The Natural Capital of Mission Creek in Kelowna: The Value of Ecosystem Services

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Contents

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Disclaimer

This study should be considered a preliminary and coarse-scale natural capital account for a small portion of the Mission Creek watershed. This work is a first step towards a more comprehensive accounting of natural capital assets in the region and is primarily intended to support ongoing efforts to restore a portion of this important stream.

More Canadian and local research is needed to determine the full range of ecosystem service values relevant to this ecoregion and the landcover types found therein. This work is intended to encourage others to consider the value of natural capital and its ecosystem services, as well as to stimulate a growing dialogue regarding the real value of natural capital, ecosystem services, stewardship and conservation.

The content of this study is the responsibility of its authors and does not necessarily reflect the views and opinions of those acknowledged above.

Every effort to ensure the accuracy of the information contained in this study has been taken; however, peer review was limited by time constraints. Suggestions for improvements that can be incorporated into future work are welcome.

Executive Summary

The lower stream segment of Mission Creek is located within the city of Kelowna, British Columbia, Canada where it outlets into Okanagan Lake. This stream provides significant value to the people of Kelowna as a source of water for both drinking and irrigation, recreation, socializing, fundraising, wildlife viewing, unwinding, and experiencing and connecting with nature.

Mission Creek remains of central importance to the well-being of the community of Kelowna, despite the fact that, from an ecological perspective, Mission Creek has been severely compromised largely due to diking of the creek (i.e. channelization), which began in the 1950s. The result is that more than 60% of the stream length has been lost, approximately 80% of the spawning and rearing habitat is now gone, and approximately 75% of the associated wetland and riparian areas have been eliminated.

One of the main reasons for ecosystem degradation (including that associated with Mission Creek) is the exclusion of the value of natural capital from current measures of progress and decision-making. Ecosystem services are derived from natural capital, which are critical to both the survival and well-being of humans. Natural capital and ecosystem service accounts provide information that can inform decisions related to policy and land use planning. It is imperative that the value of natural capital and ecosystem services is clearly understood by all stakeholders.

Interest in restoring the lower section of Mission Creek — especially sections downstream of East Kelowna Road Bridge - to a more natural condition appears to be growing. This is largely due to the efforts of the Mission Creek Restoration Initiative (MCRI), and the Mission Creek Working Group which have been working toward the restoration of this important resource for more than a decade. The Mission Creek Working Group with funding from the Okanagan Basin Water Board, have commissioned this study of the value of some of the 'ecosystem services' associated with Mission Creek. It is hoped that a better understanding of the value of the ecosystem services provided by Mission Creek today and under a restoration scenario will assist with future decision-making and with obtaining the funding necessary to undertake restoration efforts.

In its current state, Mission Creek provides extensive benefits to Kelowna's residents, businesses and visitors. However, it is expected that the value of many of these benefits are below what they once were and would increase, sometimes (as in the case of habitat for rare, or endangered species) quite considerably, as a result of restoration activities.

This report estimates the current value of a number of important ecosystem services to help demonstrate the importance of Mission Creek. The study also presents a second scenario that identifies and explores how some of these values would change as a result of hypothetical restoration activities.

Ecosystem services selected and valued as part of this assessment include: farmland, habitat, outdoor recreation, water supply, forest carbon storage and sequestration, wetland carbon storage, grassland carbon storage, air filtration by forests, flood protection (water regulation), waste treatment by wetlands and fishing. The table below summarizes the results of the analysis of the value of these select ecosystem services. Both baseline valuations (the value of ecosystem services today) and restoration valuations (for

a select number of ecosystem services) are shown. The current value of natural capital associated with the Mission Creek study area is estimated to be nearly $19 million (2012$). The restoration scenario, which includes the restoration of portions of the creek within the lower 12 kilometres of it, is expected to result in a 10% increase in the value of select ecosystem services. The restoration scenario results in an increase in the value of ecosystem services to nearly $21 million (2012$).

Summary of Mission Creek Ecosystem Services Based on Two Scenarios			
Ecosystem Service	**Baseline valuation (2012$)**	**Increase in select ecosystem services resulting from restoration (2012$)**	**Total value of ecosystem services with restoration (2012$)**
Farmland[1]	4,220,353		4,220,353
Habitat	369,073		369,073
Outdoor recreation	12,192,768		12,192,768
Water supply	231,349		231,349
Water filtration	29,817		29,817
Climate regulation (storage)	610,439		610,439
Climate regulation (sequestration)	50,306	1,203	51,509
Air quality	263,538		263,538
Flood protection (forests)	518,652	12,488	531,140
Flood protection (wetlands and stream)	138,973	12,892	151,865
Waste treatment	205,740		205,740
Fishery		1,931,547	1,931,547
TOTAL	**18,831,009**	**1,958,130**	**20,789,139**

Two important assumptions were made in this analysis. First, is the assumption that salmon fishing in Mission Creek can resume following restoration. Second, is the assumption that restoring select sections of Mission Creek will result in a 2.4% increase in a number of provision services.

This study is a first step towards a full natural capital account for the Mission Creek watershed and surrounding areas.

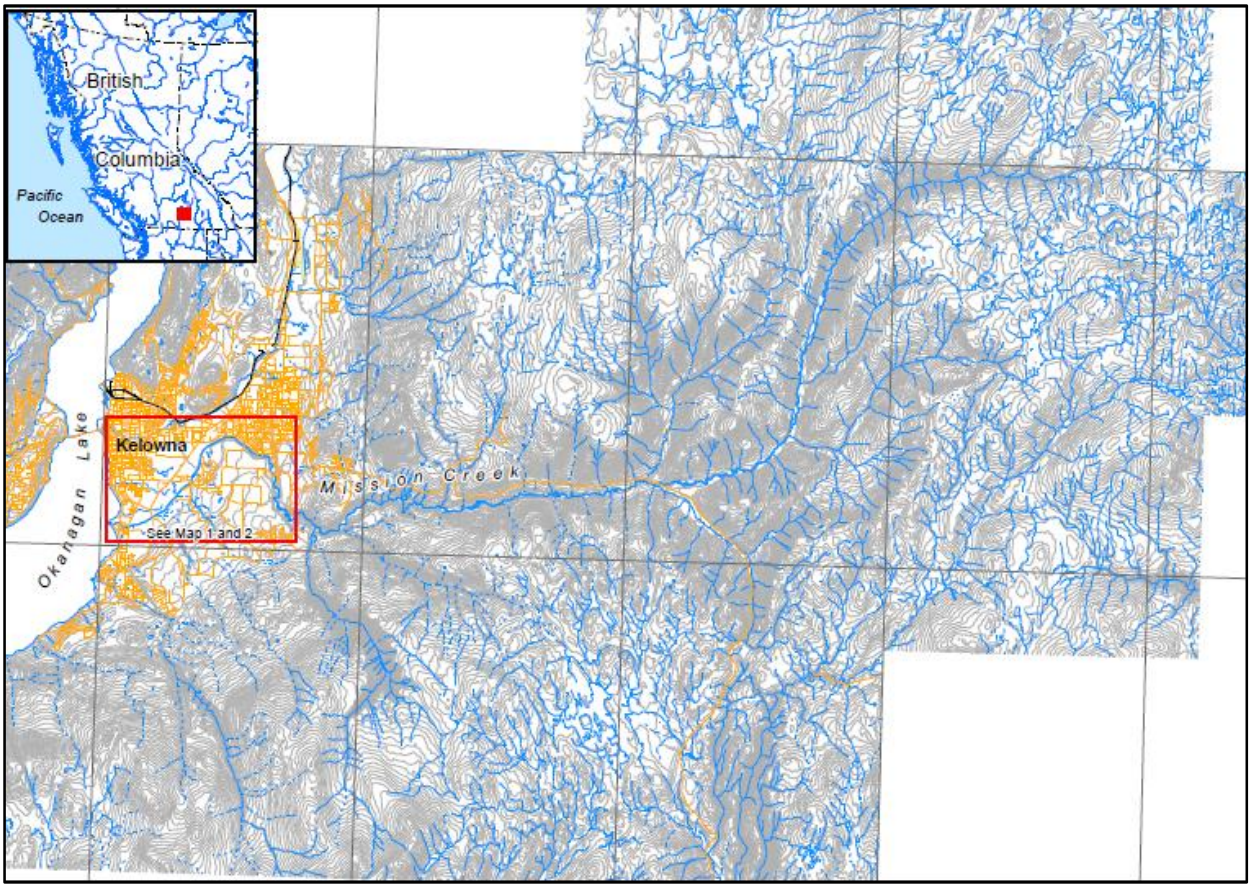
[1] Willingness to pay for the protection of farmland for agriculture purposes.

Introduction

The lower section of Mission Creek is located within the city of Kelowna, British Columbia (Map 1, below) where it meets Okanagan Lake. The importance of this creek to the people of Kelowna is evident on a number of levels. Mission Creek was central to the initial settlement of the city and the economic development of Kelowna that has taken place over time. First Nations relied on Mission Creek and the associated riparian areas for food, building materials and medicines. Kokanee salmon, which were historically abundant in Mission Creek, were particularly important to Okanagan First Nation communities. Anecdotal evidence suggests that over 60 years ago Mission Creek was red with kokanee each fall when it has been suggested that "millions of kokanee" returned to the creek to spawn.

Today, Mission Creek continues to provide significant value to the people of Kelowna as a source of drinking and irrigation water, recreating, socializing, fundraising, wildlife viewing, unwinding, and experiencing and connecting with nature. This is true despite the fact that, from an ecological perspective, Mission Creek has been severely compromised by human interventions within and along the stream corridor.

Map 1: **Mission Creek Watershed including the city of Kelowna, British Columbia**



Based upon historic orthophotos which date back to 1938, it is estimated that the main Mission Creek channel between the East Kelowna Road bridge and the outflow of the creek at Okanagan Lake was a meandering channel 60 to 80 meters wide and 30 kilometres in length. In the 1950s most portions of lower Mission Creek were channelized and diked for flood control.[2] Relative to the condition of Mission Creek prior to channelizing, today the stretch of Mission Creek that flows through Kelowna averages just 31 meters in width and the creek length has been reduced to 12 kilometres.[3] As a result of extensive diking efforts in the 1950s, more than 60% of the length of the creek has been lost, spawning and rearing habitat has diminished by 80%, and 75% of the wetland and riparian areas have been eliminated.

Given the abundant alterations to the lower segment of the stream and the increasing knowledge of the array of negative impacts associated with these alterations from a natural environment perspective, mounting interest in stream restoration is not surprising. The Mission Creek Restoration Initiative (MCRI) is a multi-disciplinary, multi-stakeholder initiative with a goal of restoring the lower section of Mission Creek — from the East Kelowna Road Bridge, downstream to Okanagan Lake - to a more natural condition. While in its current state, Mission Creek provides numerous benefits to Kelowna's residents, businesses and visitors, it is expected that the value of many benefits would increase as a result of stream restoration. To help demonstrate the importance of Mission Creek, this report presents estimates of the current value of some of the ecosystem goods and services (referred to as ecosystem services) provided by Mission Creek. The report also considers an alternate future scenario assuming the restoration of some portions of the lower 12 km of stream. The restoration scenario explores how some of the values may change as a result of restoration activities.

The Importance of Natural Capital and Ecosystem Services

Natural capital refers to the value of earth's land, water, atmosphere, living organisms and all formations of the earth's biosphere (i.e. nature). This capital is organized and bundled within the earth's natural ecosystems, which provide resources and flows of ecosystem services (many of which are of use to and valued by humans). The goods and services provided by ecosystems are critical to the economic and social well-being of humans. Ecosystem services are often defined as the benefits that people obtain either directly or indirectly from ecological systems.[4] Ecosystems provide numerous services, including the storage of flood waters, water capture and filtration by watersheds, air pollution absorption by trees, and climate regulation from carbon storage in trees, plants and soils. Ecosystem services are generally organized into four classes: provisioning services, regulating services, habitat services, and cultural and amenity services.[5] Table 1 below provides examples of each of the four classes of services.

Table 1 - Typology of Ecosystem Services[6]

[2] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.

[3] Ibid.

[4] Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being*: *Synthesis*. Island Press. Washington, DC.

[5] See, for example, Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being*. Island Press. Washington, DC.

[6] http://www.teebweb.org/Home/tabid/924/Default.aspx

Provisioning Services	
Food	Food, fish and meat for human consumption.
Water Supply	Water for human consumption, irrigation, and industrial use.
Raw Materials	Timber, fuelwood.
Medicinal Resources	Providing drugs, pharmaceuticals, tests, tools & assay organisms.
Ornamental Resources	Resources for fashion, jewelry, handicraft, worship and decoration.
Regulating Services	
Gas Regulation	Providing clean, breathable air, disease prevention, and planet habitability.
Climate Regulation	Provides a stable climate preventing increased climatic variability, glacial and permafrost melt, increased storm frequency and force, and global sea rise.
Disturbance Prevention	Preventing and mitigating natural hazards such as floods, storm surges, hurricanes, fires, and droughts.
Soil Retention	Retaining arable land, slope stability and coastal integrity.
Water Regulation	Providing water supply for natural irrigation, drainage, ground water recharge, river flows and navigation.
Biological Control	Providing pest and disease control.
Waste Treatment	Absorption of organic waste, natural water filtration, pollution reduction.
Soil Formation	Creating soils for agricultural and ecosystems integrity.
Pollination	Providing pollination of wild and domestic plan species.
Nutrient Regulation	Promoting healthy soils, and gas, climate and water regulating services.
Habitat Services	
Habitat and Biodiversity	Maintaining habitat for genetic and biological diversity, the basis for most other functions.
Nursery	Providing habitat for spawning and nesting for reproduction.
Cultural & Amenity Services	
Aesthetic	Enjoying and appreciating the scenery, sounds and smells of nature.
Recreation and Tourism	Experiencing outdoor activities in natural ecosystems.
Science and Education	Learning and research activities in natural ecosystems.
Cultural and Artistic	Experiencing nature through art, film, folklore, books, cultural symbols, architecture religion, spiritual activities and media.

Ecosystem services are typically undervalued in market economies (if valued at all), despite being worth trillions of dollars per year, globally.[7] As a result, quantifying, measuring and monitoring natural capital and ecosystem services is an increasingly common practice to inform decision-makers of the implications of resource and land use decisions by communities, businesses and governments. Generally, the full costs of human activities and their impacts on the environment are not accounted for, and as a result these costs are externalized.[8] Modern societies are now facing severe environmental problems due to the decline in ecosystem services as a direct result of ignoring these external costs to the natural environment. The United Nations Millennium Ecosystem Assessment (2005) reported that over the past 50 years humans have changed the Earth's ecosystems more rapidly and extensively than in any other period in

[7] Costanza, R. et al. 1987. *The value of the world's ecosystem services and natural capital*. Nature. 387:253-259.
[8] External costs are costs that are not reflected in market prices and are therefore borne by society as a whole (e.g. the cost of pollution).

human history. The Assessment concluded that approximately 60 per cent of the world's ecosystem services are being degraded or used unsustainably.[9] The results are an unprecedented decline in global biodiversity[10] and precious natural assets that provide humans with life-supporting services.

The Economic Significance of Ecosystem Services

Quantifying ecosystem services is increasingly recognized as a valuable approach to account for the value of ecosystems.[11] Communities, groups and governments are beginning to recognize the essential benefits that nature provides. As a result, valuing ecosystem services is an emerging trend at the global, national and local levels. A global study has estimated the value of the world's ecosystem goods and services - $16 – 54 trillion/year, with an average of $33 trillion/year - to be worth more than the value of the entire global economy – which was $18 trillion in the year the study was completed.[12]

In Canada, two studies have assessed the non-market value of natural capital for Canada's boreal region. In 2009, it was estimated that the Mackenzie Valley Region was worth $570 billion per year (an average of $3,426 per hectare). This is more than 13 times greater than the market value of the natural resources (e.g. oil and natural gas) extracted from the same region.[13] In southern Ontario, four studies have assessed the non-market values of nature's benefits to range from $2,948 to $5,060 per hectare per year. In 2008, a study estimated that the value of ecosystem services provided by the Ontario Greenbelt was over $2.6 billion each year (an average value of $3,487 per hectare).[14] A similar study estimated the value of the Lake Simcoe watershed at $975 million per year (an average value of $2,948 per hectare).[15] In 2009, the value of the Credit Valley Watershed was estimated at $371 million each year (an average of $490 per local resident).[16] Also, in 2009, a benefit transfer study was undertaken for the Ontario Ministry of Natural Resources that reported the annual value of nature's benefits for the entire southern Ontario region to be worth an estimated $63 billion (updated in 2011). This study area of 12.5 million hectares had an estimated average value of $5,060 per hectare each year.[17]

In 2010, a study of the ecosystem services provided by British Columbia's Lower Mainland and its watersheds was commissioned by the Pacific Parklands Foundation. In this study, the top three ecosystem

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[9] Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press. Washington, DC.

[10] Biodiversity or biological diversity refers to the variety of species and ecosystems on Earth and the ecological processes of which they are a part.

[11] Troy,A. and Wilson, M.A. 2006. *Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer*. Ecological Economics. 60: 435-449.

[12] Costanza, R. et al. 1987. *The value of the world's ecosystem services and natural capital*. Nature. 387:253-259.

[13] Anielski, M., and Wilson, S. 2009. *The Real Wealth of the Mackenzie Region: Assessing the Natural Capital Values of a Northern Boreal Ecosystem*. (2009 Update). Canadian Boreal Initiative. Ottawa, Canada.

[14] Wilson, S.J. 2008. *Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*. Greenbelt Foundation and David Suzuki Foundation.

[15] Wilson, S.J. 2008. *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services*. Friends of the Greenbelt Foundation Occasional Paper Series. Lake Simcoe Region Conservation Authority and The Friends of the Greenbelt Foundation. Ontario, Canada.

[16] Kennedy, M., and Wilson, J. 2009. *Natural Credit: Estimating the Value of Natural Capital in the Credit River Watershed*. The Pembina Institute and Credit Valley Conservation. Note: natural capital values per hectare were not provided in the study.

[17] Troy, A., and Bagstad, K. 2009. *Estimation of Ecosystem Service Values for Southern Ontario*. Spatial Informatics Group. Prepared for the Ontario Ministry of Natural Resources. Ontario. Updated values cited were received directly from the authors. The larger value per hectare in this study, compared to the other southern Ontario studies, was the result of higher values attributed to urban and suburban natural cover, because of the greater sized population dependent on these greenspaces.

services were identified as: 1) climate regulation provided by carbon storage in forests, wetlands, grasslands and shrublands ($1.7 billion/year); 2) water filtration services by forests and wetlands ($1.6 billion/year); and, 3) flood protection provided by water regulation through forests ($1.2 billion/year). The total value assessed for the ecosystem services considered by this study was an estimated $5.4 billion/year (an average value of $3,959 per hectare). This equates to $2,449 per person or $6,368 per household/year.[18]

These studies demonstrate the importance of nature. Yet, as previously noted, many of these values are not reflected in market prices and are therefore not taken into consideration when making important land use decisions. In the context of the current study, given the importance of Mission Creek to the people of Kelowna and the larger Okanagan Valley, the restoration of Mission Creek has the potential to result in significant increases in the value of ecosystem services provided by the creek. In some cases these improvements yield a direct improvement in quality of life (e.g. water quality), while in others the connection is more indirect (e.g. wildlife habitat). Yet without information on the current value, or how that value will change should restoration activities take place, such information is merely speculation. By estimating natural capital values for Mission Creek and examining how some of those values can be expected to change under a restoration scenario, decision makers and members of the public in Kelowna will be able to make more informed decisions about how this important community asset should be managed over time.

Ecological Goods and Services in Mission Creek

This analysis focused on the lower segment of Mission Creek - from the Mission Creek Falls (east boundary of the City of Kelowna) to the outlet of the creek at Okanagan Lake – a segment of the creek that measures 12 km. This section of creek was chosen because of the significant changes that have occurred to channel morphology, watershed processes, and aquatic and terrestrial habitat due to the channelizing and diking that has taken place within it. By contrast, Mission Creek upstream of the study area remains in a relatively natural state.[19]

Quantifying the value of ecosystem services associated with Mission Creek first requires the identification and quantification of the study region by land cover type (see Appendix A for a description of the methods employed in this study). Ecosystem services can then be ascribed to each of the land cover types for the study area.

To arrive at the study area for this assessment, a 500 metre buffer was created along the length of Mission Creek (i.e. 250 metres on each side of the stream). With a 500 metre buffer and segment length of 12 km, the total study area is 3,624 hectares. Table 2 presents area figures for each of the land cover types contained within the Mission Creek study area based on Terrestrial Ecosystem Mapping (TEM) data.

[18] Wilson, S.J. 2010. Natural Capital in B.C.'s Lower Mainland: Valuing the Benefits from Nature. Pacific Parks Foundation and David Suzuki Foundation. Vancouver, Canada.

[19] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.

Table 2 - Land Cover Type, Areas and Per Cent Cover in Mission Creek Study Area[20]

Land Cover Type	Area (ha)	Per Cent Cover
Herb	387	10.7
Forb-dominated	6	0.2
Graminoid-dominated	2	0.1
Shrub/Herb	25	0.7
Low shrub	4	0.1
Pole/Sapling Broadleaf	40	1.1
Pole/Sapling Coniferous	93	2.6
Pole/Sapling Mixed	2	0.1
Young Forest Broadleaf	117	3.2
Young Forest Coniferous	485	13.4
Young Forest Mixed	32	0.9
Mature Forest Broadleaf	26	0.7
Mature Forest Coniferous	47	1.3
Mature Forest Mixed	1	0.0
Canal	3	0.1
Cultivated field	569	15.7
Cultivated orchard	498	13.7
Cutbank (sparse hybrid)	6	0.2
Exposed Soil	21	0.6
Golf Course	102	2.8
Gravel Pit	8	0.2
River	94	2.6
Road Surface	2	0.1
Rural	160	4.4
Shallow Open Water	19	0.5
Urban/Suburban	874	21.1
TOTAL	**3,624**	**100**

At nearly 30% of the study area, cultivated fields and orchards (i.e. agricultural land) account for the largest share of the study area at present. Urban/suburban development has the second largest share of the study area at 21.1%.

In terms of natural areas, wetlands account for 62.2 hectares (or 1.7%) of the Mission Creek study area (Table 3 below). This area includes 24.7 hectares of marsh, 17.6 hectares of shallow water wetlands, 11 hectares of flood wetlands, and 8.7 hectares of swamp.

Table 3 - Wetland Types in the Mission Creek Study Area[21]

[20] Data derived from Terrestrial Ecosystem Mapping (TEM) data: http://www.env.gov.bc.ca/fia/terrecomap.htm.
[21] Ecoscape Environmental Consultants Ltd. 2009. Wetland Inventory, Classification, Evaluation & Mapping (WIM).

Wetland Type	Area (ha)
Marsh	24.7
Shallow water	17.6
Flood Mid Bench	10.7
Swamp	8.7
Flood Low Bench	0.3
Unclassified	0.2
TOTAL	**62.2**

As noted previously, each land cover type is associated with different ecosystem services. Table 4 identifies the land cover types gathered from the spatial datasets for the Mission Creek study area, the associated ecosystem services, and the potential ecosystem service benefits.

Table 4 - Mission Creek Land Cover Types, Ecosystem Services and Associated Benefits

Land Cover Type	Ecosystem Services[22]	Potential Benefits for Human Well-being
Wetlands	• Food • Water/Water regulation • Climate regulation • Moderation of extreme events • Waste treatment • Erosion prevention • Maintenance of life cycles of migratory species • Maintenance of genetic diversity • Cultural services • Recreation and tourism	• Food provision • Water supply • Flood protection • Carbon Storage/Stable climate • Waste processing • Stable shoreline • Nursery habitat (nesting/spawning) • Habitat provision • Biological and genetic diversity • Cultural/heritage conservation • Amenity/tourism/recreation
Lakes & Rivers	• Food • Water/Water regulation • Climate regulation • Moderation of extreme events • Waste treatment • Erosion prevention • Maintenance of life cycles of migratory species • Maintenance of genetic diversity • Cultural services • Recreation & Tourism	• Food provision • Water supply • Carbon Storage/Stable climate • Flood protection • Waste processing • Stable shoreline • Nursery habitat (nesting/spawning) • Habitat provision • Biological and genetic diversity • Cultural/heritage conservation • Amenity/tourism/recreation
Forests	• Food • Water • Air quality regulation • Climate regulation • Water filtration • Water regulation	• Food provision • Water supply • Good air quality • Carbon storage • Clean water • Flood protection

[22] The typology of the ecosystem services presented here are consistent with those used by The Economics of Ecosystems and Biodiversity (TEEB): http://www.teebweb.org/

	• Erosion prevention • Pollination • Biological control • Maintenance of life cycles of migratory species • Maintenance of genetic diversity • Cultural services • Recreation & Tourism	• Soil erosion control • Pollination of wild and cultivated plants • Pest control • Nursery habitat (nesting) • Habitat provision • Biological and genetic diversity • Cultural/heritage conservation • Amenity/tourism/recreation
Grassland & Shrubland	• Water flow regulation • Air quality regulation • Carbon storage • Pollination • Erosion prevention • Habitat services • Cultural services • Recreation & Tourism	• Flood protection • Good air quality • Carbon storage/stable climate • Pollination of wild and cultivated plants • Soil erosion control • Biological and genetic diversity • Cultural/heritage conservation • Amenity/tourism/recreation
Cultivated Areas	• Food • Pollination • Climate regulation • Erosion prevention • Recreation • Cultural services	• Provision of food • Pollination of crops • Carbon storage in soils (depends on management practices) • Erosion control • Amenity and recreation • Cultural/heritage conservation
Urban Greenspace	• Air quality regulation • Water flow regulation • Climate regulation • Habitat services • Cultural services • Recreation	• Abatement of air/noise pollution • Flood protection • Carbon storage • Habitat provision • Inspiration/spiritual enhancement • Cultural/heritage conservation • Amenity/tourism/recreation

Valuing the Ecological Goods and Services in Mission Creek

This section of the report presents information on each of the ecosystem services analyzed for the Mission Creek study area. Background information/context, a description of the methods employed to value it, and the results of the valuation analysis are presented for each ecosystem service. We begin with the baseline (current) valuation estimates and later in the report present the results of the restoration scenario. The ecosystem services valued in the baseline assessment are as follows (in order of appearance):

- Farmland
- Habitat
- Recreation and tourism
- Water supply
- Forest carbon storage and sequestration
- Wetland carbon storage

- Grassland carbon storage
- Air filtration by forests
- Flood protection (water regulation)
- Waste treatment by wetlands

Farmland

The Value of Farmland: Background

Farmland represents natural capital. Many people place a value (referred to as a public value) on farmland that is greater than the market value of the products derived from it. In addition to the value derived from the production of goods from agricultural land, some of the values that are associated with the presence of farmland include habitat, groundwater recharge, local food production capacity, agricultural heritage, scenic vistas and urban growth containment.[23] A 2009 survey of households in Metro Vancouver identified the three most important benefits households place on farmland as: local food (91%), green space (69%), wildlife habitat (51%), nature (33%), jobs (15%), rural life (13%), animals (9%), and culture (7%).[24] These values, however, because they are not traded in the market place are not included in market prices.[25] As a result, when decision-makers make land use allocation choices (e.g. to convert agricultural land to urban land uses) there may be a tendency to take only market prices into consideration. In doing so, the full spectrum of value considerations are not be accounted for. By estimating the value that the public places on the presence of farmland in a region, decision-makers may be in a better position to account for the true value associated with land allocated to farm uses.

Agricultural lands within and in the area surrounding Kelowna provide important value to the people in the region. The Agriculture Land Reserve (ALR) was implemented in 1974 in recognition of the importance of agriculture lands to the Province of British Columbia. Today, approximately 40% of Kelowna's land base is within the ALR, with extensive land being considered "prime" agricultural land.[26] The agricultural lands in and around Kelowna provide a variety of agricultural products including field crops (e.g. hay and alfalfa), fruits (e.g. apples, peaches, cherries, grapes), nuts, berries and vegetables. Livestock farms (e.g. chickens and hens, cattle and calves, beef cows, and horses and ponies) are also present in the area surrounding Kelowna.[27] In total, 555 farms, farming 13,127 hectares of land, were located within Kelowna in 2006. Those farms accounted for about 50% of all of the land being farmed in the Regional District of Central Okanagan. In 2006, the farm population was estimated at 1,665 persons or 1.6% of Kelowna's population.[28]

[23] Robbins, Mark, Nancy Olewiler and Marion Robinson. 2009. *An Estimate of the Public Amenity Benefits and Ecological Goods Provided by Farmland in Metro Vancouver.*
[24] ibid.
[25] ibid.
[26] City of Kelowna. 2008. *City of Kelowna Agricultural Overview*.
[27] Ministry of Agriculture and Lands. *Agriculture in Brief – City of Kelowna*.
http://www.al.gov.bc.ca/resmgmt/sf/agbriefs_2006census/AgInBriefFactsheet_Kelowna.pdf
[28] City of Kelowna. 2008. *City of Kelowna Agricultural Overview*.

The Mission Creek study area has a very large component of farmland within it. In fact, over 1,000 hectares of the 3,624 hectare study area is comprised of cultivated fields and cultivated orchards. Close to 30% of the study area is currently dedicated to agricultural use.

The Value of Farmland: Methods

There are two key components to the method used to estimate the value of ecosystem services associated with food production from the Mission Creek study area. The first component involves the estimation of the market value of the crops derived from the agricultural lands contained within the study area. To estimate the market value of crops from the Mission Creek study area, total gross farm receipts from Kelowna's agricultural sector were identified ($59,686,182, 2012$).[29] Dividing this number by the number of farms in Kelowna (555)[30] and the average hectares per farm (23.7 ha)[31] allowed us to estimate gross farm receipts per hectare for farms in Kelowna ($4,538, 2012$). Multiplying this by the hectares of agricultural land in the study area (sum of cultivated orchards and cultivated fields; 498 ha and 569 ha respectively) results in the value of gross farm receipts for agricultural lands in the Mission Creek study area.

The second component of the ecosystem services associated with agricultural land in the study area is to estimate the collective public value of farmland. Here, we transferred an estimate derived for the public value of farmland in Metro Vancouver to the Mission Creek study area.[32] The Metro Vancouver study was chosen for a number of reasons, namely, it is based on a region in British Columbia, it was recently conducted, and it involved primary research through use of a survey. For these reasons, it was deemed an appropriate proxy for the Mission Creek study area. The Metro Vancouver study estimated the value that an average household places on farmland by measuring the willingness to pay to protect farmland. The Metro Vancouver study calculated the willingness to pay to protect 400 ha of farmland as $77 per household (2012$).[33] This value is consistent with the range of values obtained by a variety of other studies on this subject conducted in North America.[34] The transferred value ($77 per household) was then multiplied by the number of households in Kelowna (54,760)[35] to get a total willingness to pay for the protection of 400 hectares of farmland in the Kelowna area.

The Value of Farmland: Results (2012$)

Market value of food production from farmland in the Mission Creek Study Area: based on a value of $4,538/hectare/year the total value of food production for the study area is estimated at $4,841,800.

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[29] Ibid.
[30] Ibid.
[31] Ibid.
[32] Robbins, Mark, Nancy Olewiler and Marion Robinson. 2009. *An Estimate of the Public Amenity Benefits and Ecological Goods Provided by Farmland in Metro Vancouver.*
[33] The degree to which the willingness to pay estimate reflects specific circumstances in Kelowna were not examined (for example, we did not correct for differences in the scarcity of agriculture land between the two locations). It thus may over or under estimate the willingness to pay in Kelowna.
[34] Ibid.
[35] Number of private dwellings in Kelowna according to Statistics Canada's 2011 Census.

Public value (willingness to pay) to protect 400 hectares of farmland: $3,955/hectare/year; $4,220,353 total.

Habitat

The Value of Habitat: Background

Mission Creek is known to provide important habitat to numerous birds, mammals and amphibians, including species-at-risk and species of concern. Bird species that have been identified in the area include sand hill cranes, great blue herons, northern flickers, pileated woodpeckers, and numerous species of songbirds. Mammals that have been identified in the Mission Creek area include beaver, mink, white-tailed deer, black bears, coyote and raccoon. The marsh and pond habitats located along Mission Creek provide habitat for pond-breeding amphibians such as the Great Basin Spadefoot toad. The Great Basin Spadefoot toad is blue-listed provincially and threatened federally (on Schedule 1 of Species at Risk Act). Numerous records of the red-listed western screech owl have occurred along Mission Creek between Gordon Drive and the eastern boundary of the study area, and the red-listed Lewis' woodpecker has been recorded along Mission Creek to the east of the study area.[36]

The Mission Creek study area is also home to a large stand of black cottonwood trees, which represents a rare ecosystem in the Okanagan. The black cottonwoods, some of which are over 100 years old, are located in the Benvoulin Woods area adjacent to Mission Creek. Great blue herons roost in the largest of these trees.[37] Groups of turkey vultures (up to 15) have been observed roosting in trees around the viewing platform northeast of the Casorso Road bridge.[38]

The Value of Habitat: Methods

The value of habitat services provided by the study area was derived by summing the estimated habitat value for each of four habitat land cover types – forest, grasslands, wetlands and agriculture lands. With the exception of agricultural lands, the value of habitat services was estimated by transferring a value estimate per hectare per year to the appropriate area of land cover type for each of the land covers.

The study area encompasses 843 hectares of forest land cover.[39] An estimate from a 2009 study on the value of ecosystem services in Ontario was applied to this area.[40] Troy and Bagstad apply the average of three values derived in previous studies, all of which apply to forests located adjacent to streams. The

[36] Personal communication, Josie Symonds, Ecosystem Biologist, Ministry of Forests, Lands and Natural Resource Operations, February 15, 2013.
[37] Gaboury et. Al. 2004. *Mission Creek Habitat Restoration: Detailed Feasibility Studies*. Report prepared for the Ministry of Water, Land and Air Protection.
[38] Personal communication, Josie Symonds, Ecosystem Biologist, Ministry of Forests, Lands and Natural Resource Operations, February 15, 2013.
[39] 842 hectares represents the sum of pole/sapling broadleaf, pole/sapling coniferous, pole/sapling mixed, young forest broadleaf, young forest coniferous, young forest mixed, mature forest broadleaf, mature forest coniferous and mature forest mixed.
[40] Troy, Austin and Ken Bagstad. 2009. *Estimating Ecosystem Services in Southern Ontario*. Report commissioned by the Ontario Ministry of Natural Resources.

resulting figure ($142, 2012$) was applied to the area of forest within the Mission Creek study area (843 ha) to estimate the habitat value of the forested area within the study area.

The 2009 study was also used to estimate the habitat value associated with wetlands. Consistent with forests, the wetlands estimate derived by Troy and Bagstad used an average of three relevant studies. The per hectare per year value ($81, 2012$) was applied to the wetlands within the study area (62 ha) to derive the total value of habitat derived from wetlands.

The same approach was employed to estimate the habitat value associated with grasslands in the study area. In this case, the value per hectare per year ($101, 2012$) was transferred from a study by Willis and Benson that compared the user benefits and costs of three nature reserves in the United States.[41] This value was applied to the 425 hectares[42] of grasslands within the study area to derive the total habitat value of grasslands.

The final component of the habitat value associated with the Mission Creek study area is that which is derived from farmland. A 2009 study on the value of farmland estimated the willingness of households to pay into a fund that would be used to pay farmers to set aside farmland for wildlife.[43] The study concluded that the willingness to pay was $25 (2012$) for the protection of 2,428 hectares. For the current study, the $25 value was converted to a per hectare per year estimate by dividing by 2,428. The resulting figure was then multiplied by the estimated number of households in Kelowna that would be willing to make such a payment (54,760[44]*33%[45]) to get a per hectare per year estimate of the value of farmland for wildlife habitat in the Mission Creek study area.

The Value of Habitat: Results (2012$)

The value of habitat (by land cover type) in the Mission Creek study area is summarized in Table 5 below.

Table 5 – Value of Habitat by Land Cover Type

Land Cover Type	Land Cover Area (ha)	Habitat Value (2012$ per ha per year)	Habitat Value (2012$ total)
Forest	843	142	119,802
Wetlands	62	81	5,006
Grasslands	425	101	43,028
Farmlands	1,067	189	201,238
TOTAL	**2,396**	**513**	**369,073**

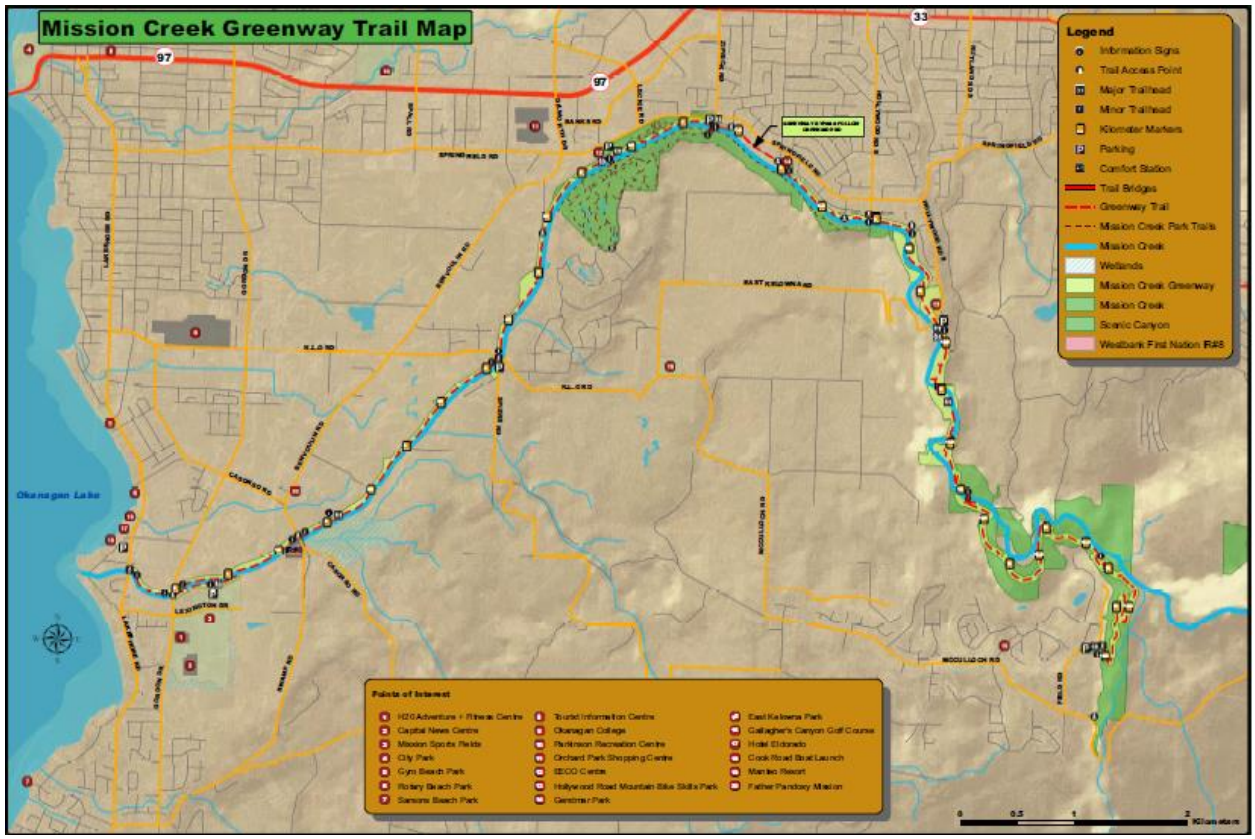
[41] Willis, K. G. and J. F. Benson. 1988. *A comparison of user benefits and costs of nature conservation at three natural reserves*. Regional Studies: The Journal of the Regional Studies Association, Volume 22.
[42] Grasslands are the sum of herb, forb-dominated, graminoid-dominated, shrub/herb, and low shrub landcover types.
[43] Robbins, Mark, Nancy Olewiler and Marion Robinson. 2009. *An Estimate of the Public Amenity Benefits and Ecological Goods Provided by Farmland in Metro Vancouver*.
[44] Number of private dwellings in Kelowna, Statistics Canada 2011 Census.
[45] Number of survey respondents from a study on the public amenity value of farmland in Abbotsford, BC that said they would be willing to pay into a fund that would be used to compensate farmers that set land aside for wildlife habitat. Source: Ministry of Agriculture and Lands. 2007. *Public Amenity Benefits and Ecological Services Provided by Farmland to Local Communities in the Fraser Valley.*

Outdoor Recreation

The Value of Outdoor Recreation: Background

Mission Creek is extremely important from a recreation perspective, not just for the people of Kelowna but also for the surrounding area and for tourists and visitors from further away. As one of the highest use parks in the region, Mission Creek Regional Park is considered a flagship park for the Regional District of Central Okanagan (RDCO) Parks Service.[46] The Mission Creek Greenway (figure below), a jewel for the city of Kelowna, is comprised of 16.5 kilometres of trail adjacent to Mission Creek. The Greenway is host to a number of outdoor recreational and tourism activities including walking, running, cycling (for recreation and commuting), horseback riding, and bird watching – all of which help demonstrate the importance of Mission Creek to the people of Kelowna. Annual Kokanee stream spawning is also a popular viewing opportunity for residents and visitors to Kelowna. In 2007 it was estimated that the number of Greenway users per day averaged 1,450.[47]

Map 2: Mission Creek Greenway



Construction of the Mission Creek Greenway was completed in phases. Phase 1, which included 7.3 km of trail, was completed in 1998. Phase 1 benefited from the donation of over 16 hectares of land, with an estimated market value of $300,000 (1998$). Community support for the construction of the second phase of the Greenway was overwhelming. Design and construction of 9 km of trail took place between

[46] Personal communication, Sandra Mah, Regional District of Central Okanagan – Parks Service, January 31, 2012.
[47] Ibid.

2004 and 2005. The project partners and fundraising campaign raised a total of $1.47 million for the construction of the trail and amenities. Commitments from partners, individuals, and corporate donors included:[48]

- Donation from land owners: $525,000
- Regional District of Central Okanagan: $250,000
- City of Kelowna: $200,000
- Provincial-Federal Grant: $250,000
- Other grants: $70,000
- Corporate and community donations: $177,000
- Consultants and contractors donated services: $31,500

More Land Gifted to Greenway

A small section of the Mission Creek Greenway will be tidied up with a wider trail and landscaping, thanks to a gift from the province. The B.C. government has granted nearly thee hectares of Crown land along Hollywood Road South that has sat vacant for decades. The city of Kelowna plans to spruce up the Greenway section so it's easier and more pleasing for hikers and bikers….The land [a 2.83 hectare parcel], which has an assessed value of $473,700, fills a gap in the Greenway park and allows the city to complete a network of trails running along the creek.

Source: http://www.kelownadailycourier.ca/front-page-news/more-land-gifted-to-greenway-10112.html

The Environmental Education Centre for the Central Okanagan (EECO) is located in Mission Creek Regional Park. Staff at EECO provide recreational and educational programs to local school children and the general public. In 2012, it was estimated that 25,000 visitors stopped into the EECO to view the displays and spend time in the park or greenway. In the same year, EECO bookings and events specifically relating to the Mission Creek Greenway attracted 6,600 people onto the Greenway. School programs brought an additional 11,000 visitors.[49] Some of the more significant events held on or in association with the Mission Creek Greenway include: [50]

- Kokanee Salmon Exhibit at the EECO – one of three major exhibits held at the EECO – which drew an estimated 8,100 people in 2012.
- Kokanee Salmon Festival - held in 2012, the festival hosted 25,000 attendees.
- Kokanee Run – in 2012, this annual event, which began in 2005 drew 45 local school children and 160 participants in total with the proceeds from the run going to support the Friends of Mission Creek Society.
- Take Off on a Hike Program - guided hikes led by Parks Services interpreters along the Greenway.
- Tracks program – walking program for novice walkers involving bi-weekly walks along the Greenway and in Mission Creek Regional Park.

In addition to the events identified above, a number of fundraising events were held on the Greenway in 2012. Specifically, 15 fundraisers were booked for the Greenway with participants estimated at 4,000. As

[48] Ibid.
[49] Other small group events (walking groups, sports teams, run clubs) are common on the greenway and are not booked through the RDCO and therefore not accounted for in these estimates of users.
[50] Personal communication, Sandra Mah, Regional District of Central Okanagan – Parks Service, January 31, 2012.

a result of these bookings $1,700 was paid to the RDCO. Examples of 2012 events include Hike for Hospice, Juvenile Diabetes Research Foundation, Prostate Canada Foundation, and Plan Okanagan.[51]

The Value of Outdoor Recreation: Methods

There are three components to the estimated ecosystem service values associated with outdoor recreation for the study area. The first component estimates expenditure on nature-related experiences, specifically outdoor activities in a natural environment[52] and wildlife viewing. Expenditure estimates were derived from a significant study done by Environment Canada in 1996 on the value of nature to Canadians. The study estimated nature-related expenditure by province. The study revealed that in 1996, per capita expenditure on outdoor activities in a natural environment in British Columbia was $320.[53] Per capita expenditure on wildlife viewing was estimated at an additional $65. For the purposes of this study, these estimates were inflated to 2012 dollars and applied to the population of Kelowna to estimate total annual nature related expenditures for all of Kelowna. To approximate the portion of these expenditures attributable to the Mission Creek study area we divided the Mission Creek study area (3,624 ha) into the total area for the Kelowna district (21,737 ha)[54] and applied the result to the nature related expenditures estimate for the city of Kelowna. The study area comprises 17% of the area of the jurisdiction of Kelowna. Thus it is assumed that 17% of nature-related expenditures incurred by the Kelowna residents would translate to our study area.

The second component of the outdoor recreation value associated with the study area pertains to the consumer surplus associated with recreation. For recreation, consumer surplus is the difference between how much consumers value outdoor recreation and how much they spend on outdoor recreation (as described above). In other words, in this context, consumer surplus is the maximum amount that a person recreating would be willing to pay in excess of actual expenditures rather than forgo the experience. Numerous methods exist to estimate consumer surplus, the most common of which is contingent valuation. With contingent valuation consumers are asked how much they would be willing to pay in a hypothetical market for outdoor goods (e.g. access to provincial parks), over and above their expenditure on equipment, travel, and fees or licenses. An Environment Canada study estimated the willingness of British Columbians to pay for outdoor activities and wildlife viewing in a natural environment.[55] These estimates were used to calculate the willingness to pay for these experiences on a per capita basis. This value was then applied to Kelowna's population. The total value for the city was then apportioned to the study area (i.e. 17% of total area).

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[51] Ibid.

[52] "Outdoor activities in natural areas" were defined as trips taken to natural areas such as forests, water bodies and other areas for the main reason of participating in one or more of the following activities: sightseeing in natural areas, photographing in natural areas, gathering nuts, berries and firewood, picnicking, camping, swimming/beach activity, canoeing/kayaking/sailing, power boating, hiking/backpacking, climbing, horseback riding, cycling in natural areas, off-road vehicle use, downhill skiing, x-country skiing/snowshoeing, snowmobiling and relaxing in an outdoor setting. Participants also indicated whether wildlife viewing, recreational fishing or hunting were secondary reasons for the trips.

[53] Environment Canada. 2000. *The Importance of Nature to Canadians: The Economic Significance of Nature-related Activities.*

[54] City of Kelowna. 2008. *Official Community Plan*.

[55] Environment Canada. 2000. *The Importance of Nature to Canadians: The Economic Significance of Nature-related Activities.*

The final component of the value of recreation estimate is the aesthetic and amenity value associated with outdoor recreation. This value was derived from a study that evaluated the benefits of employing pollution control on an urban/suburban river in Massachusetts.[56] This same value was presented in the Troy and Bagstad study on the value of ecosystem services in Ontario.[57] The per hectare per year value was converted to 2012 dollars and applied to the study area that is river (94 ha) to derive a total aesthetic and amenity value for the river habitat of the Mission Creek study area.

The Value of Outdoor Recreation: Results (2012$)

The value of recreation and tourism for the Mission Creek study area is summarized in Table 6 below.

Table 6 – Value of Outdoor Recreation

Value component	Value (2012$ per ha per year)	Value (2012$ total)
Expenditure on outdoor activities	2,299	8,331,344
Expenditure on wildlife viewing	510	1,848,392
Willingness to pay for outdoor activities	419	1,517,221
Willingness to pay for wildlife viewing	130	471,439
Aesthetics and amenity	259	24,372
TOTAL	**3,617**	**12,192,768**

Water Supply and Quality

The Value of Water Supply and Water Quality: Background

Water is fundamental to the survival of humans and wildlife. It is a necessary input to both our society and the economy. The supply of water has a value because it is used for drinking, irrigation, food production, sanitation, energy production, forestry and tourism. While water is a provisioning service itself, it is also necessary for all other provisioning services (e.g. food, fibre, timber) and many supporting services (e.g. photosynthesis, nutrient cycling) as well as some cultural services (e.g. recreation, aesthetic).

[56] Rich, Peter and Joe Moffitt, 1982, "Benefits of pollution control on Massachusetts' Housatonic River: A Hedonic pricing approach," *Journal of the American Water Resources Association,* Volume 18, Issue 6, 1033-1037, December 1982.
[57] Troy, Austin and Ken Bagstad. 2009. *Estimating Ecosystem Services in Southern Ontario*. Report commissioned by the Ontario Ministry of Natural Resources.

Wild Water is Also Tap Water

There are still people who don't realize that very often the water rushing by in an upland stream or lapping the shore of a fishing lake is the same water that comes out of their tap into a glass for drinking.

Certainly the renters who piled 12 truckloads of horse manure within a few metres of Mission Creek last winter either didn't know or didn't care.

Staff from the Black Mountain Irrigation District had to move in with a backhoe to load up the steaming mass of E. coli-laden excrement and remove it before spring brought millions of gallons of snowmelt running off high elevations, raising the level of Mission Creek and washing those piles into the roiling water – just above the BMID intake…..Larratt admits that waterfront is attractive for recreation, particularly in a dry landscape such as the Okanagan, but she says it's important to spend the effort, time and money to protect such areas, "or, we'll spend alot more for treatment of drinking water.

Source:
www.kelownacapnews.com/news/137199743.html

Watersheds collect, capture, filter and deliver water. Forested watersheds are a vital component of a clean and regular supply of drinking water. Wetlands also play important roles in the supply of water as they provide water filtration, detoxification, and nutrient retention services, as well as flood attenuation. The Mission Creek watershed is part of the Okanagan Lake Basin. It is the largest tributary in the basin, providing 28% of the flow.[58] The average annual use of water within the Basin is 219,000 ML (31% of this total is domestic water use; 67,890 ML).[59] The City of Kelowna is one of the main users drawing much of its water from Okanagan Lake. The flow and quality of water from Mission Creek is therefore a key component of the provision of a sufficient supply of clean water for the Okanagan Basin and the City of Kelowna.

Mission Creek is also an important source of irrigation water for surrounding agricultural lands. The two major water licence holders on Mission Creek are the Black Mountain Irrigation District (BMID) and the Southeast Kelowna Irrigation District (SEKID).[60] The average annual demand from BMID from 1991 to 2006 was 11,610 ML,[61] and the average annual demand from SEKID between 1995 and 2007 was 11,080 ML (total demand is 22,700 ML). Annual total water demand from Mission Creek has grown at a rate of 0.65% in the last 29 years.[62] About 65% of the total consumption in 2004 was for agricultural purposes with the remainder for domestic water use including residential housing, commercial entities and industrial lots.[63] Water withdrawals for agricultural purposes occur primarily between May and September, with the peak occurring in August.[64]

[58] Summit Environmental Consultants. 2010. Okanagan Water Supply and Demand Project: Phase 2 Summary Report. Okanagan Basin Water Board. http://www.obwb.ca/wsd/about/project-reports
[59] Ibid.
[60] Water Management Consultants. 2010. *Mission Creek Water Use Plan*. Report prepared for the Mission Creek Watershed Partnership.
[61] Ibid.
[62] Agua Consulting, 1995. *2005 Drought Management Plan.* Report to the Black Mountain Irrigation District
[63] Water Management Consultants. 2010. *Mission Creek Water Use Plan*. Report prepared for the Mission Creek Watershed Partnership.
[64] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.

The Value of Water Supply: Methods

Mission Creek contributes approximately 28% of the stream flow for the Okanagan Basin (i.e. Okanagan Lake).[65] The Okanagan Basin Water Board reported that the average annual water use within the basin is 219,000 ML, of which 31% is for domestic water use (67,890 ML). Assuming that 28% of water use in the Basin is supplied by Mission Creek, the total water supplied by the Creek is estimated at 61.3 million cubic metres (28% of 219,000 ML), and the total domestic water use supplied by the Creek is estimated at 19 million cubic metres (28% of 67,890 ML). In order to value this water supply, we applied 50% of the current bulk user's water price from the City of Kelowna ($0.80/$m^3$*0.5)[66] to the estimated average total water use (61.3 M m^3), and the domestic water supplied by Mission Creek to the Basin (19 M m^3).[67] The entire Mission Creek watershed contributes to this water supply value by capturing, releasing and transporting this water. As a result it was necessary to attribute the value of water supply to the natural cover area for the entire watershed (46,785 hectares).[68] The value of water supply from the Mission Creek watershed is estimated to be between $7.6 million and $24.5 million/year. This translates to a range of $162.52/ha/year (domestic water use) to $524/ha/year (total water use). The portion of the Mission Creek watershed within our study area has 1,423.5 hectares of natural cover (comprised of forest, wetland, river, grassland, herb and shrub cover). The estimated value of natural cover for the study area is $231,349 to $746,286 per year using the value per hectare for water supplied by the Mission Creek watershed.

The Value of Watershed Filtration Services: Methods

Natural cover in watersheds including forest, grasslands and wetland contribute to water filtration services that influence the water quality of water flows in rivers and streams. Estimates of the value of water filtration services provided by forests and wetlands were transferred from a study on ecosystem services provided by watersheds in the B.C. Lower Mainland.[69] The study relied on a US-wide study of municipalities that found the cost of treatment for surface drinking water supplies varies with the per cent forest cover in the watershed source area.[70] This study concluded that there is a 20 per cent increase in water treatment costs for each 10 per cent conversion of forest cover. In other words, where forest cover is lower, water treatment costs are higher.

The results from the Lower Mainland study were used to assess the value of water filtration services by forests and wetlands in our study area. The economic value of water filtration was based on avoided water treatment costs due to the forest/wetland cover in the watershed. We were able to transfer this value per hectare given that the per cent forest/wetland cover was found to be similar to that of the Mission Creek watershed (i.e. 74%).

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[65] Summit Environmental Consultants. 2010. Okanagan Water Supply and Demand Project: Phase 2 Summary Report. Okanagan Basin Water Board. http://www.obwb.ca/wsd/about/project-reports

[66] City of Kelowna Water Rates. http://www.kelowna.ca/CM/page398.aspx

[67] 50% of the bulk water user price was used for the cost of water supply, and 50% of this price was used to estimate the value for water filtration in the following section.

[68] Area includes forest cover, wetland cover, rangelands, and rivers.

[69] Wilson, S.J. 2010. Natural Capital in B.C.'s Lower Mainland: Valuing the benefits from Nature. Pacific Parks Foundation and David Suzuki Foundation. Vancouver, B.C.

[70] Ernst, C., Gullick, R. and Nixon, K. 2007. "Protecting the Source: Conserving forest to protect water." In *The Economic Benefits of Land Conservation*. The Trust for Public Land. www.tpl.org

The Lower Mainland study estimated that water treatment costs would increase by 20 per cent if the average forest and wetland cover declined by 10 per cent. Based on the domestic water use within Metro Vancouver, the total avoided value applied to the watershed forest and wetland cover was $2,127.76/ha/year (inflated to 2012$). For the Mission Creek watershed, we adjusted the dollar value per hectare according to the total annual domestic water supply for the Basin (19 million m^3; see derivation above), and used 50 per cent of the bulk water users price of $0.80/$m^3$.[71] The adjusted value was a total value of $1.5 million for the entire Mission Creek watershed, or $32.95/ha/year (forest and wetland area) based on the avoided cost of a 20 per cent increase in the cost of water. The adjusted value of $32.95 was multiplied by the area of forest and wetland within the study area (i.e. 905 hectares combined) to arrive at an estimate of the value of water supply and filtration.

The Value of Water Supply and Filtration Services: Results (2012$)

The annual value of water supplied by the Mission Creek watershed to the Okanagan Basin is between $7.6 million and $24.5 million per year, or $162.52/ha/year (domestic water use) and $524/ha/year (total water use). These values applied to the natural cover within our study area result in total estimated values of $231,349 and $746,286 per year.

The water filtration services provided by the entire Mission Creek watershed were estimated at $1.5 million or $32.95/ha/year (forest and wetland area). The total value for the study area is $29,817 per year.

Forest Carbon

The Value of Forest Carbon: Background

Forest ecosystems are known to store large amounts of carbon. Over half of the global land-based carbon (terrestrial organic soil and biomass carbon) is currently stored in forests. The carbon stored in standing trees and in the soil surrounding them has a direct correlation with forest age because of their cumulative years of growth.[72] Carbon sequestration, meanwhile, refers to the annual uptake of carbon by an ecosystem after subtracting the carbon released to the atmosphere due to respiration, disturbance and decomposition.

The Value of Forest Carbon: Methods

The estimated carbon stored by forests located within the study area is based on three studies that estimate forest carbon within the Montane Cordillera ecoregion (which includes the Mission Creek watershed). The studies provide estimates of 260, 300, and 324 tonnes of carbon per hectare of forest. The average value (i.e. 295 tonnes of carbon per hectare of forest)[73] was applied to the forested portion

[71] 50% of the bulk water user price was used to estimated value because other 50% was used to estimate value of water supply. City of Kelowna Water Rates. http://www.kelowna.ca/CM/page398.aspx

[72] Pregitzer, K.S., and Euskirchen, E.S. (2004). "Carbon cycling and storage in world forests: biome patterns related to forest age." *Global Change Biology*. 10:2052-2077.

[73] Stinson et al. 2011. Canada's Managed Forest C Dynamics. Global Change Biology. Vol 17; 2227-2244; Kurz, and Apps 1999. A 70-Year Retrospective of Carbon Fluxes in the Canadian Forest Sector. *Ecological Applications*. 9:526-547; Shaw, C.H., J.S. Bhatti, and K. Sabourin. 2005. An ecosystem carbon database for Canadian forests. Northern Forestry Centre Information Report NOR-

of the Mission Creek study area.

The economic value of carbon can be estimated based on several different valuation methods. Examples include: the avoided costs of the predicted impacts of climate change (i.e. damages avoided due to avoiding the release of carbon from a forest); replacement costs; and, employing the market price of carbon resulting from a carbon trading scheme. In general, policy makers use an estimated social cost of carbon (SCC) or a shadow price for carbon that reflects avoided costs to assess the economic benefits of climate change mitigation.[74] Avoided costs reflect the avoided damages in terms of the predicted impacts of climate change due to rising concentrations of atmospheric carbon dioxide if the stored carbon were to be released. Carbon prices that result from cap and trade programs and carbon taxes also exist. In some instances the value of a carbon tax is set at the marginal cost representing the cost to abate one tonne of CO_2e (carbon dioxide equivalent) towards achieving an emission reduction target.

An average carbon value was calculated based on multiple sources of market and SCC estimates for the purposes of this study. The estimated carbon value (inflated to 2012$) used in this study is $79.50 per tonne of carbon based on a combination of the following:

- The Alberta government's Emission Reduction Regulations for large industrial emitters carbon price of $15 per tonne of CO_2e, which is equal to $55.05 per tonne of carbon (constant price).[75]
- The 2011 carbon tax rate of $25 per tonne of CO_2 or $91.75 per tonne of carbon in British Columbia.[76]
- In the U.S., the federal government conducted a year-long inter-agency consultation to develop a SCC estimate to be used in cost-benefit analyses of potential U.S. federal regulations. The SCC values used by the US government ranged from $5 to $65 per ton of CO_2e (2007 U.S. $), with a central value of $21 per ton of CO_2e (2007 U.S. $). This value equates to $75.78 per metric tonne of carbon (2012 Canadian $).[77]
- Environment Canada uses an SCC estimate of $25 per tonne of CO_2e, equal to $94.64 per tonne of carbon in its Regulatory Impact Analysis Statement on the Renewable Fuels Regulations. Sensitivity values ranging from $10 to $100 per tonne of CO_2e, equal to $36.70 to $367.00 per tonne of carbon are used to establish the value.

The average dollar value per tonne of carbon ($79.50/tonne of carbon) was applied to the average carbon stored per hectare of montane cordillera forest (295 tC/hectare), to arrive at a dollar per hectare estimate

X-403. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB.

[74] Price, Richard, Thornton, Simeon and Stephen Nelson. (December 2007). *The Social Cost of Carbon and the Shadow Price of Carbon: What they are, and how to use them in economic appraisal in the UK*. Department for Environment, Food and Rural Affairs (UK).

[75] Specified Gas Emitters Regulation (SGER), under Alberta's Emission Reduction Regulations, requires 12% reduction in emissions intensity from facilities that emit greater than 100,000 tonnes of CO_2e. Compliance may be achieved through emissions performance credits, generation or purchase of offsets or contribution to the Climate Change Technology Fund at a price of $15 per tonne of carbon dioxide equivalent. http://environment.alberta.ca/02486.html Other country programs in comparison have higher prices: Finland at $89.39/t carbon (US dollars) and Sweden at $150/t carbon.

[76] B.C. Ministry of Finance, "How the Carbon Tax Works,". http://www.fin.gov.bc.ca/tbs/tp/climate/A4.htm

[77] In the U.S., carbon and CO2e is reported per ton, rather than metric tonne. The value per ton of CO2e was converted to dollars per metric tonne (1 ton = 0.907 metric tonne), then converted to Canadian dollars (http://www.bankofcanada.ca/rates/exchange/10-year-converter/), then converted to Canadian dollars per tonne of carbon (1 tC = 3.67 tCO2), and then converted to 2012 Canadian dollars per tonne of carbon (using Bank of Canada online inflation calculator).

of $23,425. Given that the carbon is stored at a fixed point in time, we considered the carbon value as a carbon annuity similar to a carbon annuity account (CAA). A CAA is an account where the full carbon price is made directly into an annuity account, and as long as the sink remains in place, the carbon provides an annual earning/value from the annuity account.[78] The annuity coefficient applied to the full carbon value was based on 3% earnings over 50 years to estimate the annual value of the carbon storage.[79] The resulting annual value is an estimated $910.41/ha/year. While the estimated carbon stored per hectare of forest (295 tC/ha) is an average for the forest region, to be conservative the value per hectare was adjusted according to the forest age type provided in the land cover data. Forest carbon values were estimate at $227.60/ha/year ($910.41*0.25) for pole/sapling forest cover; $455.20/ha/year ($910.41*0.5) for young forest cover; and $910.41/ha/year ($910.41*1.0) for mature forest cover.

The annual carbon sequestration estimate was based on an analysis from the Lower Mainland ecosystem services study[80] which calculated forest carbon sequestration using CITYgreen software.[81] The analysis found that the total tree canopy cover area within the lower Fraser Valley and Metro Vancouver sequesters an annual average of 0.8 tonnes of carbon per hectare. This value was transferred to the study area and the average carbon value ($79.50) was applied to it to derive a total value for the study area.

The Value of Forest Carbon: Results (2012$)

The forest carbon stored within the study area is estimated at $386,480 per year.

The value of forest carbon sequestration is $59.70 per hectare per year resulting in an estimated value of $50,306 per year for carbon sequestration.

Wetland Carbon

The Value of Wetland Carbon: Background

Wetlands store large amounts of carbon in their soils and peat. As evidence, peatlands occupy about three per cent of the world's surface but store between 16 and 33 per cent of the global soil carbon pool.[82]

The Value of Wetland Carbon: Methods

The carbon stored in wetland soils was transferred from a Lower Mainland study[83] that determined wetland carbon storage using data from Canada's Soil Organic Carbon Database.[84] The soil organic carbon

[78] Swingland, I. (ed). 2003. Capturing Carbon and Conserving Biodiversity: The Market Approach; Feng, H. et al. 2002. "The Time Path and Implementation of Carbon Sequestration." American Journal of Agricultural Economics. 84:134-149.

[79] Calculation: ($23,425*0.03887) 3% interest rate was used as this is the low end discount rate used by Environment Canada for ecosystem related studies. 50 years was used as an average discount rate period.

[80] Wilson, S.J. 2010. Natural Capital in B.C.'s Lower Mainland: Valuing the benefits from Nature. Pacific Parks Foundation and David Suzuki Foundation. Vancouver, B.C.

[81] American Forests. CITYgreen software ArcGIS 8.x http://www.americanforests.org/productsandpubs/citygreen/

[82] Bridgham, S.D. et al. 2006. "The Carbon Balance of North America Wetlands." *Wetlands*. Vol. 26: 889-916.

[83] Wilson, S.J. 2010. Natural Capital in B.C.'s Lower Mainland: Valuing the benefits from Nature. Pacific Parks Foundation and David Suzuki Foundation. Vancouver, B.C.

[84] Tarnocai, C., and B. Lacelle. 1996. *Soil Organic Carbon Database of Canada*. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Canada.

data was extracted spatially from this geo-referenced database by land cover type. The data suggests that wetlands store between 169 and 642 tonnes of carbon per hectare in the Lower Mainland study area, depending on the wetland type (i.e. shallow water wetland, bog). The average carbon stored by wetlands (i.e. 339.7 tonnes of carbon per hectare) was transferred to the wetland area in the study area (339.7tC/ha*62.2 ha). The annual value was calculated using the average carbon value of $79.50/tC (see forest carbon section for the derivation of this number), which was then annualized using an annuity calculation at 3 per cent over 50 years (also see forest carbon section).

The Value of Wetland Carbon: Results (2012$)

The annual value of carbon stored by wetlands is estimated at $65,230 for the study area.

Grassland Carbon

The Value of Grassland Carbon: Background

Grassland ecosystem services are often overlooked, despite their provision of several vital services such as climate regulation, genetic biodiversity, and soil conservation. Grasslands store far more carbon than cultivated lands because they provide a complete vegetative cover and plants grow for seven to eight months of the year versus the typical three to five months for agricultural crops in this region.[85] When grasslands are ploughed or converted to agricultural lands, carbon is rapidly released to the atmosphere. It has been determined that even when grasslands are restored, carbon recovery is slow.[86]

The Value of Grassland Carbon: Methods

The carbon stored in grassland soils was estimated at 121 tonnes per hectare based on the results of a Canadian grassland study.[87] The carbon value was calculated at $9,619/ha based on the average carbon value of $79.50 (see forest carbon section) and using the estimate of 121 tonnes per hectare. To estimate an annual value for this stored carbon per hectare, a carbon annuity of 3% over 50 years was applied. The result ($373.84/ha) was applied to the grassland/shrub/herb cover area (425 hectares) in the study area, to arrive at an estimated annual value (425 ha*$373.84/ha).

The Value of Grassland Carbon: Results (2012$)

The annual value of the carbon stored by grasslands/shrub/herb cover is estimated at $158,729 within the study area.

[85] Sala, O.E., and Paruelo, J.M. 1997. "Ecosystems Services in Grasslands." In: *Nature's Services: Societal Dependence on Natural Ecosystems*. G.C. Daily (Ed.). Island Press. Washington, D.C.
[86] ibid.
[87] Smith, W.N., Desjardins, R.L., and Grant, B. 2001. "Estimated changes in soil carbon associated with agricultural practices in Canada." *Canadian Journal of Soil Science*. 81:221-227.

Air Filtration

The Value of Air Filtration by Forests: Background

Trees play an essential role in the provision of good air quality on two fronts. First, they produce oxygen for the air humans' breathe. Second, trees provide air filtration services by absorbing air pollution into their leaves. Studies show that trees can remove 8 to 12 grams of air pollutants per square metre of canopy.[88]

The Value of Air Filtration by Forests: Methods

The value for air filtration services provided by the trees within the study area was transferred from an ecosystem services study undertaken for B.C.'s Lower Mainland[89] which relied on CITYgreen software[90] to assess the amount of air pollutants removed by the tree canopy cover in that study area. CITYgreen calculates the value of air cleansing by trees using average removal rates for carbon monoxide, nitrogen dioxide, particulate matter and sulphur dioxide. The analysis found that trees in the study area remove about 100 kilograms of pollutants per hectare. The kilograms removed per hectare range from 6 kilograms for carbon monoxide to 33 kilograms for ozone. The transferred annual value of $620.80 per hectare of forest was adjusted for age as follows: pole/sapling forest cover ($620.80*.25/ha/year), young forest ($620.80*0.5/ha/year), and mature forest ($620.80*1.0/ha/year).

The Value of Air Filtration by Forests: Results (2012$)

The annual value of air filtration provided by the forests is estimated at $263,538 within the study area.

Flood Protection

The Value of Flood Protection (Water Regulation): Background

Floods occur along streams and rivers during peak water flows due to high rainfall and/or snowmelt as well as the characteristics of the stream or river through which water moves. Stream characteristics are influenced by both human (e.g. stream channelization due to diking) and environmental factors such as terrain slope, vegetation type and cover, soil, and floodplain characteristics. Not all flooding should be regarded as bad as floods can provide for cleansing and regeneration. For example, flooding that occurs on floodplains provides increased fertility for agricultural soils.

Unfortunately people, houses and businesses are often located in historical floodplain areas. Flooding can cause extensive damages. As a result, resources are often deployed to eliminate or minimize the risk

[88] Nowak, D.J., Wang, J., and Endreny, T. 2007. "Environmental and Economic Benefits of Preserving Forests within Urban Areas: Air and Water Quality." In: *The Economic Benefits of Land Conservation*. The Trust for Public Land. San Francisco, California. http://www.tpl.org/tier2_rp1.cfm?folder_id=175

[89] Wilson, S.J. 2010. *Natural Capital in B.C.'s Lower Mainland: Valuing the benefits from Nature*. Pacific Parks Foundation and David Suzuki Foundation. Vancouver, B.C.

[90] American Forests. CITY green software ArcGIS 8.x www.americanforests.org/productsandpubs/citygreen/

of flooding. Managing for flood risk is typically done at the expense of nature and ecosystem services and can often be counterproductive.

Natural capital such as forests, rivers, lakes, wetlands and permeable soils provide natural flood protection services for communities. For example, forests and wetlands collect and regulate water flow within watersheds by storing and slowing the release of water and thereby provide natural protection against flooding and erosion. Permeable soils allow surface water to infiltrate through the soil horizons (rather than immediately running-off as with urban impermeable surfaces) and recharge groundwater resources. Changes in stream flow due to a reduction in natural cover such as forest cover and wetland cover can result in: lower water levels in dry seasons; higher than normal water levels in wet seasons or during storm events; greater amounts of sediments entering rivers; and increased water temperatures.[91]

Stormwater runoff is a significant problem in urbanized areas, due to the sheer area of impervious surfaces (e.g. roofs, roads, sidewalks, driveways). Parkland reduces the stormwater runoff as well as stormwater management costs by capturing rainfall and slowing its runoff. Vegetation and pervious soil cover in parks allow rainfall to infiltrate and recharge the groundwater, and provide a surface area that intercepts and stores water. A study of Philadelphia's 10,334 acre park system found that the parks reduced runoff by 496 million cubic feet, which was found to translate into $5.95 million in annual cost savings ($1,421/ha/year).[92]

The Value of Flood Protection (Water Regulation): Methods

The economic value of flood protection provided by forest cover in the study area was transferred from an assessment of B.C.'s Lower Mainland ecosystem services values[93] which calculated the economic value for stormwater run-off control as a replacement value provided by forest cover. The study relied on the CITYGreen software.[94] This GIS-based analysis tool measured the canopy cover in the study area and evaluated the stormwater management replacement cost using a scenario where the current forest cover was removed and converted to urban land use.[95] The change from forest cover to urban land uses typically involves the removal of a large proportion of the forest canopy and conversion of most pervious surfaces to impervious surfaces. In the Lower Mainland primary study area (i.e. the lower part of watersheds), the

[91] Nowak, D.J., Wang, J., and Endreny, T. 2007. "Environmental and Economic Benefits of Preserving Forests within Urban Areas: Air and Water Quality." In: *The Economic Benefits of Land Conservation*. The Trust for Public Land. San Francisco, California. http://www.tpl.org/tier2_rp1.cfm?folder_id=175

[92] Harnik, P., and Welle, B. 2009. *Measuring the Economic Value of a City Park System*. Center for City Park Excellence. The Trust for Public Land. Washington, D.C.

[93] Wilson, S.J. 2010. *Natural Capital in B.C.'s Lower Mainland: Valuing the benefits from Nature*. Pacific Parks Foundation and David Suzuki Foundation. Vancouver, B.C.

[94] American Forests. CITYgreen software ArcGIS 8.x http://www.americanforests.org/productsandpubs/citygreen/

[95] CITYgreen estimates the stormwater runoff reduction capacity of trees within a study area, using curve numbers for urban and suburban soils developed by the USDA Natural Resources Conservation Service. The software employs methods documented in Technical Release 55: Urban Hydrology for Small Watersheds, commonly known as "TR-55," to estimate the flow of water over land within the study area boundary. For stormwater and water quality modeling, CITYgreen applies the TR-55 model from the USDA Natural Resources Conservation Service (NRCS) and the long-term hydrologic impact analysis (L-THIA) spreadsheet from the U.S. EPA and Purdue University. CITYgreen assesses how land cover, soil type, slope, and precipitation affect stormwater runoff volume, time of runoff concentration, and runoff peak flows. It calculates the volume of runoff that would need to be contained by stormwater retention basins if the vegetation were removed. Multiplying this volume by construction costs, estimates the dollars saved by tree canopy cover.

forest cover provided an estimated annual benefit worth $615.49 per hectare,[96] in terms of the replacement cost of stormwater management (replacement cost of $57/cubic metre).[97] This per hectare flood protection value was transferred to the forest cover for the Mission Creek study area (843 ha).

Wetlands also provide natural mini-reservoirs for the storage of water runoff. International studies have reported on ranges of values for the ecosystem services provided by wetlands. For example, a meta-analysis of 89 studies found the median value of flood control provided by wetlands to be $889.60 (US$464/ha/year in 2000$ converted and inflated to 2012 CDN $).[98] A recent study by TEEB on water and wetland values reported that the value of flood protection provided by wetlands ranges from $14/ha/year to $9,369/ha/year (average of $4,691.50/ha/year). The range is based on just four estimates, and the wide range is likely a result of the type of valuation and study area.

The Mission Creek stream corridor and wetlands provide flood control because of their ability to collect and transport water through the watershed. In this study we transferred the median value from the meta-analysis ($889.60/ha/year) to the area of wetlands (62.2 ha) and stream (94 ha).

The Value of Flood Protection (Water Regulation): Results (2012$)

The value of water regulation services provided by forest covers in the study area is $518,652 per year. The estimated value of the flood protection provided by wetlands and the stream are an additional $138,793 per year.

Waste Treatment

The Value of Waste Treatment by Wetlands: Background

Wetlands absorb nutrients such as nitrogen and phosphorus that run off farmlands due to the use of fertilizers and manure, and from livestock. The amount of nutrients that a wetland can absorb varies depending on the type, size, plants and soils. Estimates range from 80 to 770 kilograms per hectare per year for phosphorus removal, and 350 to 32,000 kilograms per hectare per year for nitrogen removal.[99]

The Value of Waste Treatment by Wetlands: Methods

The costs of removing nitrogen and phosphorus by waste treatment plants have been estimated to range from $3.57 to $9.98 per kilogram of nitrogen and $25.66 to $71.87 per kilogram of phosphorus based on water treatment costs in Metro Vancouver (inflated to 2012$).[100] These replacement costs can be used as a proxy for the value of waste treatment services provided by wetlands in the study area. Using the low end values for both the removal of nitrogen and phosphorus and the amount of nitrogen and phosphorus removed by wetlands, the value of waste treatment by wetlands was estimated. The annual value for

[96] Forest cover provided additional stormwater storage/management of 59.4 million cubic metres.
[97] Based on construction cost of $57 per cubic metre of stormwater volume (average cost from U.S. municipalities) annualized over 20 years at 6% interest by CityGreen software.
[98] Schuyt, K. and Brander, L. 2004. *The Economic Values of the World's Wetlands*. Swiss Agency for the Environment, Forests and Landscape and WWF-International. Amsterdam, The Netherlands.
[99] Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and the Nature Conservancy of Canada.
[100] Ibid.

nitrogen removal is estimated at $1,249.50 per hectare (350 kg/ha/year multiplied by $3.57; 2012$), and the annual value for phosphorus removal is estimated at $2,060.50 per hectare (80 kg/ha/year multiplied by $25.66; 2012$). The combined total value per hectare is $3,310/ha/year. This annual value was applied to the total wetland area in the study area (62.2 ha).

The Value of Waste Treatment by Wetlands: Results (2012$)

The waste treatment services provided by wetlands in the study area are valued at $205,740.

Value of Ecosystem Services Summary

Table 7 summarizes the estimated value of ecosystem services associated with the study area in its present state. The total value of $18,831,009 does not include the value of gross farm receipts for the agricultural land located within the study area, which are valued at an additional $4,841,800 (see the Value of Farmland: Results).

Table 7 – Summary of the Value of Ecosystem Services in the Study Area

Ecosystem Service	Total Annual Value (2012$)
Farmland (WTP only)	4,220,353
Habitat	369,073
Outdoor recreation	12,192,768
Water supply (low estimate)	231,349
Water filtration	29,817
Climate regulation (storage)	610,439
Climate regulation (sequestration)	50,306
Air quality	263,538
Flood protection (forests)	518,652
Flood protection (wetlands and streams)	138,973
Waste treatment (wetlands)	205,740
TOTAL	**18,831,009**

The Value of Restoring Mission Creek

The purpose of this section of the report is to present estimates of the value of select ecosystem services for the Mission Creek study area under a restoration scenario. The need for restoration on Mission Creek is first established and a description of a number of key benefits associated with priority restoration activities follows.

Mission Creek Today

Based on the type and degree of alteration that has taken place over time to Mission Creek as well as the effects of these alterations on the ecosystem and the value of the creek to residents and visitors, portions of Mission Creek within the City of Kelowna have been identified as high priority for stream restoration activities. While Mission Creek was historically a very important spawning stream for the Okanagan Lake fishery, degraded habitat conditions as a result of human alterations to the stream have severely limited the habitat potential. Research on the suitability of fish habitat (salmon habitat in particular) has demonstrated that simplified, uniform channels, resulting from losses of large woody debris (LWD) and particularly log jams, and/or channelization impair the capacity and viability of salmonid habitats.[101]

Most portions of lower Mission Creek were diked for flood control in the 1950's.[102] Today, the majority of lower Mission Creek is straight, diked or riprapped to protect private property from flooding and prevent the lateral movement or shifting of the channel.[103] Of the 12 kilometres of Mission Creek upstream from the mouth, eight kilometres or approximately 67% has been diked, channelized or confined.[104] The diking has impaired natural stream processes and negatively impacted spawning, rearing and overwintering habitat for two fish species - rainbow trout and kokanee - especially.[105] Figures 1 and 2 below depict the lower portion of Mission Creek before and after diking.

[101] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.
[102] Ibid.
[103] Ministry of Environment, Lands and Parks. 1998. *Status report on Mission Creek and Upper Mission Creek Watershed.*
[104] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.
[105] Ibid.

Figure 1: 1939 OrthoPhoto Illustrating the Natural Stream Alignment(s) of Mission Creek Pre-Diking

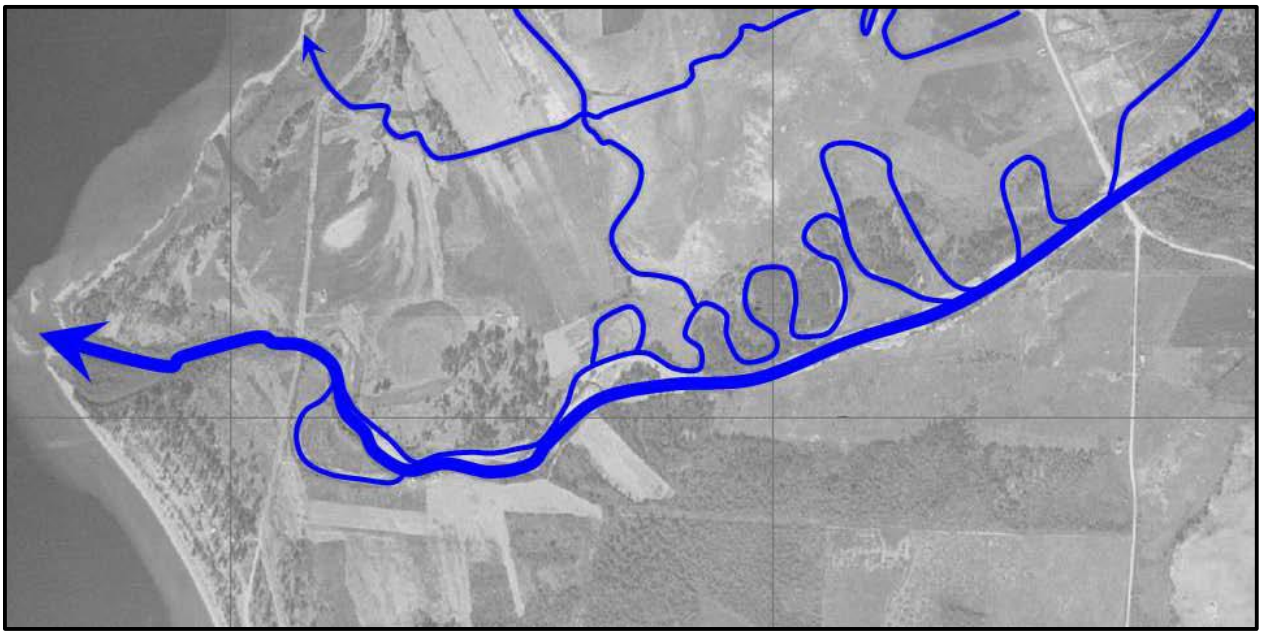

Figure 2: 2009 OrthoPhoto Illustrating Current Stream Alignment of Mission Creek Post-Diking

Channelized rivers are characterized by higher flow velocities, vegetation removal, and increased sediment erosion and deposition processes.[106] The tributary floodplains in Mission Creek have been largely cleared to the streamside to increase land area for agriculture and/or urban development. Further, large woody debris that previously slowed flow velocities and played an important role in fish habitat has been largely removed from the stream. An instream survey of the 12 kilometres upstream of the mouth

[106] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.

of the creek revealed that only a few residual pieces of functional wood remain.[107] At the same time, sediment produced by the erosion of banks and from upstream sediment sources that would naturally be stored in the floodplain or creek channel is instead carried downstream to lower gradient reaches of the creek where they accumulate.[108] The result is to reduce instream capacity in these sections. From a fisheries perspective, silt and sand in what would otherwise be spawning gravel has increased, resulting in a loss of spawning habitat throughout much of the study area.[109]

The cumulative impact is a significant decline in suitable fish habitat in Mission Creek. Research points to two significant factors affecting production from Mission Creek spawning areas: minimum water flows and spawning gravel quality. Very low spawning and incubation flows are known to have a negative impact on kokanee production and excessive amounts of sand have been identified in Mission Creek spawning area substrates. The increase in sand particles meanwhile is known to significantly reduce salmonid egg to fry survival.[110]

Restoration Benefits

A number of studies have investigated the potential benefits of restoring Mission Creek, especially the lower portion of the stream that has been heavily diked and channelized, to a condition more representative of its historical state. Prior to diking, a large proportion of the flow was not confined to the meandering channel in high flow years and the stream was able to flood out of its channel. Benefits associated with the overbank flow of Mission Creek include:[111]

- Reducing the erosive forces to which the stream banks are subjected.
- Deposition of many of the finer silt and sand sediments on the flood plain, fertilizing the flood plain, and reducing the amount of sand/silt size sediments left in the channel gravels following flooding.
- Connecting, for varying periods of time, the wetlands of the floodplain with Mission Creek, providing rearing areas and nutrition input for fish.

The restoration of Mission Creek is expected to result in significant habitat improvements for the Mission Creek fishery. As discussed earlier, the dramatic decline in the fishery is largely attributed to channel modifications and loss of critical in-stream spawning habitat. A primary goal in restoring Mission Creek is to replace in-stream habitat and improve aquatic habitat in support of kokanee salmon and rainbow trout in particular. Past research on habitat potential has estimated that Mission Creek is capable of supporting 3,700-6,000 fall rainbow parr and 186,000-221,000 kokanee spawners with discharges in the range of 0.42-2.83 m^3/s. This comprises 65 per cent of the total known rainbow rearing capability and over 50 per cent of the kokanee spawning capacity in the Okanagan Lake tributaries.[112] At appropriate flow rates,[113]

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[107] Ibid.
[108] Ibid
[109] Ministry of Environment, Lands and Parks. 1998. *Status report on Mission Creek and Upper Mission Creek Watershed.*
[110] Trdger, C. D. 1989. *Fish Production Capacity of Mission Creek at 4 Modelled Discharge Levels*. Fisheries Project Report No. FAIU–12.
[111] Ministry of Environment, Lands and Parks. 1998. *Status report on Mission Creek and Upper Mission Creek Watershed.*
[112] Wild Stone Resources. 1992. *Okanagan Lake Tributaries Plan, Volume 1, Mission Creek Management Plan.* Submission to the Southern Interior Region Executive Committee.
[113] Kokanee migrating and spawning flows (September and October) = 1.13 m3/s; and Kokanee incubation flows and trout rearing (November to August) = 0.85 m3/s. Source: Mission Creek Management Plan

it is estimated that the capacity of Mission Creek is 308,000 spawning kokanee, and 5,500 fall rainbow trout parr and 57,000 rainbow fry.[114]

Agricultural lands bordering Mission Creek may also benefit from restoration. A high water table in much of the agricultural land adjacent to Mission Creek limits crop production and yield in these areas. Restoration would result in a wider stream cross-section that should lower the water table. It is hoped that the loss of agricultural land due to dike setbacks (an essential element of restoration) would be offset by the lower water table and improved soil conditions in upland agricultural areas.[115]

The restoration of Mission Creek is also expected to reduce the annual risk of flooding during the spring freshet. The channelization of Mission Creek has resulted in a straightened, narrowed and diked waterway. The justification for channelization was for better flood protection and increased agricultural land use. The straight, narrow, shortened waterway has, however, resulted in a greater flood threat given the loss of the meandering pattern of the river, which would have slowed the water flow. The trapezoidal channel is also subject to sediment deposition eroded from upstream locations. Sediment deposition is especially troublesome in the lower gradient stretches and is believed to have significantly reduced channel capacity in some stretches in addition to increasing the water table and some flooding of agricultural land.

Channelization has also resulted in a 75% loss in wetland/riparian areas that would have provided spring flood storage for the watershed and river. Stream restoration would restore riparian habitat allowing for natural wetlands to re-establish. Stormwater capacity will also be increased with a wider stream.

In addition to the benefits described above, restoration is expected to result in improvements to habitat for species (especially birds and amphibians) that rely on the stream's riparian zone. The increased meandering is expected to increase wildlife values through increases in the density and species composition of riparian vegetation, and increases in vegetated cover.[116] Restoration will allow important riparian vegetation such as wild rose, dogwood, willow and cottonwood to re-establish.

Mission Creek and its riparian zone host, or have the potential to host, numerous species at risk or species of concern. Species listed as "rare" or "endangered" associated with this area include: Black Cottonwoods, Lewis' Woodpecker, Western Screech-owl and Grasshopper Sparrow. At-risk species associated with this area and habitat type include: Gopher snake, Racer, Western Rattlesnake, Painted Turtle, Great Basin Spadefoot, Great Blue Heron, Long-billed Curlew, and Spotted Bat.

Urban forests are known to enhance carbon storage. Healthy and abundant urban and peri-urban forests are even more important in B.C. where the rapid loss of carbon storage is occurring in coniferous forests as mountain pine beetle and tussock moth continue to devastate Okanagan forests. Further, Kelowna has set goals for reducing greenhouse gas emissions that can be partially met or at least enhanced by creating

[114] Wild Stone Resources. 1992. *Okanagan Lake Tributaries Plan, Volume 1, Mission Creek Management Plan.* Submission to the Southern Interior Region Executive Committee.

[115] Mission Creek Working Group. 2011. *Capital Funding Proposal for the Mission Creek Restoration Initiative*.

[116] Gaboury et. Al. 2004. *Mission Creek Habitat Restoration: Detailed Feasibility Studies*. Report prepared for the Ministry of Water, Land and Air Protection.

greater carbon stores through the re-establishment of forests, tree cover, grasslands and wetlands. Enhancing riparian habitat will enhance carbon sequestration as a result of increased vegetation along the stream corridor.

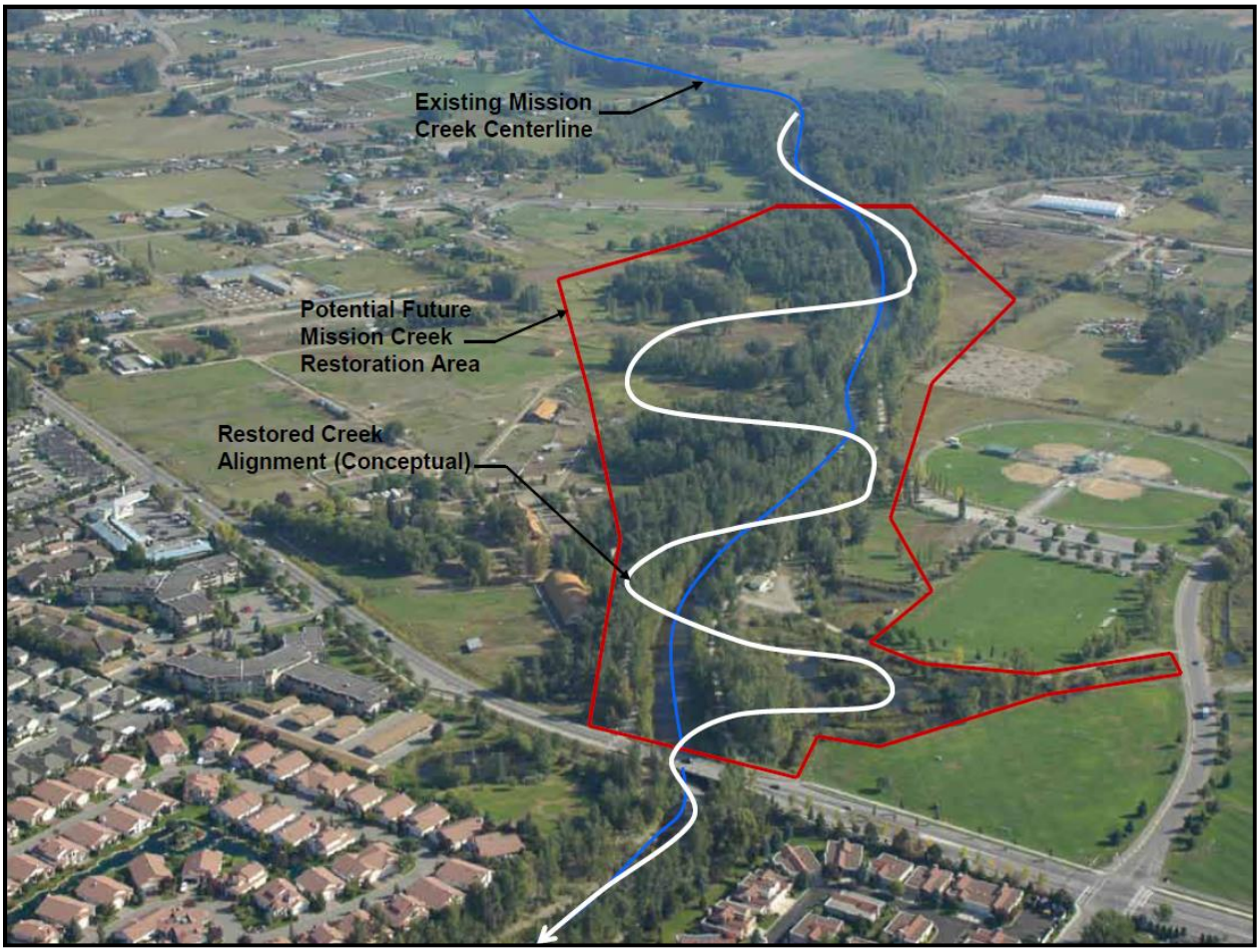
Restoration Priorities

While the complete removal of the dikes along Mission Creek may not be feasible in the near term, dike setback is expected to result in significant habitat improvements. One study shows that even a 10 to 20 metre widening of the channel, to a width of 40 to 50 metres between dikes, can result in bar formation, better pool and riffle definition, some substrate sorting to improve the quality and quantity of spawning gravels, and the creation of a few small vegetated islands.[117] These are all features characteristic of Mission Creek prior to channelization.

Meandering the stream could result in numerous desirable habitat characteristics, including areas of shallow riffles and deep pools, discrete micro and macro-habitats where silt, sand, gravel, cobbles and boulders have been sorted, increased instream cover, local velocity and depth diversity, and reduced in-stream sedimentation and embeddedness. The need to replace large woody debris in meander pools to facilitate the creation of deeper pools, cover, habitat diversity and off-channel connectivity was also identified as a priority.[118] Figure 3 below depicts a potential restoration result within Mission Creek (between Casorso Road Bridge and Gordon Drive Bridge) and demonstrates the hypothetical meandering that could be restored to the steam in this location.

[117] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.
[118] Ibid.

Figure 3: Conceptual Meandering in a Segment of Mission Creek Between Casorso Road and Gordon Drive



These habitat enhancements will maximize the benefits to all native fish species within Mission Creek, with particular improvement to spawning and/or rearing habitats for kokanee and rainbow trout.[119] The Mission Creek Rehabilitation Feasibility Study summarizes the expected impacts of the priority restoration activities as follows:

> *In lower Mission Creek, the restoration of pool-riffle sequences would provide hydraulic gradients where spawning gravels would readily deposit, particularly within pool tail-outs. These habitats would be highly utilized by kokanee spawners and provide holding areas for adult fish. It would also restore rearing areas for rainbow juveniles in the lower river. Such measures would restore much of the fish habitat in lower Mission Creek.*

Restoration Results

The following sections of the report present values for select ecosystem services assuming priority restoration activities are undertaken. The analysis focuses on ecosystem services for which the most significant changes are expected and include fishing, flood control and waste treatment and carbon

[119] Gaboury et. al. 2004. *Mission Creek Habitat Restoration: Detailed Feasibility Studies*. Report prepared for the Ministry of Water, Land and Air Protection.

storage and sequestration. Background information as well as details for the methods used is provided for the expected increase in the value of the Mission Creek fishery along with valuation results. For flood protection, waste treatment and carbon storage and sequestration, only results are presented as background information and details of the methods used were presented earlier in the report.

The Value of the Mission Creek Fishery: Background

Recreational fishing in British Columbia is an extremely valuable activity. The province's lakes, rivers and streams support a wide variety of recreational angling opportunities for tens of thousands of anglers. In fact, close to half of all adult British Columbians have bought an angling licence at some point during their lifetime.[120] A 2009 study states that:

"*Freshwater angling is not just an enjoyable pastime or outdoor thrill, but also a powerful economic engine in many regions of BC. Despite this important fact, the sector remains little known and underappreciated. A major reason for the inadequate public understanding is the lack of accessible information on the sport fishery's economic dimensions and importance."*[121]

Poll Results Show Value of Salmon to B.C. Residents

Results from a recently conducted poll show just how important salmon are to the people of B.C. An overwhelming majority of British Columbians says that economic development shouldn't come at the expense of salmon habitat and that local salmon runs should trump commercial fishing interests. Just over half of B.C. residents say they would pay higher taxes in order to protect wild salmon habitat and 89 per cent say laws meant to protect salmon habitat should be more strictly enforced.

Source:
http://outdoorcanada.ca/9934/news/articles

To provide some perspective on the importance of recreational fishing in the province in general and the study area more specifically, it is useful to examine results of a 2005 survey of the economic importance of freshwater recreational fishing in British Columbia.[122] The results were published in 2009 and revealed that 270,000 anglers spent $480 million on equipment, travel, accommodation and other items related to recreational fishing in 2005. Expenditures on a daily fishing excursion ranged from $25 per day (close to home) to $1,500 per day (for a higher end fishing experience). The average angler spends $120 per day catching 2.1 fish. The $480 million spent by the recreational fishing community in 2005 had a ripple effect throughout the provincial economy, resulting in $210 million in gross domestic product and $120 million in total wages and benefits for B.C. workers. About 7,500 jobs or 2,500 person-years of employment directly related to angling and an additional 3,875 in indirect and induced employment result from recreational fishing. The province meanwhile realized an estimated $53 million in provincial tax revenues with the federal government reaping an additional $72 million in revenues. All told, every $1 of angler spending is estimated to contribute 11 cents to the provincial treasury and 15 cents to the federal government.[123] An important recreational fishing region in British

[120] GSGislason and Associates Ltd. 2009. *Freshwater Sports Fishing British Columbia: Sending ripples through the economy*. Report prepared for the Freshwater Fisheries Society of BC.
[121] Ibid, page ii.
[122] Ibid.
[123] Ibid.

Columbia, Table 8 presents details on the economic impact of the recreational fishery for the Okanagan region in particular.

Table 8 – Economic Impacts from Freshwater Sport Fishing in the Okanagan, 2005[124]

Active anglers	35,400
Angler-days	362,000
Total catch (fish)	702,000
Angler expenditures	$44,600,000
Gross domestic product	$21,500,000
Wages and benefits	$12,200,000
Taxes paid	$12,600,000
Employment (person-years)	395

Mission Creek is the single most important tributary to Okanagan Lake in terms of both kokanee and rainbow trout production. Up to 80 per cent of the lake's stream spawning kokanee and rainbow trout populations use Mission Creek.[125] The two most important fish species to the fishing industry in British Columbia are also the two species that have historically been the most important to Mission Creek. Rainbow trout is the backbone of the fishing industry in B.C., accounting for close to half of B.C.'s total angler-days, fish caught and angler expenditures. Salmon is the next most important species in terms of angler interest and spending.[126] Historically, Mission Creek has been the main spawning grounds for kokanee in the Okanagan system.[127] Estimates from the 1950s suggest between 700,000 and 1.2 million fish spawned in Mission Creek per year. The first government assessment of kokanee spawning populations was conducted over 30 years ago and estimated stream spawners at 300,000 in Mission Creek. Table 9 provides a brief snapshot of kokanee spawner escapement in Mission Creek between 1971 and 1977.[128]

Table 9 - Historic Kokanee Spawner Escapement from Mission Creek

Year	Spawner Escapement
1971	312,100
1974	91,000
1975	30,000
1976	49,000
1977	52,000

The Mission Creek fishery was closed in 1995 as spawning numbers continued to decline far below acceptable numbers. In 1998 and 1999 less than 1,000 kokanee spawned in Mission Creek. Some

[124] Ibid.
[125] Trdger, C. D. 1989. *Fish Production Capacity of Mission Creek at 4 Modelled Discharge Levels*. Fisheries Project Report No. FAIU–12.
[126] GSGislason and Associates Ltd. 2009. *Freshwater Sports Fishing British Columbia: Sending ripples through the economy*. Report prepared for the Freshwater Fisheries Society of BC.
[127] Pearson, G. A. 1977. *Degradation in the Production of Stream Spawning Kokanee in the Okanagan Lake System.* Technical report prepared for the Ministry of Environment.
[128] Ibid.

population stabilization has been witnessed in recent years, though kokanee stream spawning numbers remain well below historic numbers.

Natural stream ecosystems are a prerequisite for abundant spawning and rearing habitat of stream fishes. Unfortunately, insufficient flows, a lack of suitable spawning gravel quantity and quality, agriculture, urban development, forestry and highway encroachment in the Mission Creek watershed have had negative impacts on fish habitat. As a result, restoring habitat for salmon and rainbow trout within Mission Creek has the potential to be significant.

The Value of the Mission Creek Fishery: Methods

To estimate the value resulting from the restoration of the Mission Creek fishery, three important value components were considered. First was to estimate the hypothetical spending on recreational fishing if the Mission Creek fishery were re-opened. This estimate was derived in much the same way that the estimate for spending on recreation was estimated.

Expenditure estimates were derived from the Environment Canada study on the value of nature to Canadians.[129] The study estimated recreational fishing expenditure by province. The study revealed that in 1996, per capita expenditure in British Columbia on recreational fishing was $62 (excluding boats and accommodation). This figure was inflated to 2012 dollars and applied to Kelowna current population to estimate total annual recreational fishing expenditures for Kelowna residents. To approximate the portion of these expenditures attributable to the Mission Creek study area, we divided the Mission Creek study area into Kelowna's total area (17 per cent) and applied the result to the recreational fishing expenditure estimate for Kelowna. It was assumed that 17 per cent of recreational fishery expenditures incurred by Kelowna residents would occur in the study area should the fishery be restored.

The second component of the recreational fishery value is the consumer surplus (measured as the willingness to pay for the activity in addition to expenditures incurred) associated with this activity. The Environment Canada study on the importance of nature to Canadians estimated the willingness of British Columbians to pay for recreational fishing.[130] As with fishing expenditures, the Environment Canada study estimates were used and the willingness to pay for this experience was calculated on a per capita basis and applied to Kelowna's population. The total value for the city was then apportioned to the portion of the jurisdictional area attributable to our study area (i.e. 17 per cent).

The final component was to estimate the value of restored habitat. For this estimate the results of a seminal study on the value of freshwater habitat used for salmon spawning and rearing in British Columbia was used.[131] This study examines different degrees of habitat quality and measures the resulting change in the value of the fishery. The authors conclude that the value of habitat is $2.63 (2004$) per hectare of spawning stream length or $3,730 (2004$) per kilometre of spawning stream length.

[129] Environment Canada. 2000. *The Importance of Nature to Canadians: The Economic Significance of Nature-related Activities.*
[130] Ibid.
[131] Knowler, D. et. al. 2004. *Valuing Freshwater Salmon Habitat as a Benefit of Protected Areas on the West Coast of Canada*.

For the purposes of this study, it was assumed that 12 kilometres of stream length would be restored. This length was multiplied by $3,730 (inflated to 2012$) to arrive at a value of the restored fishery habitat. This number was then converted to a per hectare estimate by dividing the result by the number of hectares classified as river for the study area.

The Value of the Mission Creek Fishery: Restoration Results (2012$)

Table 10 presents the value estimates associated with the restoration of fishing in Mission Creek.

Table 10 – Value Estimates of an Enhanced Mission Creek Fishery

Value component	Value (2012$ per ha per year)	Value (2012$ total)
Expenditure on recreational fishing	393	1,425,955
Willingness to pay for recreational fishing	139	504,924
Value of fishery habitat	668	62,861

The Value of Flood Protection and Waste Treatment: Background

In the past, engineering practices in urban areas frequently resulted in the conversion of natural rivers and streams into channels to minimize flooding and reduce erosion. These practices, however, destroy the natural balance of water systems and often result in the demise or elimination of aquatic and riparian species. In addition, channelization of streams and rivers often contributes to flooding problems instead of reducing or eliminating them.

According to Gaboury (2003), the instantaneous peak flow with a recurrence interval of 100 years for Mission Creek was estimated at 98 cubic metres per second.[132] However, stream capacity is known to vary along the length of the stream, and sedimentation within the channelized stream may have reduced the maximum capacity in some sections. The highest peak flow rates from 1960 to 2010 included 1969 (97.7 m^3/s); 1972 (91.2 m^3/s); 1986 (84.9 m^3/s); and, 1997 (84.5m^3/s). Each of 2011 and 2012 saw much higher than average peak flows, with peak discharge estimated near 120 cubic metres per second in 2012. These flows led to some localized flood impacts and emergency flood protection in the lower sections of Mission Creek.[133]

Historical measurements of B.C.'s climate show that the average annual temperature in the interior has changed by 1.1 degrees Celsius over the past century, and scientific estimates suggest that by the 2050s the mean annual temperatures across B.C. will be 1.4 to 3.7 degrees Celsius warmer.[134] Most of the province will be wetter in the winter (i.e. up to 26 per cent more precipitation), and in the summer southern B.C. may be up to 20 per cent drier. These changes will have significant impacts on natural systems including water resources and the water cycle, fisheries, forests and recreational opportunities. Many of the expected climate change impacts (i.e. costs) are associated with increased frequency and

[132] Gaboury, Marc and Pat Slaney. 2003. *Mission Creek Habitat Restoration Feasibility*. Report submitted to Ministry of Water, Land and Air Protection.
[133] Greg Sauer, City of Kelowna. Personal communication.
[134] Carlson, D. 2012. *Preparing for Climate Change: An Implementation Guide for Local Governments in British Columbia.* West Coast Environmental Law. Vancouver, B.C.

intensity of extreme weather events (i.e. heavy rainfall events, urban flooding). In addition, smaller snow packs and shrinking glaciers will contribute to lower summer stream flows, which will increase the frequency of summer water shortages in some regions. The increased risk of flooding will require the enhancement and protection of natural areas, investment in flood control and erosion control structures, or alternative strategies such as investing in green infrastructure. Most likely a combination of these measures will need to be implemented. The protection of natural areas and the ecosystem services that they provide (e.g. water regulation and flood protection) should be key components of these adaptation strategies. Thus, the predicted changes in the climate will likely increase the need for flood protection and the regulation of water flows.

Flood protection is important because it reduces the hazards associated with flood events that can affect people, the economy and the environment. The cost of flooding includes costs associated with fatalities and evacuations, transportation costs such as delays, destroyed infrastructure, loss of essential public services such as water supplies and power, agricultural losses, and private property costs including damage to homes and businesses (including loss of business when business operations are restricted). While the estimation of potential costs associated with Mission Creek flooding is outside the scope of this assessment, they have the potential to be significant in Kelowna. For comparative purposes, in the Chehalis River Basin (Oregon), flood events occurred in 1972, 1975, 1986, 1996, 2007 and 2009. The 2007 storm, delivered a record 20 inches of rain in 48 hours. The resulting flooding caused at least $166 million in private and public damages.

The Value of Flood Protection and Waste Treatment: Methods

Restoration of Mission Creek will increase the capacity for instream flow because the dikes will be set back resulting in a wider stream area. In addition, riparian areas and re-established riparian vegetation cover will increase infiltration rates and decrease storm water runoff. Restoration efforts along Mission Creek could feasibly result in an increase of 13 hectares of stream area, and 57 hectares in riparian cover types. A 57 hectare increase is equal to a 2.4 per cent increase in natural cover areas (restoration area is estimated to be 57 hectares divided by 2,384 ha, the current natural cover in the study area). It is estimated (extrapolated) that this could mean an increase of 20.1 hectares forest cover, and 1.5 hectares of wetland. These increased land cover areas were used to estimate restoration value estimates for flood protection and waste treatment (using the same methods described earlier in the report).

The Value of Flood Protection and Waste Treatment: Restoration Results (2012$)

Increased land cover types as a result of restoration translate into estimated increases in the annual value of ecosystem services as follows:

- $12,488 for flood protection by forests;
- $1,327 for flood protection by wetlands;
- $11,565 for flood protection (i.e. within the additional 13 hectares of stream area); and
- $4,918 for the annual increase in waste treatment by wetlands.

The Value of Carbon Sequestration: Methods

Restoration efforts are expected to increase vegetation cover along the stream length which will provide opportunities for increased carbon sequestration. It is estimated that restoration of Mission Creek could result in a 20.1 hectare, or 2.4 per cent increase in forested area. This value was used to estimate the increase in carbon sequestration resulting from the restoration of Mission Creek.

The Value of Carbon Sequestration: Restoration Results (2012$)

The increase in forested area results in an increase in the annual value of carbon sequestered by forest cover of $1,203.

Summary of the Value of Restoration

Table 11 summarizes the results of the restoration analysis. Key differences between the baseline and restoration scenario are based on the assumptions that the Mission Creek fishery could be revived and a 2.4 per cent increase in select provisioning services results from restoration. These assumed increases are relatively conservative given what is known with respect to the loss of some of the relevant land cover types that has occurred over time (i.e. a 75 per cent loss in wetlands) within the study area.

As a result of restoration, the value of ecosystem services in Mission Creek is expected to increase from almost $19 million to almost $21 million, an increase of about 10 per cent. This increase is largely owing to the value derived from the restoration of the Mission Creek fishery.

Table 11 – Summary of Mission Creek Ecosystem Services Based on Two Scenarios

Ecosystem Service	Baseline valuation (2012$)	Increase in select ecosystem services resulting from restoration (2012$)	Total value of ecosystem services with restoration (2012$)
Farmland (WTP only)	4,220,353		4,220,353
Habitat	369,073		369,073
Outdoor recreation	12,192,768		12,192,768
Water supply	231,349		231,349
Water filtration	29,817		29,817
Climate regulation (storage)	610,439		610,439
Climate regulation (sequestration)	50,306	1,203	51,509
Air quality	263,538		263,538
Flood protection (forests)	518,652	12,488	531,140
Flood protection (wetlands and stream)	138,973	12,892	151,865
Waste treatment	205,740		205,740
Fishery		1,931,547	1,931,547
TOTAL	**18,831,009**	**1,958,130**	**20,789,139**

Conclusion

The value of natural capital is often excluded from current measures of progress and is not taken into account in some land-use and policy decisions. For example, the value a forest provides in controlling stream-bank erosion and sediment load in a river is not reflected in the market price of forest land. Likewise, the value a wetland provides in purifying water and recharging an aquifer is not reflected in the price of water. Unfortunately in most cases the non-market value of natural capital is not recognized until services become so degraded or scarce that society is forced to pay to replace what was previously provided by nature at no cost.

Natural capital and ecosystem service accounts provide resources for policy development and land use decisions. These accounts provide an inventory of the ecosystem services provided by a forest as well as the associated values, such as the value of stormwater flow management, erosion control, and carbon storage for example.

The value of natural capital provided by the Mission Creek study area is estimated at $18,831,009 (2012$). The restoration of the lower 12 kilometres of Mission Creek is expected to result in a 10% increase in the value of select ecosystem services associated with the area under examination. This study is a first step towards a full natural capital account for the Mission Creek watershed and surrounding areas. More comprehensive accounting and monitoring of the services provided by the natural capital assets in the study area is needed to improve the reporting of the flows of ecosystem services. In addition, information on the users of the Mission Creek and other natural areas are required for a more accurate and detailed report on the values that the study area provides to nearby communities and visitors. More Canadian-based research and data sources, in general, are required to determine a full range of ecosystem service values relevant to Canadian ecozones, watersheds, and land cover types. At the municipal level, improved and updated information sources for land cover as well as environmental monitoring data for water supply, water quality, air quality, forest cover, recreational use, and cultural values are key to improving natural capital accounting and environmental reporting.

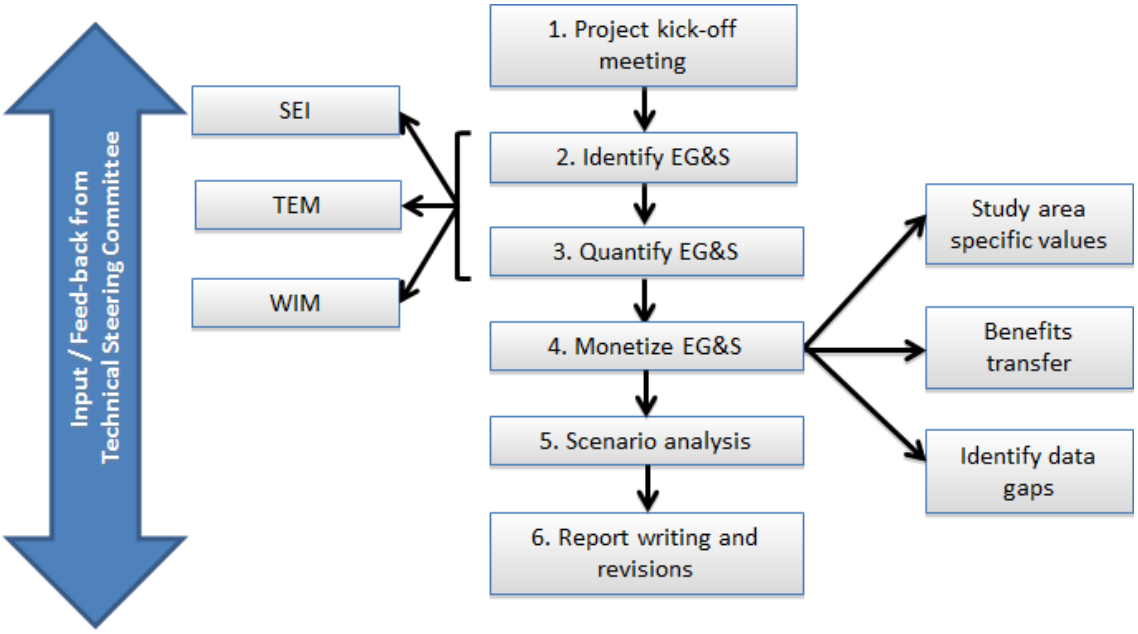
The results presented in this study are estimates for a select group of ecosystem services provided by the lower section of Mission Creek. Limitations in conducting ecosystem service valuation research include: 1) the availability of quantitative ecosystem service data; 2) spatial data on the current state of ecosystems and land; and, 3) studies documenting the impacts of various human land use types on ecosystem service values.

While there is uncertainty associated with the methods employed in this study (i.e. because of the reliance on benefits transfer), value approximations are superior to assuming a value of zero (as is current practice) when designing policy or making land-use planning decisions. Based on a comprehensive literature review and the application of economic valuation methods, estimates provided, while not comprehensive, are based on the best available information and are thus meaningful in representing some of the values that have not been monetized previously. This report is intended to be a building block in the process of natural capital accounting and ecosystem service valuation and monitoring.

Appendix A: Overview of Methodology

The figure below describes the general methodology that was employed to estimate the value of the ecosystem goods and services (EG&S) associated with the Mission Creek study area. Each step is described in more detail following the diagram.

Methodology Overview for Mission Creek Ecosystem Service Assessment.



Ecosystem Goods and Services Identification and Inventory

Identification of the ecosystem services of relevance to Mission Creek using the Millennium Ecosystem Assessment (MA)[135] and The Economics of Ecosystems and Biodiversity's (TEEB) reports was the first step. MA and TEEB are the leading sources of information on ecosystem services internationally. TEEB, for example, is an international initiative led by the United Nations, the European Commission, and the German and U.K. governments to develop a state-of-the-art foundation to link economics and ecology.[136]

The ecosystem services from the TEEB report are organized into four classes: provisioning services, regulating services, habitat services, and cultural and amenity services as presented in the table below.

[135] Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press. Washington, DC.
[136] http://www.teebweb.org/Home/tabid/924/Default.aspx

Typology of Ecosystem Services

Provisioning Services	
Food	Food, fish and meat for human consumption.
Water Supply	Water for human consumption, irrigation, and industrial use.
Raw Materials	Timber, fuelwood etc.
Medicinal Resources	Providing drugs, pharmaceuticals, tests, tools & assay organisms.
Ornamental Resources	Resources for fashion, jewelry, handicraft, worship and decoration.
Regulating Services	
Gas Regulation	Providing clean, breathable air, disease prevention, and planet habitability.
Climate Regulation	Provides a stable climate preventing increased climatic variability, glacial and permafrost melt, increased storm frequency and force, and global sea rise.
Disturbance Prevention	Preventing and mitigating natural hazards such as floods, storm surges, hurricanes, fires, and droughts.
Soil Retention	Retaining arable land, slope stability and coastal integrity.
Water Regulation	Providing water supply for natural irrigation, drainage, ground water recharge, river flows and navigation.
Biological Control	Providing pest and disease control.
Waste Treatment	Absorption of organic waste, natural water filtration, pollution reduction.
Soil Formation	Creating soils for agricultural and ecosystems integrity.
Pollination	Providing pollination of wild and domestic plan species.
Nutrient Regulation	Promoting healthy soils, and gas, climate and water regulating services.
Habitat Services	
Habitat and Biodiversity	Maintaining habitat for genetic and biological diversity, the basis for most other functions.
Nursery	Providing habitat for spawning and nesting for reproduction.
Cultural & Amenity Services	
Aesthetic	Enjoying and appreciating the scenery, sounds and smells of nature.
Outdoor Recreation	Experiencing outdoor activities in natural ecosystems.
Science and Education	Learning and research activities in natural ecosystems.
Cultural and Artistic	Experiencing nature through art, film, folklore, books, cultural symbols, architecture religion, spiritual activities and media.

Cover data was obtained in an effort to identify the specific ecosystem services for the study area. The figure below outlines the methodological progression from land cover data to the benefits derived from ecosystem services.

Linkages for Identifying Ecosystems and Ecosystem Services

For this project, land cover data was sourced from:

- Terrestrial Ecosystem Mapping (TEM)

- Sensitive Ecosystem Inventory (SEI)
- Wetlands Inventory Mapping (WIM)

The outcome was an inventory of EG&S of relevance to the Mission Creek study area, as well as an overview of the potential benefits they provide to the local community. Particular attention was paid to EG&S that were known to be of direct relevance to the study area, including recreational opportunities, water flow regulation, water supply (for irrigation and drinking), and habitat (for fish and wildlife).

EG&S Quantification

To quantify the EG&S identified, the ecosystems and environmental resources that exist in the study area were defined by land and water cover types and land use. The physical area for each of the relevant land and water covers was then quantified and ascribed the relevant EG&S to each type of land and water cover for the study area. The result was the derivation of a physical estimate for each relevant EG&S.

EG&S Valuation

Local valuation data was relied on to the extent that it was available for EG&S relevant to Mission Creek. In the absence of local data, valuation estimates were either derived using the local information or transferred from previously completed studies using a benefits transfer approach. With benefits transfer, relevant EG&S valuation studies were compiled and adapted to the Mission Creek study area. Appropriate studies were identified through a literature review using Environment Canada's Environmental Valuation Reference Inventory (EVRI), other EG&S valuation databases (e.g. ESVD), and relevant academic and grey literature.

The best available benefit transfer values were employed in this analysis and were adjusted to provide relevant monetary values to approximate the value of EG&S for the Mission Creek study area. Particular attention was paid to EG&S that were known to be of direct relevance to the study area, including recreational opportunities, water flow regulation, water supply, and habitat.