City of Surrey Ecosystem Management Study

HB LANARC

Raincoast

Book 1. Main Report

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TABLE OF CONTENTS

1.0 INTRODUCTION

The City of Surrey has a rich natural environment composed of an interconnected network of streams, wetlands, forests, fields, and shorelines. This network includes regionally important natural areas such as Surrey Bend Regional Park and Green Timbers Urban Forest, neighbourhood-scale sites such as Port Kells Park and Redwood Park, and countless forested backyards, urban parks, and agricultural fields. These features together form the "green infrastructure" that helps sustain clean water, recharge groundwater, maintain clean air, and support healthy plant, fish and wildlife communities. The green infrastructure of the City is as essential as the network of roads that allow the movement of goods and people, or the agricultural landscape that provides food and other products.

1.1 Project Purpose

This study uses a science-based approach to identify the Green Infrastructure Network in the City of Surrey. It is the first phase of broader initiative, originating from the City of Surrey's Sustainability Charter (2008), to strategically manage the ecosystems throughout the City. The results of the EMS will inform the Official Community Plan update (2010–2011). The second phase of the project will include a "Biodiversity Conservation Strategy" and will identify management guidelines and strategies to maximize the health and benefits of Surrey's green infrastructure, and integrate it as a key foundation in the City's ongoing success.

"Green infrastructure is the ecological framework needed for environmental, social and economic sustainability—in short it is our nation's *natural life sustaining system.*" *From Benedict and McMahon (2002):* Green Infrastructure: Smart Conservation for the 21st Century.

1.2 A New Approach: Green Infrastructure

"Green infrastructure" is a term that is rapidly gaining ground in land use planning, engineering, and site design. In general, green infrastructure is an interconnected network of natural or "green" elements that occur at a variety of scales – site/building, neighbourhood, community-wide, regional, and beyond. Similar to traditional "grey" infrastructure (roads, power, gas and other utilities, etc.), green infrastructure provides a critical underlying foundation to support the function and quality of communities and also supports the function of ecological systems. (Wilkie and Ascroft, 2009).

The concept of integrating green networks in planning is not new, but it is an approach that has not be used for environmental planning in urban areas of the lower Fraser Valley. The term "green infrastructure" was coined as a strategic move by leading practitioners to reposition green features and functions as community necessities, not community amenities (Wilkie and Ascroft, 2009). Green infrastructure also differs from conventional approaches to land use planning because it looks at conservation values and actions in concert with land development, growth management, and built infrastructure planning (Benedict and McMahon, 2002).

A Green Infrastructure assessment uses Geographic Information Systems (GIS) and the principles of landscape ecology and conservation biology to identify a connected network of natural and semi-natural lands most critical to an area's long-term ecological health. Sites can be prioritized for their relative importance within the network. The Green Infrastructure Network approach has been used successfully to identify priorities for environmental management in other jurisdictions at both large (e.g, State of Maryland, State of Florida) and small (e.g., City of Catherine, Ontario, Harlow Area, UK, Kent County, Maryland) scales.

Green infrastructure has definitions depending on the scale and context of the resource management question

Most frequently used with large spatial scales and in non-urban environments. …an interconnected network of natural elements only.

Refers mostly to functional wildlife habitat, watercourses, riparian areas and native vegetation, etc. Less natural elements may be included such as agricultural fields, recreational parks and gardens.

Focuses on low impact development techniques. for stormwater management. …a network of "green" elements to address rainwater management only.

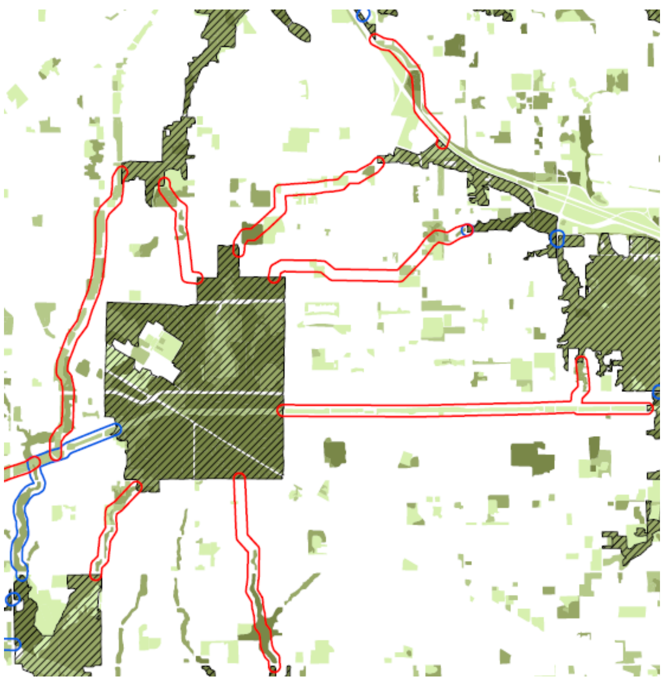
Includes engineered green features as well as natural elements; e.g., stormwater wetlands, green roofs, bioswales, dry ponds.

Used mostly in an urban context and the definition that captures the intent of this Ecosystem Management Strategy. … an interconnected network of natural and engineered green elements to maintain ecological function at a variety of spatial scales.

"Green" elements are not limited to land uses – they are green in terms of function and outcomes.; e.g., district energy systems, green buildings, permeable pavement, eco-industrial parks.

What are the higher level features of a Green Infrastructure Network?

The map below shows a mosaic of significant ecosystem features. The dark green areas have a higher measure of naturalness in terms of less human disturbance. The lighter green areas are landscape features that are mainly natural (undeveloped), but not wild – similar to agricultural areas. The red outlined areas are corridor connections that need to be restored in order to connect the existing natural landscape. The blue outlined areas are functioning corridor connections. The hatching lines indicate significant hubs of natural areas considered to be high priority environmental management areas.



1.2.1 Why Green Infrastructure in Surrey?

In the Surrey context, a Green Infrastructure Network (GIN) approach builds on traditional Environmentally Sensitive Area (ESA) identification and mapping methods. Both approaches address the need to spatially delineate important environmental and natural assets. However, unlike traditional ESA mapping, the GIN approach also emphasizes the spatial relationships between natural and semi-natural areas within the landscape and their important functional role in landscape processes, such as sustaining natural flows of water, nutrients, and energy.

Key to this approach is the identification of hubs, the largest intact sites of naturally-functioning ecosystems, and corridors, which provide physical or functional linkages between hubs of similar or different ecosystem types. This approach takes into account the role of natural ecosystems as habitat and movement corridors for biodiversity and in providing clean water and air, flood protection, and slope stability.

1.3 Previous Studies

Several studies provide an important context for environmental inventory and management in Surrey. Environmentally Sensitive Area (ESA) mapping was first completed in 1990 (Abs et al., 1990) and updated in 1997 (Coast River Environmental, 1997). The purpose of this ESA mapping was to identify features within the City that may be sensitive to human use and development. The focus of past ESA mapping has been to delineate areas that provide important habitat for biodiversity (e.g., wetlands, coastal marshes), protect significant natural features (e.g., watercourses), contain natural hazards (e.g., bluffs, ravines), or are significant heritage sites.

The 1990 and 1997 ESA studies were award winning projects at the time, and were a useful tool to assist with the review of land development applications and to help identify priority areas for parkland acquisition. However, the mapping is in now out of date, and the ESA approach, which rated ESAs as "high", "medium" or "low", has been replaced by an "Ecosystem Management" approach guided by the City of Surrey's Sustainability Charter. The Ecosystem Management approach shares many of the components of an ESA approach, however, it focuses not just on the protection of existing priority areas, but recognizes that all parts of the City, including developed areas, can contribute to ecological sustainability.

1.4 Links to Other Initiatives

The Biodiversity Conservation Strategy Parnership completed a regional biodiversity mapping project[1] in 2006 to identify regionally-important habitats and the relative biodiversity among different habitat types (Axys, 2006). The regional mapping, while useful at a broad scale, requires more detailed mapping and ground-truthing to be useful for environmental management within the City of Surrey. Metro Vancouver's Regional Biodiversity Conservation Strategy has produced several additional reports to improve collaboration and guide biodiversity conservation in the region.

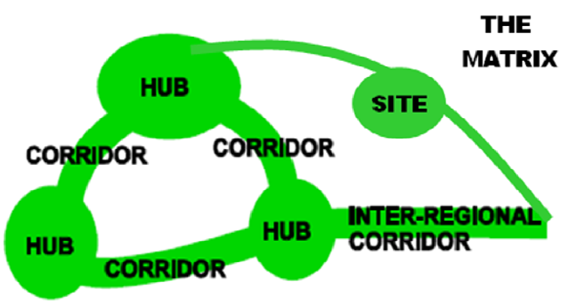
A detailed wildlife habitat mapping and status report[2] has been completed for the Township of Langley in 2005 by Langley Environmental Partners Society (LEPS). It includes detailed mapping of vegetation and habitats throughout the Township. This mapping provides an opportunity to examine linkages between the two municipalities and to examine the natural assets of Surrey within their regional context.

1.5 Fulfilling Surrey's Environmental Goals

The City of Surrey is committed to protecting and enhancing the integrity and diversity of its natural environment. Environmental goals are highlighted in the Sustainability Charter and the Official Community Plan. Other plans and bylaws such as the Surrey Storm Water Drainage Regulation and Charges Bylaw, Tree Protection Bylaw and Soil Conservation & Protection Bylaw echo the ethic to protect, preserve and nurture natural ecological process.

To help achieve this commitment this Ecosystem Management Study focuses on four main elements of Surrey's landscape.

- **Hubs** – large areas of complex ecological processes
- **Sites** – smaller sites of less complex ecological activity
- **Corridors** –pathways that offer species and ecological process connection between hubs
- **The Matrix** – the rest of the land base with varying ecological value



[1] Axys Environmental Consulting. 2006. Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region. Biodiversity Conservation Strategy Partnership, Burnaby, BC.

[2] Langley Environmental Partners Society: Mapping & Inventory (www.leps.bc.ca/programs/mapping-a-inventory)

2.0 METHODS

The methods for identifying a Green Infrastructure Network (GIN) for the City of Surrey involved four parts:

(1) Collection and review of existing GIS data;

(2) Mapping of natural and semi-natural vegetation communities;

(3) Delineation of the Green Infrastructure Network; and

(4) An evaluation of the relative ecological significance of hubs and corridors.

2.1 Collection and Review of Existing GIS Data

The first step in identifying Surrey's GIN was to collect and review existing GIS data. Existing spatial data on the physical (e.g., slopes and watersheds) and biological (e.g., species at risk, wildlife habitat) features was used to characterize the ecological significance of different components of the GIN. Although all available related GIS data was collected for this project, emphasis was given to consistent City-wide datasets. More site specific information, while useful, was difficult to incorporate into the city-wide assessment. Existing environmental data was available on aquatic features such as stream location and fisheries values, steep slopes, watershed boundaries, and some wildlife species including Bald Eagle nests and Great Blue Heron colonies. In general, terrestrial environmental features collected during development planning were less consistently documented and more difficult to use.

Data example: Surrey Watercourse Classification.

The City of Surrey maps watercourses and collects data on their relative value for fish populations. Watercourses range from larger rivers such as the Serpentine and Little Campbell rivers to small roadside ditches that are typically dry in the summer. Watercourses are classified according the presence or potential presence of salmon and trout, the seasonality of fish use, and their contribution of food and nutrients to downstream fish populations. The watercourse classification is used for development planning, operational activities such as emergency works, and for restoration planning. Similar mapping projects have been developed by other municipalities based on Surrey's model.

In the map below; red lines indicate year round presence or potential presence of salmonids, yellow lines indicate streams that provide food and nutrients to downstream fish and green ditches with insignificant food and nutrients.

Existing GIS data layers used for this study are listed below:

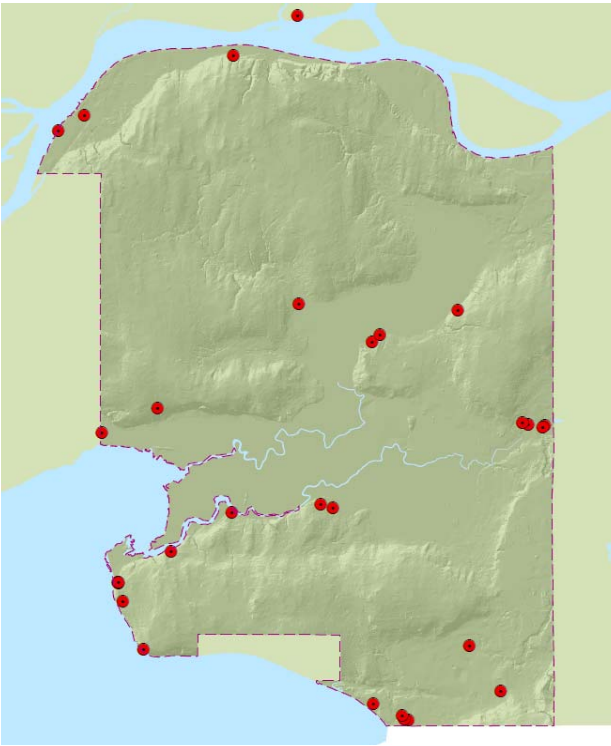
- Watershed boundaries from City of Surrey and Metro Vancouver
- Stream location and fish community classification from City of Surrey (see text box)
- Non-forested wetlands (marshes, shallow open water, etc.) from Canadian Wildlife Service
- Aquifers and groundwater recharge areas from BC Ministry of Environment
- Shoreline habitat mapping and sensitivity coding from Fraser River Estuary Management Program (FREMP) shoreline habitat mapping
- Fish presence from Fisheries Inventory Information System (DFO and MOE)
- Rare species and ecological communities from BC Conservation Data Centre
- Bald Eagle nests from City of Surrey
- Great Blue Heron nest sites (from City of Surrey, Conservation Data Centre, and BC Ministry of Environment)
- Location of raptor nests, amphibian habitats, and other wildlife from City of Surrey and unpublished datasets
- Topography (contour and digital elevation model (DEM) from City of Surrey
- Slope stability and slope failure risk from City of Surrey
- Land cover mapping (2006) from Metro Vancouver
- Cadastral mapping (lot boundaries, road edges, etc.) from City of Surrey
- Road classification and use from City of Surrey
- Land use zoning from City of Surrey

See Map 1. Aquifers, Slopes. Watersheds and Sub-watersheds and Map 2. Sensitive Species in Appendix D - Map Catalogue for a view of Surrey's background environmental setting.

Data Example: Bald Eagle Nests.

Bald Eagles are protected under the BC Wildlife Act and there is increased emphasis on protecting nest and perch trees in developing urban areas. The City of Surrey, in cooperation with the BC Nature Wildlife Tree Stewardship program, maintains a database of nest locations. This is used as a development planning tool and City staff work with landowners to protect nests and perch trees, or mitigate their loss through nest relocation and other methods. The map below should not be presumed as exhaustive and not all Bald Eagle Nests in the City are shown.

In the map below; red dots show a distribution of Bald Eagle trees along shorelines and the edges of valleys. These areas are close enough to food supplies and offer trees large enough for nesting.



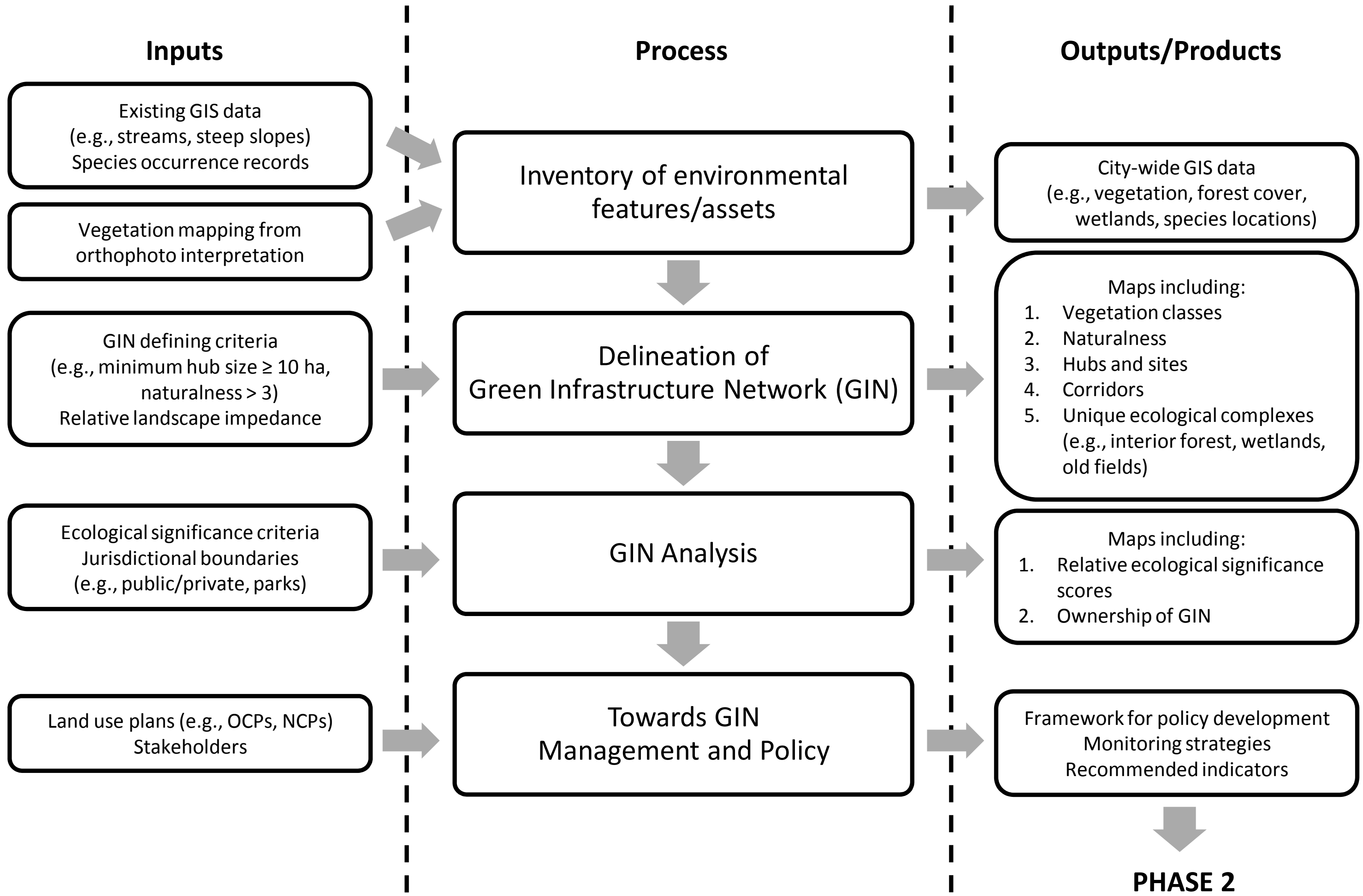


Figure 2.1. Flowchart of general methods used to the Surrey Ecosystem Management Study, including inputs and data products.

2.2 Vegetation Mapping

An important gap in the existing dataset was the lack of consistent City-wide vegetation mapping. Vegetation provides the structure which supports biodiversity and is a key indicator of ecological function. Vegetation can also be mapped consistently using the interpretation of orthophotos (rectified air photos). To fill this gap in existing data, natural and semi-natural vegetation was initially mapped across the entire City using orthophotos taken in April 2007 and updated using orthophotos taken in April 2010. Vegetation polygon mapping was conducted in ArcView 3.2 and ArcGIS 9 at a scale of 1:4,000 with a minimum polygon size of approximately 0.1 ha.

The analysis used a modified version of the U.S. National Vegetation Classification (USNVC; Grossman et al., 1998) to classify all natural and semi-natural vegetation across the City. The USNVC was selected as the best standardized approach for mapping vegetation in Surrey for several reasons:

- There is no consistent, standardized approach currently being used for urban areas of the lower Fraser Valley;
- Terrestrial Ecosystem Mapping (TEM) is the most standard method in BC, but it is often too coarse for urban areas;
- The USNVC is a documented method that can be further refined to look at specific plant communities of conservation significance; and
- The USNVC is used by the BC Conservation Data Centre and NatureServe (the North American conservation data management system) and future data collected on ecological communities can be used for regional conservation planning.

Why vegetation communities as the basis for identifying hubs and sites?

- Vegetation communities have inherent value that is worth conserving. They encompass a unique set of interactions among species and contribute to important ecosystem functions. Communities can be used as surrogates for species and for ecological process. With a lack of consistent City-wide wildlife species data for Surrey and the complex nature of delineating ecological process, vegetation mapping provides an efficient, accurate and comprehensive method to delineate ecological vitality.
- By protecting vegetation communities, we protect many species not specifically targeted for conservation. This is especially important for poorly known groups such as fungi and invertebrates.
- Monitoring change over time is often most meaningful when done at the level of communities. Changes may be detected:
  - in overall species abundance, including the proportion of non-native species;
  - in structure, such as the development of old-growth characteristics; and
  - in function, such as alterations in nutrient cycling.
- Vegetation communities are an important tool for systematically characterizing the current pattern and condition of ecosystems and landscapes.

From: Maybury, K. P., editor. 1999. Seeing the Forest and the Trees: Ecological Classification for Conservation. The Nature Conservancy, Arlington, Virginia.

The USNVC classifies vegetation into a series of physiognomic (structural) classes based on vegetation type. There are seven physiognomic classes: forest, woodland, shrubland, dwarf-shrubland, herbaceous, non-vascular, and sparse vegetation (see Appendix A). However, Surrey does not contain any woodland or dwarf-shrubland vegetation. Subclasses are used to further divide the classes based on vegetation composition and characteristics, such as leaf phenology. Examples of some subclasses are:

- Forest subclasses: evergreen, deciduous, mixed evergreen-deciduous.
- Herbaceous subclasses: perennial grasslands, perennial forb vegetation, annual grass and forb vegetation, and hydromorphic rooted vegetation.

The analysis also defined some natural areas that do not have vegetation but were important to the study, such as waterbodies, mudflats, or recently cleared sites. To include these, the mapping added one additional class, unvegetated (UV), with two subclasses, unconsolidated material (UC) and water (WA). All classes and subclasses used are shown in Table 2.1.

All terrestrial areas in the City of Surrey were mapped. For coastal areas, the FREMP shoreline habitat mapping polygons were used, but the attributes were modified to correspond with the classification scheme.

Selected field review of vegetation communities was undertaken to better identify polygon boundaries and characterize dominant species in representative sites (see Appendix D for examples). As well, the boundaries and classification of many polygons were reviewed by a second project team member to ensure consistency.

See Map 3. Vegetation Inventory in Appendix D - Map Catalogue for a view of Surrey's vegetation communities.

Table 2.1. Vegetation classes (5) and subclasses (13) used in the Surrey Ecosystem Management Study.

Class	Subclasses
Forest (FO)	Evergreen Forest (FO-EV) Deciduous Forest (FO-DE) Mixed Evergreen-Deciduous Forest (FO-MX)
Shrubland (SH)	Evergreen Shrubland (SH-EV) Deciduous Shrubland (SH-DE) Mixed Evergreen-Deciduous Shrubland (SH-MX)
Herbaceous (HB)	Perennial Graminoid Vegetation (HB-GR) Annual Graminoid or Forb Vegetation (HB-AN) Hydromorphic Rooted Vegetation (HB-HY)
Sparse Vegetation (SV)	Boulder or Cobble Sparse Vegetation (SV-BO) Unconsolidated Material Sparse Vegetation (SV-UC)
Unvegetated (UV)	Unvegetated Unconsolidated Material (UV-UC) Unvegetated Water (UV-WA)

2.2.1 Vegetation Modifiers

To further characterize vegetation, modifiers and submodifiers were added to denote more specific land cover types or uses (e.g., pasture, crops, golf courses, ponds) that affect vegetation management. For forested polygons, forest age was assessed as young, mature, or old-growth. Tables 2.2 and 2.3 summarizes the range of vegetation modifiers used.

Small areas of vegetation were not mapped (e.g., one or few street trees, house lawns, and gardens) in urban or dense suburban areas where natural or semi-natural vegetation was not the dominant land cover type. While they are a part of green infrastructure in the City, mapping efforts focused on the larger areas of vegetation.

2.2.2 Vegetation Naturalness

As part of the vegetation mapping, the study assessed the naturalness of each vegetation polygon, taking into account the history and frequency of human disturbance. Naturalness is an important aspect of vegetation in urban areas because modification includes initial logging, changes to ecological disturbance processes such as reduced flooding, succession, and the establishment of non-native plants. A scale from 1 to 5 was used, where 1 was least natural and 5 was most natural. Table 2.4 provides the naturalness scale used with example habitat types.

See Map 4. Naturalness in Appendix D - Map Catalogue for a view of the range of naturalness that occurs across Surrey's vegetated landscape.

2.2.3 Regional Vegetation Mapping

To assess existing and potential regional linkages between Surrey and other neighbouring areas, the study mapped vegetation in adjacent municipalities. Wildlife habitat mapping was completed for the Township of Langley in 2005 (Township of Langley 2005). This existing vegetation data was translated to fit the GIN classification scheme. For all other adjacent municipal areas, a simplified version of vegetation mapping using fewer polygon attributes was undertaken. This larger regional vegetation layer was used in the subsequent Green Infrastructure Network delineation and analysis steps.

Photos of Representative Vegetation Classes in the City of Surrey

a

b

e

c

d

Figure 1. Photos of representative habitat classes in the City of Surrey: (a) evergreen forest near Little Campbell River; (b) hardhack shrubland in Tynehead Regional Park; (c) old field in south Surrey; (d) sparsely-vegetated shoreline at Crescent Beach; and (e) unvegetated mudflats in Boundary Bay. Photos by N. Page and P. Lilley 2008.

See Appendix C – Representative vegetation photos for more images.

Table 2.2. Vegetation modifiers (3) and submodifiers (19) used in Surrey Ecosystem Management Study.

Modifier	Submodifier	Modifies	Surrey Examples
Agricultural (AG)	Pasture (AG-PA)	HB-GR	Hay fields and pastures
	Old field (AG-OF)	HB-GR	Unmaintained fields with previous agricultural activity
	Seasonally flooded (AG-SF)	HB-GR	Agricultural fields with seasonal flooding
	Row Crop (AG-RC)	HB-GR, SH	Vegetable fields, blueberry fields
	Corrals (AG-CO)	SV-UC	Corrals, horse riding rings, feed lots
	Bare Ground (AG-BG)	SV-UC	Recently plowed or cleared fields with no evidence of crop
Developed (DV)	Playing Field (DV-PF)	HB-GR	Turf soccer fields
	Lawn (DV-LA)	HB-GR	Developed lawns in parks
	Old fields (DV-OF)	HB-GR	Unmaintained fields without previous agricultural activity
	Garden (DV-GA)	SH, HB	Large residential gardens, parks
	Golf Course (DV-GC)	HB-GR	Grass areas in golf courses
	Bare Ground (DV-BG)	SV-UC	Gravel road, dirt road, and similar clearings
	Road Margin (DV-RM)	HB-GR	Road medians and edges, may be sporadically maintained
	Urban Trees (DV-UT)	FO	Planted hedges, landscaping trees, forest with no natural understory
Aquatic (AQ)	Wetland (AQ-WN)	HB-HY	Freshwater wetlands: fens, marshes, swamps
	Lake/Pond (AQ-LP)	HB-HY, UV-WA	Farm and golf course ponds, natural lakes
	River/Fluvial (AQ-RF)	HB-HY, UV-WA	Larger river channels including the Fraser River
	Marine/Intertidal (AQ-MI)	NV-AL, SV-UC	Mud flats, beaches, river flats with tidal activity
	Ditches (AQ-DI)	UV-WA	Large ditches

Table 2.3. Forest age ratings (3) for Surrey Ecosystem Management Study.

Forest Age	Name	Definition	Examples
Y	Young	Typically 5 to 35 years with canopy closure; often very even in appearance	Young red alder or cottonwood stands
M	Mature	35 to 120 years old; multilayered canopy; more structural diversity	Mature second-growth coniferous, deciduous, and mixed forests
O	Old	>120 years old	Old growth forest (does not occur in Surrey)

Table 2.4. Vegetation naturalness ratings (5) for Surrey Ecosystem Management Study.

Code	Name	Definition	Examples
5	Natural	Undisturbed by direct human activity	Old-growth Forest
4	Mainly Natural	Disturbed historically (logged) by sufficient time to restore native species and structure; eg forests greater than 120 years old	Older forest, saltmarshes; some older deciduous forests
3	Semi-natural	Disturbed vegetation; predominantly native species but lacking some species and structures associated with natural vegetation	Red alder forest
2	Semi-modified	Heavily disturbed vegetation that is often a mix of native and non-native species; may be recovering or rapidly changing	Old fields; hedgerows, shrub communities on cleared sites
1	Modified	Vegetation that is regularly maintained	Crops, pasture, gardens, lawns

2.3 Delineation of the Green Infrastructure Network

The study used several GIS-based analysis methods to identify hubs and corridors. These GIS methods were supplemented with more qualitative assessments of hub boundaries and corridor integrity.

2.3.1 Hub Identification

Hubs were initially defined as contiguous areas of ecological importance at least 10 ha in size. Ten hectares was selected as the size threshold for hubs because it encompasses moderately large natural areas that can support populations of many native wildlife species, particularly if there are other natural areas nearby. Also tested were 15 ha and 20 ha criteria but they excluded some areas we considered to be important ecological features in the City.

GIS analysis was first used to identify and delineate hubs of contiguous or near-contiguous vegetation of naturalness 3 or greater at least 10 ha in size. Polygons with naturalness 3 or greater include young red alder forests, structurally-diverse old fields with shrub development, natural wetlands, and more mature forest types. Less natural communities such as pasture lands and golf courses were excluded.

Second, to the hubs that met this first criterion, the study added any adjacent areas of naturalness 2 or greater. This acknowledged that hub boundaries will likely change over time as some areas are lost to development or other activities while others areas may become more natural through succession. For example, old fields classified as naturalness 2 were added to adjacent hub areas.

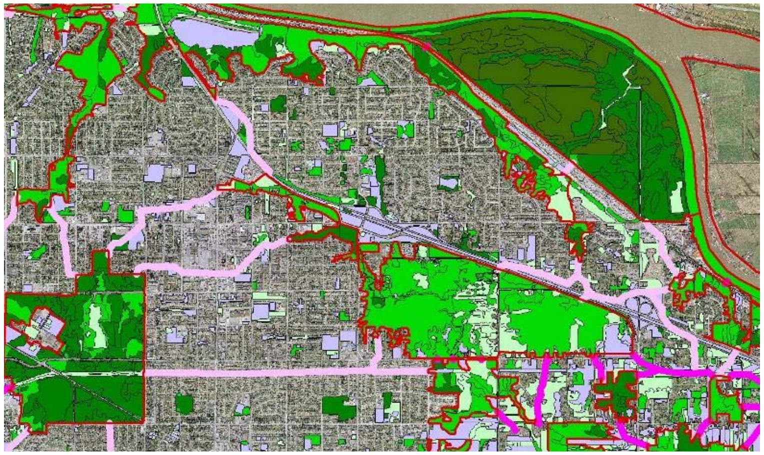
Third, the study conducted a manual review of GIS-generated hub boundaries and made minor modifications to eliminate small breaks or holes such as two-lane roads or utility rights-of-way and to remove linear “arms” on hubs which are subject to substantial edge effects.

Finally, the study identified any remaining existing natural park lands and added them either to existing hubs or as new hubs, whether or not they met the 10 ha or naturalness criteria. This was done in recognition of their important role in the Green Infrastructure Network. Blackie Spit Park and Mound Farm Park were added to the GIN during this step. Less natural portions of the Serpentine Wildlife Area and Colebrook Park were also added to existing hubs delineated using the naturalness criteria.

What is a hub?

Hubs are the largest intact areas of natural or semi-natural vegetation and form the core components of the GIN. They are the important reservoirs of biodiversity and function as major areas for soil replenishment, water filtration, and groundwater recharge. Examples of large hubs in the City of Surrey include Surrey Bend Regional Park, Green Timbers Urban Forest, Tynehead Regional Park, and Colebrook Park.

In the map below hubs are shaded in dark green.



2.3.2 Sites

Sites are smaller areas of natural or semi-natural vegetation between 0.25 and 10 ha in size. They are also important to the functioning of the GIN but are too small to be considered hubs. Many neighbourhood parks have areas of forest or shrub vegetation in this size range with significant ecological value.

2.3.3 Assessing Landscape (Hub) Linkage Potential

A corridor suitability layer (Weber & Wolf 2000) was created in order to assess the linkage potential across the landscape between hubs and to identify conduits and barriers for wildlife migration and seed movement. This corridor suitability layer is a landscape assessment of relative impedance to wildlife travel. Several layers were combined in an overlay process to represent lower impedance values for natural features and higher impedance values for human made features such as roads.

The base layer of this raster layer is vegetation. To the vegetation layer, the study filled in areas not mapped during the vegetation mapping (unvegetated areas, urban areas,) using the Metro Vancouver land cover layer from 2006 to form a single layer covering the entire City. Then, the study overlaid the City of Surrey's watercourse and roads as these have the potential to be conduits and barriers respectively, to the movement of animals and plants. As the watercourses were linear (vector-based) features, they are shown at a 1 metre width.

Once all the layers (vegetation, development, watercourses, roads) were combined through overlay, the study assigned an impedance value which measures the degree to which each landscape type inhibits wildlife use and movement. Wildlife, in this context, should be considered a hypothetical species rather than a specific mammal, bird, or amphibian species. Selected impedance values used for each land cover type are summarized in Table 2.5. Although numerical, the values represent the qualitative judgment of the authors.

See Map 5. Relative Impedance in Appendix D - Map Catalogue for a view of the range of impedance that influences wildlife use and movement.

Table 2.5. Impedance Values for Surrey Ecosystem Management Study.

Type	Category	Feature	Impedance Value
Vegetation	Forest	Coniferous/evergreen	50
		Deciduous or Mixed	75
	Shrubland	Evergreen, Deciduous or mixed	100
		Deciduous Shrubland	100
		Mixed Shrubland	100
	Herbaceous	Graminoid or Forb	150
		Hydromorphic Rooted	100
	Sparsely Vegetated or UnVegetated	Boulder, Cobble, Gravel, or Talus	200
Modifiers	Agriculture	Pasture	150
		Old Field/Rough Pasture	50
		Forage	200
		Row Crop	250
		Corral	300
		Bare Ground	300
	Developed	Playing Field	250
		Lawn	250
		Garden	250
		Golf Course	250
		Gravel/dirt road	300
		Road margin	150
		Urban trees	200
	Aquatic	Wetland, Lake/Pond or River/Fluvial	50
		Creeks and ditches (higher values for channels less supportive of fish life)	50 to 150

Table 2.5. Impedance Values for Surrey Ecosystem Management Study (cont).

Type	Category	Feature	Impedance Value
Other veg	Forest age	Young	add 25
		Mature	add 0
		Old	substract 25
	Forest type	Riparian forest (adjacent to streams 30m)	substract 25
		Interior forest (>100 m from edge)	substract 13
	Naturalness	Natural	substract 20
		Mainly Natural	substract 10
		Semi-natural	add 0
		Altered	add 10
		Cultural	add 20
Urban	Generalized land use	Residential - Rural	500
		Residential - Single Detached/Duplex	1000
		Residential - Townhouse	2500
		Residential - Low-rise Apartment	3500
		Residential - High-rise Apartment	4000
		Residential - Commercial/Mixed, Industrial and other Intensive Uses*	5000
*Note: there are added impedance values to buffers around these land uses (900 for 20m buffer, 500 for 20-50m buffer and 250 for 50-100m buffer)			
Traffic	Roads	Provincial Highway	5000
		Arterial	1000
		Major Collector	500
		Local	300
		Green	100
		Lane	200
		Margin/Lane	200
Terrain	Slopes	0-8% slope	add 0
		9-15% slope	add 2
		16-25% slope	add 5
		>25% slope	add 10

2.3.4 Corridor Identification

A detailed process was undertaken to propose optimum connections between hubs. This process involved using GIS analysis followed by detailed review to find the shortest, most natural route between hubs.

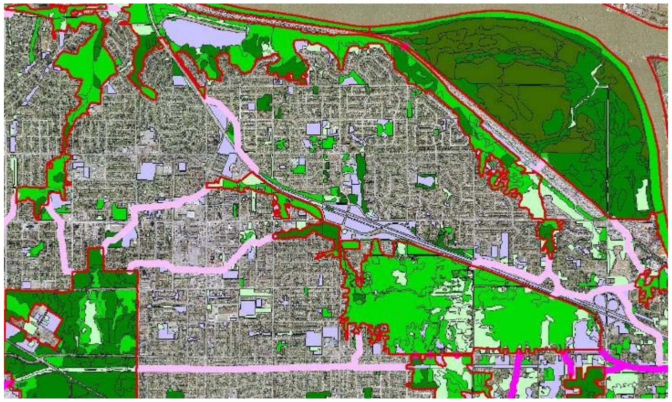
Least-cost path analysis was used to determine the best ecological routes between hubs. Least-cost path analysis is a GIS method used to assess connectivity between habitat sites by examining the condition of the intervening landscape. The analysis identifies pathways between hubs that offer the lowest cumulative resistance to movement by plant and animal species. A manual review of the GIS identified least-cost paths was conducted, leading to minor adjustments to the network to remove errors and merge or remove redundant or closely parallel paths. Potential corridors were then created by buffering the least-cost paths by 50 m on each side for a total width of 100 m.

The term "potential corridor" is used to indicate that these are potential alignments for connection and can be adjusted and changed in terms of width and location to best suit the local area and opportunities.

What is a corridor?

Corridors allow for animal movement and seed dispersal between hubs and other parts of the GIN. They are linear pathways such as stream corridors, however, as Meiklejohn et al. (2009) state: "more recent definitions of corridors reflect a broadened understanding of habitat corridors, which are now described as components of the landscape that facilitate the movement of organisms and processes between areas of intact habitat. Implicit in this definition are two ideas: (1) corridors support the movement of both biotic processes (e.g. animal movement, plant propagation, genetic exchange) and abiotic processes (water, energy, materials); and (2) corridors are process- or species-specific."

In the map below potential are shaded in pink.



2.4 Network Evaluation

To evaluate the components of Surrey's Green Infrastructure Network, the study developed a scoring system that assesses the relative ecological significance of different hubs and potential corridors. The scoring system assigns a composite "ecological significance score" out of 100 calculated using 12 metrics that characterize the function and integrity of each hub or corridor. Metrics were chosen based on well-established landscape ecology and conservation biology principles and the availability of data. Example of metrics used in evaluating hubs and potential corridors include:

- Average vegetation naturalness (area-weighted)
- Number of vegetation polygons with high values of naturalness
- Presence of streams and wetlands
- Number of biodiversity features (rare species occurrences, raptor nests, amphibian habitats)

Metrics unique to hubs include:

- Size
- Area-to-perimeter ratio
- Road density

Metrics unique to corridors include:

- Average vegetation naturalness (area-weighted)
- Corridor length
- Number of hubs within a 1 km buffer
- Number of road or railway crossings

Evaluation of Sites:

The ecological significance of sites has not been calculated in depth as with hubs and potential corridors. Although sites are not critical components of the Green Infrastructure Network, they present opportunities to increase the success of corridors and provide neighbourhood pockets of natural ecological functioning. In these respects the value of a site can be considered higher when it:

- Is located along a corridor
- Has a higher naturalness value
- Is close to a hub

Each metric's contribution to the final score is weighted based on its importance to ecological function and integrity, relative to the other metrics. For example; factors such as average naturalness, hub size, and corridor length are of greater importance to ecological functioning than other factors, and contribute more significantly to the overall score. The full list of metrics used to calculate the ecological significance scores for hubs and potential corridors are found in Tables 2.6 and 2.7.

Ecological significance metrics in Tables 2.6 and 2.7, although numerical, represent the qualitative judgment of the authors for purposes of comparing alternative corridors.

Table 2.6. Metrics used to calculate ecological significance scores for hubs.

Component	Parameter	Range	Value
Vegetation naturalness	Area-weighted average naturalness	1–3.0	5
		3.0–3.5	15
		3.5–5	25
Habitat size and configuration	Size (ha)	10–35	5
		35–60	15
		> 60	25
	Area-to-perimeter ratio (roundness)	0–0.05	1
		0.05–0.1	3
		0.1–1	5
	% of interior forest (50 m from edge)	0–10%	1
		10–25%	3
		>25%	5
Habitat diversity	# of vegetation classes with naturalness ≥ 3	1	0
		2	2
		3 or more	4
	Presence of watercourses	none	0
		B or C	2
		A or A(O)	4
	Presence of wetlands	none	0
		naturalness < 3	2
		naturalness ≥ 3	4
	Watercourse density (m/ha)	0–10	0
		10–30	2
		> 30	4
Habitat integrity	% of habitat with naturalness ≤ 2	> 40%	1
		20–40%	3
		0–20%	5
	Road density (m/ha)	> 150	1
		50–150	3
		0–50	5
Biodiversity	# of biodiversity features (rare species occurrences, raptor nests, etc.)	none	0
		1	2
		2 or more	4
Total Impervious Area	% impervious cover in 100 m surrounding buffer	> 50%	0
		30–50%	2
		20–30%	4
		10–20%	6
		5–10%	8
		< 5%	10
	ECOLOGICAL SIGNIFICANCE SCORE	**14-100**	**out of 100**

Table 2.7. Metrics used to calculate ecological significance scores for corridors.

Component	Parameter	Range	Value
Vegetation naturalness	Area-weighted average naturalness	1–1.2	5
		1.2-1.6	15
		1.6-5	25
Habitat size and configuration	Corridor length (m)	> 4000	5
		1000–4000	15
		0–1000	25
	# hubs within 1 km buffer	1–3	1
		4–6	3
		7–10	5
	% of interior forest (25 m from edge)	0–10%	1
		10–25%	3
		>25%	5
Habitat diversity	# of vegetation classes with naturalness ≥ 3	0–3	0
		4–7	2
		7 or more	4
	Presence of watercourses	none	0
		B or C	2
		A or A(O)	4
	Presence of wetlands	none	0
		naturalness < 3	2
		naturalness ≥ 3	4
	Watercourse density (m/ha)	0–15	0
		15–60	2
		> 60	4
Habitat integrity	% of habitat with naturalness ≤ 2	> 40%	1
		20–40%	3
		0–20%	5
	# of road or railway crossings	> 10	1
		5–10	3
		0–4	5
Biodiversity	# of biodiversity features (rare species occurrences, raptor nests, etc.)	none	0
		1	2
		2 or more	4
Total Impervious Area	% impervious cover in 100 m surrounding buffer	> 50%	0
		30–50%	2
		20–30%	4
		10–20%	6
		5–10%	8
		< 5%	10
	ECOLOGICAL SIGNIFICANCE SCORE	**14-100**	**out of 100**

3.0 RESULTS

3.1 Vegetation Mapping

A total of 16,600 ha (52.1%) of Surrey's land area was mapped as part of the vegetation inventory. Unmapped parts of Surrey include urbanized areas where vegetation was heavily modified (e.g., backyards, road margins) or sites that were smaller than the minimum polygon size. Mapped polygons range in size from 0.001 ha to 101.3 ha with a mean polygon size of 1.722 ha. Totals and percentages of the different vegetation classes, naturalness values and unique ecological complexes are summarized below and shown in Figures 3.1 & 3.2 and Table 3.1.

Vegetation Classes

1) Forest cover: Seventeen percent (approximately 5,500 ha) of Surrey's land area is forested: 4% evergreen or coniferous forest composed of western hemlock, Douglas-fir, and other conifer trees, 8% deciduous forest composed of red alder, black cottonwood, or big-leaf maple, and 6% mixed forest which is usually red alder and big-leaf maple mixed with coniferous trees. Of these forested areas 61% is classified as mature forest (35–120 years) years old) and 39% as young forest (5–35 years old). There are no areas of old-growth forest (>120 years old) remaining in Surrey although there are some isolated older trees. Forest cover is highest in the Guildford community (27.4%) and lowest in the City Centre community (4.9%) (Table 3.1).

2) Herbaceous cover and shrub cover: Herbaceous cover is by far the most dominant vegetation cover in Surrey and covers 27.2% of the City's land area. It encompasses fields used for pasture or forage production, turfgrass parks and playing fields, sedge marshes, and old fields with grasses and sedges intermixed with shrubs and tall forbs. Shrub vegetation accounts for another 5.2%. The dominant herbaceous cover is perennial graminoid (e.g. grasses and sedges) and the dominant shrub covers are deciduous species such as hardhack, Himalayan blackberry, or planted crops. Shrub areas are a mix of natural shrub cover and agricultural crops, predominantly blueberries.

3) Sparse vegetation or unvegetated cover: Some small areas of Surrey are only sparsely or entirely unvegetated. This includes beach and mudflat areas within the City's boundary, rocky or riprap shorelines or dykes, gravel pits, recently cleared sites, and waterbodies (lakes, ponds, etc.). Together, they constitute 2.4% of Surrey's total land area.

Figure 3.1. Vegetation classes (as a percentage of land area) within the City of Surrey.

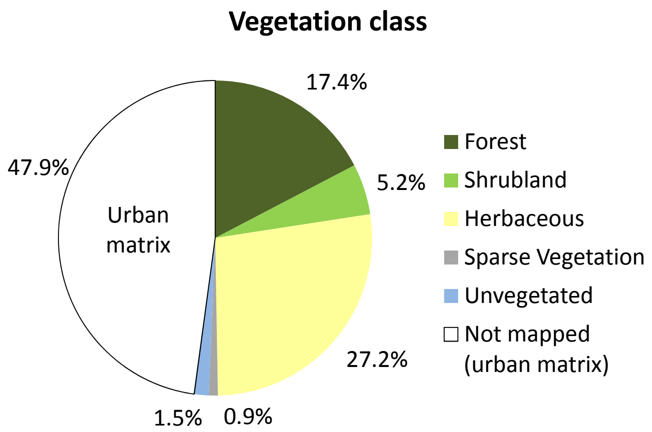
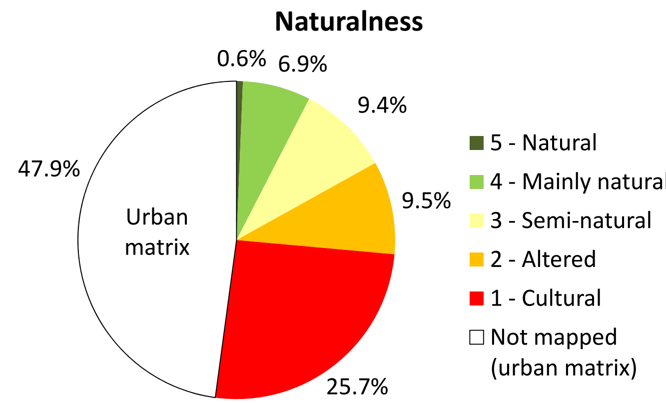


Figure 3.2. Naturalness (as a percentage of land area) within the City of Surrey.



Naturalness

Of the 16,600 ha of vegetation mapped in Surrey, over 8,190 ha or approximately 49.3% is classified as having some natural characteristics (Classes 3, 4 and 5). Approximately 2210 ha (13.3%) of vegetation is classified as mainly natural (Class 4) and 203 ha (1.2%) is classified as natural (Class 5), most of which is forest in Surrey Bend Regional Park. Figure 3.2 shows the naturalness values as a proportion of Surrey's land area (including areas not mapped).

Unique Ecological Complexes

1) <u>Interior forest</u>: The largest contiguous sites of interior forest (50 m from a forest edge) are in Surrey Bend and Tynehead regional parks, Sunnyside Acres Urban Forest, and in Colebrook Park along the escarpment. Large concentrations of interior forest are also found along Fraser Heights Bluffs, in Green Timbers Urban Forest, west of the Campbell Heights Industrial Park, and on the Semiahmoo First Nation Reserve. Interior forest constitutes 1,274 ha (4.0%) of Surrey's land area.

2) <u>Wetlands and other aquatic habitats</u>: In addition to river, estuarine, and foreshore habitats, the largest concentrations of freshwater wetlands in Surrey can be found in the Serpentine Wildlife Area, as part of the Northview Golf &

Country Club lakes and ponds, and along middle sections of the Serpentine River in the agricultural lowlands in the form of seasonally-flooded fields. It is important to note that forested swamps were not mapped during the inventory because of the difficulty interpreting their extent from orthophotos. Freshwater wetlands and other aquatic habitats (lakes, ponds, rivers), mapped during this study constitute 1,115 ha (3.5%) of Surrey's land area.

3) Old fields: The largest concentrations of old field habitat are in Colebrook Park (at the base of the escarpment), north of the Serpentine River between 152 St and 168 St, along the north side of the Nicomekl River between 148 St and 160 St, and along Colebrook Rd between 184 St and 192 St. Old fields constitute 1,638 ha (5.1%) of Surrey's land area. Almost 1,131 ha (69%) of Surrey's old field habitat is found within the Agricultural Land Reserve. Old fields are a complex vegetation community to map because they change rapidly, and vary in terms of ecological value. Some old fields support monotypic reed canary grass and have limited value to wildlife, while others are structurally diverse with shrub sites, hedgerows, and native forbs.

Table 3.1. Amount of forest cover, interior forest, freshwater wetlands, and old fields by City of Surrey community.

Community	Forest cover		Interior forest		Wetlands and other aquatic habitats		Old fields	
	Area (ha)	% of land area	Area (ha)	% of land area	Area (ha)	% of land area	Area (ha)	% of land area
City Centre	26.9	4.9%	0.0	0.0%	< 0.1	0.0%	10.4	1.9%
Whalley	485.5	15.7%	134.0	4.3%	48.6	1.6%	58.7	1.9%
Fleetwood	214.0	11.8%	39.6	2.2%	1.9	0.1%	11.5	0.6%
Guildford	1208.6	27.6%	387.1	8.8%	425.3	9.7%	123.1	2.8%
Newton	716.9	12.2%	105.0	1.8%	163.2	2.8%	369.6	6.3%
Cloverdale	450.7	9.2%	62.0	1.3%	24.8	0.5%	413.1	8.4%
South Surrey	2424.7	21.6%	543.9	4.8%	48.6	1.6%	651.5	5.8%
City of Surrey	**5527.3**	**17.4%**	**1271.6**	**4.0%**	**1115.3**	**3.5%**	**1638.0**	**5.1%**

Of note, the distribution and quantity of ecosystem vegetation types varies by neighbourhood (Table 3.1). For example, City Centre percentages are well below the City of Surrey average, whereas South Surrey percentages are above City averages except for wetlands and other aquatic habitats.

Establishment of large scale regional and city parks have had a strong influence on the relative percentage of natural areas in Surrey neighbourhoods.

Table 3.2 Vegetation inventory summary results.
Note: Summary includes all mapping completed within the City of Surrey land area boundary and does not include any regional mapping.

Class	Area (ha)	Percent
Forest (FO)	**5527.3**	**17.4%**
Evergreen Forest (FO-EV)	1243.4	3.9%
Deciduous Forest (FO-DE)	2431.9	7.6%
Mixed Evergreen-Deciduous Forest (FO-MX)	1852.0	5.8%
Shrubland (SH)	**1658.0**	**5.2%**
Evergreen Shrubland (SH-EV)	7.5	0.0%
Deciduous Shrubland (SH-DE)	1616.1	5.1%
Mixed Evergreen-Deciduous Shrubland (SH-MX)	34.3	0.1%
Herbaceous (HB)	**8644.4**	**27.2%**
Perennial Graminoid Vegetation (HB-GR)	8207.1	25.8%
Annual Graminoid or Forb Vegetation (HB-AN)	315.2	1.0%
Hydromorphic Rooted Vegetation (HB-HY)	122.1	0.4%
Sparse Vegetation (SV)	**472.6**	**0.9%**
Boulder or Cobble Sparse Vegetation (SV-BO)	0.4	0.0%
Unconsolidated Material Sparse Vegetation (SV-UC)	297.6	0.9%
Unvegetated (UV)	**472.6**	**1.5%**
Unvegetated Unconsolidated Material (UV-UC)	275.3	0.9%
Unvegetated Water (UV-WA)	197.2	0.6%
Total	16000.2	52.1%

Naturalness Value	Area (ha)	Percent
1 (Cultural)	8190.3	26.2%
2 (Altered)	3015.2	9.5%
3 (Semi-natural)	2982.1	9.4%
4 (Mainly natural)	2209.6	6.9%
5 (Natural)	203.1	0.6%
Not classified	15235.7	47.9%

Forest Age	Area (ha)	Percent
Old Forest (O)	0.0	0.0%
Mature Forest (M)	3366.9	10.6%
Young Forest (Y)	2160.4	6.8%

Summary Data	
Total Area of City of Surrey	31836.0 ha
Number of Mapped Polygons	9639
Total Area Mapped (ha)	16600.2 ha
Total Area Mapped (%)	52.1%
Polygon Area Range	0.001 - 101.3 ha
Mean Polygon Area	1.722 ha

3.2 Green Infrastructure Network

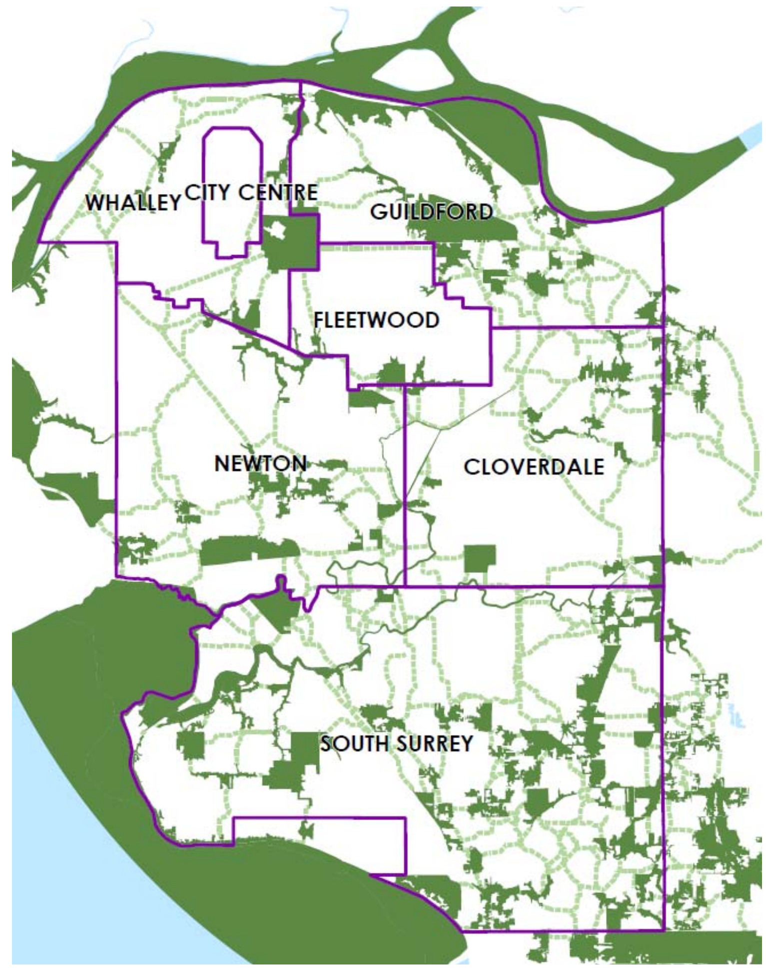
Surrey's Green Infrastructure Network is composed of hubs, sites, potential corridors, and the surrounding matrix of urban and agricultural lands. All are important for sustaining ecological functions and values in the City. Hubs as larger areas (>10ha) of contiguous natural landscape (semi-natural and better) that support ecological processes. Sites represent other natural areas between 0.25–10 hectares and are included as important stepping stones and neighbourhood-scale ecological pockets. Potential corridors delineate connections between hubs that are critical to the long-term function of the overall network. Corridors often incorporate sites and these inter-connections further complements network success. This section describes the important characteristics and patterns of the hubs, sites, and corridors that were identified in this study.

Table 3.3. Green Infrastructure Network components.

	Hubs	Sites	Potential Corridors	Matrix
Definition	Large areas of natural and semi-natural vegetation	Small areas of natural, semi-natural, and semi-modified vegetation	Linear connections between hubs, variable width when finally established	Urban and other modified areas surrounding hubs, sites, and corridors
Size	>10 ha	0.25–10 ha	100 m wide study area	n/a
Total Area	4543.6 ha	1245.4 ha	2265.9 ha	23781.1 ha
Percentage	14.3%	3.9%	7.1%	74.4%
Number	88 hubs	803 sites	396 corridors segments	

See Map 6. Green Infrastructure Opportunities in Appendix D - Map Catalogue for a view of ecological network opportunities within Surrey.

In the following pages components of the Network are summarized based on Surrey Communities. Please refer the map below for geographic orientation.



3.3 Hubs

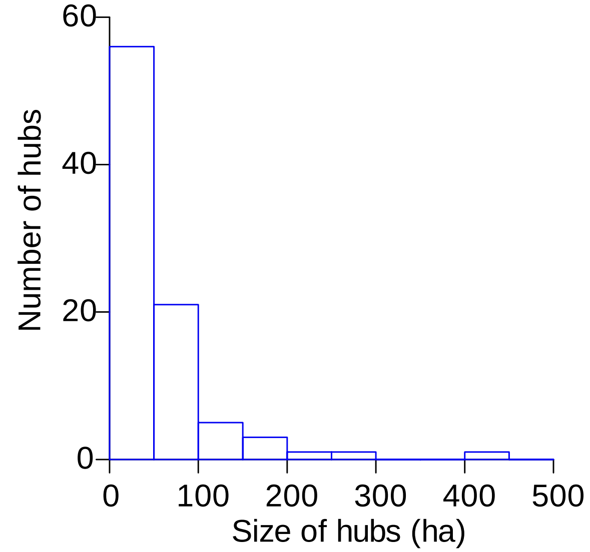
A total of 88 terrestrial hubs falling either fully or partially within Surrey's municipal boundary were identified using the analysis. In addition, six large aquatic hubs were identified either within or immediately adjacent to Surrey. Using the regional vegetation mapping, an additional 26 regional hubs (24 terrestrial, 2 aquatic) were also delineated outside of Surrey in neighbouring jurisdictions. Though not part of summary statistics presented here, they were delineated as a means of assessing regional connectivity (see Corridors section). Some of the important details and summary statistics of the hubs identified in Surrey are:

- Hubs range in size from 11.0 ha (forest patch on east side of Serpentine River west of Cloverdale) to over 428 ha (Surrey Bend). See Figure 3.3 for a size distribution of hubs. Only three hubs are greater than 200 ha in size. The lower boundary is determined by a 10 ha threshold for hubs.

- The five largest hubs within the City of Surrey are: Surrey Bend (428 ha), Tynehead (294 ha), Green Timbers (239 ha), Fraser Heights Bluffs (198 ha), and the Colebrook Escarpment (169 ha).

- A total of 4,544 ha (14.3%) of Surrey's land area is located within hubs.

Figure 3.3. Histogram showing distribution of hub sizes wholly or partially within the City of Surrey.



- The mean hub size is 54.5 ha. This is slightly smaller than the size of Bear Creek Park in Whalley (62 ha) and slightly larger than Crescent Park in South Surrey (52 ha).

- Of the seven communities that make up Surrey, South Surrey has the largest number of hubs with 42 wholly or partially within the community (Table 3.2). This is almost 50% of the hubs found in Surrey. On a per area basis, South Surrey and Guildford have the largest number of hubs at 0.37 hubs per sq. km. Guildford has the largest mean hub size (98.3 ha) and contains the greatest land area falling within hubs relative to its size (27.8%). The City Centre does not contain any hubs. Fleetwood contains the next least number of hubs with five (5.7% of land area).

- Many of the large hubs are contained in City Parks. A good portion of mid-size hubs are owned by the City of Surrey or other government agencies. Most of the smaller hubs are located in areas of private ownership.

- The majority of hubs (approximately 60%) are on private land. Of the remaining hubs, most are located across ownership designations with some private, some government and some utility owned.

- Of the six large aquatic hubs identified within or bordering Surrey's land area, two fall predominantly under Surrey's jurisdiction: the lower Serpentine River and the lower Nicomekl River. Four other important regional aquatic hubs exist on Surrey's perimeter: the Fraser River foreshore, Parson's Channel foreshore (Fraser River channel near Barnston Island), Mud Bay foreshore, and the Ocean Park/Semiahmoo Bay foreshore. These hubs have both regional and global significance as habitat for migratory birds, fish, and other species.

- Ecological significance for the 88 terrestrial hubs ranged from 90 (Surrey Bend) to 32 (Whalley West, Ocean Estates) (Figure 3.4). The mean ecological significance score was 57.9. The ecological significance score is a measure of the relative importance of the hub within the GIN based on its area, shape, overall average naturalness, presence and amount of high quality habitats (such as interior forest and wetlands), presence of species at risk , raptor nest sites, and streams, road density, surrounding land uses, and other factors.

Table 3.4. Hub statistics by Surrey community.

Community	Number of hubs[1]	Total hub area[2] (ha)	% of land area	Mean hub size[3] (ha)	Hubs per community area (hubs/km²)
City Centre	0	0	0.0%	-	-
Whalley	8	392.6	12.7%	73.6	0.26
Fleetwood	5	104.0	5.7%	59.7	0.28
Guildford	16	1217.6	27.8%	98.3	0.37
Newton	16	561.1	9.5%	44.4	0.27
Cloverdale	13	359.7	7.3%	42.7	0.26
South Surrey	42	1908.6	17.0%	49.0	0.37
City of Surrey	**88**	**4854.3**	**14.3%**	**57.9**	**0.28**

[1]*Hubs lying across community boundaries were included in the total number of hubs for each community they were a part of.*

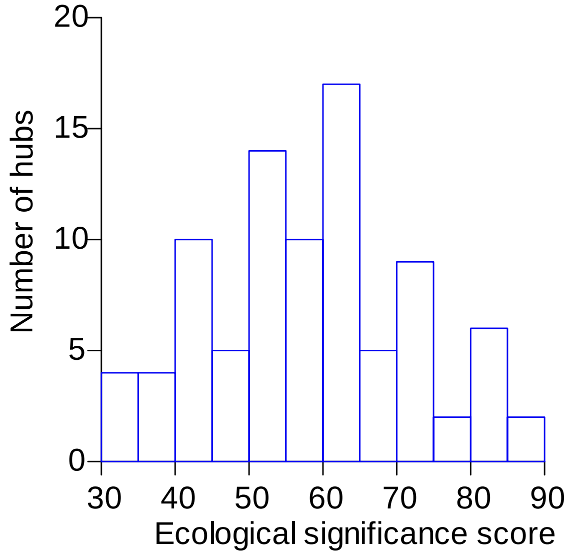
[2]*For hubs that lie across community boundaries, only the area of the hub within that Surrey Community was included in the total hub area calculation.*

[3]*Mean hub size was calculated based on full hub areas, regardless of whether the hubs were wholly or partially within that Surrey Community.*

- The five hubs with the highest ecological significance are: Surrey Bend (90), Campbell Heights West (86; northwest of the Campbell Heights Industrial Park), Green Timbers (84), Campbell Heights Northeast (84), and Sunnyside Acres (82).

See Map 7. Ecological Significance of Hubs in Appendix D - Map Catalogue for a view of the range of ecological vitality found in Surrey's hubs.

Figure 3.4. Histogram showing distribution of the ecological significance scores for hubs.



3.4 Sites

A total of 803 terrestrial sites exist within Surrey's municipal boundary. These sites are any contiguous vegetative polygon that has a naturalness value of 3 or greater (semi-natural, mainly natural, and natural). Some of the important details and summary statistics of the sites identified in Surrey are:

- Sites can range in size from 0.25 ha (small pieces of vegetation along a roadside) to around 10 ha (forest stands in a neighbourhood park). See Figure 3.5 for a size distribution of sites. The majority of sites are less than a hectare and number of sites decreases as the sites area increases.
- Twenty-two percent of the sites are owned and managed by the City of Surrey and 18% of these exist in dedicated parks.
- Twenty-seven percent of all sites are found along corridors. These sites offer great opportunity as stepping stones for connectivity.

Figure 3.5. Histogram showing distribution of the size of sites.

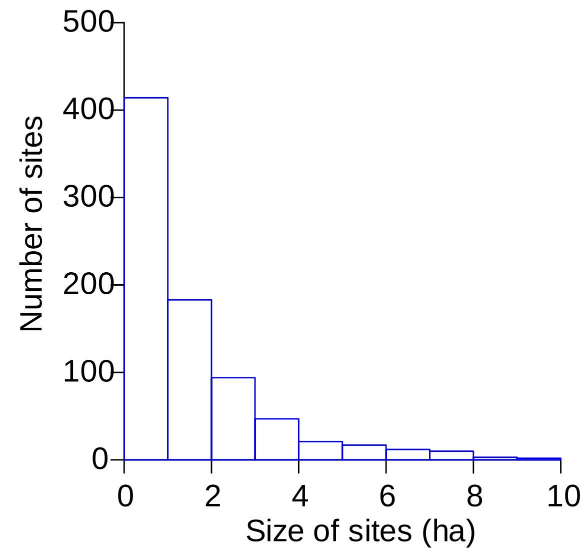


Table 3.5. Site statistics by Surrey community.

Community	Number of sites[1]	Total site area[2] (ha)	% of land area	Mean site size[3] (ha)	Sites per community area (sites/km^2)
City Centre	17	15.7	2.9%	1.1	3.1
Whalley	78	123.9	4.0%	1.6	2.5
Fleetwood	44	82.3	4.5%	1.9	2.4
Guildford	114	172.2	3.9%	1.6	2.6
Newton	220	279.5	4.8%	1.3	3.7
Cloverdale	71	118.8	2.4%	1.7	1.6
South Surrey	273	453.1	4.0%	1.7	2.4
City of Surrey	**803**	**1245.4**	**3.9%**	**1.6**	2.6

[1]*Sites that lie across communities boundaries were included in each community total.*

[2]*For sites that lie across community boundaries, the area of each separate potion of the site was included in the total site area and mean site size calculations.*

See Map 8. Sites inside and outside of Corridors in Appendix D - Map Catalogue for a view of sites that offer a stepping stone opportunity for hub connection.

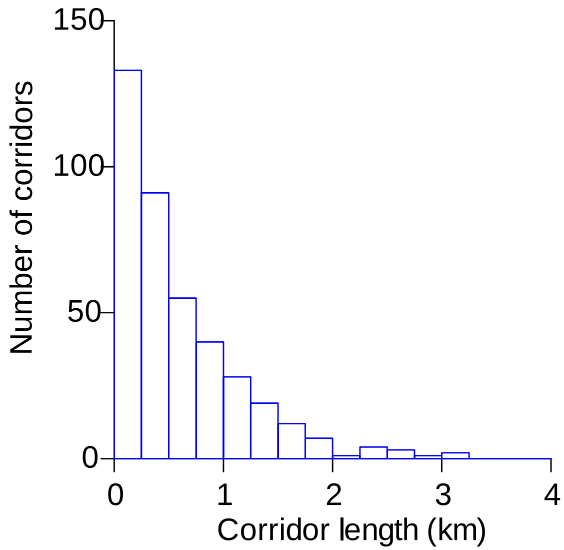
3.5 Potential Corridors

A total of 463 potential corridors (both full hub-to-hub corridors and corridor segments) connecting adjacent or near-adjacent hubs were identified. Three hundred and ninety-six of these corridors lie within Surrey's land area while the rest are with neighbouring municipalities or the US. This includes corridors connecting adjacent hubs within Surrey as well as connections to other regional hubs. The following points summarize some of the key attributes of the corridor network:

- Corridors range in length from 9.5 m (connecting the Campbell Heights Southwest hub to Campbell Heights South hub across 20 Ave, at the 188 St alignment) to 8.6 km (connecting the Robson Ravine hub to Hyland West hub via the BC Hydro railway right-of-way). Longer corridors are generally more difficult for animals and plants to move through.

- The mean corridor segment length for all identified potential corridors is 571 m. This is approximately the straight-line distance from Colebrook Park to Mud Bay Park across the Highway 99 corridor.

Figure 3.6. Histogram showing distribution of corridor lengths in the City of Surrey.



- A total of 2265.9 ha (7.1%) of Surrey's land area falls within one or more potential corridors.
- Of the seven communities that make up Surrey, Whalley has the highest density of potential corridors, both on a length per area basis and on an area basis (Table 3.3). However, corridors running through Whalley have lower mean ecological significance while corridors in South Surrey have the highest mean ecological significance.

Table 3.6. Number, length, and area of potential corridors by Surrey community.

	Number of corridors[1]	Total corridor length[2] (km)	Total corridor area[2] (ha)	% of land area	Length of corridors per unit area (m/ha)
City Centre	1	2.7	17.0	3.1%	4.9
Whalley	40	38.4	270.3	8.8%	12.5
Fleetwood	12	12.6	67.5	3.7%	7.0
Guildford	78	42.7	358.4	8.2%	9.8
Newton	77	57.1	486.6	8.3%	9.7
Cloverdale	63	41.1	361.6	7.4%	8.4
South Surrey	158	72.1	704.5	6.3%	6.4
City of Surrey	**396**	**234.2**	**2265.9**	**7.7%**	**7.4**

[1]*Corridors that lie across communities boundaries were included in each community total.*

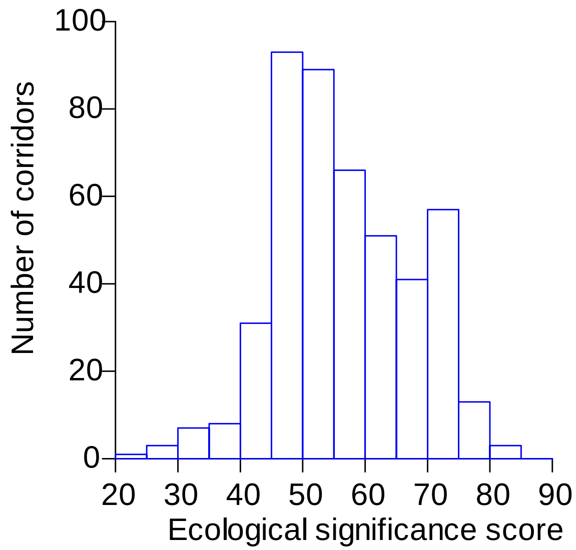
[2]*Final corridor area will be based on variable widths determined during detailed planning. For corridors that overlap, the overlapping length and area was only counted once in the total corridor length and area calculations.*

- Ecological significance for the corridors ranges from 80 to 23. The mean ecological significance score is 56.1. The ecological significance score is a measure of the relative functioning of the corridor within the green infrastructure network based on its length, overall average naturalness, habitat diversity, proximity to hubs, presence and amount of high quality habitats (such as interior forest and wetlands), presence of species at risk, raptor nest sites, and streams, number of road or railway crossings, and other factors.
- The five highest ranked hub-to-hub corridors are: (1) the corridor connecting the east and west portions of the Campbell Heights Northeast hub; (2) the corridor connecting the West Cloverdale North hub to the Serpentine River; (3) the corridor connecting the Upper Fergus and Lower Fergus hubs across 168 St; (4) the corridor connecting the Kensington North hub to the Campbell Heights Southwest hub across 24 Ave and 184 St; and (5)the corridor connecting the Rosemary Heights West hub to the Rosemary Heights East hub along the

south bank of the Nicomekl River. All five of these corridors have an ecological significance score greater than or equal to 78.

See Map 9. Ecological Significance of Corridors in Appendix D - Map Catalogue for a view of the range of ecological vitality found within Surrey's corridors.

Figure 3.7. Histogram showing distribution of the ecological significance scores for corridors in the City of Surrey



4.0 ECOSYSTEM MANAGEMENT STRATEGY

Surrey's environmental goals as identified in the Sustainability Charter and Official Community Plan demonstrate good stewardship of the land, water, air and built environment, protecting, preserving and enhancing Surrey's natural areas and ecosystems for current and future generations while making nature accessible for all to enjoy.

An Ecosystem Services approach expands the focus beyond how development affects the environment to include how development depends on ecosystems and a city wide green infrastructure network. In addition to focusing on how to protect significant ecosystems, the City can prioritize how and where to invest in managing ecosystem development and enhancement of the **Green Infrastructure Network** (GIN).

The ecological inventory in Table 3.6 reveals that high-value ecosystems are not evenly distributed across the City. They are less prevalent and less interconnected in some of the developed neighbourhoods of the City than in other more rural areas.

Planning and implementation of future development will need greater effort to integrate ecological systems into neighbourhoods, along with an assessment of conservation values and enhancement priorities in concert with land development, growth management, and infrastructure planning. This should be done in a way that is complementary to the design of leading urban communities that meet the goals in the Sustainability Charter, the Official Community Plan and other city environmental policies.

4.1 Framework for Implementing Ecosystem Management

Phase Two of the Ecosystem Management Study will develop a strategy and guidelines for ecosystem management in Surrey that adopts the premise that *all parts of the city matrix can contribute, in varying degrees, to the creation of a GIN comprised of a network of ecological hubs, sites and linking corridors.* To create a framework that will assist Surrey in achieving the GIN, draft strategies and policy topics are introduced below. The order of the policies does not infer any priority.

4.2 Proposed Ecosystem Management Strategies

1. Continue to develop programs and information to raise public and development community awareness and understanding of ecosystem planning and management.
2. When considering Neighbourhood Concept Plans and development applications, work to ensure that the core areas of key remaining large natural areas (hubs) are protected in sufficient scale to be refuges of biodiversity, while having regard to economic and social priorities.
3. Give priority to the protection and/or restoration of effective aquatic and/or wildlife corridors that link hubs and sites together, so that plant and animal species are able to disperse and intermix for genetic diversity and population security.
4. Where possible, integrate smaller natural sites and neighbourhood tree canopy and 'naturescape' practices into the general urban matrix.
5. Continue with City strategies that effectively manage stormwater, control sediment and erosion, promote tree cover and minimize harmful emissions - recognizing that

clean water and natural stream flow regimes, clean air, and mitigation of climate change are key ingredients to support a GIN.

6. Recognize that Agricultural Lands, both cultivated and fallow, make a strong contribution to biodiversity and wildlife passage in Surrey, and work co-operatively with the farm community to support this function while recognizing the key role of agricultural land in food production.
7. Provide leadership to and encourage public agencies, both City and other levels of government and utilities, to protect, enhance and restore the GIN, with priority given to establishing linkages between hubs and sites, as well as other biodiversity enhancements on their properties.
8. Incorporate protection and restoration of ecosystems and biodiversity into the planning and development processes of the City. Neighbourhood scale planning in particular should incorporate green infrastructure features as a part of any development planning or development application process.
9. Explore mechanisms to facilitate a fair and equitable distribution of costs and benefits of managing ecosystems and biodiversity in Surrey.

4.3 Policy and Guideline Topics

The above Strategies will be implemented through policies and guidelines that need to be completed for the following topics:

1. ***Public Information:*** Continue to develop programs and information to raise public and development community awareness and understanding of ecosystem planning and management and the protection, restoration and enhancement of a green infrastructure based on a network of hubs, sites and linking corridors in Surrey.
    a. Develop brochure, web and other materials to communicate the importance of and promote a green infrastructure in Surrey as the City undergoes on-going development.
    b. Target and customize communication materials to key audiences – homeowners, landowners/developers, utility and transportation corridor managers, city staff and consultants.
    c. Create a toolkit of neighbourhood plan and individual parcel solutions in support of a green infrastructure including typical solutions to typical issues such as corridor widths, corridor restoration, hub boundary determination and interface with adjacent land uses, as well as 'naturescape' and street tree canopy approaches that promote biodiversity.
    d. Promote dialogue about ecosystem management among the environmental, agriculture, infrastructure, recreation, design and development organizations active in Surrey.

2. ***GIN Hubs:*** Set as a priority, the protection of key remaining large natural areas (hubs) so that their cores are protected in sufficient scale to be refuges of biodiversity, at the same time recognizing the economic and social needs of development.
    a. Map 6 shows 8 aquatic hubs in Surrey, and these and other stream areas are under various levels of protection. Map 6 also shows 88 opportunities for terrestrial hubs within the City. These relatively large areas with high 'naturalness' are key assets for upland biodiversity. In areas where urban development is permitted adjacent to hubs, the final boundary of the urban development and the hub 'core' should be planned in tandem during the neighbourhood or development planning process.
    b. Defining the 'minimum core' of upland hubs to be retained should continue to be informed by detailed biological studies prior to development planning decisions. In general hub cores that are round and as large as practical are preferred, so that interior habitats are preserved. Streams, wetland areas, and habitats of any threatened or endangered species, and access to both refuge cover and food supply for existing or desired species are features which should be protected.
    c. Where hubs currently exist in close proximity to one another, neighbourhood planning studies informed by detailed biological assessments may determine what configuration of 'core hubs' and 'corridors' are effective at protecting biodiversity while allowing a compatible development in adjacent lands. In such considerations, priority should be given to protecting hubs of higher ecological significance as shown in Map 7.
    d. Map 6 also shows many 'sites' which are smaller areas of natural vegetation with ecosystem values. These sites may be linked or combined with 'hub' areas or corridors to accommodate both biodiversity and adjacent urban development. In other cases, green infrastructure network 'sites' may be traded off for higher density development and protection of a larger 'core' hub.
    e. Public appreciation of the natural values and biodiversity in hubs is important to successful management. Trails, utilities and other access to hubs, however, should be planned in ways that limit disturbance to the species resident in the hub. Trails may be restricted to adjacent lands or outer limits, so that the core is undisturbed.
    f. Agricultural lands -in wildlife terms - are functioning as both a hub and a large corridor – supporting wildlife populations and allowing relatively free movement - which allows wildlife to adapt to agriculture practices and co-exist with active farming. Restricted public access to private agricultural land also provides a refuge for wildlife. Co-operation with the agriculture community to respect and maintain these values is warranted.

3. ***GIN Corridors:*** Protect or restore effective aquatic and/or wildlife corridors that link hubs together, so that species are able to disperse and intermix for genetic diversity and population security.
    a. Map 6 shows opportunities for 'corridors' to connect hubs and sites. These connections are critical to allow species to disperse to new habitats, to avoid inbreeding and lack of genetic diversity, and to provide escape from predation or disease. At least one effective corridor should be provided between each hub. Provision of a second or redundant corridor connection reduces risks to biodiversity. Where choices on which corridor or priority must be made, preference should be given to protecting or restoring continuity of the corridor with higher ecological significance as shown on Map 9.
    b. Utility corridors fill an important role in the development of a network of corridors. Guidelines are required for the management of these corridors while still respecting the utility maintenance function, land ownership and neighbourhood context. In developing areas of the City and in the neighbourhood planning process, continuous corridors between hubs should be planned. While looking for a reasonably direct route between hubs, corridors will likely follow existing watercourse and riparian areas, steep slopes, floodplains and wetlands, wooded sites, and other areas that are constrained to development wherever possible.
    c. Width of corridors will vary and should be determined based on detailed biological studies of the species that are or could use the habitat provided by the linked hubs and the corridor. Wider corridors are preferable with guidelines that reflect this variable width objective but that also set minimums are needed. Corridors in the ALR show only 'conceptual wildlife routes' and are not intended to restrict agricultural practices, in the knowledge that there are a myriad of wildlife connections possible in the agricultural areas. Guidelines for co-operation with the agricultural community which respect the primary agricultural activities are needed.
    d. Barriers to species movement such as road crossings should be minimized in the wildlife corridors. Where roads or other barriers are being constructed or rebuilt, provision for ease of passage of the fish or wildlife species that the corridor serves should be provided. Guidelines for the maintenance and restoration of various corridor types should be developed.

4. ***GIN Sites and the Urban Matrix:*** Integrate smaller natural sites and neighbourhood tree canopy and 'naturescape' practices into the general urban matrix, to complement the core hubs and corridors.
    a. Surrey' green infrastructure must go beyond the hubs and corridors shown in Map 6. Many species such as songbirds, butterflies, bees and amphibians are compatible and popular in urban areas. Smaller natural sites, street trees, green roofs and walls, private tree cover in backyard habitat and naturescaping adds much to the amenity and liveability of the urban area. In keeping with the Sustainability Charter, Surrey maintains the objective of a lush tree and vegetation cover across the City, focused on the values of plantings in the urban and suburban areas.
    b. In some cases, continuous corridors will only be achieved through the development and redevelopment process, as land is dedicated or otherwise acquired for these purposes. Tree and naturescape cover can provide 'stepping stones' that facilitate some wildlife passage in the meantime.

5. ***Existing City Programs:*** Clean water and natural stream flow regimes, clean air, and mitigation of climate change are key ingredients to support biodiversity. The City should continue with strategies that manage stormwater, sediment and erosion control, tree cover and that minimize harmful emissions.
    a. Planning for hubs, corridors and urban habitat should be co-ordinated with existing and evolving City programs on stormwater management, sediment and erosion control, tree protection and replacement, and management of greenhouse gases and other pollutants, to maximize relationships and related policy or practice improvements to respect green infrastructure values.

6. ***Agricultural Lands:*** Recognize that agricultural land, both cultivated and fallow, is making a strong contribution to biodiversity and wildlife passage in Surrey, and work co-operatively with the farm community to support this function.
    a. Whereas agricultural management often is supportive of wildlife, road and utility development crossing the agricultural areas may introduce barriers to wildlife. The City should use its transportation /engineering and advocacy functions to promote wildlife passage through any necessary road / utility extensions across agriculture.
    b. The City should continue its work with the Agricultural Advisory Committee to promote agriculture success in Surrey, and co-operatively resolve conflicts.

7. ***Public and Utility Lands:*** Provide leadership to public agencies, other levels of government and utilities, to protect and restore the identified green infrastructure network and other enhancements on their properties.
    a. Map 10 illustrates the general pattern of land ownership under the Green Infrastructure Network opportunities. Many of the hubs, sites and corridors are Parkland under City, Regional or Provincial jurisdiction. Others belong to the City or institutions for other uses, such as education, health or civic facilities. The City should use both its own land management processes as well as its land use/design influence to build biodiversity into development and management actions for these locations.
    b. As a priority, the City should lead by example in incorporating green infrastructure and ecosystem management measures into its own properties.
8. ***Land Use Planning and Development:*** Incorporate protection and restoration of the GIN into the planning and development processes of the City. Neighbourhood scale planning in particular should incorporate biodiversity features.
    a. Surrey is a rapidly growing community, and if it is to be a model of ecosystem management, it must provide for urban growth in ways that do not reduce the City's environmental sustainability. This must be done on private land that is being developed as well as on public lands. The communication products listed under Strategy 1 will be important to inform about the possibilities.
    b. Map 10 shows private lands that have opportunities for the Green Infrastructure Network. The majority of these private lands are in relatively undeveloped areas of the City. Most will be subject to Neighbourhood Concept Plan or similar plan processes that define the pattern of land use, transportation, parks, greenways and other linkages. It is at this neighbourhood planning scale that the boundaries of hubs, sites and corridors are defined.
    c. The city should continue to require detailed biological studies at the time of neighbourhood planning to determine what species and ecosystem values exist in the study area, how they are distributed, and the key ecological functions that need to be protected. Defining the

boundaries of hubs and corridors should be done simultaneously with planning for land use, densities, transportation, utility and trail alignments. etc. The objective is to find the optimum arrangement of places for all the elements that make up a complete community, included places for nature and biodiversity both within protected hubs and corridors, and where appropriate throughout the neighbourhood.

d. Map 10 shows corridors that are impaired, and are targets for habitat restoration efforts. In some cases it may be defensible to provide some 'site' or 'hub' extremity for development in exchange for intensive restoration efforts on an impaired corridor if that would create a net gain in habitat value overall.
e. A standardization of biological data collection and reporting is advisable to provide a growing information base for ecological management in Surrey. The City should develop Guidelines for data collection and reporting standards.
f. Monitoring of key biological indicators is also required, both for conserved natural areas and for restoration areas, to provide reporting on successes, failures, and related adjustments to the planning and implementation of future projects.

9. ***Equitability:*** Explore mechanism to facilitate a fair and equitable distribution of costs and benefits of managing ecosystems and biodiversity in Surrey.
    a. The city should maximize Green Infrastructure opportunities through the planning and development review process in order to find the balance that would allow development while maintaining ecological function.
    b. In many cases, private lands that are core to the Green Infrastructure Opportunities (Map 6 and 10) will be candidates for dedication as park or greenway at the time of development. In these cases the 'normal' development approval process would apply, with the addition of detailed biological assessments at the time of land use and subdivision planning.
    c. The City should continue to consider the values of a green infrastructure network when making decisions on park acquisition and distribution.
    d. Mechanisms such as density bonus or the transfer or clustering of density, zoning amenity contributions, restrictive covenants, statutory rights-of-way and other tools should be researched and utilized to achieve the integration of green infrastructure values into the planning and development of the City.
    e. Monitor regional, provincial, and federal government and NGOs for grants or programs that would provide support for the Surrey Ecosystem Management effort.

4.4 Opportunities for GIN Protection and Restoration

Continued ecological functioning of the existing Green Infrastructure Network (GIN) depends not only on the long-term protection of key elements from loss or degradation, but also restoration and enhancement to improve the functioning of the GIN. To maximize the effectiveness of protection and restoration efforts, it is recommended that City efforts focus on two general priority areas:

1. growth of the GIN (adding protected areas).
2. restoration and enhancement of GIN elements.

4.4.1 Priorities for Growth of the Green Infrastructure Network

High priority hubs: Map 7 (see Book 2) identifies the relative ecological significance of hubs in the proposed GIN. Ecological significance is an indicator of the importance of the hub as a refuge for biodiversity and habitat, and for sustaining the GIN's ecological function.

It is recommended that hubs with less than 50% protection be considered as high priorities for future acquisition or some other form of protection such as a development permit area designation, a conservation easement agreement, or private land stewardship.

High priority corridors: Map 9 (see Book 2) identifies the relative ecological significance of corridors in the proposed GIN. Ecological significance is an indicator of the importance of the corridor for sustaining the GIN's ecological function.

It is recommended that corridors with less than 50% protection be considered as high priorities for future acquisition or some other form of protection such as a development permit area designation, a conservation easement agreement, or private land stewardship.

4.4.2 Priorities for Restoration and Enhancement

There may be hubs and corridors that are well protected but in which restoration and enhancement activities would improve their ecological functioning as part of the GIN. It is recommended that priorities for restoration and enhancement be placed on hubs and corridors that are already under some form of protection but which are not functioning to their full potential due to low naturalness, fragmentation, degraded imperviousness, significant barriers or other factors. Opportunities for restoration or enhancement within Surrey's GIN can be considered to fall into six general categories:

a) Riparian habitat enhancement: Riparian areas serve highly important ecological functions, ranging from water purification and erosion protection to habitat for fish and wildlife. Riparian corridors represent good candidate areas for restoration. Some riparian areas remain degraded from past land clearing activities.

b) Urban parkland reforestation: Many municipal parks contain areas that could be reforested to enhance ecological value, as well as store carbon and contribute to rainwater management. Developed parks within or adjacent to high priority hubs and corridors could be replanted with native trees and managed to improve structural diversity and species diversity.

c) Road crossing improvements: Road crossings and associated infrastructure, such as sidewalks, ditches, concrete barriers, and fencing, can act as major barriers to wildlife movement. Both small (e.g., fencing improvements, narrowed roadways, vegetated road medians) and large improvements such as underpasses or replacing culverts with bridges can improve passage of wildlife.

d) Foreshore and wetland function restoration: Surrey's foreshore areas and floodplains are significant interfaces between the terrestrial and aquatic environments. In many areas, dykes have altered hydrologic functioning critical to maintaining rare and important habitats, such as salt marsh along foreshore areas and freshwater wetlands (marshes and swamps) in river floodplain areas. Land development has occurred up to the back of the dyke, leaving little adjacent transition habitats. Even within small areas, dykes can be altered and vegetation can be improved to restore natural hydrologic function while not compromising flood protection.

e) Revegetating utility-rights-of-way: In urban areas, options for establishing corridors are generally limited. Utility corridors offer important linear connections between hubs and sites in these areas. Surrey has many large utility rights-of-way. Although often used as trail corridors for recreational use, these rights-of-way can also be enhanced for wildlife and other ecological values. However, enhancements must be suited to existing uses. For example, corridors with overhead powerlines are ideal locations to manage for old field habitat, rather than reestablishing tree cover.

f) Enhancing urban backyard habitats: Some urban areas of Surrey have limited opportunities for establishing dedicated corridors for wildlife movement. However, in key areas, it may be possible to work with private landowners to encourage the creation of backyard wildlife habitat to act as stepping stone for the movement of some components of wildlife (e.g., songbirds, butterflies).

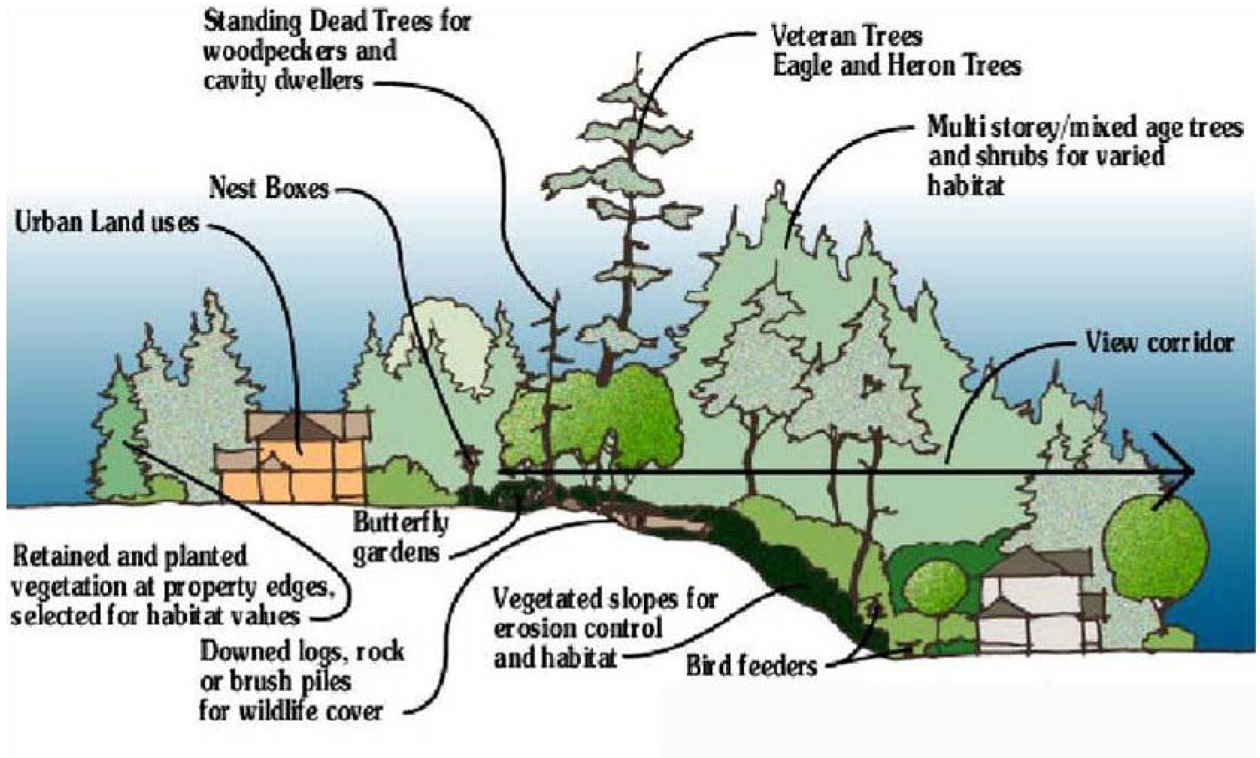
4.5 Examples of Ecosystem Management Approaches

Shown in the next pages are examples of ecosystem management approaches on the ground, both in suburban residential areas and in more urban contexts..

Corridor Connection Example:

Upland Corridor Connectivity:

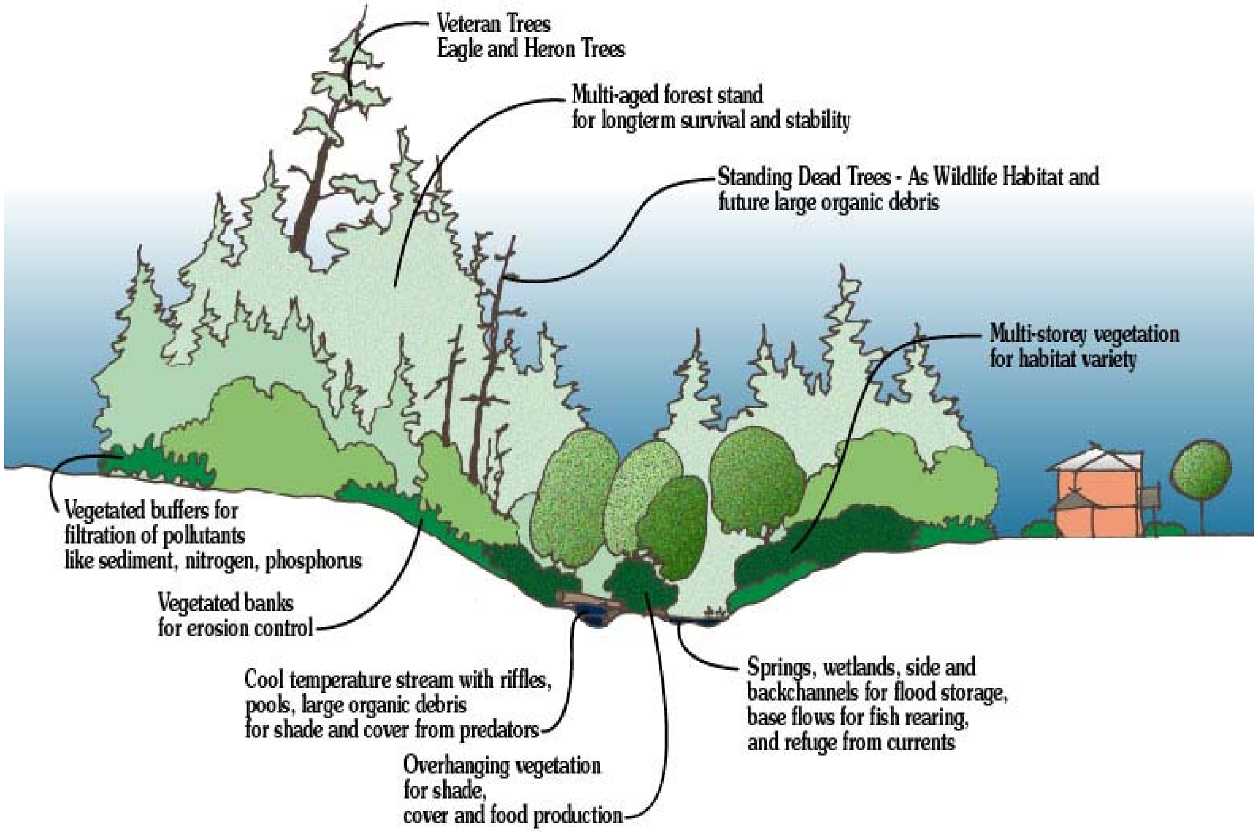
The protection of steep sloped areas offers a wide range of vegetative structure and habitat niches as well as view possibilities that offer complex visuals and wildlife sightings.



Corridor Connection Example:

Stream Corridor Connectivity:

The protection of riparian vegetation corridors offers a wide range of vegetative structure and habitat possibilities.



Portland Green Streets Project

Street side rain gardens:

These landscape planters in the sidewalk filter street runoff, provide habitat, slowly release storm flows and recharge the groundwater. Located on SE Division Street in front of New Seasons Market.

Portland Green Streets Project

Pervious road cover:

These Ecolock pavers in parking strips filter street runoff, slowly release storm flows and recharge the groundwater.


Ecolock Pavers for parking


Ecolock Pavers curb-to-curb


Porous Pavement


Porous Asphalt

Stormwater Parks

Silver Ridge in Maple Ridge:

This stormwater park integrates a vegetation corridor with the maintenance of natural water flows.

Multifamily Developments in Natural Setting

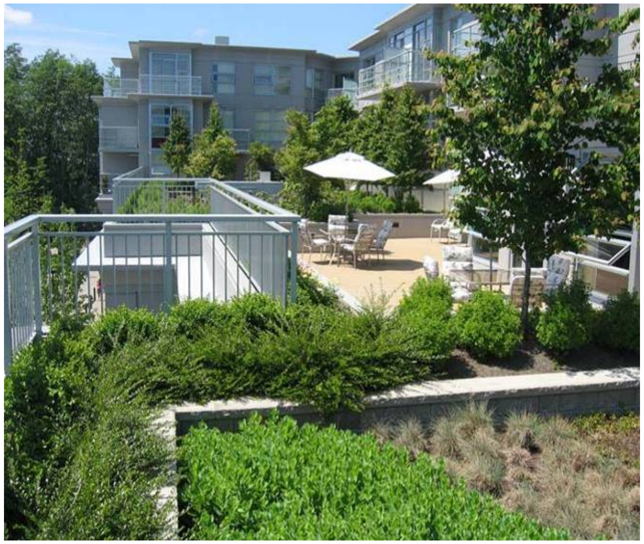
Univercity at SFU:

Stormwater surface ponds (before and after) to accommodate the Univercity development provide habitat for a chorus of birds, frogs and other species.

Multifamily Developments in Natural Setting

Univercity at SFU:

This development achieves high density of residences and natural features.



Landscaping the Single Family Home with Nature in Mind

Naturescape BC:

A Naturescape kit includes:

Stage 1

- provincial guide on how to design wildlife habitat for a particular site
- a native plant and animal book that lists indigenous plants and animals by provincial region
- a regional resource book with publications, organizations, gardening clubs and centres and wildlife rehabilitation centres
- a membership card that affords discounts at participating retailers

Stage 2

- a questionnaire to describe the participants outdoor space and rearrangements in support of wildlife
- once this is returned, the participant will receive a Naturescape Participant sign and a regular newsletter

Engaging the Broader Community

City of Edmonton Master Naturalist Program:

This program offers 35 hours of training and field trips in return for 35 hours of volunteer time. The volunteer time can be covered by time spent at any of the following five levels of commitment:

- Steward which involves taking care of an area through ongoing activities
- Volunteer which involves helping City staff and community groups
- Educator which involves providing information at fairs and conferences as well as to students and new volunteers
- Monitor which involves inventory of plants and animals, water quality or wildlife census

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City of Surrey Ecosystem Management Study

HB LANARC

Raincoast

Book 2. Appendices

April 2011

Appendix A

VEGETATION CLASSES FOR SURREY ESA (from USNVC)

FOREST: Trees with their crowns overlapping (generally forming 60-100% cover).

WOODLAND: Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarfshrub, herb, and nonvascular cover, respectively.

SHRUBLAND: Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class.

DWARF-SHRUBLAND: Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover). Dwarfshrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively

HERBACEOUS: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.

NONVASCULAR: Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover, respectively.

SPARSE VEGETATION: Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).

Appendix B

INVENTORY COMPONENTS

The inventory is divided into three groups of features: (1) biological features; (2) physical features; and (3) cultural features. Each is described below with a discussion of existing and new information sources that will be incorporated. It is important to note that there are a variety of limitations posed by the use of existing spatial data. In many cases, information from consultants' reports is difficult to incorporate because it focuses on a single site in a single point in time using undefined methods. Datasets from consistently applied methods that can be used across the entire municipality are much more useful. However, we will be attempting to obtain as much anecdotal or unpublished data from our review of the City's report collection.

Biological Features

1) Vegetation / Habitat

Existing information sources: There is no consistent spatial data on vegetation for the City of Surrey. Consultants' reports and previous park studies contain some information.

New information sources: Mapping natural and cultural vegetation using standard classification and mapping method (USNVC) based on interpretation of existing vegetation in recent (2007) orthophotos. Vegetation within highly developed areas, such as gardens and lawns, will not be mapped. Degree of naturalness will be estimated. Fieldwork will review representative sites and boundaries.

2) Watercourses, Wetlands, and Riparian Areas

Existing information sources: CWS and TRIM existing spatial data for wetlands; City of Surrey / MOE floodplain mapping (200-yr); MOE Little Campbell wetland mapping; City of Surrey drainage features (i.e., detention ponds, etc.); City of Surrey watercourse classification [includes ditches]; City of Surrey riparian policy; *SHIM mapping.*

New information sources: No new mapping of watercourses; mapping and verification of wetlands from orthophotos concurrent with vegetation mapping; mapping of riparian areas based on zonal approach (e.g., 30 m from watercourse with widening in obvious ravine sites); some field review of representative sites.

3) Shorelines and Coastal Habitats

Existing information sources: FREMP habitat mapping; FREMP habitat coding; CSIM mapping?

New information sources: Mapping and verification of intertidal wetlands and other coastal habitats from orthophotos concurrent with vegetation mapping.

4) Species at Risk Occurrences:

Existing information sources: BC Conservation Data Centre occurrence records; consultants' reports; MOTH (Gateway) reports for north Surrey; MOE / South Coast Conservation Program data; CWS data?; anecdotal information?

New information sources: No new information on wildlife habitats or occurrences will be collected using fieldwork.

5) Significant Wildlife Habitats or Occurrences:

Existing information sources: City of Surrey / MOE wildlife tree mapping; CWS or MOE mapping of wildlife habitats; other sources such as amphibian (wetland) habitats; interpretation of some information from consultants' reports (note, we will not be going through consultant reports and transferring all wildlife occurrences; the data is considered too inconsistent or dated to be useful in many cases).

New information sources: No new information on wildlife habitats or occurrences will be collected using fieldwork.

Physical Features

6) Watersheds and Aquifers

Existing information sources: Metro Vancouver or City of Surrey watershed boundaries; MOE developed groundwater aquifer boundaries.

New information sources: No new information on watersheds or aquifer boundaries will be collected.

7) Steep Slopes

Existing information sources: City of Surrey 1 m contour information; TRIM layers, 1997 ESA mapping of steep slopes; regional-scale DEM models.

Appendices

New information sources: No new contour or slope mapping will be undertaken, however, existing data may be re-interpreted or mapped.

8) Landscape Units

Existing information sources: No existing information available.

New information sources: Mapping of large landscape units (e.g., Serpentine-Nicomekl Lowlands; White Rock / Ocean Park Uplands) based on topography, land use, or ecological units.

Cultural Features

1) Administrative Units (OCP zoning, NCPs)

Existing information sources: City of Surrey mapping layers.
New information sources: No new sources will be developed.

2) Public and Private Lands

Existing information sources: City of Surrey cadastral lot layer.
New information sources: No new sources will be developed.

3) Parks and Protected Areas

Existing information sources: City of Surrey mapping layers; Metro Vancouver or provincial datasets from regional and provincial parks, Wildlife Management Areas (etc.).
New information sources: No new sources will be developed.

4) Agricultural Lands

Existing information sources: City of Surrey or provincial mapping layers.
New information sources: No new sources will be developed.

Appendices

5) Land Use/Land Cover

Existing information sources: GVRD land use layer using provincial standards (i.e., CLUCS codes; created from 1995 orthophotos, updated in 2001).
New information sources: No new land use differentiation will be undertaken for urban areas although vegetation mapping will capture land cover in agricultural and natural areas.

6) Roads

Existing information sources: City of Surrey centerline road network.
New information sources: No new sources will be developed.

Appendix C – REPRESENTATIVE VEGETATION PHOTOS

Mature Evergreen Forest (MEF-1)

Class/Subclass: FO-EV
Modifier/submodifer: none
Age: M
Naturalness: 4

Waypoint: N5447532, E513283
Green Timbers Urban Forest

Mature Evergreen Forest (MEF-2)

Class/Subclass: FO-EV
Modifier/submodifer: none
Age: M
Naturalness: 4

Waypoint: N5428862, E519739
Along Little Campbell River in South Surrey

Mature Deciduous Forest (MDF-1)

Class/Subclass: FO-DE
Modifier/submodifer: none
Age: M
Naturalness: 4

Waypoint: N5438605, E509051
Joe Brown Park in South Newton

Mature Deciduous Forest (MDF-2)

Class/Subclass: FO-DE
Modifier/submodifer: none
Age: M
Naturalness: 4

Waypoint: N5450529, E513212
Invergarry Park

Mature Mixed Forest (MMF-1)

Class/Subclass: FO-DE
Modifier/submodifer: none
Age: M
Naturalness: 4

Waypoint: N5433053, E510115
Crescent Park in South Surrey

Mature Mixed Forest (MMF-2)

Class/Subclass: FO-DE
Modifier/submodifer: none
Age: M
Naturalness: 4

Waypoint: N5446443, E513187
Green Timbers Urban Forest

Young Deciduous Forest (YDF-1)

Class/Subclass: FO-DE
Modifier/submodifer: none
Age: Y
Naturalness: 2

Waypoint: N5433053, E510115
Elgin Heritage Park in South Surrey

Young Deciduous Forest (YDF-2)

Class/Subclass: FO-DE
Modifier/submodifer: none
Age: Y
Naturalness: 2

Waypoint: N5451096, E513626
Southwest corner of 115A St and Roxburgh Rd
(near Port Mann Bridge)

Natural Shrubland (SH-1)

Class/Subclass: SH-DE
Modifier/submodifer: none
Age: n/a
Naturalness: 2

Waypoint: N5438543, E514567
Abandoned field on northeast corner of Colebrook Rd and 152nd St

Shrub Hedgerow (SH-2)

Class/Subclass: SH-DE
Modifier/submodifer: AG
Age: n/a
Naturalness: 2

Waypoint: N5437030, E512112
Serpentine Wildlife Area

Natural Wet Shrub Swamp (SH-3)

Class/Subclass: SH-DE
Modifier/submodifer: AQ-WN
Age: n/a
Naturalness: 5

Waypoint: N5448957, E519361
Surrey Bend Regional Park

Old Field (OF-1)

Class/Subclass: HB-GR
Modifier/submodifer: AG-OF
Age: n/a
Naturalness: 3

Waypoint: N5437168, E510237
Mud Bay Park

Old Field (OF-2)

Class/Subclass: HB-GR
Modifier/submodifer: AG-OF
Age: n/a
Naturalness: 3

Waypoint: N5447654, E513115
Field area north of lake at Green Timbers Urban Forest

Corn Field (AG-1)

Class/Subclass: HB-AN
Modifier/submodifer: AG-RC
Age: n/a
Naturalness: 1

Waypoint: N5438018, E510713
Corn field along Colebrook Rd, west of King George Hwy

Grapes/Vineyard (AG-2)

Class/Subclass: SH-DE
Modifier/submodifer: AG-RC
Age: n/a
Naturalness: 1

Waypoint: N5438483, E515400
Vineyard along Colebrook Rd, east of 152nd St

Blueberry Field (AG-3)

Class/Subclass: SH-DE
Modifier/submodifer: AG-RC
Age: n/a
Naturalness: 1

Waypoint: N5435775, E513937
Blueberry field along 40th Ave, east of 156th St

Pasture/Hay Field (AG-4)

Class/Subclass: HB-GR
Modifier/submodifer: AG-PA
Age: n/a
Naturalness: 1

Waypoint: N5436622, E512595
Hay field adjacent to Serpentine Wildlife Area

Playing Field and Park (DV-1)

Class/Subclass: HB-GR
Modifier/submodifer: DV-LA
Age: n/a
Naturalness: 1

Waypoint: N5449346, E513720
Holly Park in West Guildford

Utility Right-of Way (DV-2)

Class/Subclass: HB-GR
Modifier/submodifer: DV-PL
Age: n/a
Naturalness: 1

Waypoint: N5446984, E513660
BC Hydro/Terasen Gas Right-of-Way crossing 148th St, south of 96th Ave

Golf Course (DV-3)

Class/Subclass: HB-GR
Modifier/submodifer: DV-GC
Age: n/a
Naturalness: 1

Waypoint: N5441180, E517010
Northview Golf Course

Sparsely Vegetated Shoreline (SV-1)

Class/Subclass: SV-UC
Modifier/submodifer: AQ-HY
Age: n/a
Naturalness: 3

Waypoint: N5433213, E508387
Shoreline at Crescent Beach

Unvegetated Mudflat (UV-1)

Class/Subclass: UV-UC
Modifier/submodifer: AQ-MI
Age: n/a
Naturalness: 4

Waypoint: N5437104, E510062
Mudflats in Mud Bay

River Channel (UV-2)

Class/Subclass: UV-UC
Modifier/submodifer: AQ-RF
Age: n/a
Naturalness: 3

Waypoint: N5435170, E512836
Nicomekl River west of Highway 99

Lake (UV-3)

Class/Subclass: UV-UC
Modifier/submodifer: AQ-WN
Age: n/a
Naturalness: 3

Waypoint: N5442843, E514769
Surrey Lake

Coastal Saltmarsh (WET-1)

Class/Subclass: HB-HY
Modifier/submodifer: AQ-WN
Age: n/a
Naturalness: 4

Waypoint: N5434049, E508976
Coastal saltmarsh at Blackie Spit

Freshwater Wetland (WET-2)

Class/Subclass: HB-HY
Modifier/submodifer: AQ-WN
Age: n/a
Naturalness: 3

Waypoint: N5437011, E512056
Freshwater wetland at Serpentine Wildlife Area

Agricultural Ditch (WET-3)

Class/Subclass: HB-GR
Modifier/submodifer: AQ-DI
Age: n/a
Naturalness: 2

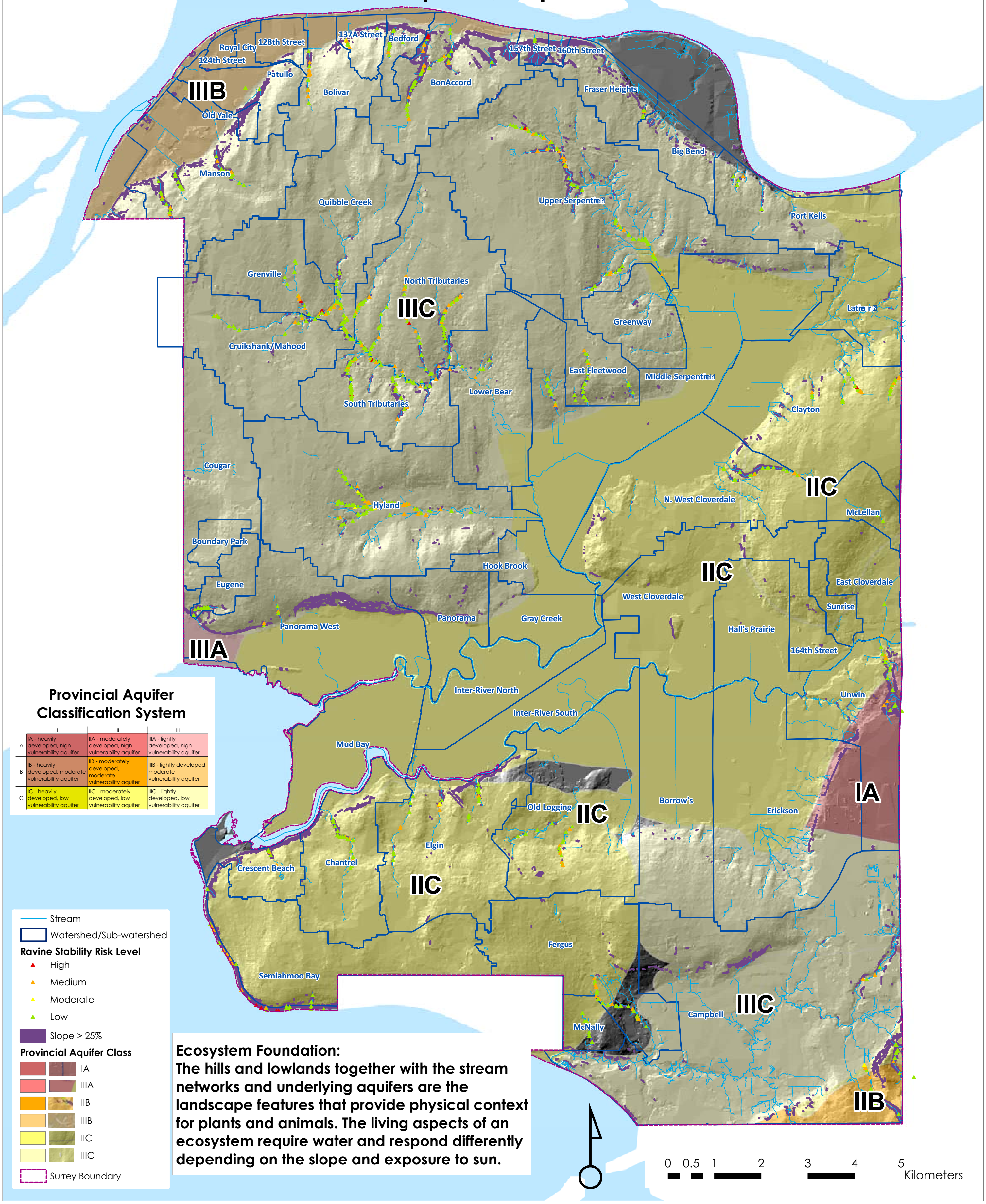
Waypoint: N5438029, E510932
Roadside ditch along south side of Colebrook Rd

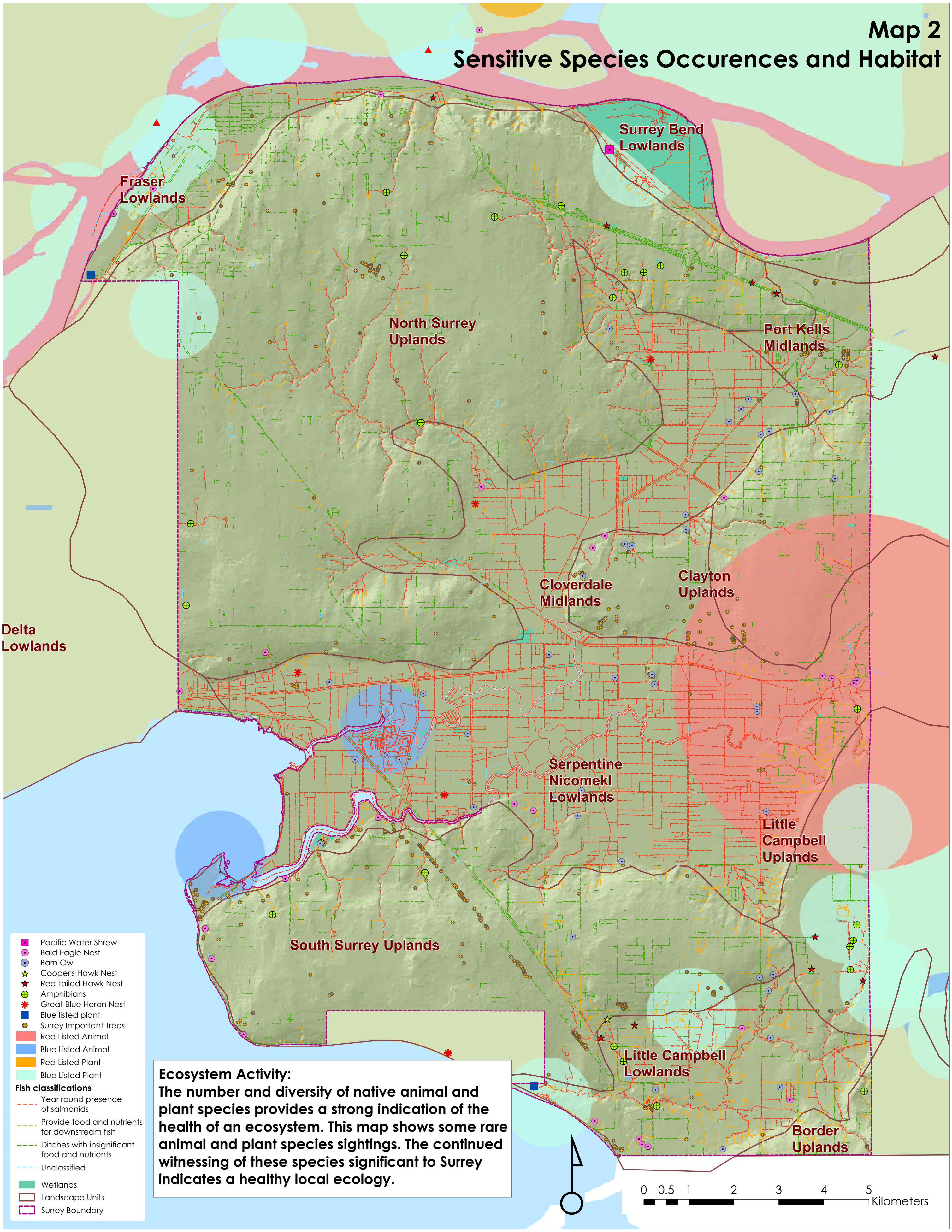
Natural Riparian Forest (RIP-1)

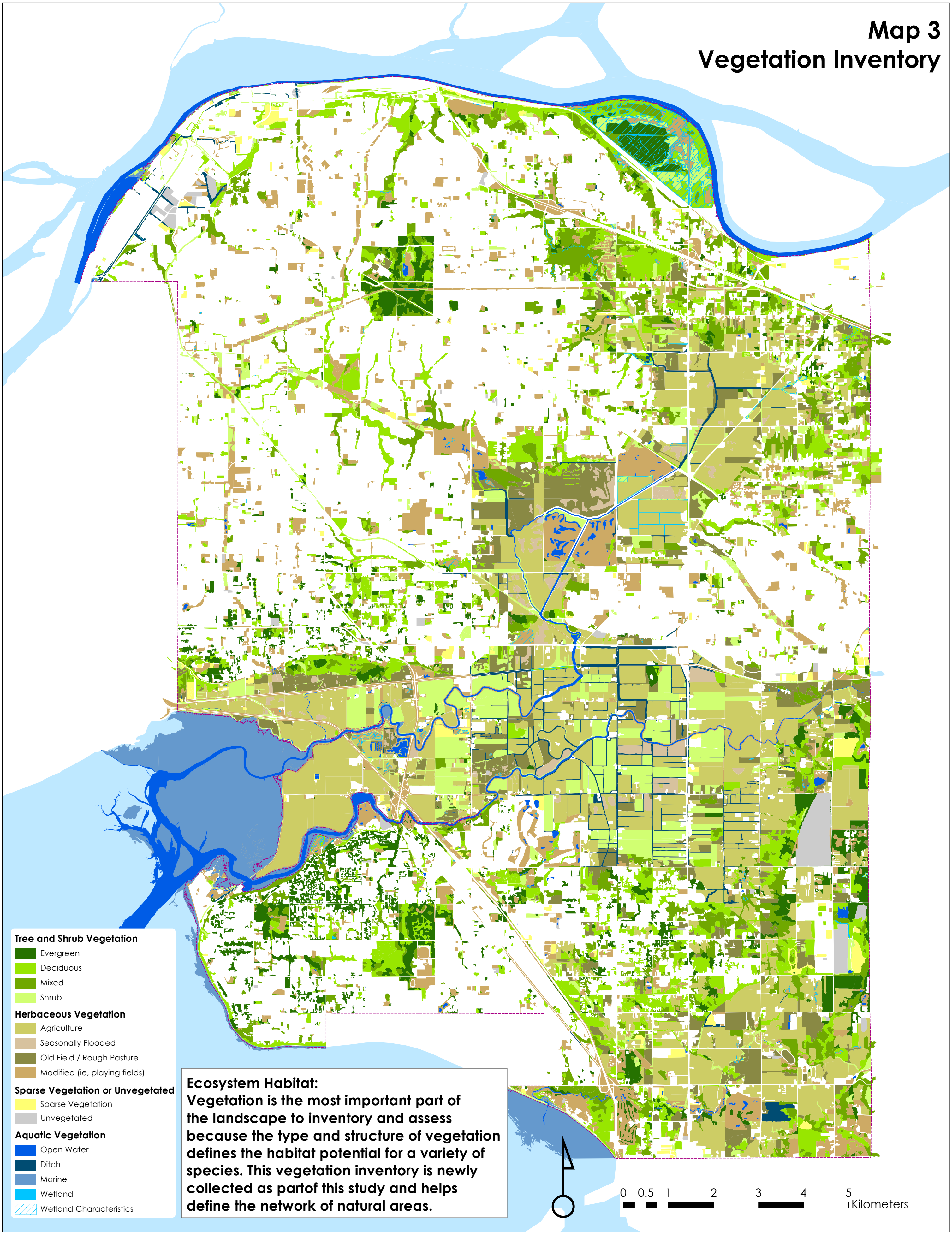
Class/Subclass: FO-MX
Modifier/submodifer: none
Age: n/a
Naturalness: 3

Waypoint: N5447483, E517344
Along Serpentine River through Tynehead Regional Park

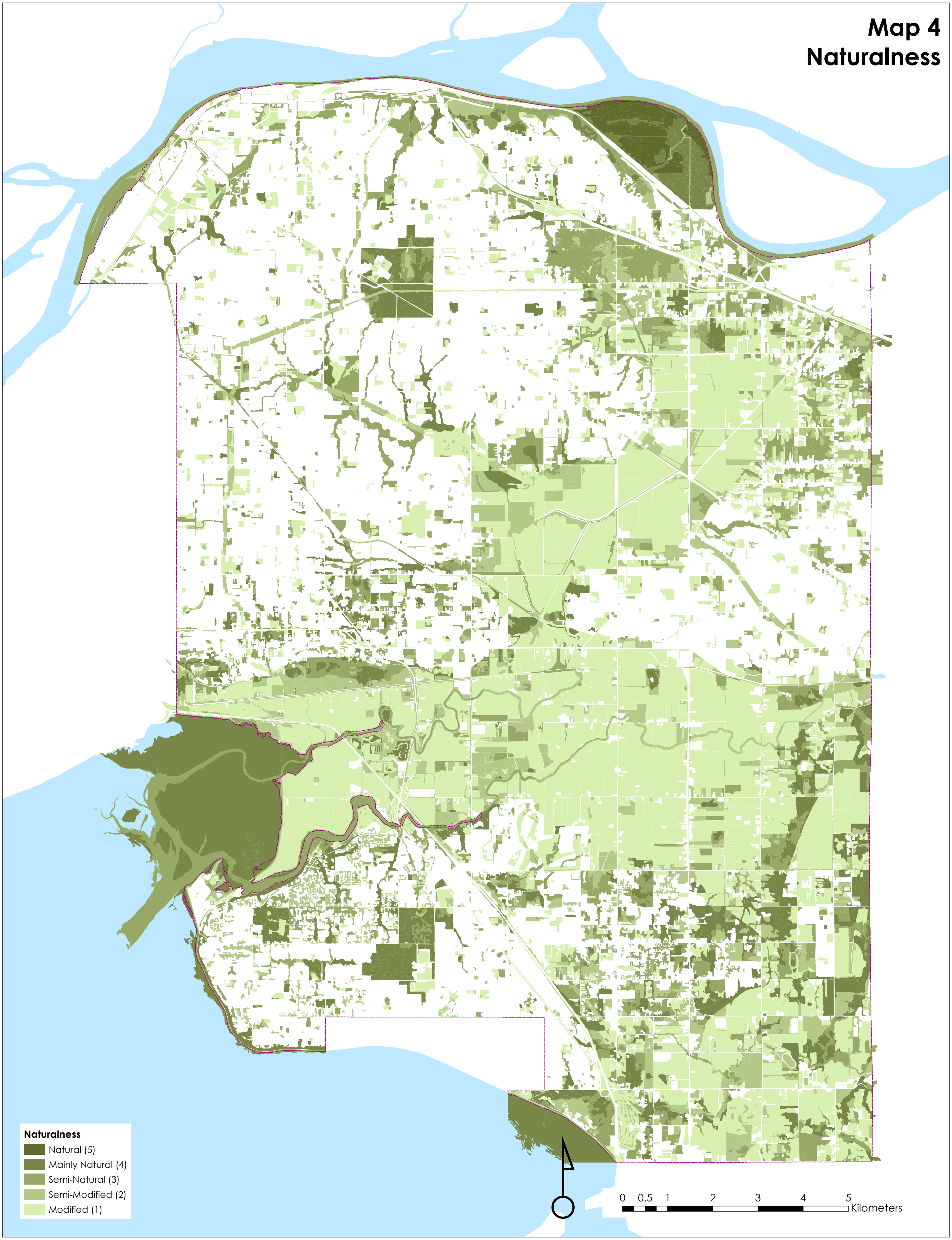
Map 1
Aquifers, Slope, Watersheds and Sub-watersheds



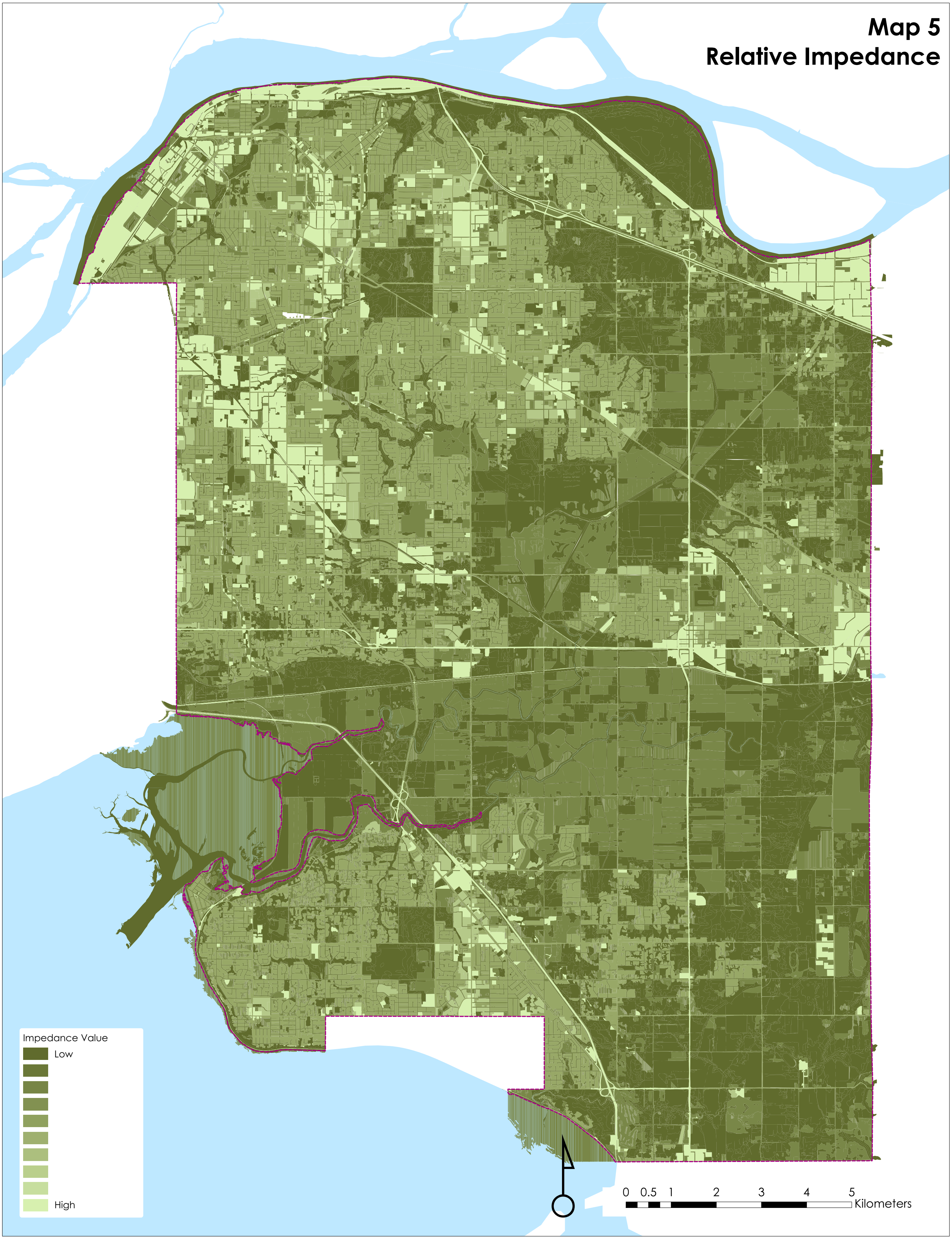

Map 2
Sensitive Species Occurences and Habitat
Surrey Bend Lowlands
Fraser Lowlands
North Surrey Uplands
Port Kells Midlands
Cloverdale Midlands
Clayton Uplands
Delta Lowlands
Serpentine Nicomekl Lowlands
Little Campbell Uplands
South Surrey Uplands
Little Campbell Lowlands
Border Uplands
Pacific Water Shrew
Bald Eagle Nest
Barn Owl
Cooper's Hawk Nest
Red-tailed Hawk Nest
Amphibians
Great Blue Heron Nest
Blue listed plant
Surrey Important Trees
Red Listed Animal
Blue Listed Animal
Red Listed Plant
Blue Listed Plant
Fish classifications
Year round presence of salmonids
Provide food and nutrients for downstream fish
Ditches with insignificant food and nutrients
Unclassified
Wetlands
Landscape Units
Surrey Boundary
Ecosystem Activity:
The number and diversity of native animal and plant species provides a strong indication of the health of an ecosystem. This map shows some rare animal and plant species sightings. The continued witnessing of these species significant to Surrey indicates a healthy local ecology.
0 0.5 1 2 3 4 5 Kilometers


Map 3
Vegetation Inventory
Tree and Shrub Vegetation
Evergreen
Deciduous
Mixed
Shrub
Herbaceous Vegetation
Agriculture
Seasonally Flooded
Old Field / Rough Pasture
Modified (ie, playing fields)
Sparse Vegetation or Unvegetated
Sparse Vegetation
Unvegetated
Aquatic Vegetation
Open Water
Ditch
Marine
Wetland
Wetland Characteristics
Ecosystem Habitat:
Vegetation is the most important part of the landscape to inventory and assess because the type and structure of vegetation defines the habitat potential for a variety of species. This vegetation inventory is newly collected as partof this study and helps define the network of natural areas.
0 0.5 1 2 3 4 5
Kilometers

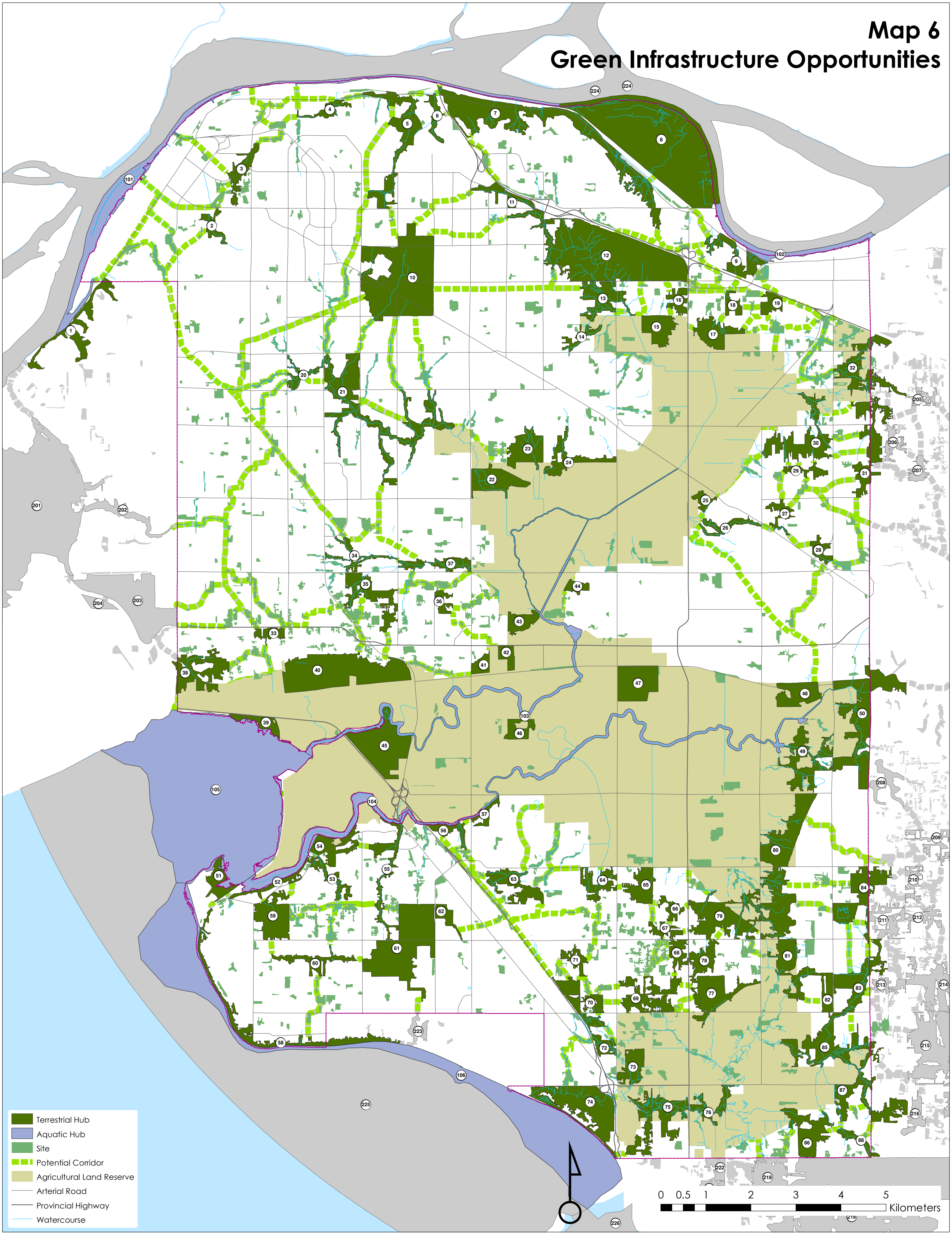
1:25,000


Map 4
Naturalness
Naturalness
Natural (5)
Mainly Natural (4)
Semi-Natural (3)
Semi-Modified (2)
Modified (1)
0 0.5 1 2 3 4 5
Kilometers
1:25,000

Map 5
Relative Impedance



Map 6
Green Infrastructure Opportunities



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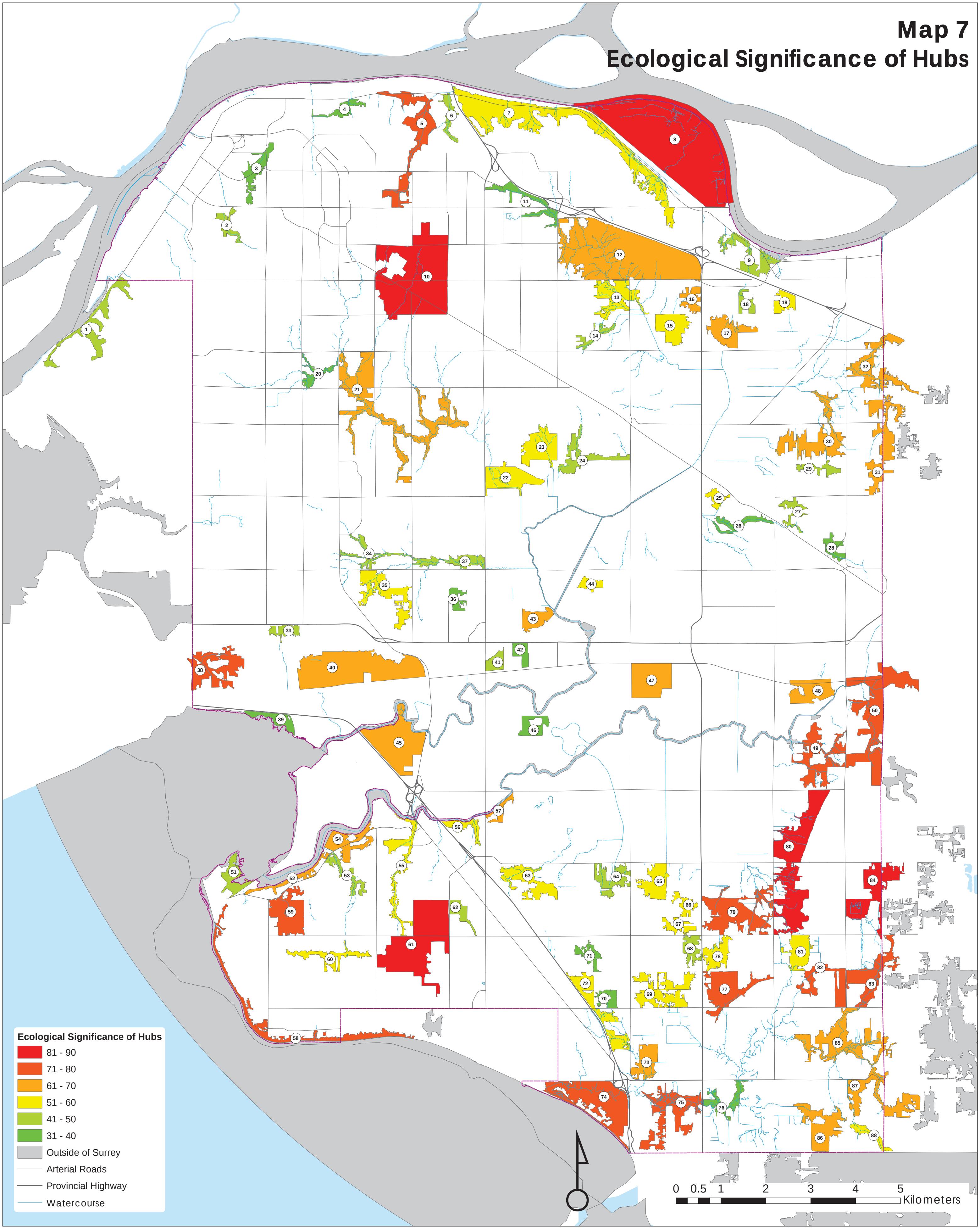
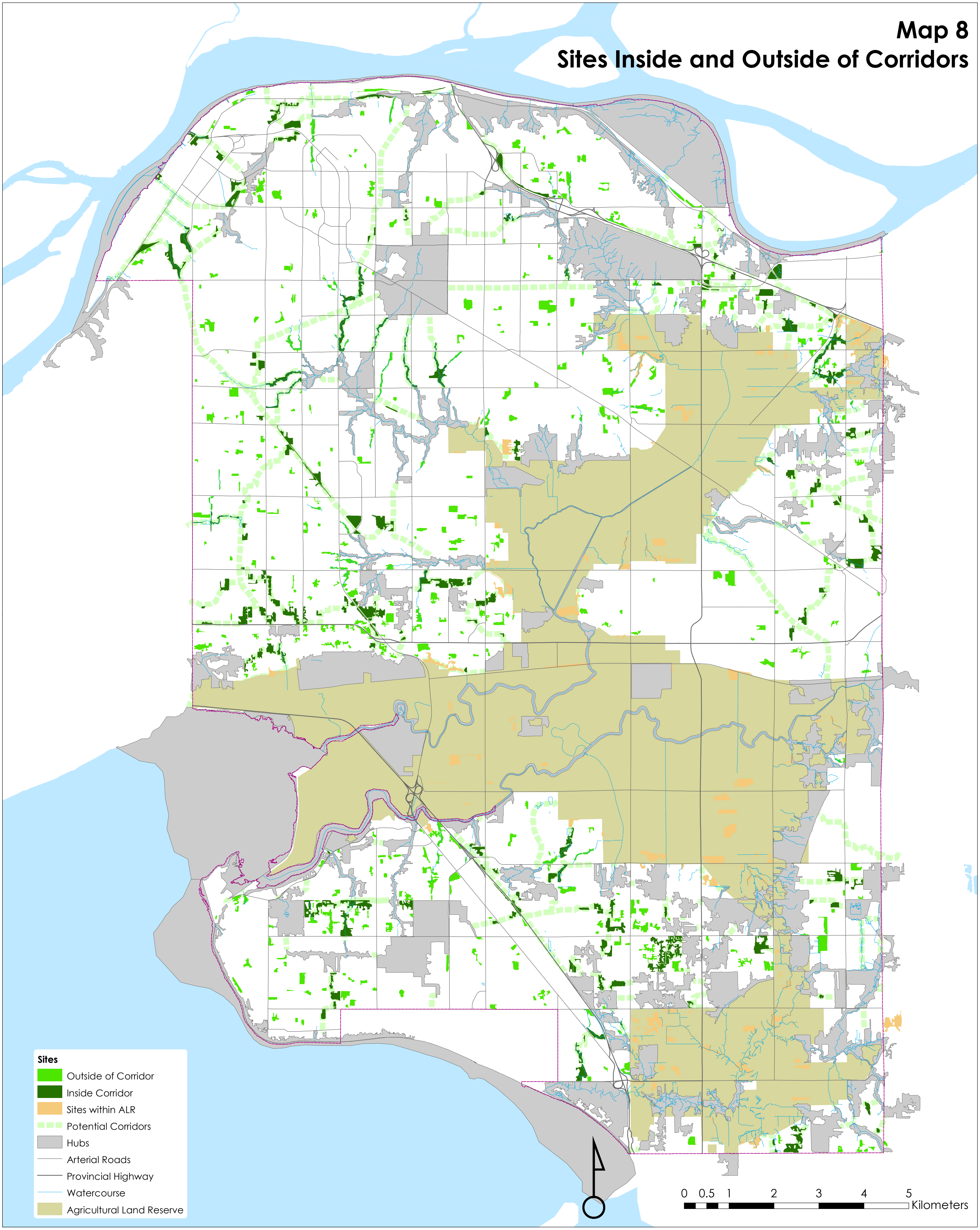
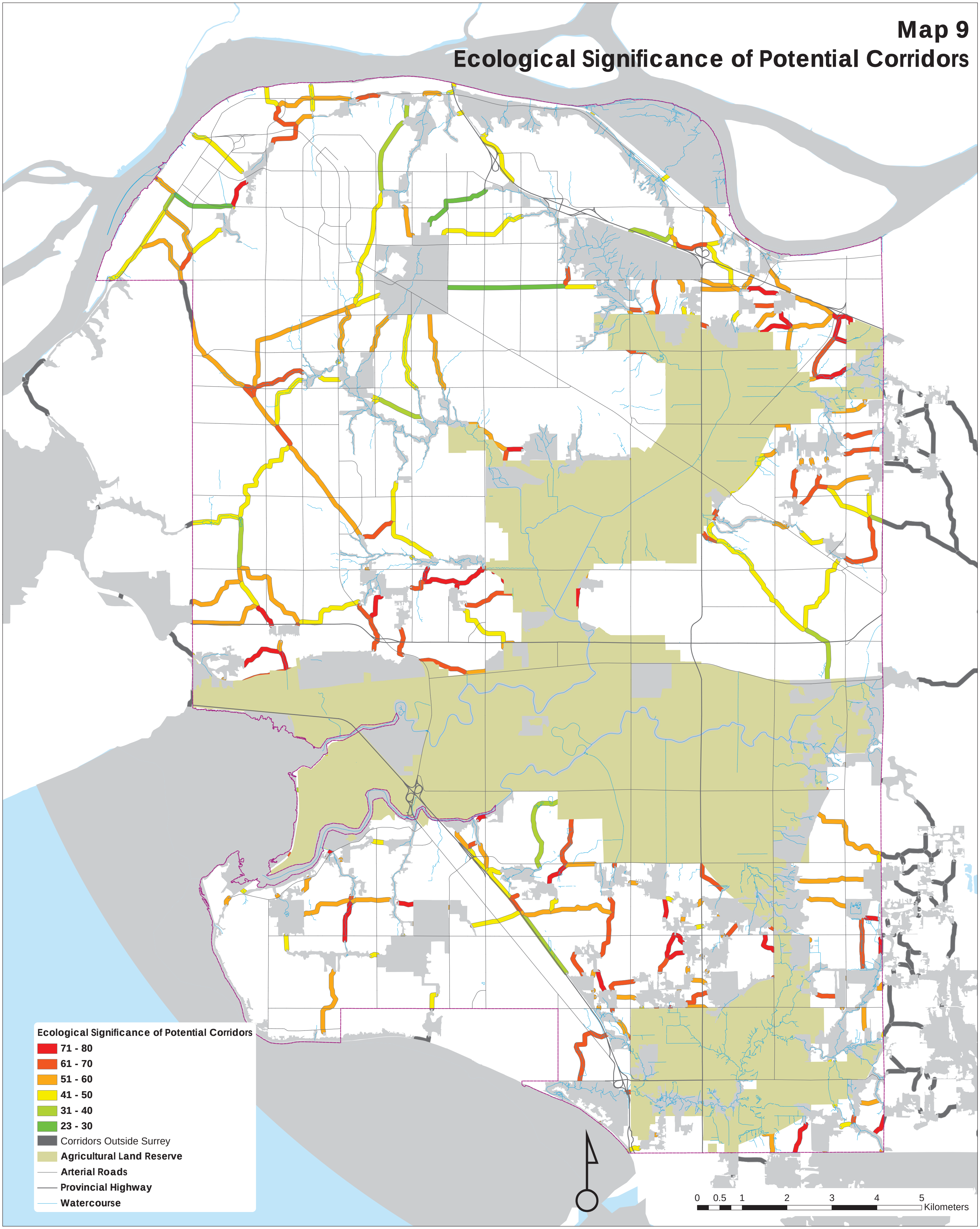

Map 7
Ecological Significance of Hubs
Ecological Significance of Hubs
81 - 90
71 - 80
61 - 70
51 - 60
41 - 50
31 - 40
Outside of Surrey
Arterial Roads
Provincial Highway
Watercourse
0 0.5 1 2 3 4 5
Kilometers


Map 8
Sites Inside and Outside of Corridors
Sites
Outside of Corridor
Inside Corridor
Sites within ALR
Potential Corridors
Hubs
Arterial Roads
Provincial Highway
Watercourse
Agricultural Land Reserve
0 0.5 1 2 3 4 5
Kilometers

Map 9
Ecological Significance of Potential Corridors



Map 10
Ownership of Network