Associated Environmental

DRAFT REPORT - VERSION 2

City of Penticton

Drought Management Plan

APRIL 2021

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CHANGES FROM PREVIOUS VERSION

This document is Version 2 of the Penticton Drought Management Plan (DMP) and supersedes the previous version – Associated (2020).

Changes within this version include an update made by the City of Penticton to the Irrigation, Sewer, and Water Bylaw No. 2005-02. Specifically, Bylaw No. 2020-25 is an amendment to Bylaw No. 2005-02 that includes a revision to the City's drought stages (changing from five [Normal, Stage 1, Stage 2, Stage 3, and Stage 4] to four [Stage 1, Stage 2, Stage 3, and Stage 4]) and associated drought triggers and water conservation strategies per stage. Also, included within this version is an update to the Emergency Response Plan by the City.

EXECUTIVE SUMMARY

1 OVERVIEW

The City of Penticton (the City) has developed this Drought Management Plan (DMP) as a tool to assist in ensuring that adequate water supplies are available under water shortage or drought conditions in the near term, as well as in the future considering population growth, changes in agricultural and municipal needs, and climate change. The City is commitment to reviewing and updating the DMP every 3-5 years to update the DMP as required to account for any changes to water management operations and water conservation strategies.

The following version of the DMP was prepared at the request of the City to include new drought management strategies included within Bylaw No. 2020-25[1] (i.e., an amendment to the City's Irrigation, Sewer, and Water Bylaw No. 2005-02).

2 WATER SUPPLY AND DROUGHT MANAGEMENT TEAMS

The City is required to provide water supply services to the City's distribution area (as outlined the City's Irrigation, Sewer, and Water Bylaw No. 2005-02). To meet these servicing needs, operations and maintenance of the City's water supply and treatment system is completed by the City's Designated Officer under the direction of Chief Administrative Officer and/or City Council. During times of drought, the City Manager, or any other person that the City Council designates, is responsible for implementing all stages of the DMP. This individual will coordinate with administrative and operations staff to comprise the City's Water Supply Management Team.

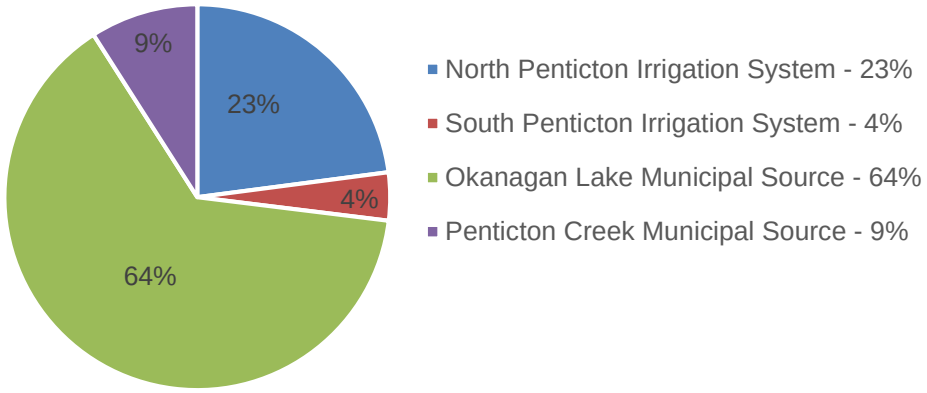
In addition, to help the City consider impacts to the local economy and community livelihoods during period of drought, a Drought Management Team is planned to be developed.

3 WATER SYSTEM PROFILE

The City relies on surface water for raw water supply for municipal (i.e., potable) and irrigation (i.e., non-potable) purposes. The City uses Penticton and Ellis Creeks and Okanagan Lake as water sources; all of which are subject to water licensing, runoff, and storage limitations. Water supplied from Penticton and Ellis Creeks is managed by the City, while the BC Ministry of Forests, Lands, and Natural Resource Operations, and Rural Development manages Okanagan Lake water levels to optimize water use and environmental needs. The City uses water from Okanagan Lake for municipal purposes, water from Penticton Creek for municipal and agricultural irrigation purposes, and water from Ellis Creek for agricultural irrigation purposes only. From a municipal water supply standpoint, on average, the City sources approximately 90% from Okanagan Lake and 10% from Penticton Creek through the water treatment plant (WTP).

A breakdown of the City's average total water use by system (for 2004-2020) is shown in the figure below and is generally considered representative of the total distribution of annual water use by the City.

[1] All bylaw referencing within this executive summary hereafter includes Bylaw No. 2005-02, which includes all amendments up to Bylaw No. 2020-25.



System interconnections provide the City with the flexibility of meeting water demands by individual or through a combination of water supply sources. Interconnections that are in place are as follows:

- The City's municipal water supply can be supplied by Okanagan Lake, and during times of water shortages, a combination of water from Okanagan Lake and Penticton Creek can be used to meet water demands.
- A pipe from the WTP can be used to support the South Penticton Irrigation System during times of water shortage, but the connection is not currently operational.
- Warren Avenue well has been declared as emergency backup well (or available during very dry periods) for the City's municipal water supply.

4 DROUGHT STAGES AND COMMUNICATION PLAN

To support periods of drought, the City has established four drought stages: Stage 1 (Dry), Stage 2 (Very Dry), Stage 3 (Extremely Dry), and Stage 4 (Emergency). Each stage is in reference to the volume of water available within the upland reservoirs and current and projected water demands, but the stages are applicable to the entire City's distribution area. The stages form the basis for the DMP and the associated responses implemented (i.e., watering restrictions) through Bylaw No. 2005-02 (or as amended) and appropriate communication strategies.

In addition, since the City relies on Okanagan Lake as a primary water source for municipal water supply, the City has adopted the use of the Okanagan Lake drought stage triggers and modified the trigger water level values as outlined by the OBWB (2019). The Okanagan Lake drought stage triggers are to help provide water suppliers and other large water users (using the mainstem lakes for supply) an understanding of their risk to water availability during times of drought. These drought triggers are included within Bylaw 2005-02 to help the City make operational decisions for water restrictions, blending of water sources, and drought stage declarations.

The City's drought stages have been aligned with the four Provincial Drought Levels: Level 1, Level 2, Level 3, and Level 4. The Provincial Drought Levels provide guidance to the City on the general water supply conditions within the region and are used to support decisions around system operations, water restrictions, and reservoir management responses.

Following the above, communication of drought by the City is through public notification procedures. Once a change to drought stage has been triggered, specific public communication strategies and appropriate responses are implemented. Although not fully implemented at this time, the City is currently updating their drought management communications approach for municipal and agricultural users following the new communication strategy developed to support this DMP.

5 DROUGHT STAGE DECISION PROCESS AND TRIGGERS

To determine the status of water supplies, the City's Water Supply Management Team (WSMT) meets formally and informally to review the current water supply status. The purpose of these meetings is to discuss the current state of water supplies (by water supply source and/or as a whole) and forecasted trends to develop an understanding of the potential for future shortages and to what level of severity (i.e., stage). These meetings also provide the opportunity to implement operational measures (e.g., regulating spill from the upland reservoirs to increase storage volumes) prior to the triggering (and declaration) of drought stages and associated responses.

The triggering (and declaration) of a drought stage involves complex considerations, as personal hardship, economic losses to the agricultural and industrial-commercial-institutional communities, damage to infrastructure such as parks, and lost revenue to the City may result because of the declaration. Thus, the WSMT will recommend the implementation of a stage in an informed manner with the understanding of the consequences.

To support the triggering of a drought stage, a decision tree is used by the City. The decision tree is a guide for decision-makers in weighing information and understanding the potential outcomes when deciding what water shortage action(s) to undertake. The decision tree is used by the WSMT to determine the status of water supplies at any point throughout the year, on a critical decision date, or forecasted for the near future. The decision tree was adopted from the Regional District of North Okanagan who have been using this decision tree since 2011 to support drought management decisions with the Greater Vernon Water distribution area.

The decision tree is used by the City to independently determine the water supply status of each water supply source (i.e., Penticton Creek, Ellis Creek, and Okanagan Lake). From there, the City determines if an individual source is experiencing different water supply conditions than the others. Using this approach, an individual drought stage may be declared by water supply system or for the entire City system.

Once a drought stage has been triggered, the WSMT continues to review storage volumes and other drought forecast parameters and recommend a change (or rescinding) of stage following the drought stage decision tree. When a drought stage change is triggered, the Drought Response Plan is enacted by the WSMT for the respective stage. The WSMT also engages with the Drought Management Team once a trigger (or impending declaration) has occurred to effectively communicate the drought stage status and potential future supply challenges.

6 DROUGHT AND EMERGENCY RESPONSE PLANS

The overall components of the City's drought stages and triggers are summarized within the drought response plan provided below. The drought response plan is the staged approach to water management during periods of drought through the identification and evaluation of factors that trigger a response. The City Manager or the City's Designated Officer is responsible for implementing all stages of the DMP, and therefore determining whether a response action is warranted. Response actions are those included within Bylaw No. 2005-02 (or as amended) that are focused on the reduction (and/or conservation) of water use during periods of drought. Alternatively, the City during periods of loss of supply or other emergencies, can invoke the Emergency Response Plan.

Item	Drought Stage				
	Normal Condition – No Drought	**1 - Dry**	**2 – Very Dry**	**3 – Extremely Dry**	**4 – Emergency**
Explanation of Water Supply Status	Defined by the ability to meet or exceed the average storage condition.	Stage 1 indicates an early drought condition. It is the first indication of potential water shortage.	Stage 2 represents prolonged periods of no rain and hot and dry weather and/or with below-average snowpack conditions. This represents moderate level of drought where water supply is becoming stressed.	Stage 3 represents severe drought conditions. This occurs when water supplies are experiencing a critical shortage or short-term loss of critical infrastructure.	Stage 4 is characterized by a loss of supply via loss of upland storage or Okanagan Lake supply through drought, or due to contamination, or loss of critical infrastructure.
Goal	Encouragement of water use efficiencies and promotion of drought awareness and preparedness. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce municipal consumption by 10%. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce municipal consumption by 20%. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce consumption by 50%. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce consumption by 90%. Maintain minimum water supply to maintain community health and basic needs. As best as possible meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.
Stage Triggers per Bylaw 2005-02	Upland storage volumes are >95% of storage capacity (based on time of year)	Upland storage volumes are 70-95% of storage capacity (based on time of year)	Upland storage volumes are 60-70% of storage capacity (based on time of year). Projected daily municipal water demand is estimated to be 90% of treatment capacity of the WTP and actual daily treated water demand is 5% above the five-year historic average.	Upland storage volumes are 60% of storage capacity (based on time of year). Projected daily municipal water demand is estimated to be >90% of treatment capacity of the WTP and actual daily treated water demand is 10% above the five-year historic average.	Upland storage volumes are 60% of storage capacity (based on time of year). Projected daily municipal water demand is estimated to be ≥95% of treatment capacity of the WTP and actual daily treated water demand is 10% above the five-year historic average.
Other Triggers per Decision Tree	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.
Okanagan Lake Drought Stage Triggers	1st of the month elevation of Okanagan Lake is equal to or greater than the 1st of the month target.	1st of the month elevation of Okanagan Lake is lower than the 1st of month target elevations and equal to or greater than the 20th percentile 1st of month elevation.	1st of month elevation of Okanagan Lake is lower than the 20th percentile 1st of month elevation and greater than or equal to the 10th percentile 1st of month elevation.	1st of month elevation of Okanagan Lake is lower than the 10th percentile 1st of month elevation and greater than or equal to the 5th percentile 1st of month elevation.	1st of month elevation of Okanagan Lake is lower than the 5th percentile 1st of month elevation.
Provincial Drought Level[1]	Level 1	Level 2	Level 3	Level 3	Level 4
Regulation and Response	Alternating day watering schedule for outdoor water use to promote/ensure water conservation.	Water use restrictions are primarily focused on the reduction of residential outdoor and City Park water use. Agricultural water users encouraged to reduce water needs by matching irrigation with soil and crop types.	Implementation of a two-day a week residential sprinkler irrigation schedule, various reductions in City Park irrigation schedules, and a 10% reduction to golf course irrigation. Agricultural water users encouraged to reduce water use by decreasing (where possible) irrigated acreage or reducing irrigation to some lesser-value plants.	Residential sprinkler irrigation is restricted to a 1-day a week schedule and irrigation for City Parks, golf courses, and playing fields are restricted. Recreation (i.e., hot tubs, pools, and ponds) and commercial (i.e., car washes) outdoor water use restricted. Agricultural water users limited to irrigate only high-value perennial plants and to only irrigate at night.	Water supplies are limited to residential (indoor) use only; at the base (winter) demand rate (i.e., 12 ML/day). Elimination of residential, recreation (i.e., hot tubs, pools, and ponds), and commercial (i.e., car washes) outdoor water use. Agricultural water users restricted to irrigation for livestock and for high-value perennial plants only.
Communication	Normal levels of communication and education. Roll out best management and conservation practices.	Increased level of effort by the City – including communication and public education to understand actions necessary to reduce potential move to Stage 2.	High level of education and communication maintained.	High level of education and communication maintained.	City's Emergency Response Plan and Provincial Emergency Program invoked. High levels of communication and education maintained.
Enforcement	Normal	Increased enforcement and monitoring of large water users with warning issued if misuse is deemed to be occurring.	Lower tolerance for misuse and moderate fines issued.	Zero tolerance for misuse and moderate fines issued.	Zero tolerance for misuse and stiff fines issued.

Note:

1. The provincial drought levels are independent of the drought stages used by the City but are aligned here only to provide guidance on general water supply conditions. The levels do not directly correlate to the City's system operations, water restrictions, and reservoir management.

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1 INTRODUCTION

1.1 Overview

The following version of the Drought Management Plan (DMP) was prepared at the request of the City of Penticton (hereafter referred to as the City) to include new drought management strategies included within Bylaw No. 2020-25[2] (i.e., an amendment to the City's Irrigation, Sewer, and Water Bylaw No. 2005-02).

With water supply determined by rain, snowfall, and the storage capacity of reservoirs and aquifers, water shortages are a major concern to the City, which could become more pronounced in the future. During dry years, the City imposes conservation measures to help ensure that both human and environmental needs are met. These conservation measures are outlined within the City's Irrigation, Sewer, and Water Bylaw No. 2005-02 (Appendix A), which identifies procedures and actions to be implemented at various stages of drought and water availability (i.e., Stages 1, 2, 3, and 4) for their treated water source. Each of the identified stages outline specific triggers to help guide water restriction implementation. The triggers are based on projected demands, reservoir capacities, forecasted drought conditions, and emergency situations (e.g., power outages, treatment plant failure). Water restrictions for municipal irrigation supplies are reported by Bylaw No. 2005-02 to be at the discretion of the City based on irrigation systems present and projected water supplies.

As water demand increases in the future, the City may need to augment their surface withdrawals by increasing upland reservoir storage and management. Increasing water withdrawals and storage could impact environmental flow needs, downstream water licences, and water availability to all users. Balancing water supply and use, determining effects of future climate change, defining the role of water in land use and economic development, and protecting the ecological functions of water all depend on good scientific, socio-economic, and governance information. As a result, the City understands that a DMP is needed to balance the health of watersheds, water supplies during normal, dry, and wet years, and future development plans and growth.

To this end, the City has developed this DMP to allow for a more informed management plan during drought years for all water sources and infrastructure interconnections for the present and into the future. The goal of City's DMP is to ensure that adequate water supplies are available under drought conditions in the near term, as well as in the future, considering population growth, changes in agricultural practices, and climate change.

1.2 Components of the Drought Management Plan

The objective of the DMP is to provide the City with a decision-making framework to prepare, plan, communicate, and respond to situations of drought within their service area. To meet this objective, the DMP outlined herein is structured to be consistent with components of the template provided by MOE (2016) in *Dealing with Drought – A Handbook for Water Suppliers in BC* and by Associated (2016) in *Building Drought Resilience in the Okanagan*, and draws upon the DMP developed by the Regional District of North Okanagan to support drought management decisions for the Greater Vernon Water distribution area.

The specific components of this DMP are as follows:

- Water Supply and Drought Management Teams (Section 2);
- Water System Profile (Section 3);
- Drought Stages and Communication Plan (Section 4);
- Drought Stage Decision Process (Section 5); and
- Drought and Emergency Response Plans (Section 6).

[2] All bylaw referencing within this document hereafter includes Bylaw No. 2005-02, which includes all amendments up to Bylaw No. 2020-25.

2 WATER SUPPLY AND DROUGHT MANAGEMENT TEAMS

The following section summarizes the water supply management team structure of the City, as well as the Drought Management Team that the City is proposing to implement to advise on water conservation strategies from a stakeholder and community perspective.

2.1 Water Supply Management Team

As outlined within Bylaw No. 2005-02, the City is mandated to provide for the supply, distribution, and use of treated and irrigation water, and the collection, conveyance, and discharge of sanitary sewage and storm drainage into or from the irrigation water, treated water, sanitary sewer, and storm sewer systems. The specific scope of services is summarized as follows:

- Establish, operate, maintain, and control an irrigation water system for the City;
- Establish, operate, maintain, and control a reclaimed water system for the City;
- Establish, operate, maintain, and control a treated water distribution system for the City;
- Establish a system of sewerage works for the collection, conveyance, and disposal of sewage and operate and maintain this system for the City; and
- Establish a system of storm water drainage from the impounding, conveyance, and discharging of surface and other waters, and operate and maintain this system for the City.

To meet these servicing needs, operations and maintenance of the City's water supply and treatment system is completed by the City's Designated Officer under the direction of Chief Administrative Officer and/or City Council. During times of drought, the City Manager, or any other person that the City Council designates, is responsible for implementing all stages of the DMP. This individual will coordinate with administrative and operations staff to comprise the City's Water Supply Management Team.

Note that for this version of the DMP, water conservation measures and drought stage triggers are outlined within Bylaw 2005-02.

2.2 Drought Management Team

To help the City consider impacts to the local economy and community livelihoods during periods of drought, a Drought Management Team (DMT) is proposed. The DMT is supported by City staff and the scheduling of meetings depends on the severity of the actual or impending water supply shortage. The specific roles of the DMT are to assist in the development of efficient water use strategies, inform the community on water supply levels, and provide feedback on the effect of water use restrictions on the community. The DMT includes representation from institutions, local businesses, agricultural producers, provincial government staff, as well as other local large water users and community members. The terms of reference for the DMT (including recommended team member representation) is provided in Appendix B and is consistent with that used by the Regional District of North Okanagan to support drought management decisions.

3 WATER SYSTEM PROFILE

The City relies on surface water for raw water supply for municipal (i.e., potable) and irrigation (i.e., non-potable) purposes. The City uses Penticton and Ellis Creeks and Okanagan Lake as water sources; all of which are subject to water licensing, runoff, and storage limitations. Water supplied from Penticton and Ellis Creeks is managed by the City, while the BC Ministry of Forests, Lands, and Natural Resource Operations, and Rural Development (FLNRORD) manages Okanagan Lake water levels to optimize water use and environmental needs. The City uses water from Okanagan Lake for municipal purposes, water from Penticton Creek for municipal and agricultural irrigation purposes, and water from Ellis Creek for agricultural irrigation purposes only. From a municipal water supply standpoint, on average between 2004 to 2020, the City sourced approximately 90% from Okanagan Lake and 10% from Penticton Creek through the water treatment plant (WTP).

A breakdown of the City's average total water use by system (for 2004-2020) is shown in Figure 3-1 and is generally considered representative of the total distribution of annual water use by the City.

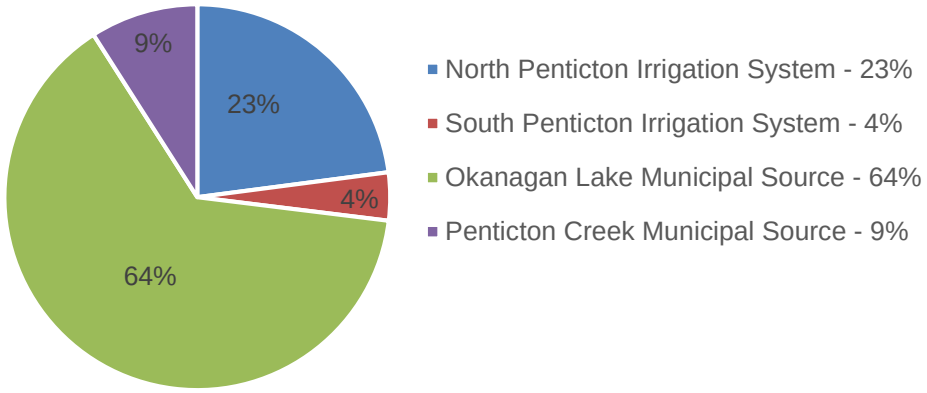

Figure 3-1Summary of the City of Penticton's water use by water supply system (2004-2020)

The following sections provide an overview of the City's water sources, demand, and capital components.

3.1 Penticton Creek Water Supply System

3.1.1 Overview of System

Penticton Creek is a tributary to Okanagan Lake. The watershed is located to the northeast of Penticton within the Thompson Plateau of the Interior Plateau Physiographic Region. The total drainage area of the Penticton Creek watershed is 194 km^2 and elevations range from 342 metres above sea level (masl) to 2,154 masl. The Penticton #2 dam water intake defines the most downstream extent of the water supply source area for the City's Penticton Creek water supply (Figure 3-2). The contributing area to the Penticton #2 dam water intake is 175 km^2 and it is designated as a community watershed under the *Forest and Range Protection Act*. The Penticton #2 dam water intake is used to supply water to the WTP for direct municipal water distribution or for blending with the Okanagan Lake supply.

Figure 3-2City of Penticton's water sources and selected watershed and hydrologic characteristics

Approximately 3.5 km upstream of the Penticton #2 dam water intake, the City also operates the Campbell Mountain Diversion Dam (Figure 3-2). This dam is used to divert water through a 3 km tunnel to irrigate farms, orchards, and wineries along Naramata Road north of Penticton. This diversion is referred to as the North Penticton Irrigation System.

A portion of the City's municipal and North Penticton Irrigation System water supplies are provided by Greyback Reservoir and the contributing areas within the watershed between the reservoir and the intakes. The City's total annual licensed volume for Penticton Creek is 12,085 ML for municipal (6,670 ML) and agricultural irrigation (5,415 ML) water use purposes. The total licensed storage capacity for Greyback Reservoir is 11,693 ML (9,480 acre-feet) and the current (live) storage capacity for the reservoirs is 12,630 ML (10,239 acre-feet) (Canada-British Columbia Okanagan Basin Agreement 1974a). The City also holds an irrigation water licence on Howard Lake for 308 ML and storage licences for both Howard Lake (86 ML [70 acre-feet]) and Penticton Creek (62 ML [50 acre-feet]). Under the 'first-in-time, first-in-right' licensing system under the *Water Sustainability Act*, the City holds senior level water licences on Penticton Creek.

3.1.2 Hydrologic Regime

The Penticton Creek watershed lies in the Southern Thompson Plateau Hydrologic Zone #24 (Obedkoff 1998). Streams within this hydrologic zone are generally characterized by a snowmelt dominated peak rising in April or May and peaking sometime in May or June. Rain-on-snow events occasionally occur in this region enhancing winter streamflow and spring peaks. In addition, late fall rainstorms are common, recharging soil moisture heading into the winter and producing short duration peak streamflows. Low streamflows occur generally from the end of November to March, and in the hot summer months, with the lowest streamflows commonly occurring in January or February. The primary source of runoff for Penticton Creek during the spring period is from snowmelt from the upper 40% of the watershed (i.e., above 1,660 masl) (Urban Systems Ltd. 2013), while Winkler (2010) reported that streamflows within the summer and early fall are sustained by deep groundwater.

Streamflows within Penticton Creek are regulated by Greyback Reservoir, Campbell Mountain Diversion dam, and Penticton #2 dam. The Water Survey of Canada (WSC) historically monitored streamflows within Penticton Creek at the mouth (WSC Station No. 08NM118; Period of Record = 1950-1971) and the City historically monitored streamflows at Nanaimo Avenue and installed a new hydrometric station at Ellis Street in 2021. The location of each hydrometric station is included in Figure 3-2.

3.1.3 Reservoir Management and Storage Trends

Greyback Reservoir

Greyback Reservoir storage is managed by the City to ensure adequate water supplies are available to downstream users and aquatic resources. Under normal conditions, Greyback Reservoir is managed under two settings: (1) winter and (2) summer. The two settings are summarized by the City of Penticton (2014) as follows:

- Winter Setting (November 15 to April 15) – gate (i.e., 8" gate) is set to provide enough water within Penticton Creek for potable usage, WTP operations, and fall kokanee salmon spawning.
- Summer Setting (April 16 to November 14) – gate (i.e., 24" gate open and 8" gate closed, or 24" and 8" gates open proportionally) is set to provide enough water within Penticton Creek for potable and irrigation usage and WTP operations.

The City has no specific documented operational parameters defined during times of drought or water shortages – beyond the drought stage (water storage volume) definitions outlined Bylaw No. 2005-02. However, in general the City reviews projected storage targets for November and May (i.e., between 6,785 ML [5,500 acre-feet] and 7,400 ML [6,000 acre-feet]) to support reservoirs operations (City of Penticton 2014). If the projected storage values for November are deemed to be met, the winter setting (above) is set, and if the projected storage values for May are deemed to be met, all gates are closed to fill the reservoir (City of Penticton 2014). If the storage values are not projected to be met, the City manages the reservoir releases to capitalize on all available water to help fill the reservoir (City of Penticton 2014).

Total reservoir storage volume for Greyback Reservoir has been monitored manually from 1980 to present. The annual storage reservoir pattern is illustrated in Figure 3-3.

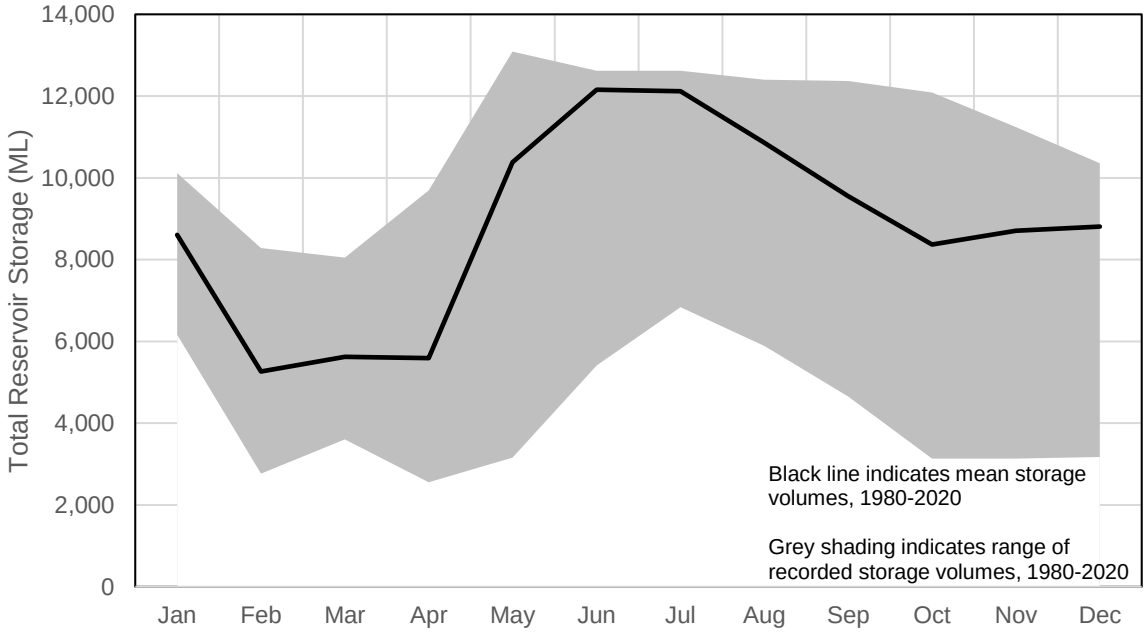

Figure 3-3Summary of total reservoir storage volume for the Greyback Reservoir, 1980-2020

Referring to Figure 3-3, the general storage trends for Greyback Reservoir are as follows:

- Inflows into the reservoir generally begin between late March and early April, but can occur in early March, or be delayed until late April or early May. Inflows are largely related to the melting of the upland watershed snowpack.
- The reservoir reaches full storage capacity generally in June. Seasonal snowpacks within the upper portion of Penticton Creek watershed have generally melted by mid-May; therefore, rainfall supplements inflows to the reservoirs within the late spring periods.
- During July, August, and September, water is released from the reservoir to meet consumption requirements. Maximum consumption occurs from mid-July to mid-August and is related to the peak irrigation demands for the North Penticton Irrigation System.
- In late fall and winter, the reservoir is managed to meet WTP operations, which depend on the amount of water being used for municipal purposes during that period.

Campbell Mountain Diversion Dam

The Campbell Mountain Diversion dam supports the diversion of water through a tunnel to supply the North Penticton Irrigation System. The diversion is only operational during the agricultural irrigation season (i.e., April to September), but the diversion tunnel remains left in the loaded (i.e., full) position year-round, ready for operation at any time. With a total storage capacity of 31 ML (25 acre-feet), the dam was designed as a flow through system, with water diverted as necessary and the reminder spilling to maintain streamflow. During periods of drought or reduced water supply, the volume diverted is managed based on City-implemented watering restrictions for any residential users (as outlined within Bylaw No. 2005-02) and/or through City recommended conservation measures for agricultural users.

The North Penticton Irrigation System services 308 parcels and each parcel is allocated an application rate based on soil type within the defined irrigable area at the property. The allocation rates vary between 0.13 – 0.18 L/s/ha, with a total irrigable area of 610 ha serviced by the North Penticton Irrigation System (Urban Systems Ltd. 2009). The North Penticton Irrigation System is currently not fully metered, but the City has an intermediate term plan to add meters to the system.

Penticton #2 Dam

The Penticton #2 dam was designed to support the diversion of water to the WTP. The diversion operates as required year-round based on the requirements of the WTP for blending of water from different sources and distribution purposes. With a total storage capacity of 71.5 ML (58 arce-feet), the dam was designed as a flow-through system, with water diverted as necessary and the remainder spilling to maintain streamflow. During periods of drought or reduced water supply, the volume of diversions is managed based on City-implemented watering restrictions outlined within Bylaw No. 2005-02.

3.1.4 Fishery Flow Release Targets

Currently there are no provincially regulated fishery flow requirements for Penticton Creek. However, the City has implemented a year-round minimum streamflow criterion of 0.231 m^3/s (or 20 ML/day), which is monitored by the City's hydrometric station at Ellis Street.

The Okanagan Basin Water Board (OBWB) lead an initiative within the Okanagan Basin to establish Environmental Flow Needs (EFN) on several Okanagan tributaries. Penticton Creek was one of the tributaries and EFN and critical flows were recommended by ONA (2020) to support Rainbow trout and Kokanee salmon life stages within the creek. Thus, future water management under normal and drought conditions will need to consider these recommended values.

3.1.5 Water Demand

The Campbell Mountain Diversion dam currently shares water licences with the Penticton #2 dam water intake. Thus, both diversions are licensed to withdraw 12,085 ML annually from Penticton Creek for irrigation and municipal purposes.

Based on City's diversion records, the total annual diversions for the North Penticton Irrigation System from 2004-2020 have ranged between approximately 1,133 ML (2018) and 3,462 ML (2012), with an average of approximately 2,253 ML. Since the Campbell Mountain Diversion is only used for agricultural irrigation purposes, water is typically only diverted between April and October. During that period, diversions during the months of July and August are the highest, with an average daily demand of 17 ML/day.

In addition, based on available records, the total annual Penticton Creek diversions for the WTP from 2009-2020 have ranged between approximately 257 ML (2009) and 1,841 ML (2011), with an average of approximately 900 ML. Water diversions vary throughout the year largely due to the WTPs blending of water with Okanagan Lake diversions; however, approximately 55% of the diverted water is used between April and September. During the summer months (July and August), average daily diversions are 5.3 ML/day, while during the winter (November – February), average daily diversions are 2.1 ML/day.

3.2 Ellis Creek Water Supply System

3.2.1 System Overview

Ellis Creek is a tributary to the Okanagan River between Okanagan and Skaha Lakes (Figure 3-2). The watershed is located to the east of Penticton within the Thompson Plateau of the Interior Plateau Physiographic Region. The total drainage area of the Ellis Creek watershed is 158 km^2 and elevations range from 342 masl to 2,010 masl. The Ellis Creek Diversion dam water intake defines the most downstream extent of the water supply source area for the City's Ellis Creek water supply (Figure 3-2). The contributing area to the Ellis Creek Diversion dam water intake is 153 km^2 and it is designated as a community watershed under

the *Forest and Range Protection Act*. The Ellis Creek Diversion dam water intake is used to supply irrigation water to the South Penticton Irrigation System.

The City's total annual licensed volume for Ellis Creek is 8,287 ML for municipal (5,727 ML) and agricultural irrigation (2,560 ML) water use purposes. The total licensed storage capacity for the Ellis #2 and #4 dams is 1,317 ML (1,068 acre-feet) and the current (live) storage capacity for the reservoirs is 1,254 ML (1,017 acre-feet). Although the City holds a municipal water licence for Ellis Creek, water is only used to support agricultural irrigation for the South Penticton Irrigation System. Under the 'first-in-time, first-in-right' licensing system under the *Water Sustainability Act*, the City holds senior level water licences on Ellis Creek.

3.2.2 Hydrologic Regime

Like Penticton Creek watershed, the Ellis Creek watershed also lies in the Southern Thompson Plateau Hydrologic Zone #24 (Obedkoff 1998). The general hydrologic regime of Ellis Creek watershed is consistent with Penticton Creek, as summarized in Section 3.1.2. The primary source of runoff for Ellis Creek during the spring period is from snowmelt. Streamflows within Ellis Creek are regulated by Ellis #2 and #4 dams and the Ellis Creek Diversion dam. The WSC has monitored streamflows within Ellis Creek near the mouth (WSC Station No. 08NM135; Period of Record = 1965-1979) and the City has monitored streamflows at Industrial Avenue from 2009 to present. The location of each hydrometric station is included in Figure 3-2.

3.2.3 Reservoir Management and Storage Trends

Ellis #2 Dam Reservoir

Ellis #2 Dam Reservoir is managed by the City to supplement water supplies at the Ellis Creek Diversion dam. The dam is only operational during the irrigation season (i.e., April to October) and is drained at the end of the season (i.e., late October). Normal operations of Ellis #2 dam as outlined by the City of Penticton (2014) include:

- Fall / Winter Setting (November to March) – gate (i.e., 18" [450 mm] gate) is set to empty the reservoir and to keep the reservoir empty during the fall and winter.
- Spring / Summer Setting (April to October) – gate (i.e., 18" [450 mm] gate) is closed in April to capture spring snowmelt runoff. The gate remains closed until late July or August for water releases downstream on a demand driven basis.

The total storage capacity of the Ellis #2 Dam Reservoir is 450 ML (365 acre-feet) and once the storage has been depleted, Ellis #4 Dam Reservoir is used to supplement water demands downstream. Total reservoir storage volume for Ellis #2 Dam Reservoir has been monitored manually by the City from 1998 to 2020. The annual storage reservoir pattern is illustrated in Figure 3-4.

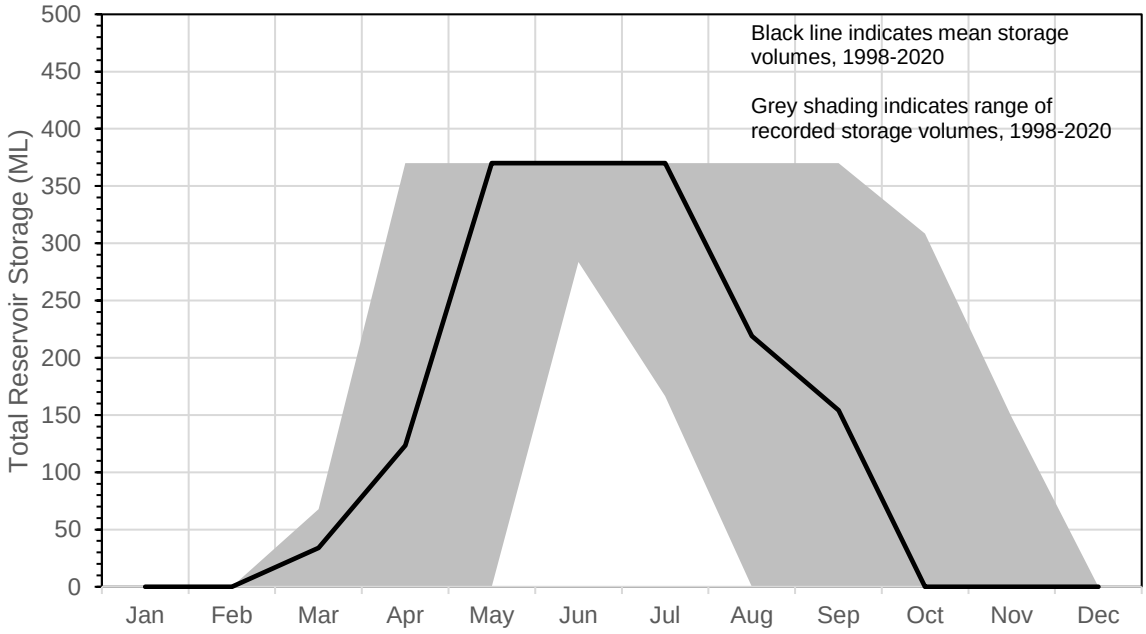

Figure 3-4Summary of total reservoir storage volume for the Ellis #2 Dam Reservoir, 1998-2020

Referring to Figure 3-4, the general storage trends for Ellis #2 Dam Reservoir are as follows:

- Inflows into the reservoir generally begin between early April, but can occur in early March, or be delayed until late April or early May. Inflows are largely related to the melting of the upland watershed snowpack.
- The reservoir reaches full storage capacity generally in late April or May.
- During July, August, and September, water is released from the reservoir to meet downstream demand requirements. Maximum demand occurs from mid-July to mid-August and is related to the peak irrigation demands for the South Penticton Irrigation System.
- In late fall and winter, the reservoir is emptied.

Ellis #4 Dam Reservoir

Like Ellis #2 dam, Ellis #4 dam was designed to supplement water supplies at the Ellis Creek Diversion dam. The dam is also only operational during the irrigation season (i.e., April to October) and is drained at the end of the season (i.e., late October). Normal operations of Ellis #4 dam as outlined by the City of Penticton (2014) include:

- Fall / Winter Setting (November to March) – gate (i.e., 24" [600 mm] gate) is set to empty the reservoir and to keep the reservoir empty during the fall and winter.
- Spring / Summer Setting (April to October) – gate (i.e., 18" [450 mm] gate) is closed in April to capture spring snowmelt runoff. The gate remains closed until August or September for water releases downstream on a demand driven basis.

The total storage capacity of the Ellis #4 Dam Reservoir is 860 ML (697 acre-feet) and storage is generally not used until Ellis #2 Dam Reservoir has been emptied. Total reservoir storage volume for Ellis #4 dam reservoir has been monitored manually by the City from 1980 to 2020. The annual storage pattern is illustrated in Figure 3-5. The general storage trends for Ellis #4 Dam Reservoir are similar to Ellis #2 Dam Reservoir (Figure 3-4); however, reservoir inflows tend to begin earlier (i.e., March) and storage is maintained longer within the reservoir due to the City's use of Ellis #2 Dam Reservoir storage first to support downstream demands.

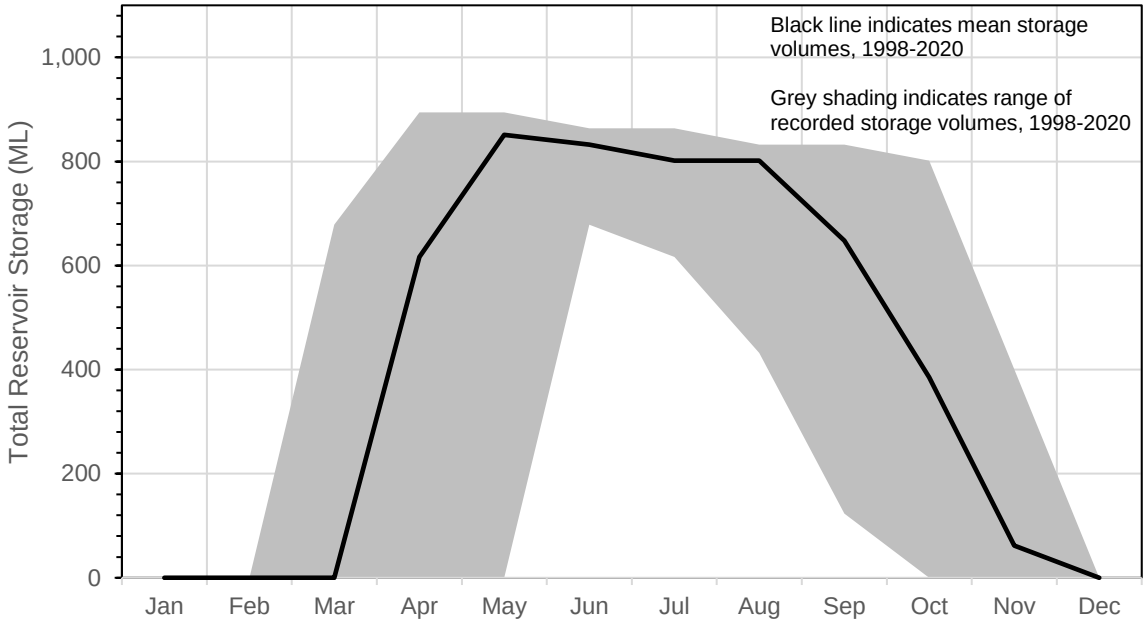

Figure 3-5Summary of total reservoir storage volume for the Ellis #4 Dam Reservoir, 1980-2020

Ellis Creek Diversion Dam

The Ellis Creek Diversion dam was designed to support the diversion to the South Penticton Irrigation System. The diversion is only operational during the agricultural irrigation season (i.e., April to September). With a total storage capacity of 6 ML (5 acre-feet), the dam was designed as a flow through system, with water diverted as necessary and the reminder spilling to maintain streamflow. During periods of drought or reduced water supply, the volume of diversion is managed based on City implemented watering restrictions.

The South Penticton Irrigation System services 84 parcels and each parcel is allocated an application rate based on soil type within the defined irrigable area at the property. The allocation rates vary between 0.13 – 0.18 L/s/ha, with a total irrigable area of 122 ha serviced by the South Penticton Irrigation System (Urban Systems Ltd. 2009).

3.2.4 Fishery Flow Release Targets

Currently, there are provincially regulated fishery flow requirements for Ellis Creek as follows:

- January to August = 0.084 m^3/s; and
- September to December = 0.126 m^3/s.

The City ensures that the fishery flow requirements are met by monitoring streamflows at their Ellis Creek hydrometric station at Industrial Avenue.

3.2.5 Water Demand

Based on City's diversion records, the total annual diversions at the Ellis Creek Diversion dam (for the South Penticton Irrigation System) from 2004 to 2020 have ranged between approximately 248 ML (2011) and 886 ML (2017), with an average of approximately 501 ML. Since the Ellis Creek Diversion dam is only used for agricultural irrigation purposes, water is typically only diverted between April and October. During that period, diversions during the months of July and August are the highest with an average daily demand of 4.1 ML/day.

3.3 Okanagan Lake Water Supply System

3.3.1 System Overview

Okanagan Lake is a large valley bottom lake that is located to the north of the City, with a surface area of approximately 340 km^2. The total contributing area to Okanagan Lake covers approximately 6,090 km^2 which includes inflows from numerous tributaries, including Penticton Creek. The headwaters of Okanagan Lake are located within the Thompson Plateau of the Interior Plateau Physiographic Region. Okanagan Lake has a mean and maximum depth of 76 m and 242 m, respectively. The residence time of the lake is approximately 60 years (Canada-British Columbia Okanagan Basin Agreement 1974b). The City operates a single water intake on Okanagan Lake that is used to supply municipal water (Figure 3-2). The intake is located 1 km offshore and approximately 39 m below the water surface. All water pumped from Okanagan Lake is treated by the City's WTP.

The City's total annual licensed volume for Okanagan Lake is 13,805 ML for municipal (12,695 ML) and irrigation (1,110 ML) use purposes[3]. Under the provincial 'first-in-time, first-in-right' licensing system, the City holds intermediate and senior level water licences on Okanagan Lake.

3.3.2 Hydrologic Regime

The contributing watershed to Okanagan Lake is in the Southern Thompson Plateau (Hydrolgoic Zone #17; subzone "b") and the Fraser Plateau (Hydrologic Zone #15; subzone "e") (Obedkoff 1998). Streams within these hydrologic zones are generally characterized by a snowmelt dominated peak rising in April or May and peaking sometime in May or June. Low flows occur generally from the end of November to March, and in the hot summer months, with the lowest flows commonly occurring in January or February.

The general water level trend for Okanagan Lake is summarized within the next section.

3.3.3 Reservoir Management and Storage Trends

Okanagan Lake water levels are managed by FLNRORD by releasing water into the Okanagan River and other mainstem lakes south of Penticton (Figure 3-2). Water levels within Okanagan Lake are managed as part of the Okanagan Lake Regulation System and follow water level and downstream streamflow release targets outlined by the Okanagan Basin Implementation Board (MOE 1982). The operating targets (i.e., month end water levels) are maintained by FLNRORD at the Okanagan Lake dam (Figure 3-2).

The operating targets were developed to balance economic development (e.g., flood control, water supply, lakeshore development, tourism), environmental quality (e.g., environmental flows for fish), and social betterment (OBWB 2019). Okanagan Lake is regulated to capture and store as much freshet volume as possible for use later in the year and under drought years FLNRORD closely monitors levels and streamflow releases to balance environmental and human needs (OBWB 2019). There is no formal drought operational procedure currently for Okanagan Lake; however, the OBWB (2019) have produced Okanagan Lake drought stage triggers for local water purveyors to consider for drought planning purposes (discussed further in Section 4.2).

Water levels within Okanagan Lake have been monitored (near Kelowna) by the WSC (Station No. 08NM083) and the annual pattern of lake inflows and releases from 1943-2020 is illustrated in Figure 3-6. Figure 3-6 also includes the month end water level operating targets used by FLNRORD to manage Okanagan Lake.

[3] All West Bench Irrigation District water licences (i.e., one licence for 1,100 ML/yr for irrigation purposes and two licences for 1,359 ML/yr for waterworks purposes) transferred to the City have been superseded by the City's Okanagan Lake licence (i.e., Water Licence No. C130923).

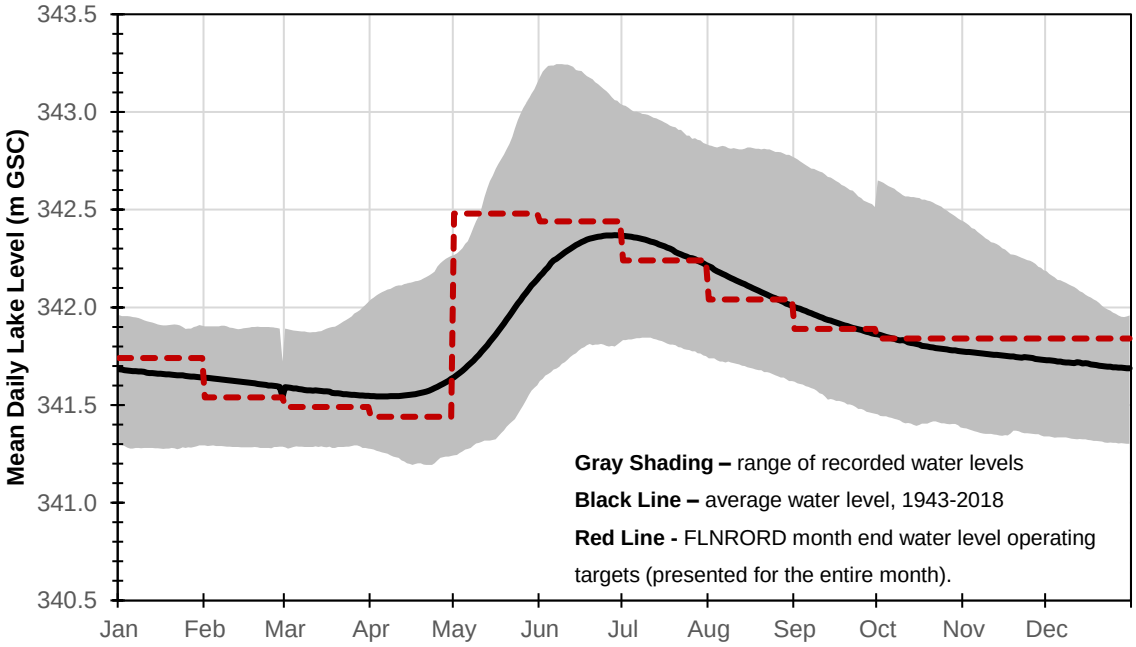

Figure 3-6Summary of Okanagan Lake water levels (WSC Station No. 08NM083), 1943-2020

According to Figure 3-6, the general pattern of inflows and releases from Okanagan Lake are as follows:

- Inflows into the lake generally begin around mid-April, but can occur in March, or be delayed until early May. Inflows are largely related to the melting of the upland watershed snowpacks.
- The lake reaches its highest water levels generally between June and July. Seasonal snowpacks within the headwaters have generally melted by mid-May; therefore, rainfall supplements inflows into the lake within late spring periods.
- During July, August, and September, water is released from the lake to meet downstream consumption and fisheries flow requirements.

3.3.4 Fishery Flow Release

Minimum fishery flow releases from Okanagan Lake into the Okanagan River are governed by the Okanagan Fish Water Management Tool (FWMT). The FWMT provides in-depth information and models for making weekly water release decisions from Okanagan Lake dam that account for flood, drought, protection of sockeye salmon eggs in the Okanagan River and kokanee salmon eggs in the lake (ONA 2017). All releases from Okanagan Lake follow the FWMT tool guidelines and the releases are determined collaboratively by a FWMT Steering Committee that includes representatives from Okanagan Nation Alliance, Fisheries and Oceans Canada (DFO), and FLNRORD.

3.3.5 Water Demand

The Okanagan Lake water intake diverts raw water to the WTP through a 750 mm diameter transmission line. The design capacity of the WTP is 100 ML/day, although operationally the maximum for water from the Okanagan Lake water intake is 60 ML/day.

The Okanagan Lake intake is currently licensed to withdraw 13,805 ML annually from Okanagan Lake. Based on City diversion records, the total annual diversions from 2004 to 2020 have ranged between approximately 5,054 ML (2011) and 7,561 ML (2005), with an average of approximately 6,288 ML. However, the volume of water that is withdrawn annually from Okanagan Lake is also dependent on the volume of water from Penticton Creek that is blended at the WTP. Blending is completed by the

City for maintenance of Okanagan Lake and Penticton Creek water intake infrastructure and for maintaining the best water chemistry for municipal residential water use. The City generally uses a 70% Okanagan Lake and 30% Penticton Creek blend.

Water diversion at the Okanagan Lake intake is consistent throughout the winter and increases between April and August in accordance with lawn and garden watering requirements (since there are no or very limited agricultural water use due to water license and system limitations). During the summer months (July and August), average daily water use is approximately 30 ML/day, while during the winter (November – February), average daily water use is 9.7 ML/day.

3.4 Groundwater Supply System

Groundwater is not a primary source of water for the City; however, it remains a viable emergency source. The City currently maintains one groundwater well: Warren Avenue Well (Figure 3-2). The well is located at a depth of 92.9 meters below ground surface (mbgs) within a confined and flowing artesian aquifer comprised of sands and gravels (City of Penticton 2017). The well was commissioned in 1984 to supplement water to the WTP during times of high summer water demands but use was discontinued in 1997 due to ongoing water quality problems (i.e., iron and manganese concentrations at and above aesthetic objectives, respectively) (AE 2004).

The annual groundwater supply by the Warren Avenue Well under average and selected drought return periods (e.g., 1:10-year, 1:20-year) is 2,350 ML (EarthTech and Agua Consulting Ltd. 2005). The pumping capacity for the Warren Avenue Well is 16 ML/day, but with treatment, the capacity is expected to be 13 ML/day, with a normal daily capacity of 11 ML/day.

3.5 System Interconnections

System interconnections provide the City with the flexibility of meeting water demands by individual or through a combination of water supply sources. Interconnection opportunities are particularly important for periods of drought or water supply shortages, as this builds redundancy and a more resilient system. Interconnections are also considered part of the City's emergency response plan during situations of loss of surface source.

A summary of the City's current system interconnection options are as follows:

- The City's municipal water supply can be supplied by Okanagan Lake, and during times of water shortages, a combination of water from Okanagan Lake and Penticton Creek can be used to meet water demands.
- An 8-inch (200 mm) pipe from the WTP can be used to support the South Penticton Irrigation System during times of water shortage, but the connection is not currently operational.
- Warren Avenue well has been declared as emergency backup well (or available during very dry periods) for the City's municipal water supply.

3.6 Current and Future Water Demands

3.6.1 Current Water Demands

As reported by City the Penticton (2017), there are 9,812 service connections, with approximately 381 agricultural connections. Sections 3.1.5, 3.2.5, and 3.3.5 provide a summary of water demand by water supply source, while the total annual water demand within the City's distribution area has ranged between 8,258ML to 11,152 ML (for the period 2004 to 2020). Approximately 72% of the total water used is for municipal purposes, while approximately 28% is used by agriculture. However, total municipal water demands are managed each year following the water schedules outlined within Bylaw No. 2005-02, while agricultural irrigation water demands supplied through the North and South Irrigation Systems are currently not limited by the City.

Over the same period as noted above, population has been increasing at a slow and steady pace. In addition, the City also supplies water to the West Bench Irrigation System (RDOS Area "F") on a bulk sales arrangement (City of Penticton 2017). However, even with these additions, annual water consumption has declined since 2006.

The total area available for agricultural purposes within the City's distribution area is 733 ha, but as of 2006 only 287 ha was being supplied with water (Urban Systems Ltd. 2009). Unit allocation rates are based on soil types within individual properties and range between 0.13 L/s/ha and 0.18 L/s/ha. Hence, the total water volume of allocation is 7,970 ML for the entire available area, while currently only 2,304 ML is being used (based on 2006 data) (Urban Systems Ltd. 2009).

A summary of the peak daily demand values for the City's various water sources is provided in Table 3-1 and the distribution of total water use by month is provided in Table 3-2.

Table 3-1 City of Penticton peak daily demand summary by water source

Water System	Flow Rate[1,2] (ML/day)			
	Average (ADD)	Base (BD)	Seasonal	Maximum (MDD)
North Penticton Irrigation System	N/A	N/A	10.6	34.0
Penticton WTP (Municipal)	19.5	12.0	24.8	48.6
South Penticton Irrigation System	N/A	N/A	2.3	12.5
Total (All Sources)	27.0	12.1	37.6	77.7

Notes:
1. Values based on 2004-2020 records by the City.
2. Average = average day demand (ADD); Base = base (winter) demand (BD); Seasonal = average irrigation season demand (April to October); Maximum = maximum day demand (MDD).

Table 3-2 Average City of Penticton monthly water demand from all sources

Month	Percent of Annual Demand[1] (%)	Month	Percent of Annual Demand[1] (%)
January	3.7	July	17.3
February	3.6	August	16.8
March	3.8	September	10.9
April	6.0	October	6.9
May	11.0	November	3.7
June	12.6	December	3.7

Note:
1. Values represent the 2004-2020 average diversion records by the City.

3.6.2 Future Water Demands

As outlined by EarthTech and Agua Consulting Inc. (2005), it is anticipated that municipal water demand would form the largest portion of increased future demands. In fact, the City's Concept Development Plan is projecting a growth rate of 2.5%. Therefore, to meet new service requirements, it is likely that the City will need to develop new infrastructure to meet this future demand and maintain the on-going operation for existing demand (EarthTech and Agua Consulting Inc. 2005). In addition, for long term sustainability, the increase in water demand must be significantly less than the rate of growth. Progress

on reducing per capita water use has already been used by the City with densification, the price of water, education programs, and public concerns over global warming being attributed with driving this change (EarthTech and Agua Consulting Inc. 2005).

AECOM (2010) provides a summary of projected municipal water demands for 2025 and 2055 and the values are summarized in Table 3-3. For the City's irrigation systems, Urban Systems Ltd. (2009) estimated that under climate change alone, annual irrigation water demands could increase by 36% for both systems, while under a build-out scenario plus climate change, the annual irrigation water demands could increase by 138% for Penticton Creek and by 207% for Ellis Creek.

Table 3-3 Summary of projected municipal water demands for 2025 and 2055 (from AECOM 2010)

Year	Maximum Day Demand (ML/day)	Peak Hourly Demand (ML/hr)
2025	38	2.4
2055[1]	90	5.6

Note:
1. Water demand values for 2055 considers a full build-out scenario.

Under future climate and water demand conditions, the City may need to look for options to support the meeting of future water supply needs. Specifically, increasing water supplies from Okanagan Lake, Penticton Creek, groundwater, and possibly expanding the supply from Ellis Creek have been identified, which may require new water licensing requirements.

4 DROUGHT STAGES AND COMMUNICATION PLAN

The following section provides a description of the existing drought stages implemented by the City and the BC provincial drought levels.

4.1 City of Penticton Drought Stages

The City established descriptions for drought stages in Bylaw 2005-02. Each stage was defined in reference to the volume of water available within the respective upland reservoirs (Section 3). More recently, the City adopted and modified the Okanagan Lake drought stage triggers recommended by OBWB (2019) to support management of the Okanagan Lake supply (described further in Section 4.2). The drought stages form the basis for the DMP and the associated responses implemented (i.e., watering restrictions) through Bylaw No. 2005-02 or as amended (Appendix A). The City's communication plan for each drought stage is as outlined in Section 4.4.

The drought stages summarized below can also apply to a localized water shortage situation resulting in similar reductions in supply availability due to limitations from infrastructure or an emergency incident. In addition, the City may implement restrictions on a single water supply source in the event of drought conditions that may affect an isolated portion of the system (i.e., Penticton or Ellis Creeks supply only). A summary of each drought stage is provided below.

Stage 1 – Normal / Dry
Stage 1 conditions are defined by the upland reservoir storage condition, where storage volumes are sufficient to meet water supply needs at current and near-future levels of water demand. Upland storage volumes that are ≥85% of available median storage capacity (based on time of year) are considered within Stage 1 operational ranges. Also, Okanagan Lake levels for each of the months July through November are at or above Stage 1 levels summarized in Section 4.2.

The water conservation goals of this stage are to encourage water use efficiencies and promote water supply shortage awareness and preparedness. A three day per week sprinkler irrigation schedule for residential outdoor water use and three to five days per week watering schedule for City Parks and Golf Courses is established year-round during Stage 1 conditions. Also, under Stage 1, agricultural users of the raw water supply may irrigate five to seven days per week.

Stage 2 – Very Dry
Stage 2 represents conditions of prolonged periods of no rain and hot, dry weather, combined with below normal snowpack conditions. This stage is considered a time of moderate drought or when water supplies are becoming stressed. The upland storage volumes are 70 to 85% of available median storage capacity (based on time of year) without any indication of recovery. The projected daily municipal water demand is to be 80% of treatment capacity of the WTP and FLNRORD has declared Level 2 drought conditions for the Okanagan Region. Also, Okanagan Lake levels for each of the months July through November are within Stage 2 levels summarized in Section 4.2.

An increased level of communication, education, monitoring, and enforcement occurs at this stage with moderate fines issued and lower tolerance for water waste. Water conservation goals during this stage are to reduce total water use by 20% to reduce the potential to move to Stage 3. Water use restrictions implemented during this stage are focused on the reduction of residential outdoor, City Parks, golf course, and agricultural water use. Specifically, this stage implements a maximum of a two-day a week residential sprinkler irrigation schedule and 20% reductions in City Park, golf course, and agricultural irrigation schedules. However, during Stage 2, the Designated Officer may consult with agricultural and reclaimed water users prior to implementing water restrictions.

Stage 3 – Extremely Dry

Stage 3 represent extremely dry conditions. This stage is considered a time of extreme drought, when water supplies are at a critical shortage level. This stage represents the condition where the upland storage volumes are at 60 to 70% % of available median storage capacity (based on time of year) without any indication of recovery and/or, specifically for the Ellis Creek reservoirs, storage capacity is at minimum levels. The projected daily municipal water demand is to be >90% of treatment capacity of the WTP and FLNRORD has declared Level 3 drought conditions for the Okanagan Region. Also, Okanagan Lake levels for each of the months July through November are within Stage 3 levels summarized in Section 4.2.

A high level of communication, education, monitoring, and enforcement occurs at this stage with fines issued and zero tolerance for misuse permitted. Water conservation goals during this stage are to reduce total water use by 50% to reduce the potential to move to Stage 4. Critical services for fire protection, household consumption, and sanitation are maintained at this stage; however, residential sprinkler irrigation is severely restricted to a 1-day a week schedule and irrigation for City Parks, golf courses, and agriculture are to be reduced by 50%. In addition, recreation (i.e., hot tubs, pools, and ponds) and commercial (i.e., car washes) outdoor water use restricted. However, during Stage 3, the Designated Officer may consult with agricultural and reclaimed water users prior to implementing water restrictions.

Stage 4 – Emergency

Stage 4 is characterized by a loss of supply because of drought, contamination, or a loss of critical infrastructure. This stage represents the condition where the upland storage volumes are at ≤60% of median available storage capacity (based on time of year) without any indication of recovery and/or, specifically for the Ellis Creek reservoirs, no water is available. The projected daily municipal water demand is to be ≥100% of treatment capacity of the WTP and FLNRORD has declared Level 4 drought conditions for the Okanagan Region. Also, Okanagan Lake levels for each of the months July through November are within Stage 4 levels summarized in Section 4.2.

During this stage, water supplies are limited to residential (indoor) use only; at the base (winter) demand rate (i.e., 12 ML/day). Water conservation goals during this stage are to reduce total water use by 90% through the elimination of residential, city parks, golf course, recreation (i.e., hot tubs, pools, and ponds), and commercial (i.e., car washes) outdoor water use. Also, under this stage the City restricts agricultural water use to livestock and for high-value perennial plants. However, during Stage 4, the Designated Officer may consult with agricultural and reclaimed water users prior to implementing water restrictions.

At this stage, fire protection services could be compromised. In addition, the City's Emergency Response Plan (Section 6) and Provincial Emergency Program would be invoked.

4.2 Okanagan Lake Drought Stage Triggers

The OBWB has an ongoing initiative to facilitate more consistent and coordinated drought planning and response in the Okanagan Basin by helping local water suppliers prepare drought plans that include a defensible decision-making framework for responding to drought conditions, particularly on the Okanagan mainstem lakes (OBWB 2019). As part of this process, the OBWB identified the need for the uniform adoption of drought stage triggers on the Okanagan mainstem lakes to help provide water suppliers and other large water users (using the mainstem lakes for supply) an understanding of their risk to water availability during times of drought.

Accordingly, OBWB (2019) produced guidelines for drought stage triggers for the Okanagan mainstem lakes using end of month lake level elevations, since current and forecasted lake level elevations are used to determine water availability. The drought stage triggers are defined for five drought stages (i.e., non-drought, stage 1, stage 2, stage 3, stage 4). However, it must be noted that the drought stage triggers have not been adopted by FLNRORD as part of the Okanagan Lake Regulation System (at this time) but are instead provided to water suppliers to consider for inclusion within DMPs for a consistent and rational processes for drought response.

Since the City relies on Okanagan Lake as a primary water source for municipal water supply, the City has included the Okanagan Lake drought stage triggers within Bylaw 2005-02 to support operational decisions for water restrictions, blending of water sources, and drought stage declarations. The Okanagan Lake drought stage triggers included by the City are modifications of those presented by OBWB (2019).

The City's modified drought stage triggers for Okanagan Lake for July to November are summarized below (and schematically presented in Figure 4-1) using the lake level elevation information included within Table 4-1 (based on hydrometric records measured by WSC 08NM083 [Okanagan Lake at Kelowna]). As the City only has four drought stages, the Non-drought and Stage 1 Okanagan Lake drought stage triggers are included within the City's drought Stage 1.

- **Non-drought** – Water suppliers would remain at their Normal stage (or no stage if they do not have a Normal stage in their bylaw) when the forecast or actual 1st of the month elevation of Okanagan Lake is equal to or greater than the 1st of the month target.
- **Stage 1** (green) – The forecast or actual 1st of the month elevation of Okanagan Lake for each of the months July through November is lower than the 1st of month target elevations and equal to or greater than the 30th percentile 1st of month elevation.
- **Stage 2** (yellow) –The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 30th percentile 1st of month elevation and greater than or equal to the 15th percentile 1st of month elevation.
- **Stage 3** (orange) – The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 15th percentile 1st of month elevation and greater than or equal to the 5th percentile 1st of month elevation.
- **Stage 4** (red) – The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 5th percentile 1st of month elevation.

Table 4-1 Okanagan Lake elevation (in metres GSC) on 1st of the month and selected statistics

Okanagan Lake Elevation Parameter	July	August	September	October	November
1st of Month Target Elevation	342.440	342.240	342.040	341.890	341.840
30th Percentile	342.286	342.170	341.968	341.808	341.715
15th Percentile	342.046	341.929	341.802	341.655	341.575
5th Percentile	341.981	341.869	341.667	341.511	341.421

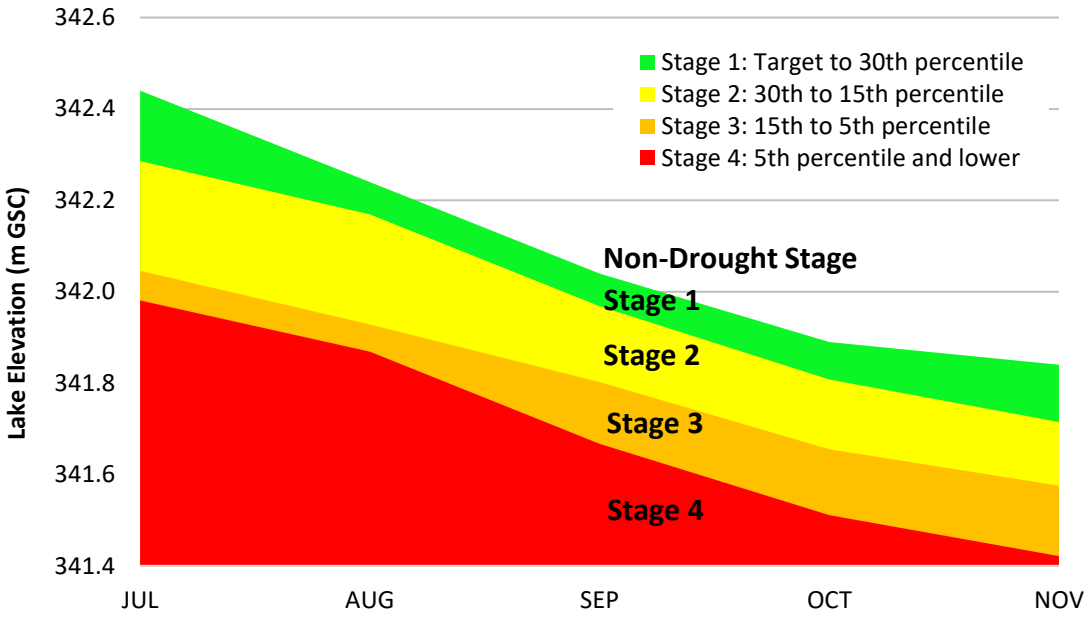

Figure 4-1Summary of drought stage triggers (based on Okanagan Lake elevations on 1st of month) for Okanagan Lake (modified from OBWB [2019] by the City)

Also, as outlined by OBWB (2019), water utilities/municipalities that use both upland and Okanagan Lake water sources (like the City) for supply purposes should have a detailed understanding of available water licensing on all water sources, and should ensure that they are flexible in their water use during times of drought. It is possible that during times of drought, upland water sources (with storage) could be used to maintain environmental flow needs within creeks (and/or other water supply needs), with the water not withdrawn until the water enters Okanagan Lake. This situation is still to be considered by the City and operational decisions would be dependent upon the severity of the drought.

4.3 Provincial Drought Levels

In striving for consistent drought response strategies across the BC, four provincial drought levels, each with specific objectives and suggested water use targets, have been established as part of the BC Drought Response Plan (MECCS 2018). The four-level drought classification system is used to determine the severity of drought conditions and the necessary steps required to avoid moving to a higher drought level and/or to move to a lower drought level. The plan also establishes triggers to identify levels of drought. The four drought levels are summarized in Table 4-2 and are declared by the Provincial Technical Drought Working Group (PTDWG).

Given that the BC Drought Response Plan relates to a regional watershed scale, it focuses on regional (watershed) triggers. Specifically, triggers are associated with regionally available information (e.g., snow water equivalent, streamflows) and are used to determine the level of drought regionally. Therefore, when provincial drought levels are in effect, they are general and not necessarily indicative of an individual water source and/or a watershed at a local scale.

Table 4-2 Summary of provincial drought levels (from MECCS 2018)

Level	Conditions	Significance	Objective
1 (Green)	Normal Conditions	There is sufficient water to meet human and ecosystem needs	Preparedness
2 (Yellow)	Dry Conditions	First indications of a potential water supply problem	Voluntary conservation
3 (Orange)	Very Dry Conditions	Potentially serious ecosystem or socio-economic impacts are possible	Voluntary conservation and restrictions
4 (Red)	Extremely Dry Conditions	Water supply insufficient to meet socio-economic and ecosystem needs	Voluntary conservation, restrictions and regulatory action as necessary

For the Penticton (and South Okanagan) region, the Thompson Okanagan Drought Response Team (TODRT) works with the PTDWG to declare drought levels for the Okanagan Basin, and conducts follow-up communications and recommends responses (as required) to local governments as outlined through the Thompson Okanagan Drought Response Implementation Plan (TODRIP) (MECCS 2018). The TODRIP is a guide for provincial staff and the TODRT to assess and respond to worsening drought conditions to help minimize the effects on both aquatic ecosystems and water users (MECCS 2018).

The provincial drought levels are determined independently of the drought stages used by the City. **The provincial drought levels provide guidance to the City on the general water supply conditions within the region, but do not directly correlate to system operations, water restrictions, or reservoir management responses**. The provincial drought levels have been included within Bylaw No. 2005-02 as triggers to support drought stage declaration but are only used as an informative tool to support drought stage decision making by the City (Section 5).

4.4 Communication Plan

The BC Drought Response Plan (MECCS 2018) highlights the importance of a well-structured and clearly defined communication strategy between key parties for effective drought preparation and response. To date, communication of drought or water shortages by the City is through public notification procedures. Once a change to drought stage has been triggered, specific public communication strategies and appropriate responses are implemented. Although not fully implemented at this time, the City is currently updating their drought management communications approach for municipal and agricultural users following the communication strategy included in Appendix C.

The City also communicates with the public on the differences between City drought stages and provincial drought levels to ensure that the public is aware of the difference between the two different types of declarations.

5 DROUGHT STAGE DECISION PROCESS AND TRIGGERS

The following section outlines the City's process for reviewing drought status, critical dates, and the decision process used to predict a potential drought and to trigger drought stage declarations. A trigger is defined as the final decision by the City to change a drought stage (as outlined within Bylaw No. 2005-02). An overview of the City's drought stage decision process and parameters used is illustrated in Figure 5-1. This overall approach is consistent with that used by the Regional District of North Okanagan for water shortage planning (i.e., Associated 2017), who depend on similar water supply sources (i.e., upland reservoirs and large mainstem lake [Kalamalka Lake]) for municipal and agricultural water needs.

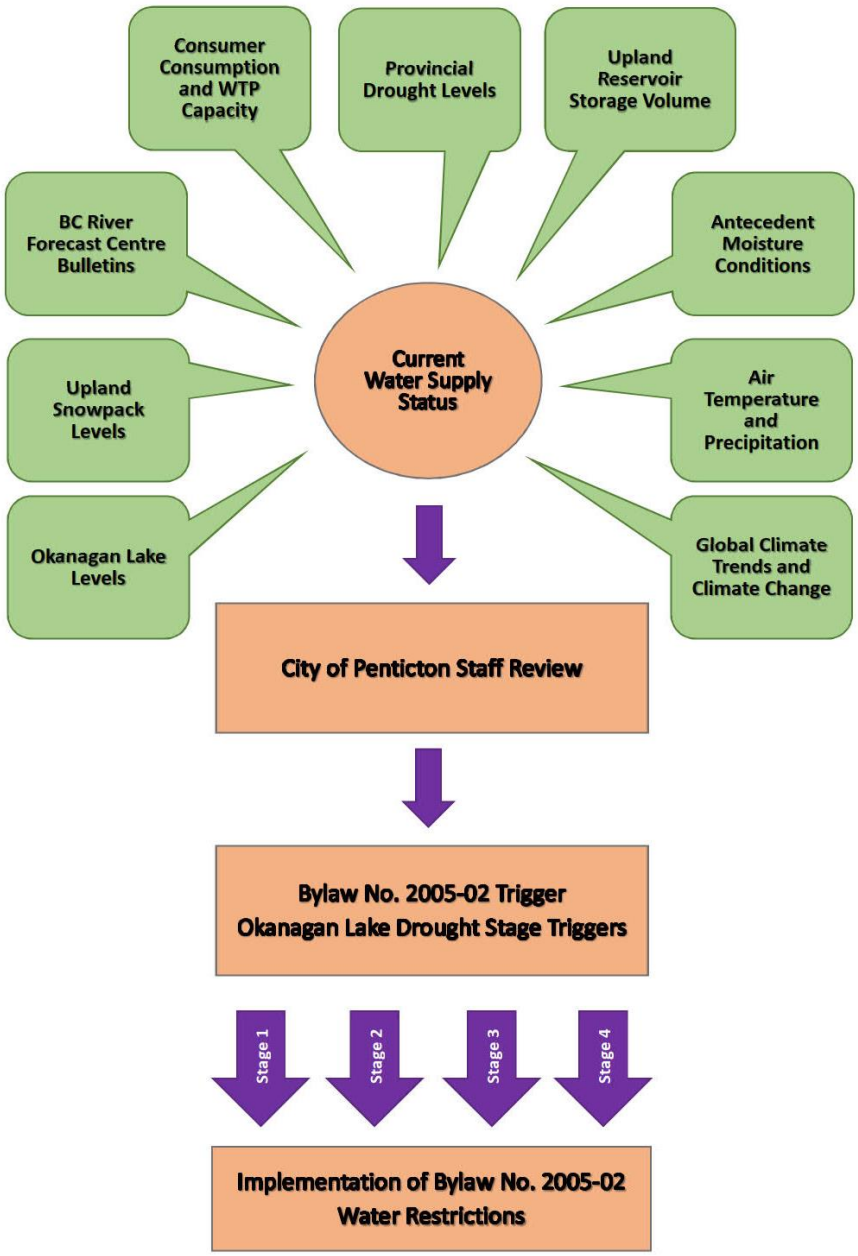

Figure 5-1City of Penticton drought stage decision process

5.1 Meetings and Critical Dates

To determine the status of water supplies, the City's Water Supply Management Team (WSMT) (Section 2.1) meets formally and informally to review the current water supply status (see Figure 5-1). The purpose of these meetings is to discuss the current state of water supplies (by water supply source and/or as a whole) and forecasted trends to develop an understanding of the potential for future shortages and to what level of severity (i.e., stage). These meetings also provide the opportunity to implement operational measures (e.g., regulating spill from the upland reservoirs to increase storage volumes) prior to the triggering (and declaration) of drought stages and associated responses.

The triggering (and declaration) of a drought stage involves complex considerations, as personal hardship, economic losses to the agricultural and industrial-commercial-institutional communities, damage to infrastructure such as parks, and lost revenue to the City may result because of the declaration. Thus, the WSMT will recommend the implementation of a stage in an informed manner with the understanding of the consequences. This includes the consequences of having to rescind a declaration within a short timeframe.

While drought forecast parameters are monitored weekly to monthly, critical decision dates are used by the WSMT to assess the year's expected water supply status as follows:

- March 15th (or as close to as possible) – decisions on this date consider the current state of storage volumes, previous fall antecedent conditions (i.e., groundwater levels), BC River Forecast Centre water supply bulletins, weather forecasts, the City's municipal water demands projected and current compared to the WTP's capacity, fishery flow (or minimum operational flow) needs, as well as the current state of the snowpack within the headwaters of Penticton Creek watershed and regionally.
- April 15th and May 15th (or as close to as possible) – decisions on this date consider the current state of storage volumes, freshet predictions, BC River Forecast Centre water supply bulletins, weather forecasts, current and projected water demands and comparisons to WTP capacities and five-year averages, fishery flow (or minimum operational flow) needs, as well as the current state of the snowpack within the headwaters of Penticton Creek watershed and regionally.
- June 15th (or as close to as possible) – decisions on this date consider the current state of storage volumes, BC River Forecast Centre water supply and snowpack bulletins, weather forecasts, provincial drought levels, as well as current and projected water demands and comparisons to WTP capacities and five-year averages, and fishery flow (or minimum operational flow) needs.
- July 15th and August 15th (or as close as possible) – decisions on this date consider the current state of storage volumes, Okanagan Lake elevation, the volume of precipitation (in the form of rain) received in the region, summer air temperatures, weather forecasts, provincial drought levels, current and projected water demands and comparisons to WTP capacities and five-year averages, fishery flow (or minimum operational flow) needs.
- September 15th and October 15th (or as close as possible) – decisions on this date consider current state of storage volumes, Okanagan Lake elevation, the volume of precipitation (in the form of rain) received in the region, late summer and fall air temperatures, weather forecasts, provincial drought levels, current and projected water demands and comparisons to WTP capacities and five-year averages, fishery flow (or minimum operational flow) needs.
- For the period October to March – the City tracks reservoir water levels and the state of the snowpack with the headwaters of Penticton Creek watershed and regionally.

Once a drought stage has been triggered, the WSMT continues to review storage volumes and other drought forecast parameters and recommend a change (or rescinding) of stage following the drought stage decision tree (Section 5.2). When a drought stage change is triggered, the Drought Response Plan (Section 6.1) is enacted by the WSMT for the respective stage.

The WSMT also engages with the DMT (Section 2.2) once a trigger (or impending declaration) has occurred to effectively communicate the drought stage status and potential future supply challenges.

5.2 Decision Tree and Stage Triggering

To support the triggering of a drought stage, a decision tree is used by the City. The decision tree is a guide for decision-makers in weighing information and understanding the potential outcomes when deciding what water shortage action(s) to undertake. The decision tree is used by the WSMT to determine the status of water supplies at any point throughout the year, on a critical decision date, or forecasted for the near future. The decision tree is provided in Figure 5-2 and was adopted from the Regional District of North Okanagan who have been using this decision tree since 2011 to support drought management decisions with the Greater Vernon Water distribution area.

Of note, the decision tree is used by the City to independently determine the water supply status of each water supply source (i.e., Penticton Creek, Ellis Creek, and Okanagan Lake). From there, the City determines if an individual source is experiencing different water supply conditions than the others. Using this approach, an individual drought stage may be declared by water supply system or for the entire City system.

The following sequence of actions are used by the City to determine water supply status (and drought stage) by water supply source (and/or as a whole system) as follows:

1. Determine reservoir storage volumes for Greyback and Ellis #2 and #4 dam reservoirs with respect to the drought stage thresholds outlined within Bylaw No. 2005-02. Also, assess Okanagan Lake elevation in reference to respective 1st of month elevation targets and drought stage triggers (Section 4.2). Assess the ability to meet fishery flow (or minimum operational flow) requirements in Penticton and Ellis Creeks.
2. Assess upland moisture conditions for the respective month/period of interest. When snowpacks are present, determine whether upland snowpack storage is above average, average, or below average, using the BC River Forecast Centre snowpillow and snow course bulletins. When snowpacks are absent (or at minimal levels), determine whether total precipitation (in the form of rain to-date) is above normal, normal, or below normal, using available real-time Environment and Climate Change Canada (ECCC) climate station records. Also, supplement snowpack and/or precipitation status by considering provincial drought levels and available real-time streamflows (from Dennis Creek [WSC 08NM242], Two Forty-One Creek [WSC 08NM241], and Two Forty Creek [WSC 08NM240]) to help track early season melt periods, summer low flow periods, and fall transition periods. In addition, observe antecedent moisture conditions measured by FLNRORD Observation Well No. 387 (Figure 3-2) as part of the Upper Penticton Creek Watershed Experiment.
3. Assess forecasted weather conditions for the respective month/period of interest. Review (or consult) the BC River Forecast Centre bulletins (and provincial drought levels) to determine whether the water supply outlooks for the Penticton area (e.g., Okanagan Lake inflows) are considered favourable or unfavourable. Also, review ECCC short-term forecasts to determine forecasted air temperatures and precipitation.
4. Assess total water demand and comparison to WTP capacity. For critical decision dates, determine whether total water consumption is 5% and/or 10% above five-year averages and what projected water demands are in comparison to WTP treated capacity. Also, consider forecasted evapotranspiration and calculated soil moisture deficit values within the local region.

Figure 5-2City of Penticton drought stage decision tree

Following Figure 5-2, the triggering of a drought stage is based on drought forecast parameter values outlined in Appendix D. A trigger is considered the point at which a drought stage change is identified (i.e., change from Stage 1 to Stage 2) following the decision tree process. A trigger is the resultant action (i.e., declaration and response measures) that is required based on the combination of all drought forecast parameters; a trigger is not specific to one forecast parameter alone (i.e., storage level). A trigger can also lead to the rescinding (i.e., moving from Stage 2 to Stage 1) of a stage declaration.

6 DROUGHT AND EMERGENCY RESPONSE PLANS

6.1 Drought Response Plan

The overall components of the City's drought stages (Section 4.1) and triggers (Section 5.2) are summarized within the drought response plan (Table 6-1). The drought response plan is the staged approach to water management during periods of drought through the identification and evaluation of factors that trigger a response.

As noted in Section 2.1, the City Manager or the City's Designated Officer is responsible for implementing all stages of the DMP, and therefore determining whether a response action is warranted. Response actions are those included within Bylaw No. 2005-02 (or as amended) that are focused on the reduction (and/or conservation) of water use during periods of drought (Appendix A). Alternatively, the City during periods of loss of supply or other emergencies, can invoke the Emergency Response Plan (Section 6.2).

The triggering (and declaration) of a drought stage is determined using a decision tree (Figure 5-2) and based on current and forecasted water supply conditions and current and projected water use. The City's decision process and associated communication plan (by stage) supporting the DMP are as described in Sections 5 and 4.4, respectively.

6.2 Emergency Response Plan

The City has developed an emergency response plan (ERP) that includes procedures to respond to a loss of water source. The ERP considers contamination of the Okanagan Lake and Penticton Creek water sources, as well as losses of Okanagan Lake raw water and treated water from the WTP. Following contamination or a loss of supply, the ERP outlines the procedures for the emergency supply of water, as well as the notification process to all water users. All other water management strategies during times of water shortages are included as part of the drought response plan (Section 6.1). The City's ERP is provided in Appendix E.

Table 6-1 City of Penticton drought response plan

Item	Drought Stage				
		1 – Normal / Dry	2 – Very Dry	3 – Extremely Dry	4 – Emergency
Explanation of Water Supply Status		Stage 1 indicates an early drought condition. It is the first indication of potential water shortage.	Stage 2 represents prolonged periods of no rain and hot and dry weather and/or with below-average snowpack conditions. This represents moderate level of drought where water supply is becoming stressed.	Stage 3 represents severe drought conditions. This occurs when water supplies are experiencing a critical shortage or short-term loss of critical infrastructure.	Stage 4 is characterized by a loss of supply via loss of upland storage or Okanagan Lake supply through drought, or due to contamination, or loss of critical infrastructure.
Goal		Reduce municipal consumption by 10%. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce municipal consumption by 20%. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce consumption by 50%. Meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.	Reduce consumption by 90%. Maintain minimum water supply to maintain community health and basic needs. As best as possible meet fishery flow (or minimum operational flow) targets in Penticton and/or Ellis Creeks.
Stage Triggers per Bylaw 2005-02		Upland storage volumes are ≥85% of available median storage capacity (based on time of year)	Upland storage volumes are 70-85% of available median storage capacity (based on time of year). Projected daily municipal water demand is estimated to be 80% of treatment capacity of the WTP and actual daily treated water demand is 5% above the five-year historic average.	Upland storage volumes are 60-70% of available median storage capacity (based on time of year). Projected daily municipal water demand is estimated to be >90% of treatment capacity of the WTP and actual daily treated water demand is 10% above the five-year historic average.	Upland storage volumes are ≤60% of available median storage capacity (based on time of year). Projected daily municipal water demand is estimated to be 100% of treatment capacity of the WTP..
Other Triggers per Decision Tree		Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.	Status of local/regional snowpacks and streamflows, current and forecasted air temperature and precipitation, and regional water supply bulletins.
Okanagan Lake Drought Stage Triggers		1st of the month elevation of Okanagan Lake is equal to or greater than the 30th percentile 1st of month elevation.	1st of month elevation of Okanagan Lake is lower than the 30th percentile 1st of month elevation and greater than or equal to the 15th percentile 1st of month elevation.	1st of month elevation of Okanagan Lake is lower than the 15th percentile 1st of month elevation and greater than or equal to the 5th percentile 1st of month elevation.	1st of month elevation of Okanagan Lake is lower than the 5th percentile 1st of month elevation.
Provincial Drought Level[1]		Level 1	Level 2	Level 3	Level 4
Regulation and Response		Three day per week sprinkler irrigation schedule for residential outdoor water use and three to five days per week watering schedule for City Parks and Golf Courses. agricultural users of the raw water supply may irrigate five to seven days per week.	Implementation of a two-day a week residential sprinkler irrigation schedule and 20% reductions in City Park, golf course, and agricultural irrigation. Designated Officer may consult with agricultural and reclaimed water users prior to implementing water restrictions.	Residential sprinkler irrigation is restricted to a 1-day a week schedule and irrigation for City Parks, golf courses, and agriculture are to be reduced by 50%. Recreation (i.e., hot tubs, pools, and ponds) and commercial (i.e., car washes) outdoor water use restricted. Designated Officer may consult with agricultural and reclaimed water users prior to implementing water restrictions.	Water supplies are limited to residential (indoor) use only; at the base (winter) demand rate (i.e., 12 ML/day). Elimination of residential, recreation (i.e., hot tubs, pools, and ponds), and commercial (i.e., car washes) outdoor water use. Agricultural water users restricted to irrigation for livestock and for high-value perennial plants only. Designated Officer may consult with agricultural and reclaimed water users prior to implementing water restrictions.
Communication		Normal and increased levels of communication and education to understand actions necessary to reduce potential to move to Stage 2. Roll out best management and conservation practices.	High level of education and communication maintained.	High level of education and communication maintained.	City's Emergency Response Plan and Provincial Emergency Program invoked. High levels of communication and education maintained.

Item	Drought Stage				
		1 – Normal / Dry	2 – Very Dry	3 – Extremely Dry	4 – Emergency
Enforcement		Enforcement and monitoring of large water users with warning issued if misuse is deemed to be occurring.	Lower tolerance for misuse and moderate fines issued.	Zero tolerance for misuse and moderate fines issued.	Zero tolerance for misuse and stiff fines issued.

Note:

2. The provincial drought levels are determined independently of the drought stages used by the City and do not directly correlate to the City's system operations, water restrictions, and reservoir management. However, the provincial drought levels are used as triggers to support drought stage declaration.

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APPENDIX A - CITY OF PENTICTON IRRIGATION, SEWER, AND WATER BYLAW NO. 2005-02

APPENDIX B - DROUGHT MANAGEMENT TEAM - TERMS OF REFERENCE

APPENDIX C - DROUGHT MANAGEMENT COMMUNICATIONS STRATEGY

APPENDIX D - DROUGHT FORECASTING PARAMETERS AND APPROACH

APPENDIX E - CITY OF PENTICTON EMERGENCY RESPONSE PLAN