

Water Quality Objectives for the Osoyoos Aquifer

British Columbia Ministry of Environment & Climate Change
Strategy



The **Water Quality Objective Series** is a collection of British Columbia (B.C.) Ministry of Environment and Climate Change Strategy water quality objectives reports. Water quality objectives are developed for waterbodies to promote the protection and stewardship of provincially significant water resources. Once approved, water quality objectives constitute formal Ministry policy and must be considered in any decision affecting water quality made within the Ministry of Environment and Climate Change Strategy. For additional information visit: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-objectives>.

ISBN: 978-0-7726-7878-2

Citation:

British Columbia Ministry of Environment and Climate Change Strategy (ENV). 2019. Water Quality Objectives for the Osoyoos Aquifer. Water Quality Objective Series, WQO-03. Prov. B.C., Victoria B.C.

Cover Photo: Online at <https://commons.wikimedia.org/wiki/File:OsoyoosBC.JPG>

Acknowledgements

The water quality objectives presented here are based on the document [Groundwater Quality Assessment and Proposed Objectives for the Osoyoos Aquifer](#) (Rathfelder and Gregory, 2019), which was developed with support from regional groundwater staff in the Ministry of Forest, Lands, Natural Resource Operations, and Rural Development in Penticton.

© Copyright 2020

EXECUTIVE SUMMARY

Water quality objectives (WQOs) are developed by the Ministry of Environment and Climate Change Strategy (ENV) for surface water and groundwater to guide the balance between human activities and healthy waterbodies. Water quality objectives have been developed for the Osoyoos Aquifer and are the first for groundwater quality in B.C., establishing benchmarks for protecting groundwater values and informing resource management decisions, including permitting waste discharges and prioritization of groundwater monitoring. Both the aquifer and the lake are on the traditional territory of the Syilx People of the Okanagan Nation. The most sensitive values for the Osoyoos Aquifer the drinking water supply and the aquatic life in the receiving waters of Osoyoos Lake as Osoyoos Aquifer is hydrologically connected to Osoyoos Lake. Groundwater is the main drinking water source for the Town of Osoyoos and the adjacent rural areas. Osoyoos Lake provides habitat to a variety of aquatic life and is important to the local tourism industry for recreation.

A groundwater quality assessment indicated the Osoyoos Aquifer is widely affected by elevated levels of nitrate and phosphorus from land-use practices (Rathfelder and Gregory, 2019). Nitrate concentrations exceed the drinking water quality guideline (10 mg/L nitrate-N) maximum acceptable concentration (MAC) in some wells, and dissolved phosphorus exceed the Osoyoos Lake total phosphorus WQO for aquatic life protection (0.015 mg/L) in most samples. Monitoring data suggests elevated nutrient levels occur throughout much of the aquifer and have generally persisted over the past two decades, indicating the nutrient sources are widely distributed and ongoing. The potential sources of nutrients include fertilizer applications in agricultural areas and residential landscaping; septic systems; discharges from municipal landfill operations; land application of wastewater treatment plant effluent; and a potential minor contribution from agricultural irrigation supply water from the lake. Nitrate and phosphorus are soluble in groundwater and will eventually flow into Osoyoos Lake. The water quality of Osoyoos Lake has been a long-term concern, especially for nutrient enrichment. In 2012, WQOs for Osoyoos Lake were developed to help manage nutrient enrichment and the WQOs for Osoyoos Aquifer support this effort.

The WQOs for the Osoyoos Aquifer are based on the technical assessment (Rathfelder and Gregory, 2019) and summarized in the following table.

Water Quality Objectives for the Osoyoos Aquifer

Parameter	Objective Value	Notes
Nitrate	≤ 10 mg/L (nitrate-N): Short-term WQO	Based on the BC Source Drinking Water Quality Guideline MAC. Applicable to the entire aquifer.
	≤ 5 mg/L (nitrate-N): Long-term WQO to 2030	Based on current nitrate concentrations in Osoyoos Aquifer and a long-term goal to decrease the risk to drinking water. Applicable to the entire aquifer.
Dissolved Phosphorus	≤ 0.15 mg/L	Based on the WQO for Osoyoos Lake after a 1:10 dilution in the transition from groundwater to surface water. Applicable to the entire aquifer.

CONTENTS

EXECUTIVE SUMMARY II

1. INTRODUCTION..... 1

2. SITE AND AQUIFER DESCRIPTION 1

3. WATER VALUES..... 2

4. WATER QUALITY OBJECTIVES FOR OSOYOOS AQUIFER 3

 4.1 Nitrate 3

 4.2 Dissolved Phosphorus 4

5. MONITORING RECOMMENDATIONS..... 5

 5.1 Ongoing Monitoring..... 5

 5.2 Recommended Monitoring for Nutrient Management and Objectives Attainment..... 5

REFERENCES 7

FIGURES

Figure 1: Map of the Osoyoos Aquifer and its overlying land use..... 2

TABLES

Table 1. Water quality objectives for nitrate in Osoyoos Aquifer. 4

Table 2. Water quality objectives for dissolved phosphorus in Osoyoos Aquifer..... 5

Table 3: FLNRORD groundwater quality monitoring sites..... 5

1. INTRODUCTION

Water quality objectives (WQO) are developed by the Ministry of Environment and Climate Change Strategy (ENV) for specific waterbodies to promote the protection and stewardship of B.C.'s water resources. Water quality objectives define conditions that represent levels of low risk to water values. They formalize expectations with respect to water quality for a given surface or groundwater source and are used to inform resource management decisions in the natural resource sector. Water quality objectives are established on a priority basis for waterbodies (fresh, estuarine, marine) of regional, provincial, inter-provincial, and international significance as part of ENV's mandate to protect, manage, and conserve B.C.'s water resources. They are set with the goal of protecting water values by maintaining existing water quality, improving existing water quality, or protecting water quality for a specific use.

WQOs are based on water quality guidelines, or similar information, water quality assessments, and the associated water values. The water quality assessment considers: the ambient water quality and its assimilative capacity; the aquatic life, wildlife, and habitat; the hydrology; the sediments; the potential contaminant loadings from point and non-point source waste discharges, and the traditional, cultural and social values associated with a waterbody. Once approved, WQOs constitute official ENV policy and must be considered in any ENV decisions potentially affecting water quality.

This document presents WQOs for the Osoyoos Aquifer. These WQOs are based on the document *Groundwater Quality Assessment and Proposed Objectives for the Osoyoos Aquifer* (Rathfelder and Gregory, 2019); readers should refer to this report for detailed water quality information on this aquifer.

2. SITE AND AQUIFER DESCRIPTION

The Osoyoos Aquifer (Aquifer 193) is adjacent to the western shore of Osoyoos Lake in the southern end of the Okanagan Valley in British Columbia (Figure 1). The Osoyoos Aquifer lies within the traditional territory of the Syilx People of the Okanagan Nation. The local First Nations community, the Osoyoos Indian Band, lives on the east side of Osoyoos Lake.

Land-use over the aquifer is dominated by agriculture, which covers about 70% of the aquifer. There are also significant areas of municipal and residential development, including the Town of Osoyoos, which bisects the central portion of the aquifer. Groundwater is the main source of domestic water supply for the Town of Osoyoos and for residents in adjacent rural areas within the Osoyoos Aquifer (Figure 1).

The Osoyoos Aquifer is a shallow sand and gravel aquifer, about 5 to 15 m thick. The aquifer sediments are well-draining and very conductive, making it highly susceptible to contamination from overlying land-use practices. Aquifer recharge is dominated by irrigation water in agricultural and urban areas.

Groundwater use is regulated under the *Water Sustainability Act*, which requires a water license for all non-domestic groundwater use. Water license applications are pending for the Town of Osoyoos water supply wells. The Okanagan Nation also hold water rights on Osoyoos Lake, the Okanagan River, and nearby water courses and springs that do not overly the Osoyoos Aquifer (Robinson and Mogus, 1999). There is an unknown number of unlicensed private irrigation wells and active domestic wells within the aquifer. There are also several active surface water licenses for irrigation and domestic supply, largely from Osoyoos Lake but also from ponds, streams and springs overlying the aquifer.

Groundwater in the Osoyoos Aquifer flows into Osoyoos Lake with an average discharge of about 10,000 m³/day. Soluble contaminants in groundwater will flow into Osoyoos Lake where they potentially affect water quality and aquatic habitat. Osoyoos Lake provides habitat to a variety of aquatic life, including

both resident and anadromous fish species. Salmon are central to the cultural, spiritual, and trade traditions of the Syilx/Okanagan communities, and the Okanagan Nation Alliance is leading efforts to protect, restore and enhance Indigenous fisheries. Osoyoos Lake is also important to the local economy and tourism industry for water-based recreation, including s̓w̓w̓s Provincial Park (Haynes Point), which is managed and operated by the Osoyoos Indian Band and is an area of significant cultural and historical importance.

The water quality of Osoyoos Lake is a long-term concern, especially regarding nutrient enrichment and eutrophication problems associated with phosphorus inputs. Water quality objectives, focussing on nutrient management, for Osoyoos Lake were updated in 2012 (Jensen et al., 2012).

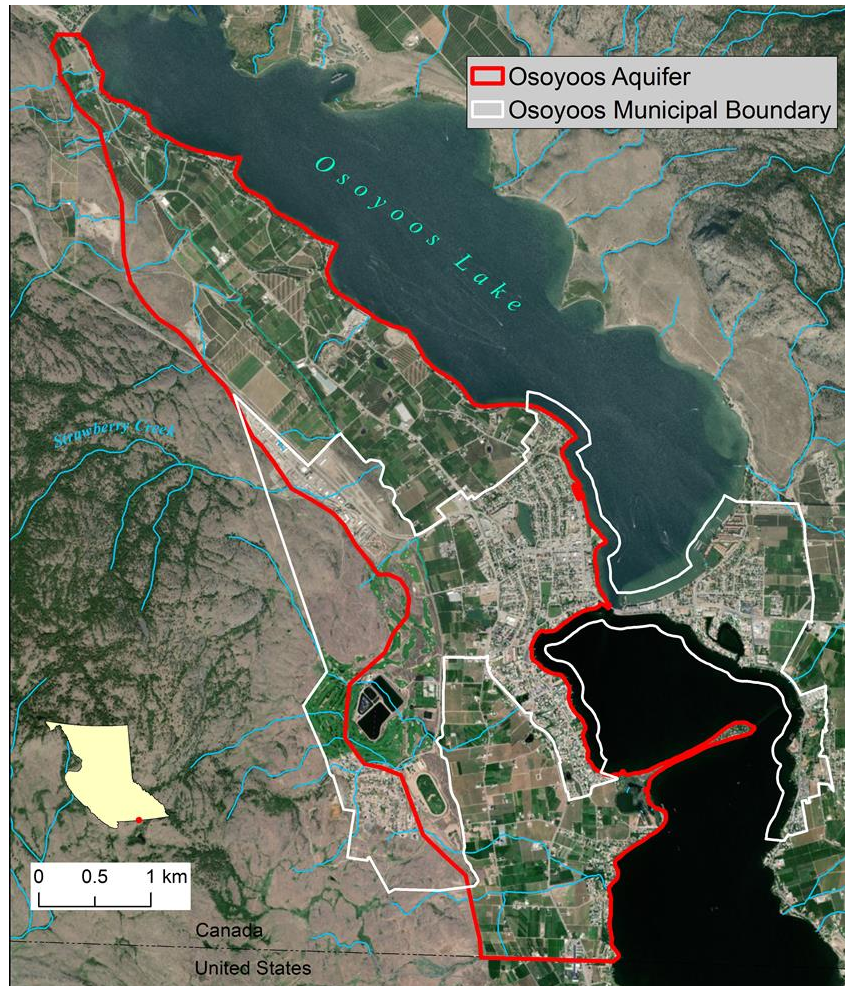


Figure 1: Map of the Osoyoos Aquifer and its overlying land use.

3. WATER VALUES

The overall goal of the Osoyoos Aquifer WQOs is to protect current groundwater values, limit the impacts from elevated nutrient levels in groundwater and improve water quality in Osoyoos Aquifer and Osoyoos Lake.

The traditional and cultural values of the Syilx People are also recognized in developing the WQOs. The Okanagan Nation Alliance Water Declaration highlights water (siwłkʷ) as an essential value to the Syilx People; “Water is life. Water is our relation. Water bonds us to our ancestry, our descendants and our land” (Syilx Nation, 2014) and as the Okanagan Nation Water Declaration points out, “challenges [related to water quality...] have become more prevalent within Syilx Territory.” By developing WQOs for the Osoyoos Aquifer, ENV is creating policy to not only highlight groundwater quality for consideration and protection in decision making but aiming to highlight the importance of water in all people’s lives living in and around the Osoyoos Aquifer and protecting water quality for future generations.

The water values to be protected in Osoyoos Aquifer include:

- Drinking water supply
- Aquatic life in the receiving waters of Osoyoos Lake

Managing nitrate and phosphorus levels for the protection of drinking water and aquatic life are the most sensitive uses and will ensure that other values such as agricultural, recreational, wildlife and traditional, cultural and social uses are also protected.

4. WATER QUALITY OBJECTIVES FOR OSOYOOS AQUIFER

A large amount of information on the quality of Osoyoos Aquifer groundwater is available. Data have been collected by multiple agencies from 44 wells between 1985 and 2018 and include more than 40 water quality parameters. Data are available for general water quality chemistry (anions, cations), nutrients (nitrogen, phosphorus), and several metals. There are also limited, older data for pesticides/herbicides. The dataset does not include hydrocarbons or pathogen indicators (*E. coli* and total coliforms).

The Osoyoos Aquifer Groundwater Quality Assessment (Rathfelder and Gregory, 2019) found nitrate and phosphorus to be the primary parameters of concern, exceeding B.C. approved water quality guidelines in a high percentage of samples, including recent samples. This demonstrates an ongoing concern with respect to high levels of nutrients in portions of the aquifer as well as increasing trends at some locations. The assessment identified potential sources of nutrient inputs to the aquifer and estimated current loads, where possible. The assessment concluded that, in the absence of management actions, conditions are not likely to improve substantially and could deteriorate with increasing populations or the expansion of agricultural activities (Rathfelder and Gregory, 2019).

The Osoyoos Aquifer groundwater is very hard, with high alkalinity and a high dissolved ion content (Rathfelder and Gregory, 2019). Metal concentrations were generally below drinking water quality guidelines, however there were a small number of exceedances for arsenic, manganese, uranium, and iron in specific areas and/or wells. These elevated levels are likely occurring naturally through the erosion of aquifer sediments, which is common in glacial aquifers. The overall quality of the Osoyoos Aquifer groundwater is within drinking water quality guidelines for parameters describing the general water quality chemistry.

4.1 Nitrate

The B.C. approved source drinking water quality guideline (10 mg/L nitrate-N) was used as the benchmark in assessing the Osoyoos Aquifer. Nitrate concentrations exceeded the background levels of 1 mg/L (nitrate-N) (Warner and Ayotte, 2014) in 92% of monitoring results. Near the central portion of the aquifer, some wells exceeded 10 mg/L and displayed visually increasing trends. The characteristics of

the Osoyoos Aquifer (shallow and permeable unconfined sediments) make it particularly vulnerable to nitrate contamination and unfavourable for denitrification. Although nutrient management has led to a reduction in the very high nitrate concentrations measured in the 1980/90's, moderate to high nitrate concentrations persist in the aquifer.

Given the current nitrate levels in Osoyoos Aquifer, a short-term and long-term WQO are specified. The short-term WQO is intended to prevent any further degradation of conditions while protecting the drinking water supply in Osoyoos Aquifer. The long-term objective is intended to improve groundwater quality over time thereby decreasing the risk to drinking water through development and coordination of nutrient management practices by community members, First Nation communities, and stakeholders. The WQOs always apply to the entire aquifer.

The short-term WQO for nitrate is a MAC of 10 mg/L (nitrate-N) (Table 1), based on the B.C. source drinking water quality guideline for nitrate (ENV 2017). The long-term WQO for nitrate is a MAC of 5 mg/L (nitrate-N), based on precautionary nitrate objectives recommended for nutrient management plans in the Hullcar Aquifer (Brandes et al., 2017) and early warning nitrate objectives in the State of Washington (Washington State, 2005).

Table 1. Water quality objectives for nitrate in Osoyoos Aquifer.

Parameter	Short Term	Long-Term (to 2030)
Nitrate	≤ 10 mg/L (nitrate-N) MAC	≤ 5 mg/L (nitrate-N)

4.2 Dissolved Phosphorus

Nutrients eventually flow from the Osoyoos Aquifer into Osoyoos Lake where they can impact the aquatic life and aquatic habitat of the lake. Nutrient enrichment of Osoyoos Lake due to phosphorus loadings is a long-term issue of concern. Water quality objectives for Osoyoos Lake established in 2012 identified phosphorus as the limiting nutrient and established an objective for total phosphorus of 0.015 mg/L. The Osoyoos Lake WQO for phosphorus was used as the benchmark in the assessment as protecting aquatic life in the receiving waters of Osoyoos Lake is a key water value for the Osoyoos Aquifer. Phosphorus levels were reviewed, assessed and fully discussed in Rathfelder and Gregory (2019).

Dissolved phosphorus levels in the Osoyoos Aquifer exceeded the WQO for total phosphorus in Osoyoos Lake in 87% of groundwater samples, often by more than an order of magnitude. Phosphorus mobility in groundwater systems is significant in certain settings and the associated groundwater discharges can be an important source of phosphorus loadings to surface water (Lewandowski et al., 2015; Meinikmann et al., 2015). Kowalenko et al. (2009) characterized the Okanagan-Similkameen soils as high to very high in phosphorus content resulting in limited phosphorus-binding capacity. Groundwater from the Osoyoos Aquifer increases phosphorus loadings to Osoyoos Lake that warrant consideration in the overall eutrophication management of the lake.

Dissolved phosphorus concentrations were greater than 0.15 mg/L in several monitoring wells, particularly in the central portion of the aquifer, over the past three years. While some wells had dissolved phosphorus concentrations below 0.15 mg/L, some of these also display increasing trends, suggesting a consistent and potentially increasing source.

The WQO for dissolved phosphorus in the Osoyoos Aquifer is 0.15 mg/L, assuming a 1:10 dilution rate in the transition from groundwater to surface water will result in attainment of the WQO for Osoyoos Lake (ENV 2012) (Table 2).

Table 2. Water quality objectives for dissolved phosphorus in Osoyoos Aquifer.

Parameter	Water quality objective	Notes
Dissolved Phosphorus	≤ 0.15 mg/L	Based on the WQO for Osoyoos Lake after a 1:10 dilution in the transition from groundwater to surface water. Applicable to the entire aquifer.

5. MONITORING RECOMMENDATIONS

5.1 Ongoing Monitoring

The current Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) monitoring locations and annual monitoring frequency should continue as the minimum level of effort for assessing WQOs attainment (Table 3).

The determination of WQOs attainment should include the assessment of groundwater monitoring data available from the Town of Osoyoos compliance monitoring activities associated with operation of the municipal water supply wells, the wastewater treatment plant, and the municipal landfill. These data are available through annual reports and/or from the ENV Environmental Monitoring System Database (EMS).

Table 3: FLNRORD groundwater quality monitoring sites.

EMS #	Site Name/Description	UTM Northing	UTM Easting
1401093	Provincial observation well (OW-96)	5433594	318957
E208022	Nested FLNRORD monitoring wells adjacent to Peanut Lake on Municipal Land:	5434142	319533
E208023	Piezometer B-1A, Piezometer B-1B (P2) Deep,		
E208024	Piezometer B-1B (P3) Shallow		
E208031	Private wells: Piezometer B-8, P-1 (Deep) and	5433334	319090
E208032	Piezometer B-8, P-2 (Shallow)		
E208018	Private wells: Piezometer A-1, P-1 (Deep) and	5435384	318866
E208019	Piezometer A-1, P-2 (Shallow)		

5.2 Recommended Monitoring for Nutrient Management and Objectives Attainment

Although discharge limits specified in permits, approvals, and orders issued by ENV may be based on WQOs, in general, WQOs are not directly enforceable. More importantly, however, WQOs provide a means to increase environmental awareness and promote and enhance shared environmental stewardship. When the minimum requirements to protect a water resource have been defined and formalized as WQOs, all community members, First Nation communities and stakeholders with an interest in that waterbody have results-based goals to help guide resource management decisions.

The following are monitoring recommendations to promote nutrient management and WQOs attainment for the Osoyoos Aquifer.

1. Increase monitoring locations for broader assessment of objectives attainment. The FLNRORD monitoring program has historically relied on access to private wells. However, the number of active monitoring locations has decreased over time, despite increased development pressures, and is now between 5-8 locations with many concentrated in the central portion of the aquifer. FLNRORD should consider increasing the number, distribution, sampling frequency, and reliability of long-term monitoring wells. These efforts would increase information about the nutrient distribution in the aquifer and improve the assessment of objectives attainment. Potential locations are:
 - agricultural areas in the northern and southern portion of the aquifer;
 - locations upgradient and downgradient of residential development in the southern portion of the aquifer; and
 - locations upgradient and downgradient of treatment plant effluent disposal areas at groundwater infiltration facilities.
2. Conduct a short-term targeted monitoring study to assess nutrient sources. Consider a 1-3 year monitoring study to improve understanding of nutrient sources from specific land use activities. This should include efforts to quantify nutrient applications in targeted land uses and measure associated groundwater nutrient levels at up-gradient and down-gradient locations, as well as efforts to understand seasonal variability in nutrients applications and associated groundwater levels.
3. To address the vulnerable and transmissive properties of the aquifer, consider short-term monitoring studies to assess contamination risks associated with land use activities: 1) groundwater monitoring to assess risks of pathogen contamination from areas with a high density of individual septic systems; and 2) groundwater monitoring to assess the presence of commonly used pesticide/herbicides in agricultural areas and residential landscaping.
4. Expand groundwater monitoring goals to improve estimation of nutrient fluxes to Osoyoos Lake. This should include efforts to monitor nearshore groundwater gradients and groundwater nutrient levels and/or monitor flow and nutrient levels in the agricultural drainage systems at the outfalls to Osoyoos Lake.

REFERENCES

- Brandes, O.M., J. Baltutis, J. O'Riordan, & J. Wilson, 2017. From crisis to solutions: Towards better source water protection and nutrient management in the Hullcar Valley, Victoria: POLIS Project on Ecological Governance, University of Victoria.
- [ENV] British Columbia Ministry of Environment. 2012. Water Quality Assessment and Objectives for Osoyoos Lake: A First Update. Environmental Protection Division, Environmental Sustainability and Strategic Policy Division and Don McQueen. Prov. B.C., Victoria B.C. Accessed online from <https://www2.gov.bc.ca/assets/download/87649ECB37684539BD3BF4E3064BB52B>
- [ENV] British Columbia Ministry of Environment. 2017. B.C. Source Drinking Water Quality Guidelines: Guideline Summary. Water Quality Guideline Series, WQG-01. Prov. B.C., Victoria B.C. Accessed online from <https://www2.gov.bc.ca/assets/download/1F11ABD2CBD24EB09A70B89AB50CE6B0>
- Jensen, V., M. Sokal, D. St. Hilaire, K. Rieberger, and D. McQueen, 2012. *Water quality assessment and objectives for Osoyoos Lake: A first update*, Ministry of Environment, Province of British Columbia, Victoria.
- Kowalenko, C.G., E. Kenney, D. Neilsen, O. Schmidt, and D. Poon, 2009. *Okanagan Agricultural Soil Study 2007*, prepared jointly by: B.C. Ministry of Agriculture and Lands, Agriculture and Agri-Food Canada, and B.C. Agriculture Council.
- Lewandowski, J., K. Meinikmann, G. Nützmänn and D.O. Rosenberry, 2015. Groundwater – the disregarded component in lake water and nutrient budgets. Part 2: effects of groundwater on nutrients, *Hydrological Processes*, 29(13), pp. 2922 - 2955.
- Meinikmann, K., M. Hupfer and J. Lewandowski, 2015. Phosphorus in groundwater discharge – A potential source for lake eutrophication, *Journal of Hydrology*, Volume 524, pp. 214-226. Rathfelder, K. and L. Gregory. 2019. *Groundwater quality assessment and proposed objectives for the Osoyoos Aquifer*, Water Science Series: WSS2019-06, Province of British Columbia, Victoria. Accessed online from http://a100.gov.bc.ca/appsdata/acat/documents/r57603/1_1571784531661_1784376098.pdf
- Rathfelder, K. and L. Gregory, 2019. Groundwater quality assessment and proposed objectives for the Osoyoos Aquifer, Water Science Series: WSS2019-06, Province of British Columbia, Victoria.
- Robinson, G.W. and D. Mogus. 1999. *First Nations water rights in British Columbia: A historical summary of the rights of the Osoyoos First Nation*, B.C. Ministry of Environment, Lands and Parks, Victoria, <https://www.for.gov.bc.ca/hfd/library/documents/bib88776-1.pdf>
- Syilx Nation. 2014. Syilx Nation Siw̓k̓m Declaration. Accessed online from <https://www.syilx.org/about-us/syilx-nation/water-declaration/>
- Warner, K. L. and J.D. Ayotte, 2014. *The quality of our Nation's water - Water quality in the glacial aquifer system, northern United States, 1993-2009*, National Water-Quality Assessment Program: U.S. Geological Survey Circular 1352, <https://pubs.usgs.gov/circ/1352/>.
- Washington State, 2005. Implementation guidance for the ground water quality standards, Olympia: Washington State Department of Ecology, Publication #96-02