Economic Analysis in the Okanagan Basin

The Importance and Value of an Unchannelized Section of the Okanagan River

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Final Report

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Executive Summary

The Okanagan Basin Water Board (OBWB) and the Okanagan Nation Alliance (ONA) have partnered in an effort to demonstrate the importance of an unchannelized section of the Okanagan River. To conduct the analysis, OBWB contracted with ECONorthwest and Summit Environmental Consultants. In this report, we describe the objectives of the analysis, our approach to conducting the analysis, the methodologies we employed, and our findings.

Analytical Focus

Objective. The objective of this analysis is to describe (in quantitative and qualitative terms) the importance and economic values of the ecosystem services that the last remaining natural section of the Okanagan River supports.

Study area. The analysis focuses on ecosystem services supported by the section of the Okanagan River known as the Osoyoos Indian Band (OIB) Reserve Natural Section. We also include undeveloped land adjacent to the OIB Natural Section. Along with these adjacent lands, this section of the River comprises the **study area** we consider in the analysis. In total, the study area covers 105 acres of land.

Scenarios. In order to illustrate the importance and values associated with the **naturalness** of the study area, we compared the ecosystem services in the study area under two scenarios. Under the Baseline Scenario, we consider the ecosystem services the study area supports, as it exists today, and as it would exist in the future, without channelization or development. Under the Development Scenario, we consider the ecosystem services the study area would support if it were channelized and developed. We consider the marginal difference between the ecosystem services supported under each scenario to demonstrate the importance and value of the study area's naturalness.

Analytical Approach

Ecosystem services. This analysis focuses on the importance and values associated with the ecosystem services the study area supports under the two scenarios. Put simply, the concept of ecosystem services is used to describe the types of benefits (e.g., enjoyment from recreation, revenue from tourism, health benefits from improved air quality) humans derive from functional ecosystems.

Total economic value. In conducting this analysis, we understand that the same ecosystem service may provide a number of different types of benefits to a number of different types of people. To incorporate as many of these benefits into the analysis, we thoroughly examine the wide array of channels through which individuals interact with natural systems. In some cases, humans derive values directly from consuming a resource (e.g., eating salmon). In other cases, humans derive benefits more indirectly (e.g., viewing bald eagles that feed on salmon. Not all these benefits are quantifiable in monetary units. We quantify values where appropriate. In other instances, we describe the importance of a particular ecosystem service to a specific group of beneficiaries.

Comparing importance and values across ecosystem services. Throughout the analysis, we discuss several different types of importance and values associated with a long list of ecosystem services. When considering all of the results, it is useful to summarize the results visually, in a way that highlights the general themes of the findings (see table below). For quantitative results, we grouped values into Low, Medium, or High categories based on their relative distributions. For qualitative results, we grouped importance into the three categories based on the availability of substitutes. A service with few substitutes is (relatively speaking) more important than a service with many easy-to-find substitutes.

Table ES-1. Comparing Importance and Value Across Ecosystem Services

Magnitude Classification	Low	Medium	High
Qualitative Description	Many Substitutes	Some Substitutes	Few (if any) Substitutes
Quantified Result	Low Value	Medium Value	High Value

Salmon-Related Ecosystem Services

Salmon populations. Over the past several decades, salmon runs throughout the Columbia Basin have declined due to several factors, including overfishing, habitat destruction, and pollution. At one point, there were eight main sockeye stocks in the Columbia Basin. Today, only three remain. Of those three, the Okanagan sockeye stock accounts for 85-90% of all the sockeye in the Columbia Basin. Due to channelization and development along most of the Okanagan River, few areas remain that can support sockeye in search of spawning grounds. The study area provides most of the spawning habitat available to the Okanagan sockeye stock. Under the Development Scenario, the Okanagan's sockeye population would decline.

Salmon harvests. Historically, individuals across the Columbia Basin have relied on the Okanagan sockeye stock for their livelihoods. Harvests have been very low in recent history, but have increased over the past few years. There are six general fisheries targeting the Okanagan sockeye stock (see table below).

Table ES-2. Okanagan Sockeye Fisheries in the Columbia Basin

Fishery	2012 Okanagan Sockeye Harvest	Location
Columbia River Commercial	300	Mouth of Columbia River to Bonneville Dam
Columbia River Recreational	31,000	Across Columbia Basin
Columbia River Tribal	39,900	Bonneville Dam to McNary Dam
Yakima Broodstock	8,800	At Priest Rapids Dam
Colville Confederated Tribes	15,600	Upstream of McNary Dam
Okanagan (FSC, Commercial, and Recreational)	63,000	Okanagan River and Osoyoos Lake

Importance of salmon-related ecosystem services. In analyzing the importance and value of salmon-related ecosystem services, we identified six different categories (see the first column in the table below). For two of these categories, we describe the importance of salmon in qualitative terms; for the other four, we provide quantitative estimates of the values associated with those particular categories. The table below briefly describes our results. In some cases, the importance indicated in each row my not be additive across different rows. For example, the values quantified for passive-use value likely include some of the values reflected in the public's willingness to pay to avoid extinction. In the body of the report, we provide thorough detail describing each of these rows and our process for analyzing its importance.

Table ES-3. Salmon-Related Importance and Value

	Not Quantified		
Cultural Importance	Sockeye are integral the Syilx People's relationship to the land and the spiritual world.		
Health and Nutrition	Individuals ingest important nutrients when consuming the sockeye they harvest.		
	50-Year NPV	**100-Year NPV**	**200-Year NPV**
Sockeye Harvest in Canada	$11.2-$14.5 million	$13.7-$17.8 million	$14.4-$18.7 million
Sockeye Harvest in the US	$36.8-$51.9 million	$45.2-$63.7 million	$47.6-$67.0 million
Avoiding Extinction	$645.6 million	$792.9 million	$834.1 million
Passive-Use Value (WA only)	$2.6-$3.5 billion	$2.6-$3.5 billion	$2.6-$3.5 billion

Other Ecosystem Services

Identifying ecosystem services. In addition to salmon-related ecosystem services, we analyzed the importance and values associated with 10 additional ecosystem services the study area supports. We began our analysis with a much longer list of ecosystem services based on our experience and on available literature describing the types of ecosystem services typically supported by ecosystems like those in and around the study area. We went through this list of services and identified instances in which each service was or was not supported under the Baseline Scenario or the Development Scenario. After conducting this process, we focused our attention on the 10 ecosystem services with the most potential to change between the two scenarios.

Process for analyzing importance and value. For each ecosystem service, we described how the supply of the ecosystem service would be different between the Baseline Scenario and the Development Scenario. With this change in supply, we identified the most appropriate methodology available for describing or quantifying the importance or value associated with this marginal difference. In some instances, data were not sufficient to quantify the value of the change in ecosystem services. In those instances, we describe the magnitude of the value in qualitative terms.

Importance of other ecosystem services. We used a number of different approaches and methodologies to describe (in quantitative and/or qualitative terms) the importance and value of 10 ecosystem services, in addition to the salmon-related services described earlier. The table below summarizes our results. For three of the ecosystem services, we found that there likely would be no difference between the Baseline Scenario and the Development Scenario within the context of the Okanagan Valley. There were insufficient data available to quantify the value of education benefits or to tease out the specific values attributable to open space. We were able to quantify values for the other five ecosystem services.

Table ES-4. Importance and Value Associated with Other Ecosystem Services

	Not Quantified		
Open Space	There would be a decrease in open space with development, however many substitutes exist.		
Water Supply	There would be no net difference in water demand between the scenarios.		
Water Quality	Regulations on agricultural runoff would mitigate potential changes to water quality.		
Recreation	There would be little difference in non-fishing-related recreation between the scenarios.		
Education	There would be a decrease in education opportunities associated with the study area.		
	50-Year NPV	**100-Year NPV**	**200-Year NPV**
Stormwater Treatment	$5.2-$24.0 million	$5.9-$28.1 million	$6.1-$29.3 million
Flood Protection	$2.0 million	$2.5 million	$2.6 million
Carbon Sequestration	$0.2–$0.3 million	$0.4–$0.5 million	$0.7–$0.8 million
Air Quality	$0.2-$0.8 million	$0.2-$1.0 million	$0.2-$1.0 million
Habitat and Wildlife	$6.6 million	$6.9 million	$7.0 million

Distribution of Results

Distribution over time. For most ecosystem services, this analysis looks at the differences in ecosystem services between the two scenarios over time. The two most important factors to consider when conducting an analysis over time are the discount rate and the time horizon. The best way to consider the streams of different types of values over time is to apply a discount rate to values across the time horizon of the analysis, and calculate their respective net present values (NPVs).

Throughout the analysis, we apply a 3% discount rate, which represents the social discount rate the Treasury Board of Canada Secretariat recommends when "consumer consumption is involved and there are no or minimal resources involving opportunity costs (such as certain human health and environmental goods and services)." If, however, individuals within this current generation place equal importance on the quality of life of future generations, then a smaller discount rate may be warranted. This increase in inter-generational equity would increase the NPVs calculated in this analysis.

Throughout the analysis, we apply the 3% discount rate to values across three time horizons: 50 years, 100 years, and 200 years. Economists typically consider benefits during the time horizon over which those benefits can be guaranteed. In this case, 50 years represents the foreseeable future in terms of programs and projects that are currently being funded. The 200-year time horizon reflects the ONA's seven generations approach to natural resource management.

Distribution across beneficiaries. In summarizing the results of the analysis, we used three categories describing the level of importance and value associated with each ecosystem services (High, Medium, and Low). The table below summarizes the results and identifies the beneficiaries most closely tied to each ecosystem service. The first column identifies different types of importance or value tied to the ecosystem services the study area supports. The second column describes the magnitude of the importance or value of ecosystem services supported under the Baseline Scenario relative to those supported under the Development Scenario (these magnitudes are color-coded as they were elsewhere in the report). The columns that follow identify the relevant beneficiaries tied to the specific benefit category. Cells that are color-coded identify the relevant beneficiary groups for the benefit category. For cells labeled with an "X", we provided quantified results describing their importance

Generally speaking, the benefits derived from salmon-related ecosystem services represent higher magnitudes of importance and values relative to other ecosystem services the study area provides. This is because salmon-related services have few substitutes, and where quantification was possible, demonstrated large economic values. Furthermore, these benefits accrue primarily to residents within the Okanagan Valley, with fewer benefits going to groups outside the Columbia Basin.

Table ES-5. Distribution of Importance and Value Across Beneficiaries

		Beneficiaries					
		Okanagan Valley		Elsewhere in the Columbia Basin		Elsewhere in North America	
Benefit Category	**Magnitude of Importance/Value**	Indigenous Populations	Other Residents	Indigenous Populations	Other Residents	Canadian Residents	US Residents
Salmon (Cultural)	High						
Salmon (Harvest)	Medium	X	X	X	X		
Salmon (Avoiding Extinction)	High	X	X	X	X	X	X
Salmon (Passive-Use)	High	X	X	X	X		
Salmon (Health and Nutrition))	Low						
Stormwater Treatment	Medium	X	X				
Flood Protection	Low	X	X				
Open Space	Low	X	X				
Carbon Sequestration	Low	X	X	X	X	X	X
Air Quality	Low	X	X				
Water Supply	N/A						
Water Quality	N/A						
Recreation	N/A						
Habitat and Wildlife	Medium	X	X				
Education	Medium						

Conclusions

The study area is unique. Most of the Okanagan River has been dyked, channelized, or developed. The study area represents the only remaining natural section of the Okanagan River in British Columbia. As such, some of the ecosystem services it provides under the Baseline Scenario are unique (e.g., salmon-related services).

Development would decrease the supply of ecosystem services. By channelizing the River and developing adjacent lands in the study area, the Development Scenario would result in a decrease in ecosystem services the study area supports. While the study area is unique, many of the ecosystem services it supports are also supported elsewhere in the Okanagan Valley (e.g., air quality). Some of the ecosystem services, however, are indeed unique to the study area and would be lost with development.

Cultural importance has no substitutes. This importance defines and pervades the relationships among indigenous populations within the Okanagan Valley (the Syilx People), their relationships with other inhabitants of the region, and with the land. It is impossible to characterize cultural importance in the monetary language of economics, but it is essential to understanding the overall importance of the Okanagan sockeye stock. Adrienne Vedan writes, "The Okanagan view of the world is one in which people, beliefs, and nature are intertwined and inseparable. The plants, animals, hills, and water were viewed as having their own spirits and were likewise treated with the utmost respect." In the past, the well-being of the Syilx People was tied to the salmon, and the salmon's survival depended on the integrity of the ecosystem. Salmon are still important to the Syilx People, and the study site plays an important role in the salmon's lifecycle and survival.

Salmon-related benefits have few substitutes. Of all the ecosystem services we analyzed, those associated with the Okanagan sockeye stock are most unique and have the fewest substitutes available. Under the Baseline Scenario, the study area supports the existence of nearly the entire Okanagan sockeye stock. Individuals in the Okanagan Valley, elsewhere in the Columbia Basin, and indeed across the continent derive several different types of benefits from this sockeye stock. Under the Development Scenario, the overall viability of the Okanagan sockeye stock would decline, and insofar as the stock represents the largest sockeye stock in the Columbia Basin, the availability of substitutes is minimal.

Other ecosystem services are also important. While salmon-related benefits rise to the top of the ecosystem services the study area supports, it also supports many other important and valuable ecosystem services. There are substitutes for many of these services provided elsewhere in the Okanagan Valley. Their existence in the study area, however, is important insofar as it provides evidence of co-benefits tied to salmon and river restoration that could help promote future restoration efforts in the Okanagan Valley.

Local residents are not the only beneficiaries. The distributional analysis we conducted on our results show that indigenous populations and other residents in the Okanagan Valley derive many of the benefits tied the ecosystem services the study area supports under the Baseline

Scenario relative to the Development Scenario. They are not, however, the only beneficiaries. Individuals throughout the Columbia Basin (and elsewhere in Canada and the US) derive both use and passive-use benefits from the sockeye the study area supports. To the extent that the study area helps support other forms of wildlife and helps absorb greenhouse gases, it provides benefits that people across the continent consider important.

Next Steps

The results of this analysis provide useful insight into the ecosystem services the study area supports from an economic perspective. These results, however, represent one perspective on the issues at hand. Additional research could shed light on many of the hurdles we faced while conducting our economic analysis. Furthermore, while conducting our research, we have identified a number of other areas (tied to, but not necessarily under the umbrella of economics) that would benefit from additional research. After concluding the analysis, we conducted a brainstorming session during which we: (1) reflected on the data and information we compiled for the analysis, (2) identified hurdles we encountered, (3) discussed the results of the analysis within the context of cross-border natural resource management, and (4) compiled a list of guiding questions and potential next steps. We summarize these questions and next steps below.

- What is the overall approach to managing the Okanagan sockeye stock from the context of the Columbia Basin? How do the relevant agencies interact? Are there ways to improve cross-agency or cross-border management? Are there hurdles associated with ultimate responsibility for the stock?
- Do residents in the Okanagan Valley understand the extent to which the Columbia Basin relies on the sockeye stock that spawns in the Okanagan River? Do downstream residents understand which spawning habitats the Columbia Basin's sockeye rely on? To what extent do stakeholders see substitutes for wild, native sockeye salmon?
- What types of opportunities exist that link river restoration to multiple benefits? Can future restoration efforts (like the Okanagan River Restoration Initiative) support several types of benefits (e.g., recreation, salmon, open space) at once? Is the local community particularly interested in one set of benefits?
- To what extent do other fish species benefit from habitat restoration efforts that target sockeye salmon?
- Identify and describe resource tradeoff decisions that the area will face in the near-term (e.g., decisions that affect water availability, water quality, and development in the region).
- Identify potential future threats to the study area, and develop strategies for mitigating their negative effects on the ecosystem services the study area supports.
- Inform the relevant beneficiary groups of the valuable benefits the study area provides.

1 Introduction

The Okanagan Basin Water Board (OBWB) and the Okanagan Nation Alliance (ONA) have partnered in an effort to demonstrate the importance of a natural section of the Okanagan River north of the City of Oliver. To conduct the analysis, OBWB contracted with ECONorthwest and Summit Environmental Consultants.

The Okanagan River flows from Okanagan Lake in British Columbia, through the Okanagan Valley, and across the Canadian border into the State of Washington. The Okanagan River lies within the Columbia Basin and flows into the Columbia River near the City of Brewster in the State of Washington, between Wells Dam and Chief Joseph Dam. Much of the Okanagan River was channelized during the 20th century for agricultural and hydroelectric development, and to protect local residents from flooding. In the course of this development, very few sections of the Okanagan River remain in their natural states.

This study focuses on one natural section, north of the City of Oliver. The objective of this analysis is to describe the ecosystem services this natural section of river supports, from an economic perspective. To begin, we identify two scenarios, one describing the natural section as it exists today and in the future without development, and another describing that same natural section assuming it is channelized.

During early discussions with ONA staff, OBWB staff, and others participating in the project, it became clear that the Okanagan sockeye stock is the most important natural resource that the natural section of the Okanagan River supports. With this priority in mind, the majority of this report is dedicated to discussing the extent to which this stock relies on spawning habitat provided in natural sections of the Okanagan River, and the different ways individuals derive valuable benefits from the stock.

In order to clearly communicate the results of the analysis while meeting the stated objective, we have divided the remainder of this report into five pieces.

- First, we provide a general discussion supporting the analytical approach we applied in conducting the analysis.
- Second, we discuss salmon-related data, analyses, and results, including the cultural importance and economic values associated with salmon stocks in the Okanagan.
- Third, we discuss several other ecosystem services and the importance and value associated with each of them.
- Fourth, we summarize our findings within the context of a distributional analysis that looks both at the distribution of benefits over time and across beneficiaries.
- Fifth, we summarize several conclusions that our analysis supports and briefly discuss potential next steps that would be helpful to decision makers in the Okanagan Valley and elsewhere in the Columbia Basin.

2 Background, Approach, and Focus

Understanding the importance and values associated with the natural section of the Okanagan River requires a series of rigorous economic analyses, covering a broad suite of issues. In this section, we describe some of the concepts, methods, and approaches we use in the analysis.

2.1 Approach

In this section, we describe our approach to the analysis. We begin with a brief description of what ecosystem services are, and how they relate to economic analysis. Next, we describe the concept of total economic value, and identify several tools and guidelines commonly used for analyzing ecosystem services from an economic perspective. We conclude the section by describing our approach to understanding values over time and comparing the magnitude of importance and values associated with each ecosystem service considered in the analysis.

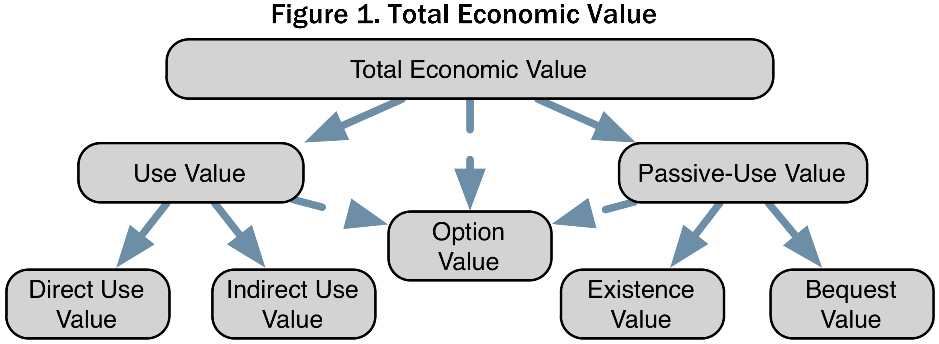
2.1.1 Ecosystem services

The term **ecosystem services** is used to describe the types of benefits humans derive from functional ecosystems (e.g., enjoyment from recreation, revenue from tourism, health benefits from improved air quality). We provide a thorough discussion of ecosystem services (including definitions, interactions with forms of capital, and feedback loops) in Appendix A. Put simply, ecosystem services represent instances in which outputs from natural systems and processes align with demands from humans and society. Our relationship with natural systems is tied to many different types of valuable benefits enjoyed by many different groups of people.

2.1.2 Total economic value

Figure 1 demonstrates the major categories of economic value for ecosystem services. We use this concept of total economic value to drive our analysis of ecosystem services from an economic perspective. The left side of the figure shows use value, perhaps the clearest type of economic value. Direct use value describes the value associated with the direct use of an ecosystem service, such as spending a day fishing. Indirect use value describes the ecosystem services that precede that direct service, such as the aquatic habitat that nurtures and provides refuge for the targeted fish.

Figure 1. Total Economic Value



The right side of the figure shows passive-use value, which represents nature's values that exist when there is no direct or indirect use of an ecosystem. Passive-use values are less obvious than use values, but – in some instances – can represent a greater total value because they incorporate demands from a larger population. The figure separates passive-use value into two categories. One, existence value, comes from people's desire for the continued existence of a species, landscape, or some other aspect of an ecosystem, or of the ecosystem as a whole. The other, bequest value, arises because people desire to ensure that the ecosystem will be available for enjoyment by future generations. Typically, these passive-use values are described in terms of an individual's willingness to pay for an object's current or future existence.

The middle of the figure shows another component of the total value, option value. Option value refers to the benefit of maintaining an opportunity to derive services from an ecosystem in the future. It can originate from either side of the figure. Sometimes, market prices exist that provide information useful for quantifying option values, but not always.

2.1.3 Economic tools

In some instances, markets exist that provide monetary values for some types of economic values associated with a particular ecosystem service. Oftentimes, however, functioning markets do not exist. In the absence of well-formed markets, economists have developed techniques for estimating the value of ecosystem services. Table 1 summarizes six of these economic techniques.

Table 1. Summary of Techniques Used to Estimate the Value of Ecosystem Services

Valuation Method	Description of Methodology
Avoided Cost	Estimate the value of a service by identifying and estimating the cost of future projects or programs that would be needed but for the current existence of the service.
Benefit Transfer	Estimate the value of a service at a particular site based on analyses estimating the value of a similar service in another geographic location.
Contingent Valuation	Estimate the value of a service with questionnaires asking respondents how much they would be willing to pay to protect the service, or how much they would be willing to accept to forego the service.
Hedonic Analysis	Estimate the value of a service by comparing property values of multiple households, controlling for several factors, and determining the impact of changes in quantity or quality of the service on property value.
Replacement Cost	Estimate the value of a service by identifying and estimating the cost for projects or programs required to replace the service.
Travel Cost	Estimate the value of a service by calculating the time and money spent by individuals traveling to enjoy or experience the service

In some instances, available time and resources, as well as the characteristics of the benefits themselves, will preclude compiling quantitative estimates of economic value. That is not to say, however, that these ecosystem services have no value. In its guidelines for conducting cost-benefit analysis, the Treasury Board of Canada Secretariat states that: (1) quantifying benefits is important in helping decision makers understand their options, (2) quantifying all benefits in monetary terms can be difficult, (3) non-monetized benefits can be too important to ignore.[1] The guidelines go on to suggest that, for non-monetized benefits, analysts should list relevant quantitative information (in non-monetary units), explain why monetization is not possible, describe the timing and potential magnitude of the non-monetized benefits, and discuss the strengths and limitations of the qualitative description of benefits. When quantification is not possible, we compile relevant information describing the ecosystem service in non-monetary terms, and discuss the ways in which people derive valuable benefits from the ecosystem service.

Benefit Transfer

In its guidelines for conducting cost-benefit analysis, the Treasury Board of Canada Secretariat describes the methods identified in Table 1, along with guidelines for best practices. Most relevant to this analysis, is the Secretariat's recommendations regarding benefit transfer. As described in the guidelines, the following steps should be taken when conducting benefit transfer:

- The selected study should be similar to the change in question, in terms of the type of goods or services as well as the socio-economic conditions.
- The selected study should be comprehensive, and should be based on high-quality data and sound theoretical concepts.
- Welfare measurements from the selected study should be similar to those in the analysis.

Due to time and resource limitations, we rely on benefit transfer several times throughout the analysis. When applying the technique, we describe how our approach complies with the Secretariat's guidelines.

2.1.4 Values over time

In many instances, the values we quantify in our analysis occur annually, over many years. The best way to consider the streams of different types of values over time is to apply a discount rate and calculate their respective net present values (NPVs). In general, the value of an asset declines over time reflecting opportunity costs and time preference for consumption or access sooner rather than later. This declining value over time is accounted for by applying a **discount rate** to future values. The Treasury Board of Canada Secretariat states that the discount rate "refers to the time value of the costs and benefits from the viewpoint of society . . . it is similar

[1] Treasury Board of Canada Secretariat. 2007. *Canadian Cost-Benefit Analysis Guide*. Catalogue No. BT58-5/2007.

to the concept of the private opportunity cost of capital used to discount a stream of net cash flows of an investment project . . ."[2]

The Secretariat recommends, "that a real rate of 8.0% be used as the discount rate for the evaluation of regulatory interventions in Canada."[3] This discount rate, however, is a **market-based discount rate** representing the average return on financial investments and is not necessarily applicable to values derived from ecosystem services. The values individuals derive from ecosystem services are unique in that they are not perfectly substitutable with other forms of capital. Some ecosystem services, for example, will be more scarce in the future than they are today (e.g. clean drinking water). With regard to these services, future generations likely will be worse off than the current generation.[4] The Secretariat acknowledges this difference and states that a **social discount rate** based on "the rate at which individuals discount future consumption and projected growth rate in consumption" should be applied to values derived from ecosystem services, and that, for Canada, this social discount rate is about 3.0%.[5]

Another issue to consider when discounting future values is the time horizon over which the values will accumulate. Typically, the time horizon of an economic analysis of ecosystem services should align with the time horizon over which the supply of ecosystem services is expected to persist. For this analysis, we will apply a range of time horizons to the values we quantify: 50-years, 100-years, and 200-years. The low end of this range (50-years) represents the foreseeable future, during which time public agencies can enact and implement policies associated with local ecosystem services. The high end of this range (200-years) represents the ONA's "seven generations" approach to natural resource management.

2.1.5 Comparing importance and values across ecosystem services

Throughout the analysis, we discuss several different types of importance and values associated with a list of ecosystem services. When considering all of the results, it is useful to summarize the results visually, in a way that highlights the general themes of the findings. Table 2 summarizes our approach to providing this comparison.

Table 2. Tool for Comparing Importance and Values Across Ecosystem Services

Magnitude Classification	Low	Medium	High
Qualitative Description	Many Substitutes	Some Substitutes	Few (if any) Substitutes
Quantified Result	Low Value	Medium Value	High Value

[2] Treasury Board of Canada Secretariat. 2007. *Canadian Cost-Benefit Analysis Guide*. Catalogue No. BT58-5/2007.

[3] Treasury Board of Canada Secretariat. 2007. *Canadian Cost-Benefit Analysis Guide*. Catalogue No. BT58-5/2007.

[4] See, for example, Pearce, D. and R. Turner. 1990. *Economics of Natural Resources and the Environment*. Great Britain: Johns Hopkins University Press; Saez, C. and J. Requena. 2007. "Reconciling Sustainability and Discounting in Cost-Benefit Analysis: A Methodological Proposal." *Ecological Economics*. 60: 712-25.

[5] Treasury Board of Canada Secretariat. 2007. *Canadian Cost-Benefit Analysis Guide*. Catalogue No. BT58-5/2007.

For each ecosystem service, we describe importance or value in qualitative or quantitative terms. Furthermore, we group these descriptions into three categories (High, Medium, or Low) based on their relative importance or value. In instances where we include quantitative results, we group those with the values at the high end of the distribution, those with values in the middle of the distribution, and those at the low end of the distribution. In instances where we include qualitative results, we use the relative substitutability of the ecosystem service as an indicator of its importance/value. If, for example, there are many readily available substitutes to the benefits derived from a particular ecosystem service, it would fall into the Low category. On the other hand, if there are no substitutes to the benefits derived from a particular ecosystem service, it would fall into the High category.

2.2 Analytical Focus

In this section, we identify and describe the analytical focus of the analysis and introduce several components that guide the analysis. We begin this section by identifying the study's objective. To clarify this objective, we describe the study area we examine in the analysis, as well as the two scenarios we use to consider values in the study area. These parameters help clarify and focus the scope of the analysis.

2.2.1 Study objective

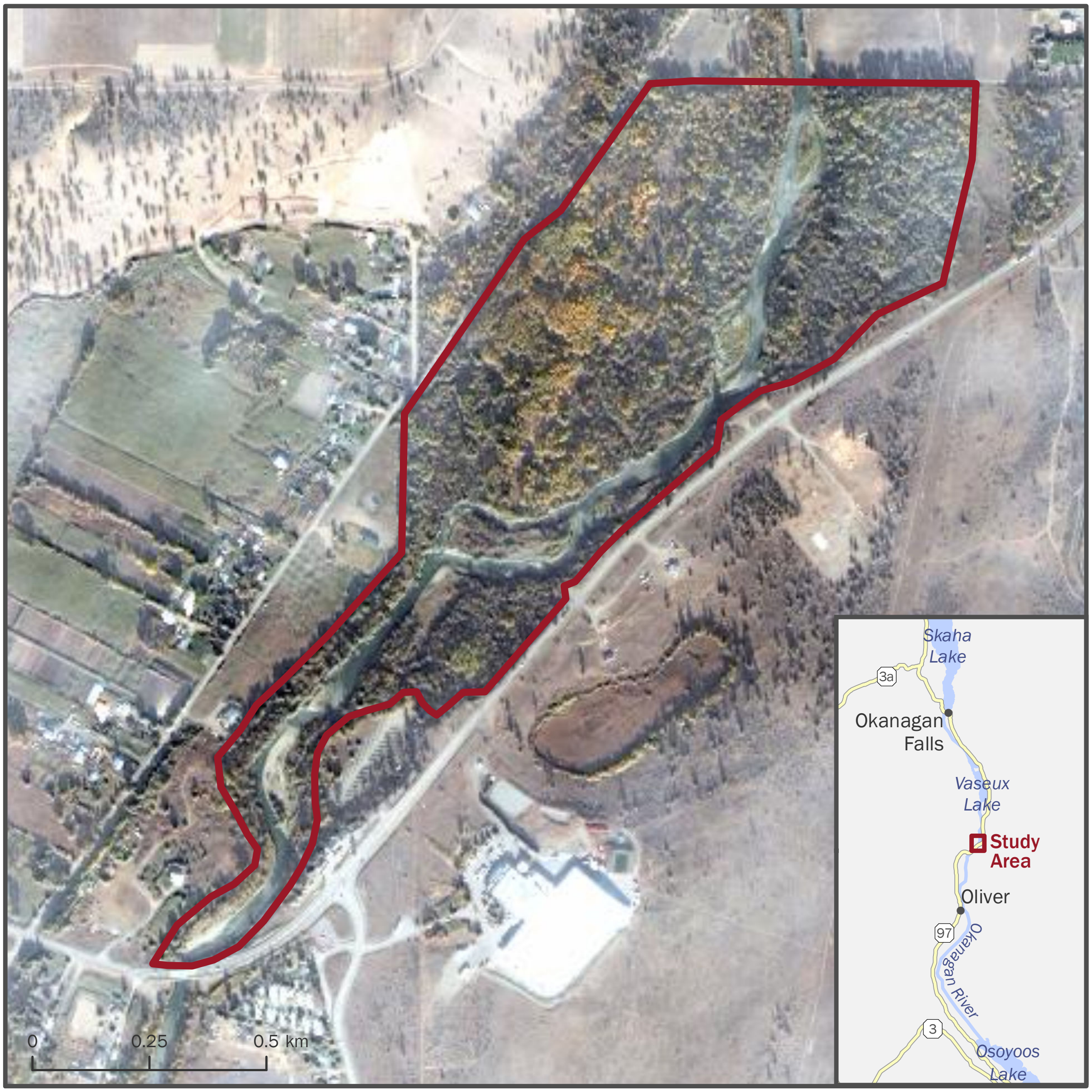
The objective of this analysis is to describe (in quantitative and qualitative terms) the importance and economic values of the ecosystem services that the last remaining natural section of the Okanagan River supports.

2.2.2 Study area

The analysis will focus on ecosystem services supported by the section of the Okanagan River known at the Osoyoos Indian Band (OIB) Reserve Natural Section (see Figure 2). Currently, the OIB owns and maintains the land adjacent to this section of the River. In addition to the River itself, we include all adjacent undeveloped land. We refer to this as the **study area**. In total, the study area covers 105 acres of land. For our analysis, we assume that the River itself covers 10% of the study area (10.5 acres) and the remaining 90% (94.5 acres) is covered by sparse riparian forestland.

In some instances, the ecosystem services the study area supports will materialize locally (e.g., benefits from fishing for salmon within the study area). In other instances, they will materialize at a broader geographic level (e.g., individuals downstream of the study area derive valuable benefits from fishing for salmon elsewhere in the Columbia River Basin). While the analysis will focus on ecosystem services the study area supports, it will rely on an understanding of how other sections of the river support ecosystem services. For example, we will use data and information describing ecosystem services in channelized segments of the river to understand the potential effects of channelization in the study area (see Figure 2). Similarly, we will use data and information describing ecosystem services in the ORRI Restored Section to understand how partial development could impact the ecosystem services in the study area (see Figure 2).

Figure 2. Study Area Boundaries



Map credits: ECONorthwest with imagery and data from ESRI.

2.2.3 Scenarios

As stated in the objective, the analysis will focus on describing the ecosystem services the study area supports. The essence of this analysis, however, is focused on understanding how the **naturalness** of the study area supports ecosystem services differently than more developed sections of the River. To conduct this type of marginal analysis, we will focus on the marginal difference in the importance and value of ecosystem services under two scenarios. In the first scenario, we will consider the ecosystem services the study area supports, as it exists today, and as it would exist in the future, without development (what we call the Baseline Scenario). In the second scenario, we will consider the ecosystem services the study area would support if it were channelized (what we call the Development Scenario). Furthermore, this second scenario will incorporate the effects of potential development that would accompany channelization.[6] By analyzing the marginal difference between these two scenarios, we will focus our attention on the ecosystem service values unique to the **naturalness** of the study area that would be lost with channelization.

Development in the Okanagan Valley

In comparing the ecosystem services supported by each scenario, we assume that, across the Okanagan Valley, the total level of development would be the same in both the Baseline Scenario and the Development Scenario. The difference between the scenarios is the location of future development. We assume that under the Development Scenario, development would occur in the study area. The analysis focuses on the net differences between the two scenarios. In some instances, the specific location of future development (inside or outside the study area) does not influence the overall level of ecosystem services supported in the Valley. In other instances, there is a difference. This comparison helps illustrate the uniqueness of the study area and its capacity to support ecosystem services in the Okanagan Valley.

2.3 Past Efforts and Literature

The analysis relies on a broad range of existing literature describing conditions and human interactions with ecosystem services in the study area, elsewhere in the Okanagan Basin, and across the Columbia Basin, as well as interviews with key informants. We also rely on economic literature describing the values individuals derive from ecosystem services. Below is a brief summary of the types of information and data sources we used in conducting our research.

2.3.1 Cultural studies in the Okanagan Basin

We relied on two general sources for information describing cultural issues in the study area and elsewhere in the Okanagan Basin:

- Published literature describing indigenous fisheries and other indigenous issues related to the study area and the ecosystem services it provides.[7]
- Personal communication with ONA staff with knowledge of cultural issues in the Basin.

2.3.2 Ecosystem services in the study area

While conducting the analysis, we identified three studies that consider ecosystem services in and around the study area (one of the three studies is currently in draft form and was not available for our review).[8] While none of these studies had the same objective as this analysis,

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[6] The OIB currently controls the land at issue and has the authority to determine what happens in the study area. Our analysis is based on a *general concept* of what developing the site could do to the natural resources and ecosystem services the study area provides, rather than the consequences of a specific development proposal,

[7] For example, Ernst, A. 2000. *Aboriginal Fisheries Information within the Okanagan Basin*. Prepared for the Okanagan Nation Fisheries Commission.

[8] Bouchette, B. 2012. *Cost BenefitAnalysis, Okanagan River Wetland;* Salverda, M. 2013. *The Value of the Very Last Stretch of Natural Okanagan River – Draft*. Okanagan Floodplain Ecological Services Valuation Project. January. Taylor, A. No Date. *The City of Kelowna's Ecological Valuation of the Mission Creek Area.*

they did look into several of the ecosystem services we include in this analysis. The two available studies provided several details useful to this analysis, including data sources, descriptions of potential beneficiary groups, discussions of types of values derived from specific ecosystem services, and general context describing the Okanagan Basin and the study area.

2.3.3 Ecosystem services in the Okanagan Basin and other biophysical studies

Over the past decade, a number of analyses and reports describing biophysical components and ecosystem services in the study area and across the Okanagan and Columbia Basins have been published. While conducting our research, we identified the specific biophysical components most relevant to describing the ecosystem services the study area provides. We worked with our project partners (Summit Environmental Consultants Inc., the ONA, and the OBWB) to identify the most relevant reports available. These reports describe biophysical conditions in the study area under the Baseline Scenario. They also provide details regarding the potential conditions in the study area under the Development Scenario based on channelization and development in other areas in the Okanagan Basin.

2.3.4 Data describing salmon populations

We relied on three general sources for the salmon-related data and information for the analysis:

- ONA staff provided data and information describing the three general sockeye fisheries in the Okanagan Basin (the food, social, and ceremonial fishery, the demonstration commercial fishery, and the recreational fishery in Osoyoos Lake).
- Canada's Department of Fisheries and Oceans provided summary data describing sockeye populations, harvests, and regulations both within the Okanagan Basin and across the Columbia Basin.
- The Washington Department of Fish and Wildlife provided information regarding historical salmon populations in the Columbia Basin, fish counts at dams along the Columbia River, and sockeye harvests within the Columbia Basin.

2.3.5 Economic literature

We use a number of different sources to quantify the values of the ecosystem services the study area provides. In general, we used three types of economic literature:

- We contacted fishery managers and other relevant individuals to compile local, service-specific values to apply to our analysis where feasible.
- We relied on academic research (e.g., results from contingent valuation studies) to estimate values of some ecosystem services. In searching for relevant literature sources, we used several databases including the Environmental Valuation Reference Inventory (EVRI) and Oregon State University's Recreation Use Values Database.
- We also relied on expenditure data describing some of the avoided costs tied to the preservation of specific ecosystem services.

3 Salmon-Related Ecosystem Services

Past research and preliminary discussions with ONA and OBWB staff made it clear early on that salmon-related issues would be at the core of any analysis in the study area. As such, we decided to report the cultural importance and economic value associated with salmon first, in a stand-alone section. We begin this section by describing salmon populations and harvests in the Columbia Basin, in the Okanagan, and in the study area. We then identify and describe several salmon-related issues relevant to the analysis (e.g., cross-boundary issues, efforts aimed at improving salmon stocks). We conclude by identifying and describing the cultural importance and some of the values associated with the sockeye populations the study area supports.

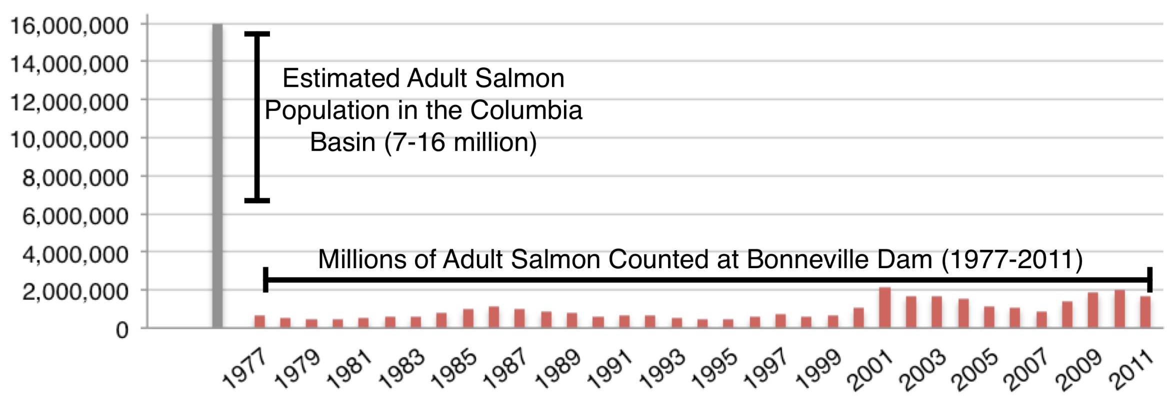
3.1 Salmon Populations

In this section, we describe how salmon populations have changed over time. First we discuss salmon populations, in general, across the entire Columbia Basin. Then, we focus our attention on the Okanagan's sockeye stock and the role the study area plays in supporting that stock.

3.1.1 Salmon in the Columbia Basin

Salmon populations across the Columbia Basin declined during the 19th and 20th centuries due to harvest pressures, development, and pollution. Dams in particular have put pressure on sockeye populations (e.g., Grand Coulee Dam, Swan Falls Dam, Black Canyon Dam, and Brownlee Dam).[9] Prior to European settlement, an estimated 7-16 million salmon populated the Columbia Basin. Since 1977, adult salmon counts (Chinook, coho, sockeye, and steelhead) passing Bonneville Dam have ranged from about 0.5-2.1 million per year (see Figure 3).

Figure 3. Historical Salmon Populations in the Columbia Basin



Source: Fish Passage Center. 2013. *Adult Salmon Annual Totals*. Retrieved on February 7, 2013 from http://www.fpc.org/; Committee on Protection and Management of Pacific Northwest Anadromous Salmonids. 1996. "Upstream: Salmon and Society in the Pacific Northwest." National Academy Press: Washington, DC.

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[9] Joint Columbia River Management Staff. 2013. *2013 Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations*. January.

In 2011, about 20% of the salmon (Chinook, coho, steelhead, and sockeye) that passed Bonneville Dam went on to pass Wells Dam, which is where the Okanagan River enters the Columbia River system. Most of those salmon were sockeye. At one point in time, there were eight main sockeye stocks in the Columbia Basin. Today, there are three: (1) the Snake River-Redfish Lake system accounts for less than 0.1% of the Basin's stock, (2) the Wenatchee River-Lake Wenatchee system accounts for about 10-15% of the Basin's stock, and (3) the Okanagan River-Osoyoos Lake system accounts for about 85-90% of the Basin's stock (see Figure 4).[10]

Figure 4. Columbia Basin, Dams, and Sockeye Stocks

Map Credits: ECONorthwest with data from Natural Earth and USGS.

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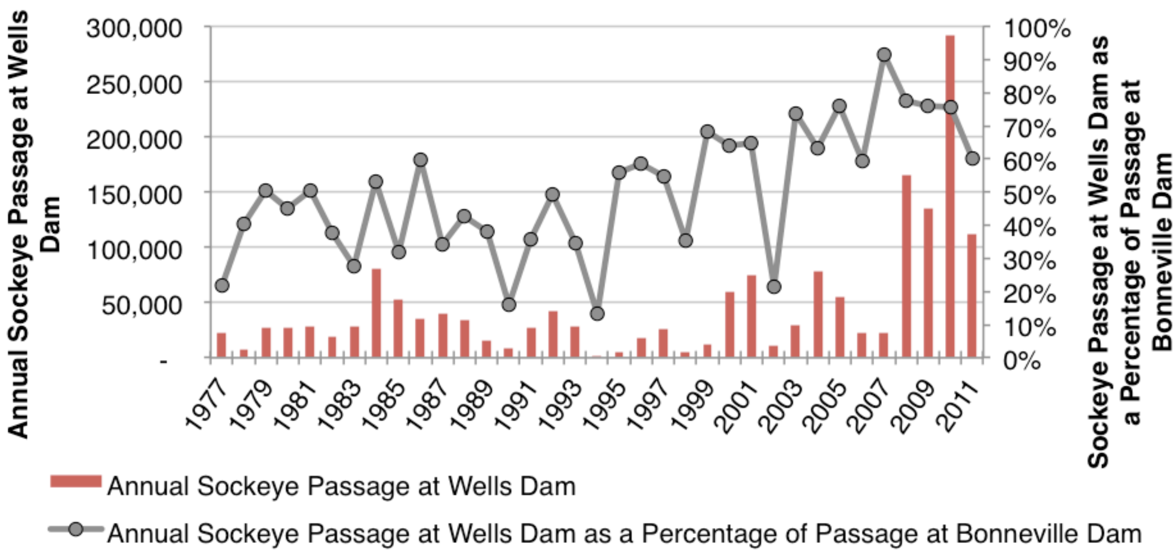
[10] Fryer, J., J. Mainord, H. Wright, et al. 2010. *Studies into Factors Limiting the Abundance of Okanagan and Wenatchee Sockeye Salmon*. Columbia River Inter-Tribal Fish Commission Technical Report for BPA Project 2008-503-00.

3.1.2 Sockeye in the Okanagan

Research suggests that the Okanagan's sockeye stock accounts for 85-90% of the sockeye in the Columbia Basin. Figure 5 demonstrates the Columbia Basin's increasing reliance on sockeye from the Okanagan. The red columns represent the number of sockeye counted at Wells Dam each year from 1977 to 2011. Sockeye populations recorded since 2007 have been much higher than populations from 1977-2006. The gray line represents the number of sockeye counted at Wells Dam as a percentage of sockeye counted at Bonneville Dam. The general trend since 1977 suggests that, while the Okanagan sockeye stock has always been an important contributor to the Columbia Basin's salmon populations, its contributions have increased in recent years relative to other sockeye stocks.

Figure 5. Sockeye Salmon at Bonneville Dam and Wells Dam (1977-2011)



Source: Fish Passage Center. 2013. *Adult Salmon Annual Totals*. Retrieved on February 7, 2013 from http://www.fpc.org/.

Several Factors Contribute to the Okanagan Sockeye Stock's Success

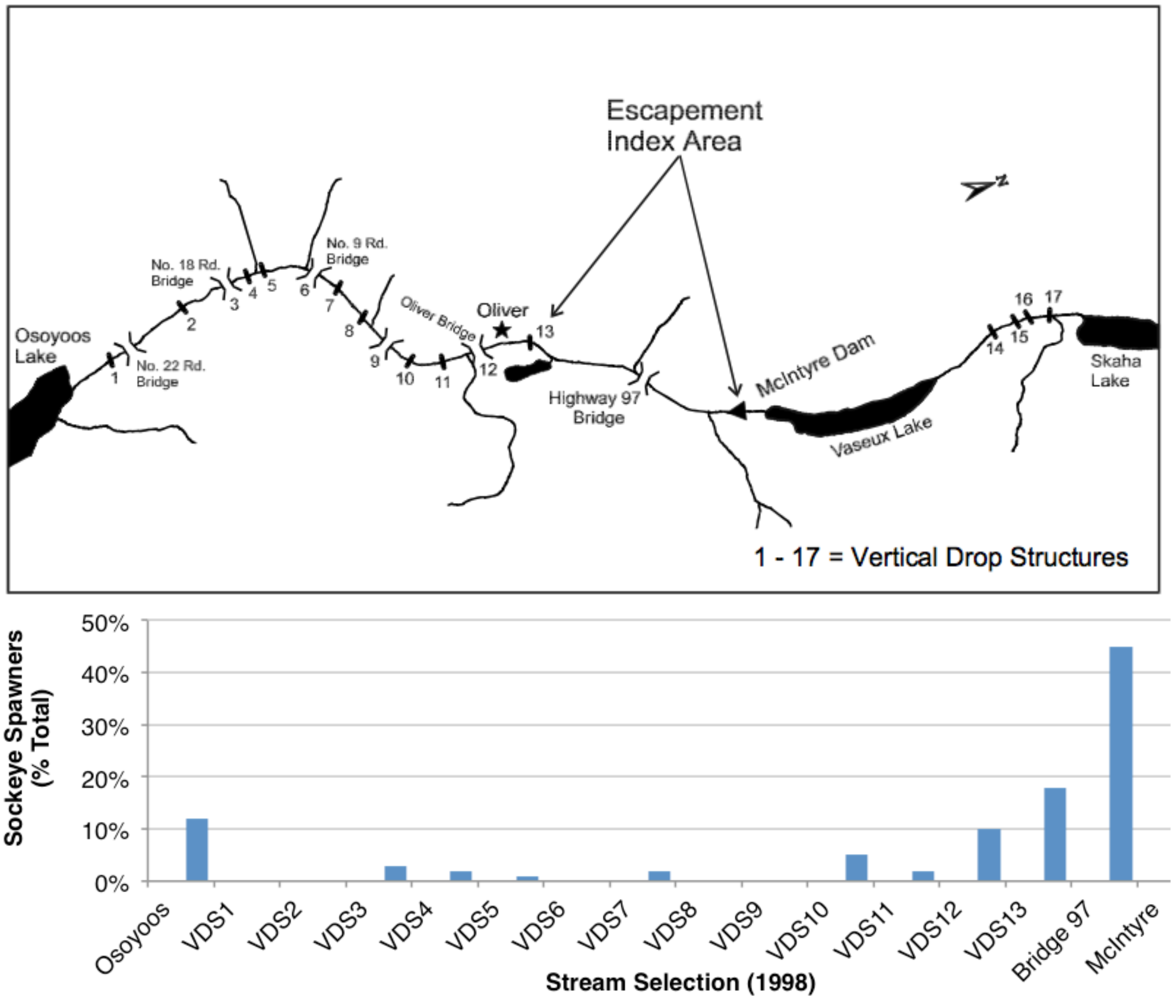
- Improved operation schedules at dams throughout the Columbia Basin improve juvenile and adult survival as the fish migrate to and from spawning grounds.
- Efforts aimed at improving and increasing the amount of spawning habitat in the Okanagan.
- Hatchery efforts in the Okanagan have helped support local stocks. Eggs from Okanagan sockeye have also been used to help support sockeye stocks elsewhere in the Columbia Basin.
- Water management (e.g., the Okanagan Fish Water Management Tool) has improved and there are currently triggers and decision tools that help release/manage water resources in fish-friendly ways.
- Harvest schedules and quotas are based on annual run size, which helps reduce pressures on the stock from harvests.
- El Nino has also temporarily boosted sockeye populations.

Source: Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

3.1.3 Sockeye in the study area

Within the Okanagan River, sockeye spawning is concentrated in and around the study area (see Figure 6). In 1998, 63% of all sockeye spawning that was observed upstream of Osoyoos Lake took place in the study area. The study area accounted for up to 98% of sockeye spawning upstream of Osoyoos Lake three separate times (1984, 1989, 1990) from 1984-1998.[11] On average, over 90% of the Okanagan sockeye stock used the unchannelized portion of the River for spawning, while less than 10% used channelized portions for spawning.[12]

Figure 6. Sockeye Spawning in the Okanagan (1998)



Source: Hyatt, K. and D. Rankin. 1999. *A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives*. Canadian Stock Assessment Secretariat Research Document 99.191.

[11] Hyatt, K. and D. Rankin. 1999. *A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives*. Canadian Stock Assessment Secretariat Research Document 99/191.

[12] Hyatt, K. and D. Rankin. 1999. *A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives*. Canadian Stock Assessment Secretariat Research Document 99/191.

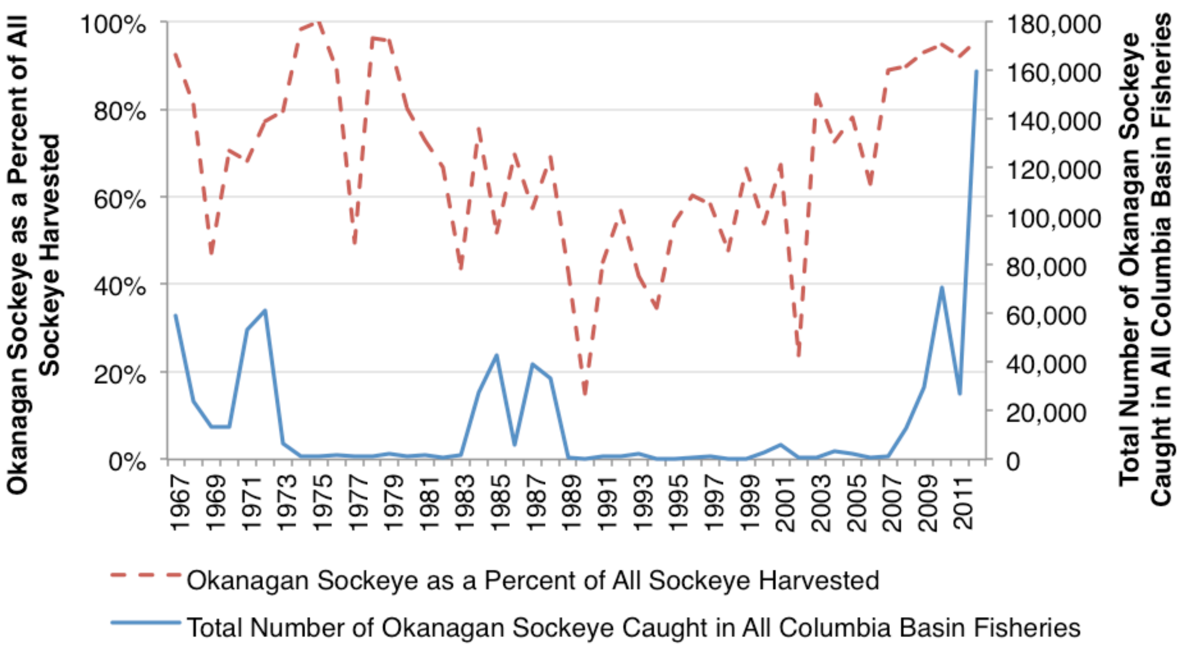
3.2 Sockeye Harvests

In this section, we describe how sockeye harvests have changed over time. First, we discuss sockeye harvests across several different sockeye fisheries in the Columbia Basin. Then, we focus our attention on sockeye harvests in and around the study area.

3.2.1 Sockeye harvests in the Columbia Basin

As described in the previous section, the study area's biggest contributions to the Columbia Basin's salmon populations are through the provision of spawning habitat for sockeye. As such, this section will focus on salmon harvests within the Columbia Basin in terms of the Okanagan sockeye stock. The blue line in Figure 7 shows how many Okanagan sockeye were harvested in the Columbia Basin from 1967-2012. The dashed red line shows the Okanagan stock's share of all sockeye harvested in the Columbia Basin.

Figure 7. Okanagan Sockeye Harvested in the Columbia Basin (1967-2012)



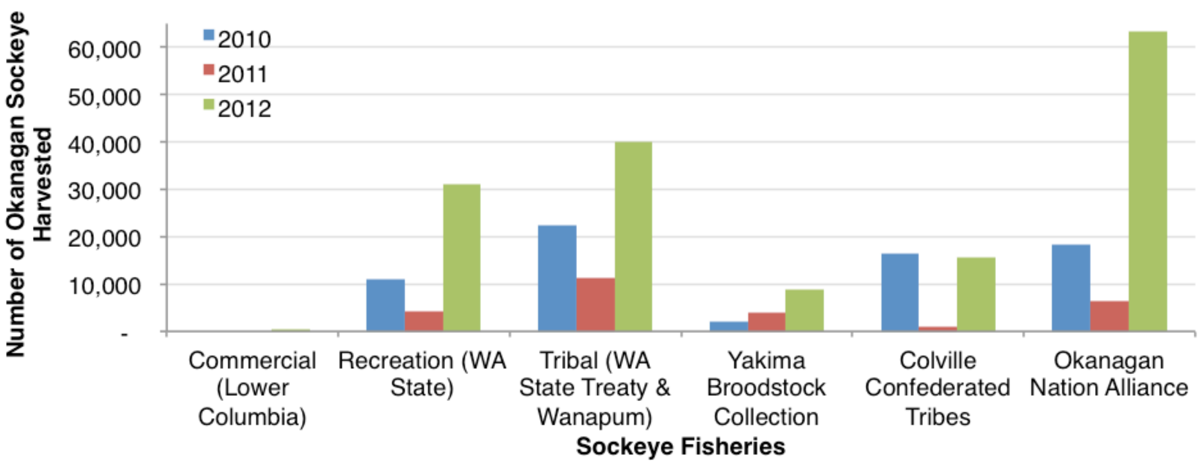
Source: Personal Communication (e-mail). February 25, 2013. Margot Stockwell, Research Biologist, Salmon & Freshwater Ecosystems, Fisheries & Oceans Canada, Pacific Biological Station.

Over the past several years, the number of sockeye harvested in the Columbia Basin has increased. Figure 8 shows the number of Okanagan sockeye harvested in all of the sockeye fisheries in the Columbia Basin from 2010-2012. The fisheries are presented in geographic order, with the commercial fishery (on the left) stretching from the mouth of the Columbia River to Bonneville Dam to ONA-related fisheries (on the right) in the Okanagan Basin. Below, we provide a brief description of each of the six sockeye fisheries in the Columbia Basin:

- The commercial sockeye fishery in the Columbia River consists of five zones (Zones 1-5) stretching from the mouth of the Columbia River to Bonneville Dam. Commercial fishermen did not harvest any sockeye in this fishery in 2010 or 2011, but in 2012, they harvested just over 300 Okanagan sockeye.

- The recreational sockeye fishery in the Columbia River stretches across the State of Washington, with most of the harvest coming from areas above Wells Dam. In 2012, these recreational anglers harvested about 31,000 Okanagan sockeye.
- The Columbia River Tribal fishery is located in Zone 6 of the Columbia River, which runs from Bonneville Dam to McNary Dam. The treaty's harvest schedule (2008-2017) states that this fishery can harvest 5% of the run when the upriver sockeye run size is less than 50,000, 7% when the run size is 50,000-75,000, and potentially over 7% when the run size is over 75,000.[13] Some of the harvest is sold in formal and informal markets, most of it is retained for household consumption.[14]
- Since 2009, efforts to re-introduce sockeye to the Upper Yakima Basin have harvested Okanagan sockeye from the Columbia Basin (at Priest Rapids Dam) and transported them to Lake Cle Elum.[15] The volume of this broodstock harvest is based on a sliding scale relative to the total run size, with a maximum harvest of 10,000 sockeye.
- The Colville Confederated Tribes in northern Washington harvest sockeye for household use. In 2012, they harvested about 15,600 sockeye, which they distributed to tribe members.[16]
- The Canadian portion of the sockeye fishery is composed of three general sub-fisheries, which we discuss in more detail in the next section. In 2012, this fishery harvested over 63,000 sockeye.

Figure 8. Okanagan Sockeye Harvest, by Fishery (2010-2012)



Source: Personal Communication (e-mail). February 25, 2013. Margot Stockwell, Research Biologist, Salmon & Freshwater Ecosystems, Fisheries & Oceans Canada, Pacific Biological Station.

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[13] Joint Columbia River Management Staff. 2013. *2013 Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations*. January.

[14] Personal Communication (Telephone). February 27, 2013. Stuart Ellis, Fisheries Manager, Columbia River Inter-Tribal Fish Commission, Portland Main Office.

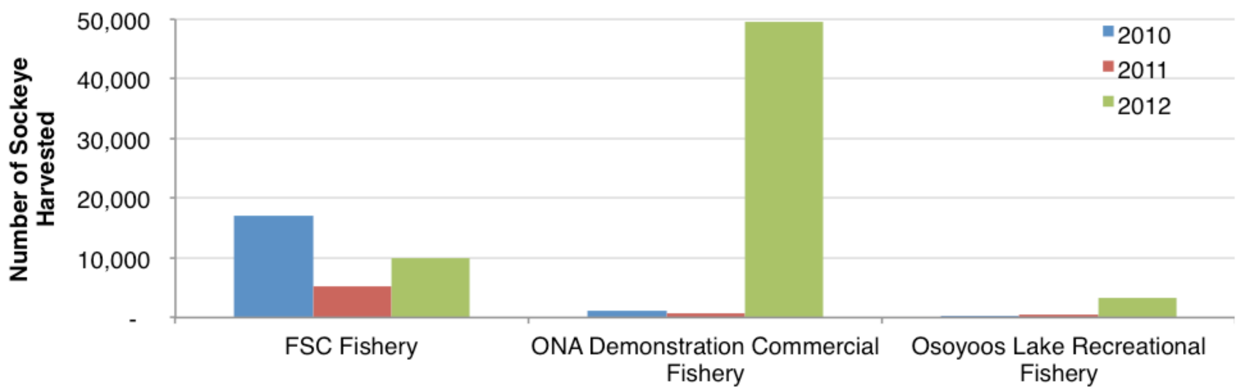
[15] Columbia Basin Bulletin. 2012. *Returning Salmon to Upper Yakima Basin*. September 27.

[16] Personal Communication (Telephone). February 27, 2013. Stuart Ellis, Fisheries Manager, Columbia River Inter-Tribal Fish Commission, Portland Main Office.

3.2.2 Sockeye harvest in and around the study area

As previously mentioned, the sockeye fishery in Canada's Okanagan Basin is composed of three sub-fisheries. In general, these three fisheries are prioritized as follows: (1) the food, social, and ceremonial (FSC) fishery, (2) the ONA's demonstration commercial fishery, and (3) the recreational fishery in Osoyoos Lake. Figure 9 summarizes sockeye harvests, by fishery, from 2010-2012. Harvest limits are based on the estimated run size, which is based on mid-season sockeye counts at Wells Dam. Harvest allocation is typically distributed on a sliding scale between the fisheries, while maintaining a conservation goal of 30,000 spawning adults. Total sockeye demand in the FSC fishery is satisfied with about 10,000 sockeye. The rest of the harvest is distributed across the commercial and recreational fisheries to meet local demand.[17] In 2012, these three fisheries harvested a total of about 63,400 sockeye. It was one of the largest harvests in recent history.

Figure 9. Distribution of Canada's Okanagan Harvest, by Fishery (2010-2012)



Source: Personal Communication (e-mail). February 25, 2013. Margot Stockwell, Research Biologist, Salmon & Freshwater Ecosystems, Fisheries & Oceans Canada, Pacific Biological Station.

3.3 Other Salmon-Related Issues

So far, we have discussed salmon populations across the Columbia Basin and in the study area, as well as harvest rates specific to the Okanagan sockeye stock. Several factors, however, come together to help support these populations and fisheries. In this section, we discuss some of these salmon-related issues that play important roles in supporting current and potential future salmon populations.

3.3.1 Cross-boundary issues

The Okanagan sockeye stock begins its journey in British Columbia's Okanagan River. From there, the fish migrate downstream, through the State of Washington, to the Columbia River (a large portion of which borders the State of Oregon). These sockeye spend a portion of their lifecycle in the Pacific before entering the Columbia River once again to begin their journey

[17] Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

upstream to spawning habitat in the Okanagan. As suggested by their migration patterns, the Okanagan sockeye stock travels through a number of political jurisdictions (Canada, the US, British Columbia, Washington, Oregon, as well as several First Nation and Tribal lands).

In order to survive, these sockeye need access to their historical migration routes. Over the past century, several dams have been constructed along this migration route. These dams present physical barriers to sockeye migration, and the artificial manipulation of waterflow affects sockeye health (by increasing water temperature and damaging eggs).[18] Recently, efforts in both Canada and the US have helped sockeye populations by: (1) providing access past these dams, and (2) rescheduling the timing of water releases to improve instream flow for migration and spawning conditions.[19]

Canada and the US have signed two bilateral treaties affecting the Columbia Basin's salmon stocks. The Columbia River Treaty, enacted in 1964, is an agreement between the two countries regarding the construction and operation of dams in the Columbia Basin, and offers provisions for distributing benefits and costs associated with power and flood control from these dams across the border.[20] The two countries are currently analyzing the treaty in terms of potential future conditions (after 2024) affecting power generation and flood control. These analyses are anticipated to evolve into discussions of additional circumstances (e.g., fish and wildlife, recreation, cultural resources, and irrigation) that have changed since the treaty was originally signed.[21] The Pacific Salmon Treaty, enacted in 1985, is an agreement between the two countries to limit fish harvests in the Columbia Basin and the Fraser River, and to enhance salmon stocks (in both countries) through improvements in freshwater spawning and rearing habitat.[22]

Historically, Salmon Chiefs were responsible for regulating salmon fishing at communal sites within the Okanagan Basin. The Salmon Chief's responsibilities included controlling the construction of fishing equipment, managing the harvest and distribution of salmon across the communities, and performing ceremonies associated with the salmon harvest.[23] Currently, the Okanagan sockeye stock is managed piece-meal, by a number of different agencies. These agencies and organizations have maintained efforts to tie harvest rates to anticipated run sizes and have implemented conservation and habitat improvement initiatives all aimed at supporting the stock.

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[18] Joint Columbia River Management Staff. 2013. *2013 Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations*. January.

[19] Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

[20] US Army Corps of Engineers and Bonneville Power Administration. 2009. *Columbia River Treaty Fact Sheet*. March. Retrieved on March 26, 2013 from http://www.crt2014-2024review.gov/Files/TreatyFactSheet.pdf.

[21] US Army Corps of Engineers and Bonneville Power Administration. 2009. *Columbia River Treaty: History and 2014/2024 Review*. Retrieved on March 26, 2013 from http://www.crt2014-2024review.gov/FactSheets.aspx.

[22] Northwest Power and Conservation Council. 2008. *Pacific Salmon Treaty*. Retrieved on March 26, 2013 from http://www.nwcouncil.org/history/pacificsalmontreaty.

[23] Sturtevant, W. and D. Walker. 1998. *Handbook of North American Indians, V. 12: Plateau.* Smithsonian Institution.

3.3.2 Endangered species management

The Okanagan sockeye stock is not considered threatened or endangered in either Canada or the US. Even so, we describe the relevant agencies in the two countries that are responsible for managing threatened and endangered species because of the management relevance to protection of important and scarce wildlife populations.

The Canadian government relies on the Species at Risk Act (SARA) to prevent species extinction. Under SARA, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identifies species at risk based on scientific research, community knowledge, and traditional aboriginal insights. Once COSEWIC determines that a species is at risk, the federal Cabinet is responsible for listing the species under SARA. The Cabinet considers COSEWIC's findings as well as the results compiled through consultations with affected groups and economic and social implications that listing could have on Canadians. Once listed, SARA makes it illegal to kill, harass, capture, or harm the species. It also requires the formation of critical habitats, recovery strategies, action plans, and management plans. No species of Pacific salmon are currently listed under SARA. In its 2012 Economic Action Plan, the Canadian government proposed a budget of $50 million over two years to support the implementation of SARA.[24]

In the US, the federal government uses the Endangered Species Act (ESA) to help prevent species extinction. In 2010, there were a total of 1,349 species listed as threatened or endangered under the ESA. The US Fish and Wildlife Service oversees ESA-related spending, and in 2010, it reported a total of $1.4 billion in ESA-related expenditures. The Service totals species-specific expenditures (not including land acquisition costs), and of the 50 species receiving the most funding, 22 were salmon/steelhead species.[25] In addition to the ESA, several tribes in the US have used their senior water rights to preclude water withdrawals for irrigation and help support struggling species.[26]

3.3.3 Improving sockeye populations

There have been a number of efforts aimed at improving sockeye populations in the Okanagan and across the Columbia Basin. Below, we briefly describe three recent efforts aimed at improving spawning habitat in the Okanagan and using Okanagan salmon to reintroduce sockeye populations to locations in which they previously existed.

- **Okanagan River Restoration Initiative (ORRI).** The ORRI represents a collaborative ecosystem approach to return a channelized portion of the Okanagan River back to more

[24] Her Majesty the Queen in Right of Canada. 2012. Economic Action Plan 2012. Retrieved on February 11, 2013 from http://www.budget.gc.ca/2012/plan/toc-tdm-eng.html.

[25] US Fish and Wildlife Service. 2010. *FY 2010 Federal and State Endangered and Threatened Species Expenditures*.

[26] Most recently, the Klamath Tribes' senior water rights were recognized and supported by the courts in a decision that denied a request to prevent the State of Oregon from shutting off irrigation water in the upper Klamath Basin. The Tribes intend to leave the water in the stream to help protect threatened fish. See: http://seattletimes.com/html/localnews/2021405593_klamathbasinxml.html.

natural conditions. The process involved several Canadian and American partners and funding sources. The first phase of the ORRI was completed in 2009, and involved the restoration of 0.5 kilometers of the River by setting back a portion of the dyke (monitoring and re-vegetation funded through the first phase will continue through 2013). These changes improved spawning habitat for sockeye and provide a number of additional ecosystem services.[27]

- **Skaha Lake Reintroduction Efforts.** In 2004, the Central Okanagan Basin Technical Working Group initiated a 12-year program (2004-2016) aimed at reintroducing sockeye to Skaha Lake.[28] In 2004 (the first year of the reintroduction efforts) about 1.6 million eggs were collected at the spawning grounds and transported to the Shuswap River Hatchery in Lumby. By 2005, 1.1 million sockeye fry remained, and they were released into the Okanagan River at Penticton.[29]
- **Yakima Basin Reintroduction Efforts.** Since 2009, the Yakima Nation has been harvesting adult sockeye at Priest Rapids Dam as part of an effort to improve salmon populations in the Yakima Basin. The harvested sockeye are released in Lake Cle Elum where they travel through the Yakima Basin to spawn.

3.3.4 Interested groups and individuals

A number of different groups and individuals rely on the Okanagan sockeye stock, and our analysis will identify and describe the importance of the sockeye to their livelihoods. In this section, we briefly introduce these groups; we discuss them in more detail throughout the remainder of our analysis. To summarize, we describe four general groups: (1) indigenous populations in British Columbia, and Tribal communities in the Pacific Northwest US, (2) individuals that participate in the recreational sockeye fishery, (3) individuals that participate in the commercial sockeye fishery, and (4) other individuals that derive benefits from knowing the Okanagan sockeye stock is healthy.

3.4 Describing the Importance and Value of Sockeye in the Study Area

Baseline Scenario. At one point in time, there were eight main sockeye salmon runs in the Columbia Basin. Today, there are three: (1) the Snake River-Redfish Lake system accounts for less than 0.1% of the Basin's stock, (2) the Wenatchee River-Lake Wenatchee system accounts for about 10-15% of the Basin's stock, and (3) the Okanagan River-Osoyoos Lake system accounts for about 85-90% of the Basin's stock.[30] The study area provides important spawning habitat for

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[27] Masters, Z. 2012. *Sockeye Salmon Utilization of Restored Okanagan River Habitat*. Retrieved on March 4, 2013 from http://restoration2012.org/program/abstract-list/entry/1/89/.

[28] Bussanich, R. 2011. *Reintroduction of Sockeye Salmon into Skaha Lake*. Retrieved on March 4, 2013 from http://www.obtwg.ca/2011bobtwg/4_Skaha_ReIntro_RBussanich.pdf.

[29] Okanagan Nation Alliance. No Date. *Okanagan Sockeye Reintroduction Backgrounder*. Retrieved on March 4, 2013 from http://www.turtleisland.org/news/oksalmon.pdf.

[30] Fryer, J., J. Mainord, H. Wright, et al. 2010. *Studies into Factors Limiting the Abundance of Okanagan and Wenatchee Sockeye Salmon*. Columbia River Inter-Tribal Fish Commission Technical Report for BPA Project 2008-503-00.

the Okanagan sockeye stock. One study observed that, on average, over 90% of the Okanagan sockeye stock used the unchannelized portion of the River for spawning, while less than 10% used channelized portions for spawning.[31] While sockeye represent the largest salmon population using the study area, other important fish (Chinook, coho, and steelhead) also use the habitat the study area provides. Insofar as the Baseline Scenario maintains the study area's current conditions, it protects the study area's ecosystem services, which support (and are supported by) the Okanagan sockeye stock.

Development Scenario. Channelization and development in the study area would decrease the amount of high-quality spawning habitat available for the Okanagan sockeye stock, which would decrease sockeye salmon populations in the Okanagan Basin and across the Columbia Basin. One study concluded that rapid development in the Okanagan Valley would place the Okanagan sockeye stock at clear risk of extinction in the foreseeable future.[32] Since the Okanagan sockeye stock accounts for so much of the Columbia Basin's sockeye population, the Development Scenario would drastically reduce the sockeye salmon population across the Columbia Basin.

By the end of the 1950s, most of the Okanagan River was dyked and channelized as a means of flood control. These alterations to the River affected functional processes and the River's capacity to provide valuable ecosystem services. For example, channelization reduced/eliminated riffle-pool sequences, diverse riparian vegetation, large woody debris, undercut banks, emergent boulders, back eddies, wetlands, and floodwater overflow channels. More specifically, the alterations decreased the quantity/quality of spawning and rearing habitat for salmon, trout, and whitefish native to the region.[33]

3.4.1 Changes in supply

From 1984-1998, the study area accounted for 63-98% of annual sockeye spawning upstream of Osoyoos Lake.[34] Given the study area's historical contribution to the Okanagan sockeye stock (as well as its contribution to salmon populations throughout the Columbia Basin), we assume that the Development Scenario would reduce the Okanagan sockeye stock's population by 63-100% within the Okanagan River. Since the Okanagan sockeye stock accounts for 85-90% of all sockeye in the Columbia Basin, we assume that the Development Scenario would reduce sockeye populations throughout the Columbia Basin by 54-90%.[35] Furthermore, we assume that

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[31] Hyatt, K. and D. Rankin. 1999. *A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives*. Canadian Stock Assessment Secretariat Research Document 99/191.

[32] Hyatt, K.D., D. Rankin, J. Fryer, et al. 2000. "Anatomy of a Population at Risk: Current Status of Okanagan River Sockeye (*Oncorhynchus nerka*) the Last Surviving Stock of Anadromous Salmon in Canadian Waters of the Columbia River Basin.

[33] Gaboury, M. 2004. *Okanagan River Restoration Setback Dyke Proof of Concept Project*. Ministry of Water, Land and Air Protection. June.

[34] Hyatt, K. and D. Rankin. 1999. *A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives*. Canadian Stock Assessment Secretariat Research Document 99/191.

[35] Assuming that Okanagan sockeye account for 85% of all of the Columbia Basin's sockeye, a 63% decrease in the Okanagan would cause a 54% decrease across the Columbia Basin. Assuming that Okanagan sockeye account for 90% of all of the Columbia Basin's sockeye, a 100% decrease in the Okanagan would cause a 90% decrease across the Columbia Basin.

this reduction would be sufficient to list the species as threatened or endangered, which would substantially alter fisheries throughout the Columbia Basin. This approach may overstate the potential effects of development in the study area in that it does not fully account for potential increases in sockeye populations associated with spawning efforts in the Penticton channel or reintroduction efforts elsewhere in the Basin.

Dealing with Substitution

Changes in the quantity/quality of natural resources available in a certain area changes the options that people have for interacting with those natural resources. While this issue of substitution is relevant to all the ecosystem services we consider in this analysis, it is of particular relevance when considering the Okanagan sockeye stock. Without a local sockeye stock, individuals will need to find alternatives for the values and importance lost. In some cases, there may be no feasible alternatives.

Insofar as the Development Scenario supports a trend toward extinction of the Okanagan sockeye stock, it represents a tipping point rather than a marginal change. In economic terms, the tipping point represents an instance in which substitutes become important. Without the Okanagan sockeye stock, individuals in the Okanagan Valley and throughout the Columbia Basin that rely on sockeye would need to find substitutes, which, for some groups, may not exist.

3.4.2 Discussing cultural and economic importance

People interact with the Okanagan sockeye stock in a variety of ways. We distill these interactions into three broad categories: cultural importance, fishery-related values, and non-market values. Readers should consider all three of these categories together to understand the total cultural and economic value associated with the Okanagan sockeye stock.

Cultural importance. The interactions that came first and persist to this day between the people in the Okanagan Valley and the Okanagan sockeye stock we recognize under the heading of cultural importance. This importance defines and pervades the relationships among indigenous populations within the Okanagan Valley (the Syilx People), their relationships with other inhabitants of the region, and with the land. It is impossible to characterize cultural importance in the monetary language of economics, but it is essential to understanding the overall importance of the Okanagan sockeye stock.

Fishery-related values. Interactions that involve sockeye harvests generate economic value that, for the most part, can be measured through market transactions. Beyond market transactions, however, some fishery-related activities (e.g., recreational fishing) provide additional benefits that can be measured using economic techniques previously discussed. A variety of groups enjoy these benefits, including local indigenous populations, recreational anglers, and commercial fishermen both in Canada and the US.

Non-market values. Other interactions improve people's well-being in ways that are less tangible, but no less important. For instance, when a young person says she wants to secure the opportunity for her grandchildren to catch a fish, that expression of intention and hope has value. As we described earlier, economists have developed techniques to measure these improvements in well-being in monetary terms. As with importance that can be measured through market transaction, many groups of individuals enjoy these benefits, including residents of Canada and the US and potentially other places in the world.

3.4.3 Cultural importance

The Okanagan way of life is intertwined with salmon and the ecosystems that support them.[36] From the earliest of times, the Syilx People depended on salmon to sustain them. To this day, the rhythm of the Okanagan sockeye stock remains linked to the social organization of the Syilx People and helps support their relationship with the land.[37]

Historically, salmon served as the most important source of food for the Syilx People within the Okanagan Valley. Though other types of wild food have always been part of the diet, and today many other sources of food are available, salmon continues to play a central role in the Syilx diet. The Syilx People harvests different types of salmon throughout the year. The sockeye harvest occurs in the summer and fall. The kokanee (the landlocked form of sockeye salmon) harvest extends throughout the year, at different locations that families return to generation after generation.[38] More than simply a source of nutrition, access to traditional foods reinforces long-standing cultural traditions through preparation methods, trading networks, and mealtime gatherings.

Social relationships evolved around the salmon harvest. The Salmon Chief controlled salmon fishing, and his authority guided people's activities during the harvest period. He resolved conflicts over fishing locations, and directed collaborative efforts to construct weirs and traps. He also conducted ceremonies when the first salmon was harvested each year. Cultural norms dictated who could fish for salmon, where, and when. Women were largely restricted from fishing, but were in charge of preparing and preserving them for the rest of the year. Through salmon traditions, stories, and fishing practices, the older generations educated the younger generations.[39]

Salmon are integral to defining the relationship between the Syilx People, the land, and the spiritual world. Adrienne Vedan writes, "The Okanagan view of the world is one in which people, beliefs, and nature are intertwined and inseparable. The plants, animals, hills, and water were viewed as having their own spirits and were likewise treated with the utmost respect." The well-being of the Syilx People was tied to the salmon, and the salmon's survival depended on the integrity of the ecosystem. This translated to a complex relationship between the Syilx People and the land. Jeannette Armstrong, describes that the land is "a fundamental part of the

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[36] Vedan, A. 2002. *Traditional Okanagan Environmental Knowledge and Fisheries Management.* Okanagan Nation Fisheries Commission. May.

[37] Salverda, M. 2013. *The Value of the Very Last Stretch of Natural Okanagan River.* January.

[38] Ernst, A. 2000. *Aboriginal Fisheries Information Within the Okanagan Basin.* Okanagan Nation Fisheries Commission.

[39] Vedan, A. 2002.

self, along with family and community."[40] This understanding of the land, the community, and the people's place in each, is essential to the Syilx People's way of life. Without the salmon, this world-view looses its integrity (e.g., legal rights to hunt and fish, cultural identity).

3.4.4 Value of sockeye harvested in Canada's Okanagan

In this section, we begin discussing the fishery-related values associated with the Okanagan sockeye stock. This section focuses on the value of the sockeye harvested in Canada's portion of the Okanagan Basin. As previously mentioned, the sockeye harvest in Canada's portion of the Okanagan is divided into three fisheries: (1) the FSC fishery, (2) the demonstration commercial fishery, and (3) the recreational fishery in Osoyoos Lake.[41] Table 3 summarizes the decision rules used to allocate the sockeye harvest across these three fisheries. As the table suggests, the FSC fishery has the highest priority, followed by the commercial fishery and the recreational fishery.

Table 3. Sockeye Fisheries in Canada's Okanagan (2012)

Projected Escapement Past Wells Dam	Okanagan Nation FSC Fishery	Recreational Fishery	Commercial Fishery
< 10,000	Permitted, but limited	Not permitted	Not permitted
10,000 – 60,000	5% of the run past Wells permitted	Not permitted	Not permitted
60,000 – 80,000	Minimum of 10% of the run past Wells permitted	Not permitted	Not permitted
> 80,000	Incrementally scaled up to 600,000 adults (total harvest rate 15-50% all fisheries of which FSC 90-95% of total Canadian harvest share)	May be considered	May be considered

Source: Personal Communication (e-mail). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

We summarize the 2012 harvests of each of these fisheries, some of the relevant market prices associated with the harvested sockeye, and their respective market values in Table 4. Below, we briefly describe the values we quantified for each of the three fisheries. To the extent that the Development Scenario would reduce sockeye populations in the Okanagan, it would also reduce sockeye harvests (potentially completely). The values we discuss in this section reflect the value of benefits associated with continued sockeye harvests in the future under the Baseline Scenario. Under the Development Scenario, we assume that no sockeye would be harvested in the Okanagan.

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[40] Armstrong, J. 1999. "Let us Begin with Courage." *Ecoliteracy: Mapping the Terrain.* February. Retrieved March 13, 2013, from http://www.ecoliteracy.org/essays/let-us-begin-courage

[41] There are two additional fisheries which we do not include in this summary: (1) an ONA recreational fishery, which accounted for 48 sockeye in 2012, and (2) an individual food fishery, which accounted for 668 sockeye in 2012.

Table 4. Sockeye Harvests and Market Values in Canada's Okanagan (2012)

Fishery	Sockeye Harvested in 2012	Market Prices	2012 Market Value
FSC Fishery	10,000	• $10-$15/fish	$100,000-$150,000
Commercial Fishery	49,490	• $2.50-$3.65/lb (dock price) • $6.75-$8.50/lb (local wholesale price) • $12.50-$19.00/lb (retail price) • $1.50/lb (non-local wholesale price)	$225,000-$275,000
Recreational Fishery	3,183	• $45/angler trip (travel cost) • $76/angler trip (total value)	$72,000 (travel cost) $121,000 (total)
Total	**52,673**	**N/A**	**$397,000-$546,000**

Source: Personal Communication (e-mail). February 25, 2013. Margot Stockwell, Research Biologist, Salmon & Freshwater Ecosystems, Fisheries & Oceans Canada, Pacific Biological Station; Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

FSC fishery

In 2012, ONA members harvested a total of 10,000 sockeye through the FSC fishery. These sockeye were destined for household consumption during the winter. One way to consider the value of these sockeye is in terms of their consumption value. According to ONA staff, sockeye harvested in the FSC fishery represent a consumer surplus value of $10-$15 per fish (or $100,000-$150,000 across the fishery).[42]

ONA demonstration commercial fishery

In 2012, the ONA harvested 49,490 sockeye as part of its demonstration commercial fishery. The fishery sold its harvest to a number of different markets including local retailers and wholesalers, as well as non-local wholesalers. In total, the ONA's revenues associated with the commercial fishery's harvest in 2012 are projected to total $225,000-$275,000.[43] Without details describing production costs, it is unclear the extent to which these revenues lead to profits.

Recreational fishery at Osoyoos Lake

In 2012, recreational anglers harvested a total of 3,183 sockeye from Osoyoos Lake. The ONA has surveyed these anglers for the past two years. Many anglers stated that they always caught their daily limits (two sockeye per day per angler), which suggests a total of about 1,600 angling trips in 2012. As part of these survey efforts, ONA researchers are compiling expenditure data describing average travel costs associated with the recreational fishery. Preliminary results suggest that 85% of all anglers are local to the Okanagan Valley, and that, on average, anglers spend about $45 per angler per trip.[44] Combining these findings suggests total expenditures associated with the recreational fishery in 2012 were about $72,000.

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[42] Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

[43] Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

[44] Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

Angling expenditures alone, however, do not represent the total value associated with the recreational fishery. Several studies have estimated the total value associated with recreational salmon fishing by implementing contingent valuation studies. These studies ask anglers how much they would be willing to pay to go fishing for a day. Unfortunately, we did not identify any relevant studies conducted in the Okanagan Basin.

In 2008, the US Bureau of Reclamation conducted a literature review of over 80 studies examining the values associated with recreational salmon fishing.[45] Of those studies, 18 provided original value estimates for salmon angling in rivers. There were insufficient data, however, to estimate species-specific values for anglers targeting sockeye. In identifying the best value to use for salmon angling in the Yakima Basin, the US Bureau of Reclamation used the existing literature to estimate an average value of approximately $76 per trip. Combining this per-unit value with the estimated number of angler days in the fishery in 2012 suggests a total value of approximately $121,000.

Summary

The values described above shed light on the different types of economic values associated with the harvests across the three fisheries. These values depend on their respective harvests over time. The sum of all the values calculated in this section is $397,000-$546,000. Assuming that future harvests are similar to those in 2012, the 50-year NPV of these values is $10.5-$14.5 million, the 100-year NPV is $12.9-$17.8 million, and the 200-year NPV is $13.6-$18.7 million. We assume that these benefits are solely associated with the Baseline Scenario, and that no fish from the Okanagan sockeye stock would be harvested under the Development Scenario.

These estimates, however, may understate the potential future value of these fisheries. The ONA's demonstration commercial fishery is still in its infancy. As previously stated, by the time it's all sold, the ONA's 2012 harvest is expected to generate $225,000-$275,000 in revenue. The ONA hopes to expand the commercial fishery to generate a total of $500,000 per year.[46] Substituting the potential future value of the fishery for its 2012 value increases the NPVs listed above (the 50-year NPV is $17.8-$20.4 million, the 100-year NPV is $21.9-$25.1 million, the 200-year NPV is $23.0-$26.4 million).

Table 5. Economic Values Associated with Sockeye Harvested in Canada's Okanagan

Fishery	50-Year NPV	100-Year NPV	200-Year NPV
FSC Fishery	$2.7-$4.0 million	$3.3-$4.9 million	$3.4-$5.1 million
Commercial Fishery	$6.6-$7.3 million	$8.1-$9.0 million	$8.6-$9.4 million
Recreational Fishery	$1.9-$3.2 million	$2.3-$3.9 million	$2.5-$4.1 million
Total	**$11.2-$14.5 million**	**$13.7-$17.8 million**	**$14.4-$18.7 million**

[45] US Bureau of Reclamation. 2008. *Economics Technical Report for the Yakima River Basin*. Technical Series No. TS-YSS-23. January.

[46] Personal Communication (Telephone). February 25, 2013. Richard Bussanich, Fisheries Biologist, Okanagan Nation Alliance.

3.4.5 Value of Okanagan sockeye harvest elsewhere in the Columbia Basin

In addition to the Canadian fisheries described above, several US fisheries rely on the Okanagan sockeye stock. We identified and described the major sockeye fisheries targeting Okanagan sockeye in the US earlier in this report. Below, we briefly describe the values we quantified for each of the fisheries. As in the previous section, these sockeye harvests reflect the benefits associated with the Baseline Scenario. Under the Development Scenario we assume that no sockeye from the Okanagan stock would be harvested anywhere in the Columbia Basin.

FSC fisheries

In 2012, Washington's Treaty Indian Fishery and the Colville Confederated Tribes Fishery harvested an estimated 55,625 Okanagan sockeye (39,948 and 15,677, respectively). While some of these sockeye entered the market, the vast majority were retained by tribe members and used for household consumption. To estimate the value of these sockeye from a purely consumptive perspective, we apply the $10-$15 per fish estimate we used in the previous section. Across these fisheries, the consumptive value of the sockeye harvested totals about $556,000-$834,000.

Commercial fisheries

In 2012, the commercial sockeye fishery in Washington, which operates from the mouth of the Columbia River to Bonneville Dam, harvested a total of 328 Okanagan sockeye. The average revenue per sockeye from the ONA's demonstration commercial fishery was $5.05-$5.56 per fish. To estimate the value of Washington's commercial fishery, we apply this range of per-fish revenues to the 2012 harvest, which results in a value of about $1,700-$1,800.

Recreational fisheries

In 2012, recreational anglers in the US harvested an estimated 31,024 Okanagan sockeye. This fishery covers a broad range of the Columbia Basin in the State of Washington, but is primarily consolidated in the Columbia River's upper sections (upstream of the confluence of the Columbia and Snake Rivers). To estimate the potential value associated with this recreational fishery, we apply the average, per-trip value we used in the previous section ($76 per trip). While the catch limit is two sockeye per angler per day in Canada, Washington's recreational fishery allows anglers to catch up to six sockeye per day. Assuming that each angler catches three sockeye per trip, there were a total of about 10,300 angler days in 2012. Combining the per-unit value with the estimated number of angler days in the fishery in 2012 suggests a total value of about $787,000.

Yakima broodstock program

In 2012, the Yakima Nation in Washington harvested an estimated 8,800 Okanagan sockeye at Priest Rapids Dam. They transported these sockeye to Lake Cle Elum, where they hope the sockeye will mature and migrate throughout the Yakima Basin to spawn.

Harvesting sockeye at Priest Rapids Dam has opportunity costs: mainly the reduction in potential harvests in upstream fisheries. As described in previous sections, these sockeye have different market values depending on the type of fishery they are harvested in. For FSC fisheries, sockeye have a market value of $10-$15 per fish. For commercial fisheries, sockeye have a market value of $5.05-$5.56 per fish (based on the average per-fish revenue generated in the ONA's demonstration commercial fishery). For recreational fisheries, sockeye have a market value of about $25-$38 per fish (based on a total angling trip value of $76 divided by average catch rates of 2-3 sockeye per trip).

Table 6. Opportunity Costs of the Yakima Broodstock Program

Fishery	50-Year NPV	100-Year NPV	200-Year NPV
FSC Fishery	$2.3-$3.5 million	$2.9-$4.3 million	$3.0-$4.5 million
Commercial Fishery	$1.2-$1.3 million	$1.5-$1.6 million	$1.5-$1.7 million
Recreational Fishery	$5.9-$8.9 million	$7.3-$10.9 million	$7.6-$11.5 million

Table 6 summarizes the 50-year, 100-year, and 200-year NPVs of these opportunity costs. These values are not additive across fisheries. In calculating these values, we assume that the broodstock program would harvest 8,800 Okanagan sockeye at Priest Rapids Dam each year. We use the full range of potential annual opportunity costs in our summary of values associated with the broodstock program. If the sockeye population is successfully reintroduced to the Yakima Basin, then the broodstock program would stop harvesting sockeye at Priest Rapids Dam, and these fish would continue upstream to these fisheries, where harvest levels would rise.

Using Costs to Estimate Value of Broodstock Program

Another way to think about the value of the sockeye harvested for the broodstock program is to look at the costs associated with reintroduction efforts in the Yakima Basin. According to the Final Environmental Impact Statement of the Cle Elum Dam Fish Passage Facilities and Fish Reintroduction Project, the program includes two components.

- The first component incorporates costs associated with fish passage facilities, which would include juvenile and adult passage facilities upstream and downstream of the dam. Depending on the approach, construction costs for these facilities would total $90-$102 million and average annual operation, maintenance, replacement, and power costs would total about $0.3 million.
- The second component incorporates costs associated with fish reintroduction efforts coordinated between the Yakima Nation and Washington Department of Fish and Wildlife. Average annual costs would total about $0.3-$0.5 million. An additional option would be to construct and operate a hatchery to supplement reintroduction efforts. The hatchery would cost $11-$21 million to construct and an additional $1.1 million in annual operation costs.

These costs help shed light on the magnitude of the economic benefits anticipated from reintroducing sockeye to the Yakima Basin. Assuming that the construction costs for all the components occur this year and that annual costs commence next year, the 50-year NPV of these efforts would total about $144-$173 million, the 100-year NPV would total about $154-$184 million, and the 200-year NPV would total about $157-$188 million.

Source: US Bureau of Reclamation. 2011. *Final Environmental Impact Statement: Cle Elum Dam Fish Passage Facilities and Fish Reintroduction Project*. April.

Summary

The values described above shed light on the different types of economic values associated with the harvests across the three fisheries and the broodstock program. These values depend on their respective harvests over time. The sum of all the values calculated in this section is $1.4-$2.0 million per year. Assuming that future harvests are similar to those in 2012, the 50-year NPV of these values is $36.8-$51.9 million, the 100-year NPV is $45.2-$63.7 million, and the 200-year NPV is $47.6-$67.0 million.

Table 7. Economic Values Associated with Okanagan Sockeye Harvested Elsewhere in the Columbia Basin

Fishery	50-Year NPV	100-Year NPV	200-Year NPV
FSC Fishery	$14.7-$22.1 million	$18.1-$27.2 million	$19.0-$28.6 million
Commercial Fishery	$44,000-$48,000	$54,000-$59,000	$57,000-$62,000
Recreational Fishery	$20.9 million	$25.6 million	$26.9 million
Broodstock Program	$1.2-$8.9 million	$1.5-$10.9 million	$1.5-11.5 million
Total	**$36.8-$51.9 million**	**$45.2-$63.7 million**	**$47.6-$67.0 million**

We assume that these benefits are solely associated with the Baseline Scenario, and that no fish from the Okanagan sockeye stock would be harvested under the Development Scenario. These estimates, however, may understate or overstate the potential future value of these fisheries. If, for example, sockeye populations increase in the future, harvests likely would also increase, which would result in increased harvest values across these fisheries. If, however, sockeye populations decline in the future, harvests likely would also decline along with the values associated with those harvests.

Economic Activity

Most of this analysis focuses on **economic values**, which represent the effects ecosystem services have on individuals' standard of living. Here, we briefly consider **economic activity**, which represents the jobs, incomes, and other related variables associated with ecosystem services (in this case, harvesting efforts aimed at the Okanagan sockeye stock). These impacts occur directly, as workers are employed in fisheries, for example, and indirectly, as dollars are spent locally on other goods and services – dollars that multiply through the local economy, supporting additional jobs and incomes.

As previously mentioned, the ONA's demonstration commercial fishery anticipates total revenues of $225,000-$275,000 from its 2012 sockeye harvest. An additional 10,000 sockeye were harvested in the FSC fishery, and another 3,183 in the recreational sockeye fishery in Osoyoos Lake.

Tracking Expenditures

Commercial Fishery. The ONA's commercial fishery sells sockeye within the Okanagan Valley and elsewhere in British Columbia. By selling fish outside the Valley, the fishery brings money into the Valley. By selling fish within the Valley, the fishery keeps money in the Valley that would have otherwise been used to purchase sockeye or other food from elsewhere.

FSC Fishery. Individuals in the Okanagan Valley harvest sockeye for personal consumption. By consuming the fish they harvest, these individuals retain more of their incomes for other spending, which may support local or non-local businesses. Without this harvest, these individuals would purchase food to consume, which may support local or non-local businesses.

Recreational Fishery. Individuals from the Okanagan Valley and visitors from elsewhere harvest fish recreationally in Osoyoos Lake. These anglers spend money on equipment and travel, and consume the fish they harvest. To the extent that their angling-related expenditures are made locally, they support local businesses and keep money in the Valley. As with the FSC fishery, to the extent that the portion of the harvest these anglers consume replaces other food expenditures, they have more of their incomes left over for other purchases in the Valley and elsewhere.

Net Impacts

It is difficult to tease out the net differences in economic impacts associated with sockeye harvests in the Okanagan Valley between the two scenarios. There are many opportunities under the Baseline Scenario for incomes to be retained within the Valley. According to an input-output model specific to British Columbia's economy, fishing, hunting, and trapping industries have a direct, indirect, and induced jobs multiplier of 8.8 jobs per $1 million. Given the relatively small revenues associated with the sockeye harvest in the Okanagan Valley, the fishery likely supports very few jobs – perhaps 10 at most - but it is not clear whether these individuals would be unemployed without the fishery, or if they would find additional work in other careers in the Valley or elsewhere.

Under the Development Scenario, depending on the extent to which development would impact the spawning sites in the study area, the sockeye fishery in the Okanagan Valley could close, which would eliminate the jobs the fishery currently supports. Further more, if the fishery were to grow in the future under the Baseline Scenario, the Development Scenario would eliminate even more jobs over time.

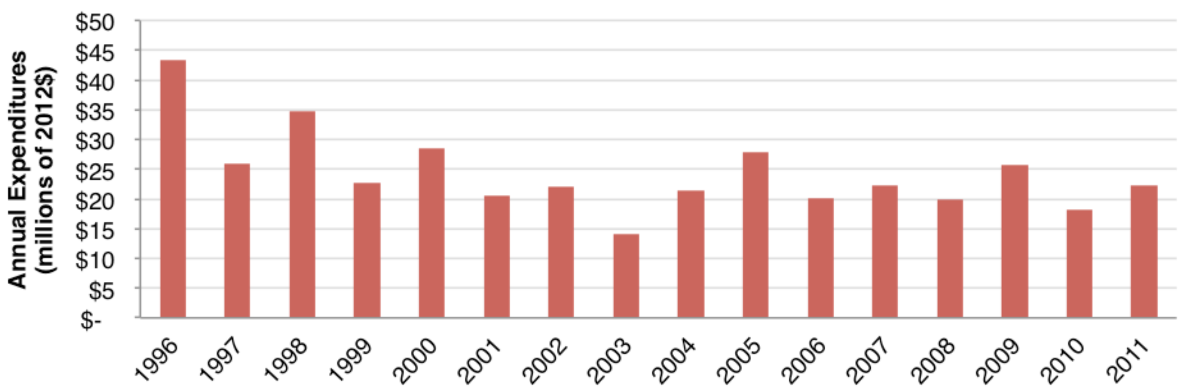
Source: Home, G. 2008. "2004 British Columbia Provincial Economic Multipliers." *BCStats*. March.

3.4.6 The value of avoiding extinction

While the Development Scenario likely would not, on its own, cause the extinction of all sockeye in the Columbia Basin, it has the potential to cause population extinction specific to the Okanagan sockeye stock. The costs associated with extinction are difficult to quantify in precise terms. One way to consider the value of a particular species or population is to look at efforts aimed at preventing extinction. These efforts demonstrate the low end of society's willingness to pay for species/population preservation.

As previously stated, the Canadian government relies on SARA and the US government relies on the ESA to prevent extinction. In its 2012 Economic Action Plan, the Canadian government proposed a budget of $50 million over two years to support the implementation of SARA.[47] In 2010, the US Fish and Wildlife Service oversaw a total of $1.4 billion in ESA-related spending.[48] Currently, the Snake River sockeye stock is listed as endangered in the US. Each year, the US Fish and Wildlife Service publishes a report summing all ESA-related expenditures by species/population, to the extent that those expenditures can be tied to a particular species/population. Figure 10 summarizes ESA-related expenditures on the Snake River sockeye stock from 1996-2011.

Figure 10. ESA-Related Expenditures on Snake River Sockeye Efforts (1996-2011)



Source: US Fish and Wildlife Service. 1996-2011. *Federal and State Endangered and Threatened Species Expenditures*. Retrieved on February 12, 2013 from http://www.fws.gov/endangered/esa-library/index.html.

Notes: These cost estimates are based only on state and federal expenditures that are specifically assigned to Snake River sockeye efforts. They do not include any land acquisition costs.

The Snake River sockeye stock was listed as endangered in 1991, and a review of the program in 2011 concluded that the species should remain on the list.[49] From 1996-2011, ESA-related expenditures have averaged about $24.4 million per year. With no de-listing anticipated in the near future, these expenditures could continue for many years. The 50-year NPV of annual expenditures (discounted at a rate of 3%) is $645.6 million, the 100-year NPV is $792.9 million, and the 200-year NPV is $834.1 million (see Table 8). In other words, these values represent avoided future costs that would potentially be incurred if the Okanagan sockeye stock were listed as threatened or endangered.

These expenditures, however, represent only part of the story. Government efforts to support species at risk also impose costs on society, primarily by restricting land use in protected areas (opportunity costs). For example, recreational and commercial fishing efforts for the Snake

[47] Her Majesty the Queen in Right of Canada. 2012. Economic Action Plan 2012. Retrieved on February 11, 2013 from http://www.budget.gc.ca/2012/plan/toc-tdm-eng.html.

[48] US Fish and Wildlife Service. 2010. *FY 2010 Federal and State Endangered and Threatened Species Expenditures*.

[49] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Regional Office. 2012. *Snake River Sockeye ESU*. Retrieved on February 12, 2013 from http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Sockeye/SOSNR.cfm.

River stock are prohibited, as are many other types of activities that may interfere with efforts to improve the population. Furthermore, other entities (e.g., non-profit organizations and private individuals) bear costs in implementing their own efforts to help support the species.

In economic terms, the total value of preventing species extinction is equal to the total value of all the benefits humans derive from the species. The costs discussed thus far provide some information on the value society places on these species.

Table 8. Summary of Avoided Costs of Species Protection

Benefit Description	50-Year NPV	100-Year NPV	200-Year NPV
Avoided costs of species protection based on recent ESA expenditures on Snake River sockeye stock.	$645.6 million	$792.9 million	$834.1 million

3.4.7 Passive-use value associated with sockeye

So far, our analysis of the importance and the different types of values associated with the study area's support of the Okanagan sockeye stock under the Baseline Scenario has focused on: (1) the cultural importance of the sockeye stock, (2) the market values associated sockeye harvests, and (3) the potential value of avoiding efforts to improve the population if it were to become endangered. These types of importance and values align with specific groups of individuals that, for the most part, interact directly with the sockeye. Other groups, however, also derive valuable benefits from healthy sockeye populations despite not directly interacting with the sockeye. In economic terms, this is referred to as **passive-use value**.

One of the best ways of quantifying this type of value is by applying a stated preference methodology, or more specifically for example, a contingent valuation study in which survey responses are used to estimate non-market values. As described by the Treasury Board of Canada Secretariat, the methodology "asks respondents in a hypothetical market if they would pay a specified amount for a prescribed commodity."[50] In this case, a contingent valuation survey would ask respondents across a wide geography (at least the provinces and states through which Okanagan sockeye travel) how much they would be willing to pay for a program that prevented a reduction in sockeye populations equal to that associated with the Development Scenario. Unfortunately, time and resources were not sufficient to conduct a contingent valuation study specific to the issues considered in this analysis. In lieu of conducting primary research, we can apply the principles of benefit transfer, which allow us to use the results of other studies to inform our quantification of the value associated with the decrease in sockeye populations under the Development Scenario.

[50] Treasury Board of Canada Secretariat. 2007. *Canadian Cost-Benefit Analysis Guide*. Catalogue No. BT58-5/2007.

Literature review

Our review of available literature uncovered only a handful of studies examining the public's willingness to pay for programs aimed at improving Pacific salmon populations. None of the available studies are specific to the Okanagan sockeye stock, or to describing the willingness to pay of residents within the Okanagan Valley. Table 9 summarizes information describing five of the most relevant studies and their results. All five of these studies used surveys to estimate the public's willingness to pay to improve specific salmon populations. These values shed light on the total economic value of these species as do not distinguish between individuals that participate in commercial or recreational salmon fishing. These results suggest that households are willing to pay $0.04-$22.70 per year per 1,000 fish for improvements to salmon populations.

Table 9. Literature Describing Willingness to Pay for Improvements in Salmon Populations

Source	Location	Annual WTP per Household (2012$)	Start Fish Population - End Fish Population	Annual WTP per Household per 1,000 fish (2012$)
Bell, K., D. Huppert, and R. Johnson. 2003. "Willingness to pay for local Coho Salmon enhancement in coastal communities." *Marine Resource Economics*. 18: 15-31.	Coastal Washington and Oregon	$143.36	64,000 - 128,000	$2.24
Hanemann, M., J. Loomis, and B. Kanninen. 1991. "Statistical efficiency of double-bounded dichotomous choice contingent valuation." *American Journal of Agricultural Economics*. Nov:1255-1263.	California	$338.25	100 - 15,000	$22.70
Layton, D., G. Brown, and M. Plummer. 1999. *Valuing Multiple Programs to Improve Fish Populations.* Washington State Department of Ecology. April.*	Washington*	$68-$90*	N/A*	$1.20-$1.50*
Loomis, J. 1996. "Measuring the economic benefits of removing dams and restoring the Elwha River: Results of a contingent valuation survey." *Water Resources Research.* 32(2): 441-447.	Washington	$112.82	50,000 - 325,000	$0.35
Olsen, D., J. Richards, and R. Scott. 1991. "Existence and sport values for doubling the size of Columbia River Basin salmon and steelhead runs." *Rivers*. 2(1): 44-56.	Washington, Oregon, Idaho, Montana	$92.38	2.5 million - 5.0 million	$0.04

Source: US Bureau of Reclamation. 2008. *Economics Technical Report for the Yakima River Basin*. Technical Series No. TS-YSS-23. January.

*See Appendix B for more details regarding our application of the results of this study.

Identifying the most relevant study to apply to this analysis

The Treasury Board of Canada Secretariat provides three best practices to consider when identifying appropriate studies for benefit transfer:

- The selected study should be similar to the change in question, in terms of the type of goods or services as well as the socio-economic conditions.
- The selected study should be comprehensive, and should be based on high-quality data and sound theoretical concepts.

- Welfare measurements from the selected study should be similar to those in the analysis.

Of the five studies, we conclude that the 1999 study conducted in the State of Washington (which we refer to as the **LBP Study**) provides the most relevant results to our analysis. Table 10 briefly summarizes the main pros and cons of this study within the context of the Secretariat's best practices. While this study is not an ideal candidate for benefit transfer in this instance, it is the most applicable given the set of available literature, and applying it can be useful in quantifying the potential magnitude of this value within the context of this analysis.

Table 10. Pros and Cons of Applying the Results from the LBP Study to this Analysis

Pros	Cons
The LBP Study examined household willingness to pay for changes in migratory fish populations from Eastern Washington and the Upper Columbia Basin. This fish population includes the Okanagan sockeye stock.	The LBP Study was based on surveys asking households for their willingness to pay for increases in salmon populations while our analysis would best be served by a survey asking households for their willingness to accept for a decrease in salmon populations.
The LBP Study was comprehensive. It collected nearly 3,000 surveys from across the State of Washington.	The LBP Study's results were based on surveys collected in the State of Washington, which may not represent the preferences of households in the Okanagan Basin or in British Columbia.
The LBP Study asked households for their willingness to pay in terms of percent changes in fish populations, which aligns with the way our analysis considers changes in fish populations.	The LBP Study focused on a broad range of fish species, while our analysis is focused on changes in sockeye populations.

Estimating the value

The LBP study asked households how much they would be willing to pay per month, for 20 years, for an increase in salmon populations by the end of the 20-year period. To apply the results of the LBP Study, we assume that the Development Scenario occurs, and decreases salmon populations. Then we apply the results to estimate the public's willingness to pay for programs to increase salmon populations to their levels under the Baseline Scenario. For this analysis, we assume that a program would need to increase the Columbia Basin's salmon population by 5-9% after population declines from the Development Scenario to return to population levels under the Baseline Scenario within 20 years. Using this approach suggests that Washington households would be willing to pay about $64-$86 per year, for 20 years, to increase salmon populations to pre-Development Scenario levels.

Table 11 summarizes our results. We calculated the results for four regions: (1) Washington, (2) Oregon, (3) the Okanagan Valley, and (4) British Columbia. We extrapolated household estimates from Washington to other regions by incorporating differences in the median and mean household incomes in each region (see Appendix B for more details). As previously stated, this study is not ideal for benefit transfer in this case. However, applying the results of this study certainly sheds light on the potential values associated with the salmon supported under the Baseline Scenario. Applying the results to Washington is the most justifiable because that is where the original study took place. Applying the results to Oregon is similarly justifiable due to the iconic nature of salmon and the Columbia Basin to Oregon residents. Applying the results across the border into regions in Canada may not be appropriate. Below, we list a few reasons why our use of these values for Canadian households may overstate or understate household willingness to pay for improvements in salmon populations.

- The importance of the Columbia Basin's salmon stocks to Washingtonians, in general, is perhaps greater than the importance of the Okanagan sockeye stock to British Columbians because the Okanagan stock is but a small subset of all salmon populations in British Columbia (the Fraser River system supports much larger salmon populations). As such, households in British Columbia may be willing to pay large sums of money to support salmon populations in the Fraser River, and smaller sums of money to support stocks in the Okanagan.
- Given the geographic proximity to the Okanagan sockeye stock, households within the Okanagan Valley may be willing to pay more than the average household in Washington to support the population.
- Cross-boundary issues may influence decisions due to perceived responsibilities of areas containing spawning grounds, fishing grounds, or other matters.

Table 11. Summary of Willingness to Pay Estimates for Increased Salmon Populations (2012$)

	Washington	Oregon	Okanagan Valley	British Columbia
Household willingness to pay per year	$64-$86	$54-$72	$67-$90	$77-$103
Number of households	2.7 million	1.6 million	163,000	1.8 million
Total willingness to pay per year	$172-$230 million	$84-$112 million	$11-$15 million	$136-$182 million
20-year present value	$2.6-$3.5 billion	$1.3-$1.7 billion	$0.2 billion	$2.1-$2.8 billion

Notes: See Appendix B for more details

3.4.8 Health and nutrition values

In addition to all the different forms of importance and value associated with Okanagan sockeye described thus far, individuals also derive health and nutrition values from these fish. Data are not sufficient to quantify the value/importance of these benefits. In this section, we briefly introduce and describe the importance of these benefits.

Historically, indigenous peoples across Canada relied on a variety of foods harvested from local environments (e.g., fish, wild game, plants, and berries). Over time, their diets have changed as traditional foods have become more scarce and commercial foods have become more prevalent.[51] While obesity rates across Canada have been rising steadily over the past 25 years, rates among indigenous populations have increased even more rapidly. These changes in diet, along with smoking and lack of physical activity precipitate problems associated with diabetes,

[51] National Collaborating Centre for Aboriginal Health. 2013. *Nutrition Fact Sheet*. Retrieved on March 5, 2013 from http://www.nccah-ccnsa.ca/Publications/Lists/Publications/Attachments/71/Nutrition.pdf.

cardiovascular disease, high blood pressure, and some types of cancer.[52] To the extent that the Development Scenario would reduce the number of sockeye available for local consumption, it could further contribute to declining health trends of indigenous and non-indigenous populations that would substitute sockeye consumption with a less healthy option.

3.5 Summary

In this section, we described salmon populations and harvests in the Columbia Basin as they relate to differences in conditions in the study area under the Baseline Scenario and the Development Scenario. We used available data and information to describe and quantify the importance and values associated with changes to sockeye populations resulting from the Development Scenario. This analysis assumes that the Development Scenario would reduce the availability of spawning habitat for the Okanagan sockeye stock, which could reduce sockeye populations across the Columbia Basin by 54-90%.

In Table 12 we summarize the types of importance and values we discussed in this section. These values are not necessarily additive, but even so, the results suggest that the value of quantified benefits associated with salmon under the Baseline Scenario (relative to those under the Development Scenario) likely total tens of millions of dollars over the next 200 year. Indeed society's willingness to pay to protect the Okanagan sockeye stock may total over $1 billion. Depending on the specific benefit category, the beneficiaries range from individuals living with the Okanagan Basin to individuals across North America. While some sockeye may be harvested and consumed in the Basin, others may be sold out of the region, at which point those final consumers also derive benefits. To quantify the value of the sockeye harvest, we quantified revenues from sockeye sales and avoided costs of sockeye consumption in the FSC fisheries. These benefits all occur within the Columbia Basin and in the Okanagan Valley. Sockeye sold outside of this region provide additional benefits to consumers, which we did not quantify.

Table 12. Summary of Findings Related to Changes in Sockeye Populations (2012$)

	50-Year NPV	100-Year NPV	200-Year NPV
Cultural Importance	Not Quantified	Not Quantified	Not Quantified
Sockeye Harvest in Canada	$11.2-$14.5 million	$13.7-$17.8 million	$14.4-$18.7 million
Sockeye Harvest in the US	$36.8-$51.9 million	$45.2-$63.7 million	$47.6-$67.0 million
Avoiding Extinction	$645.6 million	$792.9 million	$834.1 million
LBP Study Results (WA only)	$2.6-$3.5 billion	$2.6-$3.5 billion	$2.6-$3.5 billion
Health and Nutrition	Not Quantified	Not Quantified	Not Quantified

[52] National Collaborating Centre for Aboriginal Health. 2013. *Nutrition Fact Sheet*. Retrieved on March 5, 2013 from http://www.nccah-ccnsa.ca/Publications/Lists/Publications/Attachments/71/Nutrition.pdf.

4 Other Ecosystem Services

In this section, we identify, analyze, and describe the marginal benefits of the ecosystem services the study area provides under the Baseline Scenario relative to those it provides under the Development Scenario. We have identified 10 ecosystem services to include in our analysis. This analysis does not represent an exhaustive examination of all the ecosystem services the study area provides. These 10 ecosystem services do, however, represent the main differences between the two scenarios, and hence shed light on the value of the **naturalness** of the study area.

Table 13 identifies the 10 ecosystem services we include in this section. We discuss each ecosystem service in four parts:

- We describe the relevant conditions under the Baseline and Development Scenarios.
- We describe how the supply of the ecosystem service differs between the two scenarios, using service-specific metrics (e.g., recreation days, tonnes of carbon).
- We identify sources of demand for this change in supply, and quantify or describe the value of the change.
- We summarize our findings.

Table 13. Ecosystem Services Considered in this Analysis

Stormwater Treatment	Water Supply
Flood Protection	Water Quality
Open Space	Recreation
Carbon Sequestration	Habitat and Wildlife
Air Quality	Education

In comparing the ecosystem services supported by each scenario, we assume that, across the Okanagan Valley, the total level of development would be the same in both the Baseline Scenario and the Development Scenario. The difference between the scenarios is the location of future development. We assume that under the Development Scenario, development would occur in the study area. In the sections that follow, we attempt to focus on the net differences between the two scenarios. In some instances, the specific location of future development (inside or outside the study area) does not influence the overall level of ecosystem services supported in the Valley. In other instances, there is a difference. This comparison helps illustrate the uniqueness of the study area and its capacity to support ecosystem services in the Okanagan Valley.

4.1 Stormwater Treatment

Baseline Scenario. The study area is currently entirely permeable, which means that all ground surfaces in the study area have the capacity to capture and treat precipitation. Some of the stormwater the study area captures flows into the Okanagan River and some of it flows into the groundwater supply. These permeable surfaces filter potentially harmful pollutants from the precipitation captured in the study area before the water enters the River or the groundwater supply.

Development Scenario. Channelization and development would decrease the amount of permeable surface in the study area and would increase the amount of impervious surface (e.g., building footprints, concrete roads, and sidewalks). This increase in impermeable surfaces would require stormwater infrastructure (either a new system or an expansion of the existing system) to convey stormwater from developments to receiving water bodies. This system would either convey stormwater along with wastewater to a wastewater treatment facility or it would travel in its own set of pipes to a stormwater treatment facility. Either way, conveying and treating this stormwater would result in an increase in stormwater treatment costs, which represents the cost of re-creating the existing functionality of the study area under the Baseline Scenario.

4.1.1 Changes in supply

Much of the Okanagan Basin lies in the dry shadow of the Cascade Mountains (to the west), which makes for dry conditions. On average, 326 mm of precipitation falls on the study area each year.[53] Under the Baseline Scenario, much of this precipitation falls directly onto the River or filters through the undeveloped land adjacent to the River. After it filters through the soil, the precipitation enters back into the water cycle (e.g., vegetation absorbs it, it filters through to groundwater sources or back into the River). Under the Development Scenario, precipitation would fall onto impermeable surfaces, after which a stormwater system would collect and convey the stormwater to a treatment facility.

In this analysis, we assume that development in the study area under the Development Scenario would replace all the forestland in study area (94.5 acres). Not all of this area, however, would be covered with impermeable materials. For this analysis, we assume that 40-60% of the developed area would be covered with impermeable materials. Given the study area's average annual precipitation, this increase in impermeable surfaces would result in about 5,000-7,500 cubic meters of stormwater runoff each year.

4.1.2 Value of relevant benefits and affected groups

The stormwater runoff generated in the study area under the Development Scenario could be collected and conveyed in a number of different ways to re-create the natural functionality of the study area. Table 14 identifies 18 different techniques for collecting and treating stormwater, as well as a range of one-time costs associated with each technique (costs are in terms of dollars

[53] The Weather Network. 2013. *Statistics: Oliver, BC, Canada*. Retrieved on February 14, 2013 from http://www.theweathernetwork.com/statistics/cl1125760.

per cubic meter of runoff treated). The median range of costs is about $462-$905 per cubic meter of runoff treated.[54]

Table 14. Summary of Stormwater Retrofit Costs (2012$ per cubic meter of runoff treated)

Retrofit Technique	Range	Retrofit Technique	Range
Pond Retrofits	$40-$402	Structural Sand Filter	$643-$885
Rain Gardens	$121-$201	Impervious Cover Conversion	$744-$865
New Storage Retrofits	$101-$362	Stormwater Planter	$724-$1,448
Larger Bioretention Retrofits	$302-$694	Small Bioretention Retrofits	$1,005-$1,609
Water Quality Swale Retrofits	$281-$885	Underground Sand Filter	$1,126-$3,016
Cisterns	$241-$1,005	Stormwater Tree Pits	$2,332-$3,338
French Drain/Dry well	$422-$543	Permeable Pavers	$3,860-$5,791
Infiltration Retrofits	$402-$925	Extensive Green Roofs	$5,791-$12,064
Rain Barrels	$503-$1,609	Intensive Green Roofs	$12,064-$16,890

Source: Schueler, T., D. Hirshman, et al. 2007. *Urban Subwatershed Restoration Manual No. 3: Urban Stormwater Retrofit Practices, Appendix I.* Center for Watershed Protection and US Environmental Protection Agency, Offices of Watershed Management.

One way of quantifying the value of the precipitation capture and treatment benefits of the study area under the Baseline Scenario is to use stormwater retrofit costs as a proxy for society's willingness to pay for precipitation capture and treatment to protect water quality and aquatic habitat. To quantify this value, we apply the median range of costs of the techniques identified in Table 14 ($462-$905 per cubic meter treated) to the increase in stormwater runoff under the Development Scenario (5,000-7,500 cubic meters). Using this method, the stormwater benefits the study area provides under the Baseline Scenario total $2.3-$6.8 million.

In addition to these costs, however, are annual operation and maintenance costs associated with the stormwater retrofits. One study found that, depending on the specific retrofit, average annual costs could total about 5-10% of construction costs.[55] Assuming the full range of capital costs from above, average operation and maintenance costs would total about $0.1-$0.7 million per year. If the initial costs were incurred this year, and the annual costs would accrue after that, the 50-year NPV would total $5.2-$24.0 million, the 100-year NPV would total $5.9-$28.1 million, and the 200-year NPV would total $6.1-$29.3 million.

4.1.3 Summary

In this section, we quantified the difference in stormwater capture and treatment under the two scenarios and quantified and described some of the benefits associated the service. We used stormwater management costs as a proxy for society's willingness to pay for the study area's capacity to capture and treat stormwater. Table 15 summarizes our results. To estimate annual

[54] These values do not include the costs associated with green roofs because those costs were well beyond the range of values associated with other types of retrofits.

[55] Rain Garden Initiative. No Date. *Operation and Maintenance of Green Infrastructure*. Retrieved on March 13, 2013 from http://www.raingardeninitiative.org/documents/pdfs/3pm_Maintenance_Christian.pdf.

values, we assumed capital costs of man-made stormwater capture and treatment facilities would be incurred this year, and annual costs would accrue after that. Inherent in these assumptions is that the retrofits would continue functioning over the 200-year period of analysis.

Table 15. Summary of Stormwater Treatment Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
Stormwater management costs as a proxy for society's willingness to pay for the study area's capacity to capture and treat stormwater.	50-year NPV: \$5.2-\$24.0 million 100-year NPV: \$5.9-\$28.1 million 200-year NPV: \$6.1-\$29.3 million	Public agencies, utilities, and ratepayers responsible for stormwater management, and downstream agencies and water users affected by water quality.

4.2 Flood Protection

Baseline Scenario. Since the study area currently contains no development, there are no structures or individuals at risk of incurring flood-related damages within the study area. Furthermore, the study area has the capacity to regulate streamflow and capture and store precipitation, which reduces the likelihood and severity of flood events downstream.

Development Scenario. Channelization and development in the study area would increase the number of structures and individual at risk of incurring flood-related damages within the study area. The Development Scenario would also decrease the study area's capacity to regulate streamflow and capture and store precipitation, which would increase the likelihood and severity of flood events downstream.

4.2.1 Changes in supply

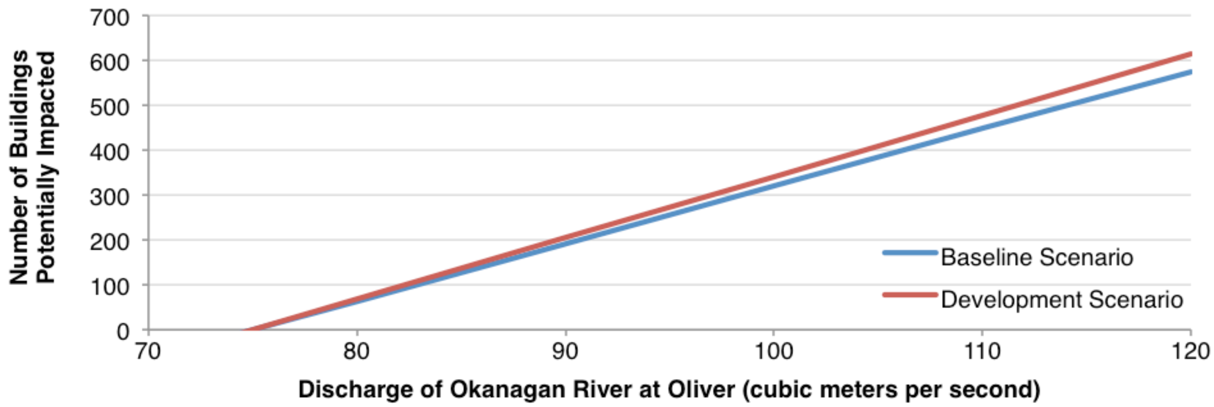
A 2002 study in the Okanagan Basin estimated the number of buildings potentially impacted by high flows in three stretches of the Okanagan River.[56] Given the location of the study area, we will focus on the results for the stretch of the River flowing from Vaseux Lake to Osoyoos Lake. The blue line in Figure 11 represents the relationship identified in the 2002 study, which we assume to be similar to the relationship under the Baseline Scenario. The blue line ends at 119 cubic meters per second, the 200-year flood event for this particular stretch of the Okanagan River.

The length of the Okanagan River running through the study area accounts for about 7% of the length of the River running from Vaseux Lake to Osoyoos Lake. Here, we assume that the increase in number of buildings potentially impacted by flooding under the Development Scenario is proportionate to the River's length within the study area relative to the distance between the two lakes (7%). The red line in Figure 11 represents the relationship between

[56] Summit Environmental Consultants Ltd. 2002. *Draft Report - Fish/Water Management Tool Project: Hydrology and Socio-Economic Submodel*. Prepared for the Okanagan Nation Alliance/Okanagan Nation Fisheries Commission.

streamflow and building impacts under the Development Scenario. For example, when the Okanagan River's discharge at Oliver is 119 cubic meters per second, about 563 buildings would be subject to flood-related damages under the Baseline Scenario, while about 600 buildings would be subject to damages under the Development Scenario (a difference of 37 buildings).

Figure 11. Streamflow and Building Damages between Vaseux Lake and Osoyoos Lake



As previously mentioned, the Development Scenario would also decrease the study area's capacity to regulate streamflow, which could increase the likelihood and severity of future flood events downstream of the study area. Data, however, are not sufficient to quantify this change in likelihood. Furthermore, the complex system of canals and reservoirs in the Okanagan Valley likely has the capacity to mitigate the changes in the study area's capacity to regulate streamflow.

4.2.2 Value of relevant benefits and affected groups

Our analysis of the flood protection benefits provided by the study area is based on the avoided costs of flood-related damages to structures in the study area under the Development Scenario. As described above, a 200-year flood event would damage 563 buildings under the Baseline Scenario and 600 buildings under the Development Scenario (a difference of 37 buildings). A 1974 study looking at costs associated with flood damages along the banks of Osoyoos Lake identified 58 homes sustaining damages totaling about $2.0 million (adjusted from 1975 to 2012 dollars using the Statistics Canada's consumer price index), or about $35,000 per home.[57] Applying this value to the 37 additional buildings subject to flooding under the Development Scenario yields a total cost of $1.3 million. After accounting for the annual likelihood of the 200-year flood event, and discounting future values by 3%, the 50-year NPV of these flood-related structural damages is $174,000, the 100-year NPV is $214,000, and the 200-year NPV is $225,000.

While development would occur elsewhere in the Okanagan Valley under the Baseline Scenario, it is unlikely that future development would be as susceptible to potential future flood events as the development in the study area under the Development Scenario. Given this

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[57] Okanagan Basin Study Office. 1974. Technical Supplement 3 to the Final Report - Water Quantity Alternatives and Supporting Water Quantity Data. March.

difference, we assume that these avoided costs represent avoided costs of development specific to the Development Scenario.

Recently, we conducted an analysis in King County, Washington estimating the value of several different flood-related costs, including: structural damage, inventory loss, content loss, debris removal, tree removal, vehicular damage, hazardous material cleanup, general cleanup, displaced households, temporary shelter, health, business interruption, and lost income. In that study, we found that costs associated with structural damages accounted for only 9% of total flood-related costs. If that same relationship applies to flood-related damages in the study area under the Development Scenario, the 50-year NPV of all flood-related damages is $2.0 million, the 100-year NPV is $2.4 million, and the 200-year NPV is $2.6 million. These benefits are linked to the avoided damages themselves. To some extent potential future property owners within the study area would derive these benefits. Some of the benefits extend beyond individual property owners and are incurred by society in the form of public disaster relief efforts.

These estimates consider only the costs associated with a 200-year flood event. In addition to that large potential flood, the study area (under the Development Scenario), likely would be vulnerable to damages from other, smaller flood events. Data are not sufficient to quantify the total value of all potential flood events with the capacity to cause damages in the study area (under the Development Scenario). To the extent that these additional flood events would cause damages, our estimates understate the total value of flood-related benefits associated with the Baseline Scenario. Furthermore, these estimates do not incorporate the study area's capacity to reduce flood-related damages downstream, by regulating streamflow.

4.2.3 Summary

In this section, we quantified and described the flood-related benefits under the Baseline Scenario by analyzing the potential costs of flood-related damages under the Development Scenario. Development in the study area (under the Development Scenario) would increase the number of structures, individuals, and businesses vulnerable to flood-related damages. Avoiding these costs represents a benefit under the Baseline Scenario. Table 16 summarizes our results. These estimates shed light on some of the avoided costs associated with developing in the study area stemming from a 200-year flood event. Development would also be subject to smaller flood events with additional costs, which are not included in our estimates.

Table 16. Summary of Flood-Related Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
Avoided costs associated with flood-related structural damages in the study area under the Development Scenario.	50-year NPV: $174,000 100-year NPV: $214,000 200-year NPV: 225,000	Potential future residents and businesses in the study area and public agencies that manage flood events.
Total avoided costs of flood-related damages in the study area under the Development Scenario.	50-year NPV: $2.0 million 100-year NPV: $2.4 million 200-year NPV: $2.6 million	Potential future residents and businesses in the study area and public agencies that manage flood events.

4.3 Open Space

Baseline Scenario. The study area is not developed and currently contains 105 acres of open space. For this analysis, we assume that the River covers 10% of the study area, and that the other 90% is forested.

Development Scenario. Channelization and development would decrease the amount of open space in the study area. Since development would not occur on the River itself, we assume that the Development Scenario would reduce the amount of open space available in the study area by 94.5 acres (the total forested area under the Baseline Scenario).

4.3.1 Changes in supply

As stated above, the Development Scenario would decrease the amount of open space in the study area by 94.5 acres. While there could be some open spaces available within the Development Scenario, our analysis assumes full development in order to illustrate the maximum extent of the benefit relative to the Baseline Scenario.

4.3.2 Value of relevant benefits and affected groups

Many of the benefits discussed in this analysis are tied to the existence of the open space the study area provides under the Baseline Scenario, so it is difficult to tease out the value of the open space itself, apart from other additional benefits. In this section, describe some of the ways in which people derive benefits from open space and discuss methods that have been used elsewhere to quantify other types of values that open spaces provide.

Research suggests individuals derive benefits from exposure to natural settings. This desire for contact with nature is important in restoring and improving mental health.[58] These benefits rely on both the presence of nearby natural features as well as their quality. One study found that individuals have a strong preference for natural areas over human-created areas, particularly when trees and vegetation are present. The study found that exposure to trees can help reduce stress and anxiety, and survey respondents identified a direct link between their exposure to trees and their mental health.[59]

People feel a strong emotional response to green space even if they are not directly using it. This is called existence value. One study found that after Hurricane Hugo damaged infrastructure in Charleston, South Carolina, over 30 percent of those surveyed considered urban forests as the most significant feature that was damaged, even if those respondents were not directly using the forests. Of those responses, the largest percentage of respondents (11 percent) stated that the reason this feature was special to them was the "positive feelings or emotions" green spaces

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[58] Van den Berg, A., T. Hartig, and H. Staats. 2007. "Preference for Nature in Urbanized Societies: Stress, Restoration, and the Pursuit of Sustainability." *Journal of Social Issues*. 61(1):79-96.

[59] Ulrich, R. 1986. "Human Responses to Vegetation and Landscapes." *Landscape and Urban Planning*. 13:29-44.

invoke. The author noted this finding supports previous research that suggests nature evokes positive and relaxing emotions.[60]

In 2001, the POLIS Project on Ecological Governance along with Smart Growth British Columbia compiled a report identifying several economic benefits associated with the protection of natural open spaces.[61] The study focused on identifying the benefits of protecting open space in terms of their impacts on the real estate value of adjacent and nearby properties.

Typically, these values are estimated by conducting a hedonic analysis, which uses assessor data describing nearby properties to tease out the impact of proximity to open space on property values. In 1999, a study looking at the impact of riparian greenways in British Columbia (the study looked at three sites in the Lower Mainland and one on Vancouver Island) found that proximity to greenways accounted for 15% of nearby property values.[62] Many of the households surveyed believed their proximity to the open space had a positive affect on property values (75%). Under the Baseline Scenario, there is very little residential development near the study area, so the positive impacts on property values from past studies are difficult to transfer. Under the Development Scenario, the amount of development would increase, but the amount of open space would decrease, which would lead to an overall decrease in open space-related benefits from the Baseline Scenario.

The 2001 report also cited a 1998 study that estimated household willingness to pay in Boulder, Colorado to prevent development on a 5.5-acre parcel of undeveloped land nearby.[63] The study asked households within one mile of the 5.5-acre parcel how much they would be willing to pay (in a one-time payment) to prevent development. The study found that, on average, households within one mile of the 5.5-acre parcel were willing to pay a one-time fee of $245 (2012$) to prevent the development, or about $77 per household per acre. Economic theory suggests that household willingness to pay decreases as the distance between the open space and the household increases. Furthermore, at the per-acre level, household willingness to pay for open space likely decreases as the area of open space increases (e.g., households would be willing to pay more to protect the 50th acre than the 100th acre). Ultimately, there are too many differences between these results and the study area to transfer the values to the Baseline and Development Scenarios. These results do, however, suggest that individuals near the study area likely would be willing to pay to preserve its open space, and to prevent the Development Scenario.

4.3.3 Summary

In this section, we described some of the values associated with the open space the study area provides under the Baseline Scenario. Since the Development Scenario would not provide any

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60 Hull, B. 1992. "How the Public Values Urban Forests." *Journal of Arboriculture*. 18(@): 98-101.

61 Curran, D. 2001. *Economic Benefits of Natural Green Space Protection*. May.

62 Hamilton, S. and M. Quayle. 1999. *Corridors of Green and Gold: Impact of Riparian Suburban Greenways on Property Values*. Fraser River Action Plan, Department of Fisheries and Oceans.

63 Breffle, W., E. Morey, and T. Lodder. 1998. "Using Contingent Valuation to Estimate a Neighborhood's Willingness to Pay to Preserve Undeveloped Urban Land." *Urban Studies*. 32(4):715-727.

open space, the value of open space-related benefits under the Baseline Scenario represents the marginal value between the two scenarios. Our description of the benefits focused on psychological benefits and the impacts on property values on adjacent properties. Table 17 summarizes our results.

Table 17. Summary of Open Space Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
Nearby residents and visitors benefit through increased property values and improvements in mental health.	Not quantified	Nearby residents and visitors.

4.4 Carbon Sequestration

Baseline Scenario. The study area is not developed and contains several different types of vegetation, which help remove greenhouse gases (e.g., carbon dioxide) from the air. By removing greenhouse gases from the atmosphere, the study area (under the Baseline Scenario) helps slow the impacts of climate change in the study area and across the globe.

Development Scenario. Channelization and development would affect greenhouse gas emissions in the study area (as well as the surrounding area) by reducing the amount of vegetation in the study area. With less vegetation, the study area would sequester less carbon each year, which would hasten the impacts of climate change around the world.

4.4.1 Changes in supply

During photosynthesis, trees and other vegetation absorb carbon dioxide (CO_2) from the atmosphere and, along with other inputs, convert it to biomass and oxygen.[64] The study area currently contains forested areas that, under the Baseline Scenario, would continue to absorb and sequester CO_2 from the atmosphere into the future. Under the Development Scenario, development would remove much (and potentially all) of this forested area, and no sequestration would occur in the future.

Data are not sufficient to precisely describe the forested portion of the study area. In general, the study area is sparsely vegetated with low brush as well as aspen and birch trees.[65] In total, the study area covers 105 acres. In this analysis, we assume that the river itself accounts for 10% of the study area (10.5 acres), and that the remaining 90% of the study area is forested (94.5 acres). Recently, the US Forest Service published a methodology for calculating carbon sequestration for different forest types across the US.[66] Given the prevalence of aspen and birch

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[64] Moulton, R.J. and K.R. Richards. 1990. *Costs of Sequestering Carbon Through Tree Planting and Forest Management in the United States*. US Forest Service. Technical Report WO-58.

[65] Iverson, K., and A. Haney. 2006. *An Updated Terrestrial Ecosystem Map (TEM) for the South Okanagan Valley*. Report ID 7441. Retrieved on February 22, 2013 from http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=7441.

[66] Smith, J., L. Heath, et al. 2005. *Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States*. US Forest Service. General Technical Report NE-343.

in the study area, we use a range of carbon sequestration estimates for aspen and birch forests in the Rocky Mountain region as well as the Northern Great Lakes region. For this analysis, we assume that the forestland within the study area sequesters carbon at a rate equal to the range in average annual sequestration rates for these two forests (about 0.3-0.4 tonnes of carbon per acre per year). With 94.5 acres of forestland, the study area sequesters a total of 34-39 tonnes of carbon per year under the Baseline Scenario. Under the Development Scenario, we assume that the study area sequesters no carbon.

4.4.2 Value of relevant benefits and affected groups

Extensive research shows that British Columbia and areas along North America's west coast already have experienced noticeable changes in climate, and predicts that more change will occur in the future.[67] Research has identified several types of anthropogenic greenhouse gas emissions that contribute to climate change; chief among them is the emissions of CO_2. In 2004, CO_2 accounted for approximately 77 percent of greenhouse gases emitted into the atmosphere. Since 1850, the concentration of CO_2 in the atmosphere has increased from 280 to 379 parts per million, and has grown by an average of 1.9 parts per million per year since 1995.[68]

To calculate the value of the carbon the study area sequesters under the Baseline Scenario, we model the sequestration over time (about 34-39 tonnes of carbon per year) and incorporate two values: (1) an estimate of the social cost of carbon, and (2) British Columbia's carbon tax. Since the Development Scenario would provide little (if any) carbon sequestration, the marginal value of this benefit is equal to the value of carbon sequestration under the Baseline Scenario. These values attempt to incorporate the values of carbon-related externalities associated with using fossil fuels. They represent the marginal costs of CO_2 emissions, at the global level, so the beneficiaries of the study area's carbon sequestration include individuals around the world, both now and in the future.

Value based on the social cost of carbon

Economists use the social cost of carbon to estimate the value of changes in greenhouse gas emissions. The social cost of carbon represents "the full global cost today of emitting an incremental unit of carbon at some point of time in the future, and it includes the sum of the global cost of the damage it imposes on the entire time it is in the atmosphere."[69] There are currently over 200 different estimates of the social cost of carbon. One review of the literature found values ranging from about $7 to over $100 per tonne of CO_2.[70] For our analysis, we apply a middle value of $40 per tonne of CO_2 to estimate the social cost of emissions. Furthermore, we assume that this value increases, in real terms, by 2.5 percent per year, to fold in expectations

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[67] See, for examples, British Columbia, Ministry of Environment, Climate Action Secretariat. 2013. *Climate Change: Provincial Impacts*. Retrieved on February 12, 2013 from http://www.env.gov.bc.ca/cas/impacts/bc.html.

[68] Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Synthesis Report*. Geneva, Switzerland.

[69] Shaw, M., L. Pendleton, et al. 2009. *The Impact of Climate Change on California's Ecosystem Services*. California Climate Change Center. CEC-500-2009-025-F.

[70] Shaw, R. et al, 2009. *The Impact of Climate Change on California's Ecosystem Services*. August.

that the value of the social costs would increase at an annual rate of 2 to 3 percent as climate-change related damages mount.[71] The 50-year NPV of carbon sequestered in the study area under the Baseline Scenario is about $0.2–$0.3 million, the 100-year NPV is about $0.4–$0.5 million, and the 200-year NPV is about $0.7–$0.8 million. The Development Scenario would provide no benefits related to carbon sequestration.

Value based on British Columbia's carbon tax

In 2008, British Columbia passed the Carbon Tax Act, which consumers pay when they purchase fossil fuels in the Province. According to the Ministry of Finance, "the tax puts a price on carbon emissions to encourage individuals, businesses, industry, and others to use less fossil fuel and reduce their greenhouse gas emissions."[72] The carbon tax rate has increased each year, and in July 2012 was set at $30 per tonne of CO_2 equivalent emissions.[73] The tax itself is revenue neutral, which means that all revenues collected from the tax are offset through reductions in other taxes. For this analysis, we assume that British Columbia's carbon tax rate will not change in the future. Using this tax rate as an indicator of the value of carbon sequestration, the 50-year NPV of carbon sequestered in the study area under the Baseline Scenario is about $109,000-$125,000, the 100-year NPV is about $133,000-$153,000, and the 200-year NPV is about $140,000-$160,000. The Development Scenario would provide no benefits related to carbon sequestration.

4.4.3 Summary

In this section, we described the value of carbon sequestered in the study area under the Baseline and Development Scenarios. We used per-acre carbon sequestration rates from relevant forest types and applied estimates of the social cost of carbon as well as British Columbia's carbon tax rate. These estimates shed light on the avoided, climate change-related costs associated with the carbon sequestration in the study area. Since the Development Scenario would not provide any carbon sequestration, the value of carbon sequestration benefits under the Baseline Scenario represents the marginal value between the two scenarios.

Table 18. Summary of Carbon Sequestration Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
The value of carbon sequestered under the Baseline Scenario using the social cost of carbon	50-year NPV: $247,000–$282,000 100-year NPV: $436,000–$499,000 200-year NPV: $700,000–$802,000	Individuals around the world, today and in the future, benefit from carbon sequestration efforts.
The value of carbon sequestered under the Baseline Scenario using British Columbia's carbon tax rate.	50-year NPV: $109,000-$125,000 100-year NPV: $133,000-$153,000 200-year NPV: $140,000-$160,000	Individuals around the world, today and in the future, benefit from carbon sequestration efforts.

[71] Nordhaus, W. 2008. *A Question of Balance: Weighing the Options on Global Warming Policies*. Yale University Press, New Haven, CT.

[72] British Columbia, Ministry of Finance. 2013. *Carbon Tax Review, and Carbon Tax Overview*. Retrieved on February 12, 2013 from http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm.

[73] British Columbia, Ministry of Finance. 2013. *Carbon Tax Review, and Carbon Tax Overview*. Retrieved on February 12, 2013 from http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm.

4.5 Air Quality

Baseline Scenario. The study area is not developed and contains several different types of vegetation, which help remove harmful pollutants from the air. By removing these pollutants from the air, the study area helps residents avoid several costs associated with air pollution (e.g., health costs stemming from air quality-related illnesses).

Development Scenario. Channelization and development would affect air quality in the study area (as well as the surrounding area) by reducing the amount of vegetation in the study area. With less vegetation, the volume of pollutants removed from the atmosphere in the study area would decrease, which would increase the air quality-related costs nearby residents incur.

4.5.1 Changes in supply and affected groups

Research shows that trees help improve localized air quality in two ways: (1) by filtering harmful pollutants out of the air, and (2) by reducing energy demands in nearby developments.[74] Since there is little development around the study area under the Baseline Scenario, and since there would be few trees around the study area under the Development Scenario, we focus our attention on the first mechanism through which trees improve air quality: by filtering pollutants out of the atmosphere.

Data are not sufficient to precisely describe the forested portion of the study area. In general, the study area is sparsely vegetated with low brush as well as aspen and birch trees.[75] In total, the study area covers 105 acres. In this analysis, we assume that the river itself accounts for 10% of the study area (10.5 acres), and that the remaining 90% is forested (94.5 acres). Recent research in the US has estimated the capacity for trees to remove pollutants from the atmosphere in 55 cities. The closest city to the study area is Seattle, Washington. Table 19 summarizes the study's results in terms of the study area under the Baseline Scenario. Under the Development Scenario, we assume that the study area would contain very few trees, which would provide virtually no air quality benefits.

Table 19. Air Pollutant Removal in the Study Area under the Baseline Scenario

Pollutant	Pollutant Removal (grams per acre per year)	Total Pollutant Removal (grams per year)
NO2	2,800-7,700	268,000-726,000
PM10	4,900-19,400	246,000-1,835,000
SO2	2,800-10,100	268,000-956,000
O3	2,800-17,400	268,000-1,644,000

Source: Nowak, D., D. Crane, and J. Stevens. 2006. "Air Pollution Removal by Urban Trees and Shrubs in the United States." *Urban Forestry & Urban Greening*. 4:115-123.

[74] Nowak, D., D. Crane, and J. Stevens. 2006. "Air Pollution Removal by Urban Trees and Shrubs in the United States." *Urban Forestry & Urban Greening*. 4:115-123.

[75] Iverson, K., and A. Haney. 2006. *An Updated Terrestrial Ecosystem Map (TEM) for the South Okanagan Valley*. Report ID 7441. Retrieved on February 22, 2013 from http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=7441.

The research describing the impact of trees on air quality is clear, however, in stating that urban trees provide more benefits than do trees in more rural areas. This is because air pollution is localized. With more development and air emissions, urban areas have poorer air quality than rural areas. Since our analysis relies on data describing urban trees and their potential for improving air quality, our findings likely overstate the study area's contribution to air quality.

4.5.2 Value of relevant benefits

Air pollution has been linked to several societal costs including health-related costs associated air quality-related illnesses as well as environmental costs such as those associated with acid rain. To calculate the value of the study area's air filtration under the Baseline Scenario, we apply a set of pollutant-specific avoided costs from the literature to the air quality improvements summarized in the preceding section. Table 20 summarizes our results.

Table 20. Value of Air Quality Benefits in the Study Area under the Baseline Scenario

Pollutant	Pollutant Removal Benefits ($ per tonne)	Total Pollutant Removal Benefits ($ per year)
NO2	$7,690	$2,100-$5,600
PM10	$5,134	$2,400-$9,400
SO2	$1,883	$500-$1,800
O3	$7,690	$2,100-$12,600

Source: Nowak, D., D. Crane, and J. Stevens. 2006. "Air Pollution Removal by Urban Trees and Shrubs in the United States." *Urban Forestry & Urban Greening*. 4:115-123.

The 50-year NPV of air quality improvements in the study area under the Baseline Scenario is about $185,000-$780,000, the 100-year NPV is about $227,000-$959,000, and the 200-year NPV is about $239,000-$1.0 million. The Development Scenario would provide no air quality-related benefits. As previously stated, these values likely overstate the value of air quality benefits in the study area because they are based on tree-related air quality benefits in urban areas, which tend to have more air pollution for trees to remove than more rural areas (like the study area).

4.5.3 Summary

In this section, we described the value of air quality-related benefits in the study area under the Baseline and Development Scenarios. We used per-acre rates of air quality improvements from Seattle and applied estimates of avoided costs linked to air quality-related illnesses. Table 21 summarizes our results. These estimates shed light on the avoided, air quality-related costs associated with the air filtration in the study area. Since the Development Scenario would not provide any air filtration, the value of air quality-related benefits under the Baseline Scenario represents the marginal value between the two scenarios.

Table 21. Summary of Air Quality Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
Avoided costs of air quality-related illnesses incurred under the Development Scenario.	50-year NPV: $185,000-$750,000 100-year NPV: $227,000-$959,000 200-year NPV: $239,000-$1.0 million	Residents and individuals in nearby areas benefit from localized improvements in air quality.

4.6 Water Supply

Baseline Scenario. The study area collects and filters stormwater and contributes to streamflows within the Okanagan River as well as groundwater sources. Since there is no development under the Baseline Scenario, the study area uses none of the regional water supply.

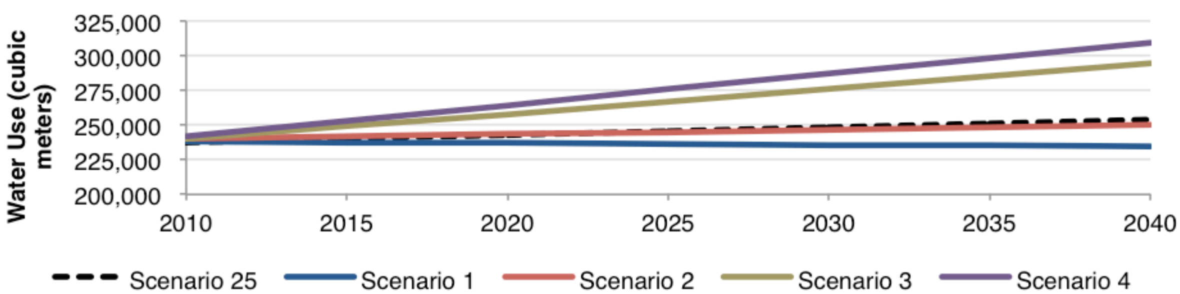
Development Scenario. Channelization and development within the study area would increase municipal and/or agricultural water demand in the study area, however there would be no change in water demand, at the Basin level.

4.6.1 Changes in supply

In 2010, Summit Environmental Consultants completed Phase 2 of its study describing the supply of and demand for water in the Okanagan Basin.[76] The study identified several future scenarios that differed in terms of climate change impacts, population growth, agricultural growth, water-use efficiency, as well as other factors. Figure 12 summarizes five of these scenarios and shows how water demand is expected to increase/decrease over time. For example, the study found that climate change alone (assuming all other factors remain constant) would increase water demand by 6.8% from 2010-2040. Adding the effects of population growth and agricultural expansion to those of climate change would increase water demand by 28% (even after taking into account increasingly efficient irrigation and domestic water use).

Figure 12. Water Demand in the Okanagan Basin (2010-2040)

Scenario	Scenario Assumptions	Change in Demand
Scenario 25	Assumes climate change.	Increase by 6.8%
Scenario 1	Same as Scenario 25 along with current trends in population growth, irrigation system improvements, and indoor water use.	Decrease by 1.5%
Scenario 2	Same as Scenario 1, but with a higher population growth rate.	Increase by 4.1%
Scenario 3	Same as Scenario 1, but with an increase in the agricultural land base.	Increase by 22.6%
Scenario 4	Same as Scenario 1, but with a higher population growth rate and an increase in the agricultural land base.	Increase by 28%



Source: Summit Environmental Consultants Inc. 2010. *Okanagan Water Supply and Demand Project: Phase 2 Summary Report – Appendix O.* July. Retrieved on February 14, 2013 from http://www.obwb.ca/wsd/about/project-reports.

[76] Summit Environmental Consultants Inc. 2010. *Okanagan Water Supply and Demand Project: Phase 2 Summary Report.* July. Retrieved on February 14, 2013 from http://www.obwb.ca/wsd/about/project-reports.

The Phase 2 study also found that, currently, average domestic water use (indoors and outdoors) totals about 675 liters per person per year.[77] As of 2010, population density in communities around the study area (including Spallumcheen, Peachland, Osoyoos, Oliver, Armstrong, and Enderby) ranged from 300-800 people per square kilometer (about 1.2-3.2 people per acre).[78] Assuming that development in the study area under the Development Scenario would mirror development in these communities, it would bring a total of about 115-305 individuals to the study area. Now, assuming they use as much water as average water users in the Basin, this population would require a total of 28.7-75.4 million liters for indoor and outdoor domestic consumption each year.

In this analysis, we assume that the same amount of development would occur in both the Baseline Scenario and the Development Scenario. The only difference is that, under the Development Scenario, some of that development would occur in the study area. Since the total amount of development is the same under both scenarios, there would be not net difference in water demand across the Okanagan Valley.

4.6.2 Value of relevant benefits and affected groups

For this analysis, we assume that the potential increase in population/agricultural activity in the study area under the Development Scenario is incorporated into the results of the Phase 2 study. After the Phase 2 study was published, several additional efforts have been launched to better understand the implications of its findings. While programs to bridge the potential gap between water demand and water supply have yet to been developed, it is clear that some entity will have to bear their costs. Individual water users, groups of residential water customers, and public agencies represent just three groups that would potentially bear costs in bridging the gap. Since there is no difference in development or water demanded between the two scenarios, there is no unique value attributable to the study area under the Baseline Scenario.

4.6.3 Summary

In this section, we described some of the ways in which the Development Scenario could affect water supply within the study area and across the Okanagan Basin. Potential population growth and agricultural expansion under the Development Scenario would add stress to the region's water supply (which is already expected to rise in the coming years while the supply itself is expected to decline). With no net difference in overall development between the two scenarios (across the Okanagan Valley), there is no difference in water demanded. If, however, the Baseline Scenario were to decrease the total volume of water demanded, it would provide a benefit in the form of avoided costs potentially incurred by water ratepayers.

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[77] Summit Environmental Consultants Inc. 2010. *Okanagan Water Supply and Demand Project: Phase 2 Summary Report.* July. Retrieved on February 14, 2013 from http://www.obwb.ca/wsd/about/project-reports.

[78] Foster, L., C. Keller, et al. 2011. *British Columbia Atlas of Wellness 2nd Edition*. Retrieved on February 14, 2013 from http://www.geog.uvic.ca/wellness/wellness2011/index.html.

4.7 Water Quality

Baseline Scenario. The study area is part of a stretch of the Okanagan River that conveys water from Vaseux Lake south through Oliver. The stretch of the Okanagan River within the study area collects runoff from adjacent undeveloped lands, and filters it as it enters the Okanagan River and other groundwater systems.

Development Scenario. Channelization and development would decrease the study area's capacity to capture and treat water before it enters the River. While urban development would increase point source runoff (which we discuss elsewhere), agricultural development would increase non-point source runoff (as stormwater and irrigation water flows off of fields and into the River). This potential increase in polluted runoff would decrease water quality within the Okanagan River.

4.7.1 Changes in supply

The Development Scenario's affect on water quality in the study area (and downstream stretches of the Okanagan River) depends on the type of development. If the study area fills with residential or urban development, then stormwater runoff is the main concern (we talked about stormwater runoff in an earlier section on precipitation capture and treatment). If the study area is used for agriculture, then agricultural runoff is the main concern.

In 2009, the British Columbia Ministry of Environment compiled a report describing water quality in the Okanagan River near Oliver from 1990-2007.[79] The report had seven concluding points:

1. In general, water quality in the Okanagan has improved.
2. Many parameters had increasing trends from 1990-2007 (including dissolved chloride, fecal coliforms, hardness, extractable magnesium, molybdenum, strontium, and turbidity).
3. Many parameters had decreasing trends from 1990-2007 (including aluminum, chromium, copper, flow, iron, lithium, manganese, pH, phosphorus, potassium, and zinc).
4. Peak summer water temperatures continue to exceed British Columbia's aquatic life guidelines.
5. Total aluminum concentrations seasonally exceeded guidelines.
6. Some metals require additional/different measurements to conduct comparisons.

By channelizing the River, removing riparian forest, and developing agricultural land adjacent to the River, the Development Scenario has the capacity to decrease water quality in the study area in a number of ways. Riparian forests help control water temperature by providing shade and regulating microclimates. Removing the trees could increase water temperatures.

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[79] Dessouki, T. 2009. *Water Quality Assessment of the Okanagan River near Oliver, British Columbia (1990-2007)*. British Columbia Ministry of Environment. March.

Furthermore, agricultural runoff could increase concentrations of pollutants from fertilizers and pesticides. One study, for example, found 40 of the 80 pesticides typically used in Okanagan agriculture in water samples taken from nearby waterways.[80] Data are not sufficient to quantify the potential change in water quality parameters associated with the Development Scenario. However, unless mitigation measures are incorporated into the Development Scenario, agricultural development within the study area likely would decrease water quality within the Okanagan River and in lakes downstream. If, however, mitigation measures effectively treat agricultural runoff, then there would be no net difference in water quality between the two scenarios.

4.7.2 Value of relevant benefits and affected groups

As described above, the Development Scenario has the potential to decrease water quality from point and non-point sources. In this section, we focus on the value of potential declines in water quality associated with agricultural runoff (we discuss the affects of urban stormwater runoff in another section). The best way to measure these water quality impacts is by identifying efforts aimed at improving water quality. The costs associated with these efforts represent the avoided costs (or benefits) of the study area under the Baseline Scenario relative to the Development Scenario. These costs are unique to agricultural development in the study area due to its proximity to the Okanagan River (agricultural development elsewhere, especially if distant from a water body, may not trigger some of the regulations associated with agricultural runoff). Furthermore, agricultural developers themselves would incur the costs associated with these mitigation measures.

In order to minimize the adverse impacts of agricultural development on water quality, Canada's federal and provincial governments have developed a number of guidelines and regulations aimed at curbing pollutant loads in agricultural runoff.[81] Assuming that mitigation measures are effective in treating agricultural runoff, there would be no change in water quality between the two scenarios. Data are insufficient to quantify these costs, which agricultural developer would bear.

As stated above, removing riparian tree-cover has the potential to further increase water temperatures, which already exceed both aesthetic drinking water guidelines and general fisheries guidelines during summer months.[82] The values of avoiding the potential increase in water temperature associated with the Development Scenario is largely incorporated in our description of the importance and value of the sockeye salmon that use the study area to spawn. There may, however, be additional benefits associated with avoiding temperature increases insofar as other fish species would be affected.

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[80] Kuo, J., A. Soon, et al. 2012. "Agricultural Pesticide Residues of Farm Runoff in the Okanagan Valley, British Columbia, Canada." *Journal of Environmental Science and Health.* 47(4): 250-261.

[81] See, for example, British Columbia, Ministry of Agriculture. 2013. *Reference Guide*. Retrieved on March 6, 2013 from http://www.al.gov.bc.ca/resmgmt/fppa/refguide/intro.htm.

[82] BWP Consulting. 2003. *Water Quality Assessment of Okanagan River at Oliver (1979-2002).* Retrieved on March 13, 2013 from http://waterquality.ec.gc.ca/WaterQualityWeb/PDFDocs/BC08NM0001.pdf.

4.7.3 Summary

Agricultural development in the study area under the Development Scenario has the potential to reduce water quality due to increased volumes of agricultural runoff. This is unique to development in the study area, because agricultural development elsewhere in the Valley may be more isolated from water bodies. If mitigation measures are effective in eliminating the harmful effects of agricultural runoff on water quality, there would be no difference between water quality under the two scenarios. Agricultural developers would bear the costs associated these mitigation measures. Data, however are insufficient to quantify their value. Furthermore, while the removal of riparian tree cover under the Development Scenario likely would increase water temperatures, the value of maintaining lower water temperatures (such as those under the Baseline Scenario) are largely incorporated in the salmon-related benefits previously discussed.

4.8 Recreation

Baseline Scenario. Few, if any, individuals use the study area for recreation. Some individuals participate in recreation activities elsewhere along the Okanagan River. During the summer, many people go on casual float trips down the river, although they tend to stay within the channelized portions. Others use trails on dykes to go on walks, jog, and cycle. The main limitation on recreation in the study area is access. With no formal access points, individuals interested in recreation typically go elsewhere, where they have access.

The study area does, however, support many downstream recreation activities. As described earlier, the study area plays a key role in supporting sockeye populations throughout the Columbia Basin. These salmon populations support recreational fishing insofar as salmon from the study area migrate to other portions of the Columbia Basin where they attract recreational fishermen.

Development Scenario. Channelization would affect recreation in two ways: (1) it would harm salmon populations, which would decrease the quantity/quality of recreational fishing tied to salmon from the study area, and (2) it would improve access for recreation opportunities within the study area (e.g., trails on dykes and easy access for floating).

4.8.1 Changes in supply

The main form of recreation associated with the Baseline Scenario is the downstream fishing opportunities it supports. We discuss how each of the scenarios affects salmon populations and the Columbia Basin's recreational fishery elsewhere in this report. To summarize, the study area provides nearly all the spawning habitat for sockeye salmon in the Okanagan Basin under the Baseline Scenario. The Development Scenario would channelize the River in the study area and remove the sockeye spawning grounds. By decreasing salmon populations throughout the Columbia Basin, the Development Scenario would decrease the value individuals derive from fishing for sockeye within the Basin.

The Development Scenario could increase the availability of recreation opportunities within the study area. It could, for example, increase the amount of paved and/or unpaved trails individuals can use for going on walks, jogging, or cycling. It could also increase access to the River for in-stream recreation activities, such as floating. Data are not sufficient to quantify the difference in recreation days between the two scenarios.

4.8.2 Value of relevant benefits and affected groups

In general, researchers rely on revealed preference and stated preference methodologies to estimate the values individuals derive from participating in recreation activities. Revealed preference studies typically compile and summarize the travel-related costs individuals incur when participating in recreation activities. These costs represent a lower bound for the benefit individuals derive from recreation. Stated preference studies, on the other hand, typically ask individuals how much they would be willing to pay to participate in a recreation activity. These studies shed light on the total value associated with recreation activities.

A 2005 analysis conducted by the US Forest Service estimated the consumer surplus[83] values associated with several different types of recreation in several different regions. Table 22 summarizes the average consumer surplus values for the Pacific coast (which includes Washington, Oregon, and California), as well as the minimum, maximum, and average values across the US.

As previously mentioned, data are not sufficient to quantify the difference in recreation days between the two scenarios. For illustrative purposes, we assume that Development Scenario would increase the number of recreation days in the study area by 300 per year, split evenly between hiking, picnicking, and boating. Using the Pacific coast mean from Table 22, the consumer surplus value derived from these recreation activities totals about $14,000 per year. Using a 3% discount rate, the 50-year NPV of this change in recreation is about $370,000, the 100-year NPV is about $450,000, and the 200-year NPV is about $480,000.

Table 22. Consumer Surplus Values by Recreation Activity per Person per Day (2012$)

Recreation Activity	Pacific Coast Mean	US Mean	US Range
Camping	$127	$45	$2-$273
Flatboating/rafting/canoeing	$34	$123	$3-$480
Hiking	$28	$37	$1-$318
Mountain biking	$60	$90	$25-$359
Picnicking	$78	$50	$11-$173
Swimming	$33	$52	$3-$163
Wildlife viewing	$88	$51	$3-$423

Source: Loomis, J. 2005. *Updated Outdoor Recreation Use Values on National Forests and Other Public Lands*. US Forest Service. General Technical Report: PNW-GTR-658.

[83] Consumer surplus represents the difference between the value of an individual's total willingness to pay and the value of the costs that individual incurs while participating in the activity.

Local residents and visitors to the area that participate in these recreation activities would derive the benefits. To some extent, new recreation opportunities in the study area may replace recreation that would have occurred elsewhere. If recreation in the study area under the Development Scenario replaces recreation that would have occurred elsewhere, the net difference between the two scenarios would be smaller than the absolute values in the previous paragraph. Furthermore, the decrease in fishing-related recreation across the Columbia Basin associated with the Development Scenario (as described earlier in this report) likely would outweigh any potential increases in recreation in the study area resulting from development.

4.8.3 Summary

In this section, we described some of the ways in which the Development Scenario would affect recreation opportunities within the study area and across the Columbia Basin. Development could increase recreation opportunities within the study area, however it would also decrease fish-related recreation throughout the Columbia Basin due to its potential effect on local salmon spawning. Data are not sufficient to quantify the marginal effect of the Development Scenario on recreation-related benefits, however the potential decrease in fishing-related benefits across the Columbia Basin likely outweigh any potential increases in recreation-related benefits within the study area.

4.9 Habitat and Wildlife

Baseline Scenario. The study area covers about 105 acres of undeveloped land, and contains two main habitat types: riverine habitat and riparian habitat. These habitat provide a number of ecosystem services discussed elsewhere in this report (e.g., precipitation capture and treatment and carbon sequestration). They help sustain many different types of wildlife including sockeye salmon (which we discuss elsewhere), and a number of other species (plants, birds, mammals, etc.).

Development Scenario. Channelization and development would reduce area of riparian habitat in the study area and would reduce the quality of its riverine habitat. It would also decrease the study area’s capacity to support wildlife that relies on undeveloped land for survival.

4.9.1 Changes in supply

Under the Baseline Scenario, the study area contains about 94.5 acres of riparian habitat and about 10.5 acres of riverine habitat. We assume that the Development Scenario would eliminate all 94.5 acres of riparian habitat, and would reduce the quality of the riverine habitat in the study area. A number of ecosystem services related to these habitat areas have already been discussed. Here, we focus on the wildlife the habitats in the study area support. Table 23 identifies some of the species most commonly associated with riparian habitat in the Okanagan Valley from Vernon to Osoyoos. The Ministry of Environment has identified a number of species at risk in the Okanagan Region (see Table 24). Data are not sufficient to describe the extent to which any of these species rely on the study area for any stage of their life cycle. Furthermore, while invasive species, in particular, pose threats to the viability of the study area to support additional ecosystem services, data are not sufficient to differentiate between the spread of invasive species under the two scenarios.

Table 23. Species Associated with Riparian Habitat in the Okanagan Valley (Vernon to Osoyoos)

Yellow-breasted Chat	Toothcup Meado-foam	Columbia Mottled Sculpin
Western Screech Owl	Small Flowered Lipocarpha	Umatilla Dace
Giant Helleborine	Western Rattlesnake	Scarlet Ammania
Purple Spikerush	Western Painted Turtle	

Source: Iverson, K., D. Curran, T. Fleming, and A. Haney. 2008. *Sensitive Ecosystems Inventory Okanagan Valley: Vernon to Osoyoos 2000 to 2007*. Report ID 15326. August.

Table 24. Red and Blue Listed Species in the Okanagan Region

Amphibians	Sharp-tailed Grouse (Grassland)	Wolverine (Forest)
Great Basin Spadefoot Toad (Grassland/Wetlands)	Long-billed Curlew (Grassland)	Fisher (Forest)
Tiger Salamander (Wetlands)	Barn Owl (Grassland)	Grizzly Bear (Forest)
Northern Leopard Frog (Wetlands)	Bobolink (Grassland)	Caribou (Forest)
Birds	Lewis's Woodpecker (Grassland/Forest/Riparian)	White-tailed Jackrabbit (Grassland)
Canyon Wren (Cliffs)	Western Screech-Owl (Riparian)	Badger (Grassland)
Prairie Falcon (Cliffs/Grassland)	Yellow-breasted Chat (Riparian)	W. Harvest Mouse (Grassland)
White-throated Swift (Cliffs/Grassland)	Western Grebe (Wetlands)	Great Basin Pocket Mouse (Grassland)
Peregrine Falcon (anatum) (Cliffs/Wetlands)	American White Pelican (Wetlands)	Badger (Grassland)
White-headed Woodpecker (Forest)	American Bittern (Wetlands)	Northern Bog-lemming (Grassland)
Flammulated Owl (Forest)	Great Blue Heron (Wetlands)	Nuttall's Cottontail (Grassland/Forest)
Williamson's Sapsucker (Forest)	Sandhill Crane (Wetlands)	Fringed Myotis (Grassland/Riparian)
Gray Flycatcher (Forest)	American Avocet (Wetlands)	**Reptile**
Swainson's Hawk (Grassland)	California Gull (Wetlands)	Yellow-bellied Racer (Cliffs/Grassland/Forest)
Ferruginous Hawk (Grassland)	**Mammals**	Gopher Snake (Cliffs/Grassland/Forest)
Sage Grouse (Grassland)	Pallid Bat (Cliffs/Grassland)	Western Rattlesnake (Cliffs/Grassland/Forest)
Burrowing Owl (Grassland)	W. Small-footed Myotis (Cliffs/Grassland)	Rubber Boa (Forest/Grassland)
Sage Thrasher (Grassland)	California Bighorn Sheep (Cliffs/Grassland)	Pigmy Short-horned Lizard (Grassland)
Brewer's Sparrow (Grassland)	Spotted Bat (Cliffs/Riparian/Forest)	Night Snake (Grassland)
Grasshopper Sparrow (Grassland)	Townsend's Big-eared Bat (Forest)	Painted Turtle (Wetlands)
Lark Sparrow (Grassland)	Cascade Groundsquirrel (Forest)	

Source: British Columbia, Ministry of Environment, Okanagan Region. 2009. *Habitat Atlas for Wildlife at Risk Red and Blue List.* Retrieved on February 14, 2013 from http://www.env.gov.bc.ca/okanagan/esd/atlas/list.html.

4.9.2 Value of relevant benefits and affected groups

In this section, we present two ways of describing and quantifying the value of the difference in the wildlife and habitat supported under the two scenarios. First, we describe how species-specific values can be used to estimate society's willingness to pay for programs that promote healthy wildlife populations. Then, we quantify the avoided restoration costs associated with the wildlife and habitat benefits supported under the Baseline Scenario.

Species-specific values

Several studies have examined the values society associates with individual species. As described in the salmon section, stated preference approaches tend to ask individuals or households how much they would be willing to pay for programs aimed at improving specific species populations. There are insufficient data to quantify the extent to which particular species are better or worse off in the study area relative to the two scenarios. Table 25 provides several estimates from the literature that shed light on the potential magnitude of society's willingness to pay to support particular species.

Table 25. Summary of Species-Specific Willingness to Pay Estimates from the Literature (2012$)

Species	Average Annual Household WTP Estimates	Species	Average Lump Sum Household WTP Estimates
Bighorn Sheep	$20	Arctic grayling	$26
Owl	$40	Bald eagle	$340
Turkey	$15	Falcon	$36
Woodpecker	$18	Wolf	$70

Source: Richardson, L., and J. Loomis. 2009. "The Total Economic Value of Threatened, Endangered and Rare Species: An Updated Meta-Analysis." *Ecological Economics*. 68:1535-1548.

Avoided restoration costs

The reduction in habitat and wildlife supported in the study area under the Development Scenario could be offset by efforts at improving wildlife and habitat conditions elsewhere along the Okanagan River. While restoration efforts may not fully offset damages in the area, recent work near the study area suggests that some improvements are possible along channelized portions of the River. In particular, the ORRI demonstrates one particular project, near the study area, that improved habitat and wildlife conditions in the River. The ORRI reconnected one kilometer of floodplain and re-meandered 500 meters of river with pools, riffles, islands, and gravel bars on a stretch of the Okanagan River just north of Oliver (south of the study area). One way of quantifying the value of the habitat and wildlife the study area supports is to estimate the avoided costs of conducting restoration efforts similar to the ORRI. The ORRI is being implemented in two phases. We briefly describe the two phases and their costs below.[84]

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[84] Personal Communication (e-mail). March 14, 2013. Joe Enns, Fisheries Biologist, Okanagan Nation Alliance.

- **Phase I.** The first phase included planning, engineering design, environmental protection, monitoring, outreach, and re-vegetation efforts. The work began in 2000 and is expected to last through the end of 2013. The total estimated cost for Phase I is about $1.3 million.
- **Phase II.** The second phase will include planning, construction, environmental protection, monitoring, outreach, and re-vegetation. The work will begin after Phase I is complete. The total estimated cost for Phase II is about $0.9 million.

To estimate these expenditures over time, we total the costs associated with the two phases, and estimate the average annual cost of implementation (about $150,000 per year assuming a 15-year implementation period). After the implementation period is completed, we assume that there are additional annual costs totaling $16,000 per year (the budget for Phase I included $16,000 per year for aquatic, terrestrial, and riparian monitoring). Furthermore, we escalate these costs by the ratio of the length of the River in the study area (1.6 kilometers) to the length restored under the ORRI (0.5 kilometers). Using these assumptions, the 50-year NPV is $6.6 million, the 100-year NPV is $6.9 million, and the 200-year NPV is $7.0 million. This estimate likely understates the actual restoration costs associated with the entirety of the study area because it is based only on the length of the River within the study area and does not capture the full extent of the adjacent forestland included in our analysis.

4.9.3 Summary

In this section, we quantified and described some of the values associated with the wildlife and habitat the study area supports under the Baseline Scenario. We quantified the potential value of these wildlife and habitat benefits in terms of the avoided restoration costs associated with future efforts that would be required to offset the decrease in habitat and wildlife benefits associated with the Development Scenario. To estimate these avoided costs, we used per-mile restoration costs from the ORRI, downstream of the study area. We also summarized some species-specific values from the literature. Data were insufficient to quantify society's willingness to pay for changes in wildlife conditions between the two scenarios. Table 26 summarizes our results. These estimates shed light on the value the habitat and wildlife the study area supports under the Baseline Scenario, however they likely potentially understate the value since they do not fully incorporate the forested area included in the study area.

Table 26. Summary of Wildlife and Habitat Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
Society's willingness to pay to support endangered or threatened species represents the benefit of maintaining habitat and wildlife conditions under the Baseline Scenario	Not Quantified	Local residents and all individuals deriving benefits from knowing specific species are protected.
The avoided restoration costs associated with offsetting damages under the Development Scenario represent the value of benefits under the Baseline Scenario	50-year NPV: $6.6 million 100-year NPV: $6.9 million 200-year NPV: $7.0 million	Local residents, developers, and public agencies responsible for funding restoration efforts.

4.10 Education

Baseline Scenario. Each year, schoolteachers, college professors, and other educators in the Okanagan Valley use the study for educational purposes. In some instances, students take trips to the study area to learn about the natural hydrology and other ecological and biological characteristics associated with the unchannelized section of the Okanagan River.

Development Scenario. Channelization and development would take away the study area's unique biophysical characteristics that serve as the basis for its use in educational programming across the Okanagan Valley and beyond.

4.10.1 Changes in supply

Under the Baseline Scenario, students from local schools, individuals participating in local education and restoration programs, and students at colleges and universities learn about the study area and sometimes take field trips to the study area to support their coursework. For example, about 25 students attending the British Columbia Institute of Technology stop by the study area during an annual field trip to the Okanagan Valley.[85] The trip is part of a certificate program for fish, wildlife, and recreation management. Other students learn from the study site indirectly, by learning about its features as a case study in the classroom.[86] Under the Development Scenario, these students would miss out on a valuable component of their current curriculum.

4.10.2 Value of relevant benefits and affected groups

The values of benefits related to education are difficult to quantify. One way to consider these benefits is to analyze the value of goods and services associated with the educational experience. For example, one benefit associated with a degree in mechanical engineering is the salary one can expect while working as a mechanical engineer and the benefits to society of the goods and services that engineer develops. Another way to consider these benefits is to analyze the costs associated with providing the educational opportunity. A third way to consider these benefits is to analyze the next best option (or opportunity cost) of the participants' time. Data are not sufficient, however, to quantify a value specific to the changes in the study area stemming from the two scenarios.

For illustrative purposes, we use the second approach described above (quantifying the costs of providing educational experiences) to show the value of education-related benefits under a hypothetical scenario. In 2008, Canada's annual educational expenditures for elementary and secondary institutions totaled about $8,400 per student, and the school year in British Columbia consisted of a total of 187 school days.[87] These figures suggest a total cost of about $48 per

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[85] Personal Communication (Telephone). March 26, 2013. Bob Gunn, British Columbia Institute of Technology.

[86] Personal Communication (Telephone). March 26, 2013. Todd Redding, Okanagan College in Penticton.

[87] British Columbia Ministry of Education. 2007. *Standard School Calendar.* Retrieved on March 26, 2013 from http://www.bced.gov.bc.ca/legislation/stdcal03.pdf; US Department of Education. 2012. *The Condition of Education 2012*. NCES 2012-045.

student per school day. At this cost, providing 100 students with one day of education costs a total of $4,800. Using a 3% discount rate, the 50-year NPV of a daylong lesson taught to 100 students each year is about $127,000, the 100-year NPV is about $156,000, and the 200-year NPV is about $164,000.

The individuals learning from the study area derive valuable benefits from their education. Some of them apply the lessons they learn directly in occupations related to restoration activities. Others apply the lessons indirectly by becoming good environmental stewards and by volunteering for restoration and conservation efforts in the future. Others benefit from education as well. By learning about the study area's natural functions, and taking on responsibilities in the restoration and conservation communities, individuals that learned from the study area provide benefits to others without links to these educational opportunities but who nonetheless benefit from the actions of restoration and conservation efforts. Under the Development Scenario, there would be other available opportunities for individuals to derive education-related benefits from the Okanagan River, but they will be different and may lack an adequate example of the unique characteristics the study area supports.

4.10.3 Summary

In this section, we described some of the ways in which the Development Scenario would affect education opportunities associated with the study area. Data are not sufficient to quantify the marginal effect of the Development Scenario on education-related benefits. However, any decrease in educational opportunities associated with the study area would affect the capacity of individuals interested in the natural characteristics of the undeveloped Okanagan Basin to learn from the study area's unique features. Furthermore, a decrease in education could result in a decrease in interest in supporting restoration and conservation efforts in the Okanagan Basin, which would decrease the value of benefits derived by individuals that value a healthy Basin.

Table 27. Summary of Education Benefits

Benefit Description	NPV of Marginal Benefit	Beneficiaries
Value of goods and services derived from education associated with the study area; costs of supplying education associated with the study area.	Not Quantified	All individuals participating in education opportunities related to the study area and individuals deriving benefits from the goods and services associated with that education.

5 Distributional Analysis

So far, the analysis has focused on identifying and describing the importance and value associated with specific ecosystem services the study area supports in the Baseline Scenario, relative to those it supports in the Development Scenario. In this section, we summarize the distribution of these service-specific results. First, we look at the distribution of importance and values across different types of beneficiaries. Then, we describe how to think about the distribution of importance and values over time.

5.1 Distribution Across Beneficiaries

Throughout the report, we described the specific beneficiaries that derive benefits from the ecosystem services included in the analysis. In this section, we summarize the distribution of all the different types of importance and value described in the report.

5.1.1 Beneficiaries

To summarize the distribution of the results, we developed six general groups of beneficiaries covering three different geographies. Within the Okanagan Valley, we distinguish between indigenous populations and other residents. We also consider other portions of the Columbia Basin, and distinguish between indigenous populations and other residents. At a broader scale, we consider residents in Canada and residents in the US that do not reside within the Okanagan Valley or the Columbia Basin.

5.1.2 Magnitude of benefits

For each ecosystem service, we described the marginal difference in importance or value between the Baseline Scenario and the Development Scenario in quantitative or qualitative terms. To summarize our results, we grouped these descriptions into three categories (High, Medium, or Low) based on their relative importance or value (see Table 28). In instances where we include quantitative results, we group those with the values at the high end of the distribution, those with values in the middle of the distribution, and those at the low end of the distribution. In instances where we include qualitative results, we use the relative substitutability of the ecosystem service as an indicator of its importance/value. If, for example, there are many readily available substitutes to the benefits derived from a particular ecosystem service, it would fall into the Low category. On the other hand, if there are no substitutes to the benefits derived from a particular ecosystem service, it would fall into the High category.

Table 28. Tool for Comparing Importance and Values Across Ecosystem Services

Magnitude Classification	Low	Medium	High
Qualitative Description	Many Substitutes	Some Substitutes	Few (if any) Substitutes
Quantified Result	Low Value	Medium Value	High Value

5.1.3 Summary of distribution across beneficiaries

Table 29 summarizes the distribution of ecosystem service values across different beneficiary groups. The first column identifies different types of importance or value tied to the ecosystem services the study area supports. The second column describes the magnitude of the importance or value of ecosystem services supported under the Baseline Scenario relative to those supported under the Development Scenario (these magnitudes are color-coded as they were elsewhere in the report). The columns that follow identify the relevant beneficiaries tied to the specific benefit category. Cells that are color-coded identify the relevant beneficiary groups for the benefit category. For cells labeled with an "X", we provided quantified results describing their importance

The summary of results shown in Table 29 is not intended to exhaustively describe the values or importance of each of the ecosystem services considered in the analysis - thorough descriptions of service-specific analyses are provided elsewhere in the report. Rather, this summary is intended to show which ecosystem services are particularly important in this analysis, and which groups of individuals derive benefits from them. Generally speaking, the benefits derived from salmon-related ecosystem services represent higher magnitudes of importance and values relative to other ecosystem services the study area provides. This is because salmon-related services have few substitutes, and where quantification was possible, demonstrated large economic values. Furthermore, these benefits accrue primarily to residents within the Okanagan Valley, with fewer benefits going to groups outside the Columbia Basin.

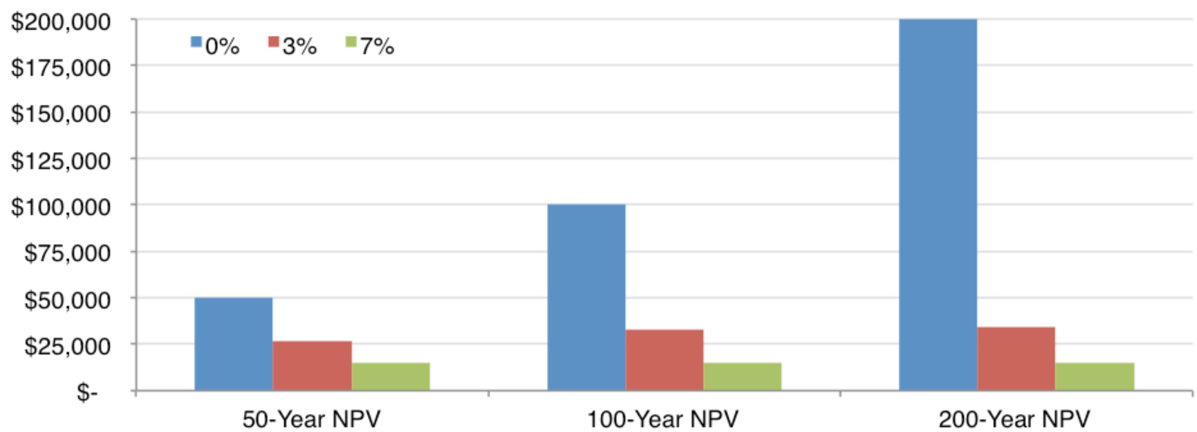
Table 29. Distribution of Benefits

		Beneficiaries					
		Okanagan Valley		Elsewhere in the Columbia Basin		Elsewhere in North America	
Benefit Category	**Magnitude of Importance/Value**	Indigenous Populations	Other Residents	Indigenous Populations	Other Residents	Canadian Residents	US Residents
Salmon (Cultural)	High						
Salmon (Harvest)	Medium	X	X	X	X		
Salmon (Avoiding Extinction)	High	X	X	X	X	X	X
Salmon (Passive-Use)	High	X	X	X	X		
Salmon (Health and Nutrition)	Low						
Stormwater Treatment	Medium	X	X				
Flood Protection	Low	X	X				
Open Space	Low	X	X				
Carbon Sequestration	Low	X	X	X	X	X	X
Air Quality	Low	X	X				
Water Supply	N/A						
Water Quality	N/A						
Recreation	N/A						
Habitat and Wildlife	Medium	X	X				
Education	Medium						

5.2 Distribution Over Time

During our discussion of the importance and value of ecosystem services, we summarized quantitative results in terms of their 50-year, 100-year, and 200-year NPVs assuming a 3% discount rate. The discount rate and the time horizon both play important roles in understanding changes in ecosystem services over time. The NPV of quantitative results can differ substantially based on these assumptions. Figure 13 provides an illustrative example of how these assumptions influence the results. In this hypothetical example, we examine the NPV of an annual $1,000 benefit. The NPVs are grouped by time horizon and color-coded by discount rate. The first group represents the 50-year NPV of this benefit using three discount rates (0%, 3%, and 7%). The second group represents the 100-year NPV, and the third group represents the 200-year NPV. As the figure demonstrates, the NPV increases as the time horizon increases. The NPV also increases as the discount rate decreases.

Figure 13. The Effects of Discount Rates and Time Horizons



Many of the ecosystem services described in this analysis are not necessarily distinguishable to the point that their values and importance are additive. In other words, some of the quantitative values we prescribe to open space may overlap with some of the values we prescribe to habitat and wildlife. Due to this potential for overlap, we do not sum any of the values quantified in the analysis.

In presenting the results, we provided quantified values for several ecosystem services using a 3% discount rate over three time horizons. As previously mentioned, the Treasury Board of Canada Secretariat recommends using a social discount rate of 3% for values like those considered in this analysis. To some extent, some beneficiaries may discount future values even less, which would suggest that they place even more emphasis on inter-generational equity. In those cases, discount rates lower than the 3% used in this analysis may be warranted.

In determining the appropriate time horizon, economists typically rely on the time horizon over which the benefit can be ensured. The ONA relies on a seven generations approach to natural resource management, which loosely aligns with the 200-year time horizon used throughout this analysis.

6 Conclusions and Next Steps

6.1 Conclusions

The study area is unique. Most of the Okanagan River has been dyked, channelized, or developed. The study area represents the only remaining natural section of the Okanagan River in British Columbia. As such, many of the ecosystem services it provides under the Baseline Scenario are unique.

Development would decrease the supply of ecosystem services. By channelizing the River and developing adjacent lands in the study area, the Development Scenario would result in a decrease in ecosystem services the study area supports. While the study area is unique, many of the ecosystem services it supports are also supported elsewhere in the Okanagan Valley. Some of the ecosystem services, however, are indeed unique to the study area and would be lost with development.

Cultural importance has no substitutes. This importance defines and pervades the relationships among indigenous populations within the Okanagan Valley (the Syilx People), their relationships with other inhabitants of the region, and with the land. It is impossible to characterize cultural importance in the monetary language of economics, but it is essential to understanding the overall importance of the Okanagan sockeye stock. Adrienne Vedan writes, “The Okanagan view of the world is one in which people, beliefs, and nature are intertwined and inseparable. The plants, animals, hills, and water were viewed as having their own spirits and were likewise treated with the utmost respect.” The well-being of the Syilx People was tied to the salmon, and the salmon’s survival depended on the integrity of the ecosystem. Salmon are still important to the Syilx, and the study site plays an important role in the salmon’s lifecycle and survival.

Salmon-related benefits have few substitutes. Of all the ecosystem services we analyzed, those associated with the Okanagan sockeye stock are most unique and have the fewest substitutes available. Under the Baseline Scenario, the study area supports the existence of nearly the entire Okanagan sockeye stock. Individuals in the Okanagan Valley, elsewhere in the Columbia Basin, and indeed across the continent derive several different types of benefits from this sockeye stock. Under the Development Scenario, the overall viability of the Okanagan sockeye stock would decline, and insofar as the stock represents the largest sockeye stock in the Columbia Basin, the availability of substitutes is minimal.

Other ecosystem services are also important. While salmon-related benefits rise to the top of the ecosystem services the study area supports, it also supports many other important and valuable ecosystem services. There are substitutes for many of these services provided elsewhere in the Okanagan Valley. Their existence in the study area, however, is important insofar as it provides evidence of co-benefits tied to salmon and river restoration that could help promote future restoration efforts in the Okanagan Valley.

Local residents are not the only beneficiaries. The distributional analysis we conducted on our results show that indigenous populations and other residents in the Okanagan Valley derive many of the benefits tied the ecosystem services the study area supports under the Baseline Scenario relative to the Development Scenario. They are not, however, the only beneficiaries. Individuals throughout the Columbia Basin (and elsewhere in Canada and the US) derive both use and passive-use benefits from the sockeye the study area supports. To the extent that the study area helps support other forms of wildlife and helps absorb greenhouse gases, it provides benefits that people across the continent consider important.

6.2 Next Steps

The results of this analysis provide useful insight into the ecosystem services the study area supports from an economic perspective. These results, however, represent one perspective on the issues at hand. Additional research could shed light on many of the hurdles we faced while conducting our economic analysis. Furthermore, while conducting our research, we identified a number of other areas (tied to, but not necessarily under the umbrella of economics) that would benefit from additional research. After concluding the analysis, we conducted a brainstorming session during which we: (1) reflected on the data and information we compiled for the analysis, (2) identified hurdles we encountered, (3) discussed the results of the analysis within the context of cross-border natural resource management, and (4) compiled a list of guiding questions for potential next steps. We summarize these questions and next steps below.

- What is the overall approach to managing the Okanagan sockeye stock from the context of the Columbia Basin? How do the relevant agencies interact? Are there ways to improve cross-agency or cross-border management? Are there hurdles associated with ultimate responsibility for the stock?
- Do residents in the Okanagan Valley understand the extent to which the Columbia Basin relies on the sockeye stock that spawns in the Okanagan River? Do downstream residents understand which spawning habitats the Columbia Basin's sockeye rely on? To what extent do stakeholders see substitutes for wild, native sockeye salmon?
- What types of opportunities exist that link river restoration to multiple benefits? Can future restoration efforts (like the Okanagan River Restoration Initiative) support several types of benefits (e.g., recreation, salmon, open space) at once? Is the local community particularly interested in one set of benefits?
- To what extent do other fish species benefit from habitat restoration efforts that target sockeye salmon?
- Identify and describe resource tradeoff decisions that the area will face in the near-term (e.g., decisions that affect water availability, water quality, and development in the region).
- Identify potential future threats to the study area, and develop strategies for mitigating their negative effects on the ecosystem services the study area supports.
- Inform the relevant beneficiary groups of the valuable benefits the study area provides.

Appendix A. Background on Ecosystem Services

In 2005, the Millennium Ecosystem Assessment (MA), a pivotal work involving over 1,300 scientists coordinated by the United Nations, formalized a definition and classification of ecosystem services that is widely recognized across the world. The MA defined ecosystem services as "the benefits people obtain from ecosystems," and grouped them into four major categories of services that support human well-being: supporting, provisioning, regulation, and cultural (Millennium Ecosystem Assessment, 2005).

The MA framework has become the basis for many studies of the economic value of ecosystem services.[88] While many economists have generally accepted the MA framework's basic organization, its complexity leads to difficulties in translating biophysical effects into economically relevant benefits and costs. To address these difficulties, several economists have proposed modified or alternative frameworks to guide economic analyses of ecosystem services.[89]

Figure A-1 illustrates a simplified framework that draws elements from the MA framework and alternative approaches and grounds ecosystem services in an economic context. The framework centers around the notion that ecosystem services exist at the nexus of the supply of natural resources and demand from individuals and communities. It recognizes that most ecosystem services only produce benefits that improve human well-being when combined with other inputs (e.g., human-built capital, such as pipes or fishing rods; knowledge; and skills). It also indicates that demand can influence the ecosystem (supply) and the benefits available from a given ecosystem can shape demand.

6.2.1 Supply of natural capital

Our understanding of ecosystem services begins with natural capital, represented by the blue box on the left of Figure A-1. Natural capital describes the inventory of nature's basic building blocks, such as vegetation, water, wildlife, soils, and gases. Some types of natural capital have value as stand-alone goods, such as a tree or a fish. Most natural capital, though, has value primarily through its many symbiotic relationships with other units of natural capital that, through the complex functions and processes of an ecosystem, provide goods and services of

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88 *See*, for example, US Environmental Protection Agency, Office of the Administrator, Science Advisory Board. 2009. *Valuing the Protection of Ecological Systems and Services: A Report of the EPA Science Advisory Board.* Report No. EPA-SAB-09-012. May.

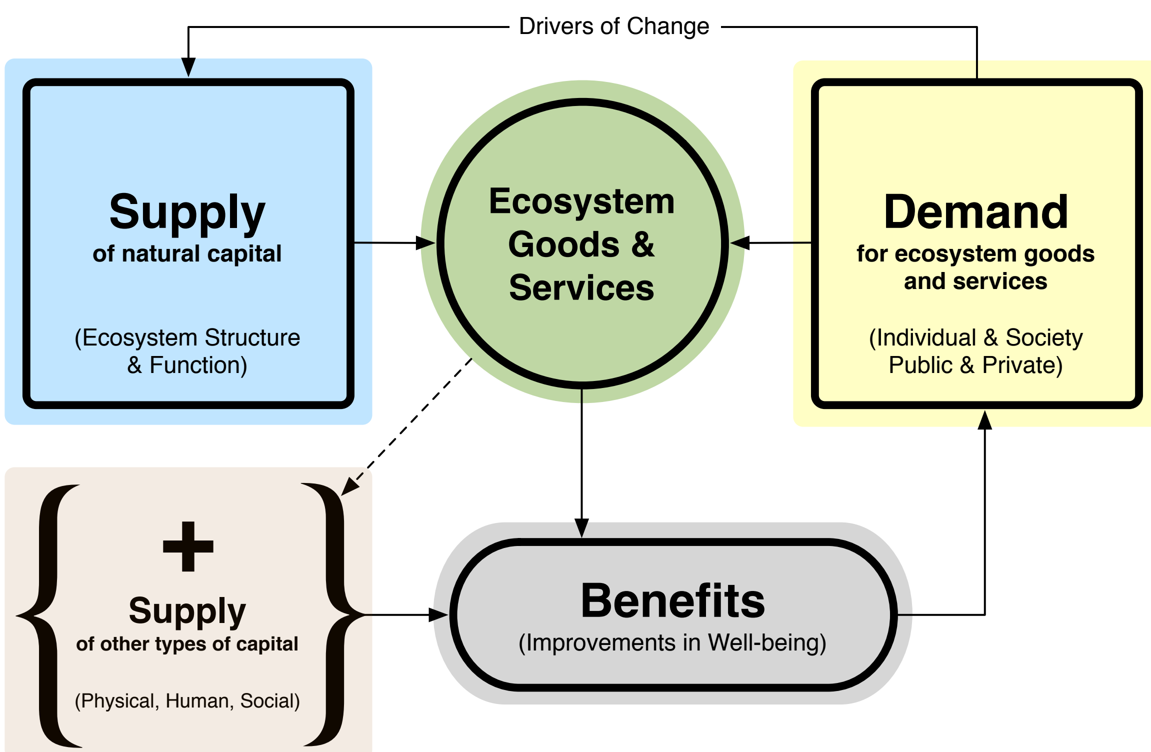
89 *See*, for example, Fu, B., C.H. Su, Y.P. Wei, I.R. Willett, Y.H. Lu, G.H. Liu. 2011. "Double counting in ecosystem service valuation: causes and countermeasures." *Ecological Research* 26(1):1-14.; Fisher, B., K. Turner, M. Zylstra, R. Brouwer, R. De Groot, et al. 2008. "Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research." *Ecological Applications* 18(8): 2050-2067; Wallace, K. 2007. "Classification of ecosystem services: problems and solutions." *Biological Conservation* 139:235-246.; Nahlik, A.M., M.E. Kentula, M. Fennessy, D.H. Landers. 2012. "Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice." *Ecological Economics* 77:37-35.

value to society. Carbon sequestration is an example of an ecosystem service that depends on inputs of natural capital (vegetation and gasses) but requires various chemical and biological processes to occur.

6.2.2 Demand for ecosystem goods and services

Ecosystem goods and services exist because people demand them. If people didn't exist, the ecosystem would persist, but there would be no need to describe the additional layer of meaning that ecosystem goods and services imparts on the natural system. Human demand is what transforms the supply of natural capital and ecosystem processes and functions into ecosystem goods and services. Demand for ecosystem goods and services arises from individuals and society, and is represented by the yellow box on the right-hand side of Figure A-1. Some types of demand for ecosystem services are obvious and routinely recognized within an economic framework: demand for trees to produce wood to build things, or demand for fish and fishing opportunities to entertain and sustain. Humans also demand other types of ecosystem services without explicitly recognizing them: clean air to breathe, for example.

Figure A-1. Ecosystem Services-Benefits Framework



Source: ECONorthwest

6.2.3 Ecosystem goods and services

The green circle in Figure A-1 represents ecosystem services. To summarize, an ecosystem service exists if the ecosystem supplies something that people want. Ecosystem services only exist insofar as there is human demand for their supply. The set of ecosystem services in an area can expand or contract depending on human preferences over time and across geographic areas.

6.2.4 Benefits

Ecosystem goods and services are precursors to, but distinct from, benefits, which are represented in the gray oval in Figure A-1. This is a subtle, but important distinction, fundamental to an economic perspective. Benefits represent improvements in human well-being. To achieve improvements in well-being, humans typically combine ecosystem services with other types of inputs. Ecosystem services rarely, if ever, produce changes in human well-being independent of other inputs.

6.2.5 Supply of other types of capital

Benefits are produced when human demands are satisfied by the ecosystem's production of goods and services, married with other factors of production. These other factors of production are represented by the tan box in Figure A-1, which represents the supply of other types of capital. In addition to natural capital, economists distinguish three categories of capital:

- Built Capital (e.g., our houses, offices, cars, and other tangible manufactured goods)
- Human Capital (e.g., the knowledge and skills embodied within people)
- Social Capital (e.g., relationships, institutions, cultural norms and values)

In most cases, people combine different forms of capital to produce a good or service they want. For example, an individual may enjoy recreational fishing (a benefit) within a lake that provides habitat for fish (ecosystem services), but would also require a fishing pole (physical capital), knowledge and skill to tie a fly or bait a hook (human capital), and a fishing license (a product of social capital). Even non-use benefits derived from ecosystem services may require inputs of other forms of capital. Improvements in well-being from simply knowing that fish populations will exist in the future usually requires knowledge of the importance of the fish and its place in the ecosystem, and may be intertwined with cultural or social notions of morality and spirituality, which are formed and maintained through social capital.

6.2.6 Feedback relationships

The framework emphasizes the feedback relationships that exist in this system. While ecosystem goods and services, in combination with other forms of capital, produce improvements in human well-being, humans drive changes in the natural world that produce changes in natural capital and ecosystem functions and processes. These changes can occur indirectly—through demographic, economic, and sociopolitical changes—or directly—through changes in local land use and land cover, species introduction or removal, or climate change. For example, human development and government policies and projects within the Okanagan Valley have affected the ecosystem’s capacity to provide spawning habitat for salmon. On the other hand, conservation efforts in the study area have maintained that particular segment of spawning habitat.

Ecosystem goods and services are already well-integrated into our communities and economies: we all depend on them, whether or not we recognize them explicitly. This framework helps decision-makers identify and incorporate ecosystem service values into decisions. By doing so, they are better-able to account for the full range of benefits and costs associated with projects and actions.

Appendix B. Applying the Results of the LBP Study

People derive value from salmon in many ways. One method of estimating the value people place on salmon is asking them how much they would be willing to pay to increase salmon population numbers. People are willing to pay for salmon recovery for several reasons, including: (1) an understanding of salmon function and contribution to the greater ecosystem, (2) a future option of fishing for salmon, eating salmon, or viewing salmon in the wild, and (3) an appreciation for the existence of salmon in the region.

The Development Scenario could decrease the Columbia Basin's sockeye population by 54-90%. From 1977-2011, sockeye represented about 9% of all salmon counted at Bonneville Dam.[90] Assuming that, on average, sockeye represent 9% of all salmon in the Columbia River Basin, this population decline of 54-90% would represent a total population decline of 4.8-8.0% across all salmon species in the Columbia Basin. To return, then, to salmon population levels under the Baseline Scenario, salmon populations across the Columbia Basin would need to increase by 5.0-8.7%. In this case, society's willingness to pay for programs that improve salmon populations represents an avoided cost (or benefit) associated with the Baseline Scenario.

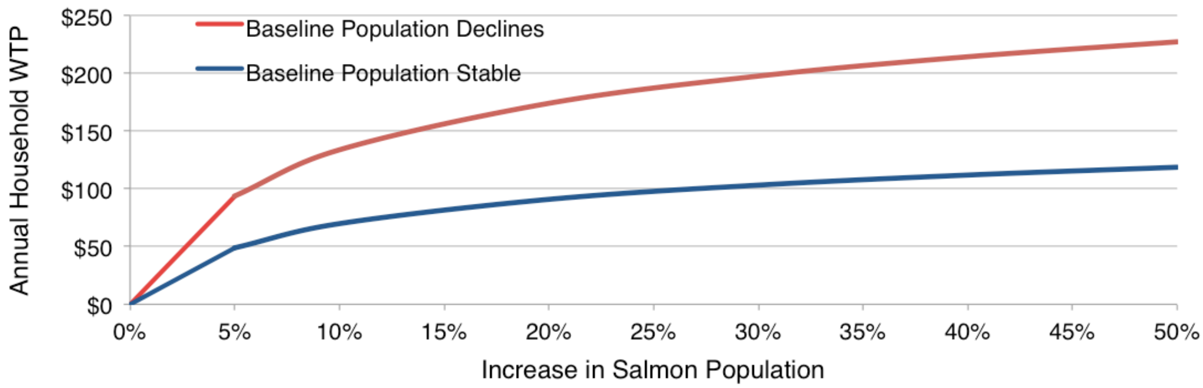
To conduct this analysis, we rely on a 1999 economic study done in the State of Washington that surveyed households regarding their willingness to pay for programs aimed at increasing salmon populations in the Columbia Basin.[91] The study (which we refer to as the LBP Study) asked households how much they would be willing to pay each month, for 20 years, for a range of increases in salmon and steelhead populations guaranteed by the end of the 20-year period. Of particular interest in this case are the study's results of willingness to pay estimates for increases in Pacific migratory fish populations in Eastern Washington and the Columbia River.

Figure B-1 shows the results of the LBP Study, specific for programs aimed at improving Pacific migratory salmon populations in the Columbia Basin. When assuming that inaction would result in stable populations in the future (the blue line), households were willing to pay about $227 per year (1999$) to increase salmon and steelhead populations by 50 percent. When assuming that inaction would results in population declines in the future (the red line), households were willing to pay about $119 per year (1999$) to increase salmon populations by 50 percent. For our analysis, we use only the results associated with the blue line. This approach results in lower annual values associated with potential future increases in salmon populations, but prevents potentially overstating these values as future salmon populations under the Baseline Scenario, across the Columbia Basin, remain uncertain.

[90] Fish Passage Center. 2013. *Adult Salmon Annual Totals*. Retrieved on February 7, 2013 from http://www.fpc.org/.

[91] Layton, D., G. Brown, and M. Plummer. 1999. *Valuing Multiple Programs to Improve Fish Populations*. Washington State Department of Ecology. April.

Figure B-1. Range of Household Willingness to Pay for Increased Salmon Populations (1999$)



We applied these results to four regions: (1) Washington, (2) Oregon, (3) the Okanagan Valley, and (4) British Columbia. We began by escalating the 1999 values in terms of the ratio of Washington's median household income in 2010 versus the median household income in 2000. From there, we escalated the values to 2012 dollars by applying changes in the consumer price index from 2010 to 2012. In order to capture some of the potential differences across regions, we tracked differences in the median household incomes in each of the regions. Table B-1 summarizes this approach and presents the adjustment factors we used for each of the four regions.

Table B-1. Conversion Factors Used in Applying Results from the LBP Study

Region	2000 Median Household Income	2010 Median Household Income	2012 Median Household Income	Adjustment Factor
Washington	$44,846	$55,584	$58,525	1.31
Oregon	N/A	$46,536	$48,998	1.09
Okanagan Valley	N/A	$58,382	$61,471	1.37
British Columbia	N/A	$66,970	$70,514	1.57

Source: US Census Bureau. No Date. *Small Area Income and Poverty Estimates*. Retrieved on March 5, 2012 from http://www.census.gov /did/www/saipe/data/interactive/#; Statistics Canada. 2012. *Median Total Income, by Family Type, by Province and Territory*. Retrieved on March 5, 2013 from http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil108a-eng.htm; Our Okanagan. No Date. *Okanagan Valley Regional Profile.* Retrieved on March 5, 2013 from http://www.ourokanagan.ca/assets/files/OK%20VALLEY%20PROFILE.pdf.

Notes: There were no data describing median household income for the Okanagan Valley. We used the relative difference between average family income between the Okanagan Valley and British Columbia in 2006 to estimate the median household income in the Okanagan Valley in 2010 based on data describing median household income in British Columbia in 2010.

Table B-2 summarizes the results we presented in our analysis. The first row shows the annual household willingness to pay for the increase in salmon populations needed counteract the potential decreases associated with the Development Scenario. The values differ across the four regions because of the adjustment factors we discussed earlier. The second row shows the total number of households in each region as of 2010. Data were not sufficient to project populations to 2012 levels, but the difference in population likely would not alter the results. The third row shows annual willingness to pay in each region. For this estimate, we multiplied the annual household willingness to pay by the number of households in each region. The final row shows the 20-year present value of the stream of payments (discounted at a rate of 3.0%). We only calculate these values for 20 years because of how the original survey used in the LBP Study was phrased.

The values in Table B-2 are not necessarily additive, and may overstate or understate the actual values in each of the regions. As stated in the report, the LBP Study is not an ideal candidate for benefit transfer in this analysis due to a number of reasons. This is particularly true when interpreting the results for the Okanagan Valley and British Columbia.

Table B-2. Summary of Willingness to Pay Estimates for Increased Salmon Populations (2012$)

	Washington	Oregon	Okanagan Valley	British Columbia
Household willingness to pay per year	$64-$86	$54-$72	$67-$90	$77-$103
Number of households	2.7 million	1.6 million	163,000	1.8 million
Total willingness to pay per year	$172-$230 million	$84-$112 million	$11-$15 million	$136-$182 million
20-year present value	$2.6-$3.5 billion	$1.3-$1.7 billion	$0.2 billion	$2.1-$2.8 billion