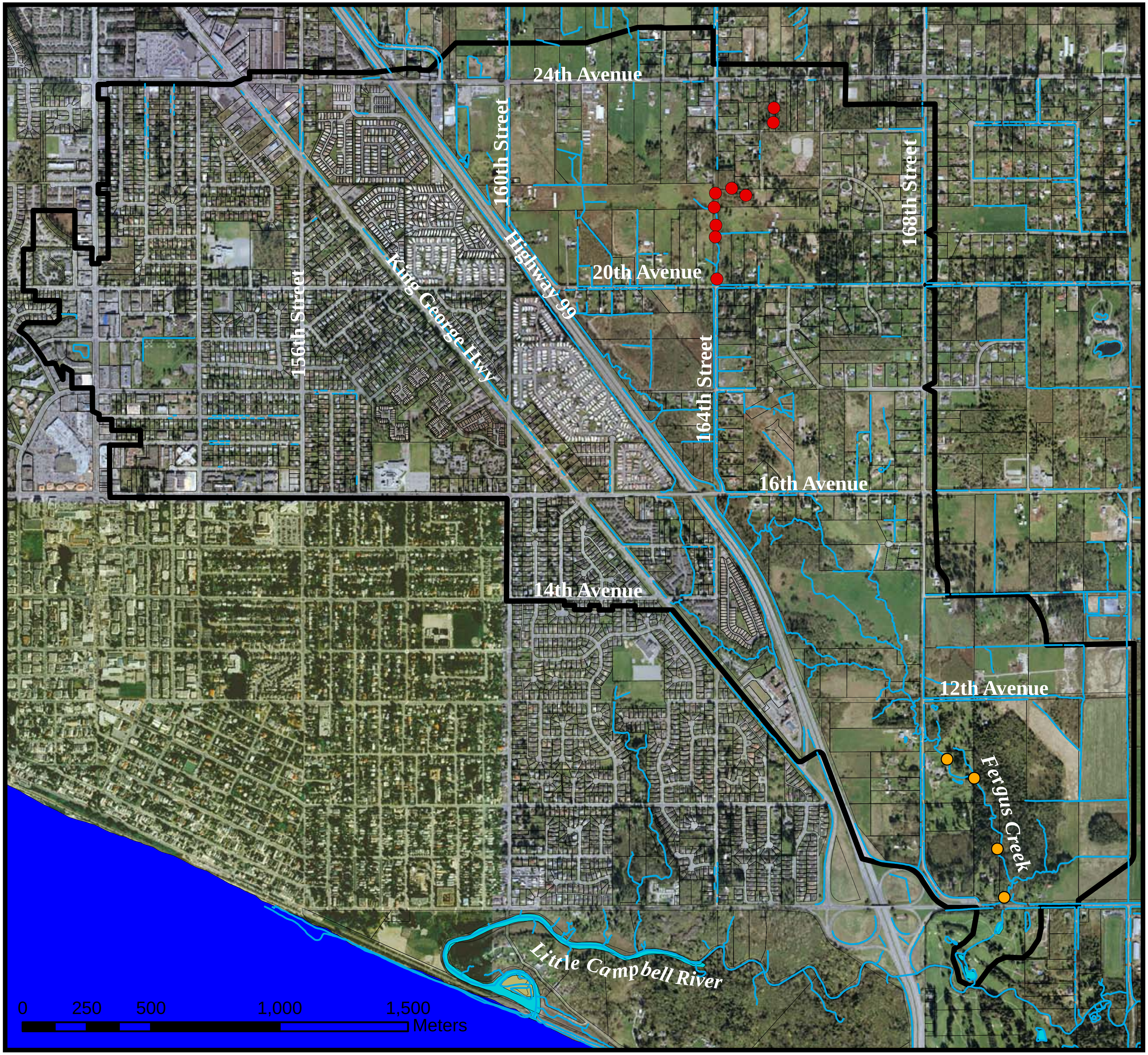
Provincially red-listed Pacific water shrews require aquatic habitat for feeding and surveys with capture success have generally located animals within 60 meters of the water's edge (RISC 1998b) in mature forest. Blue-listed Trowbridge's shrews require moist, mature forest habitat, primarily coniferous. Thus, to maximize sampling for this species, pitfall capture stations were located within 1 m from the water's edge adjacent to creeks and in wetted areas (Photograph 3: Figure 4) in both linear transect (single traps ≥ 60 m apart) and radial (3 traps at 120 degrees and 3 m from centre trap, ≥60 m apart) layout depending on site conditions. Longworth and Sherman traps were placed 2 m from pitfall traps at most stations (Figure 4: Photograph 3). The trap locations were marked with flagging tape and recorded on a hand-held GPS unit.

Pitfall traps consisted of a large, round, plastic container (height 20 cm, diameter 11 cm) each dug securely into the ground with the rim flush to the ground. Oversize lids were set above the container with clothespins to protect traps from rain and exposure. Bedding material made of cotton balls provided cover and warmth, and small pieces of foam and sponge prevented mortality from potential inflow of water. Each was baited with cat food and walnuts.

Longworth-style traps and 8 Sherman traps were placed in a cross-section of forest and shrub habitat across the entire study area. Traps were placed in clear plastic bags, open at the trap entrance, before being placed under cover of vegetation or woody debris. This provided shelter from wind and water. They were baited with peanut butter and oatmeal, carrots, lettuce and/or cat food and walnuts. Bedding material was also added for warmth.

Surveyors returned to the capture stations at 2-hour trapping intervals to inspect each Longworth, Sherman and pitfall trap for captured small mammals. All animal species captured were identified and recorded. To minimize mortalities, additional food was left for the released individuals. Upon completion of the survey, the flagging tape and small mammal traps were removed from the study site, soil pits were filled in, and an effort was made to ensure minimal disturbance to the microsite.

Photograph 3 Open Pitffall and Sherman Traps from left to right, respectively



Small Mammal Trap Locations 2005-2006

Figure 4

McElhanney Consulting Services Ltd.

Legend

- ▬ Watershed Boundary
- 🔴 2006 Trap Locations
- 🟠 2005 Trap Locations
- ─ Watercourse

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON
Environmental Ltd.

2.3.3 Herptile Surveys

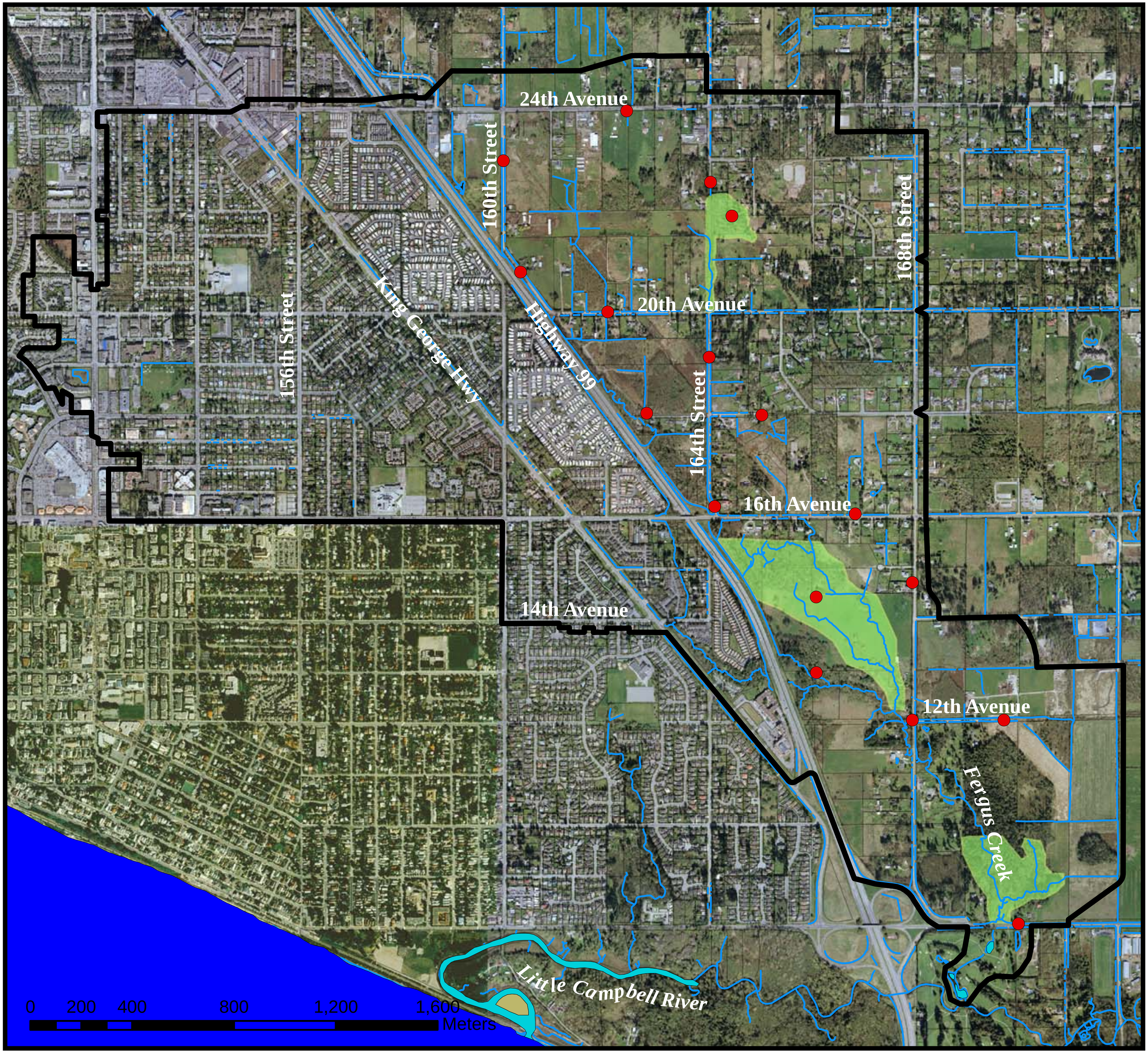
Amphibian surveys focused on 2 species (Appendix C and D) including the provincially blue-listed red-legged frog and a federal species of concern, the western toad (Photograph 4).

Photograph 4 Red-legged Frog (*Rana aurora*) and Western Toad (*Bufo boreas*) from left to right, respectively

Visual encounter surveys and systematic road transects for amphibians focused on riparian and wet upland forested areas, especially areas with vernal pools. Visual encounter surveys entailed daytime intensive searches of areas that were considered potentially high quality microhabitats such as the riparian area between 20th and 24th Avenue at 164th Street within Plan Area 2 and along Fergus Creek and the associated creeks and wetlands within the watershed (Figure 5).

Diurnal amphibian surveys consisted of examining the water's edge for the presence of adults, back eddies for the presence of tadpoles and searching aquatic vegetation and under logs and debris adjacent to the creek and wet forested sites. Outside their breeding season, amphibians disperse from shallow ponds or pooled water into moist areas of the forest. Due to their inconspicuous nature, systematic searches of their natural winter cover at random sites included investigating the ground beneath dense low shrubbery, rocks and logs in order to detect individuals. These cover areas were returned to their original condition in order to ensure that the microclimate was not significantly altered. Both species are more active at night and therefore nocturnal road surveys were conducted after sunset. Roads were surveyed just after twilight with auditory survey stations at 0.5 km intervals. Roads were traveled at low speeds using low headlight beams and flashlights to detect moving animals or road kills. Surveys were conducted in warm, wet conditions in order to increase the chance of detection. Incidental sightings of other herptile species were recorded

Surveys of reptile natural habitat cover and microhabitats were conducted under warm and sunny conditions in order to increase the chance of detection. The underside of rocks and logs were flipped over in order to inspect for hiding individuals after which they were returned to their original positions so as not to alter the cover microclimate.



Fergus Watershed Amphibian Surveys

Figure 5

McElhanney Consulting Services Ltd.

Legend

- ▬ Watershed Boundary
- ● Amphibian auditory survey
- 🟩 Amphibian intensive survey
- ─ Watercourse

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON Environmental Ltd.

2.3.4 Species of Concern

Animal species listed in the Species at Risk Act Registry (Appendix C) or the Data Conservation Centre (CDC) tracking lists (i.e. red- and blue-listed species) (Appendix C) were evaluated for their potential to occur in the Fergus Creek watershed. ENKON also acquired the relevant records of plant species and communities to confirm their presence/absence where possible (see Appendix E).

Critical habitat for provincially red- and blue-listed wildlife species and federally listed wildlife species at risk that could potentially be found within the Fergus Creek watershed was mapped based on vegetation classifications and the following basic life history requirements of each of the listed species (Table 2).

Great blue heron	o Forest – mature coniferous, deciduous, and mixed (nesting habitat) o Riparian – creeks, ponds, reservoirs (foraging habitat) o Field, pasture (foraging habitat)
Barn owl	o Field, pasture, (foraging habitat) o Urban sheds, barns, large tree cavities (nesting habitat)
Short-eared owl	o Field, clearings (foraging and nesting habitat)
Western screech-owl	o Forest – coniferous, deciduous and mixed, all ages (foraging and nesting habitat)
Band-tailed Pigeon	o Forest - mature coniferous (foraging and nesting habitat)
Trowbridge's Shrew	o Forest – mature coniferous and mixed (foraging and nesting habitat)
Pacific Water Shrew	o Forest – mature riparian forest habitat within 60 m of non-ephemeral creek edge (foraging and nesting habitat)
Red-legged Frog	o Riparian – slow moving, non-ephemeral with emergent vegetation (breeding habitat) o Adjacent Forest – mature coniferous, deciduous, and mixed within 100 m of creek edge (non-breeding habitat)
Western Toad	o Forest – moist coniferous, deciduous and mixed, all ages (foraging and hibernating habitat) o Field, clearings – moist soil, rodent burrows (foraging and hibernating habitat) o Riparian – shallow ponds and pools, slow-moving streams (breeding habitat)

Table 2 Habitat Suitability Relevant to Listed Species Potentially Occurring within the Fergus Creek Watershed

Status	Species	Coniferous	Mixed	Deciduous	Pole-Sapling	Field	Rural/ Suburban Developed
Blue	Great Blue Heron	X	X	X		X	
Blue	Short-eared Owl					X	
Blue	Barn Owl					X	X
Blue	Western Screech-owl	X	X	X			
Blue	Band-tailed Pigeon	X					
Red	Pacific Water Shrew	X	X	X			
Blue	Trowbridge's Shrew	X	X				
Blue	Red-legged Frog	X	X	X	X		
Species of Concern	Western Toad	X	X	X	X	X	

2.3.5 Incidental Wildlife Observations

All incidental audio-visual observations of wildlife, wildlife sign (scat, tracks, hair, browse and excavations) and sensitive wildlife habitat were documented throughout transect and survey locations. Overall wildlife assessment included identification of large mammals, small mammals, reptiles, amphibians and birds as well as assessment of the quality and quantity of wildlife habitat, identification of mitigation and enhancement opportunities, and areas to be protected.

2.3.6 Wildlife Movement Corridors

Determination of optimal wildlife movement corridor width is complicated by factors such as the difference in habitat values in the available linear landscape, the differing needs of plant and animals using the corridor, the influence of disturbances from outside the corridor and the long-term management and stability of the corridor within the surrounding urban matrix. Some species such as black-tailed deer and coyotes prefer corridors and riparian areas to move through the landscape, but will occasionally move into the open. Other smaller animals such as frogs and birds may be entirely dependent on wildlife corridors for cover while moving within their range.

Terrestrial corridors designed to facilitate species movement should be a minimum of 50 to 100 m in width to facilitate movement for common generalist species, depending on habitat quality, while stream corridor widths of at least 75 m are recommended to support breeding birds. Vegetation composition should be representative of the natural vegetation for the region. A corridor of 30 m in width will support 90% of natural streamside plant species diversity.

Connectivity analyses were completed for the overall Fergus Creek Watershed and important wildlife movement corridors were identified. Additional field surveys were conducted to identify high value riparian buffer and forest patches which provide connectivity between habitat patches.

2.4 Aquatic Resources

2.4.1 Watercourse Classifications

Information taken from City of Surrey datasets from January 2005 show:

- Previous fisheries and biophysical assessments conducted by Gartner Lee for Stream Reaches 4 – 7 (2000).
- Prior surveys were conducted by ECL Envirowest (1994) for Stream Reaches 1 – 7.
- All work focused on the mainstem only, no detailed surveys of tributaries were conducted with cursory references to Tributaries 4.1, 4.2 and 7.1.

The watershed boundary and vegetation classification for the study area was based on the major drainage catchments as provided in City of Surrey data base. The western and northern boundaries are based on the study area boundaries given by New East Consulting. Due to the expansion of the study area to encompass the lower (southeast) portions of Fergus and its tributaries, available contour and stormwater drainage information was utilized to construct a new preliminary watershed boundary. The watershed boundary utilized was provided by McElhanney Consulting Services for the purposes of this assessment. These boundaries may require modification as more information comes available with respect to the existing stormwater drainage system.

Preliminary surveys indicated that the classification of tributaries may require revision due to changes to local hydrology associated with land use, presence of natural barriers, or incorrect mapping and classification.

Based on the habitat surveys conducted by other researchers noted above and ENKON surveys conducted in 2005 and 2006, ENKON classified the watercourses within the Fergus Creek watershed according to the definitions in the City of Surrey's Nicomekl/Serpentine Lowlands Fisheries Watercourse Classification System based on available GIS data for the City of Surrey (COSMOS), and information gathered during ENKON's field surveys. As per the City's classification system, watercourses were ranked as follows:

1. Class A (Solid red code) - Inhabited by salmonids year round or potentially inhabited year round

2. Class A(O) (Dash red code) – Inhabited by salmonids primarily during the overwintering period or potentially inhabited during the overwintering period with access enhancement
3. Class B (Yellow code) – Significant food/nutrient value, no fish present
4. Class C (Green code) – Insignificant food/nutrient value, no fish present

Class A, A(O) and B watercourse are regulated under the federal Fisheries Act and as such require the Department of Fisheries and Oceans approval for any modification of instream or riparian habitat. Class C watercourses may or may not be regulated under the Fisheries Act and will require more detailed examination during any development permit approval process to determine their significance to the Department of Fisheries and Oceans and the City of Surrey.

It should be noted that, although ENKON has classified watercourses within the Fergus Creek watershed, time constraints did not allow for all watercourses to be examined in the field. Therefore, during the development permit approval process, further inspection of some watercourses (i.e. particularly Class C watercourses) may be required to verify the accuracy of the classification system. ENKON has recommended re-classification of some watercourses based on field inspections. No field sampling was conducted for re-assessment of fish distribution. Fish distribution information remains based on previous surveys conducted by ECL Envirowest Limited (1994), Gartner Lee Limited (2000) and available FISS database information (Province of BC, 2001)

Based on discussions with Fisheries and Oceans Canada (DFO), concerns regarding potential re-classifications which “downgrade” classes (i.e. Class B to Class C) were identified. Due to the watercourse classification scheme utilized by the City of Surrey, Class C watercourses, which are defined as those with no fish presence and insignificant food and nutrient contribution, DFO identified concerns as Class C watercourses are frequently assumed to equate to non-fish habitat. To acknowledge DFO’s concerns the downgrading Class B streams to Class C would require a comprehensive rationale to warrant consideration as Class C, acknowledging that at the planning level, many Class C streams may not be considered for protection, despite the aforementioned recommendation that all watercourses would require a more detailed and comprehensive assessment for reclassification at the development permit stage.

As such, recommendations for Class C re-classifications are limited to areas clearly identified in the field as having no significant food and nutrient or flow contribution to downstream watercourses. This definition, based on communication with DFO limits the proposed reclassifications to those areas found to either not exist in the field, lack a defined channel or visible watercourse and which were confirmed to have no direct downstream contribution to downstream aquatic resources. It should be noted, that based on the current classification system, the classifications include no provision for the permanence of a watercourse and ephemeral drainages are considered to provide potentially significant food and nutrient contributions.

The above rationale acknowledges that many Class B watercourses as classified by the City of Surrey do not contribute significant volumes of flow and are largely the result of anthropogenic influence or contemporary land use (i.e. manmade drainage ditches within agricultural fields or at property line boundaries). Ditches or poorly defined natural swales may not have typical physical indicators of fluvial erosion, but frequently contain hydrophilic vegetation suggesting frequent saturation; however, provide no indication of significant or sustained flows. Such ditches which would be best characterized as providing insignificant flow (i.e. ephemeral only) and insignificant food and nutrient contribution are retained as Class B for the purposes of this assessment.

2.4.2 Preliminary Streamside Protection and Enhancement Areas

For preliminary planning purposes, the City of Surrey directed ENKON to assess "Streamside Protection and Enhancement Areas" (SPEAs: i.e. setbacks) for Class A and B watercourses following an adaptation of the Simple Assessment Methodology of the Riparian Areas Regulations (RAR) as follows.

1. Determine the assessment area/segment length
   - Reach breaks (e.g. gradient change, confluence)
   - Culverts
   - Road intersections

2. Define Transects
   - Total length of segment/assessment area divided into 11 equal segments
   - Draw a transect at each divider distance that is 30 m in length on both sides of the watercourse

3. Measure Distance to Permanent Structures
   - Make 11 measurements to permanent structures such as houses
   - Calculate the average of the widths between the watercourse and each permanent structure
   - Measure on both sides of the watercourse, but only on one side if the watercourse is bounded by a road.

4. Determine Vegetation Category
   - Use average width to determine the Vegetation Category

5. Determine the setback from Table 3 of the RAR Simple Assessment methodology

6. Where a range in the setback is applicable, the setback width will be derived by the average width of the areas between the watercourse and permanent structures within the given assessment area or segment.

7. This approach will result in a setback determination based on general land use in the area, as distinct from site-specific determinations of individual lots or assemblies.

Table 3 Riparian Areas Regulation "Simple Assessment Methodology" Streamside Protection and Enhancement Area (SPEAs) Widths

Vegetation Category	**Streamside Protection and Enhancement Area Width (m)**		
	Fish Bearing	Non-Fish Bearing	
		Permanent	Non-Permanent
Category 1 (Average of greater than 15m wide)	30m	30m	- Minimum 15m - Maximum 30m
Category 2 (Average 10-15m wide)	- Minimum 15m - Maximum 30m	15m	
Category 3 (Average of less than 10m wide)	15m	- Minimum 5m - Maximum 15m	

In relation to the watercourses within the Fergus Creek watershed, preliminary SPEA's have been defined for Class A and B watercourses only to provide a planning tool for development sites. Due to budget constraints, Class C watercourses were not evaluated. However, it is anticipated that detailed assessments would be made of each Class C watercourse during the development application phase of individual sites to confirm the watercourse classification and determine the appropriate streamside protection and enhancement area. It also doesn't preclude the potential for a developer of a site to negotiate different SPEA's in consultation with the Department of Fisheries and Oceans and the City of Surrey or if new legislation is implemented in the future.

2.4.3 Benthic Invertebrates

On April 22, 2005, Dillon Consulting Limited (2005) sampled benthic invertebrates at two sites on the mainstem of Fergus Creek (Figure 3). Triplicate samples were collected at each location using a 250µu mesh Surber sampler.

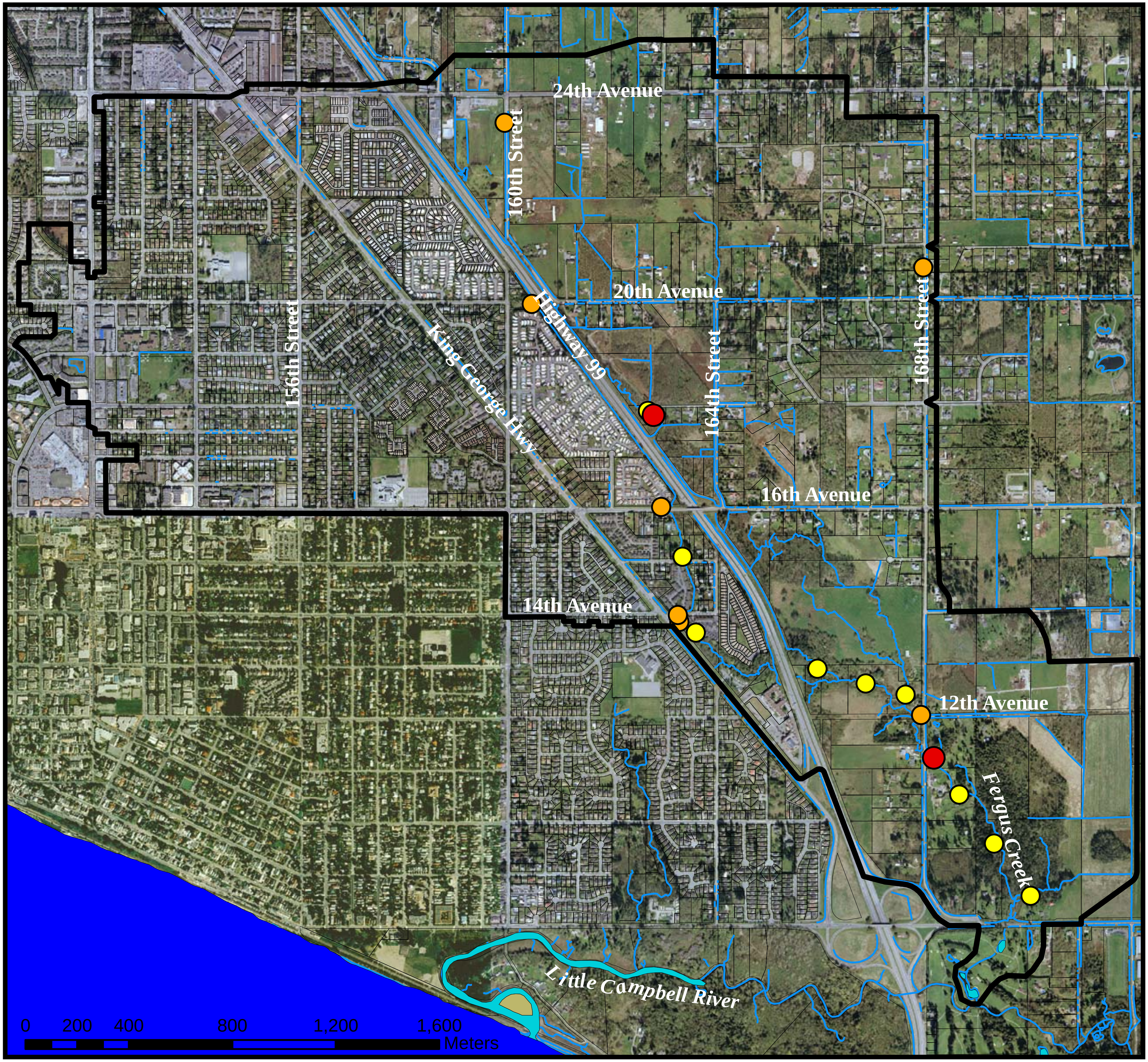
2.4.4 Water Quality

Water quality data including temperature, conductivity, turbidity, pH and dissolved oxygen was collected during dry-weather baseflow conditions (September 26, 2005) at all major storm sewer outlets, creek reaches and tributaries (Figure 6). All measurements except turbidity were made with a Horiba U-10 water tester. Turbidity was measured with a LaMotte 2020 Turbidimeter. The Horiba U-10 underwent span calibration before the crew went into the field. The Turbidimeter was calibrated in the field at the beginning of the sampling day.

Benthic Invertebrate & Water Quality Sampling Sites

Figure 6

McElhanney Consulting Services Ltd.



Legend

- ▬ Watershed Boundary
- 🔴 Benthic Samples
- 🟡 Instream WQ Sites
- 🟠 Stormwater WQ Sites
- ─ Watercourse

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON Environmental Ltd.

3.0 RESULTS AND DISCUSSION

3.1 Terrestrial Resources

3.1.1 Vegetation

The Fergus Creek watershed study area lies within the Coastal Western Hemlock Biogeoclimatic Dry Maritime Subzone (CWHdm). Forests of the study area consist of a mosaic of coniferous and deciduous species. The tree layer is formed of a mixture of deciduous species including bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera*), paper birch (*Betula papyrifera*) and red alder (*Alnus rubra*) with coniferous species including Douglas-fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), mountain hemlock (*Tsuga mertensiana*) and Sitka spruce (*Picea sitchensis*) comprising the largest component of the tree canopy cover (Table 4).

Salal (*Gaultheria shallon)*, Indian plum (*Oemleria cerasiformis*), red elderberry (*Sambucus nigra*), Oregon grape (*Mahonia nervosa*), vine maple (*Acer circinatum*) and trailing blackberry (*Rubus ursinus*) are common components of the shrub layer. The herb layer of these forests is composed primarily of ferns with abundant sword fern (*Polystichum munitum*). Spiny wood fern (*Dryopteris expansa*) and licorice fern (*Polypodium glycyrrhiza*) are present in the wetter sites and bracken fern (*Pteridium aquilinum*) is common in drier sites. Other common ground cover species are Pacific bleeding heart (*Dicentra formosa*), creeping buttercup (*Ranunculus repens*), skunk cabbage (*Symplocarpus foetidus*), western trillium (*Trillium grandiflorum*), false lily of the valley (*Maianthemum dilatatum*), foam flower (*Tiarella trifoliate*) and stinging nettle (*Urtica dioica*).

Many of the forest stands in the study area consist of a mosaic of coniferous and deciduous species. The tree layer in deciduous or early seral coniferous forests is formed of a mixture of big leaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*), paper birch (*Betula papyrifera*) and red alder (*Alnus rubra*). Coniferous species such a Douglas-fir and western redcedar dominate the tree canopy in mature mixed and conifer stands.

Introduced species are common throughout the study area and include Himalayan blackberry (*Rubus discolor*), evergreen blackberry (*Rubus laciniatus*) and English holly (*Ilex aquifolium*). Colonial bentgrass (*Agrostis capillaris*), creeping bentgrass (*Agrostis stolonifera*) and reed canary grass (*Phalaris arundinacea*) are the most important introduced grasses dominant in open disturbed areas.

Table 4 Predominant Vascular and Non-Vascular Plant Species Observed in the Fergus Creek Watershed

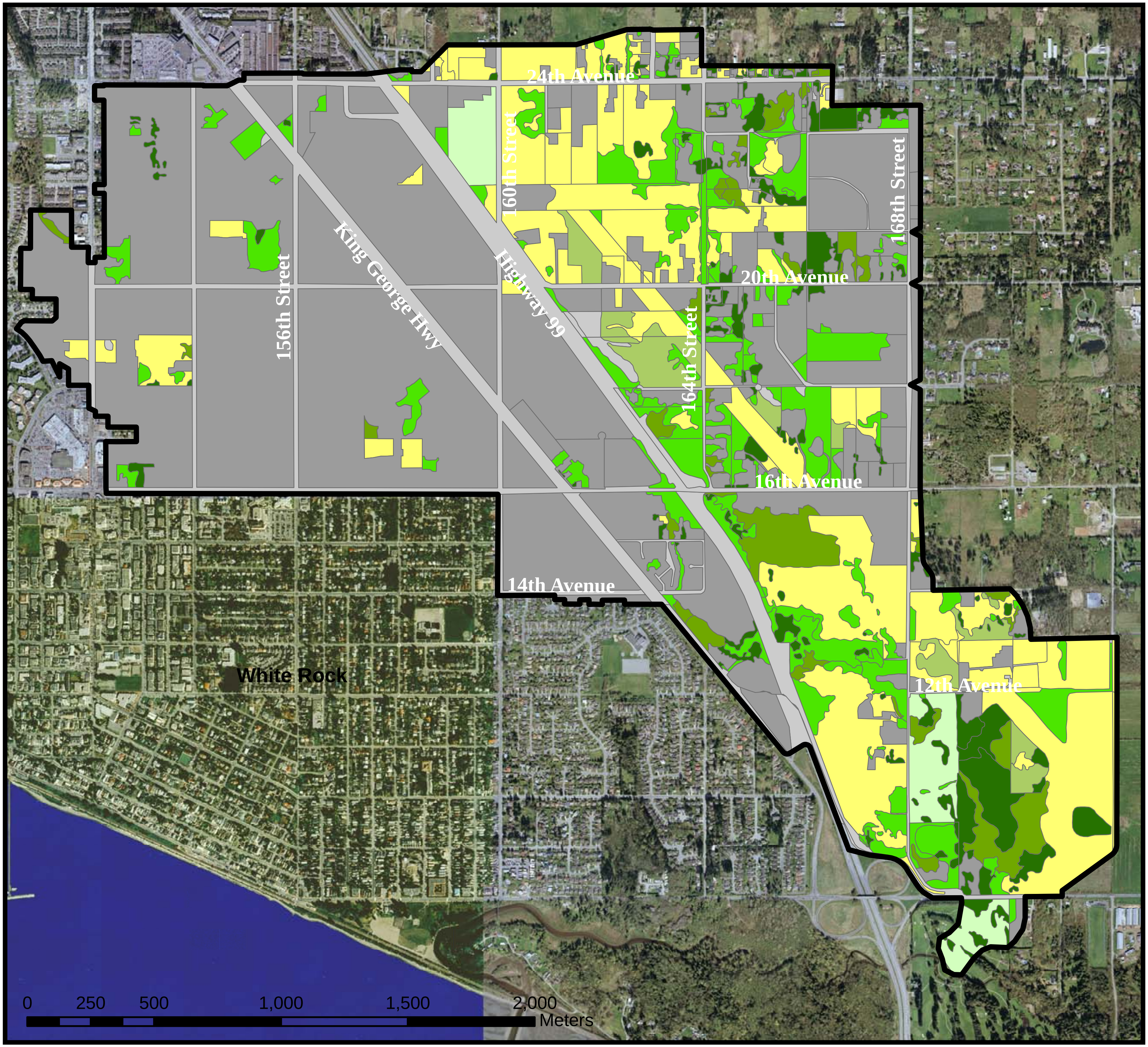
Acer circinatum	*Dryopteris expansa*	*Polystichum munitum*
Acer macrophyllum	*Eurhynchium oreganum*	*Pteridium aquilinum*
Actaea rubra	*Eurhynchium praelongum*	*Rhamnus purshiana*
Agrostis capillaries	*Gaultheria shallon*	*Rhytidiadelphus loreus*
Alnus rubra	*Geranium robertianum*	*Rubus armeniacus*
Aruncus dioicus	*Holcus mollis*	*Rubus laciniatus*
Athyrium filix-femina	*Hypericum perforatum*	*Rubus parviflorus*
Atrichum selwynii	*Impatiens parviflora*	*Rubus spectabilis*
Betula papyrifera	*Lactuca muralis*	*Spiraea douglasii*
Blechnum spicant	*Luzula fastigiata*	*Thuja plicata*
Carex dewyana	*Maianthemum dilatatum*	*Tiarella trifoliata*
Cornus unalaschkensis	*Menziesia ferruginea*	*Trillium ovatum*
Corylus cornuta	*Oemleria cerasiformis*	*Tsuga heterophylla*
Dicentra Formosa	*Plagiomnium insigne*	*Vaccinium parvifolium*
Digitalis purpurea	*Plagiothecium undulatum*	
Dryopteris cartusiana	*Polypodium glycyrrhiza*	

To aid in the assessment of the current riparian fish habitats, a vegetation classification based on orthophoto analysis and groundtruthing was conducted by ENKON for a 50m buffer zone around Fergus Creek and its major tributaries. Six general habitat types were described (Figure 7) which included:

1. Mature riparian forest;
2. Mature deciduous forest;
3. Alder pole/sapling forest;
4. Field;
5. Rural/suburban developed; and
6. Golf course.

ENKON further stratified the mature riparian forest to reflect the dominant forest cover which included:

- Coniferous; and
- Mixed.



Dominant Forest Cover Classification

Figure 7

McElhanney Consulting Services Ltd.

Legend

- ▬ Watershed Boundary

Dominant Vegetation Cover

- ■ Coniferous
- ■ Deciduous
- ■ Field
- ■ Golf
- ■ Mixed
- ■ Pole-Sapling
- ■ Roads
- ■ Rural-Suburban-Dev

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON
Environmental Ltd.

3.1.2 Rare Plant Species and Communities

No rare provincially or federally plant listed species (Appendix A), including provincially blue-listed Henderson's checker-mallow (*Sidalcea hendersonii*) or field dodder (*Cuscuta pentagona*) recorded in the Rare Elements Occurrence Report (Appendix E) were found during the July 2005 surveys. Henderson's checker-mallow was last observed near the study site in 1955 in a wet, roadside ditch along the Pacific Highway. The last recorded observation of field dodder was in 1989 at Little Campbell River. Forest survey results also did not include observations of the plant communities listed as rare by the BC Conservation Data Centre (Appendix B).

3.2 Wildlife

3.2.1 Birds

3.2.1.1 Diurnal Species

The only diurnal raptor species observed during the 2005/2006 field program were a breeding pair of Cooper's hawks (*Accipiter cooperii*) in a forested area behind the Meridian Par 3 Golf Course in the forested area. The pair of cooper's hawks were regularly observed displaying nesting behaviour. Diurnal raptors such as Cooper's hawk and sharp-shinned hawk (*Accipiter striatus*) are dependent on the dense forest areas with open understory, which are found in several locations of the Fergus Creek watershed. A pair of red-tailed hawks *(Buteo jamaicensis)* was observed attending and possibly breeding in a nest in a red alder tree at the north end of the riparian corridor surrounding the Fergus Creek tributary which is within the 164th Street municipal road right-of-way north of 20th Ave in 2006. If active, the nest would be protected under the provincial *Wildlife Act*. Provincial Best Management Practices recommend establishing a vegetated no-disturbance buffer of 50 m measured from the nest-tree and maintaining it throughout the year or until such time as the nest is no longer used by any raptor species.

The merlin (*Falco columbarius*) and American kestrel (*Falco sparverius*) may also use the watershed area for breeding and foraging in forest edges and open fields, such as agricultural land and golf courses. The forest edges and tall shrub areas are utilized for roosting and nesting.

3.2.1.2 Nocturnal Species

Both the blue-listed short-eared owl and barn owl were detected at separate locations in the southern area of Fergus Creek watershed. Both observations were of individual birds in flight and responding to call playback.

There were several detections of both barred owls (*Strix varia)* in 2005 and 2006, and great horned owls (*Bubo virginianus)* in 2006 at the call points within Plan Area 2 (Figure 3). These data and other anecdotal information provided by local residents suggest these birds are common in the plan area.

The great horned owl, northern saw-whet owl (*Aegolius acadicus)*, western screech-owl, northern pygmy-owl (*Glaucidium gnoma*) and barred owl prefer closed forest communities with riparian areas for nesting. The short-eared owl forages and breeds in open grassy areas, nesting on the ground. The barn owl forages in the same open grassy areas but nests in tree cavities, old buildings and barns. These types of habitats are all present in the Fergus Cree watershed and provide a source of small mammals (e.g., squirrels, voles, mice) for these and other raptors.The great horned owl (*Bubo virginianus*), barred owl, northern saw-whet owl (*Aegolius acadicus*), northern pygmy-owl (*Glaucidium gnoma*) and provincially blue-listed western screech-owl prefer closed forest communities with riparian areas for nesting. Small mammal species such as Douglas squirrel (*Tamiasciurus douglasii*) and deer mouse (*Peromyscus maniculatus*) in the watershed area provide an abundant source of food in the forests and open field habitats. The provincially blue-listed short-eared owl and barn owl nest and forage for small mammals in agricultural areas. Many sites within the Fergus Creek watershed can be considered high value foraging and roosting habitat for a range of raptor species.

3.2.2 Small Mammal Survey

No provincially or federally listed small mammals, such as the Pacific water shrew or Trowbridge's shrew (*Sorex trowbridgii)*, were recorded in the Fergus Creek watershed during the 2005 or 2006 surveys. The provincial Conservation Data Centre has confirmed records of Trowbridge's shrew and Pacific water shrew occurring at Fergus Creek 150 metres north of 8th Avenue in 1992. In addition, ECL Envirowest also captured Trowbridge's shrew in two tributaries to the Little Campbell River below the confluence with Fergus Creek in 2004 (Appendix E).

The only small mammal live-trapped within the Fergus Creek watershed was the ubiquitous deer mouse (*Peromyscus maniculatus*) (Photograph 5). One live and one dead coast mole (*Scapanus orarius*) (Photograph 5) were found in the riparian area between the north and south extensions of 164th Street, north of 20th Avenue. Other small mammals likely to occur within the Fergus Creek watershed include bats, rats, voles and other mouse species such as: Townsend's vole (*Microtus townsendi*), house mouse (*Mus musculus*), dusky shrew (*Sorex vagrans*), little brown bat (*Myotis lucifugus*), and introduced black rat (*Rattus rattus*).

Photograph 5 Deer mouse and coast mole from left to right, respectively, found in the riparian area north of 20th Avenue at 164th Street

3.2.3 Amphibians and Reptiles

No provincially or federally listed species (Appendix B) were detected during field surveys. Suitable habitat is present for the provincially blue-listed red-legged frog (*Rana aurora*) which has the potential to breed at ephemeral ponds and stream pools, and use adjacent forests for foraging and dispersal (Orchard 1984; Stebbins 1985, Cannings *et al.* 1999), such as the mixed older mature forest patch located northeast of the riparian right-of-way corridor at 164th St above 20th Ave. Breeding may also occur in slow moving sections or back eddies of Fergus Creek. In addition, the moist forests and riparian areas of Fergus Creek watershed provide suitable habitat for western toad (*Bufos boreas*), a federal species of concern (Appendix D). This species breeds in ephemeral pools and wetted depressions in a range of habitats from forest to urban and agriculture. Toadlets emerge and disperse to the cover of logs, rocks or moist ground under vegetation in 6 weeks from hatching.

Pacific treefrogs (*Hyla regilla*) were detected on many occasions during various terrestrial surveys in forest and shrub habitats within the Fergus Creek watershed. While the importance of protecting aquatic breeding habitats of amphibians has long been recognized, terrestrial habitats that are equally essential for their different life-history requirements have often been neglected. Some species, such as the western toad, undertake long migrations away from water outside the breeding season with adults ranging from 400m up to 1600m from breeding ponds.

Both the red-legged frog and the western toad are protected under the federal *Species at Risk Act* (SARA) and the British Columbia *Wildlife Act* from being killed, collected, or held in captivity without a permit. The degradation and loss of habitat to development and agriculture is an issue, particularly in the Greater Vancouver area where 75% of the wetlands are gone. Other threats include road traffic, pesticides, contaminants, changes in the environment that increase water temperature, and predation or competition with introduced species such as bullfrogs.

3.2.4 Other Wildlife

Other mammals that have the potential to occur within the Fergus Creek watershed include black-tailed deer (*Odocoileus hemionus)*, coyote (*Canis latrans)*, raccoon *(Procyon lotor)*, opossum *(Didelphis virginiana),* striped skunk *(Mephitis mephitis)*, and Douglas squirrel (*Tamiasciurus douglasii)* and as well as two introduced species; eastern cottontail rabbit (*Sylvilagus floridanus*) and eastern grey squirrel (*Sciurus carolinensis*) (Table 5, Photograph 6). All except the Douglas squirrel will utilize forested, riparian, shrub and open field habitats but require a significant percentage of forests within their range for cover and food. Douglas squirrels prefer coniferous forest since their diet consists primarily of the seeds and cones of fir, pine, spruce, and hemlock trees and prefers continuous forest or wide corridors connecting smaller patches of forest. Beaver sign (cut and peeled deciduous saplings and bark) was also observed along Fergus Cree near 8th Avenue.

Several signs (such as faecal droppings, hair, browsed shrubs) or direct observations of various mammal species within the Fergus Creek watershed area were recorded during the 2005 and 2006 surveys (Table 5).

Table 5 Mammal Species Observed Incidentally during Wildlife Surveys in the Fergus Creek Watershed

English Name	Latin Name
Beaver	*Castor canadensis*
Columbian Black-tailed Deer	*Odocoileus hemionus*
Coyote	*Canis latrans*
Eastern Cottontail (*Introduced*)	*Sylvilagus floridanus*
Douglas Squirrel	*Tamiasciurus douglasii*
Eastern Grey Squirrel (*Introduced*)	*Sciurus carolinensis*
Coast Mole	*Scapanus orarius*
Bat spp.	*undetermined*
Deer Mouse	*Peromyscus maniculatus*

Photograph 6 Beaver Sign along Fergus Creek near 8th Avenue

Avian species richness is likely to be much higher than the observed incidental species list (Table 6) indicates and can be evaluated most effectively by conducting structured bird surveys. Breeding bird surveys would ensure detection of both resident species and several seasonal migrants, such as the various warblers, swallows, and hummingbirds that utilize the lower mainland areas during the summer months.

The following 34 bird species were recorded as incidental observations during the wildlife and vegetation field surveys (Table 6) in 2005 and 2006.

Table 6 Birds Observed within the Fergus Creek Watershed in 2005 and 2006

English Name	**Latin Name**
American Goldfinch	*Carduelis tristis*
American Robin	*Turdus migratorius*
Bald Eagle	*Haliaeetus leucocephalus*
Bewick's Wren	*Thryomanes bewickii*
Black-capped Chickadee	*Poecile atricapillus*
Brown Creeper	*Certhia americana*
Brown-headed Cowbird	*Molothrus ater*
Bushtit	*Psaltriparus minimus*
Canada Goose	*Branta canadensis*
Chestnut-backed Chickadee	*Parus rufescens*
Dark-eyed Junco	*Junco hyemalis*
Downy Woodpecker	*Picoides pubescens*
European Starling (*Introduced)*	*Sturnus vulgaris*
Glaucous-winged Gull	*Larus glaucescens*
Golden-crowned Kinglet	*Regulus satrapa*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Hairy Woodpecker	*Picoides villosus*
House Finch	*Carpodacus mexicanus*
Northern Flicker	*Colaptes auratus*
Northwestern Crow	*Corvus caurinus*
Pacific-sloped Flycatcher	*Empodonax difficulis*
Pileated Woodpecker	*Dryocopus pileatus*
Pine Siskin	*Carduelis pinus*
Red-breasted Nuthatch	*Sitta canadensis*
Red-breasted Sapsucker	*Sphyrapicus ruber*
Red-tailed Hawk	*Buteo jamaicensis*
Rock Dove (*Introduced*)	*Columba livia*
Rufous Hummingbird	*Selasphorus rufus*
Song Sparrow	*Melospiza melodia*
Spotted Towhee	*Pipilo maculatus*

English Name	Latin Name
Steller's Jay	*Cyanocitta stelleri*
Varied Thrush	*Ixoreus naevius*
White-crowned Sparrow	*Zonotrichia leucophrys*
Winter Wren	*Troglodytes troglodytes*

Reptiles that may occur within the Fergus Creek watershed include northern alligator lizard (*Gerrhonotus coeruleus*) and three species of garter snake: common (*Thamnophis sirtalis*), northwestern (*Thamnophis ordinoides*) and western terrestrial (*Thamnophis elegans*). Habitats that provide warm, dry substrates, such as rocks, logs, stumps and open grassy patches are necessary for their persistence. They are highly adaptable and can survive in urban locations as well as in woodlands, meadows, along streams and in drainage ditches.

In addition to Pacific treefrog which were detected during ENKON surveys, other amphibians which are likely to occur in the watershed are red-legged frog (*Rana aurora*), ensatina *(Ensatina eschscholtzi)*, northwestern salamander *(Ambystoma gracile)*, long-toed salamander (*Ambystoma macrodactylum*), western red-backed salamander *(Plethodon vehiculum),* rough-skinned newts *(Taricha granulosa)* and western toad (*Bufo boreas*).

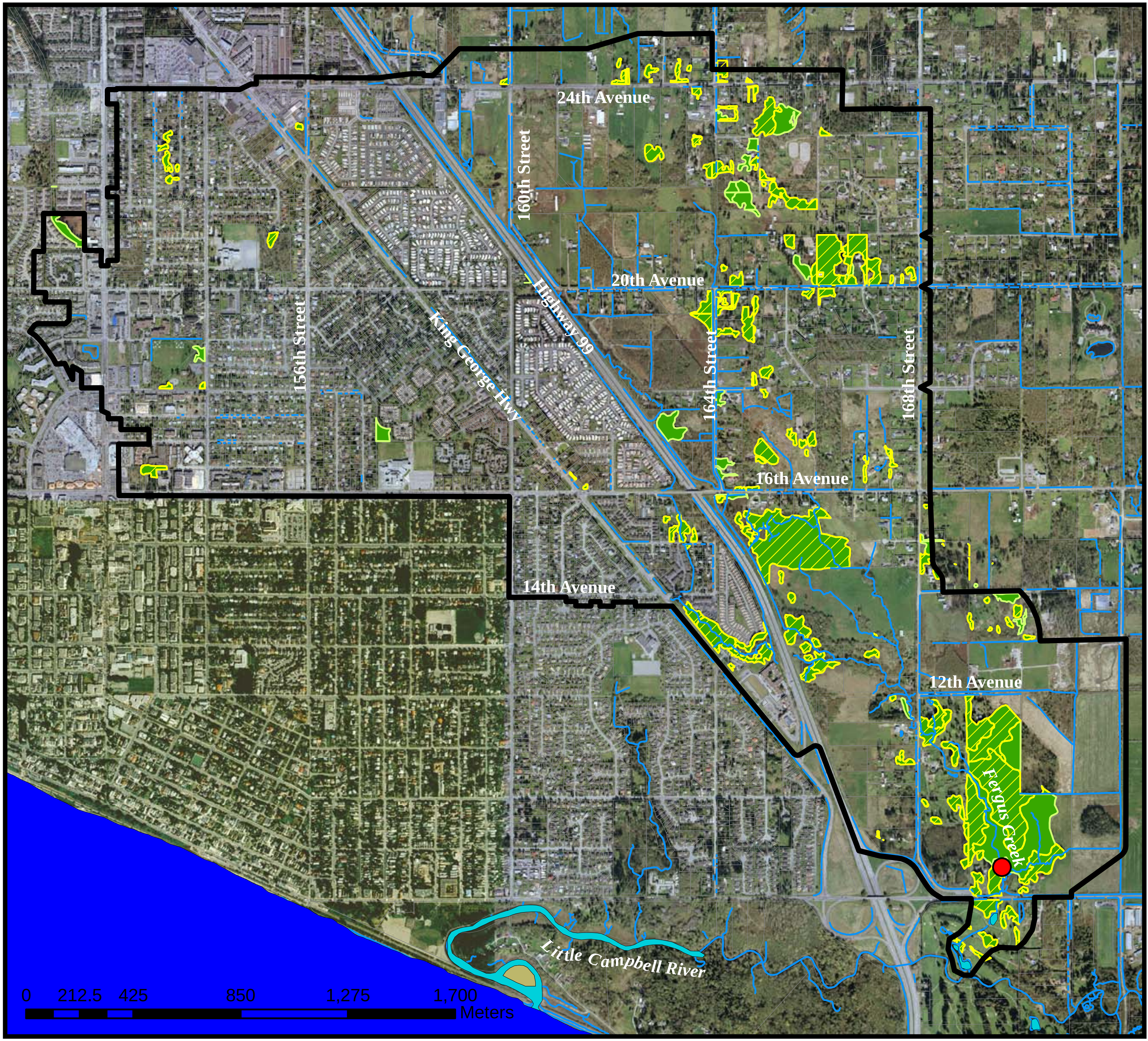
3.2.5 Species of Concern

The Conservation Data Centre's Rare Elements Occurrence Report (Appendix E) lists 5 records of red- and blue-listed vertebrates and vascular plants encountered within approximately 10 km of the Fergus Creek watershed, including two vertebrates (Pacific water shrew and Trowbridge's shrew) and three vascular plants, field dodder (*Cuscuta pentagona*), Henderson's checker-mallow (*Sidalcea hendersonii*), and western pearlwort (*Sagina decumbens*).

With regard to rare vertebrate wildlife species, there has been one capture of the red-listed Pacific water shrew and the blue-listed Trowbridge's shrew at Fergus Creek, 150 metres north of 8th Avenue (September 1992), and three captures of Trowbridge's shrew in two tributaries to the Little Campbell River downstream of the Fergus Creek confluence (June 2004). Pacific water shrew is federally identified as Threatened (Schedule 1 of the *Species at Risk Act*). Suitable habitat for both these rare species exist in the watershed (Figure 8) however, none were detected during ENKON's surveys within Plan Area 2 or the Fergus Creek watershed.

The B.C. Conservation Data Centre (CDC) lists 20 bird species in the Chilliwack Forest District as threatened or vulnerable (Appendix B). The *Species at Risk Act* (SARA) lists 23 bird species from British Columbia in Schedule 1, 2 or 3 (Appendix D). Of these species, the land within and adjacent to the Fergus Creek watershed area contains suitable breeding habitat for 4 listed species including barn owl, short-eared owl, western screech-owl and band-tailed pigeon (Figures 9 and 10). Of these, the barn owl and short-eared owl were observed during ENKON's 2006 avian surveys. Suitable breeding and foraging habitat is available for these species in all open grassy agricultural areas and the BC Hydro right-of-way. The great blue heron was not observed during ENKON's surveys; however, there is suitable habitat (groups of mature, large deciduous and coniferous trees) within the watershed (Figure 11). Due to the colonial nesting habits of great blue heron and the historical locations of their rookery sites, it is unlikely they will nest within Fergus Creek and surrounding lands. Other listed species might occasionally rest or forage within the study area, but they are not likely to nest there.

There is suitable habitat for the listed red-legged frog (Figure 12) and western toad (Figure 12) within the Fergus Creek watershed. Although neither species were detected during



Pacific Water Shrew & Trowbridge's Shrew Habitat Suitability

Figure 8

McElhanney Consulting Services Ltd.

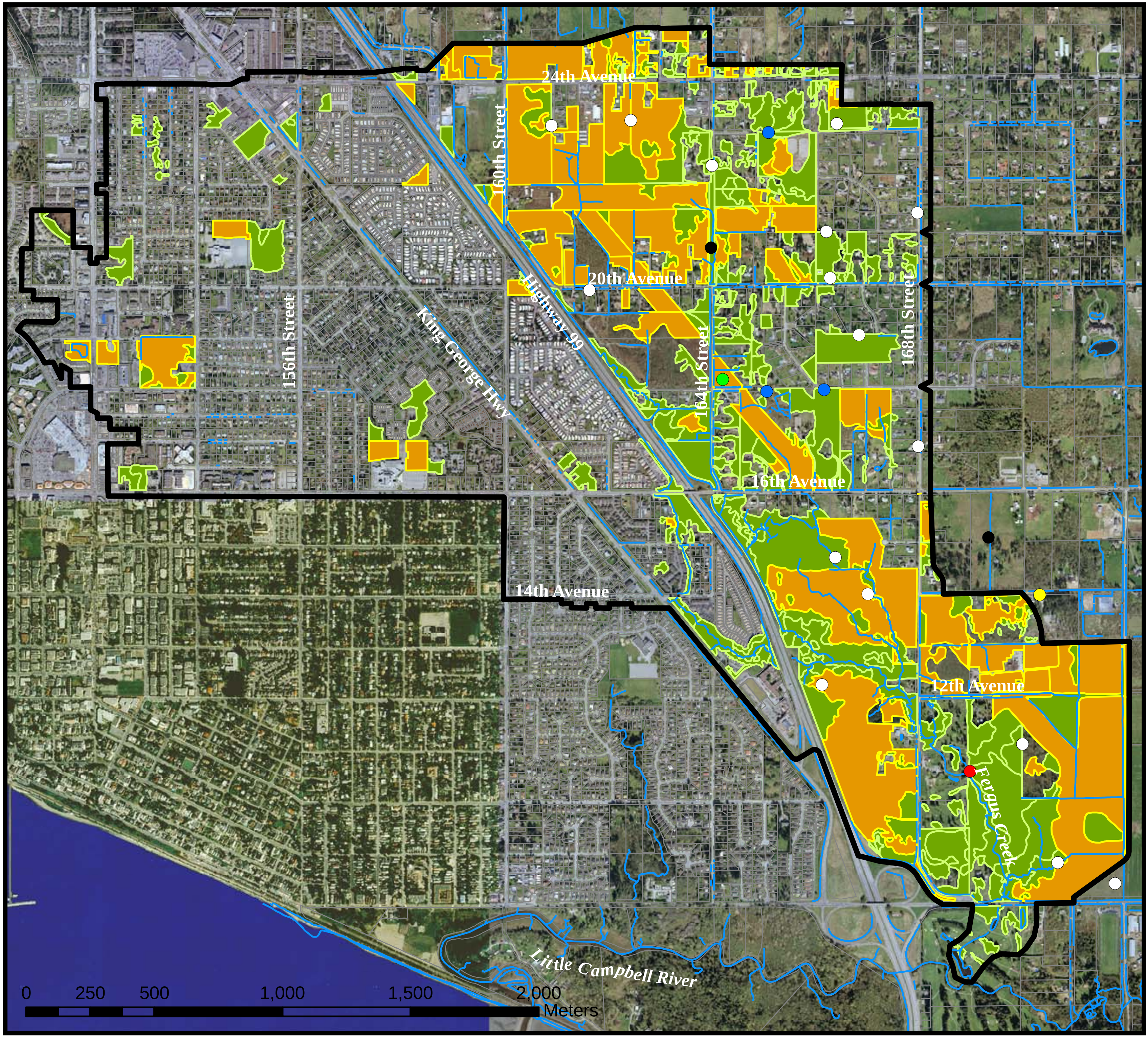
Legend

- ▬ Watershed Boundary
- — Watercourse
- ● 1992 Shrew Observation
- 🟩 Trowbridge's Shrew Potential
- ▨ Pacific Water Shrew Potential

Scale 1:20000

Map created December 2006

Prepared by:
ENKON
Environmental Ltd.



Potential Short-eared Owl, Barn Owl & Western Screech-Owl Habitat Suitability & Owl Call Playback Response

Figure 9

McElhanney Consulting Services Ltd.

Legend

- ▬ Watershed Boundary
- 🟧 Barn Owl & Short Eared Owl
- 🟩 Western Screech Owl

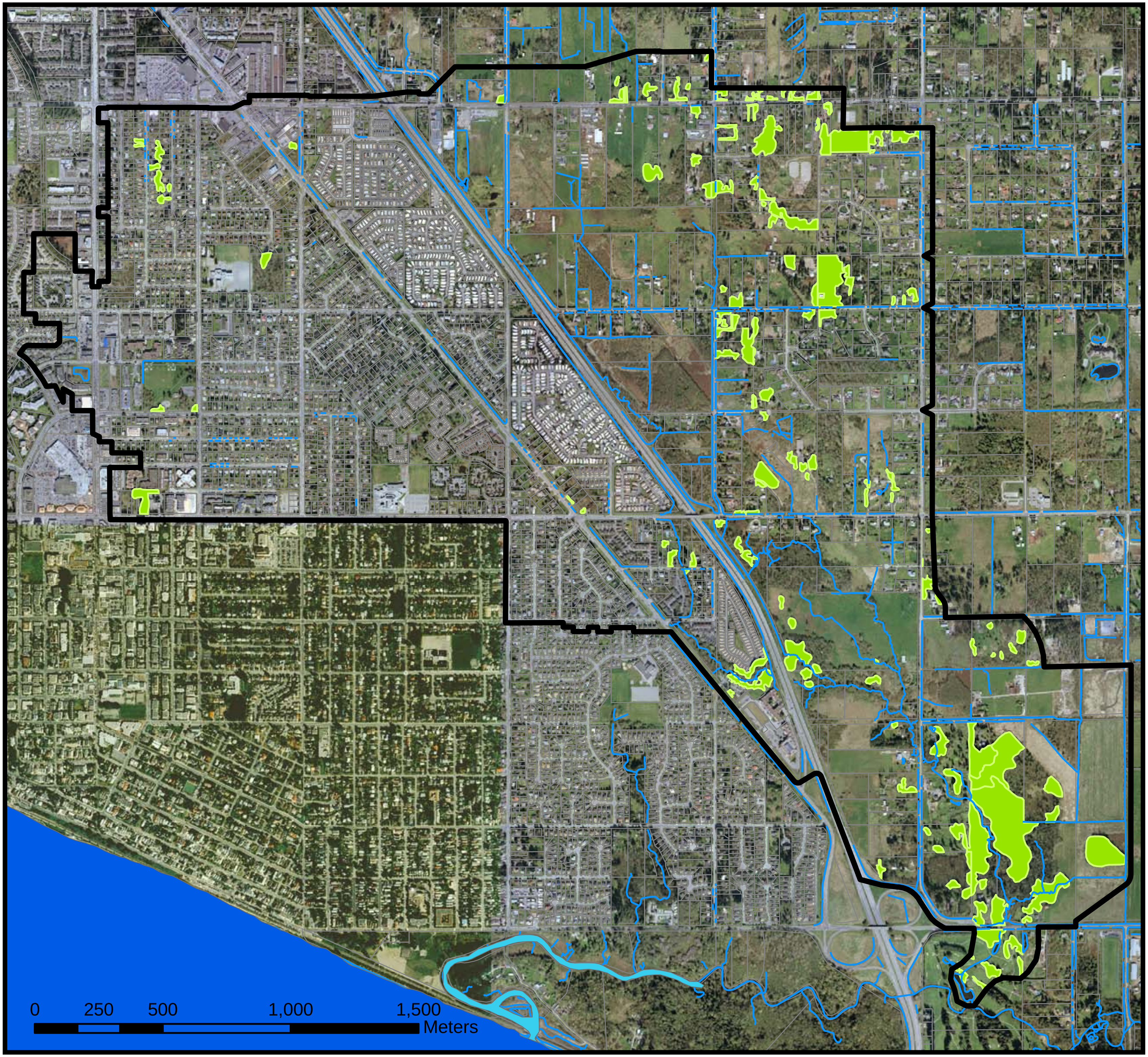
Owl Call Playback Species Response

- ● Barred Owl
- ● Great Horned Owl
- ● Barn Owl
- ● Unknown
- ○ No Response
- ● Western Screech-owl
- — Watercourse

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON Environmental Ltd.



Band-tailed Pigeon Habitat Suitability

Figure 10

McElhanney Consulting Services Ltd.

Legend

━ Watershed Boundary

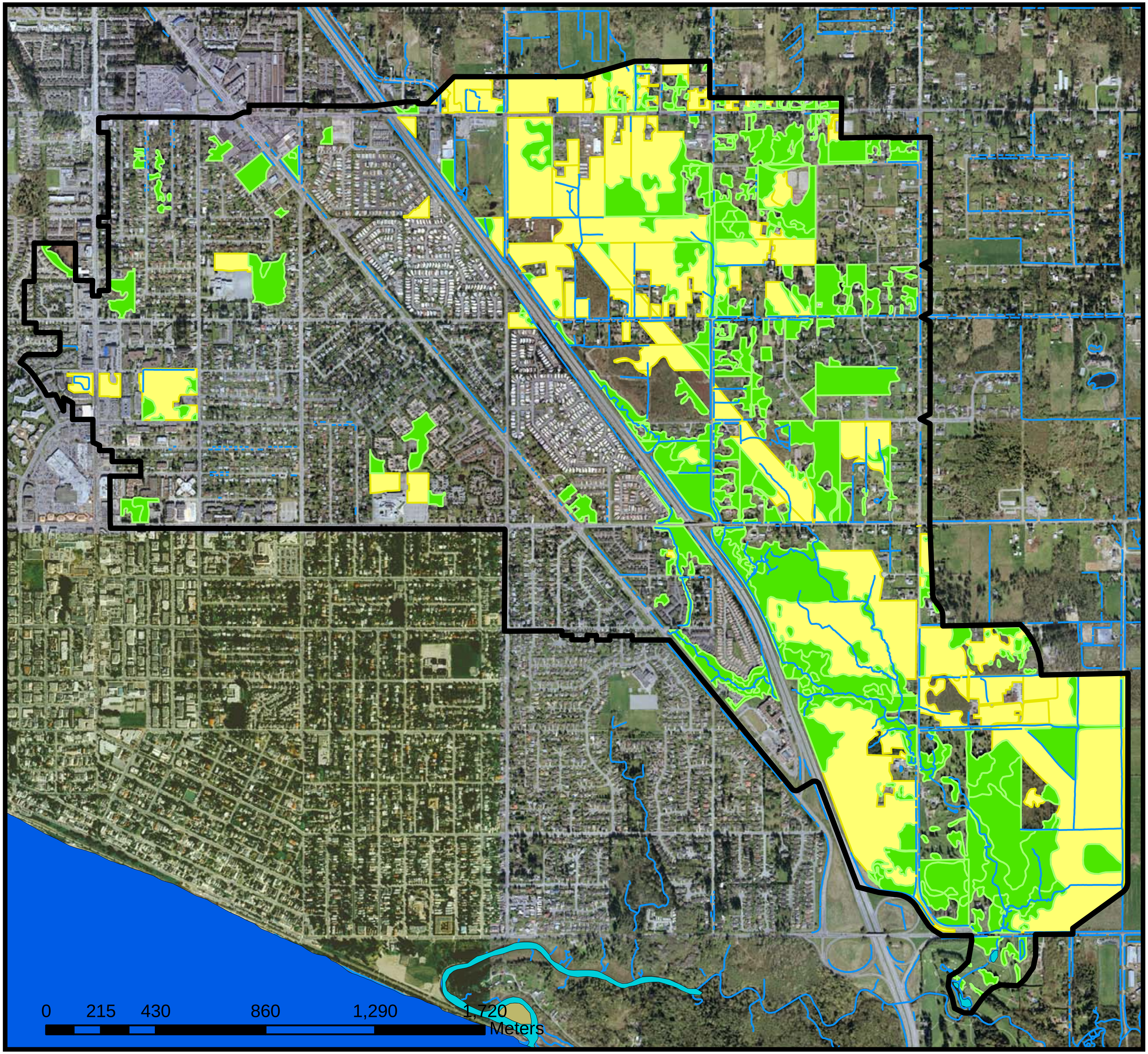
— Watercourse

🟩 Band Tailed Pigeon Suitability

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON
Environmental Ltd.



Great Blue Heron Habitat Suitability

Figure 11

McElhanney Consulting
Services Ltd.

Legend

- ▬ Watershed Boundary
- ─ Watercourse
- 🟨 Potential Forage Suitability
- 🟩 Potential Nesting Suitability

N
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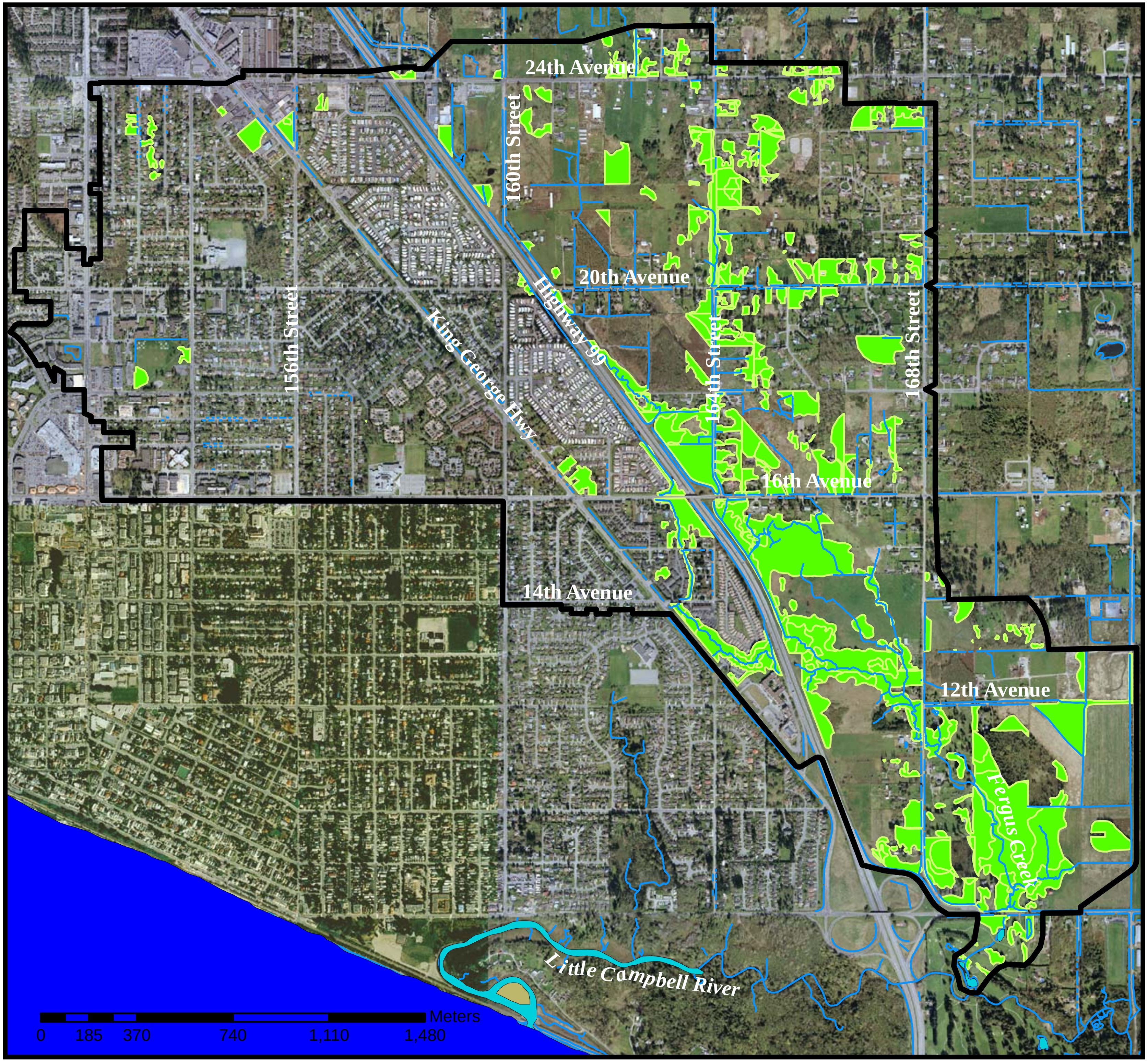
Scale 1:20000

Map created: December 2006

Prepared by:
ENKON
Environmental Ltd.



Red Legged Frog & Western Toad Habitat Suitability

Figure 12

McElhanney Consulting Services Ltd.

Legend

▬ Watershed Boundary

— Watercourse

🟩 Potential Habitat Suitability

Scale 1:20000

Map created: December 2006

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ENKON's surveys, it is important to note that they were conducted outside the breeding season which reduces the probability of detection.

None of the 46 plant species listed as red- or blue-listed in the CDC Tracking List (Appendix A) were observed during vegetation surveys, however, there have not been structured vegetation surveys conducted to confirm or deny their presence in the Fergus Creek watershed area. The observations of blue-listed Henderson's checker-mallow (*Sidalcea hendersonii*), western pearlwort (*Sagina decumbens*), and field dodder (*Cuscuta pentagona*) recorded in the Rare Elements Occurrence Report (Appendix E) were made before 1990.

3.2.6 Important Wildlife Tree Patches

As part of the environmental review of the Grandview Heights Neighbourhood Plan Concept Area 2 (ENKON 2006), seven important wildlife tree patches were identified and ranked according to significance to wildlife. Large patches of trees are important to wildlife for a number of reasons, primarily as cover from predation and inclement weather, and also as critical breeding and foraging sites within the urban landscape. Interior forest habitats not yet influenced by exotic species of plants can sustain most of the natural biodiversity of local forests. Sensitive wildlife species restricted to interior forest conditions can be protected from predators who exploit edge habitats. These larger stands, especially those that are mature or old, act as core areas with a larger diversity of wildlife and plant species from which smaller disturbed patches can be constantly re-stocked. They can also ensure continued recruitment of young wildlife and seed banks for native plant species.

The patches of forest that were assessed as "Important Wildlife Tree Patches" within Plan Area 2 are a combination of coniferous, deciduous and mixed coniferous/deciduous forests. The dominant overstory trees are greater than 30 cm in diameter and many are greater than 50 cm. The patch sizes are greater than 0.5 hectares and/or there is high connectivity value (adjacent or in close proximity) to other similar forest patches. There is a moderate to high number of individual wildlife trees present and overall structural diversity is high. Vegetation in the understory is primarily native species typical of natural forests in the Coastal Douglas-Fir Biogeoclimatic Zone.

The field evaluation criteria in combination with the initial spatial analyses resulted in seven stands of continuous forest (Figure 13) in Plan Area 2 identified as important for wildlife habitat value. A ranking system was developed as a way of assigning relative importance to facilitate decision making during development planning. The ranking analyses assigned a score of 0 to 5 for each of the 9 field evaluation criteria described in Section 2.2.2 (size, age, tree species composition, canopy cover, coarse woody debris, understory vegetation, fragmentation, connectivity, productivity) and used to compare the 7 continuous patches of forest in habitat value to a hypothetical overall perfect score of 45 (9 criteria x 5 points) for high quality habitat. The resulting overall score for each stand was then converted to a simple ranking score between 0 and 10 (10 being the highest) (Table 7) for ease of comparison. The ranking results indicated that Stand No. 1

(Figure 13) was the most valuable (7.78) stand in Plan Area 2 in terms of natural, diverse, mature forest habitat. Stand No. 2 was second most important (6.22) while Stand No. 7 had the lowest relative amount of habitat value (3.78) among the seven significant wildlife tree patches in Plan Area 2. Stand No. 4 (4.89) includes a narrow riparian area, an old patch of structurally diverse forest in the north end with wet depressions and vernal pools, a mix of seral stages, a range of native vegetation species, and a raptor nest. It is important to remember that all seven stands are important relative to the remaining patches of forest that currently exist across Plan Area 2 and as such are all important areas to be considered for wildlife conservation.

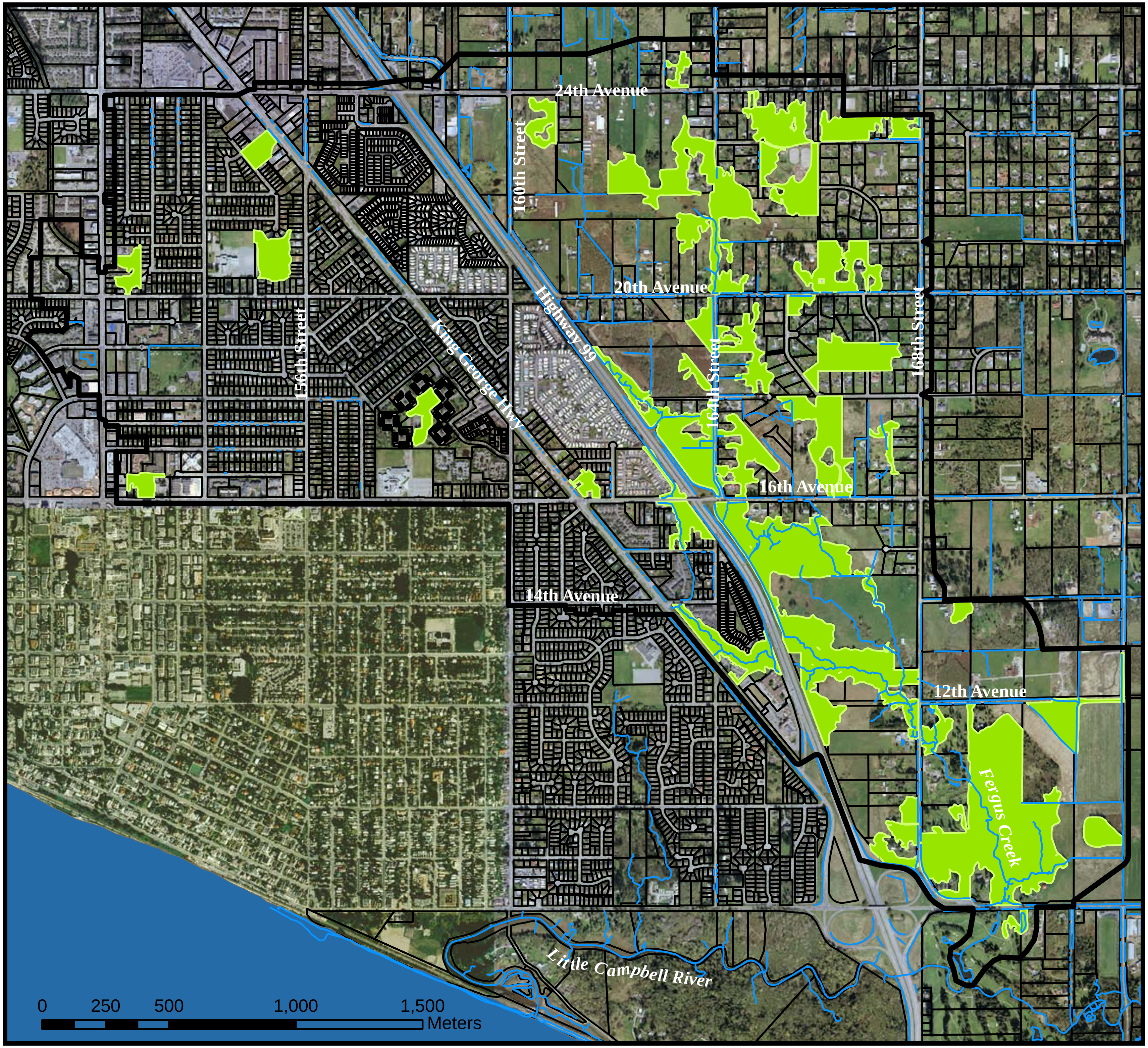
Table 7 Ranking Score (0-10) of Important Stands of Wildlife Tree Patches in Grandview Heights Neighbourhood Concept Plan Area 2

Stand No.	Forest Type	Age	Stand Location	Rank
1	Mixed Coniferous/Deciduous	Mature-Old	Between 23rd and 24th Avenue, and between 164th and 165th Street	7.78
2	Mixed Coniferous/Deciduous	Mixed Young-Mature	Between 23rd and 24th Avenue, and between 166th and 168th Street	6.22
3	Deciduous	Mixed Young-Mature	Between 16th and 18th Avenue, and between 164th and 168th Street	5.11
4	Mixed Coniferous/Deciduous/ Riparian	Mixed Young-Old	Between 20th and 23rd Avenue, and between north and south extensions of 164th Street	4.89
5	Deciduous	Mixed Young-Mature	Between 18th and 20th Avenue, and between 165A and 168th Street	4.44
6	Deciduous	Young with minimal Mature	South of 24th Avenue, and east of 164th Street	4.00
7	Coniferous	Mature	Between 20th and 21st Avenue, and between 166th and 167th Street	3.78

Important Wildlife Tree Patches

Figure 13

McElhanney Consulting
Services Ltd.



Legend

▬ Watershed Boundary

— Watercourse

🟩 Significant Tree Patches

Scale 1:20000

Map created: December 2006

Prepared by:
ENKON
Environmental Ltd.

Although ENKON did not survey stands of wildlife tree patches within the remainder of the Fergus Creek watershed, there are likely important stands of wildlife tree patches in the lower watershed north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99.

Some of the stands although relatively small, are quite typical of undisturbed forests in this CDFmm Biogeoclimatic Subzone. The older patches are of particularly high value due to their slow transition to old-growth conditions and ultimately the environmental stability of conifer dominance. As the mature forests age, what was a closed canopy environment begins to open up as old deciduous trees fail to compete and die off. Snags, logs and decaying coarse woody debris that drop to the floor provide high structural diversity, and a matrix of critical living spaces and food resource for a wide range of vertebrates and invertebrates. It also provides rich substrates for a host of native plant species. With increasing decadence, the canopy opens up and patches of sunlight in open areas support the growth of a richer diversity of herbs and shrubby understory, and the establishment of new sapling trees. Over time, with minimal disturbance, biodiversity generally increases, and the dynamic ecosystem becomes more resilient to external disturbances, especially if the patch is large and wide with significant interior space. It is important that larger stands that are maturing be left to age naturally and provide refuge for the wildlife that is persisting within the surrounding developed urban landscape.

Although, in general, small urban patches of habitat do not function very well as natural ecosystems, ENKON's survey results determined that the higher ranking significant patches were fairly representative of the natural vegetation community within this biogeoclimatic subzone. Avian species diversity was moderate relative to the expected species composition which would normally occur in less disturbed habitats and included many interior forest species. Their value, although small, appears high, possibly due to their proximity to the riparian areas within the balance of the watershed. These patches of forest offer recreational wildlife viewing, aesthetic quality, environmental services such as oxygen and nutrient recycling, noise buffering, and most importantly, habitat for the remaining persistent wildlife species in the area. If these patches are fragmented further by development, or become completely isolated from other patches of moderate to higher quality patches or green spaces, they will eventually cease to function as wildlife refuges, breeding sites or foraging areas.

In addition to recommending that most or all of the significant patches are retained, ENKON recommends that landscape planning include a system of connecting or enhancing areas to maintain green links to these stands of forest and ensure the quality of health is maintained or enhanced. Forest patches should be within 2 km of one another. Without a system of corridors or green spaces for wildlife and plants to distribute themselves throughout the forested networks, the native species will not persist.

3.2.7 Wildlife Movement Corridors

There is potential for the development of four wildlife movement corridors within the Fergus Creek watershed.

1. North-South Wildlife Movement Corridors

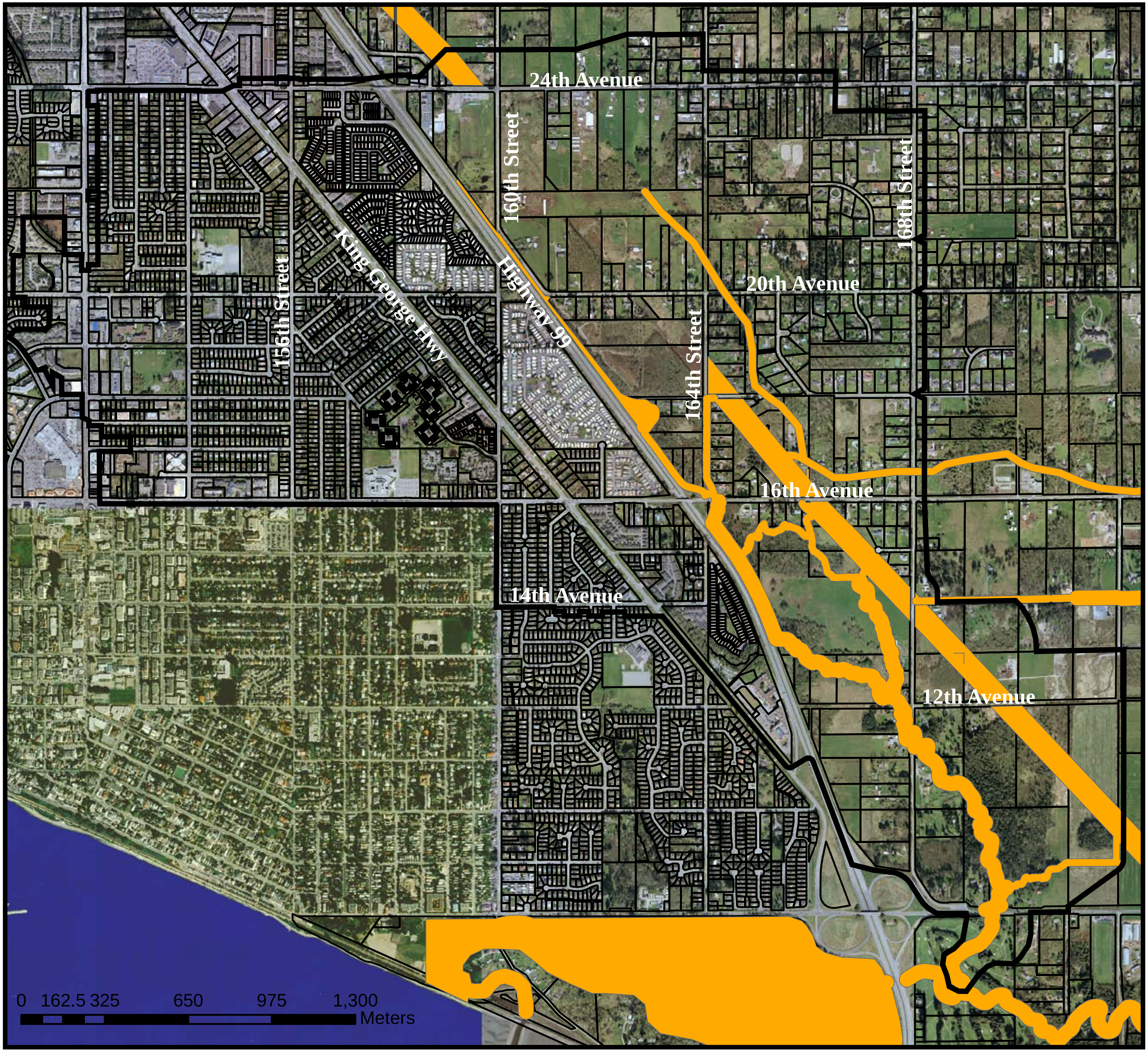
    a. The BC Hydro right-of-way (ROW) which runs northwest to southeast along the western border of Plan Area 2 connecting to the Little Campbell River (Figure 14). It presently provides ease of movement and reduced human disturbance for a variety of mammal species including black-tailed deer, coyotes, raccoons and a diversity of small mammals as well as red-tailed hawks, various owl species and a wide range of other birds. However, the right-of-way provides little value as refuge during these movements due to the lack of forest or high shrub cover. In addition, portions of the BC Hydro ROW are planned for commercial development or are immediately adjacent to business park/light industrial developments (Highway 99 Corridor Local Area Plan, February 2004) which would restrict the use of the corridor by wildlife.

    b. The Fergus Creek mainstem/tributaries and associated riparian habitat which connects at four points to the BC Hydro ROW and eventually connects to the Little Campbell River. A significant portion of the corridor is treed and passes through the proposed habitat preservation area in the lower section of Fergus Creek below 16th Avenue. While the corridor provides habitat for a variety of wildlife species, it also provides critical habitat for the red listed Pacific water shrew and blue listed Trowbridge's shrew.

2. East-West Wildlife Movement Corridors

    a. Along the "Height-of-Land" from the northwest corner of Grandview Heights Neighbourhood Concept Plan Area 2 to the southeast and connecting to Dart's Hill Garden and Redwood Parks. A significant portion of the corridor is treed and passes through portions of three important stands of wildlife tree patches (Stands No. 3, 4 and 6); however an even greater proportion is currently residential or agricultural land within that corridor. There would need to be provisions made for enhancement of sections of the corridor across private land, roads and open fields to provide a contiguous wildlife movement corridor.

    b. East from the BC Hydro ROW between 16th and 12th Avenues to Sam Hill Creek which eventually flows into the Little Campbell River just north of 8th Avenue. A significant portion of the corridor goes through a combination of field, mixed and deciduous forest habitat although restrictions imposed by agricultural requirements may limit the usefulness of the corridor.



Wildlife Movement Corridors within Fergus Creek Watershed

Figure 14

McElhanney Consulting Services Ltd.

Legend

▬ Watershed Boundary

🟧 Wildlife Corridors

N
W E
S

Scale 1:20000

Map created:
September 2006

Prepared by:
ENKON
Environmental Ltd.

Riparian areas surrounding Class A/B watercourses provide short distance travel corridors with cover and connectivity between forest patches and other larger movement corridors. It is important therefore that, as much as possible, large patches of trees and shrubs are retained or enhanced within these riparian areas.

3.3 Aquatic Resources

3.3.1 Fish Populations & Distribution

Fergus Creek is classified as a fish-bearing stream from Reach 1 to 7 based on the Year 2006 watercourse classification mapping provided by the City of Surrey (Figure 15). Coho salmon and cutthroat trout are the most abundant fish species in the creek (Envirowest, 1994), with coho observed spawning in Reaches 1 to 4 (to Highway 99). Chinook and chum salmon, prickly sculpin, threespine stickleback and lamprey have also been observed in the lower reaches of Fergus Creek (Gartner Lee, 2000). Review of the provincial Fisheries Information Summary System (FISS) datasets provides reference to previous observations of Rainbow Trout and Steelhead within the lower Fergus Creek watershed (Province of BC, 2001)

Gartner Lee (2000) and ECL Envirowest (1994) report that no fish have been observed in Reach 7, likely due to the presence of a culvert barrier to upstream migration under Highway 99. Despite the more recent assessments suggesting a lack of fish presence in the upper reaches, City of Surrey watercourse classification depicts all reaches of the mainstem as Class A fish habitat, likely due to the manmade barrier being considered as having the potential for fish presence subject to future access improvements. In addition, review of the provincial Fisheries Information Summary System (FISS) describes stocking of coho salmon at 18th Avenue (Province of BC, 2001) which would place the transplant within Reach 7. Gartner Lee (2000) summarize historical stocking of coho and cutthroat in Reaches 5 and 6 to take advantage of the rearing habitat inaccessible to migrating adult fish and . Envirowest (1994) and FISS records (Province of BC, 2001) describe fish stocking activities conducted by the Semiahmoo Fish and Game Club with Coho and Cutthroat in Reaches 6 and 7 between 15th and 20th Avenue from 1992 to 1994.

3.3.2 Aquatic Habitat

3.3.2.1 Fergus Creek Mainstem

Field assessment in support of watercourse re-classification efforts facilitated the qualitative assessment of habitat within the Fergus Creek mainstem and significant tributaries. Based on field observations, the lowermost reaches (Reaches 1 through 4) appear to provide the most valuable habitat with accessible spawning and rearing habitat coupled with diverse habitat types and intact riparian canopies characterizing Reach 2 and 4 (Reaches 1 and 3 are channelized with limited riparian cover as they traverse the Peace Portal and Meridian Par 3 golf courses, respectively).

With respect to habitat complexity, Reach 2 in particular provides the most diverse habitat and is characterized by a riffle-pool morphology, frequent deep pools, large woody debris cover, mature riparian vegetation cover and vegetated floodplain terraces. Riparian vegetation and nearby upland forests are largely intact throughout reach 2 with mature coniferous over-story providing potential woody debris recruitment and hillslope stability. The vegetated floodplain areas are characterized by peaty saturated soils and floodplain wetland species with frequent wall-base channels and small side channels observed to convey groundwater seepage and supplement summer low-flows. Protection of the riparian ecosystems is considered to be critical in this area due to the extremely sensitive nature of the vegetated floodplain and the valuable contribution of groundwater seepages to the baseflow of Fergus Creek.

Qualitative observations of channel morphology from Reach 2 through 5 identified physical indicators of bed and bank erosion which appear to be directly related to the urbanization and subsequent stormwater discharges attributed to runoff from impervious areas to the west of Highway 99. Impacts attributed to urbanization and stormwater discharges are known to impact watershed hydrology, channel morphology, water quality and habitat values. Impacts to watershed hydrology, habitat structure and water quality impacts have been documented as total impervious area (TIA) approaches 10% of the watershed area (May et al. 1997; Booth & Reinelt, 1993).

Field indicators confirm the presence of bank erosion and channel degradation attributed to stormwater related impacts to watershed hydrology and channel morphology. Field observations suggest that the most significant bed scour and bank erosion locations are located immediately below stormwater discharges or culvert crossings (Photograph 7 & 8). Gartner Lee (2000) identified a number of erosional areas with six (6) specific sites noted within Reach 5, below a major stormwater outfall, which was noted to indicate significant bed and bank scour during the 2005 and 2006 field surveys. Similarly, scour and bank erosion immediately below the Highway 99 culvert in reach 4 was observed during the 2005/2006 assessments, while Gartner Lee (2000) identified four (4) specific erosion concerns within reach 4. The observation of scour below culvert crossings implies that the culverts may be undersized and as a result, impoundments may result in an increase in the duration and magnitude of storm flows, ultimately affecting the duration of channel forming events. In addition, summer low flows appear limited with respect to the channel's bankfull width with isolated pools and extensive areas of dry/de-watered channel observed in the upper reaches (upper reach 5 through 7) during the September 2005 surveys, which is assumed to be the result of urbanization and the extensive impervious areas to the west of Highway 99.

Photograph 7 – Downstream view of degraded channel below 14th Avenue stormwater connections. Substrate dominated by boulder material and clay with "pock marked" clay surfaces indicating scour and transport of smaller cobble and boulder material -

Photograph 8 – Downstream view of bank erosion/channel widening below Highway 99 culvert outlet. Note hanging fence post depicting the relatively recent changes to the channel.

While a detailed assessment was not conducted, preliminary observations and field indicators suggest that the mainstem of Fergus Creek is not in equilibrium with the current hydrologic regime. Low flow channels were noted to appear disproportionate to the channel's bankfull width (Photograph 9) and evidence of bed scour, bank erosion and initial channel widening (Photograph 10) suggest ongoing channel adjustments. The aforementioned channel adjustments were observed primarily within Reaches 5 through 3. Further downstream along the channel continuum field observations within Reach 2 indicate localized aggradation with a distinct change in substrate characterized by a shift from predominantly boulder and cobble to predominantly gravel and fines (Photograph 11 & 12).

Photograph 9 – Low flow channels appear disproportionate to the channel's bankfull width with isolated residual pools.

Photograph 10 – Upstream view of modified channel through Reach 3. Visible bank slumping suggests initial channel widening.

Photograph 11 – Upstream view of side bars of homogenous textured gravel substrate within Reach 4. Evidence of localized aggradation.

Photograph 12 – Upstream view of side bars of homogenous textured gravel substrate within Reach 4. Evidence of localized aggradation.

Despite the apparent perturbations affecting the mainstem of Fergus Creek, the habitat appears to provide moderate spawning and moderate to high rearing potential overall. A review of previous fish habitat assessment summaries of rearing and spawning potential within the mainstem of Fergus Creek by ECL Envirowest (1994) and Gartner Lee (2000) is summarized by reach in Table 8:

Table 8 Fergus Creek Mainstem – Habitat Rating Summary

Reach	Morphology	Bed Material	Spawning Habitat Rank	Rearing Habitat Rank	Source
1	Channelized	Sand & Fines	Medium	High	Envirowest (1994)
2	Riffle-Pool	Gravel & Sand	High	High	Envirowest (1994)
3	Channelized	Cobble & Gravel	High	Low	Envirowest (1994)
4	Riffle-Pool	Gravel & Cobble	High	High	Envirowest (1994) & Gartner Lee (2000)
5	Riffle-Pool	Cobble & Gravel	High	High	Envirowest (1994)
			Medium	High	Gartner Lee (2000)
6	Riffle-Glide	Clay & Cobble	Medium	Medium	Envirowest (1994) & Gartner Lee (2000)
7	Channelized	Gravel & Fines	Medium	Medium	Envirowest (1994)
			Low	Medium	Gartner Lee (2000)

Among other factors, the long-term viability of fish populations in the Fergus Creek watershed is affected by disturbed channels, riparian habitat impacts, low summer flows, and poor water quality due to the occasional introduction of deleterious substances (i.e. spills) to the system (Province of BC, 2001).

3.3.2.2 Major Tributaries

Field assessment and review of available mapping identified the presence of three major tributaries to Fergus Creek. Based on the nomenclature from Gartner Lee (2000), tributaries are coded numerically based on their parent stream reach. Major tributaries are defined as Class A tributary streams greater than 100m in length as identified from City of Surrey digital watercourse mapping. Major tributaries include tributary 2.1, 4.1 and 4.2.

Tributary 2.1

Tributary 2.1 was described by Envirowest (1994) as a small forested ravine channel discharging to Fergus Creek at the north edge of a wetland. Field observations confirm the presence of a vegetated floodplain wetland with saturated organic peaty soils present from the confluence of Tributary 2.1 to the culvert crossing at 8th Avenue. Tributary 2.1 is characterized by a predominantly clay and organic substrate with negligible pool depth (Photograph 13). Negligible streamflow was observed during the July 2006 site assessment with no direct overland flows observed with Fergus Creek. Review of surrounding land use suggests that historical drainage alterations related to the agricultural fields to the east of the present-day ravine terminus have significantly altered the hydrology of Tributary 2.1. The presence of the ravine suggests a very different hydrological regime in the past. Field assessment of the surrounding lands identified the contemporary drainage network as stemming from a single property line ditch conveying flows from the east with potential overflows from a north-south draining ditch contributing seasonal flow. Field assessments conducted July and September 2005 corroborate the negligible spawning and rearing habitat (Envirowest, 1994) afforded by Tributary 2.1; however, ENKON recommends that the classification of Class A be retained as future enhancement (particularly flow enhancement) may significantly improve potential rearing opportunities. In its present condition, Tributary 2.1 provides valuable food and nutrient contributions to downstream resources.

A small ephemeral drainage was identified as a tributary to Tributary 2.1. Field assessment identified a linear wetland/vernal pond feature within the mature coniferous forest. This vernal pond feature is appears to be a potentially significant groundwater recharge zone with seasonal overland flow contributions to Tributary 2.1 (Photograph 14). Based on the seasonal flow contributions and groundwater recharge values, this ephemeral tributary/vernal pond feature is considered to be a potentially significant feature with respect to the maintenance of stream baseflows and food and nutrient contribution.

Photograph 13 – Upstream view of marginal habitat at Tributary 2.1. Negligible residual pools, poor substrate and high ambient turbidity.

Photograph 14 – Upstream view of vernal pond/wetland feature located immediately north from Tributary 2.1. Overland flows contribute seasonally to streamflow.

Tributary 4.1

Tributary 4.1 consists of two distinct branches. The east branch was identified as the most significant with streamflow attributed to perennial flow from an assumed spring-fed drainage originating within the BC Hydro right-of-way above 16th Avenue. The uppermost section of the east tributary is conveyed in a naturalized channel with predominantly gravel substrate and an intact riparian canopy; however, land use for the remainder of the channel's length has severely degraded the instream habitat. The channel has been destabilized by livestock activity and was observed to disperse from its channel and flow as indistinct distributaries prior to its entry into an east-west property line ditch. Ditch flow appears to rejoin the historical channel; however, bank destabilization and a lack of riparian vegetation have resulted in flows conveyed in a shallow swale channel with negligible residual pool depth or habitat complexity.

The west branch of Tributary 4.1 originates as a poorly defined grass lined swale within the open field and is defined only by a grass lined depression with sedges delineating a linear saturated zone. Orthophoto interpretation confirmed the presence of a more defined channel with visible surface flows; however, the channel has been severely degraded by livestock activities similar to the impacts described for the east branch.

Tributary 4.2

Tributary 4.2 receives drainage from two (2) distinct tributary channels above 16th Avenue. The western tributary flows parallel to Highway 99 as linear channel and the east branch receives drainage from the 164th Street ditches. Below 16th Ave the tributary flows as a channelized stream along the east edge of Highway 99 and ultimately becomes a more naturalized stream in a minor gully. Similar to the tributary 4.1 streams, extensive disturbance by livestock has degraded the channel at approximately 140m upstream from the confluence with the Fergus Creek mainstem. Habitat within the lowermost portion of

Tributary 4.2 is characterized by predominantly clay substrate with deep pools at the base of localized step features. Due to the lack of suitable spawning substrate, spawning potential is considered low; however, rearing habitat is considered moderate to high based on good cover and residual pool depth. Assessment of the upper portion of the tributary suggests that potential access constraints and negligible residual pool areas limit the potential rearing potential; however, the presence of gravel substrate indicates an increase in spawning potential.

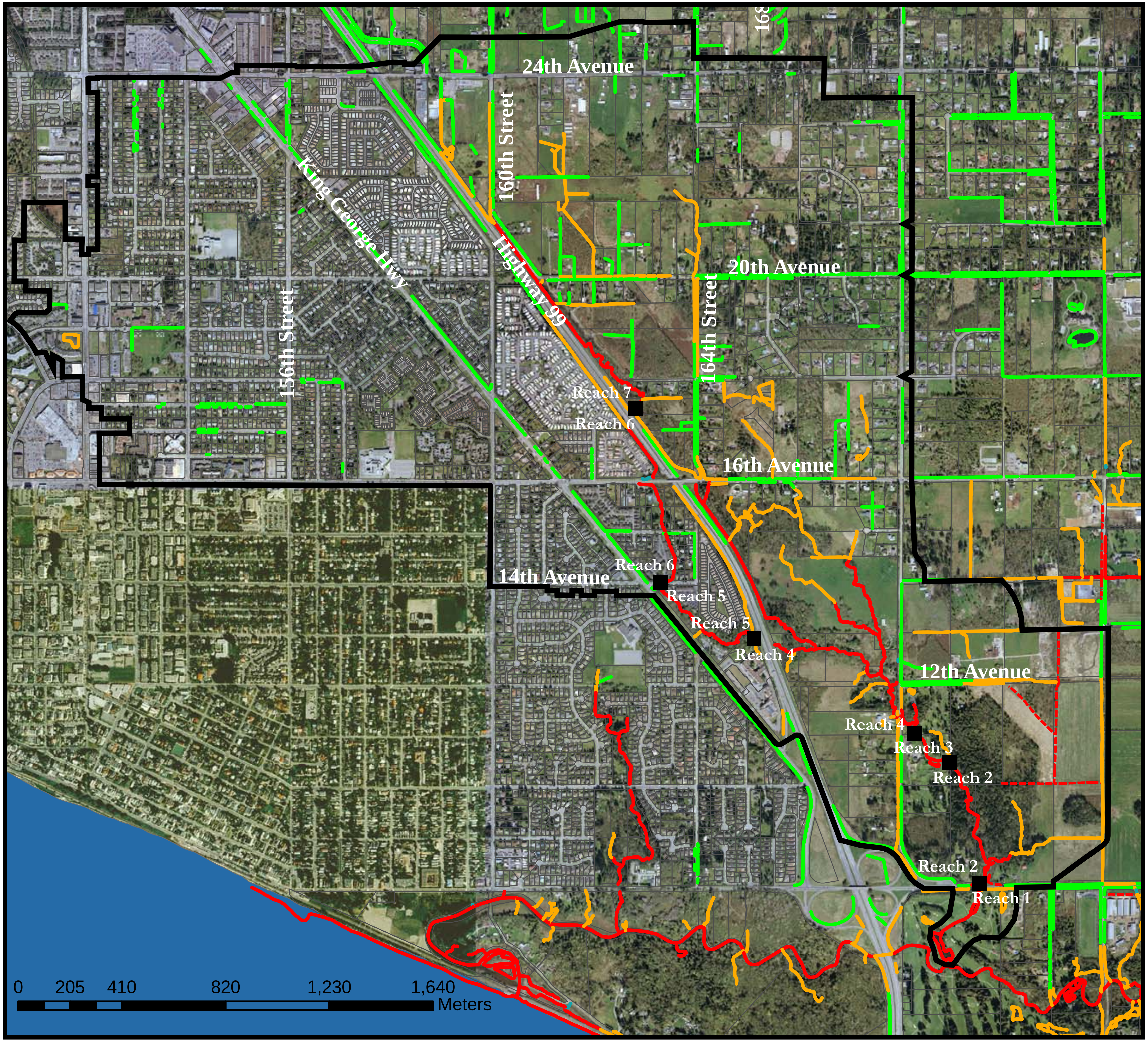
3.3.3 Watercourse Classifications

The following watercourse classifications were taken from the City of Surrey's fisheries watercourse classification mapping as available from the City of Surrey Online Mapping System (Cosmos) and digital datasets provided April 2006. Section 3.3.4 discusses recommendations for re-classification of specific watercourses within the Fergus Creek watershed and re-mapping of the extent and number of tributary streams associated with the 164th Street roadside ditch catchment. These recommendations are based on ENKON's field work completed during 2005 and early 2006.

3.3.3.1 Class A and A(O)Watercourses

Six Class A or Class A(O) watercourses were identified within the Fergus Creek (Figure 16) watershed including:

1. The Fergus Creek mainstem from its confluence with the Little Campbell River to just north of 20th Avenue;
2. A significant tributary (Trib 4.2) from its confluence with the Fergus Creek mainstem immediately east from the Highway 99 culvert crossing to 16th Avenue;
3. Two tributary branches (Trib 4.1) immediately west of 168th Street between 12th and 16th Avenues;
4. A small tributary branch east of 168th Street and below 12th Avenue;
5. The lowermost portion of a tributary channel with its confluence from the east within Reach 2, immediately north of 8th Avenue;
6. A network of property line drainage ditches in the vicinity of the BC Hydro right-of-way to the east of 168th Street, between 8th and 14th Avenues.



Fergus Creek Stream Classification

Figure 15

McElhanney Consulting Services Ltd.

Legend

- ▭ Watershed Boundary
- 🟥 Class A
- ┅ Class A(O)
- 🟧 Class B
- 🟩 Class C
- 🟦 Unclassified
- ■ Reach Break

Scale 1:20000

Map created:
Septmeber 2006

Prepared by:
ENKON
Environmental Ltd.

3.3.3.2 Class B Watercourses

A number of Class B watercourses were identified within the Fergus Creek watershed including:

1. The upper portions Fergus Creek (Reach 7) upstream of 20th Avenue;
2. In the northwestern corner of the watershed located to the southeast of 161st Street between 24th and 20th Avenues. This Class B watercourse traverses southeast across the BC Hydro ROW before discharging into the 20th Avenue roadside ditch. Riparian vegetation for the majority of its length is characterized by grasses and Himalayan blackberry;
3. The roadside ditch located along 20th Avenue, originating to the west of 164th Street is classified by the City of Surrey as a Class B watercourse. This watercourse receives seepage and surface drainage from several rural/suburban properties located north of 20th Avenue and was frequently observed with significant volumes of surface water within the ditch. The watercourse enters a large stormwater inlet to the east of the junction with Croydon Drive discharges directly to a Class A section of upper Fergus Creek (Reach 7);
4. A Class B watercourse mapped by the City of Surrey as originating from an agricultural field approximately 300m north of 20th Avenue draining south along the 164th Street right-of-way and flowing as the west 164th Street ditch to the confluence with a Fergus Creek tributary at 16th Avenue;
5. The east roadside ditch along 164th Street between 20th Avenue and 18th Avenue, which ultimately drains south to its confluence with a Class A tributary to Fergus Creek at 16th Avenue;
6. In the southern portion of the watershed located south of the 18th Avenue cul-de-sac accessed from 164th Street. This Class B watercourse is mapped as a localized network of drainages which appear to flow to the 18th Avenue roadside ditches;
7. In the southern portion of the watershed within private residential lots originating at 16691 16th Avenue including portions of 16715 and 16733 16th Avenue. This Class B watercourse originates in a cleared undeveloped portion of the lot at 16691 16th Avenue with no direct connectivity to the 16th Avenue roadside ditches;
8. A portion of the north roadside ditch along 16th Avenue which drains east and enters the stormwater drainage system and flows via 168th Street which ultimately discharges to Fergus Creek at 12th Avenue and 168th Street.
9. In the southern portion of the watershed between 16th and 18th Avenues along the 165 Street alignment. This Class B watercourse originates in the BC Hydro ROW and enters a roadside ditch along 164th Street before flowing to Tributary 4.1 below 16th Avenue;
10. Various roadside ditches and property line drainage ditches south of 16th Avenue; and

11. Various short tributary streams with direct connectivity with the mainstem of Fergus Creek.

3.3.3.3 Class C Watercourses

The remaining watercourses within the Fergus Creek watershed are Class C watercourses characteristic of roadside ditches or man-made property line ditches to drain individual properties. In many cases, the watercourses are void of riparian vegetation due to adjacent roadways or manicured lawns/developed properties. One of the most significant Class C watercourses is a ditch located along 164th Street that runs in a north-south direction from approximately 22nd Avenue to connect with Fergus Creek at 16th Avenue.

3.3.4 Proposed Watercourse Re-Classifications

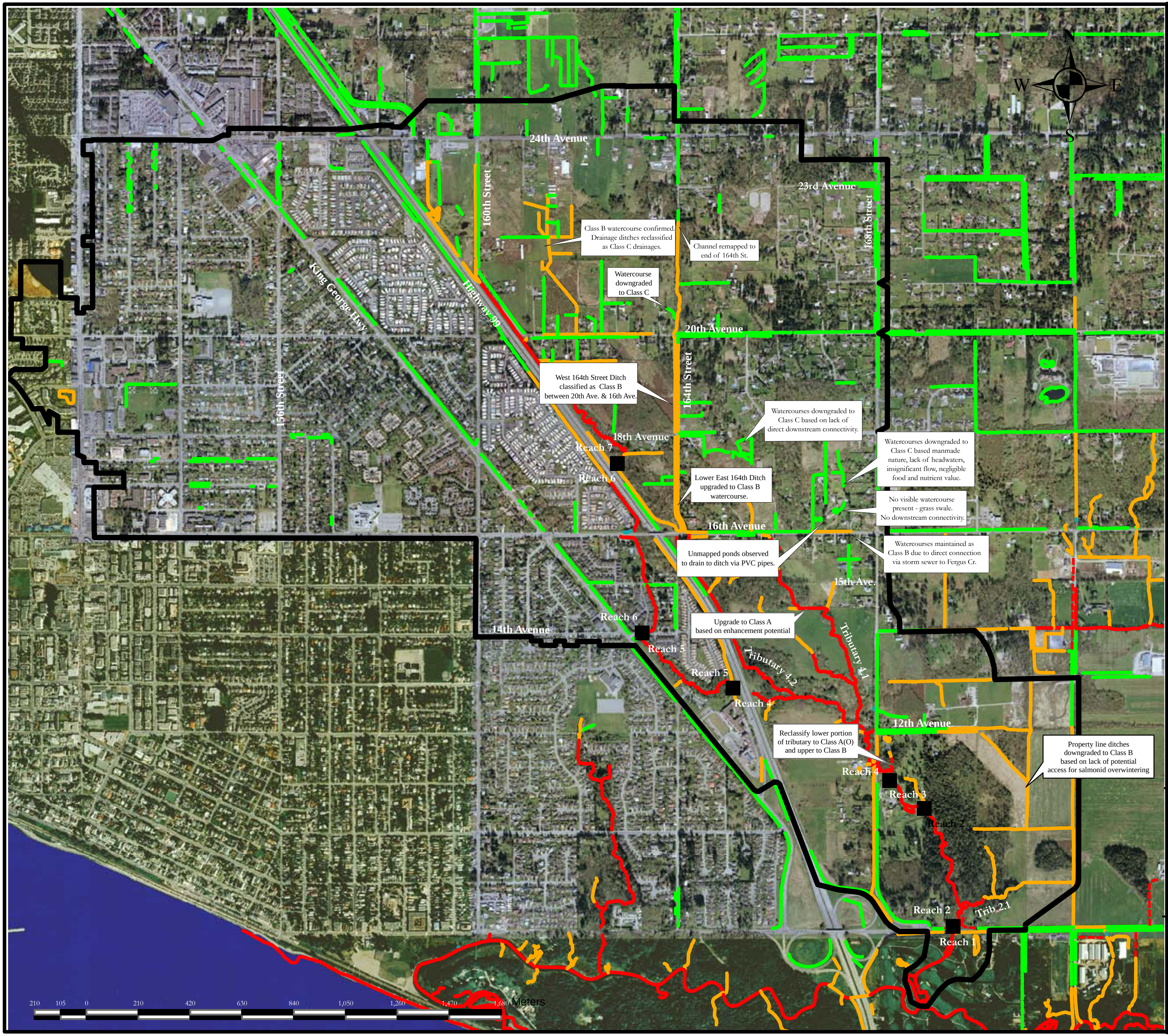
Based on ENKON's field inspections of watercourses within the Fergus Creek watershed during late 2005 and early 2006, ENKON is recommending the following changes to or confirmations of the watercourse classifications/locations (Figure 16) of portions of the existing Fergus Creek drainage network as follows:

1. Based on field assessments of the northwestern watercourse originating from 161st Street between 22nd-24th Avenue, the small tributaries were identified as manmade drainages with no discernible headwaters, no evidence of scour and minimal food and nutrient value; however, due to the presence of hydrophilic vegetation and direct downstream connectivity, a classification of Class B is recommended. Field assessment identified several additional property line drainage ditches within the nursery located at 16172-24th Avenue. Based on their lack of defined headwaters, lack of vegetation, manmade nature and negligible flow and/or scour, ENKON recommends that these drainage ditches be classified as Class C watercourses. With respect to the main Class B watercourse which flows to the 20th Avenue ditch (Photographs 15 and 16), ENKON confirms the watercourses classification as a Class B watercourse with a defined incised channel with evidence of scour at localized plunge pools, presence of alluvial substrate, and riparian cover composed of Himalayan blackberry and deciduous tree cover for much of its length. Additional tributary watercourses to the aforementioned channel were encountered and assessed. A Class C watercourse mapped along the north boundary of the residential property at 16197 20th Ave. was not encountered and should be removed from mapping; however, an un-mapped manmade ditch drainage was encountered approximately 80m north of 20th Avenue which drains east to the Class B watercourse. Based on the lack of visible scour and the manmade nature of the linear drainage feature, ENKON recommends its classification as a Class C watercourse.

Proposed WaterCourse Re-Classification Area

Figure 16

McElhanney Consulting Services



Legend:

▭ Fergus Creek Watershed

City of Surrey Watercourse Classification

- 🟥 Class A
- 🟥 Class A(O)
- 🟧 Class B
- 🟩 Class C
- 🟦 Unclassified

Scale 1:20000

Map created
December 2006

Prepared by:
ENKON
Environmental Ltd.

Photograph 15 – Class B watercourse confirmed above confluence with 20th Avenue Ditch. Drainage originates as property line ditches in agricultural field located south of 161st Street and 24th Avenue

Photograph 16 – 20th Avenue ditch receives significant flows and drains west to a Class A tributary of Fergus Creek.

2. Field inspection revealed the 164th Street right-of-way channel as extending from 20th Avenue up to its origin below the present terminus of the paved road portion in the 2200 block of 164th Street. The channel is defined by a north-south draining channel with visible channel substrate and rock gabion weirs which are assumed to have been installed with the excavation of the channel (Photograph 17). The channel is well incised with a predominantly deciduous canopy. ENKON recommends that the watercourse remain classified as a Class B watercourse; however the upstream extent of the watercourse should be remapped to join the approximate end of the paved portion of 164th Street. The western roadside ditch located along 164th Street between 20th Avenue and 16th Avenue was observed to receive flows from the right-of-way channel and flow south with direct connectivity to a Class A Fergus Creek tributary (Photograph 18). ENKON recommends the reclassification of the entire length of the western 164th Street ditch to Class B based on the following criteria:

    - Gravel/cobble substrate for portions of its length;
    - Significant flow with evidence of fluvial scour and deposition; and
    - Riparian vegetation comprised of deciduous forest along the entire right-of-way channel and the western edge of the roadside ditch;
    - Direct downstream connectivity with mapped Class A watercourse.

Photograph 17 – Downstream view of 164th Street right-of-way channel. Rock gabion weirs located throughout channel length.

Photograph 18 – Downstream view of 164th Street west ditch with alluvial substrate, visible scour and sustained flows.

With respect to the small tributary streams and headwater branches as mapped by the City of Surrey, ENKON is recommending that the short tributary branch entering the right-of-way watercourse from the property located at 16367 20th Avenue be reclassified to a Class C watercourse. The watercourse was observed to be a grass lined channel with no direct downstream connectivity to the right-of-way channel and appears to be a manmade interceptor ditch with no significant habitat value or flow contribution.

Similarly, the mapped upstream portion of the Class B watercourse as illustrated by City of Surrey mapping was found to not exist, rather the right-of-way watercourse extends north to the present terminus of 164th Street. ENKON recommends that the upper portion of the right-of-way watercourse be remapped to reflect existing conditions. Should the City of Surrey determine that the proposed extension of 164th Street cannot be re-aligned to avoid the Class B watercourse/ditch, the ditch should be re-located in consultation with the Department of Fisheries and Oceans

3. Field inspection suggests that the present classification of the upper portion of the east roadside ditch along 164th Street between 20th Avenue and 18th Avenue as Class B should be retained, and that portion between 18th Avenue and 16th Avenue presently classified as Class C should be reclassified as Class B. The upper portion of the ditch which is connected to Class C ditches along the south side of 20th Avenue is a manmade roadside ditch with limited evidence of scour or significant flows. The invert vegetation is limited to grasses with localized

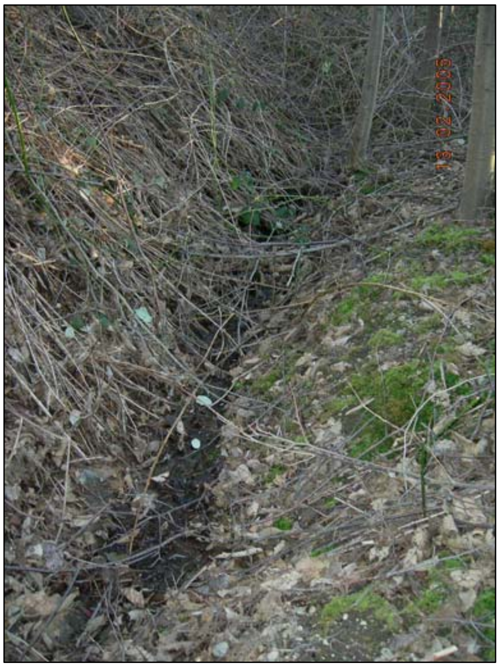
deposits of silt which suggest minimal flow conveyance (Photograph 19); however, below 18th Avenue the increased watershed area which includes seasonal drainage from the 18th Avenue ditches is significant enough to increase flows such that there is evidence of fluvial scour and localized mineral alluvium is present (Photograph 20). Due to the direct downstream connectivity with a Class A tributary of Fergus Creek and potentially significant seasonal flow contribution, ENKON recommends that the entire east 164th Street ditch, between 20th Avenue and 16th Avenue be classified as Class B. The presence of visible flows during several field observations and the direct connectivity to a Class A tributary to Fergus Creek at 16th Avenue further corroborates the recommendation to classify the east ditch, below 18th Avenue as a Class B watercourse. The classification of the uppermost portion, between 18th and 20th Avenues; however, is based on the assumption of significant seasonal flow contributions and the potential for increased allochthonous food and nutrient contributions should a change in maintenance activities along the ditch margins be precluded future disturbance.

Photograph 19 – 164th Street East ditch below 20th Avenue. Grass lined ditch with negligible flow and no significant scour.

Photograph 20 – Downstream view of 164th Street East ditch. Increased flow with localized scour, mineral alluvium and direct connectivity to Class A watercourse below 16th Avenue.

4. ENKON recommends that the Class B watercourses mapped by the City of Surrey in the southern portion of the plan area located south of the 18th Avenue cul-de-sac accessed from 164th Street be reclassified as Class C watercourses. Field observation confirmed the lack of any direct downstream connectivity of these watercourses which appear to be historical property line interceptor drainages. While the area has standing water suitable for potential amphibian habitat, there is no connectivity to downstream fisheries resources and flows surcharging from the isolated ditches disperses to ground within the hydro right-of-way (Photograph 21).

5. The watercourse originating as a drainage ditch at the rear of the private residential lots originating at 16691 16th Avenue is recommended for reclassified to a Class C watercourse based on the lack of direct channel connectivity with downstream resources (Photograph 22). The watercourse enters a concrete culvert above a private residence with unclear downstream connectivity. With respect to remapping of the areas drainage, ENKON encountered an additional east-west interceptor ditch/swale at approximately 60m upstream from the concrete culvert inlet. ENKON recommends a classification of Class C for the previously unmapped small ditch/swale.



Photograph 21 – Abandoned property line drainage ditches located south of 18th Avenue.

Photograph 22 – Manmade drainage ditch located north of residential property at 16691 16th Avenue. No direct downstream connectivity.

The lower Class B watercourse was observed as an abandoned swale below a swimming pool with no evidence of flow, scour or potential downstream connectivity (Photograph 23). ENKON recommends that all watercourses in the vicinity of 16691 be reclassified as Class C watercourses.

Two small manmade ponds were observed within front yard area of the residential property at 16679 16th Ave. No direct surface connections were visible and flows are assumed to discharge to the 16th Avenue ditch via small pvc pipes observed along the northern ditch embankments. Based on the manmade nature and lack of direct surface connection and the likely discharge via flow control structures (i.e. overflow) a classification of Class C is recommended.

6. ENKON recommends that the Class B section of the 16th Avenue ditch along the north roadside (Photograph 24) be retained based on the ultimate downstream

connectivity to a Class A portion of a small Fergus Creek tributary via a 600mm culvert, west of 12th Avenue. Field inspection confirmed the presence of localized scour and the presence of hydrophilic vegetation suggesting seasonally significant flow and perennial saturation. Discussions with DFO suggest that the discharge via the stormwater system for an estimated 920m to its point of discharge to a Fergus Creek tributary branch is not considered to negate the potential food and nutrient contributions to downstream resources.

Photograph 23 – Class C swale located above residential property located at 16733 16th Avenue.

Photograph 24– 16th Avenue ditch draining east to stormwater drainage inlet.

7. Field assessment of a network of property line drainage ditches located within the BC Hydro right-of-way to the east of 12th Avenue suggest that the original classification as Class A(O) should be downgraded to Class B. The drainage features are property line drainage ditches with no evidence of significant flow, residual pool areas or potential access to juvenile salmonids that would support a classification of A(O). Field assessment confirmed the direct downstream connectivity to Class B watercourses and the presence of riparian cover which would provide allochthonous food and nutrient input. Based on the channel presence and the likely seasonal flow and food and nutrient contributions a classification of Class B is recommended; however, physical indicators of significant flow were not observed and the drainage ditches are considered to be non-permanent features limited to seasonal flow contribution to downstream resources.

Field inspection resulted in the encounter of a previously unmapped drainage ditch along the west edge of the property at 17050 12th Avenue. This manmade drainage appears to convey seasonal flow from a locally saturated zone within the BC Hydro right-of-way to the southernmost drainage ditch (east-west). Due to the direct downstream connectivity, classification as Class B is recommended pending future detailed assessment.

8. Field assessment of the tributary 4.1 watercourses confirmed the presence of potentially significant aquatic habitat; however, land use activities have severely degraded the channel morphology and as a result the potential habitat value has been significantly impaired. The easternmost branch was identified as the most hydrologically significant with perennial flows observed during each site visit throughout surveys conducted in 2005 and 2006. Field inspection confirmed the upstream flow contributions from an assumed spring-fed headwater stream originating within the BC Hydro right-of-way above 16th Avenue. Qualitative assessment of the watercourse below 16th Avenue revealed a small well defined watercourse with an intact riparian canopy, well sorted channel substrate and a defined riffle-pool channel with moderate residual pool depth and instream cover (Photograph 25).

   Due to impacts attributed to livestock, and land management, the more naturalized upstream portion was observed to have been impacted with channel diversion via property line ditches and ultimately conveyed in a shallow swale channel with limited complexity and significant erosion and sediment deposition due to bank destabilization (Photograph 26).

Photograph 25 – Upstream view of upper reach of the east branch of Trib 4.1

Photograph 26 – Upstream view of confluence of east and west branches of Trib 4.1. Note visible bank destabilization and negligible pool depth due to livestock related impacts.

The western tributary branch was observed to be characterized by a very poorly defined swale drainage identified only by minor surface expression delineated by the presence of hydrophytes within the uppermost area (Photograph 27 & 28).

Photograph 27 – Poorly defined drainage channel/swale defined by grass lined depression with hydrophytes (*juncus sp.*) at margins of the west branch of Trib 4.1.

Photograph 28 – Downstream view of the west branch of Trib 4.1. Drainage channel poorly defined but distinguished by linear depression characterized by hydrophyte growth.

The lowermost portion of Tributary 4.1, below the confluence of the east and west branches, traverses two (2) private residential driveway crossings (1267 and 1227 16th Street) which may pose barriers to potential upstream migration. Detailed assessment of the potential obstacles was precluded by access restrictions; however, a Classification of Class A is recommended for the tributary branches as removal of introduced barriers is considered a reasonable access improvement.

Based on the perennial flows observed in the east branch, the enhancement potential for Tributary 4.1 is considered very high. Enhancement would require confirmation of potential upstream migration barriers and significant instream works to stabilize eroding banks, increase channel complexity and habitat value and re-establish a protected stream corridor with riparian vegetation. Based on the observed channel conditions in the parcels immediately south from 16th Avenue (16725 and 16734 15th Ave), ENKON recommends the upgrading of the Class B portion of the mainstem channel to Class A based on the potential for fish presence subject to the removal of barriers to fish presence, which includes the removal of potential access barriers and habitat restoration.

9. Field assessment of the small Class A tributary branch entering Reach 4 from the rear of the residential property located at 1168 168th Street, approximately 60m east from the 164th Street culvert crossing of Fergus Creek indicates negligible fish habitat value due to the lack of a defined channel or evidence of significant flow. Seasonal or ephemeral drainage was confirmed based on the presence of rafted organics. The generally low gradient of the floodplain area suggests that seasonal high water conditions may afford some off-channel rearing during the

overwintering period and as such, reclassification to Class A(O) is recommended. Based on the lack of significant channel and negligible flood potential dictates that the uppermost portion of the tributary should be re-classified to a Class B watercourse.

Table 9 summarizes a comparison of watercourse classifications from the City of Surrey's April 2006 watercourse classification mapping and the proposed reclassifications based on the year 2005 and 2006 assessment. Changes in total stream length reflect the proposed watercourse mapping edits, identification of previously unmapped ditch drainages within the NCP Area 2 boundaries.

Table 9 – Watercourse Reclassification Summary

Watercourse Class	City of Surrey (April 2006)	ENKON Re-classification	Net change
Class A	7079m	7468m	+389
Class A(O)	1336m	134m	-1202
Class B	13598m	14523m	+925
Class C	18420m	18703	+283
Unclassified	93.5m	93.5	0
Total	**40526.5**	**40921.5**	**+395**

3.3.5 Preliminary Streamside Protection and Enhancement Areas

With respect to the adapted methodologies, watercourses assessed based on coarse scale reaches and major tributaries as defined by prior assessments. The status of existing and potential vegetation was assessed within a 30m assessment area for both sides of the watercourse to assess the status of existing or potential vegetation. Distances were measured to permanent structures; however, for instances where the watercourse flowed as a roadside ditch, only one side of the watercourse was assessed. Class A and B streams assessed were based on the proposed reclassifications as summarized in section 3.3.4.

All Class A and Class B watercourses were assessed based on Orthophoto interpretation to determine the presence of permanent structures and define average widths for existing and potential vegetation (Table 10). All major Class A stream segments were assessed; however, small tributary segments were amalgamated into the parent reach for the purposes of the assessment. Assessment of Class B watercourses was stratified based on significant watercourses and ditches known or assumed to exhibit permanent flow (i.e. flow for greater than 6 months per year). Streams considered to exhibit permanent flow include natural channels or significant ditches which tend to be oriented in a north-south orientation as dictated by local topography; however, smaller tributaries and property line ditch drainages with no known headwaters are assumed to fall under the non permanent, non fish bearing classification. Preliminary Orthophoto interpretation revealed no watercourses falling within the vegetation category 3, and as such, setbacks for vegetation category 1 or 2 non-permanent non-fish bearing streams will default to a minimum 15m SPEA. Table 11 summarizes the resulting SPEA setbacks as defined by the adapted RAR methodologies. Figure 17 illustrates the respective watercourses and resulting SPEAs based on arbitrary numeric identifiers for the purposes of summarizing setbacks for the main stream reaches and unnamed watercourses.

Table 10 RAR Simple Assessment, Vegetation Status

Figure 17 ID	Watercourse	Approx. Stream Length	Assessment Length	Measurement Interval	Average Potential Vegetation Width
1	Fergus Reach 1	400m	400m	40m	Left Bank – 0m**
					Right Bank – 0m**
2	Fergus Reach 2	636	400	40m	Left Bank – 30m
					Right Bank – 30m
3	Fergus Reach 3	206	206	20m	Left Bank – 0m**
					Right Bank – 0m**
4	Fergus Reach 4	908	400	40m	Left Bank – 26
					Right Bank – 30
5	Fergus Reach 5	558	400	40m	Left Bank – 26
					Right Bank – 27
6	Fergus Reach 6	674	400	40m	Left Bank – 22
					Right Bank – 14
7	Fergus Reach 7	1085	400	40	Left Bank – 30
					Right Bank – 18
8	Fergus Trib 2.1 (Class A & B)	300	300	30	Left Bank – 30
					Right Bank – 30
9	Fergus Trib 4.1 east branch	1040	400	40	Left Bank – 30
					Right Bank –

Figure 17 ID	Watercourse	Approx. Stream Length	Assessment Length	Measurement Interval	Average Potential Vegetation Width
					30
10	Fergus Trib 4.1 west branch - PFB	271	271	20	Left Bank – 30 Right Bank – 30
11	Fergus Trib 4.1 west branch - PNFB	361	361	30	Left Bank – 30 Right Bank – 30
12	Fergus Trib 4.2 – Reach 1 (natural)	275	275	20	Left Bank – 30 Right Bank – 30
13	Fergus Trib 4.2 – Reach 1 (channelized)	599	400	40	Left Bank – 30 Right Bank – 20
14	15876 24th Ave east property line ditch	210	200	20	Left Bank – 30 Right Bank – 20
15	Hwy 99 Ditch (2169 160th)	318	300	30	Left Bank – 30 Right Bank – 0m (road)
16	160th St. Roadside Ditch	210	450	40	Left Bank – 0m (road) Right Bank – 30m
17	161st St. north-south Class B	607	60	50	Left Bank – 30 Right Bank – 20
18	20th Ave Class B Ditch	361	300	30	Left Bank – 0m (road) Right Bank – 28
19	164th Class B watercourse (above 20th Ave)	458	400	40	Left Bank – 30m Right Bank – 30m
20	164th Class B West Ditch	797	400	40	Left Bank – 0m (road) Right Bank – 30m

Figure 17 ID	Watercourse	Approx. Stream Length	Assessment Length	Measurement Interval	Average Potential Vegetation Width
21	164th Class B East Ditch	645	400	40	Left Bank 28m Right Bank – 0m (road)
22	Trib 4.2 – Class B Hwy Ditch	359	300	30	Left Bank 30m Right Bank – 18m
23	Hwy 99 Class B ditch above 20th Ave.	557	400	40	Left Bank – 13m Right Bank – 14m
23	Class B headwaters to Trib 4.1 east (above 16th	300	300	30	Left Bank – 30m Right Bank – 30m
24	Class B 16th Ave. Ditch (16679-16755 16th Ave.)	144	100	10	Left Bank – 30m Right Bank – 0m (road)
25	Class B 16th Ave. Ditch (16679-16755 16th Ave.)	144	100	10	Left Bank – 30m Right Bank – 0m (road)
26	Class B Trib to Tributary 2.1	220	200	20	Left Bank – 30m Right Bank – 30m
27	Hwy 99 Class B ditch trib to Fergus Reach 6	692	400	40	Left Bank – 0m (road) Right Bank – 21m
N/A	Non Permanent Non Fish Bearing Class B Drainages	N/A	N/A	N/A	N/A

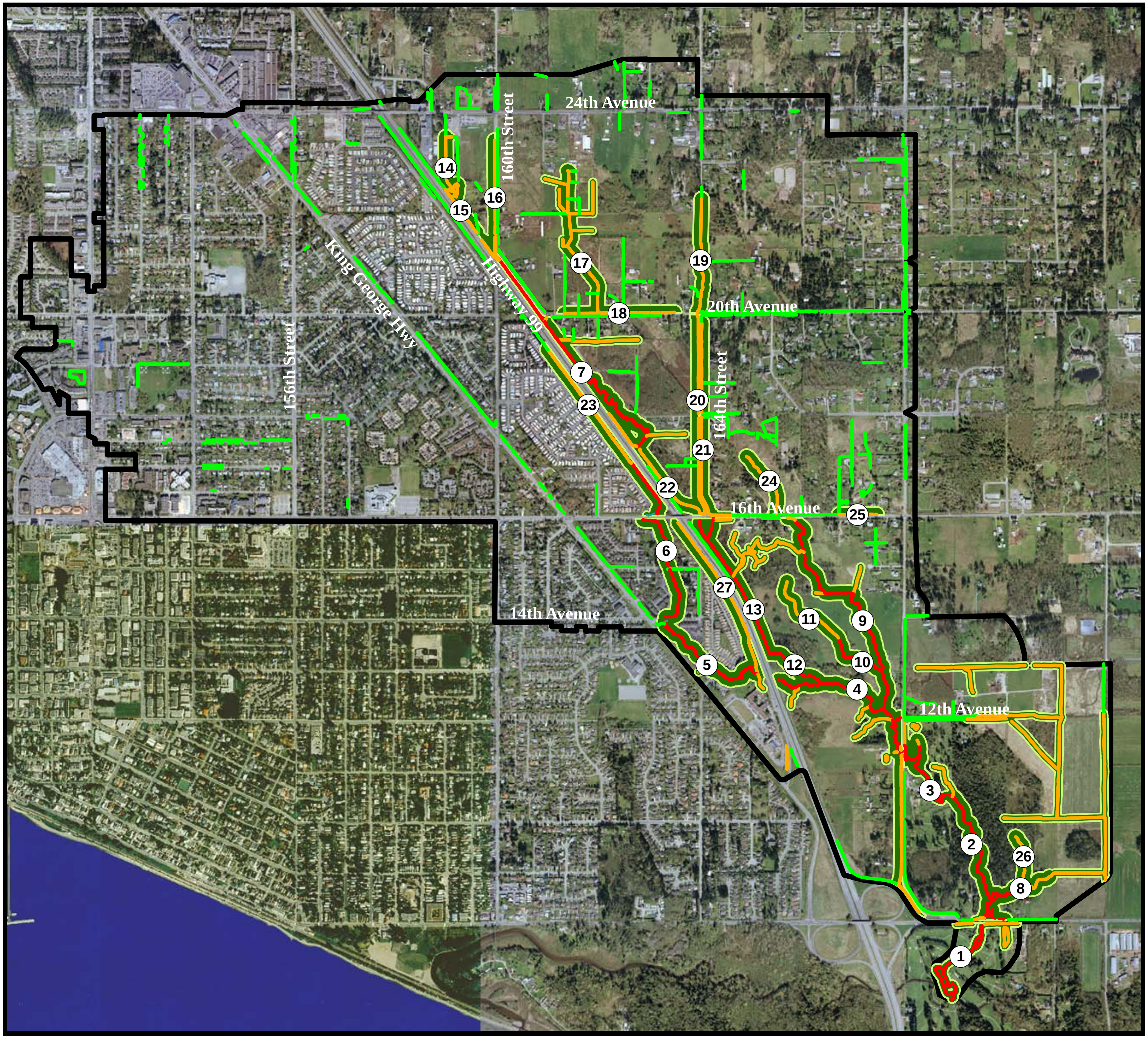
**Note: Golf course considered permanent structure; however, there may be room and opportunity to relocate structures or allow streamside areas to be ‘naturalized” without compromising the recreational use.

Based on the results of the average widths for existing or potential vegetation, all Class A and B watercourses within the Fergus Creek watershed fall in the Category 1 and 2 vegation classification.

Streamside Protection & Enhancement Area Setbacks

Figure 17

McElhanney Consulting Services Ltd.



Legend

③ Table 9 & 10 ID's

Watercourse Classification

- Class A
- Class A(O)
- Class B
- Class C
- Unclassified

🟩 SPEA Setbacks

Watershed Boundary

Scale - 1:20,000

Map Created
December 2006

Prepared by:
ENKON
Environmental Ltd.

Table 11 Preliminary SPEA Setbacks Widths for Class A and B Watercourses within the Fergus Creek Watershed

Figure 17 ID	Watercourse	Average Potential Vegetation Width	Vegetation Category	Fish Bearing Status	SPEA Width
1	Fergus Creek, Reach 1	Left Bank – 0m**	3	Permanent Fish Bearing	Left Bank – 15m
		Right Bank – 0m**			Right Bank – 15m
2	Fergus Creek, Reach 2	Left Bank – 30m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
3	Fergus Creek, Reach 3	Left Bank – 0m**	3	Permanent Fish Bearing	Left Bank – 15m
		Right Bank – 0m**			Right Bank – 15m
4	Fergus Creek, Reach 4	Left Bank – 26m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
5	Fergus Creek, Reach 5	Left Bank – 26m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 27m			Right Bank – 30m
6	Fergus Creek, Reach 6	Left Bank – 22m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 14m	2		Right Bank – 15-30m
7	Fergus Creek, Reach 7	Left Bank – 30m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 18m			Right Bank – 30m
8	Fergus Tributary 2.1	Left Bank – 30m	1	Permanent Fish Bearing/Permanent Non Fish	Left Bank – 30m
		Right Bank –			Right Bank –

Figure 17 ID	Watercourse	Average Potential Vegetation Width	Vegetation Category	Fish Bearing Status	SPEA Width
		30m		Bearing	30m
9	Fergus Tributary 4.1 East Branch	Left Bank – 30m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
10	Fergus Tributary 4.1 West Branch	Left Bank – 30m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
11	Fergus Tributary 4.1 West Branch	Left Bank – 30m	1	Permanent Non - Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
12	Fergus Tributary 4.2 Reach 1 (natural)	Left Bank – 30m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
13	Fergus Tributary 4.2 Reach 1 (channelized)	Left Bank – 30m	1	Permanent Fish Bearing	Left Bank – 30m
		Right Bank – 20m			Right Bank – 30m
14	15876 24th Ave north-south property line ditch	Left Bank – 30m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank – 20m			Right Bank – 30m
15	Hwy 99 Ditch (2169 160th)	Left Bank – 30m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank – N/A	Hwy 99		Right Bank – N/A
16	160th St. Roadside Ditch	Left Bank – N/A	160th St.	Permanent Non-Fish Bearing	Left Bank – N/A
		Right Bank – 20m	1		Right Bank – 30m

Figure 17 ID	Watercourse	Average Potential Vegetation Width	Vegetation Category	Fish Bearing Status	SPEA Width
17	161 Street North-South Class B	Left Bank – 30m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m
18	20th Ave Class B Ditch	Left Bank N/A	20th Ave	Permanent Non-Fish Bearing	Left Bank – N/A
		Right Bank – 30m	1		Right Bank – 30m
19	164th Class B Watercourse	Left Bank N/A	20th Ave	Permanent Non-Fish Bearing	Left Bank – N/A
		Right Bank – 30m	1		Right Bank – 30m
20	164th Class B West Ditch	Left Bank N/A	164th Street	Permanent Non-Fish Bearing	Left Bank – N/A
		Right Bank – 30m	1		Right Bank – 30m
21	164th Class B East Ditch	Left Bank – 28m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank – N/A	164th Street		Right Bank – N/A
22	Trib 4.2 – Class B Hwy Ditch	Left Bank – 30m	1t	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank – 18m			Right Bank – 30m (Hwy 99 at approx. 18m)
23	Hwy 99 Class B ditch above 16th Ave.	Left Bank – 13m	2	Permanent Non-Fish Bearing	Left Bank – 15m
		Right Bank – 14m			Right Bank – 15m
24	Class B headwaters to Trib 4.1 east (above 16th Ave.)	Left Bank – 30m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank – 30m			Right Bank – 30m

Figure 17 ID	Watercourse	Average Potential Vegetation Width	Vegetation Category	Fish Bearing Status	SPEA Width
25	Class B 16th Ave. Ditch (16679-16755 16th Ave.)	Left Bank – 30m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank N/A	16th Ave		Right Bank – N/A
26	Class B Trib to Tributary 2.1	Left Bank – 30m	1	Permanent Non-Fish Bearing	Left Bank – 30m
		Right Bank 30m			Right Bank – 30m
27	Hwy 99 Class B Trib to Fergus Reach 6	Left Bank – N/Am	Hwy 99	Permanent Non-Fish Bearing	Left Bank – N/Am
		Right Bank 21m	1		Right Bank – 30m
N/A	Non Permanent Non Fish Bearing Class B Tributaries	10m – Greater than 15m	1 & 2	Non Permanent Non-Fish Bearing	Minimum 15m

**Note: Golf course considered permanent structure; however, there may be room and opportunity to relocate structures or allow streamside areas to be 'naturalized" without compromising the recreational use.

3.3.6 Benthic Invertebrates

Dillon (2005) used the April 2005 benthic invertebrate data to calculate the Benthic Index of Biotic Integrity (B-IBI), one of the Greater Vancouver Regional District (GVRD) tools for assessing watershed health. The B-IBI is calculated using the following 10 metrics (EVS Environmental Consultants 2000) with predicted responses to human impact:

1. Total number of taxa (*decrease*);
2. Number of mayfly (Ephemeroptera) taxa (*decrease*);
3. Number of stonefly (Plecoptera) taxa (*decrease*);
4. Number of caddisfly (Trichoptera) taxa (*decrease*);
5. Number of long-lived taxa, defined as living at least 2-3 years in the immature state (*decrease*);
6. Number of intolerant taxa (*decrease*);
7. Percent of tolerant individuals (*increase*);
8. Percent of predator individuals (*decrease*);

9. Number of clinger taxa (*decrease*); and
10. Percent dominance, defined as the sum of individuals in the three most abundant taxa divided by the total number of individuals found in the sample (*increase*).

The B-IBI scores range from 10 to 50 and describe the health of the stream as follows:

B-IBI Score	**Stream Condition**
46 – 50	Excellent
38 – 44	Good
28 – 36	Fair
18 – 26	Poor
10 – 16	Very Poor

B-IBI scores provide condition ratings that are consistent with the GVRD's Watershed Classification System. The latter is a graphical method of classifying stream health based on the percent total impervious area (%TIA) and the percent riparian forest integrity (KWL 2002, EVS Environmental Consultants 2000). The correlation between the B-IBI and %TIA is particularly strong.

The B-IBI scores for the Fergus Creek sites ranged from poor (18 at F1) to very poor (14 at F2) (Table 12). A B-IBI score of 18 would be typical of a watershed with approximately 55% TIA, and a score of 14 would be typical of a watershed with TIA approaching 70% (EVS Environmental Consultants 2000). The actual TIA of the watershed above site F1 is 58%; thus, the B-IBI score corresponds well with the TIA. However, the TIA above site F2 is only 43%. The B-IBI score suggests a significantly more degraded benthic invertebrate community than would be expected at this site based on TIA.

Table 12 Input Values for the 10 Metric B-IBI and resulting B-IBI scores for Fergus Creek

Site	Total Taxa	EPT[1] Taxa	Intolerant Taxa	Tolerant Indiv %	Predator Indiv. %	Clinger Taxa	Dominance %	B-IBI Score	Stream Condition
F1	16	2	3	76.54	0.45	3	85.77	18	Poor
F2	9	1	2	66.59	0.18	1	97.94	14	Very Poor

[1] Three individual metrics (Ephemeroptera taxa, Plecoptera taxa and Trichoptera taxa) are combined and presented as EPT taxa

Dillon (2005) cautions against relying on B-IBI scores based on a single sampling event, especially for watercourses such as those in Surrey where baseline (i.e., pre-impact ‘healthy’ stream) conditions vary from those of the reference watercourses used to calibrate the B-IBI stream condition ratings. They point out that although fewer pollution sensitive (intolerant) taxa were found at F2 than at F1, higher numbers of intolerant individuals were present at the downstream (F2) site.

There are additional reasons for using caution when interpreting the B-IBI scores. The Dillon (2005) samples were collected in April, whereas the GVRD’s B-IBI guide (EVS Environmental Consultants 2003) specifies sampling should occur between August and late September. The spring rather than late summer sampling time might have resulted in fewer or different species being present due to differences in adult emergence and/or breeding times. It is possible as well that some species could not be identified in April because the larvae were small and/or underdeveloped. For example, it is possible that a greater number of mayfly species than the one (*Baetis tricaudatus*) listed by Dillon (2005) were present but not identified because the larvae were too small for accurate identification. However, the presence of unidentified early-stage larvae would not account for the absence of caddisflies at F2 and stoneflies at both sites.

3.3.7 Water Quality

Water quality results from the September 26, 2006 low summer flow sampling period were used to supplement the benthic invertebrate data assessment of the health of the Fergus Creek system. The field data were compared with provisional water quality objectives for the Little Campbell River and its tributaries (Swain and Holms 1988) and provincial water quality guidelines (BC Ministry of Environment 2006). The objectives and guidelines used were as follows:

pH	Objective	6.5 to 8.5
Oxygen, dissolved	Objective	6.0 mg/L minimum - June to October 8.0 mg/L minimum -June to October (long-term objective)
Turbidity	Objective	5 NTU maximum increase when upstream values are less than or equal to 50 NTU 10% maximum increase when upstream values exceed 50 NTU
Temperature	Guideline	+ or – 1° Celsius change beyond optimum temperature range for the most sensitive salmonid species present (assumed to be 16°C maximum for rearing coho salmon and cutthroat trout; 14°C maximum for chum salmon could apply to the “lower reaches”[1])

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[1] It is unclear which reaches Gartner Lee (2000) mean by the “lower reaches” where chum salmon were observed (see Section 3.3.1).

The objectives and guidelines were applied to the data as follows:

- pH outside the objective range would have been considered an indicator of "poor" water quality; however, pH was within the objective range at all sites.
- Dissolved oxygen less than 6.0 mg/L was considered an indicator of "poor" water quality; dissolved oxygen >6.0 mg/L but <8.0 mg/L was considered an indicator of "marginal" water quality.
- Turbidity and temperature objectives/guidelines are given in terms of change from background conditions and are intended to assess the effect of a discharge or other specific human activity. They are not directly applicable to the Fergus Creek sampling program. For this reason, a designation of "poor" water quality was not assigned due to turbidity or temperature alone. Rather, these parameters were used to identify "marginal" water quality, as follows.
  - Turbidity was evaluated in two ways. An increase in turbidity greater than 5 NTU from one reach to the next[2] could have been considered an indicator of "poor" water quality (but this did not occur). In addition, the distribution of turbidity values at all sampling sites was considered. At 80% of the sites the turbidity was less than 7 NTU. The remaining 20% (three sites) had turbidities greater than 20 NTU. Elevated turbidity (>20 NTU) was considered an indicator of "marginal" water quality.
  - A water temperature of 17°C or higher (i.e., >1°C above the upper optimum rearing temperature for coho salmon and cutthroat trout) would have been considered an indicator of "marginal" water quality. However, the temperatures at all sites were below 17°C.

Based on the one time sample, Tributary 4.1 had marginal water quality due to elevated turbidity. Reach 6 had poor water quality due to low dissolved oxygen levels. The 16th Avenue stormwater outfall had poor water quality due to low dissolved oxygen levels and elevated turbidity, while the 160th street at 24th Avenue stormwater outfall had marginal water quality due to dissolved oxygen level <8.0 mg/L but >6.0 mg/L (Table 13). All other sampling locations had acceptable levels of dissolved oxygen, pH, turbidity, conductivity and temperature.

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[2] i.e., Reach 2 to Reach 1 but not Reach 4 to Reach 1

Table 13 Water Quality Sampling Results within the Fergus Creek Watershed, September 26, 2006

Parameter	**Units**	**Reach 1**	**Reach 2 Tributary**	**Reach 2**	**Reach 3**	**12th Ave. Storm**	**Reach 4**	**Reach 4 Tributary**	**Tributary 4.1**
Time		**13:45**	**10:30**	**11:15**	**11:30**	**12:00**	**12:30**	**12:40**	**13:15**
pH	pH Units	7.6	6.9	7.2	7.6	7.6	7.6	7.4	7.4
Conductivity	mS/cm	0.27	0.77	0.27	0.29	0.17	0.31	0.36	0.056
Turbidity	NTU	5.92	23.9	3.23	4.37	1.64	0.83	1.99	58.5
Dissolved Oxygen	mg/L	11.3	1.0	8.9	12.5	10.6	10.8	8.4	8.2
Temperature	°C	12.2	9.6	10.8	12.6	13.8	11.6	10.6	15.2
Water Quality Condition		Acceptable	Poor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Marginal
Reason			D.O. & Turbidity						Turbidity
Parameter	**Units**	**Reach 5**	**14th Ave. Storm**	**Reach 6**	**16th Ave. Storm**	**Reach 7**	**160th Street-24th Ave. Storm**	**20th Ave. Storm**	
Time		**14:15**	**14:30**	**14:45**		**16:40**			
pH	pH Units	7.5	7.3	7.2	6.9	7.4	7.1	7.4	
Conductivity	mS/cm	0.27	0.27	0.27	0.35	0.19	0.070	0.18	
Turbidity	NTU	1.69	3.05	2.89	39.0	2.03	6.26	3.29	
Dissolved Oxygen	mg/L	9.7	9.8	4.1	4.5	9.6	6.4	8.8	
Temperature	°C	15.7	16.3	12.1	15.6	12.9	14.6	15.8	
Water Quality Condition		Acceptable	Acceptable	Poor	Poor	Acceptable	Marginal	Acceptable	
Reason				D.O.	D.O. & Turbidity		D.O.		

3.4 Proposed Habitat Preservation Areas

The City of Surrey's 2004 Highway 99 Corridor Local Area Plan outlines three environmental preservation areas including:

1. A "linear habitat feature" adjacent to Highway 99, extending approximately between the 12 Avenue and 23 Avenue right-of-ways including the upper section of Fergus Creek. This feature includes Reach 7 of the Fergus Creek mainstem which consists mainly fines substrate (i.e. clay with some gravel and cobbles). The upper half of the reach is ditched along Highway 99 and fisheries values have been assessed as medium for rearing and low for spawning, although the culvert under Highway 99 limits fish access. The lower portion of Reach 7 has a well defined riparian vegetation zone useful for a variety of wildlife species;

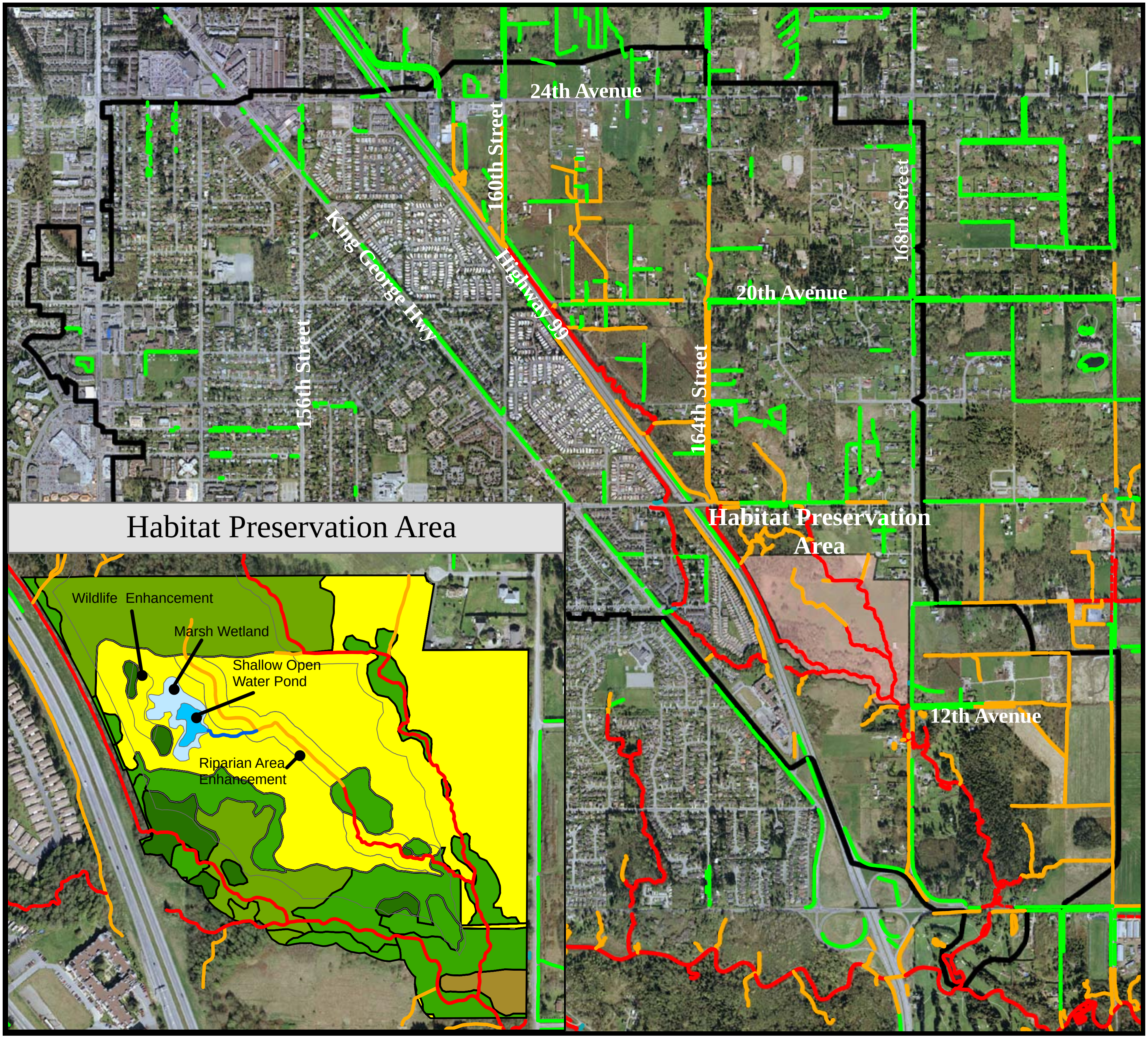
2. Two sections of proposed fisheries "food and nutrient" features to be developed along the BC Hydro right-of-way (Figure 18). This area is comprised primarily of field habitat with no forested areas and as such has limited wildlife values; and

3. A large "block" of habitat comprising the Fergus Creek ravine and most of the critical wildlife habitat located generally south of 16th Avenue. The existing habitat of this area consists of 5 vegetation types including old field, pole-sapling, deciduous, coniferous and mixed forests.

The resulting diversity of habitats supports a wide variety of wildlife species including most importantly, most or all of the previously listed species of concern.

The primary objectives of the habitat management strategy for the preservation areas are to preserve representative habitat types and a range of wildlife species currently using the proposed corridor areas, and in particular to preserve habitat for Pacific water shrew.

The habitat preservation area also encompasses a significant portion of Reach 4 of the Fergus Creek mainstem and the potential fish bearing portions of two branches (Tributaries 4.1 and 4.2) of a tributary to Fergus Creek. Reach 4 is relatively pristine and dynamic with high quality salmonid habitat (Gartner Lee 2000). This riffle-pool channel with a predominant gravel-cobble substrate and abundant overhanging vegetation, undercut banks and rootwads offers good spawning habitat and rearing habitat for coho salmon and cutthroat trout (Gartner Lee 2000). Tributary 4.1 is an ephemeral channel with limited riparian vegetation and low spawning and rearing values. Tributary 4.2 has a well developed riparian vegetation zone in the lower sections with primarily clay substrate resulting in low fisheries values.



Proposed Habitat Preservation Area

Figure 18

McElhanney Consulting Services Ltd

Legend

- Watershed Boundary
- 🟥 Enhancement Area

Watercourse Classification

- Class A
- Class A(O)
- Class B
- Class C
- Unclassified

Preservation Area Inset

- Marsh Area
- Pond Area
- Connector Channel

Scale 1:20000

Map created December 2006

Prepared by:
ENKON
Environmental Ltd.

3.5 Environmentally Sensitive Areas (ESA's)

As indicated in the previous discussions and in keeping with the City's by-laws, plans and policies, areas which were identified as environmentally sensitive include:

1. High suitability habitat for the following listed species; Great blue heron, barn owl, short-eared owl, western screech-owl, band-tailed pigeon, Pacific water shrew, Trowbridge's shrew, western toad and red-legged frog.

2. Seven important wildlife tree patches identified in the Grandview Heights Neighbourhood Plan Area 2 Environmental Review (ENKON 2006), in particular those ranking relatively high in Plan Area 2 such as Stands No. 1 and No. 2. Stand No. 1 is a moderate sized but dynamic and old patch of natural forest, with significant diversity and productivity of native species. Stand No. 2 includes a narrow riparian area, an old patch of structurally diverse forest in the north end with wet depressions and vernal pools, a mix of seral stages, a range of native vegetation species, and a raptor nest.

3. Wildlife movement corridors which provide access to important habitats such as a movement corridor along Fergus Creek and a potential corridor along the "Height of Land" from the northwest corner of Grandview Heights Neighbourhood Plan Area 2 to the southeast and connecting to Dart's Hill Garden and Redwood Park. Much of the "Height-of-Land" potential wildlife movement corridor is treed and passes through portions of 3 significant stands of trees (Stands No. 3, 4 and 6) as well as patches of mature to old forest and riparian areas. A third wildlife movement corridor exists along the BC Hydro right-of-way running along the western border of Grandview Heights Neighbourhood Concept Plan Area 2; however, the BC Hydro ROW provides little value as refuge during these movements due to the lack of forest or high shrub cover. In addition, portions of the BC Hydro ROW are planned for commercial development or are immediately adjacent to business park/light industrial developments (Highway 99 Corridor Local Area Plan, February 2004) which would reduce the value of the corridor for wildlife;

4. The proposed "Habitat Preservation Area" located south of 16th Avenue, east of Highway 99 and west of 168th Street (Figure 18). This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew; and

5. The Fergus Creek mainstem and all other Class A and B tributaries and associated riparian habitat that provide significant rearing/spawning habitat and/or food and nutrient contributions to downstream fish populations. Any Class C watercourses that are assessed as "fish habitat" during the development application phase.

4.0 ENHANCEMENT OPPORTUNITIES

The following section on fish and wildlife enhancement opportunities is intended to identify potential opportunities to enhance both fish and wildlife habitat within the Fergus Creek watershed. Recommendations for enhancement are based on field assessments, review of available information and prior recommendations for aquatic habitat and fish access improvements. Where possible, the enhancement opportunities are prioritized.

4.1 Fish Habitat

Fish habitat enhancement opportunities within the Fergus Creek watershed have been identified on the basis of human development or encroachment which has/could negatively affect the productive capacity of a given watercourse and opportunities identified from previous studies. Specific impacts affecting habitat values were classified on the following criteria:

- Fish access limitations,
- Instream habitat limitation,
- Water quality/quantity limitations, and
- Riparian habitat limitations.

Based on field observations of fish habitat, fish distribution and the hydrologic regime of Fergus Creek, ENKON proposes the following prioritization of works to address the aforementioned fish habitat impacts:

- Removal of barriers to upstream migration,
- Enhancement of baseflows/water quality,
- Riparian enhancement,
- Erosion Control; and
- Instream habitat enhancement projects.

The recommended prioritization of works proceeds in an upstream direction such that individual enhancements result in a cumulative increase in the “effective” productive habitat. The benefits from individual projects may be nominal; however, in aggregate, the completion of projects will result in a notable improvement to the overall productivity of the watershed.

The recommended prioritization is based on the assumption that increasing upstream migration potential is critical with introduced barriers taking priority; however, where natural barriers would negate the value of upstream works, the removal of natural barriers should be pursued. Watercourses discussed include those with a reasonable likelihood of providing fish habitat directly (i.e. potential upstream migration to existing productive habitat) which in some cases may be outside of the plan area.

In addition to removal of barriers, riparian enhancement opportunities are available for both Class A and B watercourses. However, it is recommended that a detailed review of the proposed riparian areas be undertaken during the subdivision applications stage. Once appropriate streamside protection and enhancement area widths are established, a detailed review of the existing vegetation, previous disturbance and enhancement opportunities will yield a better understanding of critical areas with respect to the potential benefits to fish habitat.

Following the removal of barriers and addressing low flow/poor water quality concerns, additional instream enhancements or mitigation should be pursued as required.

4.1.1.1 Barrier Removal

Removal of existing introduced barriers (i.e. culverts) will provide the greatest benefit as they will allow free access to existing productive habitat. Perched culverts were identified at various locations along the watercourses within the plan area. Culverts which themselves do not appear to be significantly perched but may limit fish distribution during low flow periods, or situations where culvert gradients may result in flow velocities prohibitive to upstream migration, are also considered enhancement opportunities.

Natural barriers including debris jams, falls or cascade barriers are identified as enhancement opportunities. As potential enhancement works proceed in an upstream direction, natural barrier removal should be considered prior to undertaking any additional introduced barriers since removal of introduced barriers for the purposes of enhancing fish access or instream habitat restoration would be redundant if natural barriers to upstream migration remain.

A key barrier is the culvert under Highway 99 in Reach 4. If adult salmon could navigate past the current barrier at this location, they could gain access to spawning habitat in Reaches 5 and 6 and their offspring could utilize the rearing habitat in this area. Fish may be able to navigate this corrugated metal pipe with the addition of steps at the downstream end with baffles throughout the length. Hydraulic modeling would determine if the culvert could be altered to pass required flows and be passable for migrating fish. An alternative plan would be to replace the culvert with an oversized baffled culvert that would guarantee fish passage. However, potential erosion from increased capacity would have to be examined to ensure no downstream impacts.

As a short term alternative to removing the culvert, if spawning habitat appears to be a limiting factor in Reaches 1 to 4 due to high fish returns, is to transport adult coho above the culvert. This would allow the fish to gain access to potential spawning habitat in Reaches 5 and 6.

Gartner Lee (2000) also provided a list of other potential barriers within the upper Fergus Creek watershed (Table 14), including:

- Potential low flow/velocity barrier at a concrete culvert located at 14th Avenue in Reach 5;
- Potential low flow barrier at a box culvert located at 15th Avenue in Reach 6;
- Potential low flow barrier at 2 corrugated metal pipes located at Frontage Road in Reach 6;
- Potential low flow barrier at 2 corrugated metal pipes located at 16th Avenue in reach 6; and
- Barrier to fish passage at 2 corrugated metal pipes located at Highway 99 in Reach 6.

4.1.1.2 Baseflow/Water Quality Enhancement

ENKON confirmed the prevalence of low flow/poor water quality concerns which are attributed to local geological, alluvial processes and existing land use. Significant portions of the area watercourses are dry throughout the summer low flow period with habitat limited to residual pools.

Addressing low flow concerns will involve the implementation of the recommendations outlined in the Fergus Creek Integrated Stormwater Management Plan, directing groundwater seepage zones and artesian wells to watercourses, and low impact development practices intended to assist in the maintenance of summer low flows. ENKON recommends that watershed environmental monitoring be conducted to assess watershed ecology prior to, during, and post development. Monitoring recommendations include benthic invertebrate monitoring, water quality sampling and flow monitoring. Establishing a pre-development baseline monitoring program will be critical for the comparison of post development conditions and facilitate an assessment of changes to the summer low flow regime. Flow monitoring should be conducted on a continuous basis to assess annual variations and the impacts on the hydrologic regime as development progresses.

Site specific opportunities for baseflow enhancement to increase potential rearing habitat includes the potential for stormwater connections with the Class A tributary 2.1. ENKON recommended retaining the Class A status based on the potential for this tributary to provide potential rearing habitat; however, flow enhancement would be required to improve habitat value beyond potential Class A(O) habitat. The alteration of historical drainage appears to have limited streamflow to this tributary resulting in stagnant discontinuous flow with high ambient turbidity observed during the year 2005/2006 assessments. Connection of treated stormwater discharges to enhance streamflow coupled with potential bank stabilization may yield an effective increase in salmonid rearing habitat.

Table 14 Potential Barriers to Fish Passage in the Fergus Creek Watershed

Structure ID	New East ID*	Crossing	Reach	Location u/s (m)	Structure	Length (m)	Diameter (m)**	Height (m)	u/s Bed to Road (m)	Comment
A		168th Street	4	0	corrugated metal pipe	11	1.6		3.4	
A		168th Street	4	0	concrete pipe	11	1.2		3.4	
B		Private drive	4	37	foot bridge	4	2.5	1.7	2.4	
C	1	Hwy. 99	4	712	corrugated metal pipe	76	1.3		9.3	barrier to fish passage
D	2		5	439	foot bridge	10	1.52			
	3	14th Ave	5	525	storm sewer outfall		1.05			flows into creek
	4	14th Ave	5	525	concrete pipe	46	1.52			potential low flow/velocity barrier
	5	14th Ave	5	525	2 concrete pipes	18	0.9		0.5	conveys high flows
	6	15th Ave	6	210	box culvert	10	2.4	1.5		potential low flow barrier
	7		6		foot bridge	5	2	1.5		
	8		6	290	foot bridge	5	1.5	1		
	9	Frontage Rd.	6	385	2 corrugated metal pipes	20	1.4		2.9	potential low flow barrier
	10	16th Ave	6	410	2 corrugated metal pipes	31	1.4		4.9	Potential low flow barrier
	11	Hwy. 99	6	674	2 corrugated metal pipes	110	1.2		2	barrier to fish passage
	12		7	125	concrete pipe	3	0.9			
	13	Private drive	7	165	concrete pipe	5	0.9			
	14		7	>706	storm sewer outfall		1.35			flows into creek
	15		7	>706	storm sewer inlet		1.35			

* From Gartner Lee Limited 2000

** or width for bridges

4.1.1.3 Riparian Enhancements

ENKON recommends that a detailed assessment of the riparian zone be undertaken during the subdivision applications stage. Once detailed designs and the proposed streamside protection and enhancement areas related to the subdivision application are available, a detailed review of the current status and potential enhancement opportunities can be undertaken and the resulting enhancement areas can be prioritized based on the respective fish habitat values. The City of Surrey Environmentally Sensitive Area study (Coast River *et al*, 1997) outlined the following sections of Fergus Creek for riparian enhancement including Sections of Reach 1 (Peace Portal Golf Course), Reach 3 (Meridian Golf Course), Reach 6 (220 to 260m and adjacent to Hwy. 99) and Reach 7 (adjacent to Hwy. 99). These areas contain banks void of shrubs and trees. Planting would increase stream cover, bank stability and wildlife corridor habitat.

Field assessments conducted in 2005/2006 identified the lack of riparian buffers and resulting land use as a major influence affecting habitat impacts affecting portions of Tributaries 4.1 and 4.2. Re-establishment of riparian cover and limiting livestock access to stream channels will significantly improve habitat values.

4.1.1.4 Erosion Control

An assessment of erosion sites was conducted by New East Consulting Services Ltd. as part of the Fergus Creek Drainage study in October 1996. The results of their assessment included the following;

1. Of particular concern with respect to erosion sites are the properties between 14 and 16 Avenues and at the mobile home location approximately 250m south of 14 Avenue. Many of the mobile homes have been located within 10m of the ravine western edge where a fallen tree has diverted flows towards the homes. The west ravine bank is 7 m high with an almost vertical face and low flows have caused significant erosion immediately below the mobile homes.

2. Along the remainder of Fergus Creek, houses and small sheds have been constructed within 10m of the channel banks particularly between 14 and 16 Avenues. Although a significant portion of the stream banks have been lined with rip-rap or are well vegetated, many areas of exposed soil material exists.

In 2000, Gartner Lee Limited assessed 16 erosion areas within the upper Fergus Creek watershed as part of the Fergus Creek Master Drainage Plan Update Environmental Review (New East Consulting September 2001). The erosion sites were examined and rated according to their severity. A rating of high was assigned to those sites which were regarded to be at high potential for degradation of fish habitat or a threat to structures and properties. The creek reaches between 16th Avenue and the south crossing of Highway 99 exhibited the highest concentration of erosion, however, two other sites were identified in downstream locations between Highway 99 and 168th Street. The erosion sites rated as high in upper Fergus Creek included:

1. E1 Reach 4 at 380-415m upstream of Reach 3 the right bank is approximately 1m high and is undercutting a concrete fence/wall. The left bank is also undercut with overhanging vegetation.

2. E8 Reach 5 at 220-260m upstream of Reach 4 where bank stabilization works were being conducted during the field assessment by Gartner Lee.

3. E10 Reach 5 350-420m upstream of Reach 4 where the 1.5m high right bank is eroding. Wooden ties were attempted to stop the erosion by a local resident.

4. E12 Reach 6 100-175m upstream of Reach 5 where the 1-2.3m high bank is eroding. Wooden ties and rip-rap have been used to attempt to stop the erosion but at one location a corner of a building is <1m from the edge of the bank.

New East Consulting Services Ltd. (2001) provided a number of recommendations to control erosion throughout Fergus Creek including:

1. Channel stabilization techniques including hardening the channel through the use of concrete lining, rip-rap, gabion baskets etc. through to softer bio-engineering techniques such as the use of vegetation to bind the soils wit their root networks. Other methods include the use of log or rock weirs to change the hydraulic gradient within the creek thus reducing velocities.
2. Possible diversion routes include high flow route along highway 99 between 16 and 14 Avenues, extensions to the King George Highway storm sewer, diversion of rural flows originating on the east side of Highway 99 and the diversion of urban flows in the area bounded by 24 Avenue, Highway 99, 16 Avenue and King George Highway.

Chronic bank destabilization due to livestock influences affecting both the east and west branches of tributary 4.1 and sections of tributary 4.2 were noted by Envirowest (1994) and confirmed during the year 2005/2006 assessments. Bank stabilization, riparian enhancement and exclusion fencing are recommended to mitigate chronic erosion and sediment transfer concerns for these areas.

The low impact development strategies developed as part of the Fergus Creek Integrated Stormwater Management plan prepared by McElhanney Consulting Services (2006) is intended to provide strategies to reduce peak flows in Fergus Creek resulting in reduction of erosion potential throughout the Fergus Creek system. However, even with reductions in peak flows, a number of the above noted erosion control opportunities and techniques should be implemented to reduce the potential for erosion or control existing erosion sites.

4.1.1.5 Instream Habitat Improvements

Instream habitat improvements such as enhancement of Class A and B watercourses should only be pursued once it is established that fish access and the low flow regime of the stream warrant such works. Instream enhancements over and above barrier removals include such concerns as bank instability, unauthorized trail crossings, dry channel sections, garbage pollution, stream fence crossings and cattle access to watercourses. While mitigation of these concerns may cumulatively result in an enhancement to fish habitat values, they are ranked low in priority.

Considering the fish and wildlife species present, and the constraints of the watercourses in the study area, the following fish habitat instream enhancement projects were identified in the City of Surrey Environmentally Sensitive Areas study (Coast River *et al*, 1997).

- Clean up litter in Reach 5: A litter program would benefit the health and aesthetics of the creek.
- Increase spawning habitat: The abundance of clay and the continued urban development in the upper Fergus Creek watershed does not provide a significant source of gravel recruitment for spawning habitat. Future flash

flows could move existing gravel downstream and leave the upper reaches void of spawning habitat. Currently, the quality of spawning habitat is high in Reach 4, moderate in Reaches 5 and 6, and low in Reach 7. If the Highway 99 culvert at Reach 4 is modified to be passable for adult salmon, weir structures should be installed within the Reaches to collect/contain gravel.

ECL Envirowest recommended a number of enhancement opportunities in their 1994 report and in the summer of 1999, one of them was implemented. Within Reach 4, at 220 to 260m (E8), a loc-bloc wall was installed at the eroded comer, a log jam removed and the creek re-directed away from the loc-block wall. Gartner Lee (2000) determined that the log barriers in Reaches 5 and 7 noted in the Envirowest report were not significant concerns. Additional habitat enhancement opportunities identified by Envirowest (1994) included the following:

- Removal of debris and garbage from within Reach 4
- Habitat complexing and pool creation within Reach 3

Rearing habitat is not a limiting factor in Fergus Creek at this time; therefore, instream complexing for rearing habitat is not a high priority. Within the study area, habitat is rated high for rearing in Reaches 4 and 5, and moderate in Reaches 6 and 7. However, channelized stream reaches which includes Reach 3 and portions of Reaches 6 and 7 would benefit from instream habitat improvements such as pool enhancement and habitat complexing. Rearing habitat enhancement in reach 3 is recommended as the highest priority due to known fish presence and the observed bank destabilization (see photograph 10), lack of instream complexity and lack of riparian cover. Habitat enhancement coupled with riparian enhancement may further alleviate stormwater related concerns via the mitigation of flood energy, facilitation of scour and deposition of bed materials and bank stabilization.

4.2 Wildlife Habitat

ENKON recommends the following wildlife habitat enhancement opportunities pertaining to amphibians, small mammals, raptors, songbirds, red and blue listed and SARA listed species:

- Where culverts are necessary it would be desirable to install oversized, natural-bottom culverts, as they provide a direct connection for small mammals, amphibians and reptiles across roads from habitat areas to adjacent, otherwise inaccessible areas. This would benefit the listed red-legged frog and other wildlife. Where topography does little to channel wildlife towards the culvert, earthworks or wing walls may be appropriate to funnel wildlife towards these culvert crossings. If standard metal, corrugated culverts on-site are expected to take higher water levels it may be necessary to build walkways along the edge of the culvert to provide a dry corridor for small mammals.
- If culvert wildlife underpasses are not feasible for residential roadways, vehicle speeds should be impeded near forest refuges by vehicle slowing

features such as speed bumps, rumble strips, traffic circles and narrow roadways.

- Where possible retain a selection of stand structural elements, such as large trees, snags, logs on the forest floor, and canopy gaps. Mature trees should have cavity-nesting characteristics such as cracks and holes in the bole where limbs have been shed. Snags (i.e., wildlife trees) that are retained should have cracks, bird holes and hollow interiors or should have the potential to develop these characteristics.
- Garbage should be removed from forested retention zones to help ensure that wildlife does not ingest anthropogenic material and that garbage does not harm amphibian egg masses in streamside channels.
- Where possible, retain tracks of forests that are linked with adjacent forests to minimize the fragmentation of wildlife habitat and maximize forest connectivity. These natural corridors should be protected with attractive, wooden fencing to minimize disturbance from humans and pets. Education signs should be posted to indicate the purpose of the fence.
- Residents or a residential organizations should take the lead in the creation of artificial nest cavities by installing nest boxes for birds and artificial roosts for bat species. Nest boxes can be created to attract various wildlife species such as red-breasted nuthatch, woodpeckers, chestnut-backed chickadee, and owls. The artificial roosting/nesting sites can be constructed to attract particular species and prevent use by introduced/exotic species. These nest boxes or bat houses are inexpensive to make and can help educate young children about local wildlife.
- The City of Surrey, and specifically the Fergus Creek watershed area slated for development, should adopt a “Wildlife Awareness” program to reduce wildlife-human conflicts.

5.0 BEST MANAGEMENT OBJECTIVES AND DEVELOPMENT GUIDELINES

5.1 Environmentally Sensitive Areas

The following “Best Management Objectives and Development Guidelines” are intended to provide some guidance to the City of Surrey during the development or re-development of the Fergus Creek Watershed Area to ensure that critical fish and wildlife habitat is protected. Although it is likely that not all of these objectives and guidelines can be followed due to density requirements, road/servicing networks and commercial/industrial developments, it is recommended that as many as possible be incorporated into environmentally sensitive areas including important wildlife tree patches, wildlife corridors, preservation areas and fish habitat.

5.1.1 Important Wildlife Tree Patches

High quality stands of older mature natural forests are critical to the survival of many wildlife and plant species in developing urban and rural areas. They provide cover, food, and nesting habitat for a wide range of taxa, buffers from human-related disturbances, greenlinks to other important habitats and refuges from natural and unnatural predators. Old, dead, and decaying trees in these areas are used by wildlife for nesting, food, shelter, denning, roosting and perching. As such, wildlife trees are a vital component of natural forests. Seven important wildlife tree patches were identified in Grandview Heights Neighbourhood Plan Area 2 and ranked in quality and importance. In addition, although ENKON did not conduct surveys to identify important wildlife tree patches within the remainder of the Fergus Creek watershed, similar tree patches likely exist within the lower watershed between 12th and 8th Avenues and 168th and 172nd Streets, near the corner of 172nd Street and 16th Avenue and south of 16th Avenue and west of 168th Street.

The following measures are recommended to protect these important areas:

- Where possible, retain at a minimum all or portions (>0.5 hectares in size) of important Wildlife Tree Patches including Stands No. 1, 2 and 4 to provide refuge, food and breeding areas for various wildlife species including listed species: Pacific water shrew, Trowbridge’s shrew, red-legged frog and western toad.
- Where possible, retain at a minimum all or portions (>0.5 hectares in size) of important Wildlife Tree Patches including Stands No. 1, 2 and 7 to provide refuge, food and breeding areas for the listed species: western screech-owl and band-tailed pigeon.
- Encourage connectivity to significant stands of trees or tree patches using Stream Protection and Enhancement Areas or wildlife corridors.

- Maximize retention of understory plants as these areas provide habitat for many wildlife species and their prey.
- Trees that provide important wildlife habitat should be identified as such in order to protect them from harm or destruction. Signs are an effective means of identifying "Wildlife Trees" and educate the public about important wildlife habitats and conservation issues.

- Monitor and protect the ecological values of forested areas and allow for the continuation of natural processes that are essential for ecosystem sustainability and resilience to environmental perturbations.
- Limit recreational access to reduce disturbance to natural vegetation and sensitive microhabitats.
- Restrict the growth of introduced/exotic plant species which may invade and compete with native vegetation, and ultimately result in greatly reduced species diversity.
- Educate the public with local tree preservation by-laws, such as The City of Surrey's Tree Preservation By-law No. 12880, and cutting regulations, such as the City of Surrey's Conditions of Tree Cutting Permits (Building Division, Doc. No. D-04-02), through educational forums and mail-outs. For example, the Tree Preservation By-law restricts the cutting of trees >30 cm in diameter and protects 10 species of trees, including arbutus and grand fir, without a cutting permit. A condition of the permit is that shrub and tree clearing cannot take place from April 1 - August 1 unless a bird nest survey is conducted by a professional prior to cutting.

5.1.2 Wildlife Movement Corridors

Most animals need and will utilize suitable wildlife movement corridors. They provide an opportunity for wildlife to move freely between two or more habitat patches or habitat types in an otherwise fragmented landscape. They are very important for wildlife requiring large ranges of movement such as birds and large mammals, and are critical for small mammals whose habitats would otherwise be isolated risking extinction of the resident population. Movement is essential to provide genetic links between populations and to compensate for temporary population declines in some habitat patches.

Corridors usually consist of linear habitats such as streamside riparian areas and are often composed of 2 or more ecosystem types contributing varied forage areas, structural complexity and species diversity. Riparian areas, natural gullies, utility corridors, golf courses and patches of urban forest can function well as wildlife corridors for some species. Riparian areas are often wildlife havens on which many insects, amphibians, reptiles, birds and mammals as well as fish rely for at least part of their life cycle. The habitat needs of all priority species should be incorporated into the design of a corridor. They must be suitably wide (≥ 50 m) to be ecologically functional, with appropriate habitat features to provide security cover during wildlife movement. The following "Best Management Practices" should be followed where possible:

- Provide and enhance north-south and east-west wildlife movement corridors along the Fergus Creek mainstem and the "Height-of-Land" from the northwest corner of Plan Area 2 to the southeast and connecting to Dart's Hill Garden and Redwood Parks. The Fergus Creek mainstem and associated riparian corridor is an important salmon and trout producing watercourse and provides suitable habitat for a number of federally and provincially listed wildlife species. Much of the "Height-of-Land" potential wildlife movement corridor is treed and passes through portions of 3 important stands of trees in Plan Area 2 (Stands No. 3, 4 and 6) as well as patches of mature to old forest and riparian areas. Wildlife movement corridors should be linked as much as possible with these high-use habitats (i.e. passive parks, riparian areas, wildlife tree patches, wetlands or shrub habitat such as patches of salmonberry or salal);
- Retain species-appropriate stream corridors around permanent watercourses, focusing width and design on particular target or at-risk species. Ideally, wildlife corridors should be a minimum of 30 m on either side of a permanent stream to maintain habitat quality in riparian corridors for wildlife;
- Protect the ecological values of wildlife corridors and allow for the continuation of processes that are essential for ecosystem sustainability during and after development;
- Ensure no topographical barriers (e.g. steep cliffs, high use recreational trails, cement barriers) are contained within the corridors that could impede wildlife movement;
- Maintain and enhance structural and compositional plant diversity in existing wildlife movement corridors to provide adequate hiding and thermal cover;
- Clearly delineate and direct the impacts of development away from corridors or areas that provide connectivity to important habitats;
- If culvert wildlife underpasses are not feasible for residential roadways, vehicle speeds should be impeded by vehicle slowing features such as wildlife crossing signs, speed bumps, rumble strips, traffic circles and narrow roadways;
- Design trails and other accesses to avoid sensitive features such as ponds, wetlands and nesting sites and ensure that trails do not fragment wildlife habitats. Create walkways that are narrow so they do not prevent a barrier to movement of wildlife (such as reptiles and amphibians) or use elevated boardwalks or install "toad tunnels" to cross wildlife travel corridors;
- Consider possible wildlife-human conflicts when siting pedestrian trails around or near corridors; and

- Encourage local stewardship of wildlife corridors (removal of garbage, fencing yards adjacent to corridors, neighborhood pet watch, local naturalist wildlife surveys) and promote the concept of naturescaping techniques through backyard wildlife habitat (local appreciation of native plantings, gardening to attract birds, installation of bird nest and bat boxes) to enhance connectivity with the plan area.

5.1.3 Proposed Habitat Preservation Areas

Preservation areas are managed differently from parks in that there are strategies in place to ensure minimal environmental disturbance, restricted human access and habitat protection and enhancement measures. These strategies promote restoration of the natural diversity of wildlife species and their habitats and ensure a safe haven for wildlife species inhabiting, and seeking food and refuge in the area. The following habitat protection guidelines are recommended to ensure preservation of the integrity of the proposed habitat preservation area ecosystems:

- Identify environmentally sensitive areas and critical habitats within the preservation area and protect the ecological values during and after development;
- Identify restoration/enhancement opportunities for disturbed areas or to increase diversity of habitats;
- Encourage the presence of special wildlife and species at risk by incorporating habitat features (e.g. wetlands) into development plans which may enhance property values, and improve the quality of life and ownership by area residents;
- Maintain snags and woody debris in buffer areas and environmentally sensitive areas to provide habitat for a diversity of wildlife;
- Prevent the spread of invasive introduced plant species with the preservation area and allow regeneration of indigenous species. Use native plants in landscaping in the surrounding area to avoid the spread of alien species into preservation areas;
- Minimize the use of pesticides and herbicides;
- Ensure that the natural (pre-development) hydrological cycles are maintained during and after development since changes in drainage patterns may impact conditions that species are adapted to;
- Use stormwater management techniques to avoid impacts on downslope wetlands, waterways, protected nest sites or reptile hibernacula and safeguard waters from pollution;
- Do not site trails or parking lots in areas known to be important habitat for special wildlife or species at risk, nor immediately adjacent to these areas;
- Schedule construction activities to avoid sensitive periods such as nesting, spawning, hibernating, migration, etc.;

- Design developments to allow for the continuation of ecological processes that are essential for ecosystem sustainability and allow the natural progression of successional stages;
- Non-disturbance buffers should be wide enough to protect the ecological integrity of critical areas;
- Restrict human access since recreation may damage the important features of environmentally sensitive areas and some wildlife species are not tolerant of human presence. In the event that trails are required, design the trail system to minimize impacts on critical areas, for example, by using boardwalks over wet areas, or by placing natural barriers that restrict people from going off trails.
- Fence critical microhabitats and riparian/wetland areas and use signage and other educational tools to inform people about the ecological importance of these environmentally sensitive areas;
- Prevent access by livestock and pets;
- Ensure wildlife have access, in particular large mammals, to the preservation area for breeding, food and refuge. Where possible, connect environmentally sensitive areas to nearby habitats using wildlife corridors. Promoting local naturescaping can create backyard habitats that provide useful corridors for some wildlife; and
- Encourage local residents to become knowledgeable stewards. Encourage naturescaping techniques such as incorporating nest boxes, bat boxes and other wildlife habitat features on their lands.

5.1.4 Federally and Provincially Listed Species

There are nine wildlife species which are of concern and could potentially occur within the Fergus Creek watershed including great blue heron, barn owl, short-eared owl, western screech-owl, band-tailed pigeon, Trowbridge’s shrew, Pacific water shrew, red-legged frog and western toad. Most important to all these species is the retention of mature to old forest stands, some for nesting and breeding, and others for cover and perching. Great blue herons require large trees for nesting but marine or freshwater fish-bearing waterways to forage in close proximity to nesting sites. Barn owls require open grassy areas to hunt for small mammals but nest in the protection of very large old snags or agricultural buildings. Although short-eared owls need open grassy areas to forage they also nest in this habitat as well, including agricultural fields. The Pacific water shrew and the red-legged frog need both high quality water and moist terrestrial habits for survival. Other species persist in deep drier forested environments such as the Trowbridge’s shrew or the western screech-owl. The following practices are recommended for the preservation of habitats for rare species.

- Clearly delineate and direct the impacts of development away from habitats that support species at risk;

- Where possible, provide and maintain species-adequate buffers to protect these species and their habitats; (i.e. 60 m vegetated no-disturbance buffer around Pacific water shrew critical habitat; or no-disturbance buffers of 1.5 tree lengths from the base of a raptor nest tree);
- Restrict recreational access to identified high suitability or sensitive habitats;
- Encourage the presence of species at risk by retaining, restoring or enhancing habitat features that promote their long-term survival, such as mature stands of trees and large coarse wood debris on the forest floor.
- Educate and encourage local residents to become knowledgeable stewards.

5.1.5 Fish Habitat

Within the Fergus Creek watershed, there are a number of Class A and B watercourses that provide important habitat for rearing and spawning for salmonids and food and nutrients for downstream fish bearing sections of watershed. In addition, although a number of insignificant food and nutrient watercourses (Class C) exist throughout the watershed many of these watercourses convey significant flows to downstream fish populations and as such it is important to maintain the hydrological function of these watercourses. In addition, some of these Class C watercourses may be regulated under the federal Fisheries Act based on further assessment during the permit application phase of individual development sites. Therefore, the following Best Management Practices are recommended to protect important fish habitat.

- Conduct a site inventory of all Class C watercourses and any unmapped watercourses that may exist prior to development of each site to ensure that watercourses and their function are accurately classified and appropriate streamside protection and enhancement areas are provided where applicable;
- Where possible, enhance instream areas by constructing weirs to reduce velocities, planting aquatic vegetation for stormwater treatment and stabilizing banks to prevent erosion;
- Where possible, enhance existing streamside protection and enhancement areas by planting native vegetation in areas presently devoid of trees and shrubs;
- Remove barriers to upstream migration, particularly the culverts under Highway 99;
- Provide fencing and signage along the edge of streamside protection and enhancement areas to maintain and promote the integrity of these areas;
- Avoid or minimize stream crossings and if a stream crossing is necessary ensure it allows fish passage and wildlife movement;
- Implement low impact development strategies as outlined in the Fergus Creek Integrated Stormwater Management Plan;
- Maintain groundwater seepage and artesian flows to watercourses wherever possible;

- Protect water quality during and after construction by:
    - Implementing sediment and erosion control measures, and ensuring other deleterious substances do not pollute watercourses;
    - Keep construction fuelling stations and fuelling equipment 30m or more away from Class B or Class C watercourses;
    - Keep all fresh concrete or concrete wash water away from watercourses;
    - Avoid using pesticides or other toxins near streamside protection and enhancement areas; and
    - Ensure all construction in and around watercourses identified as fish habitat or having connectivity with fish habitat is carried out in the appropriate timing window as set by the federal and provincial regulatory agencies.

5.2 Development or Re-Development Areas

The following Best Management Objectives and Development Guidelines are intended to be considered within development or re-development areas. It is assumed that a number of these objectives may not be feasible due to development site constraints; however, the incorporation of many of these objectives will assist in maintaining the biological diversity of the Fergus Creek watershed.

5.2.1 Raptors

The main threats to raptors in urban/rural lower mainland areas are:

- Habitat loss and alteration due to urbanization, land-clearing, and forestry,
- Depletion of old-growth forests, especially at low to moderate elevations,
- Pollution and changing practices in agricultural areas, and
- Introduction of nonnative species.

The populations of barn owl, short-eared owl and western screech-owl within the Vancouver Lower Mainland Region are declining. The main factor limiting the barn owl is the loss of nesting habitat and of small mammal prey species, mainly due to urbanization. The use of chemicals to kill rodents has led to the poisoning of many barn owls. Large-scale destruction of native grasslands has been particularly difficult for short-eared owls through wetland drainage, urban expansion and increasingly intensive farming. Because they nest on the ground they are exposed to danger from domestic predators and agricultural machinery. The decline in western screech-owl populations is due to removal of the riparian forests they inhabit and the subsequent reductions in prey availability. Management practices that include removal of dead and dying trees can eliminate this bird as a breeding species from local areas.

Raptor species that are most likely to benefit from the following Best Management Practices for the Fergus Creek watershed include the bald eagle, Cooper's hawk, sharp-shinned hawk, red-tailed hawk, great horned owl, barred owl, barn owl, short-eared owl and several small, cavity-nesting owls (western screech-owl, northern saw-whet owl, and northern pygmy-owl):

- All developments should exercise due diligence in identifying the presence of nests and in avoiding or mitigating impacts to them. In British Columbia, the active nests of all raptors are legally protected. Inactive nests of the bald eagle, peregrine falcon, gyrfalcon and osprey are protected year round;
- Where feasible, retain old farm buildings (i.e. barns and sheds) and adjacent grasslands to provide nesting and feeding habitat for barn and short-eared owls;
- Avoid disturbing raptors at nesting, roosting and feeding sites. Establish undisturbed buffers around active raptor nests, known roosts, and feeding sites, such as salmon-spawning areas. Specific minimum buffer sizes are listed below (Table 15) for various species.

Table 15 Recommended No Disturbance Buffers Around Active Raptor Nests

Sensitive Feature	Measure buffer from	Un-developed	Rural	Urban	Breeding season quiet buffer
Bald Eagle nest	Base of tree	200 m	100 m	1 ½ tree lengths	100 m
Other raptor nests	Base of tree, cliff top or base	500 m	200 m	1 ½ tree lengths or 50 m from cliff	200 m

5.2.2 Small Mammals

Changes in urban environments mainly involve spatial reduction, fragmentation and the introduction of barriers to movement such as roadways. Previous studies have shown that many small mammal species (mice, voles and shrews) persist in urban areas. Not only are they important prey items for carnivores and raptors, but they also play an important role in seed dispersal. The populations of small mammal species are threatened in developing urban and rural areas by:

- Loss of adequate natural cover, i.e. forest, riparian areas or grassland,
- Loss of riparian and wetland buffers and vegetation,
- Barriers to movement such as roads and highways,
- Habitat fragmentation resulting in isolated populations,
- Predation by domestic cats, and
- Use of pesticides and rodenticides in agricultural areas.

The Pacific water shrew is particularly vulnerable to the loss or isolation of its preferred riparian habitat with increasing fragmentation of the Vancouver Lower Mainland by roads, highways, and power lines. Particularly detrimental is the loss of canopy closure resulting in decreased security cover, increased human-related disturbance, and increased predation by domestic cats, of which 80% of captures are reportedly shrews. Water quality is also of concern because this shrew spends a considerable amount of time foraging for aquatic invertebrates. The Trowbridge's shrew requires dense drier coniferous forests and connected wooded areas and sometimes riparian forest with a thick layer of ground litter. Reduction in populations of both species can be attributed to the loss of tracts of dense forest used for cover, and the lack of structural diversity provided by logs, stumps and decaying vegetation which are used for nesting and foraging.

Best Management Practices to promote the protection of small mammal species include:

- Planting of native vegetation and retention or introduction of large coarse woody debris to increase habitat connectivity, improve the condition of the aquatic environment, and minimize erosion and sedimentation problems. Plantings should include shrubs to provide low cover for shrews, voles and mice, and large trees for high cover to maintain a moist micro-climate;
- Minimizing the effects of barriers to movement (such as roads) by creating crossing points (using open bottom structures) for animals. Natural plant stock should be planted to create a pathway to and through the crossing structure. Crossing structures should not be longer than 30 m and should not have large drops that would impede water shrew (or fish) movement;
- Placing vegetation or other cover structures (such as logs) along road right-of-ways to increase the connectivity and suitability of habitat; and
- Avoiding the use of armouring stream crossing structures. If armouring must be used, provide a variable structure ("biowalls", imbedded rocks, vegetation) that can allow small mammals to escape from high stream velocities.

5.2.3 Amphibians and Reptiles

Adult frogs absorb part of the oxygen and most of the water they need through their skin, and some salamanders without lungs obtain all their oxygen in this way. This permeable quality of the skin makes amphibians vulnerable to pollutants. Declines in populations are not caused by any single factor but by a complex of causes, including habitat loss, pollution, ozone layer depletion (increased UV), predation, road-kill and disease. Many of these factors are related to human activities including the spread of disease by the introduction of exotic species to different ecosystems. The introduction of predatory domestic pets into the natural environment has had devastating effects on native species, including snakes. The main threats to amphibians and reptiles in urban and rural areas are:

- Habitat loss and alteration,
- Draining and filling of wetlands,
- Pollution from agricultural areas,

- Predation by domestic pets, and
- Introduction of non-native species.

The red-legged frog is widespread in forested habitats within this region but the population is declining. Poor water quality, channelization of streams, and alteration of water regimes have a major impact on wetland habitats. Western toads are vulnerable to road mortality during seasonal migrations. Introduced bullfrogs and green frogs exist in many wetlands and pose a predatory threat to native amphibians as well as a host of other wildlife species.

The following Best Management Practices are recommended to protect important habitat for herptiles:

- Protect high suitability habitats such as the wet mixed forest of Wildlife Tree Patch No. 4 which may be used by multiple species of amphibians for foraging and breeding;
- Maintain or enhance critical amphibian and reptile habitat structure, such as large coarse woody debris, rock outcrops, and appropriate substrates for burrowing to survive periods of adverse dry or cold periods;
- Maintain habitat quality by providing undisturbed naturally vegetated buffer zones adjacent to important habitats which will also serve to protect the water quality by filtering out pollutants and sediments (Table 16). Where possible, a minimum buffer zone of 30 m on each side of a Class A or B watercourse or wetland should be retained, or a 3:1 ratio of undisturbed upland habitat to water;

Table 16 Recommended Buffer Zones for Protection of Amphibian Habitat

Sensitive Feature	Measure buffer from	Un-developed	Rural	Urban
Amphibians	Outer perimeter of wetlands under fully saturated conditions	150 m	100 m	30 m

- Allow natural processes to continue over the long term and promote high species diversity of amphibians and reptiles, such as maintaining the natural hydrology of wetlands and streams, retaining or enhancing the growth of natural vegetation whenever possible, avoiding compaction and disturbance of the ground including soil, litter layer, and coarse woody debris, installing barriers to human use at critical breeding sites; and
- Take actions to reduce the spread of introduced species such as bullfrogs, non-native fish, and other introduced species which can be competitive, predatory and carry disease.

5.2.4 General Wildlife

The following are general wildlife best management objectives applicable to proposed development or re-development areas within the Fergus Creek watershed:

- Conduct detailed site inventories in high suitability habitats to identify the presence/absence of species at risk prior to development planning;
- Use native plants and trees (suited to local climatic and terrain conditions) for landscaping as much as possible;
- Reduce soil compaction in areas to be left undeveloped by restricting heavy machinery use;
- Obstruct recreational and pet access to sensitive habitats by constructing fencing and maintaining dense, shrubby vegetation at edges;
- Where possible, retain groups of trees rather than isolated single trees to provide an inter-locking canopy and a minimum of interior forest habitat to maximize secure cover for nesting and foraging animals;
- Where possible, retain wildlife trees including snags;
- Build covered areas for garbage and compost that are designed to keep out problem species such as bear, skunk and rats (recent amendments to the *Wildlife Act* make it illegal to improperly manage garbage);
- Take appropriate actions to minimize human-wildlife conflicts;
- Schedule construction activities to avoid sensitive periods such as nesting, spawning, hibernating, and migration;
- Retain important natural features such as watercourses (Class A/B and Class C where appropriate), small wetlands, coarse woody debris, snags and vegetation diversity;
- Take actions to prevent and reduce the spread of introduced/invasive plant and animal species which may be predatory, competitive or carry disease; and
- Encourage local residents to become stewards of the greenspaces in their area.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

As part of the environmental review for the Grandview Heights Neighbourhood Concpet plan Area 2, seven important stands of wildlife tree patches were identified which likely contain a number of significant trees. Although ENKON did not survey stands of wildlife tree patches within the remainder of the Fergus Creek watershed, there are likely important stands of wildlife tree patches north of 8th Avenue, at the corner of 16th Avenue and 172nd Street and south of 16th Avenue near Highway 99.

Four wildlife movement corridors were identified including the Fergus Creek mainstem/tributaries and associated riparian habitat, the “Height-of-Land” from the northwest corner of the plan area to the southeast and connecting to Dart’s Hill Garden and Redwood Parks, the BC Hydro ROW along the western boundary of Plan Area 2 connecting to the Little Campbell River and east from the BC Hydro ROW between 16th and 12th Avenues to Sam Hill Creek which eventually flows into the Little Campbell River just north of 8th Avenue.

The Fergus Creek watershed contains suitable breeding habitat for 5 listed bird species including the great blue heron, band-tailed pigeon, barn owl, short-eared owl and western screech-owl. The barn owl and short-eared owl were detected during ENKON’s 2006 surveys. Suitable breeding and foraging habitat is available for these species in all open grassy agricultural areas and the BC Hydro right-of-way. High suitability habitat for Pacific water shrew exists within Wildlife Tree Patch No. 4 and for Trowbridge’s shrew within Wildlife Tree Patches No. 1 and 2. The lower Fergus Creek mainstem and associated riparian corridor also provide suitable habitat for both of these species. The red-legged frog has the potential to occur within the moist mixed forest of Wildlife Tree Patch No. 4, while the western toad could potentially occur within the mature coniferous/mixed forest of Wildlife Tree Patches No. 1 and 2.

None of the 46 plant species listed as blue- or red-listed in the Conservation Data Centre Tracking List were observed during vegetation surveys, however, there have not been structured vegetation surveys conducted to confirm their presence or absence.

There are a number of Class A/A(O) and Class B watercourses within the Fergus Creek watershed area. ENKON recommended that a number of Class B/C watercourses be re-classified or re-mapped. For preliminary planning purposes, the City of Surrey directed ENKON to assess streamside protection and enhancement areas (i.e. setbacks) for Class A/B watercourse following an adaptation of the Simple Assessment Methodology of the Riparian Areas Regulations (RAR). Given the vegetation categories and the permanent flow conditions, the resulting SPEA widths for all Class A and B watercourses assessed for the Fergus Creek watershed are 30m from top-of-bank. Although Class C watercourses were not evaluated, it is anticipated that detailed assessments would be conducted on each Class C watercourse during the development application phase of individual sites, to confirm the watercourse classification and determine the appropriate streamside protection and enhancement area. This preliminary assessment does not preclude the potential for a developer of a site to negotiate different SPEA's in consultation with the Department of Fisheries and Oceans and the City of Surrey or if new legislation is implemented in the future.

Environmentally sensitive areas included high suitability habitat for listed wildlife species, important stands of wildlife tree patches, three potential wildlife movement corridors, the proposed habitat preservation area and Class A/B watercourses.

ENKON recommended a number of potential fish and wildlife habitat enhancement opportunities, best management practices and development guidelines to protect environmentally sensitive areas and guide future development in the Fergus Creek watershed area.

6.2 Recommendations

The following recommendations are provided to the City of Surrey and developers to protect environmentally sensitive areas and provide development guidelines during the build out of the Fergus Creek watershed.

6.2.1 City Initiatives

- Where possible, retain all or portions (>0.5 hectares) of important Wildlife Tree Patches including Stands No. 1, 2 and 4 to provide refuge, food and breeding areas for various federally and provincially listed wildlife species including Pacific water shrew, Trowbridge's shrew, red-legged frog and western toad. In addition, retain all or portions of important Wildlife Tree Patches including Stands No. 1, 2 and 7 to provide refuge, food and breeding areas for the western screech-owl and band-tailed pigeon.

  Forested areas within the lower Fergus Creek watershed should be assessed for their importance to wildlife and ranked with the tree patches within Plan Area 2 to determine which tree patches should be given priority for protection.

- Where possible, provide wildlife movement corridors to maintain genetic diversity of wildlife species. Wildlife movement corridors can include riparian habitat areas, treed areas along residential lots, the Fergus Creek mainstem and associated riparian corridor and the "Height-of-Land" from the northwest corner of the plan area to the southeast and connecting to Dart's Hill Garden and Redwood Parks. Much of the proposed corridor is treed and passes through portions of 3 significant stands of trees (Stands No. 3, 4 and 6). The BC Hydro ROW is considered less important tan the other two movement corridors due to the lack of habitat diversity but is still worth promoting its value as a wildlife movement corridor due to its location ad size.

- Purchase the lands that contain the proposed "Habitat Preservation Area" located south of 16th Avenue, east of Highway 99 and west of 168th Street. This area is comprised of a diversity of fish (Fergus Creek mainstem and two tributaries) and wildlife habitat types and provides suitable habitat for a number of federally and provincially listed wildlife species, including the Pacific water shrew
- Protect high suitability habitat for other federal and provincial species at risk including field habitat and old buildings for barn and short-eared owls.
- Protect and enhance Class A/B watercourses including their associated streamside protection and enhancement areas.
- Conduct a structured vegetation inventory (spring and summer) to focus on the detection of rare plants and plant communities. If found, protect these areas and provide a suitable buffer to maintain their integrity.

6.2.2 Developer Initiatives

- If clearing is to be conducted during the active bird breeding season, March 1 to August 1, conduct a bird nest survey to ensure that active nests are protected during the breeding season.
- Conduct fish habitat assessments of all Class C watercourses prior to development of each site to ensure that watercourses and their function are accurately classified and appropriate streamside and enhancement areas are protected where applicable.
- Stormwater management for each development site should follow the recommendations of the Fergus Creek Integrated Stormwater Management Plan.
- Review the above report sections: 4.0 Protection Plans, 5.0 Best Management Objectives and Development Guidelines, and 6.0 Enhancement Opportunities, to ensure the effective protection of ecosystem integrity and environmental values and concerns.

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APPENDIX A

Rare Plant Species List – Chilliwack Forest District, July 2006

ENKON

BC Species and Ecosystems Explorer Search Results

		Status			
Scientific Name	**English Name**	**Global**	**Provincial**	**COSEWIC**	**BC Status**
Anagallis minima	chaffweed	G5	S2S3		Blue
Anemone drummondii var. *drummondii*	alpine anemone	G4T4	S2S3		Blue
Apocynum x *floribundum*	western dogbane	GNA	S2S3		Blue
Asplenium adulterinum	corrupt spleenwort	G3?	S2S3		Blue
Berula erecta	cut-leaved water-parsnip	G4G5	S1		Red
Bidens amplissima	Vancouver Island beggarticks	G3	S3	SC (Nov 2001)	Blue
Callitriche heterophylla ssp. *heterophylla*	two-edged water-starwort	G5T5	S2S3		Blue
Caltha palustris var. *palustris*	yellow marsh-marigold	G5T5	S2S3		Blue
Cardamine parviflora var. *arenicola*	small-flowered bitter-cress	G5T5	S1		Red
Carex amplifolia	bigleaf sedge	G4	S2S3		Blue
Carex comosa	bearded sedge	G5	S2S3		Blue
Carex interrupta	green-fruited sedge	G3G4	S2		Red
Carex lenticularis var. *lenticularis*	lakeshore sedge	G5T5	S2		Red
Carex scoparia	pointed broom sedge	G5	S2S3		Blue
Carex vulpinoidea	fox sedge	G5	S2S3		Blue
Centaurium muehlenbergii	Muhlenberg's centaury	G5?	S1		Red
Cephalanthera austiniae	phantom orchid	G4	S2	T (May 2000)	Red
Ceratophyllum echinatum	spring hornwort	G4?	S3		Blue
Cheilanthes gracillima	lace fern	G4G5	S2S3		Blue
Cimicifuga elata	tall bugbane	G3	S1	E (May 2001)	Red
Clarkia amoena var. *caurina*	farewell-to-spring	G5T5?	S3		Blue
Claytonia rubra ssp. *depressa*	redstem springbeauty	G5T5?	S3		Blue
Claytonia washingtoniana	Washington springbeauty	G2G4	S2		Red
Coleanthus subtilis	moss grass	G3G5	S1		Red
Crassula aquatica	pigmyweed	G5	S3		Blue
Elatine rubella	three-flowered waterwort	G5	S2S3		Blue
Eleocharis parvula	small spike-rush	G5	S2S3		Blue
Eleocharis rostellata	beaked spike-rush	G5	S2S3		Blue
Elodea nuttallii	Nuttall's waterweed	G5	S2S3		Blue
Epilobium ciliatum ssp. *watsonii*	purple-leaved willowherb	G5T3T5	S2S3		Blue
Epilobium glaberrimum ssp. *fastigiatum*	smooth willowherb	G5T4T5	S2S3		Blue
Epilobium halleanum	Hall's willowherb	G5	S2S3		Blue
Epilobium leptocarpum	small-fruited willowherb	G5	S2S3		Blue
Epipactis gigantea	giant helleborine	G3G4	S2S3	SC (May 1998)	Blue

Galium mexicanum ssp. *asperulum*	rough bedstraw	G5T3T5	S1		Red
Glyceria leptostachya	slender-spiked mannagrass	G3	S2S3		Blue
Glyceria occidentalis	western mannagrass	G5	S2S3		Blue
Helenium autumnale var. *grandiflorum*	mountain sneezeweed	G5T3T5	S2S3		Blue
Helianthus nuttallii var. *nuttallii*	Nuttall's sunflower	G5T5	S1		Red
Hydrophyllum tenuipes	Pacific waterleaf	G4G5	S2S3		Blue
Hypericum majus	large Canadian St. John's-wort	G5	S2S3		Blue
Hypericum scouleri ssp. *nortoniae*	western St. John's-wort	G5T3T5	S2S3		Blue
Idahoa scapigera	scalepod	G5	S2		Red
Juncus oxymeris	pointed rush	G5	S2S3		Blue
Juncus regelii	Regel's rush	G4?	S3S4		Blue
Leersia oryzoides	rice cutgrass	G5	S2S3		Blue
Lilaea scilloides	flowering quillwort	G5?	S2S3		Blue
Lindernia dubia var. *anagallidea*	false-pimpernel	G5T4	S2S3		Blue
Lupinus rivularis	streambank lupine	G4G5	S1	E (Nov 2002)	Red
Megalodonta beckii var. *beckii*	water marigold	G4G5T4	S3		Blue
Melica smithii	Smith's melic	G4	S2S3		Blue
Mitella caulescens	leafy mitrewort	G5	S2S3		Blue
Myriophyllum hippuroides	western water-milfoil	G5	S3		Blue
Myriophyllum pinnatum	green parrot's-feather	G5	S1		Red
Myriophyllum ussuriense	Ussurian water-milfoil	G3	S3		Blue
Navarretia intertexta	needle-leaved navarretia	G5?	S2		Red
Piperia elegans	elegant rein orchid	G4	S3		Blue
Platanthera dilatata var. *albiflora*	fragrant white rein orchid	G5T3T5	S2S3		Blue
Pleuropogon refractus	nodding semaphoregrass	G4	S3		Blue
Polygonum hydropiperoides	water-pepper	G5	S2S3		Blue
Polygonum punctatum	dotted smartweed	G5	S2S3		Blue
Potamogeton nodosus	long-leaved pondweed	G5	S1		Red
Potamogeton oakesianus	Oakes' pondweed	G4	S2S3		Blue
Potamogeton strictifolius	stiff-leaved pondweed	G5	S2S3		Blue
Pyrola elliptica	white wintergreen	G5	S2S3		Blue
Rubus lasiococcus	dwarf bramble	G5	S2S3		Blue
Rubus nivalis	snow bramble	G4?	S2		Red
Rupertia physodes	California-tea	G4	S3		Blue
Sagina decumbens ssp. *occidentalis*	western pearlwort	G5TNR	S3		Blue
Salix sessilifolia	soft-leaved willow	G4	S2S3		Blue

Sanguisorba menziesii	Menzies' burnet	G3G4	S2S3		Blue
Scrophularia lanceolata	lance-leaved figwort	G5	S2S3		Blue
Sidalcea hendersonii	Henderson's checker-mallow	G3	S3		Blue
Sparganium fluctuans	water bur-reed	G5	S2S3		Blue
Spergularia macrotheca var. *macrotheca*	beach sand-spurry	G5T3T5	S2S3		Blue
Toxicodendron diversilobum	poison oak	G5	S2S3		Blue
Verbena hastata var. *scabra*	blue vervain	G5T5	S2		Red
Wolffia borealis	northern water-meal	G5	S2		Red

Search Summary

Time Performed	Thu Sep 08 11:43:25 PDT 2005
Results	78 records.
Search Criteria	Species Group:Plant Forest District:Chilliwack Forest District (DCK) (Restricted to Red, Blue, and Identified Wildlife listed species) BGCs:CDF*, CWH* Sort Order:Scientific Name Ascending
Notes	1.Citation Guidelines 2. Forest District tracking lists are restricted to those species that breed in the District; i.e. species will not be placed on Forest District lists for Districts where they occur only as migrants.

Change Criteria | New Search | Results

APPENDIX B

Rare Plant Community List – Chilliwack Forest District, July 2006

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BC Species and Ecosystems Explorer Search Results

Scientific Name	English Name	Global	Prov Rank	BC Status
Abies amabilis - Picea sitchensis / Oplopanax horridus	amabilis fir - Sitka spruce / devil's club	GNR	S3	Blue
Abies amabilis - Thuja plicata / Gymnocarpium dryopteris	amabilis fir - western redcedar / oak fern	GNR	S3	Blue
Abies amabilis - Thuja plicata / Oplopanax horridus Moist Submaritime	amabilis fir - western redcedar / devil's club Moist Submaritime	GNR	S3	Blue
Arbutus menziesii / Arctostaphylos columbiana	arbutus / hairy manzanita	GNR	S2	Red
Carex lasiocarpa - Rhynchospora alba	slender sedge - white beak-rush	GNR	S2	Red
Carex lyngbyei Herbaceous Vegetation	Lyngbye's sedge herbaceous vegetation	GNR	S3	Blue
Carex macrocephala Herbaceous Vegetation	large-headed sedge Herbaceous Vegetation	GNR	S1S2	Red
Carex sitchensis - Oenanthe sarmentosa	Sitka sedge - Pacific water-parsley	GNR	S3	Blue
Carex sitchensis / Sphagnum spp.	Sitka sedge / peat-mosses	GNR	S2	Red
Deschampsia cespitosa - Sidalcea hendersonii	tufted hairgrass - Henderson's checker-mallow	GNR	S1S2	Red
Deschampsia cespitosa ssp. beringensis - Aster subspicatus	tufted hairgrass - Douglas' aster	GNR	S3	Blue
Deschampsia cespitosa ssp. *beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	GNR	S3	Blue
Distichlis spicata var. spicata Herbaceous Vegetation	seashore saltgrass Herbaceous Vegetation	GNR	S1S2	Red
Dulichium arundinaceum Herbaceous Vegetation	three-way sedge	GNR	S2	Red
Festuca idahoensis ssp. roemeri - Koeleria macrantha	Roemer's fescue - junegrass	GNR	S1	Red
Juncus arcticus - Plantago macrocarpa	arctic rush - Alaska plantain	GNR	S1	Red
Ledum groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador tea / western bog-laurel / peat-mosses	GNR	S3	Blue
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	GNR	S2	Red
Picea sitchensis / Rubus spectabilis Dry	Sitka spruce / salmonberry Dry	GNR	S1S2	Red
Picea sitchensis / Rubus spectabilis Moist Submaritime	Sitka spruce / salmonberry Moist Submaritime	GNR	S1S2	Red
Picea sitchensis / Rubus spectabilis Very Dry Maritime	Sitka spruce / salmonberry Very Dry Maritime	GNR	S2	Red
Picea sitchensis / Rubus spectabilis Very Wet Maritime	Sitka spruce / salmonberry Very Wet Maritime	GNR	S2	Red
Pinus contorta / Rhododendron macrophyllum	lodgepole pine / Pacific rhododendron	GNR	S2	Red
Pinus contorta / Sphagnum spp. *Very Dry Maritime*	lodgepole pine / peat-mosses Very Dry Maritime	GNR	S3	Blue
Pinus contorta var. *contorta / Juniperus communis - Arctostaphylos columbiana*	shore pine / common juniper - hairy manzanita	GNR	S1	Red
Populus balsamifera ssp. *trichocarpa / Cornus stolonifera*	black cottonwood / red-osier dogwood	GNR	S3	Blue
Populus balsamifera ssp. *trichocarpa / Salix sitchensis*	black cottonwood / Sitka willow	GNR	S2S3	Blue
Populus balsamifera ssp. *trichocarpa / Salix sitchensis - Rubus parviflorus*	black cottonwood / Sitka willow - thimbleberry	GNR	S2	Red
Populus balsamifera ssp. *trichocarpa / Salix* spp. Dry Submaritime	black cottonwood / willows Dry Submaritime	GNR	S2S3	Blue
Pseudotsuga menziesii / Acer glabrum / Prosartes hookeri	Douglas-fir / Douglas maple / Hooker's fairybells	GNR	S2	Red
Pseudotsuga menziesii - Pinus contorta / Arctostaphylos uva-ursi Dry Submaritime	Douglas-fir - lodgepole pine / kinnikinnick Dry Submaritime	GNR	S2	Red

BC Species and Ecosystems Explorer Search Results

Scientific Name	English Name	Global	Prov Rank	BC Status
Pseudotsuga menziesii - Pinus contorta / Arctostaphylos uva-ursi Moist Submaritime	Douglas-fir - lodgepole pine / kinnikinnick Moist Submaritime	GNR	S3	Blue
Pseudotsuga menziesii - Pinus contorta / Holodiscus discolor / Cladina spp.	Douglas-fir - lodgepole pine / oceanspray / reindeer lichens	GNR	S2	Red
Pseudotsuga menziesii - Pinus contorta / Racomitrium canescens	Douglas-fir - lodgepole pine / grey rock-moss	GNR	S2	Red
Pseudotsuga menziesii / Polystichum munitum	Douglas-fir / sword fern	GNR	S2	Red
Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon Dry Maritime	Douglas-fir - western hemlock / salal Dry Maritime	GNR	S2S3	Blue
Pseudotsuga menziesii - Tsuga heterophylla / Paxistima myrsinites	Douglas-fir - western hemlock / falsebox	GNR	S3	Blue
Quercus garryana - Acer macrophyllum - Prunus spp.	Garry oak - bigleaf maple - cherries	GNR	S1	Red
Ruppia maritima Herbaceous Vegetation	beaked ditch-grass Herbaceous Vegetation	GNR	S2	Red
Salicornia virginiana - Glaux maritima	American glasswort - sea-milkwort	GNR	S2	Red
Salix sitchensis - Salix lucida ssp. lasiandra / Lysichiton americanus	Sitka willow - Pacific willow / skunk cabbage	GNR	S2	Red
Sidalcea hendersonii Tidal Marsh	Henderson's checker-mallow Tidal Marsh	GNR	S1	Red
Thuja plicata / Carex obnupta	western redcedar / slough sedge	GNR	S2S3	Blue
Thuja plicata / Lonicera involucrata	western redcedar / black twinberry	GNR	S2	Red
Thuja plicata / Oplopanax horridus	western redcedar / devil's club	GNR	S1S2	Red
Thuja plicata - Picea sitchensis / Lysichiton americanus	western redcedar - Sitka spruce / skunk cabbage	GNR	S3	Blue
Thuja plicata / Polystichum munitum Dry Maritime	western redcedar / sword fern Dry Maritime	GNR	S2S3	Blue
Thuja plicata / Polystichum munitum Very Dry Maritime	western redcedar / sword fern Very Dry Maritime	GNR	S2S3	Blue
Thuja plicata - Pseudotsuga menziesii / Acer circinatum	western redcedar - Douglas-fir / vine maple	GNR	S1S2	Red
Thuja plicata / Rubus spectabilis	western redcedar / salmonberry	GNR	S1S2	Red
Thuja plicata / Tiarella trifoliata Dry Maritime	western redcedar / three-leaved foamflower Dry Maritime	GNR	S2S3	Blue
Thuja plicata / Tiarella trifoliata Very Dry Maritime	western redcedar / three-leaved foamflower Very Dry Maritime	GNR	S2	Red
Thuja plicata - Tsuga heterophylla / Polystichum munitum	western redcedar - western hemlock / sword fern	GNR	S3?	Blue
Tsuga heterophylla / Clintonia uniflora	western hemlock / queen's cup	GNR	S2	Red
Tsuga heterophylla / Plagiothecium undulatum	western hemlock / flat-moss	GNR	S2S3	Blue
Tsuga heterophylla - Pseudotsuga menziesii / Eurhynchium oreganum	western hemlock - Douglas-fir / Oregon beaked-moss	GNR	S2	Red
Tsuga heterophylla - Pseudotsuga menziesii / Rhytidiadelphus triquetrus Dry Submaritime 1	western hemlock - Douglas-fir / electrified cat's-tail moss Dry Submaritime 1	GNR	S2	Red
Tsuga heterophylla - Thuja plicata / Blechnum spicant	western hemlock - western redcedar / deer fern	GNR	S2	Red
Tsuga heterophylla - Thuja plicata / Gaultheria shallon Very Wet Maritime	western hemlock - western redcedar / salal Very Wet Maritime	GNR	S4	Blue
Typha latifolia Marsh	common cattail Marsh	GNR	S3	Blue

APPENDIX C

Rare Animal Species List – Chilliwack Forest District, July 2006

ENKON

BC Species and Ecosystems Explorer Search Results

		Status			
Scientific Name	**English Name**	**Global**	**Provincial**	**COSEWIC**	**BC Status**
Acipenser medirostris	Green Sturgeon	G3	S1N	SC (May 1987)	Red
Rhinichthys sp. 4	Nooksack Dace	G3	S1	E (May 2000)	Red
Catostomus platyrhynchus	Mountain Sucker	G5	S3?	NAR (May 1991)	Blue
Catostomus sp. 4	Salish Sucker	G1	S1	E (Nov 2002)	Red
Oncorhynchus clarki clarki	Cutthroat Trout, *clarki* subspecies	G4T4	S3S4		Blue
Salvelinus confluentus	Bull Trout	G3	S3		Blue
Salvelinus malma	Dolly Varden	G5	S3S4		Blue
Ascaphus truei	Coastal Tailed Frog	G4	S3S4	SC (May 2000)	Blue
Rana aurora	Red-legged Frog	G4	S3S4	SC (Nov 2004)	Blue
Rana pretiosa	Oregon Spotted Frog	G2	S1	E (May 2000)	Red
Dicamptodon tenebrosus	Coastal Giant Salamander	G5	S2	T (Nov 2000)	Red
Chrysemys picta	Painted Turtle	G5	S3S4		Blue
Phalacrocorax auritus	Double-crested Cormorant	G5	S2B	NAR (May 1978)	Red
Botaurus lentiginosus	American Bittern	G4	S3B		Blue
Butorides virescens	Green Heron	G5	S3S4B		Blue
Falco peregrinus anatum	Peregrine Falcon, *anatum* subspecies	G4T3	S2B	T (May 2000)	Red
Grus canadensis	Sandhill Crane	G5	S3S4B	NAR (May 1979)	Blue
Recurvirostra americana	American Avocet	G5	S2B		Red
Sterna caspia	Caspian Tern	G5	S3B	NAR (May 1999)	Blue
Brachyramphus marmoratus	Marbled Murrelet	G3G4	S2B,S4N	T (Nov 2000)	Red
Patagioenas fasciata	Band-tailed Pigeon	G4	S3S4B		Blue
Tyto alba	Barn Owl	G5	S3	SC (Nov 2001)	Blue
Asio flammeus	Short-eared Owl	G5	S3B,S2N	SC (May 1994)	Blue
Strix occidentalis	Spotted Owl	G3	S1	E (May 2000)	Red
Progne subis	Purple Martin	G5	S2B		Red
Icteria virens	Yellow-breasted Chat	G5	S1B	E (Nov 2000)	Red
Sorex bendirii	Pacific Water Shrew	G4	S1S2	T (May 2000)	Red
Sorex trowbridgii	Trowbridge's Shrew	G5	S3S4		Blue
Scapanus townsendii	Townsend's Mole	G5	S1	E (May 2003)	Red
Corynorhinus townsendii	Townsend's Big-eared Bat	G4	S2S3		Blue
Myotis keenii	Keen's Long-eared Myotis	G2G3	S2	DD (Nov 2003)	Red
Gulo gulo luscus	Wolverine, *luscus* subspecies	G4T4	S3	SC (May 2003)	Blue
Ursus arctos	Grizzly Bear	G4	S3	SC (May 2002)	Blue

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APPENDIX D

Species at Risk Act: Endangered, Threatened and Special Concern Species

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Appendix D: Species at Risk Act Public Registry of Endangered, Threatened and Special Concern Species, August 2006

Endangered, Threatened and Special Concern Species (August 2004)			
Scientific Name (non-marine species)	**English Name**	**Risk Category**	**Schedule**
Fish			
Gasterosteus sp.	Benthic Paxton Lake Stickleback	Endangered	Schedule 1
Gasterosteus sp.	Benthic Vananda Creek Stickleback	Endangered	Schedule 1
Gasterosteus sp.	Benthic Enos Lake Stickleback	Threatened	Schedule 2 (pending to 1)
Gasterosteus sp.	Charlotte Unarmoured Stickleback	Special concern	Schedule 3
Cottus bairdi hubbsi	Columbia Mottled Sculpin	Special concern	Schedule 1
Lampetra macrostoma	Cowichan Lake Lamprey	Threatened	Schedule 1
Lampetra richardsoni	Morrison Creek Lamprey	Endangered	Schedule 1
Cottus sp.	Cultus Pygmy Sculpin	Threatened	Schedule 1
Gasterosteus sp.	Giant Stickleback	Special concern	Schedule 3
Acipenser medirostris	Green Sturgeon	Special concern	Schedule 3
Gasterosteus sp.	Limnetic Enos Lake Stickleback	Threatened	Schedule 2
Gasterosteus sp.	Limnetic Paxton Lake Stickleback	Endangered	Schedule 1
Gasterosteus sp.	Limnetic Vananda Creek Stickleback	Endangered	Schedule 1
Rhinichthys sp.	Nooksack Dace	Endangered	Schedule 1
Catostomus sp.	Salish Sucker	Endangered	Schedule 2 (pending to 1)
Cottus confusus	Shorthead Sculpin	Threatened	Schedule 1
Rhinichthys osculus	Speckled Dace	Special concern	Schedule 3 (pending to 1)
Rhinichthys umatilla	Umatilla Dace	Special concern	Schedule 3
Oncorhynchus nerka	Sockeye Salmon (Sakinaw Lake)	Not listed (COSEWIC endan.)	Pending for Schedule 1
Oncorhynchus nerka	Sockeye Salmon (Cultus Lake)	Not listed (COSEWIC endan.)	Pending for Schedule 1
Oncorhynchus kisutch	Coho Salmon (Interior Fraser Pop.)	Not listed (COSEWIC endan.)	Pending for Schedule 1
Acipenser transmontanus	White Sturgeon	Special concern	Schedule 3 (pending to 1)
Herptiles			
Ambystoma tigrinum	Tiger salamander (southern mountain population)	Endangered	Schedule 1
Ascaphus montanus	Rocky mountain tailed frog	Endangered	Schedule 1
Ascaphus truei	Coastal Tailed Frog	Special concern	Schedule 1
Dicamptodon tenebrosus	Pacific Giant Salamander	Threatened	Schedule 1
Plethodon idahoensis	Coeur d'Alene Salamander	Special concern	Schedule 1
Rana aurora	Northern red-legged Frog	Special concern	Schedule 3 (pending to 1)
Rana pipiens	Northern leopard frog (southern mountain population)	Endangered	Schedule 1
Rana pretiosa	Oregon Spotted Frog	Endangered	Schedule 1
Bufo boreas	Western Toad	Not listed (COSEWIC sp. con)	Pending for Schedule 1
Spea intermontana	Great basin Spadefoot	Threatened	Schedule 1
Pituophis catenifer deserticola	Great Basin Gophersnake	Not listed (COSEWIC threat.)	Pending for Schedule 1

Appendix D: Species at Risk Act Public Registry of Endangered, Threatened and Special Concern Species, August 2006

Endangered, Threatened and Special Concern Species (August 2004)			
Scientific Name (non-marine species)	**English Name**	**Risk Category**	**Schedule**
Charina bottae	Rubber Boa	Not listed (COSEWIC sp. con)	Pending for Schedule 1
Hypsiglena torquata	Night Snake	Endangered	Schedule 1
Eumeces skiltonianus	Western Skink	Not listed (COSEWIC sp. con)	Pending for Schedule 1
Contia tenuis	Sharp-tailed Snake	Endangered	Schedule 1
Birds			
Accipiter gentilis laingi	Northern goshawk	Threatened	Schedule 1
Ardea herodias fannini	Great blue heron	Special concern	Schedule 3
Asio flammeus	Short eared owl	Special concern	Schedule 3
Athene cunicularia	Burrowing owl	Endangered	Schedule 1
Brachyramphus marmoratus	Marbled Murrelet	Threatened	Schedule 1
Coturnicops noveboracensis	Yellow rail	Special concern	Schedule 1
Falco peregrinus anatum	Peregrine falcon	Threatened	Schedule 1
Falco peregrinus pealei	Peregrine falcon	Special concern	Schedule 1
Eremophila alpestris strigata	Horned Lark Strigata sub spp	Not listed (COSEWIC endan.)	Pending for Schedule 1
Icteria virens auricollis	Western yellow-breasted chat (BC population)	Endangered	Schedule 1
Melanerpes lewis	Lewis's woodpecker	Special concern	Schedule 1
Numenius americanus	Long billed curlew	Special concern	Schedule 3 (pending to 1)
Numenius borealis	Eskimo curlew	Endangered	Schedule 1
Oreoscoptes montanus	Sage thrasher	Endangered	Schedule 1
Otus flammeolus	Flammulated owl	Special concern	Schedule 1
Picoides albolarvatus	White-headed woodpecker	Endangered	Schedule 1
Megascops kennicottii kennicottii	Western screech-owl kennicottii sub spp.	Not listed (COSEWIC sp. con)	Pending for Schedule 1
Megascops kennicottii macfarlanei	Western screech-owl marfarlanei sub spp.	Not listed (COSEWIC endan.)	Pending for Schedule 1
Strix occidentalis caurina	Northern spotted owl	Endangered	Schedule 1
Phoebastria albatrus	Short-tailed Albatross	Not listed (COSEWIC threat.)	Pending for Schedule 1
Synthliboramphus antiquus	Ancient murrelet	Special concern	Schedule 3
Tyto alba	Barn Owl	Special concern	Schedule 1
Mammals			
Antrozous pallidus	Pallid bat	Threatened	Schedule 1
Aplodontia rufa	Mountain beaver	Special concern	Schedule 1
Bison bison athabascae	Wood bison	Threatened	Schedule 1
Euderma maculatum	Spotted bat	Special concern	Schedule 3
Gulo gulo	Wolverine (Western population)	Special concern	Schedule 3 (pending to 1)
Marmota vancouverensis	Vancouver Island Marmot	Endangered	Schedule 1
Mustela erminea haidarum	Ermine	Threatened	Schedule 1
Myotis thysanodes	Fringed bat	Special concern	Schedule 3
Rangifer tarandus caribou	Woodland caribou (Boreal population)	Threatened	Schedule 1

Appendix D: Species at Risk Act Public Registry of Endangered, Threatened and Special Concern Species, August 2006

Endangered, Threatened and Special Concern Species (August 2004)			
Scientific Name (non-marine species)	**English Name**	**Risk Category**	**Schedule**
Rangifer tarandus caribou	Woodland caribou (Northern Mountain population)	Not listed (COSEWIC sp. con)	Pending for Schedule 1
Rangifer tarandus caribou	Woodland caribou (Southern Mountain population)	Threatened	Schedule 1
Reithrodontomys megalotis megalotis	Western harvest mouse	Special concern	Schedule 3
Scapanus townsendii	Townsend's mole	Threatened	Schedule 2 (pending to 1)
Sorex bendirii	Pacific water shrew	Threatened	Schedule 1
Sylvilagus nuttallii nuttallii	Nuttall's cottontail	Special concern	Schedule 3
Taxidea taxus jeffersonii	American badger	Endangered	Schedule 1
Ursus arctos	Grizzly Bear (NW population)	Special concern	Schedule 3 (pending to 1)

Schedule 1: official list of species either extirpated, endangered, threatened, or a special concern.

Schedule 2: assessment must be completed within 30 days after the minister's request.

Schedule 3: assessment must be completed within one year after the minister's request

APPENDIX E

Rare Element Occurrence Records and Mapped Locations

Element Occurrence Record (2632)

September 8, 2005

Sorex trowbridgii
(Trowbridge's Shrew)

Please see http://srmwww.gov.bc.ca/cdc/gis/eo_data_fields.htm for definitions.

This is a summary report. For a complete record contact the CDC (cdcdata@victoria1.gov.bc.ca).

Element Type:

Vertebrate Animal

Taxonomic Class:

Mammals

Status:

Global:	G5
Provincial:	S3S4
COSEWIC:	
List:	Blue

Representational Accuracy:

Location / Directions:

FERGUS CREEK: Along Fergus Creek, 150 m N of 8th Ave., Surrey. Site 39, (Zuleta and Galindo-Leal 1993).

Element Occurrence Data: (Last Observation: 1992-09-29)

2 specimens captured in pitfall traps (315 trap-nights, Sept. 22-Oct.13). Permanent, sandy creek, 6 m wide; riparian forest with high percentage canopy cover, dominated by red alder, with western redcedar, bigleaf maple, western hemlock and veteran Sitka spruce. South aspect (Zuleta and Galindo-Leal 1993).

General Description:

Riparian forest along lowland creek.

EO Type:

Habitat Keyword:

RIVERINE; RIPARIAN; FOREST MIXED

EO Rank:

Comments:

Vegetation Zone:

LOWLAND

Element Occurrence References:

(G93ZUL01BCCA) Zuleta, G.A., and C. Galindo-Leal. 1993. Distribution and abundance of small mammals at risk in a fragmented landscape. Unpubl. rep. for B.C. Minist. Environ., Lands and Parks, Wildl. Branch, Victoria. 34pp.

British Columbia
Conservation Data Centre

Element Occurrence Record (4014)

September 8, 2005

Sorex bendirii
(Pacific Water Shrew)

Please see http://srmwww.gov.bc.ca/cdc/gis/eo_data_fields.htm for definitions.
This is a summary report. For a complete record contact the CDC (cdcdata@victoria1.gov.bc.ca).

Element Type:
Vertebrate Animal

Taxonomic Class:
Mammals

Status:

Global:	G4
Provincial:	S1S2
COSEWIC:	T (MAY 2000)
List:	Red

Representational Accuracy:

Location / Directions:
FERGUS CREEK: Along Fergus Creek, 150 m N of 8th Ave. Surrey. Site 39, (Zuleta and Galindo-Leal 1993).

Element Occurrence Data: (Last Observation: 1992-09-29)
1 specimen captured in pitfall trap (only specimen caught in 315 trap-nights, Sept. 22- Oct. 13). Permanent, sandy creek, 6 m wide; riparian forest with high percentage canopy covering dominated by red alder, with western redcedar, bigleaf maple, western hemlock and veteran Sitka spruce. S aspect.

General Description:
Riparian forest along lowland creek.

EO Type:

Habitat Keyword:
RIVERINE; RIPARIAN; FOREST MIXED

EO Rank:	**Comments:**
E	Verified extant (viability not assessed)

Vegetation Zone:
LOWLAND

Element Occurrence References:
(G93ZUL01BCCA) Zuleta, G.A., and C. Galindo-Leal. 1993. Distribution and abundance of small mammals at risk in a fragmented landscape. Unpubl. rep. for B.C. Minist. Environ., Lands and Parks, Wildl. Branch, Victoria. 34pp.

British Columbia
Conservation Data Centre

Element Occurrence Record (14445)

September 8, 2005

Sidalcea hendersonii
(Henderson's Checker-mallow)

Please see http://srmwww.gov.bc.ca/cdc/gis/eo_data_fields.htm for definitions.
This is a summary report. For a complete record contact the CDC (cdcdata@victoria1.gov.bc.ca).

Element Type:
Vascular Plant

Taxonomic Class:
Dicots

Status:

Global:	G3
Provincial:	S3
COSEWIC:	
List:	Blue

Representational Accuracy:

Location / Directions:
GRANDVIEW, SOUTHEAST OF: 2 miles N of U.S. border on Hall's Prairie Road (Pacific Hwy) S of Cloverdale.

Element Occurrence Data: (Last Observation: 1955-06-27)
Wet roadside ditch, rare.

General Description:

EO Type:

Habitat Keyword:
TERRESTRIAL; ROADSIDE

EO Rank: **Comments:**

Vegetation Zone:

Element Occurrence References:
(O91DAO01BCCA) Biosystematic Research Centre., Agric. Can., Cent. Exp. Farm, Ottawa, K1A 0C6.

British Columbia
Conservation Data Centre

Element Occurrence Record (3008)

September 8, 2005

Cuscuta pentagona
(Field Dodder)

Please see http://srmwww.gov.bc.ca/cdc/gis/eo_data_fields.htm for definitions.
This is a summary report. For a complete record contact the CDC (cdcdata@victoria1.gov.bc.ca).

Element Type:
Vascular Plant

Taxonomic Class:
Dicots

Status:

Global:	G5
Provincial:	S2S3
COSEWIC:	
List:	Blue

Representational Accuracy:

Location / Directions:
LITTLE CAMPBELL RIVER, WHITE ROCK: At river mouth.

Element Occurrence Data: (Last Observation: 1989-08-03)
Parasitic on <i>Aster subspicatus</i>, moist shore.

General Description:

EO Type:

Habitat Keyword:
TERRESTRIAL

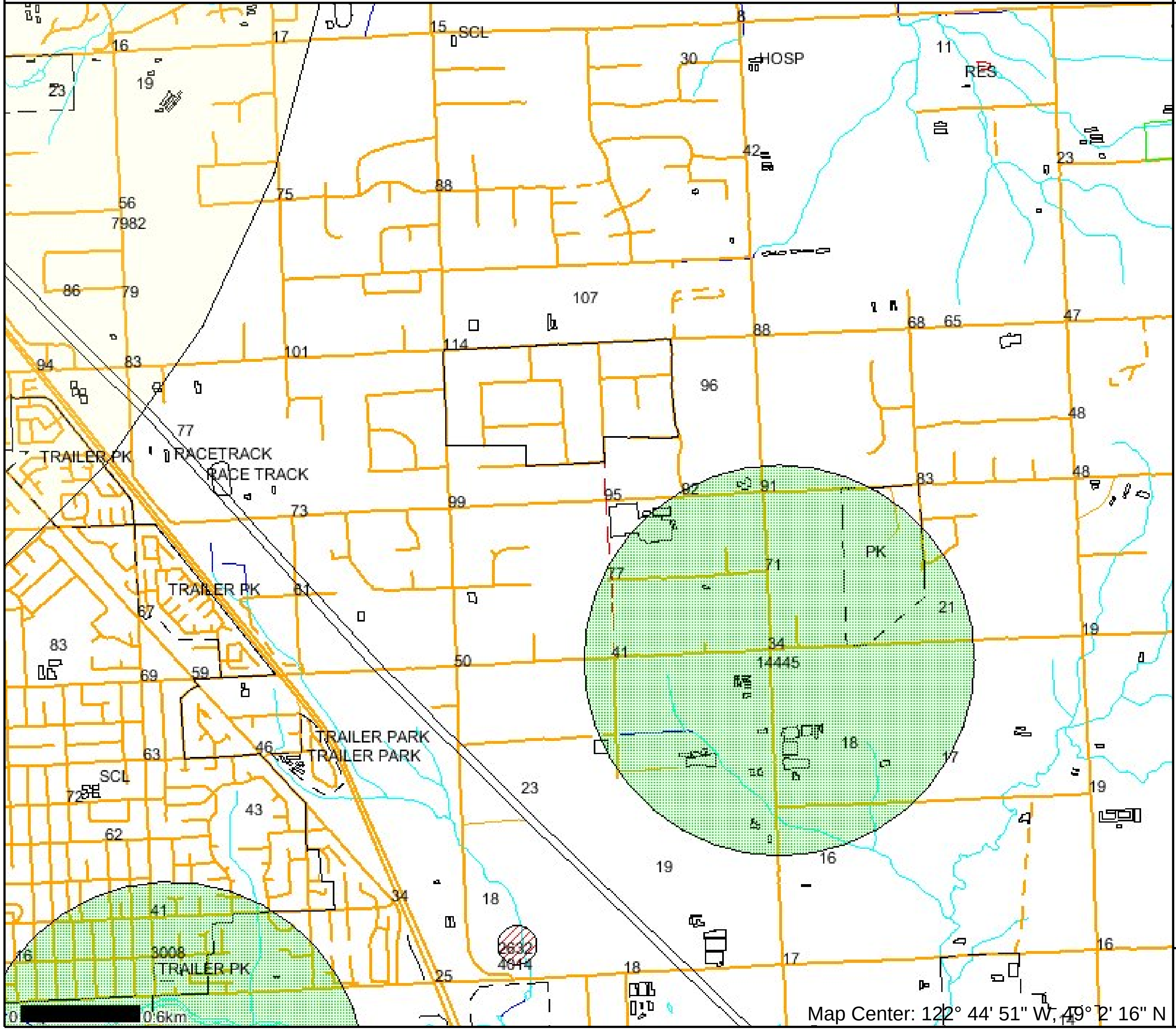
EO Rank:

Comments:

Vegetation Zone:
LOWLAND

Element Occurrence References:
(O91UBC01BCCA) University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Map created Thu Sep 08 14:56:09 PDT 2005



Map Center: 122° 44' 51" W, 49° 2' 16" N

Legend

- 1:6M Annotation
- Element Occurrence Areas - CDC
- ▨ Animal - Vertebrate
- ▨ Animal - Invertebrate
- 🟩 Plant - Vascular
- 🟩 Plant - Non Vascular
- ▥ Plant Association
- ☐ Record Tree
- ☐ Other
- ☐ Masked Sensitive Areas - CDC
- Elevation - Text (TRIM)
- Cultural Features - Text (TRIM)
- Landcover - Text (TRIM)
- Miscellaneous Features - Text (TRIM)
- Surface Features - Text (TRIM)
- Transportation - Text (TRIM)
- Water - Text (TRIM)
- Landmark - Lines (TRIM)
- Yard - Auto Wrecker
- Yard - Lumber
- Fish Hatchery
- Electrical Substation Complex
- Mine (Open-pit)
- Mine (Underground)
- Pile - Raw Material
- Pit
- Pit - Abandoned
- Campground/Campsite
- Drive-in Theatre
- Exhibition Ground
- Golf Course
- Park
- Playing Field (Sports)
- Race Track
- Race Track - Athletic
- Cemetery
- Trailer Park
- Dump
- Sewage Leaching Field
- Tailing Pile/Pond/Dump
- Mine - Tailing Pond
- Built-up Area
- Designated Area
- Barn
- Greenhouse
- School
- Fire Station
- Post Office
- Hospital
- Building
- Ski Lift
- Conveyor

Scale: 1:31,742

DO NOT USE FOR NAVIGATION

APPENDIX F

Survey Permits

BRITISH COLUMBIA

Ministry of Environment

Permit and Authorization
Service Bureau
PO Box 9372 Stn Prov Govt
Victoria, BC V8W 9M3
Tel: 1-866-433-7272 or
250-952-0932

PERMIT

78470-25

PERMIT SU06-20318

UNDER THE PROVISIONS OF THE *WILDLIFE ACT*

PERMIT HOLDER	ENKON Environmental Limited 201 – 2430 King George Highway Surrey, BC V4P 1H8 ATTENTION: Billi Gowans PHONE: (604) 536-2947 FAX: (604) 536-2948

HAS BEEN AUTHORIZED UNDER: **s. 19** of the *Wildlife Act*, RSBC 1996, c. 488 AND
s. 2(c)(i) of the *Permit Regulation*, B.C. Reg. 253/2000

TO	Live trap and on-site release Pacific Water Shrew (*Sorex bendirii*) and Trowbridge's Shrew (*Sorex trowbridgii*) for scientific purposes in the Fergus Creek watershed area in South Surrey (see attached map).

SUBJECT TO THE FOLLOWING:

CONDITIONS OF PERMIT:	The permit holder must comply with the requirements listed in Appendix "A" and Appendix "B."
OFFENCE PROVISION	The permit holder must comply with **all** applicable federal, provincial, municipal and regional district legislation and by-laws. It is the responsibility of the permit holder to inform him/herself of all relevant laws. Failure to comply with any term of this permit is an offence under the *Wildlife Act*, and may result in prosecution and/or denial of future permit requests.
TERM OF PERMIT	This permit is only valid from February 20, 2006 to March 15, 2006.
DATE OF ISSUE	February 20, 2006

T. Bell **SIGNATURE OF ISSUER**	Tom Bell A/Regional Manager Environmental Stewardship Division Lower Mainland	**PERMIT FEE** **$110.00**	**RECEIPT NUMBER (IF ISSUED)**

APPENDIX “A”

PERMIT CONDITIONS FOR SU06-20318

REPORTING REQUIREMENTS:

1. The permit holder must maintain an accurate up to date record of the wildlife hunted, trapped or killed under the permit that includes the following information:
    a) common name of the wildlife;
    b) location where the wildlife was taken;
    c) the date the wildlife was hunted, trapped or killed;
    d) the sex and age class of the wildlife taken;
    e) the bands or tags on the wildlife; and
    f) a description of all nests, dams or other structures destroyed or removed.

2. The permit holder must submit the original copy of this record to the Permit and Authorization Service Bureau **within 21 days** of the permit’s expiry.

3. The permit holder must produce a copy of this record on the demand of an officer.

GENERAL CONDITIONS:

1. This permit extends to the permit holder’s employees or contractors only when they are engaged in the direct performance of their duties on behalf of the permit holder.

2. All work is to be undertaken by trained professionals with experience in trapping small mammals.

3. The permit holder must take all reasonably necessary steps to ensure that public safety and fish / wildlife habitat are not jeopardized by any action taken under authority of the permit.

4. The permit holder must ensure that animals are treated in a humane manner, and are not subjected to any unnecessary harm or suffering.

5. Capture and handling of specimens to be in accordance with the Standards for Live Animal Capture and Handling Guidelines established by the Ministry of Environment.

    See http://ilmbwww.gov.bc.ca/risc/pubs/tebiodiv/capt/index.htm

6. Use Draft Best Management Practices for Pacific Water Shrew in Urban and Rural Areas, April 2005, by Craig and Vennesland.

7. If a shrew is caught and is not at risk any scat collected (preferably intact) should go to the regional office in Surrey (please call Ross Vennesland at 604-582-5279).

8. Traps must be checked regularly to ensure that shrews are not killed. From March 1 to November 1, traps should be checked every 8 hours (minimum). From November 1 to March 1, traps should be checked every 6 hours (minimum). If frost is expected or if heavy rainfall is expected, trapping should NOT occur. Please note that this trap checking frequency is specific to Pacific Water Shrew and may not be frequent enough to avoid mortality of other organisms. Due care should be exercised in this regard to ensure unnecessary mortality of other organisms does not occur.

9. No intentional mortality of Pacific Water Shrew or Trowbridge’s Shrew is to occur. All reasonable steps must be taken to ensure that no accidental mortality occurs.

APPENDIX “A”

PERMIT CONDITIONS CONTINUED FOR SU06-20318

10. No intentional mortality of other red or blue listed species is to occur. All reasonable steps must be taken to ensure that no accidental mortality occurs.

11. All other small mammals and other organisms captured should be released unharmed.

12. All wildlife and wildlife parts remain the property of the Province of British Columbia. The permit holder may not sell, trade or give away wildlife.

13. Permit holder shall provide upon conclusion of this years project, a copy of the final report, to the Permit and Authorization Service Bureau.

14. The permit holder is liable for all actions or omissions relating to this permit, including actions or omissions by an employee, contractor or agent of the permit holder. The Province of British Columbia is not liable for any damage or loss arising from this permit.

15. The Province is not liable for any illness contracted through wildlife handling. It is the responsibility of the permit holder to inform him/herself of possible health hazards, and to ensure that all reasonably necessary safety measures are undertaken.

16. If applicable, the permit holder is required to renew his or her own permit. There will be no reminder notice sent.

17. The permit holder must carry a copy of this permit at all times when performing the activities authorized by the permit.

18. Failure to comply with the terms and conditions of this permit may result in its revocation.

APPENDIX “B”

ADVISORY CONDITIONS FOR SU06-20318

- This permit does not authorize entry onto private lands, reserves or parks. The permit holder is responsible for obtaining appropriate permissions.

BRITISH COLUMBIA

Ministry of Environment

Permit and Authorization
Service Bureau
PO Box 9372 Stn Prov Govt
Victoria, BC V8W 9M3
Tel: 1-866-433-7272 or
250-952-0932

PERMIT

78470-25

PERMIT SU05-15073

UNDER THE PROVISIONS OF THE *WILDLIFE ACT*

PERMIT HOLDER	ENKON Environmental Limited Suite 201 – 2430 King George Highway Surrey, BC V4P 1H8 ATTENTION: Norma Powell PHONE: (604) 536-2947 FAX: (604) 536-2948

HAS BEEN AUTHORIZED UNDER: **s. 19** of the *Wildlife Act*, RSBC 1996, c. 488 AND
s. 2(c)(i) of the *Permit Regulation*, B.C. Reg. 253/2000

TO	Live-trap and on-site release for the purpose of sampling for the presence of Trowbridge's Shrew (*Sorex trowbridgii*), Pacific Water Shrew (*Sorex bendirii*) and amphibians, in the Fergus Creek watershed, from Hwy. 99 at 20th Avenue to Hwy 99 at 8th Avenue.

SUBJECT TO THE FOLLOWING:

CONDITIONS OF PERMIT:	The permit holder must comply with the requirements listed in Appendix "A."
OFFENCE PROVISION	The permit holder must comply with **all** applicable federal, provincial, municipal and regional district legislation and by-laws. It is the responsibility of the permit holder to inform him/herself of all relevant laws. Failure to comply with any term(s) of this permit is an offence under the *Wildlife Act*, and may result in prosecution and/or denial of future permit requests.
TERM OF PERMIT	This permit is only valid from July 26, 2005 to August 31, 2005.
DATE OF ISSUE	July 26, 2005

SIGNATURE OF ISSUER	Brian Clark Regional Manager Environmental Stewardship Division Lower Mainland	**PERMIT FEE** **$110.00**	**RECEIPT NUMBER (IF ISSUED)**

DISTRIBUTION:	PASB (VICTORIA) ☐	PERMITTEE ☐	REGIONAL OFFICE ☐

APPENDIX "A"

PERMIT CONDITIONS FOR SU05-15073

REPORTING REQUIREMENTS:

1. The permit holder must maintain an accurate up to date record of the wildlife hunted, trapped or killed under the permit that includes the following information:
    a) common name of the wildlife;
    b) location where the wildlife was taken;
    c) the date the wildlife was hunted, trapped or killed;
    d) the sex and age class of the wildlife taken;
    e) the bands or tags on the wildlife; and
    f) a description of all nests, dams or other structures destroyed or removed.

2. The permit holder must submit the original copy of this record to the Permit and Authorization Service Bureau **within 21 days** of the permit's expiry.

3. The permit holder must produce a copy of this record on the demand of an officer.

GENERAL CONDITIONS:

1. This permit is not transferable.

2. All work is to be undertaken by trained professionals with experience in trapping small mammals.

3. The permit holder must take all reasonably necessary steps to ensure that public safety and fish / wildlife habitat are not jeopardized by any action taken under authority of the permit.

4. Capture and handling of specimens to be in accordance with the Standards for Live Animal Capture and Handling Guidelines established by the Ministry of Sustainable Resource Management. See http://srmwww.gov.bc.ca/risc/pubs/tebiodiv/capt/index.htm.

5. Use Draft Best Management Practices for Pacific Water Shrew in Urban and Rural Areas, April 2005, by Craig and Vennesland.

6. The permit holder must ensure that animals are treated in a humane manner, and are not subjected to any unnecessary harm or suffering.

7. If a shrew is caught and is not at risk any scat collected (preferably intact) should go to the regional office in Surrey (please call Ross Vennesland at 604-582-5279).

8. Traps must be checked regularly to ensure that shrews are not killed. From March 1 to November 1, traps should be checked every 8 hours (minimum). From November 1 to March 1, traps should be checked every 6 hours (minimum). If frost is expected or if heavy rainfall is expected, trapping should NOT occur.

9. No intentional mortality of other red or blue listed species is to occur. All reasonable steps must be taken to ensure that no accidental mortality occurs.

10. All other small mammals and other organisms captured should be released unharmed.

11. All wildlife and wildlife parts remain the property of the Province of British Columbia. The permit holder may not sell, trade or give away wildlife.

APPENDIX “A”

PERMIT CONDITIONS CONTINUED FOR SU05-15073

12. The Province is not liable for any illness contracted through wildlife handling. It is the responsibility of the permit holder to inform him/herself of possible health hazards, and to ensure that all reasonably necessary safety measures are undertaken.

13. The permit holder is liable for all actions or omissions relating to this permit, including actions or omissions by an employee, contractor or agent of the permit holder. The Province of British Columbia is not liable for any damage or loss arising from this permit.

14. Permit holder shall provide upon conclusion of the project, a copy of the final report, to the Permit and Authorization Service Bureau.

15. The permit holder must carry a copy of this permit at all times when performing the activities authorized by the permit.

16. If applicable, the permit holder is required to renew his or her own permit. There will be no reminder notice sent.

17. Failure to comply with the terms and conditions of this permit may result in its revocation.

APPENDIX “B”

ADVISORY CONDITIONS FOR SU05-15073

- This permit does not authorize entry onto private lands, reserves or parks. The permit holder is responsible for obtaining appropriate permissions.

REPORTING REQUIREMENTS FOR PERMIT SU05-15073

The permit holder **MUST** submit the original copy of this report to the Permit and Authorization Service Bureau **within 21 days** of the permit's expiry or annually as indicated in "Appendix 'A' – Permit Conditions" of this permit.

Failure to comply with any term of this permit is an offence under the *Wildlife Act*, and may result in prosecution and/or denial of future permit requests.

Common name of wildlife	Location where wildlife was taken	Date wildlife was hunted, trapped or killed	Sex and age class of wildlife	Bands or tags on wildlife	Description of all nests, dams or other structures destroyed or removed

*If more room is required, please use a sheet of blank paper

Signature of Permit Holder

Date

Ministry of Environment
Permit and Authorization Service Bureau
PO Box 9372 Stn Prov Govt
Victoria, BC V8W 9M3