SUNSHINE COAST REGIONAL DISTRICT- STAFF REPORT

TO: Planning and Community Development Committee - December 13, 2018

AUTHOR: Remko Rosenboom – General Manager, Infrastructure Services

SUBJECT: **2018 WATER DEMAND ANALYSIS**

RECOMMENDATION(S)

THAT the report titled 2018 Water Demand Analysis be received for information.

BACKGROUND

The Comprehensive Regional Water Plan (CRWP) (2013) provides the Sunshine Coast Regional District (SCRD) with overall direction on how to meet regional water sustainability goals.

The document also provides guidance for water conservation and recommendations for system expansion/improvement measures to accommodate growth as projected to the year 2036.

With respect to water supply capacity, the CRWP includes the following policy objectives:

> *The SCRD policy on source water supply (for surface water sources) is to maintain sufficient storage to meet water demands under a 1:25 year drought return period scenario.*
>
> *SCRD policy on water conservation is to reduce water demand by 33% from 2010 levels by 2020.*

The CRWP lists the following Intensive Demand Management (IDM) initiatives as the conservation measures to be implemented for the Chapman Water System:

- Implementation of Universal Water Metering;
- Mandatory Stage 2 and/or Stage 3 sprinkling restrictions from May 1 to September 30 (as per the Water Rates and Regulations Bylaw, Bylaw No. 422);
- Update water rates structure when universal metering is in place;
- Leak detection and repair in areas of high water consumption;
- New incentive programs such as irrigation controls and rainwater harvesting; and
- More education and public outreach programs as each of the above strategies are implemented.

These initiatives were anticipated to result in a 20% reduction in per capita consumption in 2036 while the CRWP's policy objective is a 33% per capita reduction.

To date no further additional conservation initiatives have been planned.

The CRWP concluded that with the full implementation of these initiatives by 2016, the water supply deficit would be approximately 0.43 Mm^3.

As a result, three water supply projects were identified to address this deficit:

- Increased supply from Chapman Lake
- Additional groundwater supply
- Development of Raw Water Reservoir

In May 2018 the Board approved the Water Sourcing Policy – Framework (Attachment A) and updated the policy objective for the water supply of the Chapman Creek System:

> *The SCRD intends to supply sufficient water at Stage 2 levels throughout the year to communities dependent on water from the Chapman Creek System.*
>
> *Emergency circumstances could result in increased Stage levels.*
>
> *If, due to emergency circumstances, the water supply for Chapman Creek is completely unavailable, the SCRD strives to have adequate alternative water supply sources available to address all essential community water demands for at least one week.*

Increased frequency and intensity of droughts on the Sunshine Coast since the adoption of the CRWP, an improved insight on the impacts of Climate Change and upcoming decisions on development of additional supply sources require an updated Water Demand Analysis (WDA).

Staff have prepared a 2018 WDA (Attachment B), which is presented in this report for information and Committee discussion.

DISCUSSION

The 2018 WDA provides a realistic outlook on the potential water supply deficit for the Chapman Creek System in the short (2025), medium (2035) and long-term (2050). This outlook can assist the Board with decision making on the development of additional water supply sources (Q1 2019) and the Water Sourcing Policy (Q2 2019).

The methodology used is based on up-to-date data and the current regulatory/policy framework.

Intensive Demand Management Initiatives

The CRWP indicates that the implementation of IDM initiatives is intended to reduce average daily per capita water consumption in 2036 by 20% compared to 2010 levels.

Table 1 provides an overview of progress on IDM initiatives as listed in the CRWP.

Table 1. Progress on Intensive Demand Management Initiatives

Initiative	Progress to date
Implementation of Universal Water Metering	Meters installed in Electoral Areas. Budget proposal for installation in District of Sechelt and shíshálh Nation is forthcoming.
Mandatory Stage 2 and/or Stage 3 sprinkling restrictions from May 1 to September 30 (as per 2012 Drought Management Plan)	Drought Management Plan has been updated several times since 2012 to increase watering restrictions.
Revise conservation-based meter rates when universal metering in place	Future decision following a fully implemented metering program and data collection.
Leak detection and repair in areas of high water consumption	Fully implemented in all Electoral Areas. Pending meter installations in District of Sechelt and SIGD.
New incentive programs such as irrigation controls and rainwater harvesting	Rainwater harvesting program launched in Fall 2018.
More education and public outreach programs as each of the above strategies are implemented	Ongoing.

The 2018 WDA includes three scenarios for the effectiveness of these water conservation initiatives: 10%, 20% and 33% per capita reduction compared to the 2010 average water consumption per capita.

A water conservation objective should be confirmed in the final Water Sourcing Policy as the effectiveness of these water conservation initiatives will have an impact on the volume of the water supply deficit.

Growth Rate

The average annual population growth rate within the area serviced by the Chapman Creek System has been 1.38% since 2011. The 2018 WDA and the CRWP are both based on an average annual growth rate of 1, 2 and 3%.

Climate Change Impacts

The WDA included in the 2013 CRWP did not account for the impacts of climate change on the Sunshine Coast water supply. The WDA in the 2013 CRWP is based on a statistical analysis of historical meteorological, watershed and water consumption data.

The 2018 WDA now includes impacts of climate change by accounting for reduced snowpack at high elevations and a less-than-historical amount of rain during late spring, summer and early fall. Given the significant changes in weather patterns due to climate change, the reliance on historical data to make predictions looking forward is not the current best practice.

In the 2018 WDA, a realistic significant drought scenario for the period between now and 2050 has been created based on a combination of actual meteorological, watershed, and water consumption data from 2015 to 2018. This is currently the best possible approach; staff will continue to monitor climate prediction models and data in this evolving area.

Environmental Flow Needs – Chapman Creek

Prior to 2016, the target environmental flow of water to be maintained in the Chapman Creek was approximately 120 litres per second.

In 2016, under the *Water Sustainability Act*, the Province implemented an Environmental Flow Needs (EFN) requirement of 200 litres per second to meet the needs of fish in the creek.

The introduction of the EFN increased the water demand by 80 litres per second, which represents a reduction of approximately three weeks of community drinking water supply (equivalent volume).

Community Water Consumption

Using results of the metering program to date, the 2018 WDA is based on reliable information about actual water consumption by residents, commercial and institutional users.

This includes data on consumption when Stage 2 water restrictions are in place.

Water Sourcing Policy Objectives

Bylaw 422 outlines the watering restrictions in place at each of the four drought management stages. The 2013 CRWP water supply policy objective allowed for all these drought management stages to be called during a drought period.

The Water Sourcing Policy - Framework policy objective restricts the calling of stages to only Stage 2 (moderate water supply condition). The water supply deficit (expressed as volume) is directly influenced by the policy objective to reduce the impact to the community during a drought situation.

Water Supply Deficit

Table 2 presents the water supply deficit as determined in the 2018 WDA for 2025, 2035 and 2050.

The deficit is presented for three levels of effectiveness of water conservation initiatives and a 2% average annual population growth within the area supplied by the Chapman Creek System.

Table 2 Water Supply Deficit Outlook (in m^3 per year)

Effectiveness of water conservation initiatives (per capita, compared to 2010)	2025	2035	2050
Service Area Population	26,000	32,000	43,000
10% reduction	2,010,000	2,830,000	4,350,000
20% reduction	1,650,000	2,390,000	3,760,000
33% reduction	1,220,000	1,820,000	2,980,000

The 2013 CRWP water supply deficit for 2036 with a 2% average annual population growth rate was estimated to be 430,000 m^3.

By comparison, the 2018 WDA water supply deficit for 2035 with the same population growth rate is estimated to be 2,390,000 m^3.

Due to the differences in methodology, data used, policy and regulatory context between the 2018 WDA and the CRWP, the calculated water supply deficits in both studies are not easy to compare.

However, the 2018 WDA is the new baseline for the volume of water required and the most appropriate source for future consideration in the context of water supply sources in early 2019.

Next Steps

In early 2019 several reports will be produced and Board decisions will be sought on future water supply projects:

- Results of Phase 2 of the Groundwater Investigation Project (January 2019)
- The feasibility study of the Raw Water Reservoir (February 2019)
- Completion of the Universal Metering Program (February 2019)

For each project, reports will include a description of the potential contributions to reducing the identified water supply deficit, capital/operational costs and potential environmental impacts.

Updates on the Provincial permitting process and the grant application for infrastructure improvements on the Chapman Lake outlet will also be brought forward.

STRATEGIC PLAN AND RELATED POLICIES

The 2018 WDA increases the ability of the SCRD to make well-informed decisions on reducing impacts of droughts and increasing the redundancy in water supply sources within the Chapman Creek water system.

CONCLUSION

Staff have prepared a 2018 WDA in response to increased frequency and intensity of droughts on the Sunshine Coast since the adoption of the CRWP and to support the Board with upcoming decisions on development of additional supply sources.

The 2018 WDA provides a realistic outlook on potential water supply deficit for the Chapman Creek System in the short (2025), medium (2035) and long-term (2050).

The 2018 WDA water supply deficit for 2035 is estimated to be 2,390,000 m^3, based on achievement of a 20% per capita conservation objective.

The purpose of the report is to provide information for future policy and financial decisions in 2019.

Reviewed by:			
Manager		Finance	
GM		Legislative	
CAO	X – J. Loveys	Other	

Attachments:

Attachment A: Water Sourcing Policy – Framework
Attachment B: 2018 Water Demand Analysis

Sunshine Coast Regional District

FRAMEWORK FOR THE DEVELOPMENT OF A WATER SOURCING POLICY

A. POLICY CONSIDERATIONS

The Comprehensive Regional Water Plan (CRWP) as approved in June 2013 includes the policy objective that:

> *The SCRD policy on source water supply (for surface water sources) is to maintain sufficient storage to meet water demands under a 1:25 year drought return period scenario.*

Combined with an increased understanding of the risks to the SCRD water supply infrastructure, staff recommend the policy objective be updated to:

> *The SCRD intends to supply sufficient water at Stage 2 levels throughout the year to communities dependent on water from the Chapman System.*
>
> *Emergency circumstances could result in increased Stage levels.*
>
> *If due to emergency circumstances the water supply for Chapman Creek is completely unavailable, the SCRD strives to have adequate alternative water supply sources available to address all essential community water demands for at least one week.*

Examples of emergency circumstance are an extremely large fire (including wildfires), an earthquake or significant failure of essential infrastructure.

B. SCOPE

There are two driving factors for the determining the extent to which the SCRD is able to meet the above presented policy: a) water demands and b) the available supply sources. The following two sections will outline both factors.

a. Supply Demand

The water supply demands for the Chapman System can be differentiated into several categories:

Average Daily Demand (ADD):	the average daily water demand of the entire system (Average 2015-2017 is 13.4 million litres per day)
Maximum Daily Demand (MDD):	the highest daily demand of the entire system within a year (Average 2015-2017 is 22.7 million litres per day)
Fire/Emergency Demand:	unpredicted high supply demands for suppression of large fires or a different type of emergency requiring a large amount of water

Chapman Creek Source Failure Supply: available water supply required to meet minimum water demand in case Chapman Creek cannot be used as main water supply source due to infrastructure failure

Environmental Flow Needs: the legally required minimum flow to be maintained in Chapman Creek at all time (currently 200 litres per second)

Each of these factors require a different strategy for water supply to be met. Where the ADD and MDD are directly linked to the daily water supply capacity, the Fire/Emergency Demand requires a very large volume of water to be available at all times for a longer period of time. The ADD and in particular the MDD would be significantly higher if the Drought Management Plan would not be fully implemented.

b. Water Supply Sources

Each of the existing and additional water supply sources currently under consideration for development differ in their ability to meet the above listed supply demands as well as in their operational characteristics.

Chapman Lake: Large watershed resulting in large inflow after rain events, increasing the lake's ability to refill during summer. Typically fully replenished after five days of heavy rain in the fall. Remotely regulated outflow infrastructure.

Edwards Lake: Small watershed resulting in limited inflow after rain event and almost no refill during summer. Remotely regulated outflow infrastructure.

Chaster Well: Daily capacity of 1 million litres could sustainably be maintained throughout the summer. Significant power costs for pumping and semi-weekly visits by operator required.

Gray Creek: As per the direction of Vancouver Coastal Health, water from this source can under normal circumstances only be provided to the Sandy Hook and Tuwanek neighborhoods resulting in a maximum daily capacity of 2 million litres. Requires daily attendance by operator.

Treated water reservoirs: The total storage capacity in all current treated water reservoirs combined is 28.8 million litres.

Raw Water Reservoir: The location of the reservoir will determine if inflow and outflow of the lake can be gravity fed or if pumping is required, which could significantly influence the operational costs. There will most likely be no refill potential after late spring. A reservoir has the potential for increased water quality issues over the course of a warm summer. Could require daily attendance by operator.

New wells: Capacity of the four wells under consideration is to be determined. Significant power costs for pumping and frequent attendance by operator required. Could require frequent attendance by operator.

C. REASON FOR POLICY

The CRWP lists four projects to increase the water supply for the Chapman System to meet the current and future community demand. These projects are:

1. Universal Metering Project
2. Chapman Lake Expansion Project
3. Expansion of Groundwater Extraction
4. Raw Water Reservoir

As of April 2018 all four projects listed in the CRWP are in some stage of development. While the Universal Metering Project is intended to reduce the water demand, the other three water initiatives are intended to increase the supply, especially during the summer period.

In April 2018, Board direction was received to develop a Water Sourcing Policy for the Chapman System. Such Water Sourcing Policy (WSP) would outline how the current and future water demand of the Chapman System would be met using the available sources. The long-term water demand will be linked to the regional growth projections.

This policy framework outlines the objectives and principles to be applied during the development and implementation of the actual Water Sourcing Policy.

The Water Sourcing Policy is targeted for early 2019 and will be done in cooperation with member municipalities and First Nations.

D. OUTLINE

a. Current Supply Strategy

Table 1 presents the current strategy to supply the different types of demands with the supply sources currently available.

The current strategy is based on the following operational principles:

- Divert water from Chapman Lake prior to doing so from Edwards Lake as Chapman Lake could refill after a summer rain event, while Edwards Lake does not.
- Activate Gray Creek and Chaster Well sources when Chapman lake levels drop such that the weir needs to be opened to maintain the required lake outflow. This currently aligns with the calling of Stage 2 watering restrictions.
- Cease diversion from Chaster Well and Gray Creek once Stage 2 restrictions are lifted.
- The siphon installed since 2017 will only be used once all outdoor water use is prohibited (Stage 4 Watering restrictions) and only when authorized under provincial permits.

Table 1 Chapman System – Current sourcing strategy

Sources / Functions	Chapman Lake natural outflow	Chapman Lake -3m	Chapman Lake Siphon	Edwards Lake	Gray Creek	Chaster Well	Water Reservoirs
Average Day Demand / Maximum Day Demand	Stage 1	Stage 2-3	Stage 4	Stage 2-4	Stage 3-4	Stage 2-4	
Environmental Flow Needs	Stage 1	Stage 2-3	Stage 4	Stage 2-4			
Fire / Emergency							X
Redundancy for Chapman Creek Flows					X	X	X

Stages as per Drought Management Plan

b. Development of additional water supply sources

As previously discussed, the CRWP includes three projects to develop additional water supply sources:

1. Chapman Lake Expansion Project
2. Expansion of Groundwater Extraction
3. Raw Water Reservoir

The timelines for the development and commissioning of these sources varies between late 2019 at the earliest and 2027. When considering the actual development of additional sources the following factors could be considered to allow for a good alignment with the Water Sourcing Policy:

- Contribution to address the community water supply demand in terms of:
    - Average Daily Demand;
    - Maximum Daily Demand;
    - Fire/Emergency Flows;
    - Chapman Creek Source Failure Supply; and,
    - Environmental Flow Needs.
- Construction costs and associated impacts to rates and fees
- Ongoing operational cost and associated impacts to rates and fees
- Sustainability of the additional supply source in terms of:
    - Direct and indirect impacts to the environment resulting from the construction and operations of these additional sources
    - Impacts to other physical interests from other parties
- Financial, legal and physical risk associated with construction and operation of these additional sources

c. Future sourcing strategy

Once additional water supply sources are developed and commissioned, the current sourcing strategy will need to be revisited and updated. The actual sourcing strategy will be dependent on the type of source (groundwater or raw water reservoir) and its capacity. The following general principles could guide any future water sourcing strategy.

Any future water sourcing strategy should:

- align with the objectives of this policy
- align with the Strategic Plan of the SCRD and other SCRD policies
- be in compliance with the provincial and federal regulatory frameworks
- be sustainable in terms of its impacts to stakeholders, member municipalities and the environment (incl. indirect impacts)
- respect the interests of the *shíshálh* and Skwxwú7mesh Nations
- allow for effective and (cost) efficient operation of the water distribution system
- maximize the degree that all current and future community water supply demands are met. These demands are defined as:
    - Average Daily Demand;
    - Maximum Daily Demand;
    - Fire/Emergency Flows;
    - Chapman Creek Source Failure Supply; and,
    - Environmental Flow Needs.

Appendix A presents a possible future water sourcing strategy if all additional water supply sources currently under consideration are developed. Such strategy will need to be updated once an additional water supply source is commissioned.

With the growing population on the Sunshine Coast, the changing demographic of that population and the changing climate, the water supply demands for the communities depending on the Sunshine Coast Regional District are constantly subject to change. As the changing climate will also impact the water supply sources itself, the supply and demand analysis for the Chapman system would have to be updated at least every five years. Based on this review, a decision would need to be made on whether to update the water sourcing strategy.

Appendix A Chapman System – Possible future approach – all potential source developed

Sources / Functions	Chapman Lake natural outflow	Chapman Lake -3m	Chapman Lake -8m	Edwards Lake	Gray Creek	Chaster Well	Groundwater Wells - New	Raw Water Reservoir	Treated Water Reservoirs
Average Day Demand / Maximum Day Demand	Stage 1	Stage 2-3 (3)		Stage 3-4 (1)	Stage 3-4 (1)	Stage 2-4 (1)	Stage 2-4 (1)	Stage 2-3 (2)	
Environmental Flow Needs	Stage 1	Stage 2-3 (2)	Stage 4 (1)					Stage 2-3 (1)	
Fire / Emergency									X
Redundancy for Chapman Creek Flows					X	X	X	X	X

Stages as per Drought Management Plan
(1,2) Order in which supply sources to be operational

Attachment B

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6 December 2018
VP18-SCR-01-00-LET-WW-WaterDemandAnalysis_Rev2

Remko Rosenboom
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1975 Field Road
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Dear Sir:

RE: Water Demand Analysis

1 INTRODUCTION

Integrated Sustainability has been retained by the Sunshine Coast Regional District (SCRD) to complete a feasibility study to support development of a raw water reservoir to supplement supply to the existing Chapman Water System (the Project). The Chapman Water System is located along a narrow, coastal portion of the Sunshine Coast region within southwestern British Columbia (BC).

The SCRD has identified a need for additional water supply within the Chapman Water System to meet the current and future potable water demands, as well as flow requirements in the lower reaches of Chapman Creek. To meet these needs, the SCRD has proposed that a raw water storage reservoir be developed to supplement the existing water supply. The SCRD has proposed to use the following approach:

- Diversion of water from Chapman Creek to a raw water reservoir (for storage) during periods of high precipitation and high creek flow
- Supply of water from the raw water reservoir to the Chapman Creek Water Treatment Plant (WTP) during periods of low precipitation to meet domestic potable water demands as well as to maintain minimum environmental downstream flow requirements in Chapman Creek

Integrated Sustainability's scope of work for the Project includes carrying out a community water demand analysis, technical review of potential reservoir locations based on a desktop analysis using available information, visual field assessments at the top ranked sites, consultation with the SCRD and local stakeholders, regulatory review, detailed multi-criteria evaluation of reservoir options, and conceptual design for a select number of reservoir locations.

This Water Demand Analysis is specifically focused on the data analysis and calculations conducted by Integrated Sustainability to review and analyze historic community water demands and water supply characteristics, project future water demands, consider potential changes in water supply due to climate change, and estimate the required storage volumes to meet current and future water demands.

2 BACKGROUND

The SCRD supplies water to residents and businesses along the sunshine coast within three water service areas, including: The Regional Water Service Area (RWSA), North Pender Harbour Water Service Area, and South Pender Harbour Water Service Area (Opus DaytonKnight, 2013). The Chapman Water System is the primary water system in the RWSA.

Chapman Creek conveys water from Chapman Lake and Edwards Lake, and is the primary water source for the Chapman Creek Water Treatment Plant (WTP) and water system. Additional water sources include Gray Creek and the Chaster Well, which are only used when required. The SCRD holds waterworks and water storage licenses on Chapman Creek, which allow for specified daily and annual withdrawal volumes (Opus DaytonKnight, 2013). Water is currently conveyed from Chapman Creek to the Chapman Creek WTP via an intake in Chapman Creek and a pipeline. In 2017, a specified minimum environmental streamflow was implemented for Chapman Creek, which stipulates that a minimum flow of 200 L/s (17,280 m^3/day) must be maintained in the lower reaches of Chapman Creek (SCRD, 2018b). The point at which this flow is measured is located directly below the intake.

A Comprehensive Regional Water Plan (CRWP) was prepared in 2013 to provide direction for the SCRD to meet regional sustainability goals, guidance for water conservation, and recommendations for system expansion/improvement measures to accommodate growth projections identified to the year 2036 (Opus DaytonKnight, 2013). Demand calculations were based on the SCRD initiative to reduce water demand by 33% from 2010 levels by 2020. Water demand was calculated based on an existing demand management (EDM) scenario and an intensive demand management scenario (IDM). Included in the CRWP are recommendations for expansion of Chapman Lake, additional production wells, and a raw water reservoir to store water from Chapman Creek to supplement the potable water supply during periods with low precipitation. All water system infrastructure upgrade and expansion recommendations to meet year 2036 water demands were analyzed and costed under conditions of both EDM and IDM. The objectives for additional water storage were based on the SCRD policy on source water supply to maintain sufficient storage to meet water demands under a 1:25 year drought return period scenario. The storage volumes recommended in the CRWP report for a water storage reservoir to meet the 1:25 year drought condition for the projected year 2036 water demand under the IDM and EDM scenarios were 430,000 m^3 and 760,000 m^3, respectively. The recommendations were based on the existing water sources, current and projected water demands, and downstream flow requirements for Chapman Creek. At the time the CRWP was prepared, the Department of Fisheries and Oceans Canada's (DFO's) requested that a minimum flow of 24.5 ML/d (24,500 m^3/day) is maintained in lower Chapman Creek to provide adequate conditions for the fish hatchery operated by the Sunshine Coast Salmonid Enhancement Society, who also hold water licenses to withdraw water from Chapman Creek.

In July 2017, the Ministry of Forests, Lands, and Natural Resource Operations (FLNRO, 2017), issued an Order pursuant to Section 93 of the Water Sustainability Act, requiring the SCRD to "release an adequate volume of water from Chapman Lake to ensure a minimum flow of 200 L/s (17,280 m^3/d) in Chapman Creek, just downstream of SCRD's Water License intake structure".

In 2018, the SCRD developed a Framework for the Development of a Water Sourcing Policy (SCRD, 2018a), which outlines the policy considerations, water demands (based on the CRWP), existing and potential (additional) water sources, and an outline for the current supply strategy and strategy for development of additional supply sources. The proposed additional supply sources include three projects, one of which is this assessment of raw water reservoir options.

3 PURPOSE AND SCOPE

This report provides a summary of the water demand analysis conducted, based on historical raw water supply, potable water demand, and population census data to estimate future water demands, water storage characteristics, and the overall supply deficit for the Chapman Water System. The analysis was conducted for various population growth and water consumption scenarios as described in Section 4 - Methodology.

The water demand analysis scope of work included the following tasks:

- Review of available relevant documents and data, including the following:
  - CRWP Report (Opus DaytonKnight, 2013)
  - Framework for the Development of a Water Sourcing Policy (SCRD, 2018a)
  - Data provided by the SCRD pertaining to water license information, population statistics, water supply and consumption data, and residential and commercial water metering record summaries (SCRD, 2018b, 2018c, and 2018d)
- Meeting with the SCRD to review and confirm the basis to be used for the analysis
- Preparation of this report, which is comprised of the following:
  - Key water consumption characteristics based on an analysis of historical data
  - Key assumptions used as a basis for the water demand model scenarios
  - Water demand analysis results and discussion, including presentation of raw water storage requirements to meet projected deficits between existing water supply sources and water demand for years 2025, 2035, and 2050.

4 METHODOLOGY

The methodology used for the analysis was divided into the following models:

1) Analyze the past and present water demands, and determine future demands for a typical year, to produce the Typical Demand Model. This scenario has been modelled to check if the existing water licence and water treatment capacity are exceeded during typical summer conditions. The water demand results from this model have not been used for reservoir sizing but can be used in operational forecasting. Refer to Section 5.1.4 for information on the Typical Demand Model.
2) Analyze the water demands over the last seven years (2012 to 2018), four of which have included Stage 4 drought conditions, and determine the water demand model for a drought year, which is defined as the Drought Demand Model. The water demand results from this model have been used to determine the future water demand based on a set of assumptions defined by the SCRD. Refer to Section 5.1.5 for information on the Drought Demand Model.
3) Analyze the past and present water supply data, and determine the future supply scenarios, which is defined as the Drought Supply Model.
4) Determine the Supply Deficit, which is defined as the difference between demand and supply and is used to determine target volumes from the raw water reservoir or other secondary supply sources. For the purpose of reservoir sizing we have assumed there are no other supply sources, other than Chapman Lake, Edwards lake, and Chaster well.
5) The available water supply does not change with time; however, the water demand increases with population and decreases with demand management measures. The Drought Demand Model was applied to the serviced population in years 2025, 2035, and 2050, to calculate the Supply Deficit for those years.

Given the large number of variables considered at different stages of the analysis, there are many combinations of outcomes. To simplify the calculations, at each stage of model development where there are several scenarios considered (e.g. different population growth rates), a recommended value will be selected for use in the next stage of the model.

5 BASIS OF ANALYSIS

5.1 Water Demand Models

Development of the Water Demand Models was comprised of the following:

1) Review of historical census population statistics and development of the population growth model.
2) Review of historical water demands (winter, summer, peak month, peak day) to develop the demand model.

3) Combination of population and water demand to get the historical per capita demand model.
4) Review of demand management statistics and targets.
5) Production of a Typical Water Demand model for years 2025, 2035, and 2050.
6) Production of a Drought Demand Model specifically for the case of a dry year where Stage 2 water restrictions are imposed for all of the summer, from May through September.
7) Incorporation of the environmental flow requirements (SCRD, 2018) in the Drought Demand Model.

5.1.1 Population Model

Objective

To establish a representative population model to project future population growth for the Chapman Water System.

Issue

The existing population 2013 CRWP (Opus DaytonKnight, 2013) population model did not include consideration for the 2016 Census data and assumed all of electoral Area F was on the Chapman Water System, except for portions on other small systems (e.g. Soames, Granthams, Langdale, Eastbourne). Further, the 2013 calculation of occupants per dwelling was based on the entire Sunshine Coast, not just the areas within the Chapman Water System.

Resolution

A population model was developed using the Census data for the period of 2006 to 2016 for the major Chapman Water System areas, including the District of Sechelt (Sechelt), Sechelt Indian Government District (SIGD), and Areas B, D and E. Area F was excluded as the Chapman Water System only supplies water to a small number of properties in Area F. The few number of properties in Area F that are served by the Chapman Water System is offset by a similar number of properties within Areas B, D and E that rely on groundwater wells, and are not connected to the Chapman Water System.

Results

The Census population data for years 2001, 2006, 2011, and 2016 (BC Stats online database), shown in Table A, was used to estimate the 2017 and 2018 population.

While the population growth varied between census years, overall, there was an average 1.41 percent growth per year between 2001 and 2016. The estimated 2017 population of 22,486 was rounded up to 22,500 and used to estimate future populations based on growth rates of 1%, 2%, and 3%, as summarized in Table B. The 2013 CRWP report used a projected growth rate of 2%, and in consultation with SCRD staff, we have adopted 2% as the base case for the water demand models in this study.

Table A. Census Population for Areas within Chapman Water System (Source: BC Stats)

Year	2001	2006	2011	2016	2017	2018
Sechelt	7,343	8,454	9,291	10,216	10,360	10,676
SIGD	764	847	797	671	680	690
Gibsons Zone 3	1,104	1,182	1,325	1,475	1,496	1,533
Halfmoon Bay	2,353	2,558	2,675	2,726	2,764	2,780
Roberts Creek	3,090	3,307	3,244	3,421	3,469	3,468
Elphinstone	3,311	3,552	3,482	3,664	3,716	3,689
Total	**17,965**	**19,900**	**20,814**	**22,173**	**22,486**	**22,836**
Annual Growth (%)	-	2.08	0.90	1.27	**1.41***	**1.41***
2013 CRWP	19,277	20,889	21,722	-		-

Notes:

1. The population growth between 2001 and 2016 was 1.41% per year.

Table B. Projected Populations for Areas within Chapman Water System

Year	Growth Rates		
	1%	2%	3%
2017	22,500	22,500	22,500
2020	23,250	23,700	24,190
2025	24,445	26,190	28,041
2035	27,000	31,930	37,685
2050	31,350	42,970	58,712

The Census data (BC Stats) shown in Table C illustrates the number of people per dwelling has consistently decreased between 2006-2011, and 2011-2016 census periods. Increased numbers of apartments and condominiums, seasonally occupied dwellings, and an aging population are factors contributing to the lower dwelling occupancy statistics.

Table C. Dwelling Occupancy for Areas within Chapman Water System

Year		Sechelt	SIGD	Gibsons	Halfmoon Bay	Roberts Creek	Elphin-stone	Total
2006	Population	8,454	847	1,182	2,558	3,307	3,552	19,900
	Occupied Dwellings	3,853	350	532	1,118	1,356	1,412	8,621
	People/ Dwelling	2.19	2.42	2.22	2.29	2.44	2.52	2.31
2011	Population	9,291	797	1,325	2,675	3,244	3,482	20,814
	Occupied Dwellings	4,296	355	602	1,167	1,366	1,433	9,219
	People/ Dwelling	2.16	2.25	2.20	2.29	2.37	2.43	2.26
2016	Population	10,216	671	1475	2,726	3,421	3,664	22,173
	Occupied Dwellings	4,855	292	713	1,247	1,508	1,549	10,164
	People/ Dwelling	2.10	2.30	2.07	2.19	2.27	2.37	2.18
2018	Population	10,676	690	1,533	2,780	3,468	3,689	22,836
	Occupied Dwellings	5,085	292	756	1,275	1,516	1,578	10,502
	People/ Dwelling	2.10	2.36	2.04	2.18	2.29	2.34	2.17

The SCRD water billing system indicates 10,384 dwellings were connected to the water distribution system. This is reasonably close to the estimated number of occupied dwellings within the Chapman Water System of 10,502 noted in Table C.

The critical time of year for the demand analysis is the summer, when there is an increased water demand due to a seasonal influx of residents and tourists, as well as irrigation. As there is no data available on the number of seasonal residents or tourists, the Census population and system water records have been used as the basis for estimating the per-capita demands.

Demand Projection Implications

For modelling purposes, the following has been taken into consideration regarding population growth:

- The study population projections are based on the historic Census data for Sechelt, SIGD, Areas B, D and E, and Gibsons Zone 3, excluding Area F.
- A population growth rate of 2% has been selected, resulting in an estimated population of roughly 26,000 for 2025, 32,000 for 2035, and 43,000 for 2050.
- The Town of Gibsons Zone 3 is estimated to be responsible for approximately 6% of the summertime water demand.
- Once Zone 3 is supplied with water from the Town of Gibsons, it may still need servicing for fire flows, which would have an impact on the maximum day demand but not the monthly or daily demand for the Chapman system.
- While the data suggests the number of occupants per dwelling has been declining over the past ten years, as a conservative measure, this observation was not taken into consideration in the population model developed for this study. The model is based only on Census populations, and not the number of dwellings or the number of SCRD residential customers.

5.1.2 Historical Water Use

Objective

To determine the historical patterns of water-use statistics (e.g. average and maximum daily demand).

Issue

The water supply data provided by the SCRD for 2003 through 2017 indicate the peak water demands appear to be decreasing. This reduction could be due to a number of factors including water conservation efforts and/or water restrictions that have been imposed since 2012. While most of the commercial customers are metered, only the electoral area residential customers are presently metered.

Resolution

The system water treatment data from October through April was used to calculate a "Winter Average Daily Demand" (WADD) statistics shown in Table D, representing indoor water uses exclusive of irrigation demands.

Table D.Demand Characteristics (2003-2018)

Year	AADD (m^3/day)	WADD (m^3/day)	SADD (m^3/day)	MMDD (m^3/day)	MDD (m^3/day)	MWDD (m^3/day)
2003	13,390	10,026	18,099	22,581	25,833	-
2004	13,728	10,819	17,801	23,833	26,519	-
2005	13,316	10,888	16,715	22,846	26,646	-
2006	14,156	10,970	18,618	22,684	26,616	-
2007	13,130	10,968	16,157	19,711	26,652	-
2008	13,986	11,170	17,929	23,142	27,108	-
2009	14,521	11,561	18,666	23,628	28,543	-
2010	13,817	11,151	17,550	23,883	28,188	-
2011	12,849	10,411	16,262	21,168	23,848	-
2012	12,823	9,883	16,938	22,919	25,780	-
2013	13,096	10,598	16,594	22,922	25,980	-
2014	13,848	11,074	17,731	21,513	25,056	23,606
2015	12,884	11,081	15,409	19,946	25,056	21,261
2016	14,086	12,008	16,996	18,959	22,550	21,113
2017	13,106	10,793	16,345	20,274	21,427	21,243
2018	-	-	15,958	19,266	22,800	21,498

Where: AADD = Average Annual Daily Demand

SADD = Summer Average Daily Demand (May – September)

WADD = Winter Average Daily Demand (October – April)

MMDD = Maximum Month Daily Demand

MDD = Maximum Day Demand

MWDD = Maximum Week Daily Demand

Total water consumption data for June through September was used to calculate the "Summer Average Daily Demand" (SADD). The difference between the SADD and WADD is due to a combination of the summer irrigation demand and the additional population demand associated with seasonal dwelling occupancy and tourists.

The lack of complete residential and commercial metering means that the WADD and SADD both include industrial, commercial and institutional water uses.

Results

The historical maximum and average demand characteristics for the Chapman Water System are illustrated in Figures A and B. Figure A illustrates the daily average and maximum demand characteristics, and Figure B illustrates the same demand statistic, but normalized on a per capita basis.

The following are some observations regarding the demand characteristics shown in the two figures and summarized in Table D:

- Although the population has increased by about 20% over the last 15 years, the AADD has remained unchanged over that period at about 13,500 m^3/day and is substantially less than the SCRD's Chapman Creek water license average daily water withdrawal limit of 20,500 m^3/day.
- The WADD, while remaining relatively constant, show some indication of being affected by the increase in population, with the average WADD for 2015-2017 of 11,300 m^3/day being 7 percent greater than the average WADD for 2003-2005 of 10,600 m^3/day.
- The SADD values, like the MMDD and MDD values, show evidence of being affected by summer water use restrictions. While the SADD is generally unchanged over the period of 2003-2014, the average SADD for 2015-2017 of 16,200 m^3/day is 8 percent lower than the average SADD for 2003-2005 of 17,500 m^3/day.
- The MMDD also shows little change between 2003 and 2015, but the average MMDD for 2015-2017 of 19,500 m^3/day is 16 percent less than the average MMDD for 2003-2005 of 23,100 m^3/day.
- The MDD is relatively constant from 2003 through 2015, with the highest MDD of 28,000 m^3/day occurring in 2009 and has since been declining to 21,500 m^3/day in 2017, which is substantially less than the SCRD's Chapman Creek water license maximum daily withdrawal limit of 33,300 m^3/day. The average MDD for 2015-2017 of 22,300 m^3/day is 15 percent less than the average MDD for 2003-2005 of 26,300 m^3/day.
- The ratio between the MDD and MMDD between 2001 and 2017 ranged between 109 to 126 percent, averaging approximately 120 percent over that period.
- Although there is a modest amount of reduction indicated in the SADD, MMDD and MDD demand characteristics, with relatively recent indications of a decrease in those values, when normalized as a per capita demand characteristic, as illustrated in Figure B, it is clear there has been a significant, continuous and generally linear reduction in all of the per capita demand statistics over the past 15 years.

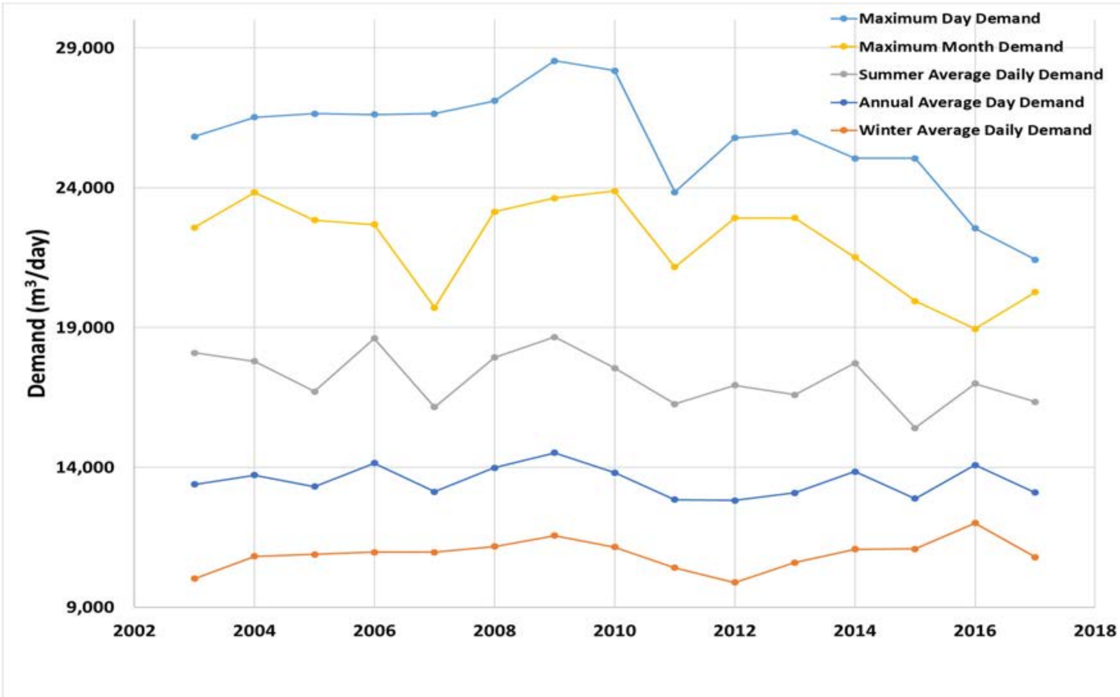

Figure A. Maximum and Average Daily Demand Characteristics (2003-2017)

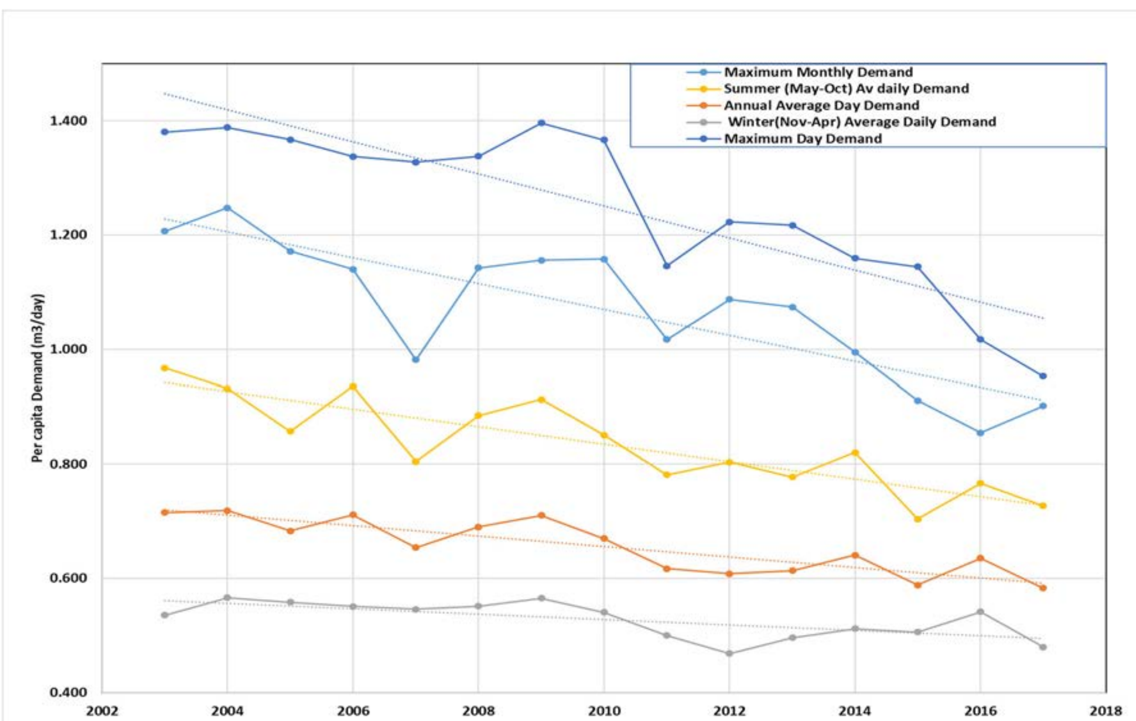

Figure B. Per Capita Maximum and Average Daily Demand Characteristics

5.1.3 Per Capita Water Use and Water Demand Management

Objective

Determine the per capita water demand management scenarios to evaluate the success and remaining potential for demand management, and use this for water demand forecasting to 2025, 2035, and 2050.

The SCRD's 2013 Comprehensive Regional Water Plan (Opus Dayton Knight, 2013) set a target to reduce the per capita AADD by 33% from 2010 levels, by 2020. A 33% target is also referenced in the Community's We Envision Plan (2010). These reductions are both in keeping with a 2008 Provincial goal that "By 2020, water use in B.C. will be 33 percent more efficient." (BC Government 2008).

Issue

In the absence of universal metering, only the overall total water can be measured, and per capita use can be calculated. There is no data available to be able to estimate the net residential per capita water use.

Resolution

The AADD, MMDD, and MDD capita water demand characteristics incorporates permanent and seasonal residential occupancy uses, commercial uses, and outdoor uses (mainly irrigation). These are assumed to change in proportion with the population.

Results

Table E presents the 2010 and 2017 per capita water demands for comparison. The data shows that there has been a steady decrease in all of the per capita demand characteristics, including a reduction in the AADD of 13% since 2010. The most significant reductions were in the SADD, MMDD and MDD values which decreased by 15, 22, and 27 percent, respectively. As previously noted, the summer and maximum month and day demands are significantly affected by water use restrictions that limit irrigation. The WADD represents winter demand patterns which are not impacted by irrigation or summer water use restrictions. The reduction in WADD is likely due to the adoption of water conservation practices, potentially including those adopted as a result of summer water use restrictions.

Table E. Change in Per Capita Water Demand Characteristics for the Chapman Water System (2010 – 2017)

	2010	2017	Change (%)
POP	20,628	22,486	9
AADD	0.67	0.58	-13

	2010	2017	Change (%)
WADD	0.54	0.50	-11
SADD	0.85	0.73	-15
MMDD	1.16	0.90	-22
MWDD	1.27	1.00	-22
MDD	1.37	1.00	-27

All values in the table, except Population and % Change, are per capita water demand (m3/day per capita)

Table F below provides a summary of the reductions achieved each year between 2010 and 2017, showing progress to reach the 2020 target of 33% reduction. It can be seen that 2017 has a large reduction in demand (13%) when compared to 2010, however the demand reduction in 2016 was small (4%).

To provide a range of future water demand, three demand management scenarios have been considered in the demand model, as shown in Table G below, which are: 10% (i.e. minimal reduction), 20% (moderate), and 33% (high).

Table F. Summary of Progress Towards CRWP Year 2020 Target

Year	Population Model	Annual Average Day Demand (AADD) (m^3/capita/day)	Reduction From 2010 (%)	Maximum Month Daily Demand (MMDD) (m^3/cap/day)	Reduction from 2010 (%)
2010	**20,639**	**0.67**	**0**	**1.16**	**0**
2011	20,814	0.62	7	1.02	12
2012	21,090	0.61	9	1.09	7
2013	21,357	0.61	9	1.07	8
2014	21,629	0.64	4	0.99	14
2015	21,903	0.59	12	0.91	22
2016	22,173	0.64	4	0.85	27
2017	22,500	0.58	13	0.90	21

Year	Population Model	Annual Average Day Demand (AADD) (m^3/capita/day)	Reduction From 2010 (%)	Maximum Month Daily Demand (MMDD) (m^3/cap/day)	Reduction from 2010 (%)
2020 (target year)	23,500	0.45	33	No specific target	

Table G. Summary of Demand Management Scenarios

Year	AADD (m^3/c/d)	Reduction from 2010 (%)	MMDD (m^3/c/d)	Reduction from 2010 (%)	MMDD/ AADD (%)
2010	0.67	0	1.16	0	173
2017	0.58	13	0.90	21	155
Minimal Demand Reduction (10%)	0.60	**10**	0.90	21	150
Moderate Demand Reduction (20%)	0.54	**20**	0.8	31	148
High Demand Reduction (33%)	0.45	**33**	0.68	41	151

Demand Projection Implications

- A ratio of MDD to MMDD of 120% will be used for demand modelling purposes,
- A ratio of maximum weekly demand (MWD) to MMDD of 110%, will be used for demand modelling purposes regardless of demand management scenarios. The MWD is used for determining treatment capacity requirements.
- The ratio of MMDD to AADD is expected to vary with demand management scenarios. Most demand management is achieved in the summer months, which lowers the MMDD, and the more demand management that is achieved, the lower the ratio of MMDD to AADD.
- For modelling purposes, it is assumed that all demand reductions in the respective scenarios are achieved by the year 2025, and that per capita water use remains unchanged from then on.

5.1.4 Typical Demand Model

Objective

Use all the parameters that have been developed to produce a quantified model for forecasting future demand in typical weather conditions. This model has been developed to check if the water licence or water treatment capacity will be exceeded in future years during typical conditions.

Issue

This model assumes the weather conditions over the last decade will continue, with a reasonable snow pack and occasional heavy summer rains that replenish water storage locations. It would typically represent an entire season at Stage 1 water restrictions, or potentially short periods at higher levels. It is not intended to represent worst case drought or climate change conditions, where supply and demand may be different.

Resolution

Assumptions for the Typical Demand Model:

- Annual population growth rate of 2%
- Gibsons Zone 3 is included, and represents 6% of the total water demand
- Chapman Creek water license limit is 20,500 m^3/day
- Chapman Creek water license limit for daily withdrawal is 33,300 m^3/day
- Chapman WTP capacity is 25,000 m^3/day based on MWDD.
- The Chapman WTP expansion will increase capacity by 50% to 37,500 m^3/day
- All water sourcing is via the Chapman WTP.
- Chaster Well is not included as the Typical Demand model assumes the summer is in Stage 1 water restrictions, in which case the Chaster Well is not used.
- Assumes that no alternative water sources are being developed, such as additional groundwater supply wells.
- All water demand reductions achieved via demand management are achieved by year 2025
- MDD is 120% of MMDD
- MWDD is 110% of MMDD

Results

The Typical Demand Model results summary is provided in Table H.

- For the 10% demand reduction scenario (essentially status-quo for 2017) the following water demand model observations are made :

- – The Chapman Water license limit for maximum daily withdrawal of 33,300 m³/day will be exceeded by about 2030.
- – The license limit for annual average daily withdrawal of 20,500 m³/d will be exceed sometime shortly after 2035.

- For the 20% demand reduction scenario, the following water demand model observations are made:
  - – The Chapman Water license limit for maximum daily withdrawal of 33,300 m³/day will be exceeded by about 2030.
  - – The license limit for annual average daily withdrawal of 20,500 m³/d will be exceeded around 2040.
- For the 33% demand reduction scenario, the following water demand model observations are made:
  - The Chapman Water license limit for maximum daily withdrawal of 33,300 m³/day will be exceeded by about 2040.
  - The license limit for annual average daily withdrawal of 20,500 m³/d will not be exceed before 2050.

The model illustrates the clear benefits of demand reductions by staying within water license limits.

Table H. Demand Model Results Summary (results in m³/day)

Water Demand Reduction from 2010	Year	2010	2017	2020	2025	2035	2050
	Pop.	20,640	22,500	23,700	26,160	31,900	42,930
10%	AADD	13,829	13,050	14,220	15,696	19,140	**25,758**
	WADD	11,166	11,250	11,613	12,818	15,631	**21,036**
	SADD	17,565	16,425	18,249	20,143	**24,563**	**33,056**
	MMDD	23,901	20,250	24,648	27,206	33,176	**44,647**
	MWDD	26,295	22,500	27,174	29,995	**36,577**	**49,224**
	MDD	28,194	22,500	29,151	32,177	**39,237**	**52,804**
20%	AADD	13,829	13,050	12,798	14,126	17,226	**23,182**
	WADD	11,166	11,250	10,191	11,249	13,717	18,460
	SADD	17,565	16,425	16,116	17,789	**21,692**	**29,192**
	MMDD	23,901	20,250	22,041	24,329	29,667	**39,925**

Water Demand Reduction from 2010	Year	2010	2017	2020	2025	2035	2050
	Pop.	20,640	22,500	23,700	26,160	31,900	42,930
	MWDD	26,295	22,500	24,155	26,662	32,512	**43,754**
	MDD	28,194	22,500	25,833	28,514	**34,771**	**46,794**
33%	AADD	13,829	13,050	10,665	11,772	14,355	19,319
	WADD	11,166	11,250	8,532	9,418	11,484	15,455
	SADD	17,565	16,425	13,509	14,911	18,183	**24,470**
	MMDD	23,901	20,250	18,486	20,405	24,882	**33,485**
	MWDD	26,295	22,500	20,230	22,330	27,229	**36,644**
	MDD	28,194	22,500	21,804	24,067	29,348	**39,496**

Notes: ***BOLD BLACK*** *– value exceeds average daily limit of 20,500 m^3/d*
BOLD RED *– value exceed maximum daily limit of 33,300 m^3/d*

5.2 Drought Demand Model

The purpose of a specific Drought Demand model (compared to the Typical Demand model of Section 5.1) is in response the fact that a "Drought" – a prolonged period of sunny, dry weather with minimal rain, creates a higher daily water demand, for a longer period, than a typical year.

To create a Drought Demand model requires establishing the conditions of a "model drought year". We have considered the case of extended drought conditions, with low snowpack, early snowmelt, and no significant summer recharge of storage. The supply objective is to keep the community at no worse than Stage 2 restrictions all summer long. The Drought Demand Model can then be compared with a Drought Supply Model, which will show the resulting Supply Deficit, that needs to be met by the Raw Water Reservoir. For the purpose of this model, we have assumed there are no other water supply sources other than Chapman and Edwards Lakes and Chaster well.

There are several components of the Drought Demand Model that need special attention:

- The length of the drought, the period in which there is no substantial rainfall, and also the period where the stored water is needed to supply the combined needs of both the SCRD water system and environmental flows in lower Chapman Creek.

- The actual customer water demand while in Stage 2 restrictions. This demand will vary by month, as outdoor water use ramps up in May and June, levels out in July and August, and decreases in September and October.

5.2.1 The Drought Period

Objective

Determine the length of time for the modelled drought period

Issue

An unresolved issue is the length of the drought to be modelled – how long should it be, and how should it compare to historical droughts? There has been an early drought in 2015, and a late one 2017, in each case being about a 90 to 100 day period of Stage-2, Stage-3 and Stage-4 restrictions. But there has not yet been a drought lasting throughout summer, that starts early and finishes late.

Figure C presents the minimum, average and maximum monthly precipitation over a ten-year period (2009 – 2018), illustrating that while the months of July and August consistently have the lowest precipitation, that extended periods of dry weather can occur from the months of April through October, inclusive.

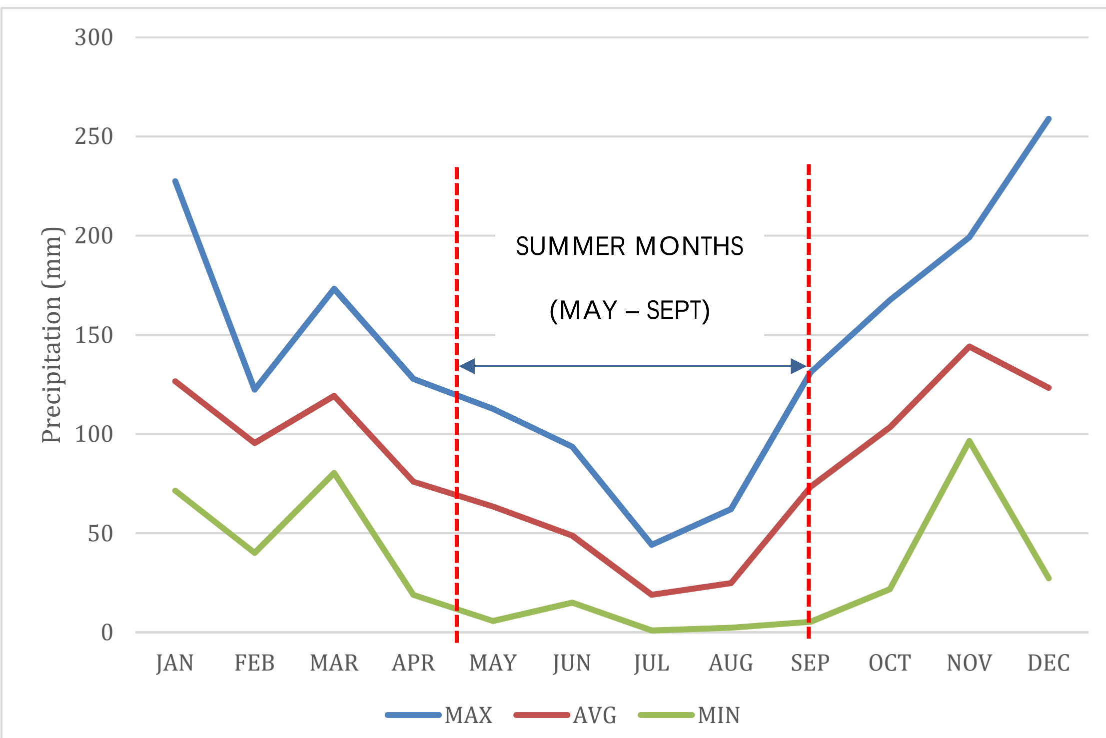

Figure C. Monthly Precipitation Min/Avg/Max for 2009-2018

Resolution

The selected methodology for the modelled drought period is to overlay the droughts of recent years, to create a blended drought, that would start early and finish late, at the earliest and latest observed dates. This is an alternative to the normal hydrology approach of using a 1:25 year drought. There have been two major droughts in the last four years (2015 and 2017), and the accuracy of return intervals has become questionable. This alternative approach allows good use of the data on hand, to see how a system can ride out the same droughts again, and the worst-case blended scenario. The Drought Period has two parts:

- The Dry Period, when there is ample sunshine and no rainfall events that cause significant recharge. This marks the beginning of the high-altitude snowmelt – the freshet. Chapman Creek stream flows are high during this period, and the sunny weather brings on outdoor water use for irrigation. The Dry Period ends when the fall rains arrive, and the storages are recharged. The earliest observed onset of the Dry period is mid-April, and the latest end is mid-October.
- The Stage 2 Restrictions Period, when customers are asked to reduce their outdoor water use. For the purposes of the Drought Demand Model, the Stage 2 period is deemed to begin when stored water from Chapman Lake is first accessed and ends when it first refills completely from rainfall.

Results

The historical dates for the begin and end of the storage periods are shown in Table I.

Note that these do not match exactly with the calling or relieving of Stage 2 restrictions, they are when Chapman lake stops overflowing, and when it first overflows again. It is obvious that droughts have spanned the entire summer period over the last six years. The SCRD has reported that in 2018 the Dry Period began in mid April, two weeks earlier than the previous early mark set at the beginning of May in 2015. But 2018 had a large snowpack, which delayed the onset of the storage period. Had there been a snowpack as small as in 2015, it is likely that storage would have been accessed up to two weeks earlier – in mid May.

At the request of the SCRD, the beginning of the Stage 2 period was set at May 1st.

Table I. Historical Dates for Storage Periods

Year	Begin Storage use (Stage 2)	Stage 3	Stage 4	End Storage use (Ch Lake Full)	Length (days)
2012	13 Sep	18 Sep	5 Oct	15 Oct	32
2013	9 Aug	-	-	30 Sep	52

Year	Begin Storage use (Stage 2)	Stage 3	Stage 4	End Storage use (Ch Lake Full)	Length (days)
2014	7 Aug	-	-	15 Oct	70
2015	29 May	11Jul	13 Aug	2 Sep	96
2016	27 Jul	26 Aug	-	7 Oct	73
2017	15 Jul	1 Sep	3 Oct	21 Oct	98
2018	18 Jul	13 Aug	31 Aug	16 Sep	60
Blended earliest and latest	29 May			21 Oct	145

Demand Projection Implications

For the purpose of the Drought Demand Model, the Stage 2 (storage) period is deemed to be from 1 May to 31 October, a period of 184 days.

5.2.2 Chapman System Drought Water Demand

Objective

Determine the consumption pattern, under Stage 2 restrictions, for the model drought period, from 1 May to 31 October

Issue

There has never been a period of water restrictions longer than 100 days, and the model premise is 184 days. Given that such a drought would, by definition, be a very sunny summer, there would be an increase in water demand irrigation and other outdoor uses (pools, water features, boat washing etc.). Although the historical data indicates water use restrictions and water conservation practices are gradually reducing the per capita demands, it is not known exactly how water users will react to such a long period of restrictions - whether they will respect or ignore them.

- The first two Stage 4 droughts in 2012 and 2015 saw a very good response from water users, with aggressive demand management happening to meet the Stage 2, and (especially) 3 and 4 targets; however, 2017 and 2018 did not see the same response during Stage 2, 3 or even 4 restrictions.

- The Drought Water Demand must be a realistic value – if the model value is larger than reality then the supply deficit will be artificially large. Too small, and the supply deficit will be underestimated.

Resolution

- For the purposes of the Drought Demand Model, the Stage 2 maximum month daily demand for the 2017 population is 20,000 (m^3/day), which corresponds to data from July 2018. This basis was set by SCRD in Water Demand Basis meeting (October 3, 2018).
- Using the same approach as for the drought period, the Drought Demand will be based on blended scenario of the maximum months of water use that have been measured since 2012. Each of these maximum months represents a dry and sunny period, and the drought period defined is six consecutive months of dry and sunny weather. The maximums for each month give an indication of the relative demand for water in sunny and dry conditions. This relative demand will then be pro-rated to the 20,000 m^3/day established as the Stage 2 demand for July.

Results

The MMDD for the years 2012-2018 are presented in Table J, as well as the model for the 2017 population of 22,500 people.

Table J. Summary of the Maximum Month Daily Demand for 2012 to 2018 and Monthly Demand Model for 2017

Year	May (m^3/d)	June (m^3/d)	July (m^3/d)	Aug (m^3/d)	Sept (m^3/d)	Oct (m^3/d)
2012	13,512	12,684	18,782	**22,919**	**16,792**	10,197
2013	13,517	15,145	**22,922**	18,275	13,109	10,988
2014	13,507	18,915	21,513	19,656	15,065	11,627
2015	16,561	**19,946**	16,149	12,668	11,722	11,664
2016	**17,431**	16,420	18,729	18,959	13,439	**12,702**
2017	12,798	15,932	20,274	19,097	13,624	10,620
2018	15,399	16,079	19,266	17,813	11,233	N/A
Maximum	17,431	19,946	22,922	22,919	16,792	12,702
% of July	76%	87%	100%	100%	73%	55%

Year	May (m^3/d)	June (m^3/d)	July (m^3/d)	Aug (m^3/d)	Sept (m^3/d)	Oct (m^3/d)
Adopted Model %	85%	90%	100%	100%	75%	60%
Adopted Model Stage 2 Monthly Daily Demand for 2017 population	17,000	18,000	20,000	20,000	15,000	12,000
Adopted Model Stage 2 Monthly per Capita Daily Demand for 2017 population	0.76	0.8	0.89	0.89	0.67	0.53

Demand Projection Implications

- The Stage 2 Drought Demand has been modelled based on a blended pattern of consumption in the Stage 2 period, and pro-rated to the Stage 2 maximum for July of 20,000 m^3/day.
- The Chapman System Drought Demand Model is thus based on the following:
  - Reference Year 2017, population 22,500
  - Duration of from the months of May through October, inclusive (i.e. 184 days)
  - Maximum Month Daily Demand is 20,000 m^3/day in July
  - Daily demand for the other Stage 2 months is pro-rated to July

5.2.3 Overall Water Demand Model

Objective

To compile the Chapman System Water Demand along with the environmental flow requirements to get an Overall Water Demand model for the demand on the watershed and storage during the drought period.

Issue

There is an environmental flow requirement for lower Chapman Creek of a minimum of 200L/s. This requirement must be satisfied at all times. During a drought period the watershed flow and the alpine storage lakes are the only sources that can presently supply the environmental flow needs.

INTEGRATED SUSTAINABILITY

Resolution

- To have a small margin for error in flow control, and remain above the 200L/s, the target has been set at 205 L/s, or 17,700 m^3/day.
- This flow is then added to the Drought Demand model for the WTP to get the overall demand on the Chapman catchment.
- When increasing the Drought Demand for population growth, the environmental flow requirement does not change.

Results

The model values are summarized in Table K.

Table K. Overall Drought Water Demand Model Summary for 2017

Month	Restriction Level	Daily Demand (m^3/day)	Per capita daily demand (2017 Pop. 22,500) (m^3/day)	Creek Flow Requirement (m^3/day)	Total Water Demand (m^3/day)
Jan	None	11,000	0.49	17,700	28,700
Feb	None	11,000	0.49	17,700	28,700
Mar	None	11,000	0.49	17,700	28,700
Apr	None	11,000	0.49	17,700	28,700
May	Stage 2	17,000	0.76	17,700	34,700
Jun	Stage 2	18,000	0.80	17,700	35,700
Jul	Stage 2	20,000	0.89	17,700	37,700
Aug	Stage 2	20,000	0.89	17,700	37,700
Sep	Stage 2	15,000	0.67	17,700	32,700
Oct	Stage 2	12,000	0.53	17,700	29,700
Nov	None	11,000	0.49	17,700	28,700
Dec	None	11,000	0.49	17,700	28,700
AADD (m^3/day)		14,000	0.62	17,700	31,700
Total Annual		5,120,000			11,580,000

Month	Restriction Level	Daily Demand (m^3/day)	Per capita daily demand (2017 Pop. 22,500) (m^3/day)	Creek Flow Requirement (m^3/day)	Total Water Demand (m^3/day)
Volume (m^3)					
Stage 2 ADD (m^3/day)[1]		17,000	0.76	17,700	34,700
Stage 2 Total (m^3)[1]		3,129,000		3,257,000	6,386,000

[1] Data applies for the duration of the Stage 2 water restriction months (May to October)

Demand Projection Implications

Recognizing the need to supply both the WTP and the Creek during drought periods has implications for the sizing of storage reservoirs and other secondary sources. During Stage 2 restrictions, these two demands exceed the natural watershed streamflow, creating a supply deficit. This deficit must be supplied from storage, and the streamflow must be supplied for the duration of the drought period (ending 31 October).

5.2.4 Drought Demand Management Scenarios

Objective

To determine the Demand Management Scenarios for the Drought Demand Model

Issue

Water demand increases in a drought year, compared to a typical year, so we must determine if the demand management targets based on the Typical Demand Model are applicable to the Drought Demand Model.

In a drought year, there are two main drivers for increased water use.

1. The sunny summer leads to an increase in water use for various activities such as irrigation, dust control, temporary backyard pools. There is also an increase in demand due to tourism and recreational activity is higher in a sunny summer.
2. There is a much longer season of outdoor water use. Irrigation and recreational activities start earlier and end later than in a typical summer.

Stage 2 water restrictions address point 1. Their purpose is to prevent excessive water use in drought conditions, this has been achieved by the SCRD and is captured in the model. It shows up as reduced ratio of maximum month demand to average daily demand.

Point 2 is considered in the Drought Demand model where an increased water use is expected in the shoulder months (May, September, October) compared to typical years when these months are often wet, and there is less demand for outdoor water use.

Resolution

The Drought Demand model considers that there is a "dry period" with no significant rainfall from May 1st to October 31st. As noted in section 5.2.3, the MMDD for the month of July has been set to 20,000 m3/day and the other Stage 2 months of May, June, August, September and October have been prorated based on this demand as follows:

- May: 85% of July MMDD (17,000 m^3/d)
- June: 90% of July MMDD (18,000 m^3/d)
- August: 100% of July MMDD (20,000 m^3/d)
- September: 75% of July MMDD (15,000 m^3/d)
- October: 60% of July MMDD (12,000 m^3/d)

Table L compares the Drought Demand model to the SCRD demand management objectives, which were presented in Table G in Section 5.1.4.

Table L. Drought Demand Model Compared to Demand Management Objectives

Year	AADD (m^3/c/day)	Reduction %	MMDD (m^3/c/day)	Reduction %	Ratio MMDD/ADD
Actual 2010	0.67	0	1.16	0	173
Actual 2017	0.58	13	0.9	21	155
Minimal demand reduction (10%)	0.60	10	0.9	21	150
Moderate demand reduction (20%)	0.54	20	0.8	31	148
High demand reduction (33%) (CRWP 2020 target)	0.45	33	0.68	41	151

Results

The degree of water conservation that is achieved makes a significant difference to the drought water demand, it is difficult to predict just how much conservation will occur, but it is easy to predict the difference made by a given amount of demand reduction.

Drought Demand Management Implications

For simplicity in the Drought Demand model, the same demand management scenarios will be considered as in the Typical Demand Model. 2017 will be considered the Reference Year, and it represents approximately a 10% reduction from the demand in 2010.

The proposed values for demand management targets for the Drought Demand model will consider four scenarios;

1) Zero reduction, at 0% below 2010
2) Minimal reduction, (2017- Reference Year) at 10% below 2010
3) Moderate reduction, 10% below Reference Year, 20% below 2010
4) High reduction (CRWP 2020 target), 23% below reference year, 33% below 2010

5.3 Drought Supply Model

The Drought Supply Model is the water supply that is available in a very dry year. It is constrained by weather factors, meaning less water is available in the form of natural streamflow, or watershed contribution than in a typical year, and the difference must be made by either bringing more supply online, or curtailing water use through demand management.

Development of the Drought Supply Model is comprised of the following:

1) Review of the SCRD's Framework for the Development of a Water Sourcing Policy (SCRD 2018c)
2) Confirmation of the available volumes of the existing water storage
3) Analysis of historical streamflow and storage use for the various drought years to determine the watershed contribution patterns
4) Production of a watershed flow for the modelled drought period

5.3.1 Water Sourcing Policy

Objective

The SCRD is developing a Water Sourcing Policy that sets out which supply sources are to be used at each Stage of water restrictions. The intention is to have a logical progression of supply in drought scenarios, with the most easily accessed and replenished sources used first, and the least desirable ones used last.

Issue

It is intended that the Raw Water Reservoir, in conjunction with other Stage 2 sources (storage and wells), is able to supply sufficient raw water to keep the community in Stage 2 water restrictions during the modelled drought. This means the required size of the reservoir depends on what other sources are deployed during Stage 2. If the intention is that the community remain in Stage 2 in the model drought, then existing sources that are reserved for Stage 3 or 4 could be deployed at Stage 2, since the purpose is to avoid Stage 3 and 4 entirely.

Resolution

The existing water sourcing policy that is under development has been used in the model to define the volumes of water accessible during Stage 2 water restrictions only. Edwards Lake is currently a Stage 3 source, but, at the request of the SCRD, has been elevated to a Stage 2 source for this model, as it is expected to be used during Stage 2 water restrictions in the future. Gray Creek remains as a Stage 3 source.

Results

A summary of a proposed water sourcing policy for use during staged water use restrictions is provided in Table M, where:

0 = available, Y = in use, X = supply exhausted

Table M. Proposed Water Sourcing Policy During Staged Water Restrictions with the Inclusion of the Raw Water Reservoir

Source		Stage			
		1	2	3	4
Chapman Creek Freshet flow	>100,000 m^3/day	Y	X	X	X
Chapman Creek baseflow	<100,000 m^3/day	Y	Y	Y	Y
Chaster Well	1000 m^3/day	0	Y	Y	Y
Chapman Lake	831,000 m^3	0	Y	X	X
Raw Water Reservoir	TBD	0	Y	X	X
Edwards Lake	810,000 m^3	0	Y	X	X
Gray Creek	1000 m^3/day	0	0	Y	Y

Drought Supply Modelling Implications

Elevating Edwards Lake to a Stage 2 source adds significant storage volume to the Stage 2 Drought Supply Model and will decrease the Supply Deficit and Raw Water Reservoir by the same amount.

5.3.2 Watershed Contribution

Objective

To produce a model for watershed contribution in the model Drought Year that is based on what has been observed for existing shorter droughts, and reasonably predicts the watershed contribution during the model-184-day drought. This component must exclude any contribution from storage in Chapman and Edwards Lakes.

Issue(s)

There has not been a drought duration of 184 days since the Chapman water system has been in place, so there is not a definitive streamflow record for this condition – a model will need to be produced by extrapolation of existing records.

A second issue relates to the measurement of the watershed contribution itself. It is measured at the Chapman Creek Monitoring Station (CMS), located at the diversion weir for the WTP intake, and combined with the measurement of flow diverted to the WTP. This total gives a measurement of the streamflow arriving at the diversion weir. But when flow is being released from storage in Chapman and Edwards Lakes, the CMS measurement is the sum of the watershed contribution and storage release. To calculate the watershed contribution requires subtracting out the storage release, which itself requires some means of determining the storage release.

The level sensor at the WTP intake was recalibrated in 2016 and it was found to be over-estimating flows by about 60 L/s (5,184 m^3/d). It is not known how long it has been out of calibration, and no correction to the historical data base has been attempted to account for the calibration error.

Flow is measured at the release valves of Chapman and Edwards Lakes, but it is not very accurate, and this measurement represents a combination of any watershed contribution into the lakes, and the change in storage. There is no means to specifically measure the inflow to the lakes, which happens on a continuous but declining basis over the summer

The storage volume in the lakes can be estimated by the use of a bathymetric volume survey, and the measured lake level at the outlet weir. The release volume each day could be estimated by calculating the storage volume each day, and the difference represents the change in storage, and – nominally – the volume released.

The volume differential also includes evaporation loss in mid-summer. The lakes lose water each day regardless of the release volume, so the change in storage is the sum of actual release and the evaporation loss. This needs to be considered when doing mass balance calculations.

Resolution

The watershed contribution response to the extended drought period modelled will be estimated by blending or overlaying the base flow curves observed during recent drought events. The years of 2015, with an early drought, and 2017, with a late drought, appear to be most applicable, but all four years of Stage 4 restrictions (2012, 2015, 2017, 2018) will be used.

Both Chapman and Edwards lakes have had bathymetric surveys done, to create a storage-depth relationship. Each lake has a level sensor at the weir that provides an accurate level measurement. Combined with the bathymetric tables, this provides an objective measurement system that is not subject to weather or operator or equipment error (in most cases). Thus, the bathymetric volume calculation will be used for estimating storage release on a weekly basis (expected duration to obtain a significant enough level change to estimate volume variations. It reasonably resolves the issue of determining inflow from watershed contributions. If there is a reduction level, it means water has been used from storage, and if it is increasing, then storage is increasing. These characteristics have been used to create a daily mass balance of the watershed, as follows:

$$Q = S + W$$

Q = total flow at diversion Weir (WTP intake + flow over weir)

S = storage change from Chapman and Edwards lakes, calculated from bathymetry.

W = watershed contribution, the catchment streamflow

And then;

$$W = Q - S$$

W is the “net” watershed contribution. It is what is seen at the diversion weir and represents the all the water other than that released from storage.

For this first-order model to evaluate the watershed contribution, the effects of evaporation have been ignored. But allowance for evaporation will be made in sizing the raw water reservoir, as, like the Edwards and Chapman lakes, it will lose water to evaporation whether it is being used or not.

Results

The watershed contribution has been calculated for each of the major (Stage 4) drought years – 2012, 2015, 2017 and 2018. This is the flow at the weir less the combined change in storage in the lakes when they are actively being released. The data are plotted in Figure C as a seven-day moving average to even out the day to day fluctuations. The data has been aligned to 2017

The watershed contribution curves for each of the years modelled in Figure D follow a similar pattern, including the following characteristics:

- A rapid decline at the start
- A levelling out at around 10,000 m³/day to 20,000 m³/day
- A gradual decline from there over several months
- A rapid increase when the fall rains arrive

Based on the above described characteristics, a "Flow model" curve has been manually created (not interpolated) to match the lower limit of the overlaid curves. It has been shifted two weeks earlier than the 2015 flow curve to represent the early dry period observed in spring 2018. The curve thus represents a blended worst-case combination of historical watershed flow patterns, including a dry summer that starts in April and continues to the end of October. The model curve on the watershed contribution has been represented as an average daily flow in each month to correspond with the Drought Demand model developed above.

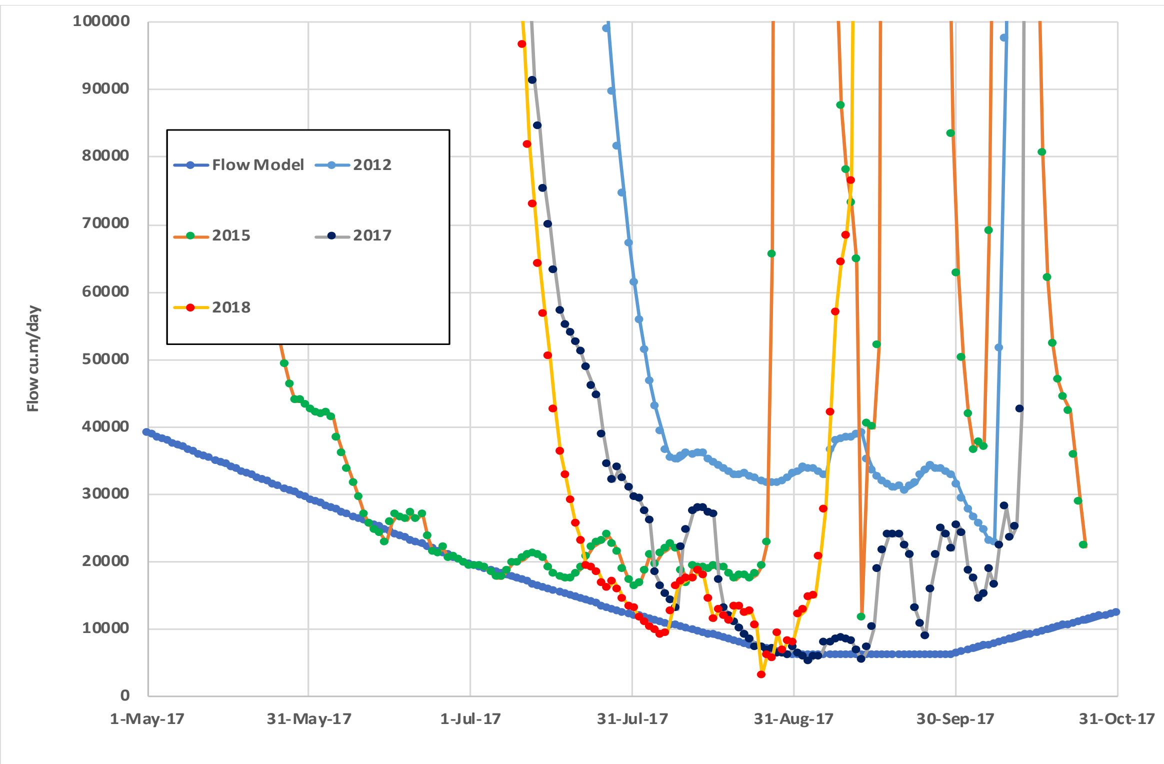

Figure D. Proposed Flow Model for Chapman Creek Watershed Contribution During the Drought Period (May – October)

The average watershed contributions over each segment of the flow curves for years 2012, 2015, 2017, and 2018, as well as for the model curve, are summarized in Table N.

Table N. Modelled Watershed Contributions over Stage 2 Drought Period

Month	Model Curve (m^3/day)	2012 (m^3/day)	2015 (m^3/day)	2017 (m^3/day)	2018 (m^3/day)
May	34,280	912,900	47,800	1,145,600	704,200
June	24,520	895,400	28,600	712,100	407,700
July	15,882	355,500	**19,700**	109600	76,500
August	8,986	36,100	84,100	167,00	**12,000**
September	**6,180**	**34,400**	281,900	**13,900**	280,500
October 1 to 10	7,280	25,300	39,400	18,000	N/A
October 11 to 31	10,380	510,700	133,900	349,900	N/A
Lowest monthly flow	6,180	34,400	19,700	13,900	12,000
May-Oct Average	16,550	380,019	93,655	298,682	N/A
May-Oct Total	3,045,000				

The model flow for August and September has been set below the 2017 average monthly flow for those two months. Reference to the actual flow curve in Figure D shows that there was significant period of watershed flow at 6,000 to 7,000 m^3/day, but this happened from mid-August to mid-September, so the monthly averages do not reflect how low this flow was.

While the model predicts flows that are significantly lower than the lowest historical recorded flows, the model curve matches the 7-day average flow at several points, as shown in Figure D. The monthly flows show the influence of summer rain events that lead to a substantial but brief increase in watershed contribution, increasing the monthly average substantially, but returning to the same or lower baseflow.

It should be noted that at 16,550 m^3/day, the average watershed flow for the Stage 2 drought period is less than the environmental flow requirement of 17,700 m^3/day (SCRD 2018a).

Demand Projection Implications

A model has been produced for the watershed contribution for the Chapman Water System catchment area for a 184-day period of Stage 2 water restrictions. The model is based upon overlaying the watershed contributions from recent drought years, to create a model scenario for a summer drought. The characteristics of the watershed contribution are:

- Stage 2 drought period: May through October (184 Days)
- Stage 2 Total water volume supplied: 3,045,000 m^3
- Stage 2 Average daily flow: 16,550 m^3/day
- Minimum daily flow: 6,180 m^3/day

Estimating the watershed contribution during the modelled drought period is critical – if over-estimated the Supply Deficit will be too low, and if underestimated then the Supply Deficit will be too high.

5.3.3 Overall Drought Supply Model

The watershed contribution can now be added to the storage volumes to create the overall Drought Supply Model. These values are summarized in Table O.

Table O. Overall Drought Supply Model Summary

Month	Period	Watershed supply (m^3/day)	Chaster Well (m^3/day)	Chapman Lake (831,000 m^3)	Edwards Lake (810,000 m^3)	Total Supply (m^3/day)
May	Dry	34,280	1,000	Variable	Variable	> 35,280
Jun	Dry	24,520	1,000	Variable	Variable	>25,520
Jul	Dry	15,880	1,000	Variable	Variable	>16,880
Aug	Dry	8,990	1,000	Variable	Variable	>9,990
Sep	Dry	6,180	1,000	Variable	Variable	>7,180
Oct	Dry	9,380	1,000	Variable	Variable	>10,380
Stage 2 average		16,550	1,000	4,510	4,400	26,500
Stage 2 Total		3,045,000	184,000	831,000	810,000	4,870,000

Demand Projection Implications

A Drought Supply model has been created using the modelled Watershed Contribution and the known characteristics of the existing Stage 2 sources of Chapman Lake, Edwards and the Chaster Well. The overall parameters are:

- Start date 1 May, end date 31 October
- Total water volume 4,870,000 m^3
- Stage 2 Average daily flow 26,500 m^3/day
- Minimum daily flow 7,180 m^3/day (incl 1000 m^3/day from Chaster Well)

5.4 Supply Deficit and Raw Water Reservoir Sizing

The Supply Deficit is defined as the shortfall of Supply compared to Demand, for a given period. In this case, it is for the Drought period, or Stage 2 Water Restrictions period, from 1 May to 31 October.

The Supply Deficit is first calculated for the reference year, and then the demand and supply models are extrapolated based on population growth, to calculate demand and supply for future years, and various demand reduction scenarios.

5.4.1 Supply Deficit for the Reference Year

Objective

Combine the models for the Stage 2 Drought Demand and Drought Supply, to calculate the Stage 2 Supply Deficit. This is done for the Reference Year of 2017, and then the model is projected into the future for the various population growth and demand reduction scenarios.

Issue

Source water from Chaster well and water stored in Chapman and Edwards Lakes, and the future raw water reservoir, can all be released in a controlled manner to make up the supply deficit when the watershed contribution is insufficient. The order in which source water is accessed is a variable that has to be set in the model.

Results

The Drought Demand and Drought Supply models have been merged to calculate the Supply Deficit for the reference year of 2017, shown in Table P. The Supply Deficit results are also presented graphically in Figure E.

It is assumed that Chaster well is accessed first, then Chapman Lake and Edwards Lake, prior to accessing the raw water reservoir (which would make up the Supply Deficit).

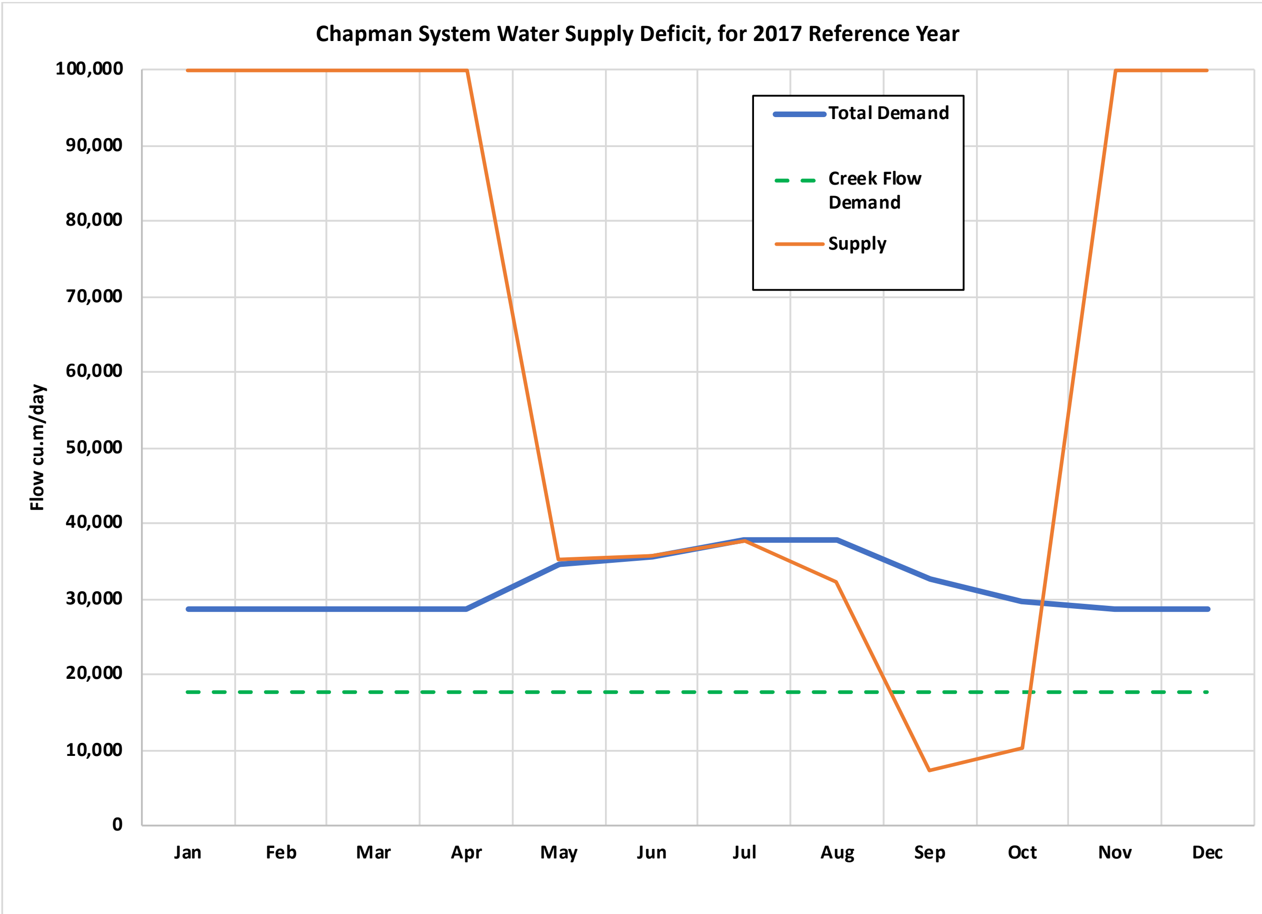

Figure E. Supply Deficit for Chapman Creek Water System in Reference Year of 2017

Table P. Supply and Demand Data and Resulting Supply Deficit for 2017 Reference Year

Month	Total Demand (m^3/day)	Watershed Cont. (m^3/day)	Chaster Well (m^3/day)	Chapman Lake (m^3/day)	Month	Total Demand (m^3/day)	Watershed Cont. (m^3/day)
Jan	28,700	>100,000	0	0	0	>100,000	0
Feb	28,700	>100,000	0	0	0	>100,000	0
Mar	28,700	>100.000	0	0	0	>100,000	0
Apr	28,700	>100,000	0	0	0	>100,000	0
May	34,700	34,280	420	0		34,700	0

Month	Total Demand (m³/day)	Watershed Cont. (m³/day)	Chaster Well (m³/ day)	Chapman Lake (m³/day)	Month	Total Demand (m³/day)	Watershed Cont. (m³/day)
Jun	35,700	24,520	1,000	10,180		35,700	0
Jul	37,700	15,880	1,000	16,955	3,864	37,700	0
Aug	37,700	8,990	1,000	0	22,265	32,251	5,450
Sep	32,700	6,180	1,000	0	0	7,180	25,520
Oct	29,700	9,380	1,000	0	0	10,380	19,320
Nov	28,700	>100.000	0	0	0	>100,000	0
Dec	28,700	>100,000	0	0	0	>100,000	0
May-Oct Average Daily	31,700	16,550	902	4,516	4,402	26,370	8,330
May-Oct Total	6,385,000	3,045,000	184,000	831,000	810,000	4,852,000	1,533,000

The total available Stage 2 watershed contribution, at 3,045,000 m³ is close to the Stage 2 potable system demand of 3,129,000 m³, and the Stage 2 streamflow requirement of 3,257,000 m³, but it falls short of the combined total demand of 6,385,000 m³. This indicates that in the model drought year, the watershed can only supply one or other of the demands, but not both. But in the late summer, the watershed cannot even supply the streamflow needs, so a release from storage is required to maintain the stream-flows.

The calculated Stage 2 Supply Deficit for the 2017 Reference year is 1,515,000 m³. This is just smaller than the combined volume of Chapman and Edwards lakes, at 1,641,000 m³. This volume is substantially larger than the 2013 CRWP estimate, which was for a reservoir size in the order of 430,000 to 760,000 m³ by the late 2020's. There are five main reasons for this;

1) The CRWP included approximately 1,000,000 m³ of additional storage from the Chapman Lake Infrastructure Improvements Project. This has since been designated as a Stage 4 source. The Drought Model developed in this report is based on staying within Stage 2 and so the Chapman Lake Infrastructure Improvement Project storage would not be used, and thus does not influence the Supply Deficit calculations

2) The CRWP recommended and assumed Universal Water Metering to be fully implemented by 2016, which would have reduced the observed demand in 2017, and hence reduce the supply deficit.
3) The CRWP model accepted Stage 3 and 4 restrictions in a drought, but this goal has been changed to maintain Stage 2 restrictions. This is an increase in the "level of service" being provided by the SCRD
4) The Chapman Creek streamflow requirement of 200 L/s (17,280 m^3/day) (FLNRO, 2017). This was not established at the time of the CRWP
5) The model drought year that has been established is likely much "drier" than the CRWP anticipated, reducing the watershed contribution significantly.

5.4.2 Future Supply Deficit Modelling

The supply deficits for future years are modelled by using the per capita demand from the 2017 reference year, using a 2% annual population growth, and extrapolating to the years 2025, 2035 and 2050 for demand reduction scenarios of 10%, 20% and 33%. These results are summarized in Table Q. The results for 1% and 3% population growth scenarios are provided as tables in Attachment 1.

Each demand-reduction scenario results in an improvement (i.e. a reduction) in the predicted supply-deficit;

- The Minimal Demand-Reduction scenario (i.e. 10% less than the per capita demands in 2010) achieves a 15 to 18 percent reduction in the Supply-Deficit
- The Moderate Demand-Reduction scenario (i.e. 20% less than the per capita demand characteristics in 2010) achieves a 26 to 33 percent reduction in the Supply-Deficit
- The High Demand-Reduction scenario (i.e. 33% less than the per capita demand characteristics in 2010) 41 to 49 percent reduction in the Supply-Deficit

Table Q. Modelled Supply Deficits at 2% Growth for the Years 2025, 2035, and 2050

Demand Reduction Factor from 2010	Supply Deficit (m^3)					
Demand Reduction	2025	Red.*	2035	Red.*	2050	Red.*
Population	26,000	-	32,000	-	43,000	-
0% (zero reduction)	2,454,000	-	3,392,000	-	5,114,000	-
10% (minimal reduction)	2,002,000	-18%	2,837,000	-16%	4,366,000	-15%
20% (moderate reduction)	1,640,000	-33%	2,391,000	-29%	3,770,000	-26%
33% (high reduction)	1,245,000	-49%	1,811,000	-47%	2,988,000	-41%

Red.* = reduction in predicted supply deficit versus a zero reduction scenario

6 CONCLUSIONS

The demand and supply of the SCRD Chapman Creek water supply system have been analysed in this study.

The major conclusions are;

- The serviced population for the reference year of 2017 is 22,500 people (including Town of Gibsons Zone 3)
- Population growth is modelled at 2% annually
- The 2017 water use was 13% below the 2010 baseline
- Three water conservation scenarios have been modelled for a typical water demand year, of 10%, 20% and 33% reduction from 2010 levels.
- A Typical Water Demand model has been produced, based on data from 2012 to 2018
- A Drought Demand model has been produced, for the specific case of a 184-day period of Stage 2 Water Restrictions. This model is based on observed demand in 2012 to 2018.
- The Drought Model for the Reference Year of 2017 shows an annual water use of 9% below the 2010 baseline. The modelled water conservation scenarios for the Drought Model are for a 0%, 10%, 20% and 33% reduction from the 2010 baseline.
- A Drought Supply model has been produced, based on observed drought years of 2012, 2015, 2017 and 2018, to determine the "watershed contribution" for Chapman Creek during the 184-day drought period. The modelled average daily flow is 16,550 m^3/day, and the minimum day flow is 6,180 m^3/day.
- The Supply Deficit has been calculated for the reference year of 2017, and for future years of 2025, 2035 and 2050, and for the four water conservation scenarios. The smallest deficit (highest demand reduction) for 2025 is 1,245,000 m^3 and the largest deficit is 5,114,000 m^3 for 2050 and zero demand reduction (for a 2% population growth). Supply Deficit projections for the 1% and 3% population growth scenarios are provided in Attachment 1.
- Regardless of the demand reduction scenarios that have been considered (i.e. 10%, 20% and 33%) based on the assumptions stated in this document, including a 2 percent population growth from 2018 onward, the system demands are expected to exceed the existing Chapman Creek water license limits well before 2050.

7 LIMITATIONS

Integrated Sustainability's services consist of professional opinions, conclusions, and recommendations that are made in accordance with generally accepted, local engineering principles and practices at the time our services were performed. This warranty is in lieu of all other warranties, either express or implied.

The recommendations contained in this report are based on the data obtained and discussions between Integrated Sustainability and the Sunshine Coast Regional District for the analysis conducted.

This report has been prepared for the exclusive use of the Sunshine Coast Regional District and their consultants for specific application of the water demand analysis for the Chapman Water System, for the Raw Water Reservoir Feasibility Study project, as described herein. In the event that there are any changes in the ownership, nature, design, or location of the proposed project, or if any future additions are planned, the conclusions and recommendations contained in this report should not be considered valid unless (1) the project changes are reviewed by Integrated Sustainability, and (2) the conclusions and recommendations presented in this report are modified or verified in writing. Reliance on this report by others must be at their risk unless we are consulted on the use or limitations. We cannot be responsible for the impacts of any changes in standards, practices, or regulations subsequent to performance of services without our further consultation. We can neither vouch for the accuracy of information supplied by others, nor accept consequences for un-consulted use of segregated portions of this report.

8 CLOSURE

Integrated Sustainability would like to thank the Sunshine Coast Regional District for the opportunity to support the Raw Water Reservoir Feasibility Study project. We trust that this Water Demand Analysis Report meets the needs and expectations of the Sunshine Coast Regional District. If you have any questions please contact the undersigned at any time.

Sincerely,

Integrated Sustainability

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Attachment 1- Tables

Table 1. Modelled Supply Deficit for the Years 2025, 2035, and 2050 (with 1% Population Growth Factor)

Demand Reduction Factor from 2010		2025 Population: 24,100	2035 Population: 26,600	2050 Population: 30,900
0% (minimal reduction)	Supply Deficit (m^3)	2,157,000	2,548,000	3,221,000
10% (minimal reduction)	Supply Deficit (m^3)	1,737,000	2,086,000	2,684,000
20% (moderate reduction)	Supply Deficit (m^3)	1,440,000	1,716,000	2,254,000
33% (high reduction)	Supply Deficit (m^3)	1,076,000	1,298,000	1,693,000

Table 2. Modelled Supply Deficit for the Years 2025, 2035, and 2050 (with 3% Population Growth Factor)

Demand Reduction Factor from 2010		2025 Population: 27,700	2035 Population: 37,200	2050 Population: 58,000
0% (minimal reduction)	Supply Deficit (m^3)	2,720,000	4,206,000	7,460,000
10% (minimal reduction)	Supply Deficit (m^3)	2,239,000	3,560,000	6,452,000
20% (moderate reduction)	Supply Deficit (m^3)	1,853,000	3,042,000	5,646,000
33% (high reduction)	Supply Deficit (m^3)	1,396,000	2,367,000	4,593,000