20 August 2013 Document No. 12-1151-0264

Meagan Leach (Director of Engineering)
City of Iqaluit
PO Box 460
Iqaluit, Nunavut X0A 0H0

RE: LAKE GERALDINE WATER BALANCE ASSESSMENT

Dear Meagan:

Having completed the above referenced project, we are very pleased to submit the final report and supplementary clarifications to the City of Iqaluit in PDF format. Please note that the report is enclosed under Attachment 2, with a subsequent information submission provided under Attachment 1.

We would like once again to thank the City of Iqaluit for providing us with the opportunity to work on this very interesting and challenging project. We hope you will find the resultant product of a high technical quality and trust that it will satisfy your intended needs.

In closing, please don't hesitate to contact us if you have any questions regarding this, or any other project to which you feel we can offer assistance.

Sincerely,

GOLDER ASSOCIATES LTD.

Greg Rose, B.Sc. (Hons), M.Sc.
Senior Water Resources Specialist

Anil Beersing, Ph.D, P.Eng
Principal, Senior Water Resources Engineer

GR/AB/am

CC: Project File

Attachments: Attachment 1: Refinement of Reported Supplementation Volumes
Attachment 2: Final Report: Lake Geraldine Water Balance Assessment

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ATTACHMENT 1

Refinement of Reported Supplementation Volumes

August 20, 2013 Project No. 12-1151-0264 (6000)

Meagan Leach
City of Iqaluit
Director of Engineering and Sustainability
PO Box 460
Iqaluit, NU
X0A 0H0

PRELIMINARY ADDITIONAL INFORMATION IN SUPPORT OF SUPPLEMENTATION DESIGN

Dear Meagan:

This letter has been prepared in response to telephone conversations held between Golder Associates (Golder), the City of Iqaluit (the City) and EXP during the week commencing May 13, 2013. Golder herewith provides several estimates of supplementation rates corresponding to a select number of climatic scenarios for your information.

It is understood that this information will serve as a first step to assisting the City and EXP in identifying a preferred supplementation volume from the adjacent Apex River watershed. The Apex River is to serve as a supplementary water supply source for the City's existing Lake Geraldine reservoir. Additional steps may subsequently be taken to further inform this process, if requested by the City.

In order to obtain appropriate context, the information provided in this letter should be read in conjunction with, and is limited to the methods and assumptions outlined in, Golder's August 20, 2013 Final Lake Geraldine Water Balance Assessment report (Golder 2013 report).

1.0 METHODS

As presented in the Golder 2013 report, a large range of possible supplementation requirements can be derived in adjusting the key relational variables affecting water supplies for the Lake Geraldine reservoir. In simplified terms, these key variables include:

- Starting reservoir level for Lake Geraldine (at the outset of winter);
- Climate regime;
- Winter duration;
- Geraldine watershed snow accumulation yields;

- Geraldine watershed rainfall runoff yields;
- Water consumption via the municipal intake; and
- Lake Geraldine reservoir ice formation.

In order to constrain the range of potential outcomes presented in the Golder 2013 report to a limited number of applicable, yet easily interpretable, representations, it was decided to place the following restrictions on the key variables presented above.

1.1 Starting Reservoir Level for Lake Geraldine

The reservoir level at the outset of winter is a key determinant in developing water supply and/or supplementation requirements in that the volume at that point in time effectively limits what will be available for conversion into ice storage and consumption until the end of winter. The information presented herein assumes that the reservoir will be filled up to its weir crest on the first day of winter. It is understood that the City's water management efforts would necessarily be focused on filling the reservoir as full as possible before the onset of every winter, subject to the availability of supplemental supplies.

1.2 Climate Regime

The information presented herein only pertains to the Historic Climate Regime, as defined in the Golder 2013 report. The Historic Climate Regime was specifically selected over the 2050s and 2080s Climate Regimes on the grounds that the latter climatic scenarios are less certain and generally expected:

- to result in higher basin yields, meaning that the supplementation volumes required to sustain identical consumption rates will become comparatively lower;
- to result in shorter winter durations, meaning that the overwinter reservoir volumes required to sustain identical consumption rates will become less constrained; and
- to provide less appropriate meteorological determinations of conditions to be encountered over the immediate future, before which reservoir storage capacity (as noted in the Golder 2013 report) will likely become the constraining factor in water supply management.

1.3 Winter Duration

The information presented herein only provides results for 50%ile, 60%ile, 75%ile and 100%ile winter durations based on the Historic Climate Regime, as defined in the Golder 2013 report. It is understood that design criteria for the proposed supplementation infrastructure would necessarily focus on this range rather than shorter winter periods in order to accommodate water supply requirements for median to worse-than-median conditions.

1.4 Geraldine Watershed Snow Accumulation and Rainfall Runoff Yields

The information presented herein only provides results for combined 50%ile, 60%ile, 75%ile and 100%ile dry year snow accumulation and rainfall runoff yields based on the Historic Climate Regime, as defined in the Golder

2013 report. Again, it is understood that design criteria for the proposed supplementation infrastructure would necessarily focus on median to worse-than-median conditions. As discussed in the 2013 Golder report, it should be noted that annual basin snow accumulation yields are not significantly correlated to annual basin rainfall runoff yields, but that their combined representation herein is provided for simplicity of interpretation alone.

1.5 Water Consumption via the Municipal Intake

To limit the potential variability associated with daily water consumption (essentially a derivative of per capita consumption and population size), the information presented herein accounts for the maximum sustainable daily water consumption rate under each winter duration scenario. This essentially limits the consumption rate to a specific population size, at a specific per capita consumption rate, for the number of days that winter persists under the Historic Climate regime. It is reasoned that this approach effectively represents a relatively conservative design horizon for examined historic winter lengths, as defined in the Golder 2013 report.

1.6 Lake Geraldine Reservoir Ice Formation

The effects of ice formation on ice storage (and therefore accessible overwinter water supplies) is highly dependent on a number of variables in that the depth of daily freeze sequesters a decreasing volume of water as the reservoir level decreases. Because the starting reservoir level, winter length and daily consumption rates will vary on a case by case basis, the information presented herein assumes that water located within the upper portion of the reservoir (corresponding to a volume of between approximately 505 and 585 megaliters depending on winter length) will freeze and be attenuated until the spring thaw.

1.7 Maximum Available Reservoir Volume

The intake elevation used for the assessment was 101.6 m ASL. It should be noted that the elevation of the intake invert and obvert were not known and that in discussion with the City it was agreed to use this elevation as the theoretical threshold below which water becomes inaccessible.

Based on the Environment Canada shapefiles provided and subsequent analysis undertaken at Golder, the Lake Geraldine reservoir is estimated to store approximately 1,956,000 m^3 when filled to its maximum storage elevation of 111.33 m ASL. The storage volumes presented in this letter and in the Golder 2013 report account for the fact that approximately 80,500 m^3 of the reservoir water is inaccessible. This allows for approximately 1,875,500 m^3 of active storage (excluding ice effects) that may be available for consumption and evaporation.

2.0 ASSUMPTIONS

In addition to the assumptions presented above and throughout the 2013 Golder report, the following considerations are presented with respect to the results presented herein:

1) Annual basin snow accumulation yields and annual basin rainfall runoff yields are evenly distributed over each day according to corresponding winter length and summer length, respectively. Therefore any given scenario assumes that daily snow accumulation will be identical over every day of winter. Likewise, for a given scenario, daily rainfall runoff will be identical over every day of summer. This necessarily negates the

temporal variability associated with individual precipitation events, but provides a suitable determination of annual basin yields for the purposes of this assessment.

2) The first day of winter is defined as the first day on which there have been six (6) successive days with each exhibiting an average daily air temperature below 0°C.

3) The last day of winter is defined as the first day which exhibits an average daily air temperature above 2°C immediately following three (3) consecutive days that have each exhibited daily average air temperatures above 0.5°C.

4) The supplementation volumes required under each presented scenario cover the needs for an entire year. This is in order to account for summer consumption, offset by meteorological surpluses, while the reservoir is being filled.

5) Estimated supplementation volumes are based on the assumption that the reservoir supply will be exhausted on the first day of spring when a portion of melting reservoir ice and watershed runoff replenishes the drinking water supply.

6) A large conservative estimate of ice formation is assumed under each scenario (i.e. only water in the top portion of the reservoir is converted to ice).

7) Given the above assumptions, and potential meteorological variability beyond historic conditions, it is recommended that the City design, and plan, for slightly higher supplementation rates than those presented.

8) Water supply deficits estimated for the 'No Basin Yield' scenarios (Table 2) do not account for atmospheric losses from the reservoir and therefore underestimate corresponding supplementation requirements.

3.0 RESULTS

The following section presents the selected scenarios and corresponding estimated supplementation requirements based on the information discussed in Section 2.

Table 1: Selected Climatic Constraints for Determining Supplementation Requirements in Table 2

Winter Duration Scenario	100%ile Scenario	75%ile Scenario	60%ile Scenario	50%ile Scenario
Sustainable daily consumption (m^3)[1]	4,745	5,316	5,587	5,830
Winter length (days)[2]	272	251	242	235
Summer length (days)[2]	93	114	123	130
Estimated Ice Storage (m^3)[3]	584,819	540,098	521,177	505,267
Estimated residual overwinter water supply available (m^3)[3]	1,290,707	1,335,428	1,354,349	1,370,259

Notes:
1. Maximum sustainable daily consumption volumes were estimated by dividing the total available liquid overwinter reservoir storage by the number of winter days for any given winter duration scenario.
2. Based on examined historic climate conditions only (See Golder 2013 report).
3. Presented values to be interpreted in conjunction with information presented herein and the Golder 2013 report.

Using the information tabulated above, Table 2 presents estimated annual supplementation requirements based on the basin yield scenarios identified in Section 2.

Table 2: Estimated Reservoir Water Deficits/Supplementation Requirements for Selected Climatic Constraints and Daily Consumption Rates (ML)

Basin Yield Scenario	Winter Duration Scenario[2]			
	100%ile Scenario	75%ile Scenario	60%ile Scenario	50%ile Scenario
No Basin Yield (No Snow; No Rain)[1]	1,732	1,940	2,039	2,128
100%ile Snow; 100%ile Rain[2]	1,515	1,691	1,776	1,853
75%ile Snow; 75%ile Rain[2]	1,083	1,247	1,328	1,401
60%ile Snow; 60%ile Rain[2]	949	1,109	1,188	1,260
50%ile Snow; 50%ile Rain[2]	845	1,003	1,080	1,150

Notes:

1. Water supply deficits estimated for the 'No Basin Yield' scenarios (Table 2) do not account for atmospheric losses from the reservoir and therefore underestimate corresponding supplementation requirements.
2. Based on examined historic climate conditions only (See Golder 2013 report).

4.0 DISCUSSION

4.1 Percentiles

The percentiles presented in this letter correspond directly to the percentages presented in Tables 9 and 10 of the Golder 2013 report. As such, the 100th percentile for basin yields (rainfall runoff or snow accumulation) represents the driest historic year examined (i.e. all historic years of record either equaled or exceeded the corresponding basin yields). The 100th percentile for winter length corresponds to the longest winter in the period of record examined, while the 0th percentile would correspond to the shortest winter. Please see these defined in further detail in the Golder 2013 report.

Percentiles were used rather than return periods for two reasons, namely:

1) Return periods should be based on a statistical distribution that projects above and beyond the period of record in cases where the period of record is shorter than the period of projection. Selecting which distribution curve to fit to the historic data is somewhat subjective and necessarily biases projected return periods to the distribution of historic conditions which may not be appropriate; and

2) Given changing precipitation and air temperature conditions, the relatively weak relationship between these two variables may skew return period projections.

4.2 Supplementation Trends

As noted below Table 1, a sustainable daily consumption rate was estimated for each winter duration (100%ile, 75%ile, 60%ile and 50%ile) based on the available reservoir supply once potential losses due to ice formation were considered. As would be expected, this means that shorter winter durations can sustain higher daily consumption rates than longer winters.

For the purposes of this evaluation, the counter-intuitive supplementation value trends presented in Table 2 (the most supplementation is required for the shortest winter) are the result of higher allowable consumption rates associated with the shorter winter durations. For the 100%ile winter duration scenario, the daily consumption value (4,745 m^3) is multiplied by 365 days to attain the calculated deficit (1,731,925 m^3) for no basin yields (for consumption alone, no evaporative losses). If the consumption rate is increased to 5,830 m^3, the overall deficit from consumption alone increases to 2,127,950 m^3. Subsequent basin yield scenarios (Table 2; rows 2 to 5) then differ as they account for the meteorological water balance surpluses.

5.0 CLOSURE

We trust the information provided in this letter meets your immediate needs. Please contact the undersigned if you have any immediate queries or concerns.

Sincerely,

GOLDER ASSOCIATES LTD.

Greg Rose, B.Sc. (Hons), M.Sc.
Senior Water Resources Specialist

Kevin MacKenzie, M.Sc., P.Eng
Associate, Senior Water Resources Engineer

GR/KM/am

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ATTACHMENT 2
Final Report

August 20, 2013

CITY OF IQALUIT

Lake Geraldine Water Balance Assessment

(Sourced from Water Survey of Canada)

Submitted to:
City of Iqaluit
Building 901 (City Hall)
Nunavut Drive
Iqaluit, NU
X0A 0H0

Report Number: 12-1151-0264

Distribution:Distribution:

1 copy - City of Iqaluit

1 copy - Golder Associates Ltd.

REPORT

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APPENDICES

1.0 INTRODUCTION

This report has been prepared by Golder Associates Ltd. (Golder) for the City of Iqaluit (the City) in accordance with Proposal Number 12-1151-0264, dated August 21, 2012. The report documents a water balance assessment carried out for the Lake Geraldine Water Supply Reservoir, located to the immediate north east of Iqaluit, Nunavut (Figure 1) and the current water supply source for the City.

1.1 Background

The City of Iqaluit currently depends on the Lake Geraldine Reservoir (the reservoir) for its year-round municipal water supply. Given that the reservoir is frozen over for approximately eight months a year, raw water supplies at the end of summer need to be sufficient to service the City over the following winter until snowmelt runoff replenishes the reservoir during the next spring melt period.

Growth forecasts for the City, as well as changing climatic conditions, indicate that the existing reservoir will not be able to supply sufficient water over the long term to meet growing demands. According to the City's General Plan it is understood that the City's population number is estimated to reach approximately 8,300 by 2014, which, according to work completed by Trow (2004), would slightly exceed the number that could be serviced following 1:100 year return low precipitation conditions.

Based on a number of different water supply alternatives investigated in 2004 (Trow 2004), the preferred water supply solution has been identified as a combination of increasing storage in the reservoir in order to capture and store a greater proportion of watershed runoff while supplementing any residual requirements by pumping to the reservoir from the nearby Niaqungok (Apex) River during the ice-free period. Although the height of the dam was increased by two meters in 2006 to provide capacity for longer-term storage within the reservoir, the water supply supplementation option (currently in the preliminary design phase) will also need to be realised in order to meet water supply requirements in the near future. Moreover, the success of the water supply supplementation option is likely to hinge on the ability to forecast the annual water supply deficit and the amount of seasonal surplus that can be withdrawn from the nearby Apex River.

As part of this assessment, the water balance work completed in 2004 (Trow 2004) is to be refined using hydrometric information collected by the Water Survey of Canada (WSC) since 2007 in order to provide more accurate water balance estimates with which to determine the range of potential basin yields that could be expected from the Lake Geraldine watershed. The derived basin yields will subsequently serve to establish the timing and magnitude of refill requirements for the reservoir over a range of climatic conditions. In addition, the report will provide the necessary technical information in support of the City's Type A water license renewal application to the Nunavut Water Board (NWB) and allow the City to address its future water supply requirements.

1.2 Assessment Purposes

There were two purposes associated with the Lake Geraldine water balance assessment:

1) The primary purpose was to provide the City with an understanding of potential long-term supplementation requirements to support their NWB supplementary source license application.

2) The second purpose of this assessment was to develop a Water Supply Forecasting and Management Tool that would allow the City to forecast its short- and medium-term water supplies in order to predict potential supplementation requirements and/or water conservation measures.

1.2.1 Determination of Long-Term Supplementation Requirements

A reliable determination of annual supplementation requirements requires that the updated water balances consider the full range of historic meteorological conditions based on data available from nearby Environment Canada meteorological stations. It is also important to account for potential effects associated with climate change. It is anticipated that low basin yields from the Lake Geraldine watershed will likely coincide with lower than average flows in the Apex River, meaning that the sensitivities of this particular source will need to be fully understood to support the City's water license application process. The Department of Fisheries and Oceans, Department of Lands and Development as well as the nearby community of Apex will likely comprise key interested parties.

1.2.2 Development of a Water Supply Forecasting and Management Tool

In addition to providing important technical input to the NWB process, the ability to forecast basin yields will also allow the City to plan for supplementation requirements each upcoming summer in a proactive manner. It is expected that the forecasting tool developed as part of this study would allow the City to input observed meteorological observations (from nearby Environment Canada stations) and residual reservoir levels before the onset of the spring melt period to develop an estimate of summer supplementation requirements to confirm whether sufficient water is available in the reservoir for the subsequent winter period. Any unanticipated conditions leading to potential water supply deficits can therefore be identified at an early point in time in order to address these in a timely manner. This latter aspect will be important for the City when it has to decide whether it can adequately augment reservoir supplies and/or, if necessary, impose water conservation measures on an annual basis to meet the City's needs.

1.3 Report Objectives

The specific objectives of this report are to:

1) Update previous water balance estimates for the Lake Geraldine Watershed using hydrometric data collected in the reservoir and water supply intake;

2) Quantify the potential implications of anticipated future climatic conditions on these water balance estimates;

3) Assess the effects of varying climatic conditions and water consumption rates on available water supplies;

4) Document the necessary information with which the City can inform its supplementary water supply design requirements and water license application process; and

5) Provide an outline for the use of the accompanying water supply forecasting and management tool.

2.0 METHODOLOGY OUTLINE

Golder adopted an approach that would generate long-term basin yield probabilities based on a range of climatic and water consumption scenarios. A water supply forecasting tool was developed to assist in predicting and, if necessary, providing possible steps that the City can take to address potential short-term water supply deficits.

Water supplies in the Lake Geraldine reservoir are the result of several underlying anthropogenic, meteorological and physiographic variables that can be numerically represented in the form of a water balance model. A sufficient representation of the meteorological and physiographic variables that determine the magnitude and timing of natural basin yields to the reservoir is required before anthropogenic effects (such as water consumption or supplementation) on water supplies can be quantified. Once the baseline natural basin yield regime has been established, the effects of anthropological variables can be retrospectively incorporated and quantified to address the purposes of the assessment.

Golder conducted an extensive review of available meteorological (precipitation, air temperatures, etc.) and hydrometric (reservoir inflows, reservoir levels, water takings) data for the Lake Geraldine watershed (detailed in Section 3) to develop the information database to support the study approach. The best available representation of hydrometric and corresponding meteorological conditions was largely limited to the period between July 2007 and May 2010. Development, calibration and validation of the Lake Geraldine water balance model therefore had to explicitly focus on this timeframe, recognising that water takings recorded by the City on a daily basis would need to be accounted for throughout.

2.1 Development of Calibrated Water Balance Model

A calibrated water balance model of the Lake Geraldine watershed was developed by comparing the net effects of meteorology, catchment physiography, reservoir storage capacity and daily water consumption on predicted water supplies/reservoir levels to observed data collected by the Water Survey of Canada. This calibrated model can then be used to simulate the underlying mechanisms that affect water supply.

Using an iterative calibration approach, model performance over the selected calibration period (July 26 2007 to July 25 2008) was progressively improved by modifying underlying water balance variables (see Section 4.7) until the model could suitably predict the timing and magnitude of observed changes in observed reservoir levels. The model was then validated against observed reservoir levels for the selected validation period (July 26 2008 to July 25 2009) to demonstrate that model setup had suitably captured underlying water balance mechanisms and was therefore capable of predicting basin yields and reservoir supplies resulting from a separate set of meteorological conditions.

2.2 Determination of Long-Term Water Supplies

The calibrated and validated water balance model was used to simulate daily water balance conditions within the Lake Geraldine watershed for each of 49 selected years (deemed adequate for the purposes of this assessment as discussed in Section 3.2). Factors such as daily water consumption, available reservoir storage and supplementation rates, which could each conceivably vary independently according to future population growth, as well as reservoir modifications or supplementation from the secondary water source, were not incorporated in the simulation so that natural long-term annual basin yields could be derived.

Daily basin yields, daily snowmelt and daily rainfall runoff, as well as freeze and thaw dates (proxies for delineating winter and summer periods), were extracted for each of the 49 years. The distributions for each parameter based on the historic data could then be used to predict daily basin yield and winter duration probabilities within the range examined to generate a daily quantification of long-term water supplies under historic meteorological conditions.

Simulations were also carried out to quantify the potential effects of climate change corresponding to predicted meteorological conditions for medium-term (2050s) and long-term (2080s) climate regime. In order to provide the appropriate meteorological input data, historic meteorological conditions were modified to account for monthly average changes in temperature (Δ-temperature) and precipitation (Δ-precipitation) between historic and predicted future climate regime. Distributions corresponding to the parameters for the 2050s and 2080s climate regime were examined and used to generate a daily quantification of long-term basin yields in a manner similar to the historic water balance simulations.

2.3 Determination of Long-Term Supplementation Requirements

A range of nominal daily consumption values ranging from 1,200 m^3/day to 16,800 m^3/day, each reflecting a combination of population equivalence forecasts (present day and 2050 under a high growth projections) and anticipated per capita consumption rates (low and high per capita consumption rates, respectively), were calculated to represent the potential future daily water supply demands that may be encountered. Water supply shortfalls (magnitude and duration) for any combination of meteorological probabilities and water consumption value could then be predicted from the maximum available storage capacity of the reservoir on any given day and applying the range of nominal water consumption rates to the previously-generated basin yield predictions . These results could also be used to determine under what future conditions consumption rates would conceivably exceed the over-winter storage capacity of the reservoir, irrespective of supplementation.

The derived results therefore provide the City with a quantification of potential water supply and supplementation issues to consider over the long-term, while providing the necessary information regarding the magnitude and timing of supplementation upon which to base their NWB Water Taking application in the short-term.

2.4 Water Supply Forecasting Tool

As previously noted, the City will need to deal with short- to medium-term water supply issues (which can be more immediately addressed by implementing interim water conservation and/or planning for supplementation volumes required over the subsequent summer) and longer-term water supply issues (which need to consider the sufficiency of available supplementation supplies and existing storage volumes in the context of future population growth).

Using the model output as a basis, a water supply forecasting tool was developed to allow the City to forecast potential short- and medium-term water supply issues (coinciding with the days before the spring melt period of the next and subsequent winters) each winter according to present-day conditions.

Present-day conditions, including existing reservoir levels and anticipated daily consumption rates, are updated by the user on a forecast-by-forecast basis. In addition, the user is prompted to update the tool with recent meteorological information (specifically covering the current winter period to date) in order to quantify the volume of snow (in water equivalence) that is currently stored within the watershed.

Once the tool has been updated to reflect present-day modifiers, the probabilities of basin yields and thaw and freeze dates are used to forecast a range of potential water supply outcomes. Where a water supply deficit is identified (see example Figure 11), the forecasting tool output quantifies the corresponding duration without water that would be encountered if supplementation does not occur, the volume of supplementation required in order to meet anticipated demand, and the most suitable period during which supplementation can occur as a function of available reservoir storage (to avoid overtopping, for example).

3.0 DATA REVIEW

Several sources of existing data were reviewed to develop the water balance model. Golder primarily sourced data from the City of Iqaluit, Water Survey of Canada and Environment Canada.

3.1 City of Iqaluit

Golder obtained the following data from the City of Iqaluit:

- Partial topographic data of the Lake Geraldine watershed (City of Iqaluit, 2012);
- Partial surficial geology of the Lake Geraldine watershed (City of Iqaluit, 2012);
- A delineation of the Lake Geraldine watershed (City of Iqaluit, 2012);
- Lake Geraldine Bathymetry (Post-dam extension) (Natural Resources Canada, 2008);
- Daily intake withdrawal rates from Lake Geraldine (2007 to 2012) (City of Iqaluit, 2012);
- Lake Geraldine Spillway configuration (Pre- and Post-dam extension) (Trow, 2006); and
- Lake Geraldine intake configuration (Natural Resources Canada, 2008).

3.1.1 Watershed Topography

Topographic data was used to confirm a delineation of the Lake Geraldine watershed generated by Environment Canada (See Section 3.1.3). The topographic elevation data was of relatively high resolution (1 m interval) and covered approximately 85% of the full extent of the watershed, with topographic information unavailable in the northwestern portion of the catchment.

3.1.2 Surficial Geology

Surficial geological information was used to infer soil storage characteristics and water holding capacities in different areas of the watershed. The available coverage for the surficial geology mapping was found to be consistent with the associated extents of the topographic data (i.e. 85% of the catchment), but was relatively detailed, describing the areas of till veneer, till blanket and bedrock outcrops within the catchment. In order to assign water holding capacities over the catchment as a whole, the distributions of surficial geology types for the missing 15% of the catchment were assumed to correspond to those in the remaining catchment.

3.1.3 Watershed Delineation

The watershed delineation was found to be in close agreement with the topographic data (where comparison was possible). The delineation included 49.6 ha not included in the topographic and surficial geology data. Although there was no way to confirm the accuracy of the watershed delineation in this area of the watershed, the watershed delineation was assumed to be correct given its good agreement where overlap existed.

3.1.4 Bathymetry

Reservoir bathymetry provided by the City was used to determine the stage-storage relationship to generate lake levels from modelled volumes. The lake bathymetry provided a detailed characterisation of lake geometry at depth intervals of 1 m. This data unfortunately only reported measurements up to an elevation of 109.6 metres above mean sea level (m asl), while the new spillway has been increased to 111.3 m asl. To generate a bathymetric representation above 109.6 m asl (the limit of the existing data), the reservoir geometry was extrapolated from 109.6 m asl (water level at time of data collection) to 111.3 m asl (crest of the spillway) to account for the increased surface area of the basin at higher elevations (see Figure 2). Due to the geometry of the lake a portion of the lake's volume is inaccessible for water takings because of the location on the intake pipe relative to deeper portions of the lake.

3.1.5 Intake Withdrawal Rates

Daily water consumption volumes between 2007 and 2012 were also received from the City, which were useful to confirm the effects of water consumption on reservoir levels over this period.

Table 1: Summary of Daily Intake Withdrawal Rates 2007 to 2012 for Lake Geraldine Reservoir

Year	Daily Water Consumption Rate (m^3/day)		
	Minimum	**Average**	**Maximum**
2007	1,230	2,460	4,410
2008	1,020	2,540	5,180
2009	1,060	2,460	3,830
2010	1,200	2,400	3,830
2011	1,350	2,300	3,480
2012	980(1)	2,380	9,500

Notes:

1. No water takings were reported for three days within 2012; as such, the lowest non-zero value is presented.

3.1.6 Spillway Configuration

Proposed engineering drawings of the spillway extension by Trow (2004) were made available to Golder, detailing the geometry for the purposes of deriving updated storage levels. The configuration of the updated spillway was used to model the maximum storage volumes of Lake Geraldine. The spillway geometry was also used to simulate potential losses via the lake outlet.

3.1.7 Intake Configuration

The Lake Geraldine intake is briefly described in Trow (2004). The report describes the elevation of the intake pipe, however, it does not detail whether this measurement refers to the pipe invert or obvert. For the purposes of this assessment, water below an elevation of 101.6 m asl, corresponding to the maximum depth at which the intake can withdraw water from the rest of the lake, was therefore assumed to comprise dead storage and be unavailable for consumption. It should be noted that any deviances from this assumed and the actual invert elevation should therefore be carefully considered in the context of the availability of projected water supplies.

3.1.8 Projected Population Growth and Anticipated Effect on Water Demand

Population projections from the City of Iqaluit General Plan (2010) were used to forecast potential increases in future water consumption. The City of Iqaluit General Plan provides population forecasts to 2030 under three growth scenarios (high, medium and low). For the purposes of this assessment, Golder used the high growth scenario given that this would likely provide a conservative estimate of long-term water demands.

3.2 Environment Canada

The water balance model requires a number of meteorological parameters in order to estimate the water balance surpluses draining to the Lake Geraldine reservoir. The required meteorological parameters are:

- Temperature;
- Precipitation;
- Barometric Pressure;
- Relative Humidity;
- Incoming Solar Radiation; and
- Wind Speed.

Meteorological data were obtained from four Environment Canada (EC) monitoring stations in the area of Iqaluit as presented in Table 2.

Table 2: Available Environment Canada Meteorological Station Records in the Vicinity of Iqaluit

Station Name	Period of Record	Measurement Resolution	Missing Model Inputs(1)
Iqaluit A (2402590)	1946 to Present	Hourly, Daily and monthly	1946 to 1957, 1994 to 1999, 2007, 2009, 2010
Iqaluit UA (2402594)	1997 to Present	Daily and Monthly	Multiple Days between 2007 and 2012
Iqaluit Climate (2402592)	2004 to Present	Hourly, Daily and Monthly	Multiple Days between 2007 and 2012
Iqaluit AWOS (2402591)	2008 to Present	Hourly and Daily	2008 to 2012

Notes:

1. Missing model inputs indicates one or more parameters crucial to the model input are missing from available record. Simulation years removed include July 1946 to July 1958, July 1992 to July 1993, July 1996 to July 1997 and July 2009 to July 2011.

Iqaluit A has a few periods of missing data but overall provides the best long-term meteorological data series for Iqaluit. Precipitation data are missing since 2008. Estimates of these missing data were made using the data from one or more of the remaining three stations, noting that even these stations had periods of missing precipitation records themselves.

While supplementing missing precipitation data at one station with that collected at another is not standard practice and generally discouraged when orographic, rain-shadow and other effects cannot be accounted for properly, this approach was deemed reasonable and necessary for the purposes of this assessment for three reasons:

i) It allows the water balance model, despite being calibrated against recent meteorological conditions, to be used to represent longer-term historic water balance conditions only available for Iqaluit A;

ii) All stations are located within very close proximity (0.5 km) of each other and should therefore reflect similar meteorological conditions; and

iii) It provides the necessary meteorological data to complement available reservoir level and water consumption data.

3.3 Water Survey of Canada

Hydrometric data, including reservoir inlet flows and reservoir water levels, were obtained from the Water Survey of Canada (WSC) stations (10UH012) and (10UH013), respectively. This data included continuous water level data, manual water level data and measured flows (at inlet location only). The recorded water level data allowed for a comparison of the water balance model outputs to measured values. Water level data from Lake Geraldine included hourly data from July 2007 to October 2012, thus providing a continuous quantification of reservoir levels.

The data from the Lake Geraldine inlet stream (10UH012) included continuous water level data (surveyed to a local datum) and manual stream flow measurements from July 2007 to October 2012. Manual flow measurements, as well as cross-sectional depth and velocity readings, were collected several times throughout the monitoring period, although the latter readings were not consistently taken from the same location (presumably due to access and safety conditions). Manual water level readings were also provided from the time of the flow measurements, which appeared complete and were in most cases accompanied by field notes. A few photographs of the inlet stream monitoring location were also provided.

4.0 METHODOLOGY

The following section details the methods used to undertake the Lake Geraldine water balance assessment, specifically the approach used to quantify long-term water supplementation requirements and short-term water supply forecasts using the data discussed in Section 3.

The water balance model used meteorological data to estimate rainfall-runoff and snowmelt yields from the watershed. Surficial geology and catchment information from the watershed was used to characterise soil storage and water holding capacities for the watershed as a whole. Stage–storage relationships were developed for Lake Geraldine using the bathymetry data. The City's water takings were based on the daily intake records provided by the City. Utilizing these model inputs the water balance could estimate reservoir levels over time.

WSC monitoring data for the reservoir were used to confirm the water balance model performance by comparing measured reservoir levels with model outputs.

4.1 Development of Lake Geraldine Inflow Representations

Inflows to Lake Geraldine have been monitored by WSC since 2007 by means of automated continuous water level measurements and intermittent manual flow measurements. The WSC-measured flows ranged from 0.004 m^3/s to 0.205 m^3/s. A continuous flow record of inlet-measured flows was generated after the existing stage-discharge relationship was extended by Golder using the United States Army Corps of Engineers (USACE) HEC-RAS model. Initially, the cross-sectional geometry of the reservoir inlet recorded during each manual flow measurement was merged with local topographic data and used as a basis for developing a cross-sectional representation of the inlet channel geometry. The HEC-RAS model was then calibrated using the manual flows and corresponding water levels collected by WSC. Lastly, HEC-RAS was used to extend the stage-discharge curve to cover the range of observed water levels. The new stage-discharge curve was then used to develop a continuous flow record from the continuous water level record. The continuous flow record was initially used to provide an indication of inflows to the Lake Geraldine water balance, recognising that differences in the temporal resolution of modelled and observed inflows would result in some differences.

4.2 Development of Reservoir Stage-Storage Relationships

The bathymetric data provided to Golder differed slightly from previous stage-storage relationships published in Trow (2004). Given that the bathymetric data had been collected relatively recently (summer of 2008) and was provided with the accompanying Description of Watershed Outline and Water Depth Survey Datasets from Geraldine Lake (Natural Resources Canada, 2008), Golder generated a stage–storage relationship using ERSI 3-D Analyst in order to more accurately estimate reservoir storage (see Figure 2). The ESRI 3-D Analyst generated numbers were verified by repeating the process in Auto-CAD.

The updated stage-storage relationship, presented in Table 3, was used to represent reservoir storage within the Lake Geraldine water balance model.

Table 3: Stage-Storage Representation of Available Water Supply in Lake Geraldine Reservoir

Elevation (m asl)	Depth (m)	Volume (m^3)
111.3	0	1,890,000
110.3	1	1,582,000
109.3	2	1,285,000
108.3	3	1,011,000
107.3	4	770,000
106.3	5	562,000
105.3	6	388,000
104.3	7	250,000
103.3	8	141,000
102.3	9	55,000

4.3 Effects of Lake Ice Formation on Reservoir Storage

Ice formation on Lake Geraldine throughout the winter affects the active storage capacity of the reservoir because the ice cover stores a portion of the available water supply, making the water unavailable for consumption during the winter. At the end of the winter, the lowest available reservoir supply also coincides with the maximum thickness of ice, therefore exacerbating the water supply issue during this period.

In order to account for this temporary loss in water supply, lake ice volumes (and commensurate water supplies) were estimated by using the monthly ice depths presented in Trow (2004) to represent ice thicknesses for a median (i.e. 50th percentile) winter duration. The total lake ice depths were applied over the surface area of the lake to determine ice volumes. The ice volumes were then converted into water volumes by comparing water and ice densities (1:0.917).

To account for differences in the ice thickness of shorter and longer winter periods, median ice volumes were adjusted according to the difference between the median duration winter during the historic climate regime and that of the winter under examination (i.e. this process was repeated for every winter duration probability to account for the effects of winter duration on ice thickness).

As such, the reservoir volumes unavailable for consumption at the end of winter could be determined for any number of different winter duration scenarios.

4.4 Development of Projected Water Consumption Estimates

The population projections provided in the City of Iqaluit General Plan 2010 report suggest a high projection of 14,625 residents by 2030. The high projection was extended to 2050 to an estimated population of 28,000 for the purposes of this study. Based on the daily intake withdrawal rates provided by the City for the 2007 to 2012 period, the average daily water consumption is approximately 2,400 m^3, which is equivalent to a consumption rate of 0.3 m^3/day/person (Iqaluit 2013, *pers. comms*). The future water taking projections are presented in Table 4 using the high (i.e. conservative) population projection and several per capita consumption rates. It should be noted that the City's design consumption rate of 0.4 m^3/person/day was subsequently adopted for the purposes of this assessment to provide a reasonable, yet conservative, representation of water consumption.

Table 4: Projected Water Consumption Rates for City of Iqaluit based on Available Population Growth Estimates

Year	Population (High Projection)	Total Daily Water Consumption (m^3)			
		0.3m^3/person/day	0.4m^3/person/day[1]	0.5m^3/person/day	0.6m^3/person/day
2005	6000	1800	2400	3000	3600
2012	8000	2400	3200	4000	4800
2019	10000	3000	4000	5000	6000
2024	12000	3600	4800	6000	7200
2029	14000	4200	5600	7000	8400
2033	16000	4800	6400	8000	9600
2037	18000	5400	7200	9000	10800
2040	20000	6000	8000	10000	12000
2043	22000	6600	8800	11000	13200
2045	24000	7200	9600	12000	14400
2048	26000	7800	10400	13000	15600
2050	28000	8400	11200	14000	16800

Notes:

1. 0.4m^3 per person per day corresponds to the City's design consumption rate.

4.5 Development of Water Balance Model

Development of the water balance model was predicated on the assumption that if it could suitably replicate observed precipitation surpluses (i.e. reservoir levels) for the calibration period (during years when water level records were available) it would also be suitable for predicting precipitation surpluses over longer-term historic and future meteorological conditions.

Due to the data gaps in the meteorological records of the Environment Canada stations in Iqaluit over the modeling period, the model utilizes multiple stations to maximize the information from the available data. The model input is predominantly from Iqaluit A because of the availability of significant complete records (1957 to 1992, 1993 to 1996, 2001 to 2006). However, the calibration and validation period (2007 to 2009) was largely populated with information available from the Iqaluit UA and Iqaluit Climate stations.

4.5.1 Water Balance Methodology

The total amount of surface water that flows from a particular discharge point is a function of how much water is gained and lost in the upstream catchment area. Total precipitation (rainfall and snowmelt) represents the input to the system, while evapotranspiration (mainly during above-zero temperatures), sublimation (mainly during sub-zero temperatures) and soil storage (during frost-free periods) represent losses from the system. When inputs exceed losses, net precipitation (or surplus) is available in the form of runoff. Infiltration was not considered for this assessment because, based on information on the geology of the catchment, it likely accounts for a negligible amount of the surplus and likely resurfaces at the reservoir.

The water balance characterisation can be simplified as follows:

(Rainfall + Snowmelt) – (Evapotranspiration + Sublimation) – Change in Soil Storage = Surplus (Runoff and/or Infiltration)

The various water balance components associated with rainfall catchments are typically presented in millimetres (mm) over their respective catchment areas, and represent the amount of water generated per unit of watershed area. The two forms in which net precipitation (net snowfall accumulation or rainfall runoff) can be generated differ considerably in terms of the rate at which they are delivered to the reservoir and, hence, become available for consumption. While reservoir inputs from rainfall runoff are delivered relatively quickly following a precipitation event, net snow accumulation is generally stored within the watershed until sufficient warming can melt the snow within the watershed and the ice overlying the reservoir at the onset of spring.

4.5.2 Water Balance Inputs

Meteorological inputs to the system include rainfall and snowfall. Depending on the meteorological (evaporation or sublimation rates) and physiographic (available soil storage) conditions at the time of precipitation, a portion of these inputs is subsequently lost to atmospheric sinks (see Section 4.5.3) in order to derive net surplus (basin yields).

4.5.2.1 Rainfall

The water balance model is provided with total precipitation values and, depending on the associated temperatures, the precipitation is treated as either rainfall or snowfall. In this assessment, rainfall in the model provides inputs to storage and runs off instantaneously. For this reason, rainfall-generated runoff (denoted as rainfall runoff in the report) simulated by the model may appear more abrupt than measured system responses.

4.5.2.2 Snowfall

Snow is a major component, if not the primary consideration of the hydrological cycle in an arctic environment (Dingman, 1973; Kane et al., 1991, Woo et al., 1983), and the subsequent spring snowmelt greatly affects the hydrology of permafrost areas (Church 1974; Kane et al., 1991).

Due to the open terrain, limited shelter and characteristically high winds across the region, arctic snow cover experiences significant redistribution. As a result, snow cover depth and snow water equivalent (SWE) are highly variable. Yang and Woo (1999) noted that most of the snow drifted into sheltered gullies and valleys and snow cover was generally shallow on exposed terrains, including rolling uplands, plateaus and lakes. Snow surveys at two sites showed that rolling hills in the area also develop snow accumulations as much as 65% greater than average on lee slopes of only 2 to 3 degrees.

Iqaluit Airport is believed to be located in a relatively open, wind-swept area, which may report snow depths lower than those in neighboring valleys or sheltered areas. For this reason, the snow depths or snow accumulations in the Lake Geraldine watershed are estimated to be greater than those recorded at the Iqaluit A station. As snow depths may be variable from one catchment to another, it is difficult to estimate snow accumulation in a catchment without watershed-specific information. Therefore, it is necessary to account for differences in snow accumulation on a catchment specific basis. The methods employed to address this issue are detailed in Section 4.7.1.1.

4.5.3 Water Balance Losses

Losses from the watershed system include evapotranspiration (ET) and sublimation. However, soil storage components within the catchment (depending on antecedent conditions) may intercept a component of the rainfall and snow melt inputs, thus making them unavailable to the reservoir.

4.5.3.1 Soil Storage

The Water Holding Capacity (WHC) represents the total amount of water that can be stored in the soil and is defined as the water content between the field capacity and wilting point (the practical maximum and minimum soil water content, respectively). WHCs are specific to the soil type and land use, whereby values of 50 mm for very shallow rooted vegetation over sandy loam are a reasonable representation for arctic environments.

Surplus water remains in the system after actual ET has been removed (ET demand is met) and the maximum WHC is exceeded (soil-water storage demand is met). The surplus can be further allocated to runoff or infiltration and is largely dependent on catchment conditions (i.e. land use and soil characteristics/properties). Some infiltrated water will be conveyed laterally in the near-surface soil layers as interflow and can re-surface at a point further down-gradient or report directly to a watercourse. It is assumed that any interflow in the Lake Geraldine watershed reports back to the reservoir.

4.5.4 Potential Evapotranspiration (PET)

The potential or maximum ET is estimated by the empirical Modified Penman-Monteith equation and represents the amount of water that would be evaporated or transpired under saturated soil-water conditions. The actual ET is the total evapotranspiration for the period of study estimated from evapotranspiration demand, available soil-water storage, and the rate at which soil water is drawn from the ground (as defined by an established drying curve specific to the soil type). The ET process is largely ineffective during the winter months and a standard rate of sublimation was instead adopted during these periods.

The Modified Penman-Monteith approach was developed to estimate water budgets for agricultural lands, intended largely for the use of irrigation. Therefore, when applying the Modified Penman-Monteith equation to different climatic and geological regions (i.e. arctic areas, mixed or conifer dominated forests, etc.) an adjustment factor is usually needed. The methods employed to address this issue are described in Section 4.7.1.2.

4.5.5 Sublimation

Due the long winter period in the region, sublimation represents a significant loss of moisture from the system. Although watershed topography varies, causing localised snow accumulation in some parts of the watershed, the catchment is largely exposed to solar radiation and wind due to the lack of significant vegetation. Since a determination of actual sublimation rates would need to be based on a comprehensive range of site-specific data (not available for this assessment), Golder estimated sublimation rates for the catchment as one unit. Literature estimates for suitable sublimation values in artic or alpine areas can account for as much as 15% to 22% of the total annual snowfall (Liston and Sturm, 1998 and Hood et al., 1999). Ohmura (1982) found that sublimation increased from a low of 0.03 mm/day in late April to 0.6 mm/day on the last days of the dry snow period at a site on Axel Heiberg Island. In one instance, sublimation losses reported on Devon Island were over one-quarter of the snow cover (Ryden, 1977). Variation of sublimation estimates were examined in exposed and sheltered areas (Reba et al., 2011), revealing sublimation rates averaging approximately 0.3 mm/day. Using catchment information combined with these estimates the daily sublimation rate of 0.3 mm/day was applied for winter periods (during times when snow cover was present).

4.6 Development of Future Climate Variables

In keeping with accepted climate practices, the description of historic climate was based on the 30-year period from 1971 to 2000 (broadly coinciding with the 1957 to 2009 period used to represent historic conditions in this assessment). The climate regime from this period was compared to the climate change projections to assess the significance of the potential change.

4.6.1 Generic Approach

Climate forecast data for Iqaluit (i.e. for the appropriate GCM grid square) were extracted from the CCCSN website (http://www.cccsn.ec.gc.ca/, accessed January 13th, 2012) for all available GCMs (24) and the three forecast scenarios (A1B, A2 and B1 – detailed in Section 4.6.2), and were summarized for magnitude of change from the climate regime baseline for the following two time horizons:

- 2041 to 2070 (denoted as 2050s); and
- 2071 to 2100 (denoted as 2080s).

In order to graphically represent the individual model output in a comparable and meaningful way, the data must have a consistent baseline. For each model, the change in temperature and precipitation was calculated relative to the respective modelled baseline values, which are unique to each model. This change was then imposed onto the historic climate baseline for Iqaluit.

4.6.2 Projected Climate Scenarios (A1B, A2, B1)

Global climate models require extensive inputs in order to characterize the physical processes and social development paths that could alter climate in the future. In order to represent the wide range of the inputs possible to global climate models, the IPCC have established a series of socio-economic scenarios that help define the future levels of global GHG emissions. The IPCC identifies many scenarios but this report focuses on three, namely, A1B, B1, A2.

The A1B and A2 scenarios represent a focus on economic growth while the B1 scenario represents a shift towards more environmentally conscious solutions to growth. Both scenarios A1B and B1 include a shift towards global solutions while the A2 scenario includes growth based on regional models.

These three socio-economic scenarios have been described more fully by the IPCC in their Special Report on Emission Scenarios (SRES) (Nebojsa and Swart, 2000). Although the IPCC has not stated which of these scenarios are most likely to occur, the A2 scenario most closely reflects the current global socio-economic situation. In relation to the A2 scenario, scenarios A1B, B1 result in lower long-term GHG emissions over the next century. Of the A1 scenario, A1B yields high emissions in the first half of the 21st century due to increasing population and high dependence on fossil fuels for energy.

Most GCMs (not all) produce the following three SRES emission scenarios put forward by the IPCC:

Scenario A1B — The A1 family of scenarios describes a future world of very rapid economic growth, a global population that peaks mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A1 family includes three groups of scenarios that describe alternative directions in the energy system. The A1B group is distinguished by a balance across all sources of energy – green and fossil.

Scenario A2 — The A2 scenario family describes a world with an underlying theme of self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is regionally oriented and per capita economic growth and technological change more fragmented and slower than for other scenarios.

Scenario B1 — The B1 scenario describes a convergent world with the same global population that peaks mid-century and declines thereafter (similar to the A1 scenarios). The B1 scenarios have rapid change in economic structures toward a service and information economy, with reductions in raw material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

4.6.3 Discretization of 2050 and 2080 Climate Scenario Variation

The following tables and figures summarize the magnitude of model-predicted changes during the 2050s and 2080s from the historic climate scenario. Figures 3 and 4 depict the monthly mean projected temperatures in Iqaluit for all future projections for the 2050s and 2080s. The figures also show a dashed line, which represents the mean of all the modelled projections. The solid line in the figures represents the monthly observed climate scenario based on data from 1971 through to 2000. The figures show a noticeable increase between the historic and projected monthly temperature means.

Figures 5 and 6 present the monthly mean projected precipitation in Iqaluit for all future projections for the 2050s and 2080s. Figure 5 shows a noticeable difference between the projected and historic monthly precipitation means for late summer. In Figure 6, the noticeable difference shifts from the late summer to fall. The remaining months are comparable between the projected and historic monthly means for both figures.

The difference between the historic climate scenario and the projected mean for the 2050s and the 2080s is shown in Tables 5 and 6. Overall, the model projected means are greater than the observed climate regime, showing an increase in both temperature and precipitation. The largest differences in temperature are during the colder months (December through March), with the smallest difference during the warmer months (May through August). For precipitation, the largest differences are during the late summer and fall (July through September/October).

Table 5: Model Projected Mean and Historic Climate Scenario in Iqaluit for the 2050s

Month	Temperature [°C]			Precipitation [mm (equivalent)]		
	Historic Climate Scenario[1]	Projected Mean	Difference	Historic Climate Scenario[1]	Projected Mean	Difference
January	-31.90	-26.89	5.01	7.32	8.78	1.46
February	-31.30	-27.64	3.66	7.10	8.05	0.95
March	-26.73	-23.43	3.31	10.15	11.66	1.51
April	-17.28	-14.63	2.65	13.79	15.34	1.55
May	-5.75	-4.11	1.64	15.24	16.72	1.48
June	4.80	6.66	1.87	24.05	24.72	0.67
July	11.22	12.78	1.56	42.88	45.90	3.02
August	9.44	10.90	1.45	46.76	51.99	5.23
September	2.52	4.20	1.68	43.59	49.72	6.13
October	-7.54	-5.15	2.39	31.22	34.00	2.79
November	-19.83	-15.85	3.98	16.61	19.05	2.44
December	-28.01	-22.45	5.57	9.80	11.97	2.17

Notes:

1. Refers to historic climatic conditions for the 1971 to 2000 period.

Table 6: Model Projected Mean and Historic Climate Scenario in Iqaluit for the 2080s

Month	Temperature [°C]			Precipitation [mm (equivalent)]		
	Historic Climate Scenario[1]	Projected Mean	Difference	Historic Climate Scenario[1]	Projected Mean	Difference
January	-31.90	-24.34	7.56	7.32	9.97	2.65
February	-31.30	-25.46	5.84	7.10	8.69	1.59
March	-26.73	-21.71	5.02	10.15	12.45	2.30
April	-17.28	-13.32	3.96	13.79	16.41	2.62
May	-5.75	-3.32	2.43	15.24	16.98	1.74
June	4.80	7.59	2.80	24.05	25.23	1.18
July	11.22	13.64	2.42	42.88	47.13	4.25
August	9.44	11.64	2.19	46.76	53.88	7.12
September	2.52	5.12	2.60	43.59	52.01	8.42
October	-7.54	-3.62	3.92	31.22	36.92	5.71
November	-19.83	-13.79	6.04	16.61	20.81	4.20
December	-28.01	-20.27	7.74	9.80	13.12	3.31

Notes:

1. Refers to historic climatic conditions for the 1971 to 2000 period.

4.6.4 Application of Climate Variation Scenarios

The forecasted climate scenario variations, included in Tables 5 and 6, were applied to the historic meteorological record. The data from both climate scenarios were used to modify the historic recorded data using with the same method.

The temperature differences for each of the climate scenarios are added to the historic temperature record on a monthly basis. Therefore, each day of each specific month is increased or decreased by the temperature difference associated with the specific month for the associated climate scenario.

The change in precipitation is also detailed on a monthly basis, presenting the total precipitation difference for each month for the given climate scenario. For simplicity, the prorated monthly differences were equally applied to each day of the month to account for the total monthly change for each scenario.

All other meteorological parameters remained unchanged from the historic data set.

4.7 Calibration/Validation of Water Balance Representations

The purpose of the model calibration/validation exercise was to optimise the accuracy of simulated mechanisms affecting the prediction of reservoir levels and, hence, the availability of water supplies.

Due to the limited availability of continuous precipitation records for the period (2007 to 2011) coinciding with available WSC hydrometric and City of Iqaluit water consumption records, the Lake Geraldine watershed water balance model calibration/validation exercise had to be focused on only two discrete annual periods: July 26 2007 to July 25 2008 for calibration and July 26 2008 to July 25 2009 for validation. Although these years have short periods of missing precipitation records (see Table 2), they provide the most reliable means of representing precipitation between 2007 and 2011. A third period (July 26 2009 to July 25 2010) is shown for comparative purposes with commentary on divergences in predicted and observed levels resulting from an under-representation of precipitation.

Using an iterative calibration approach to gradually improve representation of the calibration parameters (see Section 4.7.1), model performance over the calibration period was progressively improved until the magnitude of predicted and observed reservoir levels were suitably matched and the model could independently predict water levels for the validation period and, thus, be regarded as ‘suitable for purpose’.

4.7.1 Calibration Parameters

Two calibration parameters, the snowfall correction factor and potential evapotranspiration, were selected for the purposes of improving model performance. Given their temporal and spatial variation, in-field measurements for both parameters are difficult to apply over a watershed-scale area or prolonged timeframe in a representative manner.

It has been documented (Yang and Woo, 1999; Woo et. al. 1999) that artic snowfall measurements collected at airport-based meteorological stations can significantly under-represent snowfall amounts in the rest of the watershed and therefore require application of a ‘correction factor’ in order to provide a more suitable representation of snowfall for the watershed as a whole. Similarly, theoretical or even empirical evapotranspiration measurements available from literature sources are not always appropriate for transposition into different watersheds and therefore need to be determined from back-calculation.

Accordingly, potential differences in actual and representational values for both parameters frequently can be, and need to be, resolved through the calibration process.

Model performance was judged based on the difference between observed and predicted water levels following snowmelt and at the time of reservoir freeze-up. Although quantification of the differences between observed and predicted values was also evaluated throughout the simulation periods as a whole, this was regarded as a secondary model performance indicator, being less significant to the prediction of available water supply at key points in time than the former two factors.

4.7.1.1 Snowfall Correction Factor

To compensate for differences between snowfall recorded at Iqaluit Airport and the watershed as a whole (see Section 4.5.2.2), the snowfall correction factor (predicted actual ÷ airport measured) was progressively increased over several iterations of model calibration until the predicted increases in reservoir levels following the spring melt period corresponded to those observed in the WSC data. Following this process, the optimum snowfall correction factor to account for differences in snowfall at the airport and in the watershed was identified as 1.2 times recorded snowfall.

4.7.1.2 Potential Evapotranspiration (PET)

To correct for observed differences between observed and predicted water level reductions during the ice-free period, PET was modified iteratively to obtain an optimum value that provides the best model performance for the calibration period. The calibrated PET value was identified as 0.65 times that of the calculated value presented in Section 4.4.4.

4.7.2 Calibration Results

The results of the calibration exercise discussed in the preceding subsections are presented in Table 7 and depicted on Figure 7.

Model output for the calibration period corresponded very well with observed water levels for the same year. Minor variations at the beginning and end of the simulation period are possibly due to small differences between precipitation events at Iqaluit Airport and the catchment as a whole and/or approximations in the model's mathematical procedures to represent hydrologic processes. These include particularly sensitive periods during rapid freeze/thaw cycles when rainfall runoff could be mistakenly represented as snowfall or vice versa. The slight over-prediction in water levels for the winter period (early September to April) is likely attributed to minor differences in modelled reservoir ice-formation and melt rates, notwithstanding the fact that water levels at the onset of freeze-up and thaw are very well matched (Table 7). The overall root mean squared (RMSQ) error over the year is less than 9 cm, suggesting a reasonably well calibrated model. At the intake level (elevation of 101.6 m asl), the 9 cm difference corresponds to an error of approximately 4,300 m^3.

Table 7: Lake Geraldine Water Balance Model Performance Statistics for 2007 to 2008 Calibration Period

Calibration Measure	Result
Pearson Correlation	0.99
RMSQ Error over Period	0.087 m
RMSQ Error before Freeze-Up	0.03 m
RMSQ Error before Spring Melt	0.02 m
RMSQ Error at end of Spring Melt	0.01 m

4.7.3 Validation Results

Following model calibration, a further simulation was carried out to examine whether the model was capable of independently generating reasonable predictions of water levels for the period July 26, 2008 to July 25, 2009. The resulting model error and model output are presented in Table 8 and depicted on Figure 8.

There are some notable differences in predicted and observed water levels during the early portion of the simulation period, which coincide with gaps in the Iqaluit A record that needed to be patched with records from the nearby Iqaluit UA station. Minor fluctuations in accuracy are again noted during the melt period, whereby net error during this period remains small and predicted and observed water levels are consistent by the time the spring melt period has finished. A summary of model error over the simulation period as well as during points of specific interest is provided in Table 8 below. The overall root mean squared error over the year is less than 25 cm, suggesting that the calibration was acceptable. At the intake level, this 25 cm difference corresponds to an error of approximately 12,000 m^3.

Table 8: Lake Geraldine Water Balance Model Performance Statistics for 2008 to 2009 Validation Period

Validation Measure	Result
Pearson Correlation	0.97
RMSQ Error over Period	0.25 m
RMSQ Error before Freeze-Up	0.36 m
RMSQ Error before Spring Melt	0.32 m
RMSQ Error at end of Spring Melt	0.16 m

An additional comparison is provided in Figure 9 that depicts predicted and observed water level variations over the July 26 2009 to July 25 2010 simulation period. Again, there are minor variations between observed and predicted reservoir levels at the onset of the period, which may reflect variations between actual and recorded precipitation and/or model approximations that simplify the watershed water balance processes. Ignoring the simulation results from May onwards, which are confirmed to have resulted from significant winter precipitation gaps, model performance is reasonably good and reflects a net root mean squared error of approximately 10.3 cm, or approximately 4,900 m^3.

4.7.4 Calibration – Validation Findings

The calibration-validation process, although constrained by the number of independent periods available due to a limitation of continuous precipitation records between 2007 and 2011, suggests that the model provides a reasonably good representation of meteorological surpluses and the times of the year when they are important for quantifying water supplies within the reservoir.

The process also demonstrates, as would be expected, that large gaps in precipitation records limit the successful application of the model in simulating basin yields to those years that have an adequate precipitation record.

A further finding is that instantaneous elevation differences between modelled and observed records, particularly during the summer months, may result from the modelled rates at which rainfall runoff is attenuated within the watershed and delivered to the reservoir. It is noted that these differences appear to be at a minimum at specific points of interest, namely; immediately before freeze-up, immediately before thaw and immediately following the spring melt period.

Notwithstanding these limitations and given the goals for its use, the model is considered fit for the purposes outlined in this report (Section 1.2).

4.8 Simulation and Representation of Historic Event Probabilities

4.8.1 Simulation of Screened Meteorological Years

Once the model was deemed suitably calibrated and validated, simulations of each of the 49 individual years selected through the screening process (see Section 2.2) were carried out specifically excluding the anthropogenic modifiers of water consumption via the intake, supplementary augmentation and any potential constraints associated with reservoir storage capacity. By focusing model output on the determination of daily watershed surpluses (in the form of snowmelt and rainfall runoff) as well as freeze and thaw dates only, any combination of potential water consumption, supplementary augmentation and/or residual reservoir storage scenarios could be retrospectively applied in order to predict the magnitude and timing of future water supplies.

4.8.2 Development of Long-Term Historic Database Representations

Having generated freeze and thaw dates, daily snow accumulation, and daily rainfall runoff volumes for each of the modelled years, snow accumulation and rainfall runoff yields were calculated based on the probability of them occurring over the full range of historic observations. It should be noted that the differentiation between daily snow accumulation and daily rainfall runoff was considered key for the purposes of predicting when basin yields would be delivered to the reservoir.

Average daily snow accumulation and average daily rainfall runoff yields were consequently calculated for each meteorological probability based on the number of ‘winter’ days occurring between corresponding freeze and thaw dates and the number of ‘summer’ days occurring between corresponding thaw and freeze dates. While this normalisation process necessarily eliminated the natural variability associated with individual storm events in different precipitation years, it allowed basin yields to be represented without undue complexity, recognising that water supply forecasts need not be geared to the prediction of individual, but cumulative, events occurring over each ‘winter’ or ‘summer’.

4.9 Simulation and Representation of Climate Change Event Probabilities

4.9.1 Simulation of Future Climate Representations

Modifying the raw precipitation and air temperature data employed for the purposes of simulating historic annual water balances to account for monthly changes in both parameters anticipated for the 2050s and the 2080s climate regime, water balance simulations for all 49 years were repeated to represent daily snow accumulation, rainfall runoff and freeze and thaw dates corresponding to the 2050s and 2080s regime.

4.9.2 Development of Long-Term (2050s) Future Climate Representations

Using the same approach outlined in Section 4.8.1, daily snow accumulation and rainfall runoff yields were generated for each probabilistic year according to corresponding freeze and thaw date probabilities and stored in a database representing water supply generation for the 2050s climate regime.

4.9.3 Development of Long-Term (2080s) Future Climate Representations

Lastly, the above process was again completed to generate daily water supply generation values under corresponding ‘winter’ and ‘summer’ conditions corresponding to the 2080s climate regime.

4.10 Probabilistic Determination of Water Supplies, Days Without Water, and Supplementation Rates

Databases for all three of the climate scenarios could consequently be used in a probabilistic framework to predict the availability of water supplies associated with a combination of nominal snow accumulation and rainfall runoff probability as well as any freeze and thaw date scenarios, while tracking the daily cumulative effects of any user-defined water consumption rates. In other words, the net water supply in the reservoir on any given day could be calculated based on the number of days of accrued snow accumulation and rainfall runoff based on whether or not snow melt had occurred, what the daily consumption rate was and accounting for any reservoir overflow that may have happened.

This approach allows available water supplies for any given scenario to be examined in terms of the potential shortfalls, both in magnitude (volume) and duration (days without water), which could be encountered unless a defined supplementation volume can be added to the reservoir and/or appropriate water conservation measures are implemented.

Having accounted for potential evapotranspiration losses during the simulations, the forecasted water supply deficit therefore provides a direct representation of supplementation requirements for any given basin yield probability that can be directly used for water management purposes. However, the key underlying assumption is that the determination of water supplies, as well as corresponding shortfalls and supplementation rates, are a function of the range of meteorological conditions represented within the historic data set and may not be representative of the full range of meteorological conditions that could be encountered.

5.0 RESULTS

Results related to long-term water supplies and supplementation requirements are presented throughout Section 5.1. Section 5.2 provides a brief outline of how these relate to the water supply forecasting tool.

5.1 Water Balance Results for the Historic Climate Regime

This sub-section provides the results of the water balance assessment under historic climate regime conditions.

5.1.1 Rainfall Runoff and Snow Accumulation Yields

The annual rainfall runoff and snow accumulation yields over historic climate regime conditions vary considerably over the 49 year period of record examined (i.e. those years selected between 1957 to 2009). Of note, basin yields resulting from snow accumulation are consistently lower than those from rainfall runoff despite the longer winter versus summer periods. This is predominantly due to two reasons, including (a) a generally higher daily basin yield from rain relative to that for snow (in water equivalent) and (b) the shorter time-periods over which rainfall surpluses are attenuated and exposed to atmospheric losses within the watershed before entering the reservoir (i.e. subjected to atmospheric losses over a larger area for a longer period of time).

A summary of historic occurrence probabilities corresponding to rainfall runoff and snow accumulation yields is presented in Table 9 below. Defining the combined annual probabilities for rainfall runoff and snow accumulation yields is complicated because these two variables are neither entirely independent nor entirely dependent on one another. Examining the relationship between the two for each of the modelled years showed them to be neither negatively nor positively correlated, meaning that they must be considered based on their own, rather than their combined, probabilities.

Table 9: Historic Probability of Rainfall Runoff and Snow Accumulation Yields for Lake Geraldine

Historic Percentage Probability of Exceedance[1]	Rainfall Runoff (ML)	Snow Accumulation (ML)	Historic Percentage Probability of Exceedance[1]	Rainfall Runoff (ML)	Snow Accumulation (ML)
100	228	47	45	570	441
95	287	97	40	602	450
90	355	143	35	625	486
85	384	219	30	630	535
80	416	271	25	636	614
75	437	290	20	674	629
70	444	304	15	707	663
65	480	328	10	762	717
60	501	367	5	832	831
55	520	399	2	953	872
50	553	424	0	1090	892

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.

5.1.2 Winter Durations (Freeze and Thaw Times)

An analysis of freeze and thaw times over the 1957 to 2009 period shows that winter duration during historic climate regime conditions averages approximately 234 days (median of 236 days). During this time, the City would need to be assured that sufficient supplementation had taken place over the previous summer period to meet water demand until the first spring melt period replenishes reservoir supplies and/or supplementation from the secondary source can be undertaken. As presented in Table 10, the range of historic variation suggests the winter period could vary by almost three months meaning that sufficient redundancy (surplus) of reservoir supplies needs to be considered to ensure water supplies are available during longer than average winters.

Table 10: Historic Freeze and Thaw Dates and Corresponding Probabilities of Winter Duration

Historic Percentage Probability of Occurrence[1]	Freeze Date Later Than	Thaw Date Earlier Than	Winter Shorter Than	Historic Percentage Probability of Occurrence[1]	Freeze Date Later Than	Thaw Date Earlier Than	Winter Shorter Than
100	27-Sep	26-Jun	272	40	18-Oct	07-Jun	232
95	02-Oct	25-Jun	266	35	19-Oct	06-Jun	229
90	03-Oct	24-Jun	265	30	20-Oct	06-Jun	228
85	05-Oct	18-Jun	257	25	23-Oct	04-Jun	224
80	05-Oct	16-Jun	254	20	24-Oct	03-Jun	221
75	07-Oct	15-Jun	251	15	26-Oct	03-Jun	220
70	08-Oct	13-Jun	248	10	26-Oct	01-Jun	218
65	10-Oct	12-Jun	245	5	01-Nov	01-Jun	212
60	12-Oct	11-Jun	242	2	08-Nov	01-Jun	205
55	14-Oct	10-Jun	239	1	09-Nov	28-May	200
50	16-Oct	08-Jun	235	0	11-Nov	18-May	188
45	16-Oct	07-Jun	234	-	-	-	-

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.

5.1.3 Supplementation Requirements

Based on the range of nominal water consumption rates presented in Section 4.4 and probabilistic basin yields (for rainfall runoff and snow accumulation) and winter periods presented in sub-sections 5.1.1 and 5.1.2, a summary of predicted water supply deficits and corresponding days without water is presented in Table 11. It should be noted that because evaporative losses from the reservoir have already been factored into the basin yield estimates, the tabulated water supply deficits therefore represent the supplementation requirements required to address each scenario. A more detailed table of results is provided in Appendix A.

Table 11: Summary of Predicted Water Supply Deficits and Potential Number of Days Without Water under Historic Climate Regime Conditions

Percentage Probability of Exceedance			Daily Consumption Rate (m^3)					
			2800		5200		7600	
Winter Length[1]	Snow Accumulation [1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	100	805	288	**1681**	**323**	**2557**	**336**
	75	75	373	133	**1249**	**240**	**2125**	**280**
	50	50	135	48	**1011**	**194**	**1887**	**248**
	25	25	-	0	**732**	**141**	**1608**	**212**
	0	0	-	0	**341**	**66**	**1217**	**160**
50	100	100	747	267	1623	312	**2499**	**329**
	75	75	295	105	1171	225	**2047**	**269**
	50	50	45	16	921	177	**1797**	**236**
	25	25	-	0	595	114	**1471**	**194**
	0	0	-	0	235	45	**1111**	**146**
0	100	100	674	241	1550	298	2426	319
	75	75	195	70	1071	206	1947	256
	50	50	-	0	805	155	1681	221
	25	25	-	0	540	104	1416	186
	0	0	-	0	101	19	977	129

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.
2. Red Bold values denote cases where the winter consumption rate exceeds the active storage capacity of the reservoir (i.e. daily consumption rate x number of winter days > than active reservoir storage).
3. Assumes a portion of water is unavailable for consumption due to ice formation.

According to the summary table above and the results presented in Appendix A, some supplementation of the Lake Geraldine reservoir is likely to be required in the immediate to very near future. While the required supplementation volumes are likely to be manageable in the short term (a maximum of a few hundred thousand cubic metres per annum in more extreme probability scenarios), the projected increase in population and water consumption will make supplementation a more frequent exercise as the supplementation volumes required to attain a reasonable level of water supply security increase over the medium term.

Based on high growth projections (as defined in the City of Iqaluit General Plan), a moderate per capita consumption rate (400 litres per day per capita) and median basin yield conditions, supplementation of the reservoir supply to accommodate a nominal population of 11,000 will likely require as much as 629,000 m^3 per year (approximately 46% of the available active reservoir storage volume) for a median duration winter and as much as 719,000 m^3 per year (approximately 52% of the available active reservoir storage volume) for a maximum duration winter. These supplementation values account for the probable amount of reservoir water unavailable for consumption due to ice storage.

Under extreme climatic conditions (lowest historic snowfall accumulation) and a maximum duration winter, winter consumption will exceed the available active winter storage capacity of the reservoir by the time that the daily consumption rate reaches approximately 5035 m^3, commensurate to a moderate per capita consumption rate and a population of approximately 12,590.

5.2 Water Balance Results for the 2050s Climate Regime

The following sub-section provides the results of the water balance assessment as they pertain to 2050s climate regime conditions.

5.2.1 Rainfall Runoff and Snow Accumulation Yields for 2050s Climate Regime

Combined annual rainfall runoff and snow accumulation yields for the 2050s climate regime conditions each vary across the period considered, although slightly less than that for the historic climate regime conditions. Owing to warmer temperatures and marginally higher annual precipitation (as outlined in Section 4.6) relative to the historic climate regime, average rainfall runoff yields for the 2050s climate regime are approximately 28 percent higher, while average snow accumulation yields are approximately 29% lower. Interestingly, the forecasted change in climate results in higher combined basin yields (when considering dry rainfall runoff and snow accumulation) conditions while lower combined basin yields are associated with wet conditions and longer winter durations than during the historic climate regime.

A summary of the occurrence probabilities of rainfall runoff and cumulated snow runoff yields under the 2050s climate regime is presented in Table 12.

Table 12: 2050s Climate Regime Annual Probability of Rainfall Runoff and Snow Accumulation Yields for Lake Geraldine Watershed

Historic Percentage Probability of Exceedance[1]	Rainfall Runoff (ML)	Snow Accumulation (ML)	Historic Percentage Probability of Exceedance[1]	Rainfall Runoff (ML)	Snow Accumulation (ML)
100	398	17	45	704	303
95	429	72	40	712	364
90	445	120	35	748	400
85	479	149	30	775	457
80	546	165	25	809	482
75	571	177	20	881	498
70	590	184	15	896	535
65	611	217	10	941	553
60	618	255	5	1045	587
55	667	272	2	1078	638
50	691	290	0	1161	659

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.

5.2.2 Winter Durations (Freeze and Thaw Times) for 2050s Climate Regime

As presented in Table 13, increased air temperatures associated with the 2050s climate regime result in a marked reduction of winter durations (from a median of 236 to 220 days) relative to the historic climate regime. This reduction in winter duration appears to be relatively consistent across most probabilities (~6%), although the reduction increases to approximately 12% for 1 to 15 percentage probability conditions.

Although the average winter period is expected to decrease by approximately two and a half weeks, the range of expected winter durations is still nearly three months, suggesting that sufficient redundancy (surplus) of reservoir supplies would still need to be considered to ensure water supplies are available during longer than average winters.

Table 13: 2050s Climate Regime Freeze and Thaw Dates and Corresponding Probabilities of Winter Duration

Historic Percentage Probability of Occurrence[1]	Freeze Date Later Than	Thaw Date Earlier Than	Winter Shorter Than	Historic Percentage Probability of Occurrence[1]	Freeze Date Later Than	Thaw Date Earlier Than	Winter Shorter Than
100	05-Oct	19-Jun	257	40	27-Oct	02-Jun	218
95	08-Oct	17-Jun	252	35	28-Oct	01-Jun	215
90	11-Oct	15-Jun	248	30	01-Nov	01-Jun	212
85	12-Oct	12-Jun	244	25	01-Nov	01-Jun	212
80	14-Oct	10-Jun	240	20	02-Nov	31-May	210
75	16-Oct	09-Jun	236	15	12-Nov	23-May	192
70	17-Oct	07-Jun	233	10	13-Nov	22-May	191
65	19-Oct	05-Jun	228	5	16-Nov	18-May	184
60	21-Oct	04-Jun	226	2	16-Nov	15-May	179
55	23-Oct	03-Jun	222	1	17-Nov	15-May	179
50	25-Oct	02-Jun	220	0	17-Nov	10-May	174
45	26-Oct	02-Jun	219	-	-	-	-

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.

5.2.3 Supplementation Requirements for 2050s Climate Regime

Based on the range of nominal water consumption rates presented in Section 4.4 and probabilistic basin yields (rainfall runoff and snow accumulation) and winter durations presented in sub-sections 5.2.1 and 5.2.2, a summary of predicted water supply deficits and corresponding days without water projections is presented in Table 14. It should be noted that because evaporative losses from the reservoir have already been factored into the basin yield estimates, the tabulated water supply deficits directly represent the supplementation requirements required to address each scenario. A more detailed table of results is provided in Appendix A.

Table 14: Summary of Predicted Water Supply Deficits and Potential Number of Days without Water under 2050s Climate Regime

Percentage Probability of Exceedance			Daily Consumption Rate (m^3)					
			2800		5200		7600	
Winter Length[1]	Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	100	706	252	**1582**	**304**	**2458**	**323**
	75	75	390	139	**1266**	**243**	**2142**	**282**
	50	50	169	60	**1045**	**201**	**1921**	**253**
	25	25	0	0	**733**	**141**	**1609**	**212**
	0	0	0	0	**434**	**83**	**1310**	**172**
50	100	100	608	217	1484	285	**2360**	**311**
	75	75	274	98	1150	221	**2026**	**267**
	50	50	41	15	917	176	**1793**	**236**
	25	25	0	0	519	100	**1395**	**184**
	0	0	0	0	266	51	**1142**	**150**
0	100	100	485	173	1361	262	2237	294
	75	75	130	46	1006	193	1882	248
	50	50	0	0	759	146	1635	215
	25	25	0	0	451	87	1327	175
	0	0	0	0	57	11	933	123

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.
2. Red Bold values denote cases where the winter consumption rate exceeds the active storage capacity of the reservoir (i.e. daily consumption rate x number of winter days > than active reservoir storage).
3. Assumes a portion of water is unavailable for consumption due to ice formation.

Based on the summary above and the results presented in Appendix A, supplementation requirements of the Lake Geraldine reservoir are generally expected to decrease relative to the historic climate regime due to shorter winter durations and accompanying higher rainfall runoff versus snow accumulation yields. It should be noted that small increases in supplementation rates may be expected during longer winter scenarios.

Assuming high population growth, a moderate per capita consumption rate and median basin yield conditions, supplementation of the reservoir supplies for a population of 11,000 will likely require as much as 625,000 m^3 per year (slightly less than under the historic climate regime and approximately 46% of the available active reservoir storage volume) for a median duration winter.

In contrast, an increase in winter duration under the 2050s climate regime slightly increases supplementation requirements relative to those under the historic climate regime. Accordingly, the supplementation volume associated with the maximum winter duration under the 2050s climate regime amounts to 753,000 m^3 per year (approximately 55% of the available active reservoir storage volume). This is because snowfall accumulation accounts for a significantly decreased portion of the total annual basin yield when compared to that under the historic climate regime. Supplementation values account for the probable amount of reservoir water unavailable due to ice storage.

5.3 Water Balance Results for the 2080s Climate Regime

The following sub-section provides the results of the water balance assessment as they pertain to 2080s climate regime conditions.

5.3.1 Rainfall Runoff and Snow Accumulation Yields for 2080s Climate Regime

Similar to 2050s climate regime basin yields, combined annual rainfall runoff and snow accumulation yields for the 2080s climate regime are expected to vary less than that for the historic climate regime. Significantly however, 2080s climate regime yields are expected to decrease marginally against those predicted for the 2050s climate regime. This non-linear change over time is primarily related to subtle water balance differences related to the combined effects of changed precipitation and temperature.

Owing to warmer temperatures and marginally higher annual precipitation (as outlined in Section 4.6) relative to the historic climate regime, rainfall runoff yields for the 2080s climate regime conditions are approximately 40% higher and snow accumulation yields approximately 40% lower. In general terms, total annual rainfall runoff yields for the 2080s climate regime averages nearly three times those for snow accumulation, although this ratio dramatically increases for the drier conditions.

The forecasted change in climate again results in higher basin yields during dry conditions while lower basin yields are associated with wet conditions than during the historic climate regime.

A summary of 2080s climate regime occurrence probabilities corresponding to rainfall runoff and snow accumulation yields is presented in Table 15.

Table 15: 2080s Climate Regime Annual Probability of Rainfall Runoff and Snow Accumulation Yields for Lake Geraldine Watershed

Historic Percentage Probability of Exceedance[1]	Rainfall Runoff (ML)	Snow Accumulation (ML)	Historic Percentage Probability of Exceedance[1]	Rainfall Runoff (ML)	Snow Accumulation (ML)
100	429	7	45	735	295
95	473	69	40	772	307
90	526	98	35	790	319
85	573	149	30	827	327
80	602	152	25	878	363
75	612	161	20	927	390
70	650	188	15	980	437
65	671	198	10	1020	472
60	703	202	5	1180	502
55	710	228	2	1279	544
50	722	273	0	1308	591

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.

5.3.2 Winter Durations (Freeze and Thaw Times) for 2080s Climate Regime

Projected air temperature increases associated with the 2080s climate regime result in a further reduction of winter durations relative to the historic climate regime from a median of 236 days to 213 days (see Table 16). Compared to the historic climate regime, this equates to a ten percent reduction in longer-winter durations (from the longest to the 30 percent probability duration winter), but gradually increases to a 23 percent reduction for the shortest winter duration.

Although the average winter duration for the 2080s climate regime is expected to decrease by approximately three and a half weeks relative to the historic climate regime, the range of expected winter durations now exceeds 100 days, suggesting that sufficient redundancy of reservoir supplies (surplus to ensure water supplies are available during longer than average winters) would become a more poignant consideration than under historic conditions. This consideration is tempered by the fact that the absolute volume of redundancies for a nominal population number will be lower than it would have been under the historic climate regime.

Table 16: 2080s Climate Regime Freeze and Thaw Dates and Corresponding Probabilities of Winter Duration

Historic Percentage Probability of Occurrence[1]	Freeze Date Later Than X	Thaw Date Earlier Than X	Winter Shorter Than X	Historic Percentage Probability of Occurrence[1]	Freeze Date Later Than X	Thaw Date Earlier Than X	Winter Shorter Than X
100	11-Oct	14-Jun	246	40	04-Nov	01-Jun	209
95	13-Oct	11-Jun	242	35	05-Nov	01-Jun	208
90	17-Oct	09-Jun	236	30	07-Nov	26-May	200
85	19-Oct	08-Jun	232	25	08-Nov	23-May	197
80	21-Oct	08-Jun	229	20	14-Nov	21-May	189
75	22-Oct	07-Jun	228	15	17-Nov	18-May	183
70	25-Oct	06-Jun	223	10	18-Nov	14-May	178
65	27-Oct	03-Jun	219	5	19-Nov	13-May	175
60	28-Oct	02-Jun	217	2	19-Nov	10-May	172
55	30-Oct	02-Jun	214	1	28-Nov	06-May	159
50	01-Nov	01-Jun	213	0	08-Dec	01-May	144
45	02-Nov	01-Jun	211	-	-	-	-

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.

5.3.3 Supplementation Requirements for 2080s Climate Regime

Based on the range of nominal water consumption rates presented in Section 4.4 and probabilistic basin yields and winter periods presented in sub-sections 5.3.1 and 5.3.2, a summary of predicted water supply deficits and corresponding days without water projections is presented in Table 17. It should be noted that because evaporative losses from the reservoir have already been factored into the basin yield estimates, the tabulated water supply deficits represent the supplementation requirements required to address each scenario. A more expansive table of variable ranges is provided in Appendix A.

Table 17: Summary of Predicted Water Supply Deficits and Potential Number of Days Without Water under 2080s Climate Regime

Percentage Probability of Exceedance			Daily Consumption Rate (m[3])					
			2800		5200		7600	
Winter Length[1]	Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	100	678	242	1554	299	**2430**	**320**
	75	75	357	128	1233	237	**2109**	**278**
	50	50	143	51	1019	196	**1895**	**249**
	25	25	0	0	792	152	**1668**	**219**
	0	0	0	0	396	76	**1068**	**167**
50	100	100	585	209	1461	281	**2337**	**308**
	75	75	249	89	1125	216	**2001**	**263**
	50	50	28	10	904	174	**1780**	**234**
	25	25	0	0	581	112	**1457**	**192**
	0	0	0	0	216	42	**1092**	**144**
0	100	100	394	141	1270	244	2146	282
	75	75	25	9	901	173	1777	234
	50	50	0	0	666	128	1542	203
	25	25	0	0	377	73	1253	165
	0	0	0	0	0	0	721	95

Notes:

1. Based on the normal distribution of historic meteorological conditions examined.
2. Red Bold values denote cases where the winter consumption rate exceeds the active storage capacity of the reservoir (i.e. daily consumption rate x number of winter days > than active reservoir storage).
3. Assumes a portion of water is unavailable for consumption due to ice formation.

Based on the summary above and the results presented in Appendix A, supplementation requirements for the Lake Geraldine reservoir are expected to remain broadly similar to historic climate conditions. Nevertheless, the marginal increases in basin yields (during specific scenario combinations) and shorter winter durations associated with the 2080s climate regime are generally expected to facilitate larger water consumption needs over the winter periods than under historic climate regime conditions for a nominal population. Furthermore, the reduced variability in basin surpluses associated with the 2080s, relative to the historic, climate regime point to a reduction in risk for low-yield years.

Assuming a high growth projection, a moderate per capita consumption rate and median basin yield conditions, supplementation of the reservoir supply for a population of 11,000 will likely require as much as 612,000 m^3 per year (45% of the available active reservoir storage volume) for a median duration winter and as much as 727,000 m^3 per year (53% of the available active reservoir storage volume) for a maximum duration winter.

5.4 Assumptions and Limitations

A summary of the assumptions made as part of the study and the limitations of the model and study results are as follows:

- Meteorological data obtained from Environment Canada stations in Iqaluit are representative of the meteorological conditions in the Lake Geraldine watershed, notwithstanding applied snowmelt factors incorporated into the calibrated model.
- The proposed spillway extension drawings (Trow, 2004) are representative of the as-built extension.
- The bathymetric representation, including intake configuration, of stage-storage relationships developed for Lake Geraldine is appropriate for the purposes of this assessment.
- The water balance model provides a suitable representation of existing and future basin yield conditions.
- All interflow generated within the Lake Geraldine watershed reports back to the reservoir.
- Lake ice depths depicted in Trow (2004) are appropriate representations of ice thicknesses in a year of median winter length.

6.0 OVERVIEW OF WATER SUPPLY FORECASTING TOOL

The following section provides an outline of the purpose and functionality of the water supply forecasting tool as well as a summary of some of its uncertainties and limitations. Additional specifics including detailed instructions and assumptions and limitations are provided in the 'ReadMe' tabs accompanying the spreadsheet tool.

The water supply forecasting tool is primarily intended to be used during winter periods in order to develop a water supply prediction calculated from actual snow accumulated to the time of the forecast during the present winter, existing reservoir supplies at the time of the forecast, the effects of ice formation on water supplies, probabilistic precipitation surpluses over the immediate future and daily water consumption over the forecasted period. Although the tool can also be used during the summer months to provide forecasts for upcoming summer periods, it is primarily intended for developing forecasts accounting for recent snow accumulations and therefore automatically defaults to probabilistic estimates alone if used during the summer (i.e. excludes current meteorological conditions if used outside 'winter' months).

The tool allows for the City to plan its water supplementation strategy for the upcoming summer so that the risk of insufficient supplies for the subsequent winter can be lowered.

The tool processes information in two steps:

1) Calculation of existing watershed snow accumulation based on available meteorological information; and

2) Generation of water supply forecasts corresponding to the predicted end of the first and second winters (prior to melt) and the predicted end of the first summer (prior to the time of freeze).

6.1.1 STEP 1: Calculation of Existing Snow Accumulation

By using the 'Meteorology Processor' worksheet provided, the potential water supply accumulated within the watershed in the form of snow is calculated based on a built-in water balance model. Although the meteorological records considered during this process automatically default to the period between July 26 of the preceding summer (displayed in 'Start of Record' box) and the date entered into the 'Date of Forecast' box, the user can, under certain instances, opt to choose a more recent start date in the 'Start of Record' box for higher accuracy results if it has been confirmed that this more recent date corresponds to a time when no snow was accumulated within the watershed.

In order to provide an accurate estimate of watershed snow accumulation to date, the 'Meteorology Processor' only requires two input parameters (precipitation and air temperature) that can be obtained from the Environment Canada's 'Iqaluit AWOS' (Station Number 2402591), 'Iqaluit Climate' (Station Number 2402592) or, in some circumstances, from 'Iqaluit UA' (Station Number 2402594). It should be noted that meteorological data should not be obtained from the 'Iqaluit UA' station unless data quality at other stations is considered poor and this station provides a reasonable meteorological record. Selecting the default option may prove to provide a better surrogate under certain circumstances.

Meteorological data is downloaded from the Environment Canada site (link provided in Meteorological Processor sheet) in CSV format and imported and pre-processed using the 'Import Data' button provided.

Once processed, the tool provides a report on the number of days featuring missing or incomplete data throughout the period selected, so that the user can evaluate whether he/she deems the available meteorological record acceptable. If the user decides to proceed, the tool outputs estimated snow storage volumes that may be affected by periods of missing precipitation. Conversely, if the user selects feels the available meteorological data is not reliable, the option remains to abort the process, select an alternative climate station and start with a fresh simulation or use historic default values.

The resulting Estimated Snow Storage Volume is then provided for subsequent use in STEP 2.

6.1.2 STEP 2: Generation of Water Supply Forecasts

By inputting all the deterministic modifiers including existing reservoir levels (W_0 in Figure 10), water consumption (C), the previous freeze date and the forecast date, the Water Supply Forecast Processor allows water supply forecasts to be determined for the following dates:

1) Water supplies immediately before the first spring melt period (denoted as W_{m1} on Figure 10) coinciding with the lowest available reservoir level during the first winter.

2) Water supplies immediately before the first freeze-up (denoted as W_{f1} on Figure 10) coinciding with the available over-winter supply.

3) Water supplies immediately before the second spring melt period (denoted as W_{m2} on Figure 10) coinciding with the lowest available reservoir level during the second winter.

The dates presented in the ensuing water quality forecast plot (T_{m1}, T_{f1} and T_{m2}) are based on the probabilistic median thaw and freeze times (proxies for winter durations associated with the selected climate regime) and the probabilistic median of water supply probabilities corresponding to those dates. More detailed information is provided in the 'Tabular Results' tab which provides a matrix of probable water supply outcomes corresponding to the full range of winter duration probabilities and the full range of rainfall runoff and snow accumulation (basin yield) probabilities.

In instances where water supply deficits are tabulated, the magnitudes of these deficits are equal to the supplementation volumes required to address them as evaporative losses from the reservoir have already been accounted for in the water balance assessment.

As noted above, water supply outcomes are provided for three points in time, of which the two end-of-winter forecasts are of particular significance. The first, although supplementation is likely no longer an option, allows the City to determine whether water conservation measures may be required, while the second allows the City to evaluate the likely magnitude and timing of supplementation (W_{f1} as denoted on Figure 11) to address any potential water supply deficits for the second winter.

By identifying the period available between the likely thaw and freeze dates, it is also possible to optimise the pumping plan to address potential supplementation requirements. This potentially involves a combination of high and low pumping rates depending on flow conditions at the secondary source.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the study presented in this report and subject to the assumptions and limitations (Section 5.4) used for the study, the following conclusions can be drawn:

1) The City's water consumption is approaching the limits of the basin yields of the Lake Geraldine watershed during median precipitation years. The City will likely require supplementation in the very near future.

2) The small increases in basin yields and shorter expected winter durations associated with climate change forecasts are generally expected to marginally reduce supplementation needs under extreme dry conditions. As such, it is expected that climate change may reduce the risk associated with extremely dry basin yield years relative to the historic climate regime. Moreover, forecasted longer summer periods will also increase the available supplementation window.

3) Assuming the City maintains a high projected population growth and a per capita consumption rate of 400 L/person/day, supplementation of the reservoir should allow the City to maintain sufficient water supplies until the early 2030s. The number of years that supplementation can continue to successfully augment water supplies largely depends on the volumes available from the nearby Apex River.

4) Having addressed the supplementation issue, the next likely water supply challenge for the City to consider will be to increase the available water supply storage to accommodate water demand during long winter periods.

Based on the presented information, the following recommendations are made:

1) Forecasted supplementation rates should be increased by the City as part of their water supply planning process in order to incorporate a margin of safety. Under higher consumption rates, the available reservoir storage may constrain the factor of safety that can be applied. If the City experiences very high population growth, this will inevitably accelerate the need to consider increasing over-winter storage.

2) The City's pumping strategy should consider addressing the bulk of their annual supplementation needs during the spring melt period. By filling the reservoir close to its maximum storage capacity during the early portion of the summer, it would allow the City to strategically top up the residual storage capacity as winter approaches. This would minimise the potential risks associated with trying to supplement high volumes during a period when the Apex River may have lower than maximum flows and avoid the potential issues associated with an unexpectedly early onset of winter.

3) If possible, the City should aim to have the reservoir filled to its capacity by the earliest anticipated freeze-up date for the earliest selected freeze-up probability.

4) Monitoring of Lake Geraldine reservoir levels (at WSC gauge) should continue to remain a priority in order to provide information for water supply forecasting. In addition:

   a) the City should consider installing a secondary water level monitoring device for redundancy purposes.

   b) the City should establish a monitoring configuration that provides real-time reservoir levels.

5) Monitoring of meteorological data (specifically precipitation and air temperature) at existing Environment Canada stations should be continued with emphasis on the collection of complete records.

8.0 REFERENCES

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Report Signature Page

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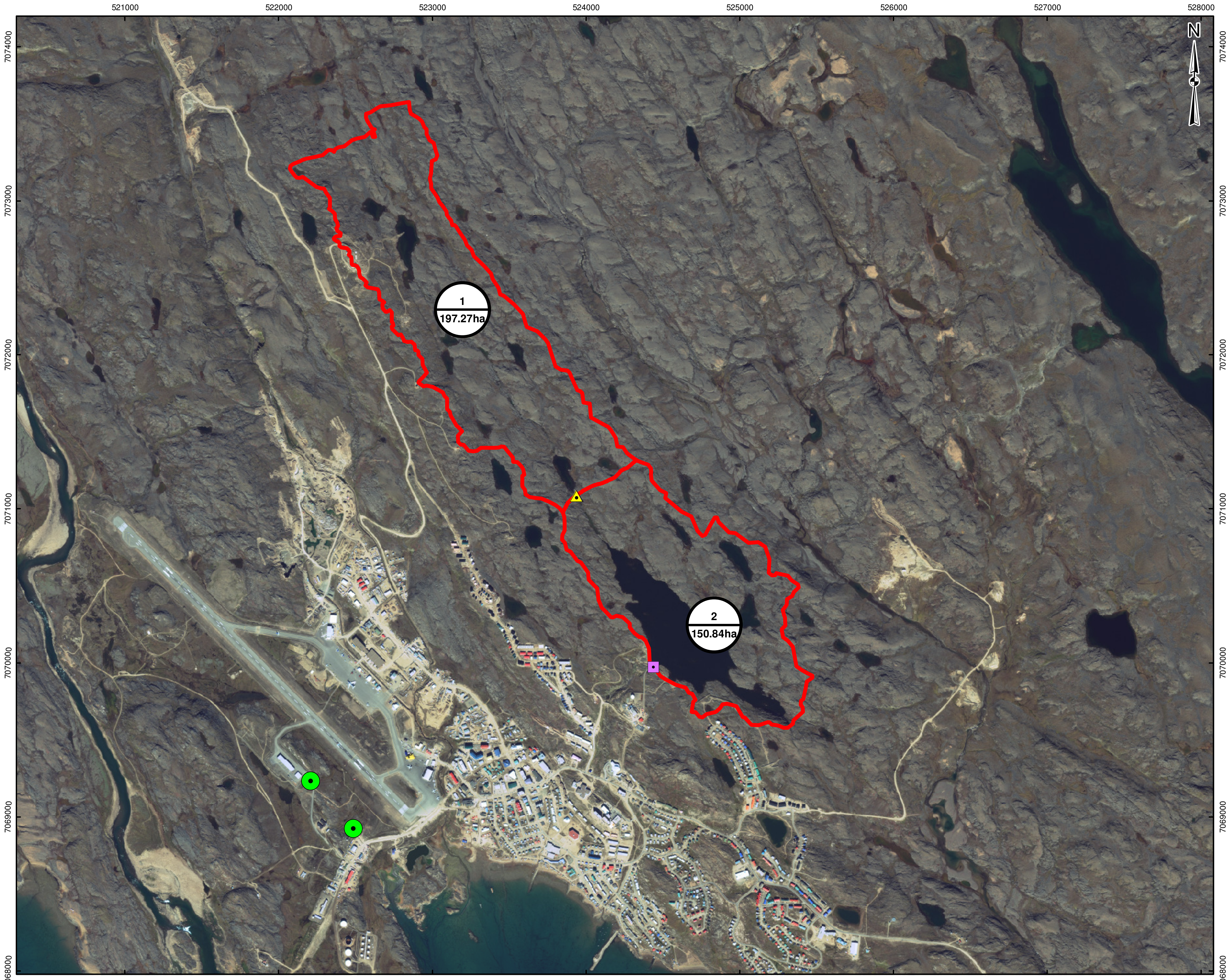
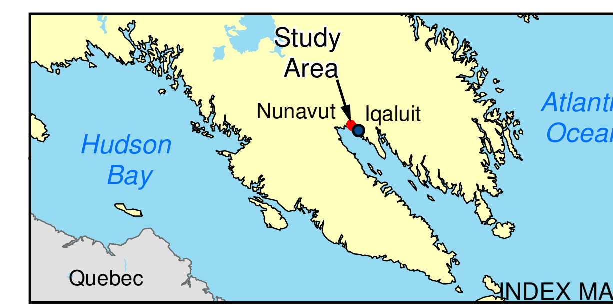
FIGURES



LEGEND

- Water Survey of Canada Inlet
- Lake Geraldine Spillway
- Iqaluit Met Stations
- Lake Geraldine Watershed (Iqaluit)



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Imagery from The City of Iqaluit, dated Sept. 4, 2012

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PROJECT
LAKE GERALDINE WATER BALANCE

TITLE
SITE PLAN

Golder Associates
Mississauga, Ontario

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GIS	KD	19 Aug. 2013		
CHECK	CDV	19 Aug. 2013		
REVIEW	GR	19 Aug. 2013		

FIGURE: 1

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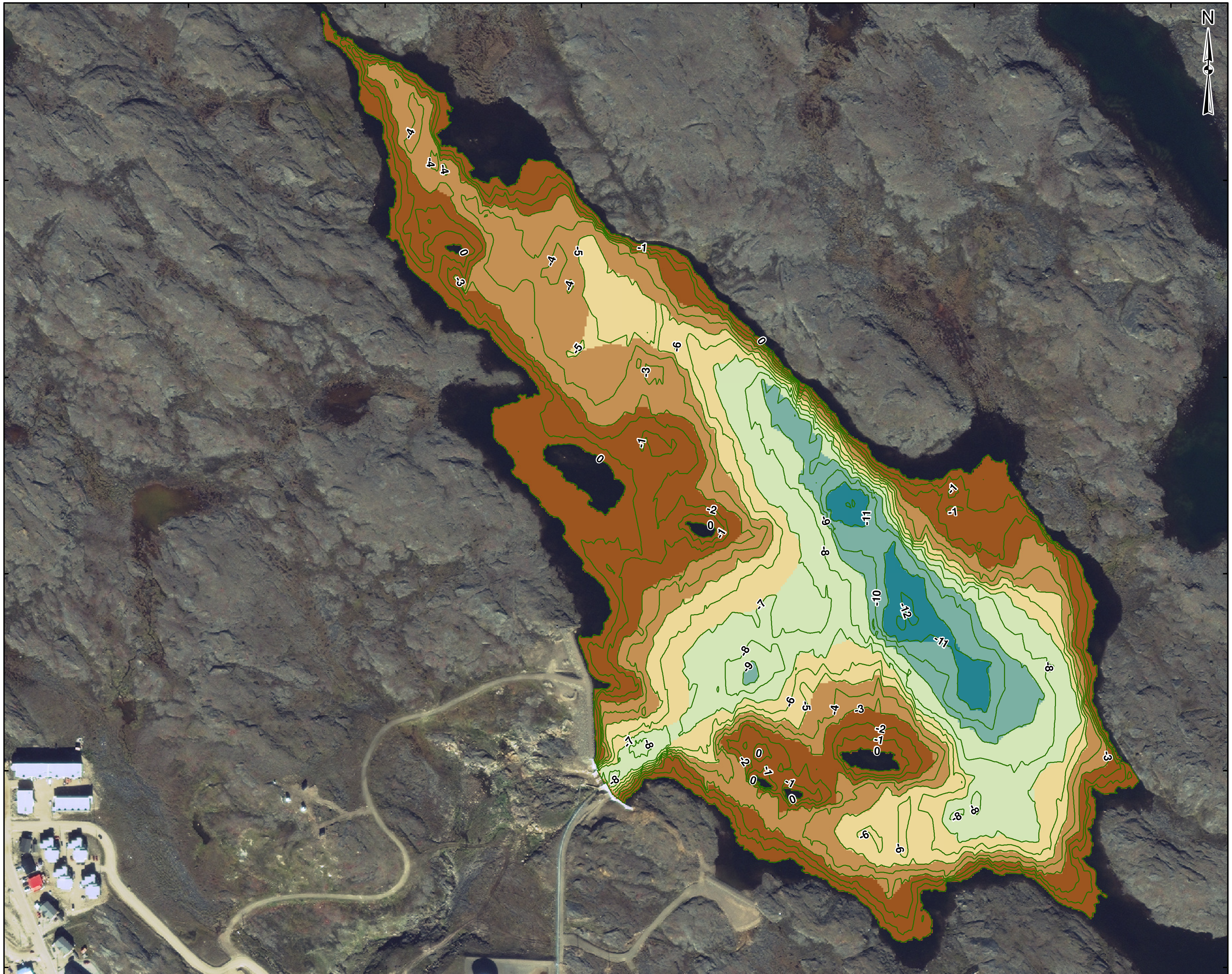
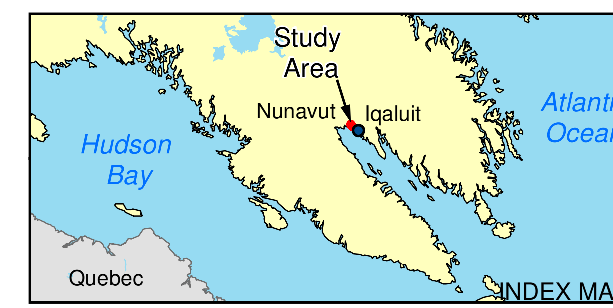


LEGEND

Lake Geraldine Bathymetry (m)

Depth (m)

- -12 - -10
- -10 - -8
- -8 - -6
- -6 - -4
- -4 - -2
- -2 - 0



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Base Data - ESRI Data, bathymetry data supplied by The City of Iqaluit
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 19
Imagery from The City of Iqaluit, dated Sept. 4, 2012

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METERS
SCALE 1:4,000

PROJECT

LAKE GERALDINE WATER BALANCE

TITLE

LAKE BATHYMETRY

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1151-0264			SCALE AS SHOWN	REV. 0.0
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GIS	KD	19 Aug. 2013		
CHECK	CDV	19 Aug. 2013		
REVIEW	GR	19 Aug. 2013		

FIGURE: 2

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Figure 3: Monthly Projected Temperatures for Iqaluit, Nunavut for the 2050s

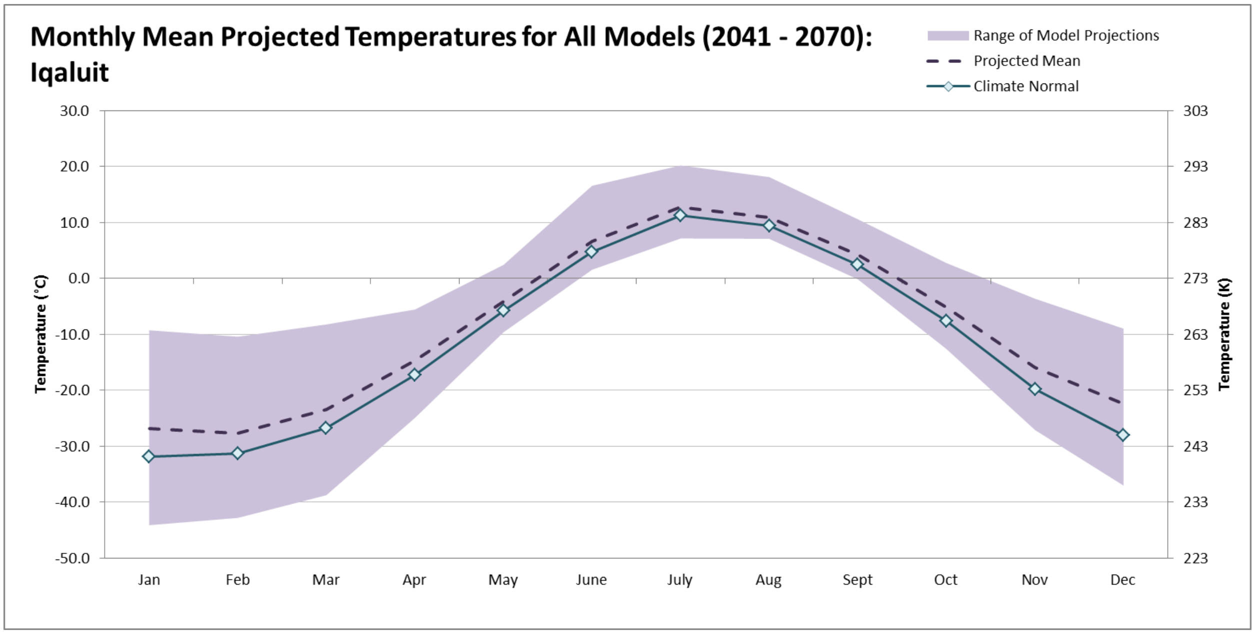


Figure 4: Monthly Projected Temperatures for Iqaluit, Nunavut for the 2080s

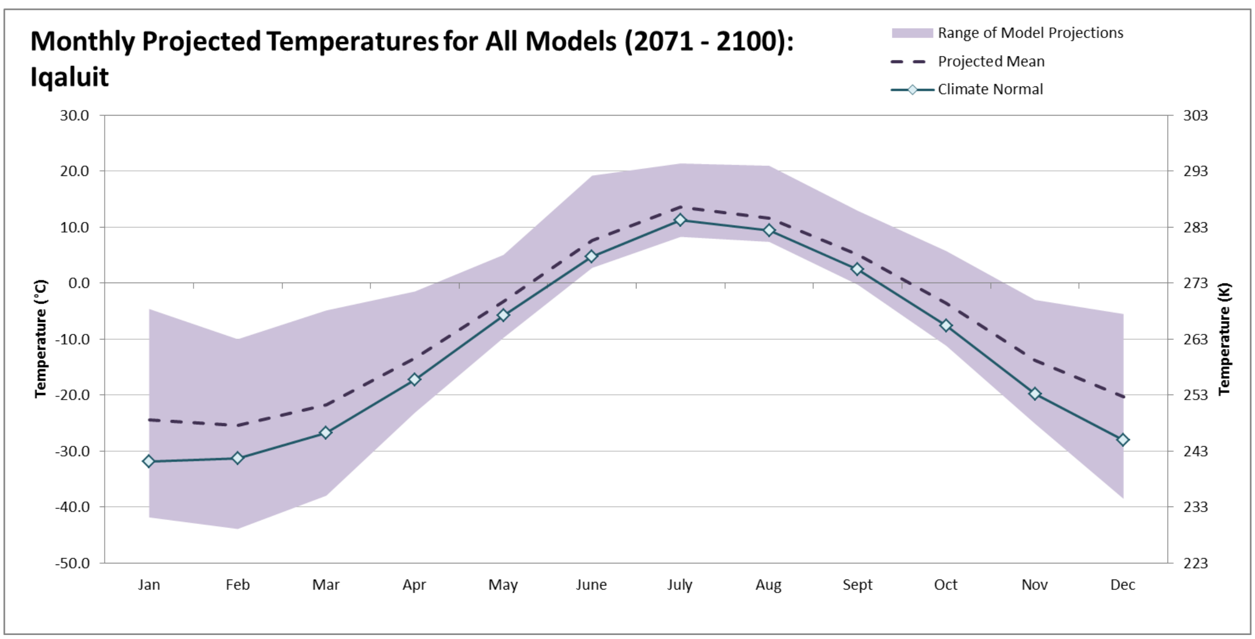


Figure 5: Monthly Projected Precipitation for Iqaluit, Nunavut for the 2050s

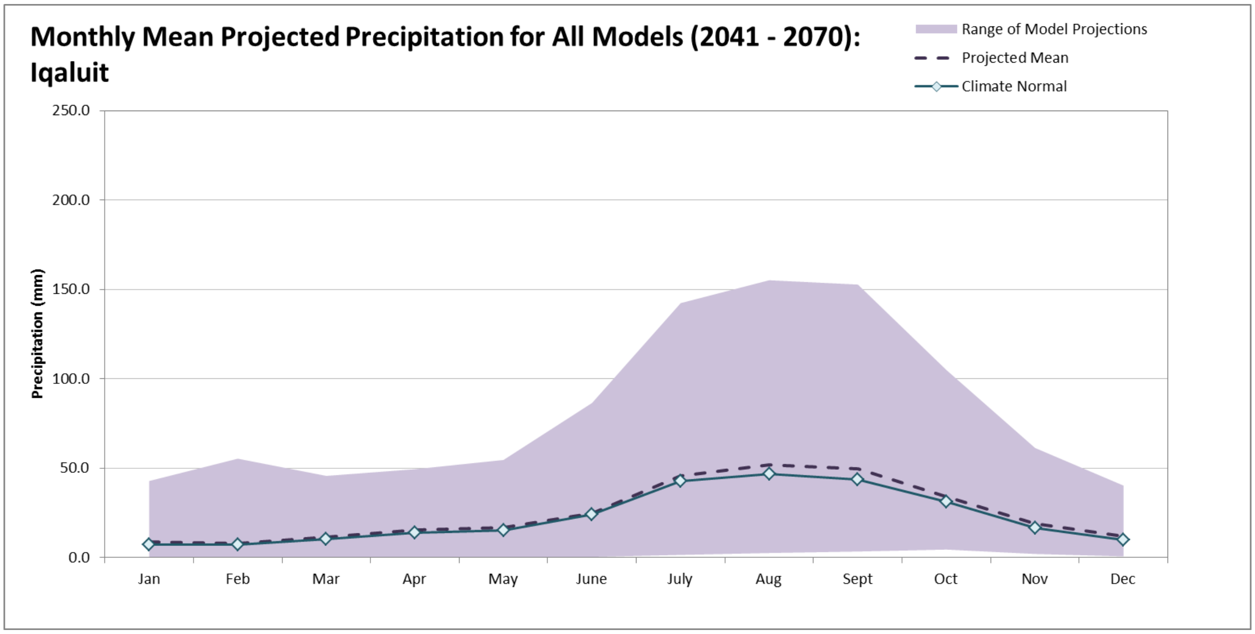
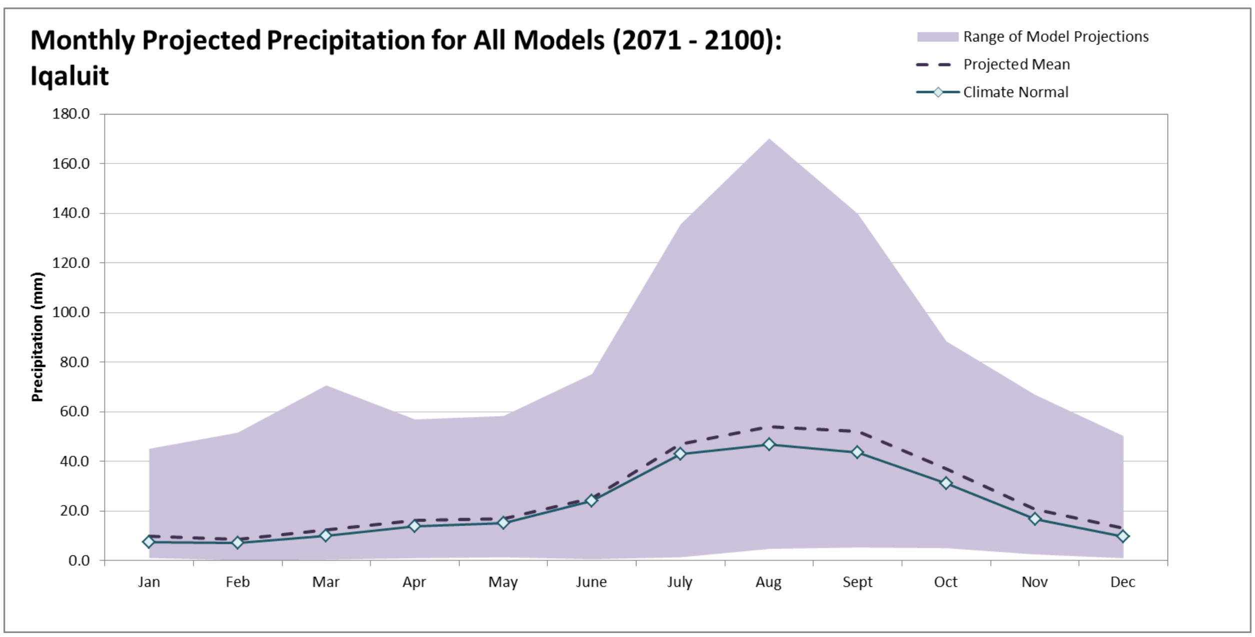
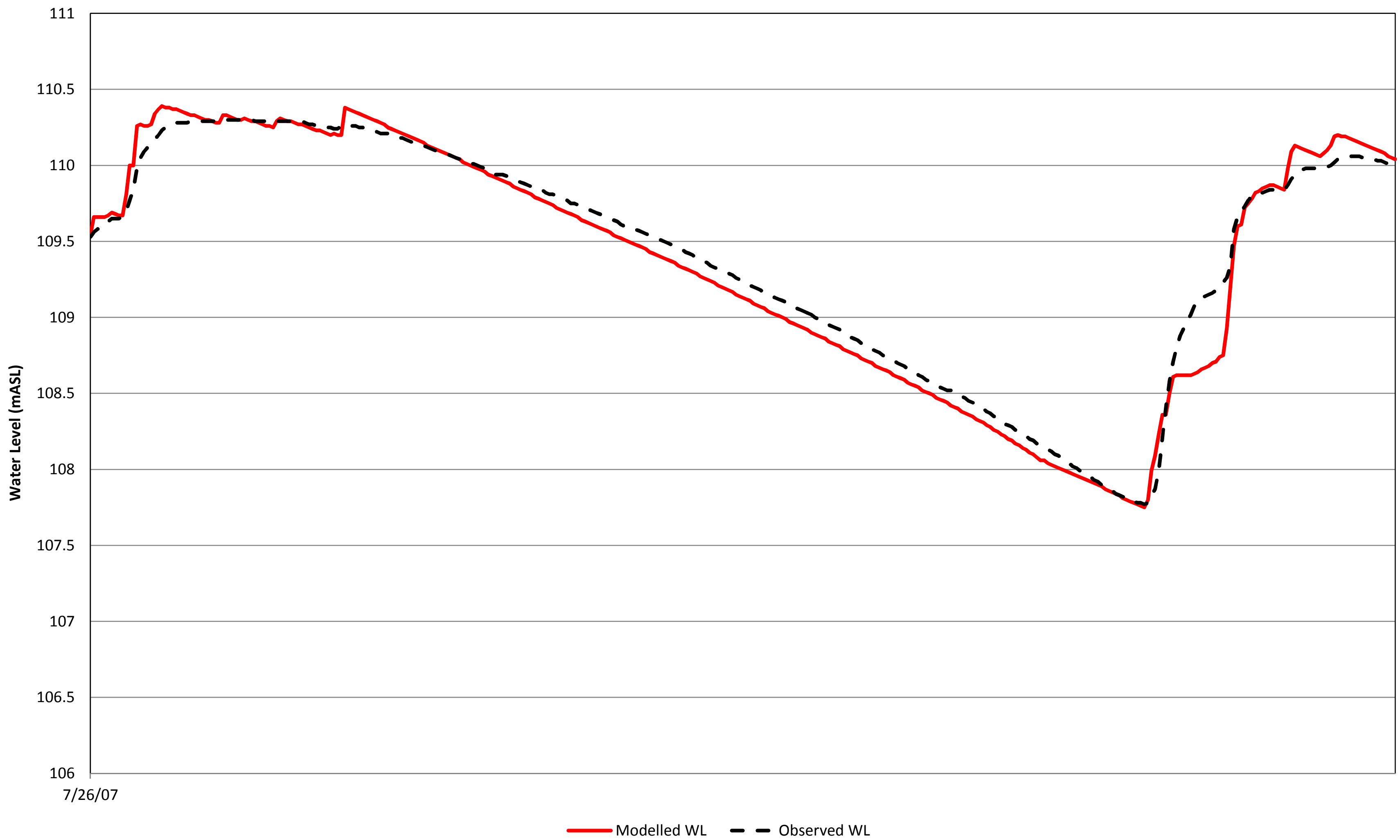


Figure 6: Monthly Projected Precipitation for Iqaluit, Nunavut for the 2080s



Comparison of Observed and Predicted Reservoir Levels over the July 26 2007 to July 25 2008 Calibration Period

Figure 7



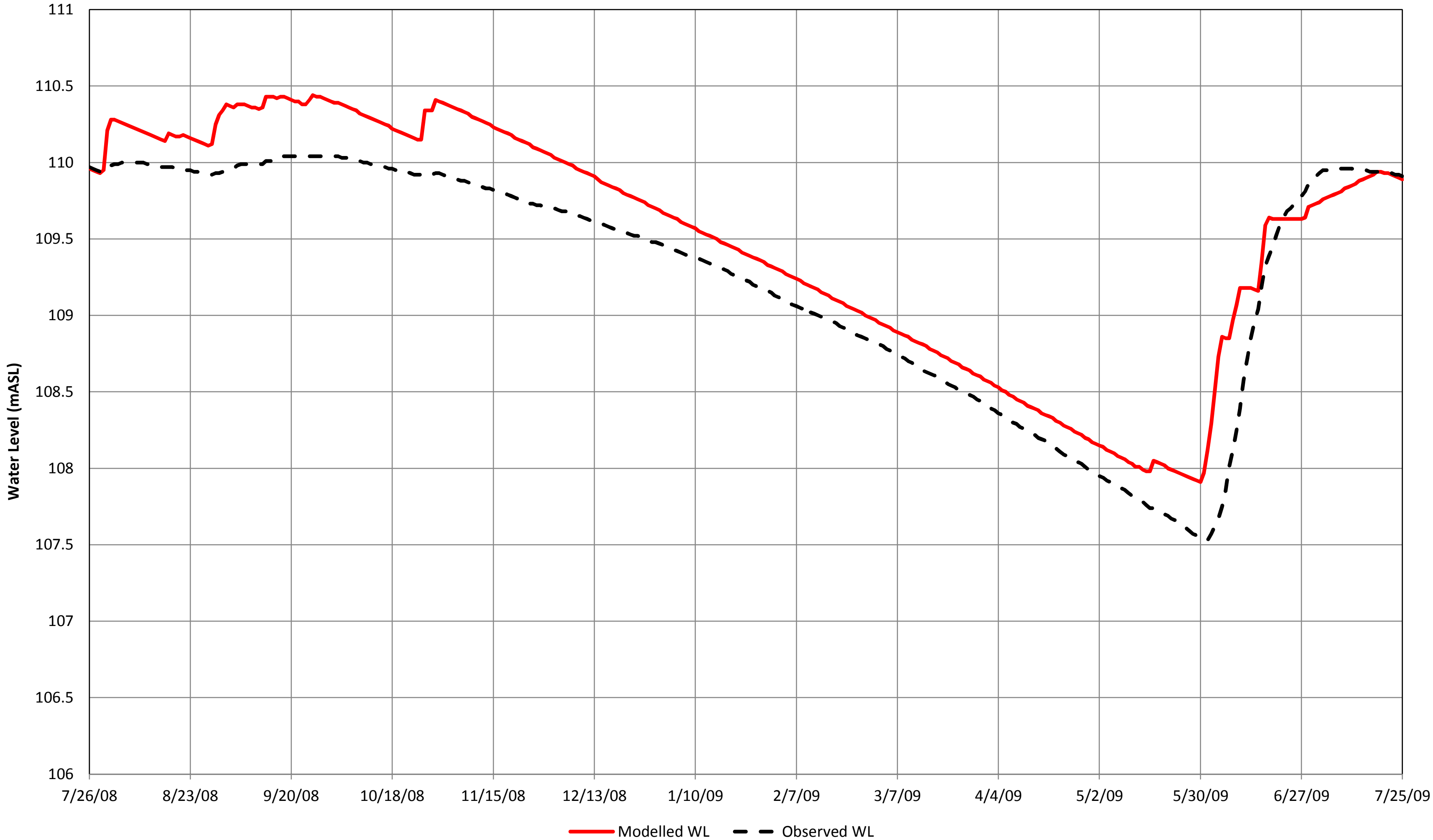
PROJECT: 12-1151-0264
DATE: August 2013

Golder Associates

DRAWN: HJ
CHECK: GR

Comparison of Observed and Predicted Reservoir Levels over the July 26 2008 to July 25 2009 Validation Period

Figure 8



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DATE: August 2013

DRAWN: HJ

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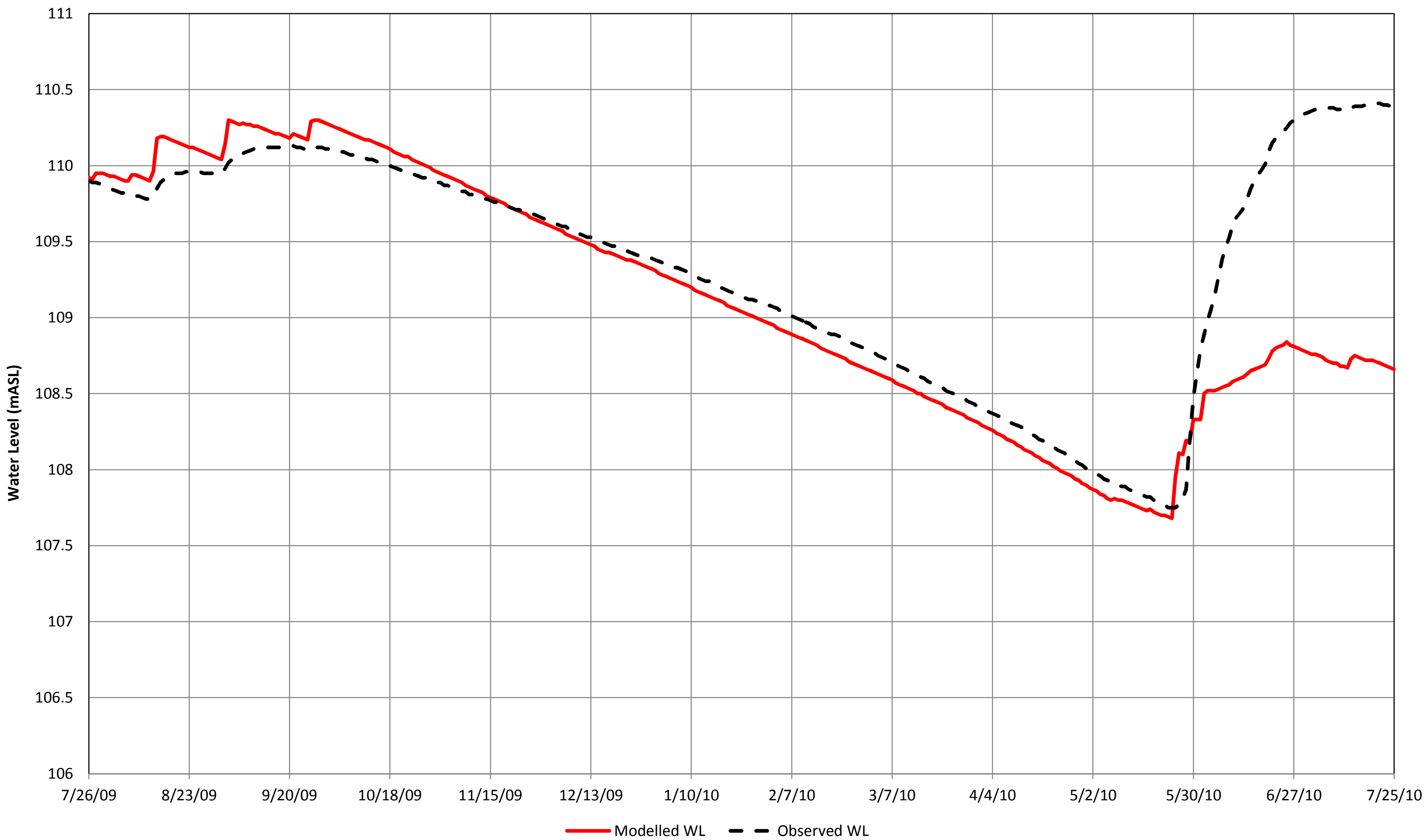
Comparison of Observed and Predicted Reservoir Levels over the July 26 2009 to July 25 2010 Simulation Period

Figure 9



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DATE: August 2013

Golder Associates

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Figure 10: Conceptualisation of Water Supply Forecast under Adequate Water Supply Conditions (No Immediate Water Supply Deficiency Projected But Additional Storage Capacity Available)

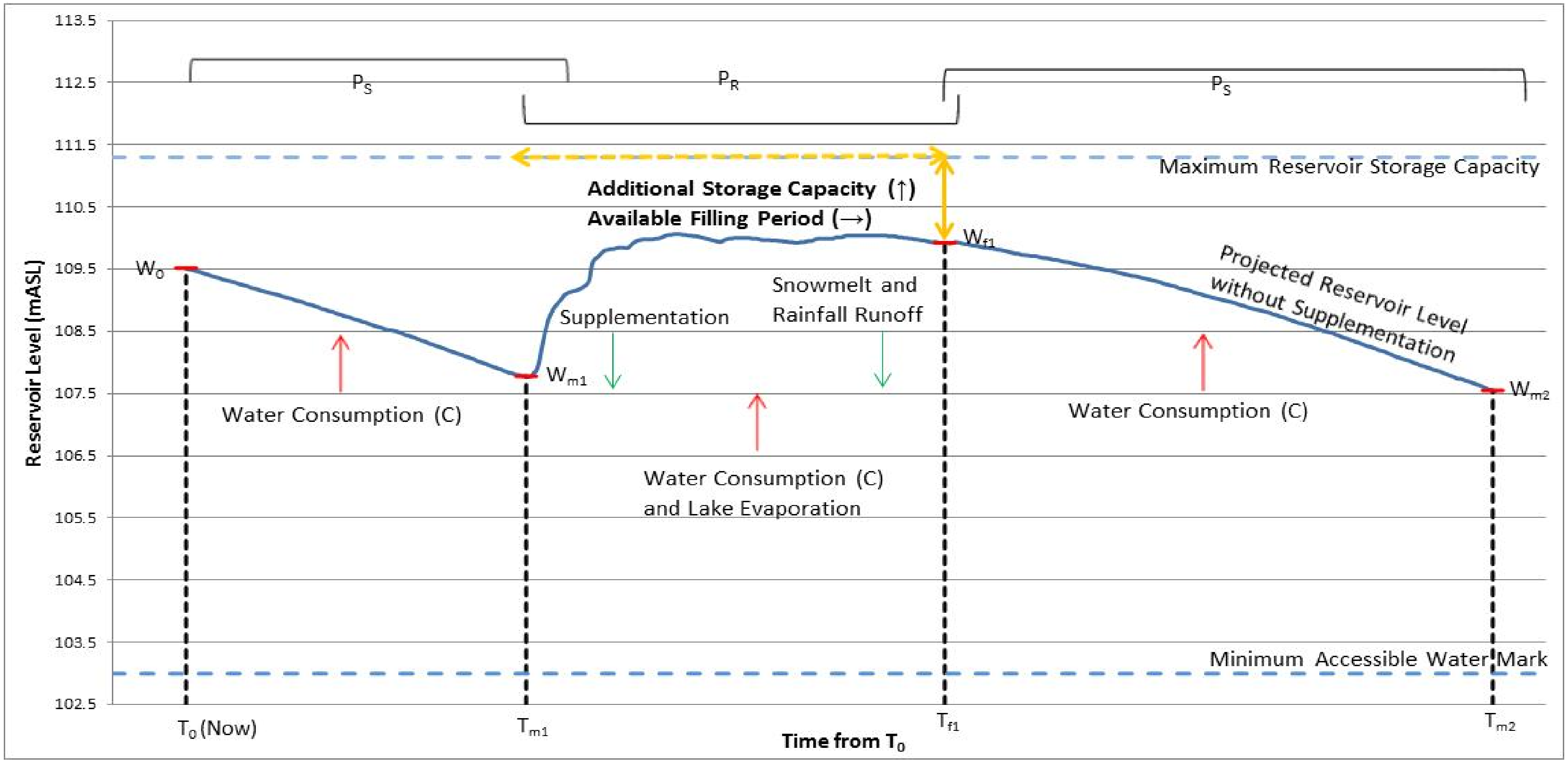
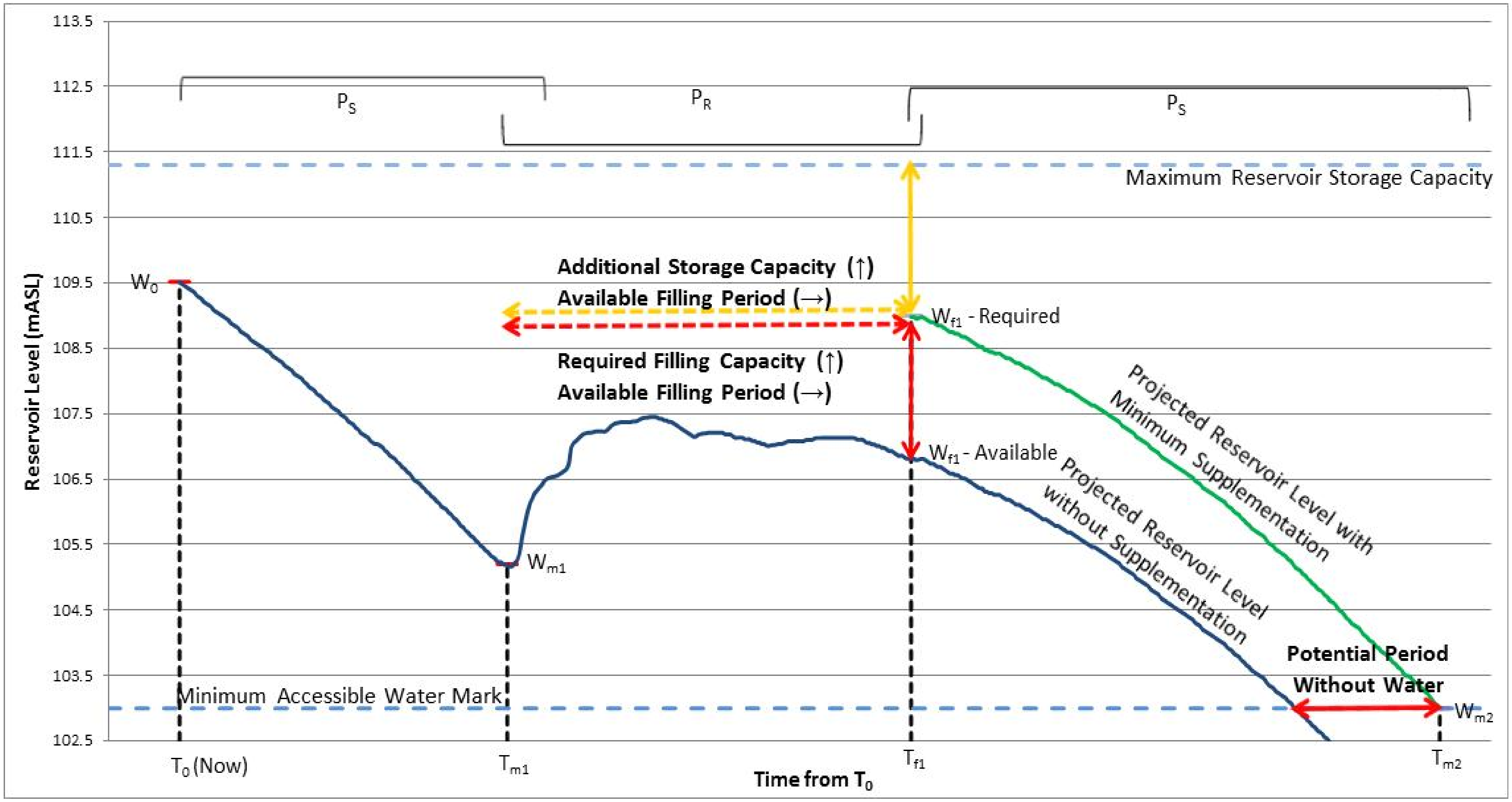


Figure 11: Conceptualisation of Water Supply Forecast under Inadequate Water Supply Conditions (Immediate Water Supply Deficiency Projected And Additional Storage Capacity Available)



APPENDIX A

Predicted Water Supply Deficits Tables

Table A1: Predicted Water Supply Deficits and Potential Number of Days Without Water during the Longest Winter Period (272 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	221	184	513	256	805	287	1097	305	1389	316	1681	323	1973	329	2265	333	2557	336	4382	348
75	100	0	0	231	116	523	187	815	226	1107	252	1399	269	1691	282	1983	292	2275	299	4100	325
60	100	0	0	142	71	434	155	726	202	1018	231	1310	252	1602	267	1894	279	2186	288	4011	318
50	100	0	0	76	38	368	131	660	183	952	216	1244	239	1536	256	1828	269	2120	279	3945	313
40	100	0	0	46	23	338	121	630	175	922	210	1214	233	1506	251	1798	264	2090	275	3915	311
25	100	0	0	0	0	149	53	441	122	733	166	1025	197	1317	219	1609	237	1901	250	3726	296
0	100	0	0	0	0	0	0	119	33	411	93	703	135	995	166	1287	189	1579	208	3404	270
100	75	71	59	363	181	655	234	947	263	1239	282	1531	294	1823	304	2115	311	2407	317	4232	336
75	75	0	0	81	41	373	133	665	185	957	218	1249	240	1541	257	1833	270	2125	280	3950	314
60	75	0	0	0	0	284	101	576	160	868	197	1160	223	1452	242	1744	256	2036	268	3861	306
50	75	0	0	0	0	218	78	510	142	802	182	1094	210	1386	231	1678	247	1970	259	3795	301
40	75	0	0	0	0	188	67	480	133	772	176	1064	205	1356	226	1648	242	1940	255	3765	299
25	75	0	0	0	0	0	0	291	81	583	132	875	168	1167	194	1459	215	1751	230	3576	284
0	75	0	0	0	0	0	0	0	0	261	59	553	106	845	141	1137	167	1429	188	3254	258
100	60	25	21	317	159	609	218	901	250	1193	271	1485	286	1777	296	2069	304	2361	311	4186	332
75	60	0	0	36	18	328	117	620	172	912	207	1204	232	1496	249	1788	263	2080	274	3905	310
60	60	0	0	0	0	239	85	531	147	823	187	1115	214	1407	234	1699	250	1991	262	3816	303
50	60	0	0	0	0	173	62	465	129	757	172	1049	202	1341	223	1633	240	1925	253	3750	298
40	60	0	0	0	0	143	51	435	121	727	165	1019	196	1311	218	1603	236	1895	249	3720	295
25	60	0	0	0	0	0	0	245	68	537	122	829	159	1121	187	1413	208	1705	224	3530	280
0	60	0	0	0	0	0	0	0	0	216	49	508	98	800	133	1092	161	1384	182	3209	255
100	50	0	0	280	140	572	204	864	240	1156	263	1448	278	1740	290	2032	299	2324	306	4149	329
75	50	0	0	0	0	291	104	583	162	875	199	1167	224	1459	243	1751	257	2043	269	3868	307
60	50	0	0	0	0	201	72	493	137	785	178	1077	207	1369	228	1661	244	1953	257	3778	300
50	50	0	0	0	0	135	48	427	119	719	163	1011	194	1303	217	1595	235	1887	248	3712	295
40	50	0	0	0	0	105	38	397	110	689	157	981	189	1273	212	1565	230	1857	244	3682	292
25	50	0	0	0	0	0	0	208	58	500	114	792	152	1084	181	1376	202	1668	219	3493	277
0	50	0	0	0	0	0	0	0	0	178	40	470	90	762	127	1054	155	1346	177	3171	252
100	40	0	0	245	122	537	192	829	230	1121	255	1413	272	1705	284	1997	294	2289	301	4114	326
75	40	0	0	0	0	255	91	547	152	839	191	1131	218	1423	237	1715	252	2007	264	3832	304
60	40	0	0	0	0	166	59	458	127	750	170	1042	200	1334	222	1626	239	1918	252	3743	297
50	40	0	0	0	0	100	36	392	109	684	155	976	188	1268	211	1560	229	1852	244	3677	292
40	40	0	0	0	0	70	25	362	101	654	149	946	182	1238	206	1530	225	1822	240	3647	289
25	40	0	0	0	0	0	0	172	48	464	106	756	145	1048	175	1340	197	1632	215	3457	274
0	40	0	0	0	0	0	0	0	0	143	32	435	84	727	121	1019	150	1311	172	3136	249
100	25	0	0	220	110	512	183	804	223	1096	249	1388	267	1680	280	1972	290	2264	298	4089	325
75	25	0	0	0	0	231	82	523	145	815	185	1107	213	1399	233	1691	249	1983	261	3808	302
60	25	0	0	0	0	142	51	434	120	726	165	1018	196	1310	218	1602	236	1894	249	3719	295
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40	25	0	0	0	0	46	16	338	94	630	143	922	177	1214	202	1506	221	1798	237	3623	288
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100	0	0	0	0	0	188	67	480	133	772	175	1064	205	1356	226	1648	242	1940	255	3765	299
75	0	0	0	0	0	0	0	198	55	490	111	782	150	1074	179	1366	201	1658	218	3483	276
60	0	0	0	0	0	0	0	109	30	401	91	693	133	985	164	1277	188	1569	206	3394	269
50	0	0	0	0	0	0	0	43	12	335	76	627	121	919	153	1211	178	1503	198	3328	264
40	0	0	0	0	0	0	0	13	4	305	69	597	115	889	148	1181	174	1473	194	3298	262
25	0	0	0	0	0	0	0	0	0	116	26	408	78	700	117	992	146	1284	169	3109	247
0	0	0	0	0	0	0	0	0	0	0	0	86	17	378	63	670	99	962	127	2787	221

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A2: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:75 Longest Winter Period (251 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3) 1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	188	157	480	240	772	276	1064	296	1356	308	1648	317	1940	323	2232	328	2524	332	4349	345
75	100	0	0	220	110	512	183	804	223	1096	249	1388	267	1680	280	1972	290	2264	298	4089	325
60	100	0	0	138	69	430	154	722	201	1014	230	1306	251	1598	266	1890	278	2182	287	4007	318
50	100	0	0	77	38	369	132	661	184	953	217	1245	239	1537	256	1829	269	2121	279	3946	313
40	100	0	0	50	25	342	122	634	176	926	210	1218	234	1510	252	1802	265	2094	275	3919	311
25	100	0	0	0	0	166	59	458	127	750	171	1042	200	1334	222	1626	239	1918	252	3743	297
0	100	0	0	0	0	0	0	161	45	453	103	745	143	1037	173	1329	195	1621	213	3446	274
100	75	5	4	297	149	589	210	881	245	1173	267	1465	282	1757	293	2049	301	2341	308	4166	331
75	75	0	0	37	19	329	118	621	173	913	208	1205	232	1497	250	1789	263	2081	274	3906	310
60	75	0	0	0	0	247	88	539	150	831	189	1123	216	1415	236	1707	251	1999	263	3824	303
50	75	0	0	0	0	186	66	478	133	770	175	1062	204	1354	226	1646	242	1938	255	3763	299
40	75	0	0	0	0	158	57	450	125	742	169	1034	199	1326	221	1618	238	1910	251	3735	296
25	75	0	0	0	0	0	0	275	76	567	129	859	165	1151	192	1443	212	1735	228	3560	283
0	75	0	0	0	0	0	0	0	0	270	61	562	108	854	142	1146	169	1438	189	3263	259
100	60	0	0	241	121	533	191	825	229	1117	254	1409	271	1701	284	1993	293	2285	301	4110	326
75	60	0	0	0	0	274	98	566	157	858	195	1150	221	1442	240	1734	255	2026	267	3851	306
60	60	0	0	0	0	191	68	483	134	775	176	1067	205	1359	226	1651	243	1943	256	3768	299
50	60	0	0	0	0	130	46	422	117	714	162	1006	193	1298	216	1590	234	1882	248	3707	294
40	60	0	0	0	0	103	37	395	110	687	156	979	188	1271	212	1563	230	1855	244	3680	292
25	60	0	0	0	0	0	0	220	61	512	116	804	155	1096	183	1388	204	1680	221	3505	278
0	60	0	0	0	0	0	0	0	0	214	49	506	97	798	133	1090	160	1382	182	3207	255
100	50	0	0	196	98	488	174	780	217	1072	244	1364	262	1656	276	1948	286	2240	295	4065	323
75	50	0	0	0	0	228	81	520	144	812	184	1104	212	1396	233	1688	248	1980	260	3805	302
60	50	0	0	0	0	145	52	437	121	729	166	1021	196	1313	219	1605	236	1897	250	3722	295
50	50	0	0	0	0	84	30	376	104	668	152	960	185	1252	209	1544	227	1836	242	3661	291
40	50	0	0	0	0	57	20	349	97	641	146	933	179	1225	204	1517	223	1809	238	3634	288
25	50	0	0	0	0	0	0	174	48	466	106	758	146	1050	175	1342	197	1634	215	3459	274
0	50	0	0	0	0	0	0	0	0	169	38	461	89	753	125	1045	154	1337	176	3162	251
100	40	0	0	152	76	444	159	736	205	1028	234	1320	254	1612	269	1904	280	2196	289	4021	319
75	40	0	0	0	0	184	66	476	132	768	175	1060	204	1352	225	1644	242	1936	255	3761	299
60	40	0	0	0	0	102	36	394	109	686	156	978	188	1270	212	1562	230	1854	244	3679	292
50	40	0	0	0	0	41	15	333	92	625	142	917	176	1209	201	1501	221	1793	236	3618	287
40	40	0	0	0	0	14	5	306	85	598	136	890	171	1182	197	1474	217	1766	232	3591	285
25	40	0	0	0	0	0	0	130	36	422	96	714	137	1006	168	1298	191	1590	209	3415	271
0	40	0	0	0	0	0	0	0	0	125	28	417	80	709	118	1001	147	1293	170	3118	247
100	25	0	0	123	61	415	148	707	196	999	227	1291	248	1583	264	1875	276	2167	285	3992	317
75	25	0	0	0	0	155	55	447	124	739	168	1031	198	1323	220	1615	237	1907	251	3732	296
60	25	0	0	0	0	72	26	364	101	656	149	948	182	1240	207	1532	225	1824	240	3649	290
50	25	0	0	0	0	11	4	303	84	595	135	887	171	1179	197	1471	216	1763	232	3588	285
40	25	0	0	0	0	0	0	276	77	568	129	860	165	1152	192	1444	212	1736	228	3561	283
25	25	0	0	0	0	0	0	101	28	393	89	685	132	977	163	1269	187	1561	205	3386	269
0	25	0	0	0	0	0	0	0	0	96	22	388	75	680	113	972	143	1264	166	3089	245
100	0	0	0	0	0	18	6	310	86	602	137	894	172	1186	198	1478	217	1770	233	3595	285
75	0	0	0	0	0	0	0	50	14	342	78	634	122	926	154	1218	179	1510	199	3335	265
60	0	0	0	0	0	0	0	0	0	259	59	551	106	843	141	1135	167	1427	188	3252	258
50	0	0	0	0	0	0	0	0	0	198	45	490	94	782	130	1074	158	1366	180	3191	253
40	0	0	0	0	0	0	0	0	0	171	39	463	89	755	126	1047	154	1339	176	3164	251
25	0	0	0	0	0	0	0	0	0	0	0	288	55	580	97	872	128	1164	153	2989	237
0	0	0	0	0	0	0	0	0	0	0	0	0	0	282	47	574	84	866	114	2691	214

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A3: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:60 Longest Winter Period (242 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	175	146	467	233	759	271	1051	292	1343	305	1635	314	1927	321	2219	326	2511	330	4336	344
75	100	0	0	216	108	508	181	800	222	1092	248	1384	266	1676	279	1968	289	2260	297	4085	324
60	100	0	0	136	68	428	153	720	200	1012	230	1304	251	1596	266	1888	278	2180	287	4005	318
50	100	0	0	77	39	369	132	661	184	953	217	1245	239	1537	256	1829	269	2121	279	3946	313
40	100	0	0	51	25	343	122	635	176	927	211	1219	234	1511	252	1803	265	2095	276	3920	311
25	100	0	0	0	0	174	62	466	129	758	172	1050	202	1342	224	1634	240	1926	253	3751	298
0	100	0	0	0	0	0	0	179	50	471	107	763	147	1055	176	1347	198	1639	216	3464	275
100	75	0	0	269	135	561	200	853	237	1145	260	1437	276	1729	288	2021	297	2313	304	4138	328
75	75	0	0	18	9	310	111	602	167	894	203	1186	228	1478	246	1770	260	2062	271	3887	309
60	75	0	0	0	0	231	82	523	145	815	185	1107	213	1399	233	1691	249	1983	261	3808	302
50	75	0	0	0	0	172	61	464	129	756	172	1048	202	1340	223	1632	240	1924	253	3749	298
40	75	0	0	0	0	145	52	437	122	729	166	1021	196	1313	219	1605	236	1897	250	3722	295
25	75	0	0	0	0	0	0	268	75	560	127	852	164	1144	191	1436	211	1728	227	3553	282
0	75	0	0	0	0	0	0	0	0	274	62	566	109	858	143	1150	169	1442	190	3267	259
100	60	0	0	209	105	501	179	793	220	1085	247	1377	265	1669	278	1961	288	2253	296	4078	324
75	60	0	0	0	0	251	89	543	151	835	190	1127	217	1419	236	1711	252	2003	263	3828	304
60	60	0	0	0	0	171	61	463	129	755	172	1047	201	1339	223	1631	240	1923	253	3748	297
50	60	0	0	0	0	112	40	404	112	696	158	988	190	1280	213	1572	231	1864	245	3689	293
40	60	0	0	0	0	86	31	378	105	670	152	962	185	1254	209	1546	227	1838	242	3663	291
25	60	0	0	0	0	0	0	209	58	501	114	793	152	1085	181	1377	202	1669	220	3494	277
0	60	0	0	0	0	0	0	0	0	214	49	506	97	798	133	1090	160	1382	182	3207	255
100	50	0	0	160	80	452	161	744	207	1036	235	1328	255	1620	270	1912	281	2204	290	4029	320
75	50	0	0	0	0	201	72	493	137	785	178	1077	207	1369	228	1661	244	1953	257	3778	300
60	50	0	0	0	0	121	43	413	115	705	160	997	192	1289	215	1581	233	1873	247	3698	294
50	50	0	0	0	0	63	22	355	99	647	147	939	181	1231	205	1523	224	1815	239	3640	289
40	50	0	0	0	0	36	13	328	91	620	141	912	175	1204	201	1496	220	1788	235	3613	287
25	50	0	0	0	0	0	0	159	44	451	103	743	143	1035	173	1327	195	1619	213	3444	273
0	50	0	0	0	0	0	0	0	0	164	37	456	88	748	125	1040	153	1332	175	3157	251
100	40	0	0	113	57	405	145	697	194	989	225	1281	246	1573	262	1865	274	2157	284	3982	316
75	40	0	0	0	0	155	55	447	124	739	168	1031	198	1323	220	1615	237	1907	251	3732	296
60	40	0	0	0	0	75	27	367	102	659	150	951	183	1243	207	1535	226	1827	240	3652	290
50	40	0	0	0	0	16	6	308	86	600	136	892	172	1184	197	1476	217	1768	233	3593	285
40	40	0	0	0	0	0	0	282	78	574	130	866	166	1158	193	1450	213	1742	229	3567	283
25	40	0	0	0	0	0	0	113	31	405	92	697	134	989	165	1281	188	1573	207	3398	270
0	40	0	0	0	0	0	0	0	0	118	27	410	79	702	117	994	146	1286	169	3111	247
100	25	0	0	81	41	373	133	665	185	957	218	1249	240	1541	257	1833	270	2125	280	3950	314
75	25	0	0	0	0	123	44	415	115	707	161	999	192	1291	215	1583	233	1875	247	3700	294
60	25	0	0	0	0	43	15	335	93	627	142	919	177	1211	202	1503	221	1795	236	3620	287
50	25	0	0	0	0	0	0	276	77	568	129	860	165	1152	192	1444	212	1736	228	3561	283
40	25	0	0	0	0	0	0	250	69	542	123	834	160	1126	188	1418	208	1710	225	3535	281
25	25	0	0	0	0	0	0	81	22	373	85	665	128	957	159	1249	184	1541	203	3366	267
0	25	0	0	0	0	0	0	0	0	86	20	378	73	670	112	962	141	1254	165	3079	244
100	0	0	0	0	0	0	0	238	66	530	120	822	158	1114	186	1406	207	1698	223	3523	280
75	0	0	0	0	0	0	0	0	0	279	63	571	110	863	144	1155	170	1447	190	3272	260
60	0	0	0	0	0	0	0	0	0	199	45	491	94	783	131	1075	158	1367	180	3192	253
50	0	0	0	0	0	0	0	0	0	140	32	432	83	724	121	1016	149	1308	172	3133	249
40	0	0	0	0	0	0	0	0	0	114	26	406	78	698	116	990	146	1282	169	3107	247
25	0	0	0	0	0	0	0	0	0	0	0	237	46	529	88	821	121	1113	146	2938	233
0	0	0	0	0	0	0	0	0	0	0	0	0	0	242	40	534	79	826	109	2651	210

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A4: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:50 Longest Winter Period (235 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	163	136	455	228	747	267	1039	289	1331	303	1623	312	1915	319	2207	325	2499	329	4324	343
75	100	0	0	212	106	504	180	796	221	1088	247	1380	265	1672	279	1964	289	2256	297	4081	324
60	100	0	0	135	67	427	152	719	200	1011	230	1303	251	1595	266	1887	277	2179	287	4004	318
50	100	0	0	78	39	370	132	662	184	954	217	1246	240	1538	256	1830	269	2122	279	3947	313
40	100	0	0	52	26	344	123	636	177	928	211	1220	235	1512	252	1804	265	2096	276	3921	311
25	100	0	0	0	0	180	64	472	131	764	174	1056	203	1348	225	1640	241	1932	254	3757	298
0	100	0	0	0	0	0	0	194	54	486	111	778	150	1070	178	1362	200	1654	218	3479	276
100	75	0	0	246	123	538	192	830	230	1122	255	1414	272	1706	284	1998	294	2290	301	4115	327
75	75	0	0	3	1	295	105	587	163	879	200	1171	225	1463	244	1755	258	2047	269	3872	307
60	75	0	0	0	0	217	78	509	142	801	182	1093	210	1385	231	1677	247	1969	259	3794	301
50	75	0	0	0	0	160	57	452	126	744	169	1036	199	1328	221	1620	238	1912	252	3737	297
40	75	0	0	0	0	135	48	427	119	719	163	1011	194	1303	217	1595	235	1887	248	3712	295
25	75	0	0	0	0	0	0	263	73	555	126	847	163	1139	190	1431	210	1723	227	3548	282
0	75	0	0	0	0	0	0	0	0	277	63	569	109	861	143	1153	170	1445	190	3270	260
100	60	0	0	182	91	474	169	766	213	1058	241	1350	260	1642	274	1934	284	2226	293	4051	322
75	60	0	0	0	0	231	83	523	145	815	185	1107	213	1399	233	1691	249	1983	261	3808	302
60	60	0	0	0	0	154	55	446	124	738	168	1030	198	1322	220	1614	237	1906	251	3731	296
50	60	0	0	0	0	97	35	389	108	681	155	973	187	1265	211	1557	229	1849	243	3674	292
40	60	0	0	0	0	71	25	363	101	655	149	947	182	1239	207	1531	225	1823	240	3648	290
25	60	0	0	0	0	0	0	199	55	491	112	783	151	1075	179	1367	201	1659	218	3484	277
0	60	0	0	0	0	0	0	0	0	213	49	505	97	797	133	1089	160	1381	182	3206	254
100	50	0	0	130	65	422	151	714	198	1006	229	1298	250	1590	265	1882	277	2174	286	3999	317
75	50	0	0	0	0	179	64	471	131	763	173	1055	203	1347	224	1639	241	1931	254	3756	298
60	50	0	0	0	0	102	36	394	109	686	156	978	188	1270	212	1562	230	1854	244	3679	292
50	50	0	0	0	0	45	16	337	93	629	143	921	177	1213	202	1505	221	1797	236	3622	287
40	50	0	0	0	0	19	7	311	86	603	137	895	172	1187	198	1479	217	1771	233	3596	285
25	50	0	0	0	0	0	0	147	41	439	100	731	141	1023	171	1315	193	1607	211	3432	272
0	50	0	0	0	0	0	0	0	0	161	37	453	87	745	124	1037	153	1329	175	3154	250
100	40	0	0	81	40	373	133	665	185	957	217	1249	240	1541	257	1833	269	2125	280	3950	313
75	40	0	0	0	0	129	46	421	117	713	162	1005	193	1297	216	1589	234	1881	248	3706	294
60	40	0	0	0	0	52	19	344	96	636	145	928	178	1220	203	1512	222	1804	237	3629	288
50	40	0	0	0	0	0	0	287	80	579	132	871	168	1163	194	1455	214	1747	230	3572	283
40	40	0	0	0	0	0	0	261	73	553	126	845	163	1137	190	1429	210	1721	227	3546	281
25	40	0	0	0	0	0	0	98	27	390	89	682	131	974	162	1266	186	1558	205	3383	268
0	40	0	0	0	0	0	0	0	0	112	25	404	78	696	116	988	145	1280	168	3105	246
100	25	0	0	47	23	339	121	631	175	923	210	1215	234	1507	251	1799	264	2091	275	3916	311
75	25	0	0	0	0	95	34	387	108	679	154	971	187	1263	211	1555	229	1847	243	3672	291
60	25	0	0	0	0	18	7	310	86	602	137	894	172	1186	198	1478	217	1770	233	3595	285
50	25	0	0	0	0	0	0	253	70	545	124	837	161	1129	188	1421	209	1713	225	3538	281
40	25	0	0	0	0	0	0	228	63	520	118	812	156	1104	184	1396	205	1688	222	3513	279
25	25	0	0	0	0	0	0	64	18	356	81	648	125	940	157	1232	181	1524	200	3349	266
0	25	0	0	0	0	0	0	0	0	78	18	370	71	662	110	954	140	1246	164	3071	244
100	0	0	0	0	0	0	0	177	49	469	107	761	146	1053	175	1345	198	1637	215	3462	275
75	0	0	0	0	0	0	0	0	0	226	51	518	100	810	135	1102	162	1394	183	3219	255
60	0	0	0	0	0	0	0	0	0	149	34	441	85	733	122	1025	151	1317	173	3142	249
50	0	0	0	0	0	0	0	0	0	92	21	384	74	676	113	968	142	1260	166	3085	245
40	0	0	0	0	0	0	0	0	0	66	15	358	69	650	108	942	139	1234	162	3059	243
25	0	0	0	0	0	0	0	0	0	0	0	194	37	486	81	778	114	1070	141	2895	230
0	0	0	0	0	0	0	0	0	0	0	0	0	0	208	35	500	74	792	104	2617	208

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A5: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:40 Longest Winter Period (232 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3) 1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	158	132	450	225	742	265	1034	287	1326	301	1618	311	1910	318	2202	324	2494	328	4319	343
75	100	0	0	210	105	502	179	794	221	1086	247	1378	265	1670	278	1962	289	2254	297	4079	324
60	100	0	0	134	67	426	152	718	200	1010	230	1302	250	1594	266	1886	277	2178	287	4003	318
50	100	0	0	78	39	370	132	662	184	954	217	1246	240	1538	256	1830	269	2122	279	3947	313
40	100	0	0	53	26	345	123	637	177	929	211	1221	235	1513	252	1805	265	2097	276	3922	311
25	100	0	0	0	0	183	65	475	132	767	174	1059	204	1351	225	1643	242	1935	255	3760	298
0	100	0	0	0	0	0	0	201	56	493	112	785	151	1077	179	1369	201	1661	219	3486	277
100	75	0	0	236	118	528	188	820	228	1112	253	1404	270	1696	283	1988	292	2280	300	4105	326
75	75	0	0	0	0	288	103	580	161	872	198	1164	224	1456	243	1748	257	2040	268	3865	307
60	75	0	0	0	0	212	76	504	140	796	181	1088	209	1380	230	1672	246	1964	258	3789	301
50	75	0	0	0	0	155	55	447	124	739	168	1031	198	1323	221	1615	238	1907	251	3732	296
40	75	0	0	0	0	130	46	422	117	714	162	1006	193	1298	216	1590	234	1882	248	3707	294
25	75	0	0	0	0	0	0	261	72	553	126	845	162	1137	189	1429	210	1721	226	3546	281
0	75	0	0	0	0	0	0	0	0	278	63	570	110	862	144	1154	170	1446	190	3271	260
100	60	0	0	171	85	463	165	755	210	1047	238	1339	257	1631	272	1923	283	2215	291	4040	321
75	60	0	0	0	0	223	80	515	143	807	183	1099	211	1391	232	1683	247	1975	260	3800	302
60	60	0	0	0	0	147	52	439	122	731	166	1023	197	1315	219	1607	236	1899	250	3724	296
50	60	0	0	0	0	90	32	382	106	674	153	966	186	1258	210	1550	228	1842	242	3667	291
40	60	0	0	0	0	65	23	357	99	649	148	941	181	1233	206	1525	224	1817	239	3642	289
25	60	0	0	0	0	0	0	195	54	487	111	779	150	1071	179	1363	201	1655	218	3480	276
0	60	0	0	0	0	0	0	0	0	213	48	505	97	797	133	1089	160	1381	182	3206	254
100	50	0	0	117	58	409	146	701	195	993	226	1285	247	1577	263	1869	275	2161	284	3986	316
75	50	0	0	0	0	169	60	461	128	753	171	1045	201	1337	223	1629	240	1921	253	3746	297
60	50	0	0	0	0	93	33	385	107	677	154	969	186	1261	210	1553	228	1845	243	3670	291
50	50	0	0	0	0	37	13	329	91	621	141	913	176	1205	201	1497	220	1789	235	3614	287
40	50	0	0	0	0	11	4	303	84	595	135	887	171	1179	197	1471	216	1763	232	3588	285
25	50	0	0	0	0	0	0	142	39	434	99	726	140	1018	170	1310	193	1602	211	3427	272
0	50	0	0	0	0	0	0	0	0	160	36	452	87	744	124	1036	152	1328	175	3153	250
100	40	0	0	66	33	358	128	650	181	942	214	1234	237	1526	254	1818	267	2110	278	3935	312
75	40	0	0	0	0	119	42	411	114	703	160	995	191	1287	214	1579	232	1871	246	3696	293
60	40	0	0	0	0	42	15	334	93	626	142	918	177	1210	202	1502	221	1794	236	3619	287
50	40	0	0	0	0	0	0	278	77	570	130	862	166	1154	192	1446	213	1738	229	3563	283
40	40	0	0	0	0	0	0	253	70	545	124	837	161	1129	188	1421	209	1713	225	3538	281
25	40	0	0	0	0	0	0	91	25	383	87	675	130	967	161	1259	185	1551	204	3376	268
0	40	0	0	0	0	0	0	0	0	109	25	401	77	693	115	985	145	1277	168	3102	246
100	25	0	0	32	16	324	116	616	171	908	206	1200	231	1492	249	1784	262	2076	273	3901	310
75	25	0	0	0	0	84	30	376	104	668	152	960	185	1252	209	1544	227	1836	242	3661	291
60	25	0	0	0	0	8	3	300	83	592	134	884	170	1176	196	1468	216	1760	232	3585	284
50	25	0	0	0	0	0	0	243	68	535	122	827	159	1119	187	1411	208	1703	224	3528	280
40	25	0	0	0	0	0	0	218	61	510	116	802	154	1094	182	1386	204	1678	221	3503	278
25	25	0	0	0	0	0	0	56	16	348	79	640	123	932	155	1224	180	1516	200	3341	265
0	25	0	0	0	0	0	0	0	0	74	17	366	70	658	110	950	140	1242	163	3067	243
100	0	0	0	0	0	0	0	151	42	443	101	735	141	1027	171	1319	194	1611	212	3436	273
75	0	0	0	0	0	0	0	0	0	203	46	495	95	787	131	1079	159	1371	180	3196	254
60	0	0	0	0	0	0	0	0	0	127	29	419	81	711	118	1003	147	1295	170	3120	248
50	0	0	0	0	0	0	0	0	0	70	16	362	70	654	109	946	139	1238	163	3063	243
40	0	0	0	0	0	0	0	0	0	45	10	337	65	629	105	921	135	1213	160	3038	241
25	0	0	0	0	0	0	0	0	0	0	0	176	34	468	78	760	112	1052	138	2877	228
0	0	0	0	0	0	0	0	0	0	0	0	0	0	193	32	485	71	777	102	2602	207

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A6: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:25 Longest Winter Period (224 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	146	122	438	219	730	261	1022	284	1314	299	1606	309	1898	316	2190	322	2482	327	4307	342
75	100	0	0	206	103	498	178	790	220	1082	246	1374	264	1666	278	1958	288	2250	296	4075	323
60	100	0	0	133	66	425	152	717	199	1009	229	1301	250	1593	265	1885	277	2177	286	4002	318
50	100	0	0	78	39	370	132	662	184	954	217	1246	240	1538	256	1830	269	2122	279	3947	313
40	100	0	0	54	27	346	124	638	177	930	211	1222	235	1514	252	1806	266	2098	276	3923	311
25	100	0	0	0	0	190	68	482	134	774	176	1066	205	1358	226	1650	243	1942	255	3767	299
0	100	0	0	0	0	0	0	216	60	508	116	800	154	1092	182	1384	204	1676	221	3501	278
100	75	0	0	212	106	504	180	796	221	1088	247	1380	265	1672	279	1964	289	2256	297	4081	324
75	75	0	0	0	0	272	97	564	157	856	194	1148	221	1440	240	1732	255	2024	266	3849	305
60	75	0	0	0	0	198	71	490	136	782	178	1074	207	1366	228	1658	244	1950	257	3775	300
50	75	0	0	0	0	144	51	436	121	728	165	1020	196	1312	219	1604	236	1896	249	3721	295
40	75	0	0	0	0	119	43	411	114	703	160	995	191	1287	215	1579	232	1871	246	3696	293
25	75	0	0	0	0	0	0	255	71	547	124	839	161	1131	188	1423	209	1715	226	3540	281
0	75	0	0	0	0	0	0	0	0	282	64	574	110	866	144	1158	170	1450	191	3275	260
100	60	0	0	143	71	435	155	727	202	1019	232	1311	252	1603	267	1895	279	2187	288	4012	318
75	60	0	0	0	0	203	72	495	137	787	179	1079	207	1371	228	1663	245	1955	257	3780	300
60	60	0	0	0	0	129	46	421	117	713	162	1005	193	1297	216	1589	234	1881	248	3706	294
50	60	0	0	0	0	75	27	367	102	659	150	951	183	1243	207	1535	226	1827	240	3652	290
40	60	0	0	0	0	50	18	342	95	634	144	926	178	1218	203	1510	222	1802	237	3627	288
25	60	0	0	0	0	0	0	186	52	478	109	770	148	1062	177	1354	199	1646	217	3471	275
0	60	0	0	0	0	0	0	0	0	213	48	505	97	797	133	1089	160	1381	182	3206	254
100	50	0	0	86	43	378	135	670	186	962	219	1254	241	1546	258	1838	270	2130	280	3955	314
75	50	0	0	0	0	146	52	438	122	730	166	1022	197	1314	219	1606	236	1898	250	3723	295
60	50	0	0	0	0	73	26	365	101	657	149	949	182	1241	207	1533	225	1825	240	3650	290
50	50	0	0	0	0	18	6	310	86	602	137	894	172	1186	198	1478	217	1770	233	3595	285
40	50	0	0	0	0	0	0	286	79	578	131	870	167	1162	194	1454	214	1746	230	3571	283
25	50	0	0	0	0	0	0	129	36	421	96	713	137	1005	168	1297	191	1589	209	3414	271
0	50	0	0	0	0	0	0	0	0	156	35	448	86	740	123	1032	152	1324	174	3149	250
100	40	0	0	33	16	325	116	617	171	909	207	1201	231	1493	249	1785	262	2077	273	3902	310
75	40	0	0	0	0	93	33	385	107	677	154	969	186	1261	210	1553	228	1845	243	3670	291
60	40	0	0	0	0	19	7	311	86	603	137	895	172	1187	198	1479	217	1771	233	3596	285
50	40	0	0	0	0	0	0	257	71	549	125	841	162	1133	189	1425	209	1717	226	3542	281
40	40	0	0	0	0	0	0	232	64	524	119	816	157	1108	185	1400	206	1692	223	3517	279
25	40	0	0	0	0	0	0	76	21	368	84	660	127	952	159	1244	183	1536	202	3361	267
0	40	0	0	0	0	0	0	0	0	103	23	395	76	687	114	979	144	1271	167	3096	246
100	25	0	0	0	0	288	103	580	161	872	198	1164	224	1456	243	1748	257	2040	268	3865	307
75	25	0	0	0	0	56	20	348	97	640	145	932	179	1224	204	1516	223	1808	238	3633	288
60	25	0	0	0	0	0	0	274	76	566	129	858	165	1150	192	1442	212	1734	228	3559	282
50	25	0	0	0	0	0	0	220	61	512	116	804	155	1096	183	1388	204	1680	221	3505	278
40	25	0	0	0	0	0	0	195	54	487	111	779	150	1071	179	1363	200	1655	218	3480	276
25	25	0	0	0	0	0	0	39	11	331	75	623	120	915	153	1207	178	1499	197	3324	264
0	25	0	0	0	0	0	0	0	0	66	15	358	69	650	108	942	139	1234	162	3059	243
100	0	0	0	0	0	0	0	89	25	381	86	673	129	965	161	1257	185	1549	204	3374	268
75	0	0	0	0	0	0	0	0	0	149	34	441	85	733	122	1025	151	1317	173	3142	249
60	0	0	0	0	0	0	0	0	0	75	17	367	71	659	110	951	140	1243	164	3068	243
50	0	0	0	0	0	0	0	0	0	20	5	312	60	604	101	896	132	1188	156	3013	239
40	0	0	0	0	0	0	0	0	0	0	0	288	55	580	97	872	128	1164	153	2989	237
25	0	0	0	0	0	0	0	0	0	0	0	132	25	424	71	716	105	1008	133	2833	225
0	0	0	0	0	0	0	0	0	0	0	0	0	0	159	26	451	66	743	98	2568	204

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A7: Predicted Water Supply Deficits and Potential Number of Days Without Water during the Shortest Winter Period (188 Days) under Historic Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3) 1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	90	75	382	191	674	241	966	268	1258	286	1550	298	1842	307	2134	314	2426	319	4251	337
75	100	0	0	188	94	480	171	772	214	1064	242	1356	261	1648	275	1940	285	2232	294	4057	322
60	100	0	0	126	63	418	149	710	197	1002	228	1294	249	1586	264	1878	276	2170	286	3995	317
50	100	0	0	80	40	372	133	664	185	956	217	1248	240	1540	257	1832	269	2124	280	3949	313
40	100	0	0	60	30	352	126	644	179	936	213	1228	236	1520	253	1812	266	2104	277	3929	312
25	100	0	0	0	0	221	79	513	142	805	183	1097	211	1389	231	1681	247	1973	260	3798	301
0	100	0	0	0	0	0	0	290	81	582	132	874	168	1166	194	1458	214	1750	230	3575	284
100	75	0	0	97	49	389	139	681	189	973	221	1265	243	1557	260	1849	272	2141	282	3966	315
75	75	0	0	0	0	195	70	487	135	779	177	1071	206	1363	227	1655	243	1947	256	3772	299
60	75	0	0	0	0	133	47	425	118	717	163	1009	194	1301	217	1593	234	1885	248	3710	294
50	75	0	0	0	0	87	31	379	105	671	153	963	185	1255	209	1547	228	1839	242	3664	291
40	75	0	0	0	0	67	24	359	100	651	148	943	181	1235	206	1527	225	1819	239	3644	289
25	75	0	0	0	0	0	0	228	63	520	118	812	156	1104	184	1396	205	1688	222	3513	279
0	75	0	0	0	0	0	0	5	1	297	68	589	113	881	147	1173	173	1465	193	3290	261
100	60	0	0	11	5	303	108	595	165	887	202	1179	227	1471	245	1763	259	2055	270	3880	308
75	60	0	0	0	0	108	39	400	111	692	157	984	189	1276	213	1568	231	1860	245	3685	292
60	60	0	0	0	0	46	17	338	94	630	143	922	177	1214	202	1506	222	1798	237	3623	288
50	60	0	0	0	0	1	0	293	81	585	133	877	169	1169	195	1461	215	1753	231	3578	284
40	60	0	0	0	0	0	0	272	76	564	128	856	165	1148	191	1440	212	1732	228	3557	282
25	60	0	0	0	0	0	0	141	39	433	98	725	139	1017	170	1309	193	1601	211	3426	272
0	60	0	0	0	0	0	0	0	0	211	48	503	97	795	132	1087	160	1379	181	3204	254
100	50	0	0	0	0	231	83	523	145	815	185	1107	213	1399	233	1691	249	1983	261	3808	302
75	50	0	0	0	0	37	13	329	91	621	141	913	176	1205	201	1497	220	1789	235	3614	287
60	50	0	0	0	0	0	0	267	74	559	127	851	164	1143	191	1435	211	1727	227	3552	282
50	50	0	0	0	0	0	0	221	62	513	117	805	155	1097	183	1389	204	1681	221	3506	278
40	50	0	0	0	0	0	0	201	56	493	112	785	151	1077	179	1369	201	1661	219	3486	277
25	50	0	0	0	0	0	0	70	19	362	82	654	126	946	158	1238	182	1530	201	3355	266
0	50	0	0	0	0	0	0	0	0	140	32	432	83	724	121	1016	149	1308	172	3133	249
100	40	0	0	0	0	164	59	456	127	748	170	1040	200	1332	222	1624	239	1916	252	3741	297
75	40	0	0	0	0	0	0	262	73	554	126	846	163	1138	190	1430	210	1722	227	3547	281
60	40	0	0	0	0	0	0	200	56	492	112	784	151	1076	179	1368	201	1660	218	3485	277
50	40	0	0	0	0	0	0	154	43	446	101	738	142	1030	172	1322	194	1614	212	3439	273
40	40	0	0	0	0	0	0	134	37	426	97	718	138	1010	168	1302	191	1594	210	3419	271
25	40	0	0	0	0	0	0	3	1	295	67	587	113	879	146	1171	172	1463	192	3288	261
0	40	0	0	0	0	0	0	0	0	72	16	364	70	656	109	948	139	1240	163	3065	243
100	25	0	0	0	0	118	42	410	114	702	160	994	191	1286	214	1578	232	1870	246	3695	293
75	25	0	0	0	0	0	0	215	60	507	115	799	154	1091	182	1383	203	1675	220	3500	278
60	25	0	0	0	0	0	0	154	43	446	101	738	142	1030	172	1322	194	1614	212	3439	273
50	25	0	0	0	0	0	0	108	30	400	91	692	133	984	164	1276	188	1568	206	3393	269
40	25	0	0	0	0	0	0	87	24	379	86	671	129	963	161	1255	185	1547	204	3372	268
25	25	0	0	0	0	0	0	0	0	248	56	540	104	832	139	1124	165	1416	186	3241	257
0	25	0	0	0	0	0	0	0	0	26	6	318	61	610	102	902	133	1194	157	3019	240
100	0	0	0	0	0	0	0	0	0	84	19	376	72	668	111	960	141	1252	165	3077	244
75	0	0	0	0	0	0	0	0	0	0	0	182	35	474	79	766	113	1058	139	2883	229
60	0	0	0	0	0	0	0	0	0	0	0	120	23	412	69	704	104	996	131	2821	224
50	0	0	0	0	0	0	0	0	0	0	0	74	14	366	61	658	97	950	125	2775	220
40	0	0	0	0	0	0	0	0	0	0	0	54	10	346	58	638	94	930	122	2755	219
25	0	0	0	0	0	0	0	0	0	0	0	0	0	215	36	507	75	799	105	2624	208
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	284	42	576	76	2401	191

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A8: Predicted Water Supply Deficits and Potential Number of Days Without Water during the Longest Winter Period (257 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	122	102	414	207	706	252	998	277	1290	293	1582	304	1874	312	2166	319	2458	323	4283	340
75	100	0	0	227	114	519	185	811	225	1103	251	1395	268	1687	281	1979	291	2271	299	4096	325
60	100	0	0	136	68	428	153	720	200	1012	230	1304	251	1596	266	1888	278	2180	287	4005	318
50	100	0	0	95	48	387	138	679	189	971	221	1263	243	1555	259	1847	272	2139	282	3964	315
40	100	0	0	9	5	301	108	593	165	885	201	1177	226	1469	245	1761	259	2053	270	3878	308
25	100	0	0	0	0	163	58	455	126	747	170	1039	200	1331	222	1623	239	1915	252	3740	297
0	100	0	0	0	0	0	0	248	69	540	123	832	160	1124	187	1416	208	1708	225	3533	280
100	75	0	0	285	143	577	206	869	241	1161	264	1453	279	1745	291	2037	300	2329	306	4154	330
75	75	0	0	98	49	390	139	682	189	974	221	1266	243	1558	260	1850	272	2142	282	3967	315
60	75	0	0	7	3	299	107	591	164	883	201	1175	226	1467	244	1759	259	2051	270	3876	308
50	75	0	0	0	0	258	92	550	153	842	191	1134	218	1426	238	1718	253	2010	264	3835	304
40	75	0	0	0	0	172	61	464	129	756	172	1048	201	1340	223	1632	240	1924	253	3749	298
25	75	0	0	0	0	34	12	326	91	618	140	910	175	1202	200	1494	220	1786	235	3611	287
0	75	0	0	0	0	0	0	119	33	411	93	703	135	995	166	1287	189	1579	208	3404	270
100	60	0	0	250	125	542	194	834	232	1126	256	1418	273	1710	285	2002	294	2294	302	4119	327
75	60	0	0	63	31	355	127	647	180	939	213	1231	237	1523	254	1815	267	2107	277	3932	312
60	60	0	0	0	0	264	94	556	154	848	193	1140	219	1432	239	1724	254	2016	265	3841	305
50	60	0	0	0	0	223	80	515	143	807	183	1099	211	1391	232	1683	248	1975	260	3800	302
40	60	0	0	0	0	137	49	429	119	721	164	1013	195	1305	217	1597	235	1889	249	3714	295
25	60	0	0	0	0	0	0	291	81	583	132	875	168	1167	194	1459	215	1751	230	3576	284
0	60	0	0	0	0	0	0	84	23	376	85	668	128	960	160	1252	184	1544	203	3369	267
100	50	0	0	196	98	488	174	780	217	1072	244	1364	262	1656	276	1948	286	2240	295	4065	323
75	50	0	0	9	4	301	107	593	165	885	201	1177	226	1469	245	1761	259	2053	270	3878	308
60	50	0	0	0	0	210	75	502	139	794	180	1086	209	1378	230	1670	246	1962	258	3787	301
50	50	0	0	0	0	169	60	461	128	753	171	1045	201	1337	223	1629	240	1921	253	3746	297
40	50	0	0	0	0	83	29	375	104	667	151	959	184	1251	208	1543	227	1835	241	3660	290
25	50	0	0	0	0	0	0	237	66	529	120	821	158	1113	185	1405	207	1697	223	3522	280
0	50	0	0	0	0	0	0	30	8	322	73	614	118	906	151	1198	176	1490	196	3315	263
100	40	0	0	180	90	472	169	764	212	1056	240	1348	259	1640	273	1932	284	2224	293	4049	321
75	40	0	0	0	0	285	102	577	160	869	198	1161	223	1453	242	1745	257	2037	268	3862	307
60	40	0	0	0	0	194	69	486	135	778	177	1070	206	1362	227	1654	243	1946	256	3771	299
50	40	0	0	0	0	153	55	445	124	737	168	1029	198	1321	220	1613	237	1905	251	3730	296
40	40	0	0	0	0	67	24	359	100	651	148	943	181	1235	206	1527	225	1819	239	3644	289
25	40	0	0	0	0	0	0	221	61	513	117	805	155	1097	183	1389	204	1681	221	3506	278
0	40	0	0	0	0	0	0	14	4	306	70	598	115	890	148	1182	174	1474	194	3299	262
100	25	0	0	108	54	400	143	692	192	984	224	1276	245	1568	261	1860	274	2152	283	3977	316
75	25	0	0	0	0	213	76	505	140	797	181	1089	209	1381	230	1673	246	1965	259	3790	301
60	25	0	0	0	0	122	43	414	115	706	160	998	192	1290	215	1582	233	1874	247	3699	294
50	25	0	0	0	0	81	29	373	104	665	151	957	184	1249	208	1541	227	1833	241	3658	290
40	25	0	0	0	0	0	0	287	80	579	131	871	167	1163	194	1455	214	1747	230	3572	283
25	25	0	0	0	0	0	0	149	41	441	100	733	141	1025	171	1317	194	1609	212	3434	273
0	25	0	0	0	0	0	0	0	0	234	53	526	101	818	136	1110	163	1402	184	3227	256
100	0	0	0	0	0	138	49	430	119	722	164	1014	195	1306	218	1598	235	1890	249	3715	295
75	0	0	0	0	0	0	0	242	67	534	121	826	159	1118	186	1410	207	1702	224	3527	280
60	0	0	0	0	0	0	0	151	42	443	101	735	141	1027	171	1319	194	1611	212	3436	273
50	0	0	0	0	0	0	0	111	31	403	92	695	134	987	164	1279	188	1571	207	3396	269
40	0	0	0	0	0	0	0	24	7	316	72	608	117	900	150	1192	175	1484	195	3309	263
25	0	0	0	0	0	0	0	0	0	178	41	470	90	762	127	1054	155	1346	177	3171	252
0	0	0	0	0	0	0	0	0	0	0	0	263	51	555	93	847	125	1139	150	2964	235

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A9: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:75 Longest Winter Period (236 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	67	56	359	179	651	232	943	262	1235	281	1527	294	1819	303	2111	310	2403	316	4228	336
75	100	0	0	187	93	479	171	771	214	1063	242	1355	261	1647	274	1939	285	2231	294	4056	322
60	100	0	0	103	52	395	141	687	191	979	223	1271	244	1563	261	1855	273	2147	283	3972	315
50	100	0	0	66	33	358	128	650	180	942	214	1234	237	1526	254	1818	267	2110	278	3935	312
40	100	0	0	0	0	278	99	570	158	862	196	1154	222	1446	241	1738	256	2030	267	3855	306
25	100	0	0	0	0	152	54	444	123	736	167	1028	198	1320	220	1612	237	1904	250	3729	296
0	100	0	0	0	0	0	0	254	70	546	124	838	161	1130	188	1422	209	1714	225	3539	281
100	75	0	0	204	102	496	177	788	219	1080	246	1372	264	1664	277	1956	288	2248	296	4073	323
75	75	0	0	32	16	324	116	616	171	908	206	1200	231	1492	249	1784	262	2076	273	3901	310
60	75	0	0	0	0	241	86	533	148	825	187	1117	215	1409	235	1701	250	1993	262	3818	303
50	75	0	0	0	0	203	73	495	138	787	179	1079	208	1371	229	1663	245	1955	257	3780	300
40	75	0	0	0	0	124	44	416	116	708	161	1000	192	1292	215	1584	233	1876	247	3701	294
25	75	0	0	0	0	0	0	289	80	581	132	873	168	1165	194	1457	214	1749	230	3574	284
0	75	0	0	0	0	0	0	99	28	391	89	683	131	975	163	1267	186	1559	205	3384	269
100	60	0	0	162	81	454	162	746	207	1038	236	1330	256	1622	270	1914	282	2206	290	4031	320
75	60	0	0	0	0	282	101	574	160	866	197	1158	223	1450	242	1742	256	2034	268	3859	306
60	60	0	0	0	0	199	71	491	136	783	178	1075	207	1367	228	1659	244	1951	257	3776	300
50	60	0	0	0	0	161	58	453	126	745	169	1037	199	1329	222	1621	238	1913	252	3738	297
40	60	0	0	0	0	82	29	374	104	666	151	958	184	1250	208	1542	227	1834	241	3659	290
25	60	0	0	0	0	0	0	247	69	539	123	831	160	1123	187	1415	208	1707	225	3532	280
0	60	0	0	0	0	0	0	57	16	349	79	641	123	933	156	1225	180	1517	200	3342	265
100	50	0	0	98	49	390	139	682	189	974	221	1266	243	1558	260	1850	272	2142	282	3967	315
75	50	0	0	0	0	218	78	510	142	802	182	1094	210	1386	231	1678	247	1970	259	3795	301
60	50	0	0	0	0	134	48	426	118	718	163	1010	194	1302	217	1594	234	1886	248	3711	295
50	50	0	0	0	0	97	35	389	108	681	155	973	187	1265	211	1557	229	1849	243	3674	292
40	50	0	0	0	0	17	6	309	86	601	137	893	172	1185	198	1477	217	1769	233	3594	285
25	50	0	0	0	0	0	0	183	51	475	108	767	147	1059	176	1351	199	1643	216	3468	275
0	50	0	0	0	0	0	0	0	0	285	65	577	111	869	145	1161	171	1453	191	3278	260
100	40	0	0	79	40	371	133	663	184	955	217	1247	240	1539	257	1831	269	2123	279	3948	313
75	40	0	0	0	0	199	71	491	136	783	178	1075	207	1367	228	1659	244	1951	257	3776	300
60	40	0	0	0	0	115	41	407	113	699	159	991	191	1283	214	1575	232	1867	246	3692	293
50	40	0	0	0	0	78	28	370	103	662	150	954	183	1246	208	1538	226	1830	241	3655	290
40	40	0	0	0	0	0	0	291	81	583	132	875	168	1167	194	1459	215	1751	230	3576	284
25	40	0	0	0	0	0	0	164	46	456	104	748	144	1040	173	1332	196	1624	214	3449	274
0	40	0	0	0	0	0	0	0	0	266	60	558	107	850	142	1142	168	1434	189	3259	259
100	25	0	0	0	0	285	102	577	160	869	197	1161	223	1453	242	1745	257	2037	268	3862	306
75	25	0	0	0	0	113	40	405	112	697	158	989	190	1281	213	1573	231	1865	245	3690	293
60	25	0	0	0	0	29	10	321	89	613	139	905	174	1197	200	1489	219	1781	234	3606	286
50	25	0	0	0	0	0	0	284	79	576	131	868	167	1160	193	1452	213	1744	229	3569	283
40	25	0	0	0	0	0	0	204	57	496	113	788	152	1080	180	1372	202	1664	219	3489	277
25	25	0	0	0	0	0	0	78	22	370	84	662	127	954	159	1246	183	1538	202	3363	267
0	25	0	0	0	0	0	0	0	0	180	41	472	91	764	127	1056	155	1348	177	3173	252
100	0	0	0	0	0	0	0	263	73	555	126	847	163	1139	190	1431	211	1723	227	3548	282
75	0	0	0	0	0	0	0	92	25	384	87	676	130	968	161	1260	185	1552	204	3377	268
60	0	0	0	0	0	0	0	8	2	300	68	592	114	884	147	1176	173	1468	193	3293	261
50	0	0	0	0	0	0	0	0	0	262	60	554	107	846	141	1138	167	1430	188	3255	258
40	0	0	0	0	0	0	0	0	0	183	42	475	91	767	128	1059	156	1351	178	3176	252
25	0	0	0	0	0	0	0	0	0	57	13	349	67	641	107	933	137	1225	161	3050	242
0	0	0	0	0	0	0	0	0	0	0	0	158	30	450	75	742	109	1034	136	2859	227

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A10: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:60 Longest Winter Period (226 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	39	33	331	166	623	223	915	254	1207	274	1499	288	1791	299	2083	306	2375	313	4200	333
75	100	0	0	167	83	459	164	751	209	1043	237	1335	257	1627	271	1919	282	2211	291	4036	320
60	100	0	0	87	43	379	135	671	186	963	219	1255	241	1547	258	1839	270	2131	280	3956	314
50	100	0	0	51	25	343	122	635	176	927	211	1219	234	1511	252	1803	265	2095	276	3920	311
40	100	0	0	0	0	267	95	559	155	851	193	1143	220	1435	239	1727	254	2019	266	3844	305
25	100	0	0	0	0	146	52	438	122	730	166	1022	197	1314	219	1606	236	1898	250	3723	295
0	100	0	0	0	0	0	0	256	71	548	125	840	162	1132	189	1424	209	1716	226	3541	281
100	75	0	0	165	82	457	163	749	208	1041	237	1333	256	1625	271	1917	282	2209	291	4034	320
75	75	0	0	0	0	292	104	584	162	876	199	1168	225	1460	243	1752	258	2044	269	3869	307
60	75	0	0	0	0	212	76	504	140	796	181	1088	209	1380	230	1672	246	1964	258	3789	301
50	75	0	0	0	0	176	63	468	130	760	173	1052	202	1344	224	1636	241	1928	254	3753	298
40	75	0	0	0	0	100	36	392	109	684	156	976	188	1268	211	1560	229	1852	244	3677	292
25	75	0	0	0	0	0	0	271	75	563	128	855	164	1147	191	1439	212	1731	228	3556	282
0	75	0	0	0	0	0	0	90	25	382	87	674	130	966	161	1258	185	1550	204	3375	268
100	60	0	0	119	60	411	147	703	195	995	226	1287	248	1579	263	1871	275	2163	285	3988	317
75	60	0	0	0	0	247	88	539	150	831	189	1123	216	1415	236	1707	251	1999	263	3824	303
60	60	0	0	0	0	167	60	459	127	751	171	1043	201	1335	222	1627	239	1919	252	3744	297
50	60	0	0	0	0	131	47	423	118	715	163	1007	194	1299	217	1591	234	1883	248	3708	294
40	60	0	0	0	0	55	20	347	96	639	145	931	179	1223	204	1515	223	1807	238	3632	288
25	60	0	0	0	0	0	0	226	63	518	118	810	156	1102	184	1394	205	1686	222	3511	279
0	60	0	0	0	0	0	0	44	12	336	76	628	121	920	153	1212	178	1504	198	3329	264
100	50	0	0	50	25	342	122	634	176	926	210	1218	234	1510	252	1802	265	2094	275	3919	311
75	50	0	0	0	0	177	63	469	130	761	173	1053	203	1345	224	1637	241	1929	254	3754	298
60	50	0	0	0	0	97	35	389	108	681	155	973	187	1265	211	1557	229	1849	243	3674	292
50	50	0	0	0	0	61	22	353	98	645	147	937	180	1229	205	1521	224	1813	239	3638	289
40	50	0	0	0	0	0	0	278	77	570	129	862	166	1154	192	1446	213	1738	229	3563	283
25	50	0	0	0	0	0	0	156	43	448	102	740	142	1032	172	1324	195	1616	213	3441	273
0	50	0	0	0	0	0	0	0	0	267	61	559	107	851	142	1143	168	1435	189	3260	259
100	40	0	0	30	15	322	115	614	170	906	206	1198	230	1490	248	1782	262	2074	273	3899	309
75	40	0	0	0	0	157	56	449	125	741	168	1033	199	1325	221	1617	238	1909	251	3734	296
60	40	0	0	0	0	77	28	369	103	661	150	953	183	1245	208	1537	226	1829	241	3654	290
50	40	0	0	0	0	41	15	333	93	625	142	917	176	1209	202	1501	221	1793	236	3618	287
40	40	0	0	0	0	0	0	257	71	549	125	841	162	1133	189	1425	210	1717	226	3542	281
25	40	0	0	0	0	0	0	136	38	428	97	720	139	1012	169	1304	192	1596	210	3421	272
0	40	0	0	0	0	0	0	0	0	246	56	538	104	830	138	1122	165	1414	186	3239	257
100	25	0	0	0	0	228	82	520	145	812	185	1104	212	1396	233	1688	248	1980	261	3805	302
75	25	0	0	0	0	64	23	356	99	648	147	940	181	1232	205	1524	224	1816	239	3641	289
60	25	0	0	0	0	0	0	276	77	568	129	860	165	1152	192	1444	212	1736	228	3561	283
50	25	0	0	0	0	0	0	240	67	532	121	824	158	1116	186	1408	207	1700	224	3525	280
40	25	0	0	0	0	0	0	164	46	456	104	748	144	1040	173	1332	196	1624	214	3449	274
25	25	0	0	0	0	0	0	43	12	335	76	627	121	919	153	1211	178	1503	198	3328	264
0	25	0	0	0	0	0	0	0	0	153	35	445	86	737	123	1029	151	1321	174	3146	250
100	0	0	0	0	0	0	0	182	51	474	108	766	147	1058	176	1350	199	1642	216	3467	275
75	0	0	0	0	0	0	0	18	5	310	70	602	116	894	149	1186	174	1478	194	3303	262
60	0	0	0	0	0	0	0	0	0	230	52	522	100	814	136	1106	163	1398	184	3223	256
50	0	0	0	0	0	0	0	0	0	194	44	486	93	778	130	1070	157	1362	179	3187	253
40	0	0	0	0	0	0	0	0	0	118	27	410	79	702	117	994	146	1286	169	3111	247
25	0	0	0	0	0	0	0	0	0	0	0	289	56	581	97	873	128	1165	153	2990	237
0	0	0	0	0	0	0	0	0	0	0	0	107	21	399	67	691	102	983	129	2808	223

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A11: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:50 Longest Winter Period (220 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	24	20	316	158	608	217	900	250	1192	271	1484	285	1776	296	2068	304	2360	311	4185	332
75	100	0	0	156	78	448	160	740	205	1032	234	1324	255	1616	269	1908	281	2200	289	4025	319
60	100	0	0	78	39	370	132	662	184	954	217	1246	240	1538	256	1830	269	2122	279	3947	313
50	100	0	0	43	21	335	120	627	174	919	209	1211	233	1503	250	1795	264	2087	275	3912	310
40	100	0	0	0	0	261	93	553	154	845	192	1137	219	1429	238	1721	253	2013	265	3838	305
25	100	0	0	0	0	143	51	435	121	727	165	1019	196	1311	218	1603	236	1895	249	3720	295
0	100	0	0	0	0	0	0	258	72	550	125	842	162	1134	189	1426	210	1718	226	3543	281
100	75	0	0	142	71	434	155	726	202	1018	231	1310	252	1602	267	1894	279	2186	288	4011	318
75	75	0	0	0	0	274	98	566	157	858	195	1150	221	1442	240	1734	255	2026	267	3851	306
60	75	0	0	0	0	196	70	488	136	780	177	1072	206	1364	227	1656	244	1948	256	3773	299
50	75	0	0	0	0	161	58	453	126	745	169	1037	199	1329	222	1621	238	1913	252	3738	297
40	75	0	0	0	0	87	31	379	105	671	153	963	185	1255	209	1547	228	1839	242	3664	291
25	75	0	0	0	0	0	0	261	73	553	126	845	163	1137	190	1429	210	1721	226	3546	281
0	75	0	0	0	0	0	0	84	23	376	85	668	128	960	160	1252	184	1544	203	3369	267
100	60	0	0	95	48	387	138	679	189	971	221	1263	243	1555	259	1847	272	2139	281	3964	315
75	60	0	0	0	0	227	81	519	144	811	184	1103	212	1395	232	1687	248	1979	260	3804	302
60	60	0	0	0	0	149	53	441	122	733	167	1025	197	1317	219	1609	237	1901	250	3726	296
50	60	0	0	0	0	114	41	406	113	698	159	990	190	1282	214	1574	231	1866	246	3691	293
40	60	0	0	0	0	40	14	332	92	624	142	916	176	1208	201	1500	221	1792	236	3617	287
25	60	0	0	0	0	0	0	214	59	506	115	798	153	1090	182	1382	203	1674	220	3499	278
0	60	0	0	0	0	0	0	37	10	329	75	621	119	913	152	1205	177	1497	197	3322	264
100	50	0	0	23	11	315	112	607	168	899	204	1191	229	1483	247	1775	261	2067	272	3892	309
75	50	0	0	0	0	154	55	446	124	738	168	1030	198	1322	220	1614	237	1906	251	3731	296
60	50	0	0	0	0	76	27	368	102	660	150	952	183	1244	207	1536	226	1828	241	3653	290
50	50	0	0	0	0	41	15	333	93	625	142	917	176	1209	202	1501	221	1793	236	3618	287
40	50	0	0	0	0	0	0	259	72	551	125	843	162	1135	189	1427	210	1719	226	3544	281
25	50	0	0	0	0	0	0	142	39	434	99	726	140	1018	170	1310	193	1602	211	3427	272
0	50	0	0	0	0	0	0	0	0	256	58	548	105	840	140	1132	167	1424	187	3249	258
100	40	0	0	1	1	293	105	585	163	877	199	1169	225	1461	244	1753	258	2045	269	3870	307
75	40	0	0	0	0	133	48	425	118	717	163	1009	194	1301	217	1593	234	1885	248	3710	294
60	40	0	0	0	0	55	20	347	96	639	145	931	179	1223	204	1515	223	1807	238	3632	288
50	40	0	0	0	0	20	7	312	87	604	137	896	172	1188	198	1480	218	1772	233	3597	286
40	40	0	0	0	0	0	0	238	66	530	121	822	158	1114	186	1406	207	1698	223	3523	280
25	40	0	0	0	0	0	0	120	33	412	94	704	135	996	166	1288	189	1580	208	3405	270
0	40	0	0	0	0	0	0	0	0	235	53	527	101	819	137	1111	163	1403	185	3228	256
100	25	0	0	0	0	196	70	488	136	780	177	1072	206	1364	227	1656	244	1948	256	3773	299
75	25	0	0	0	0	36	13	328	91	620	141	912	175	1204	201	1496	220	1788	235	3613	287
60	25	0	0	0	0	0	0	250	69	542	123	834	160	1126	188	1418	209	1710	225	3535	281
50	25	0	0	0	0	0	0	215	60	507	115	799	154	1091	182	1383	203	1675	220	3500	278
40	25	0	0	0	0	0	0	141	39	433	98	725	139	1017	170	1309	193	1601	211	3426	272
25	25	0	0	0	0	0	0	23	6	315	72	607	117	899	150	1191	175	1483	195	3308	263
0	25	0	0	0	0	0	0	0	0	138	31	430	83	722	120	1014	149	1306	172	3131	249
100	0	0	0	0	0	0	0	136	38	428	97	720	138	1012	169	1304	192	1596	210	3421	272
75	0	0	0	0	0	0	0	0	0	268	61	560	108	852	142	1144	168	1436	189	3261	259
60	0	0	0	0	0	0	0	0	0	190	43	482	93	774	129	1066	157	1358	179	3183	253
50	0	0	0	0	0	0	0	0	0	155	35	447	86	739	123	1031	152	1323	174	3148	250
40	0	0	0	0	0	0	0	0	0	81	18	373	72	665	111	957	141	1249	164	3074	244
25	0	0	0	0	0	0	0	0	0	0	0	255	49	547	91	839	123	1131	149	2956	235
0	0	0	0	0	0	0	0	0	0	0	0	78	15	370	62	662	97	954	126	2779	221

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A12: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:40 Longest Winter Period (218 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	18	15	310	155	602	215	894	248	1186	270	1478	284	1770	295	2062	303	2354	310	4179	332
75	100	0	0	152	76	444	158	736	204	1028	234	1320	254	1612	269	1904	280	2196	289	4021	319
60	100	0	0	74	37	366	131	658	183	950	216	1242	239	1534	256	1826	269	2118	279	3943	313
50	100	0	0	40	20	332	119	624	173	916	208	1208	232	1500	250	1792	264	2084	274	3909	310
40	100	0	0	0	0	259	92	551	153	843	191	1135	218	1427	238	1719	253	2011	265	3836	304
25	100	0	0	0	0	142	51	434	120	726	165	1018	196	1310	218	1602	236	1894	249	3719	295
0	100	0	0	0	0	0	0	258	72	550	125	842	162	1134	189	1426	210	1718	226	3543	281
100	75	0	0	134	67	426	152	718	200	1010	230	1302	250	1594	266	1886	277	2178	287	4003	318
75	75	0	0	0	0	268	96	560	155	852	194	1144	220	1436	239	1728	254	2020	266	3845	305
60	75	0	0	0	0	190	68	482	134	774	176	1066	205	1358	226	1650	243	1942	256	3767	299
50	75	0	0	0	0	156	56	448	124	740	168	1032	198	1324	221	1616	238	1908	251	3733	296
40	75	0	0	0	0	83	29	375	104	667	151	959	184	1251	208	1543	227	1835	241	3660	290
25	75	0	0	0	0	0	0	258	72	550	125	842	162	1134	189	1426	210	1718	226	3543	281
0	75	0	0	0	0	0	0	82	23	374	85	666	128	958	160	1250	184	1542	203	3367	267
100	60	0	0	87	43	379	135	671	186	963	219	1255	241	1547	258	1839	270	2131	280	3956	314
75	60	0	0	0	0	220	79	512	142	804	183	1096	211	1388	231	1680	247	1972	259	3797	301
60	60	0	0	0	0	143	51	435	121	727	165	1019	196	1311	218	1603	236	1895	249	3720	295
50	60	0	0	0	0	108	39	400	111	692	157	984	189	1276	213	1568	231	1860	245	3685	292
40	60	0	0	0	0	35	12	327	91	619	141	911	175	1203	200	1495	220	1787	235	3612	287
25	60	0	0	0	0	0	0	210	58	502	114	794	153	1086	181	1378	203	1670	220	3495	277
0	60	0	0	0	0	0	0	34	10	326	74	618	119	910	152	1202	177	1494	197	3319	263
100	50	0	0	13	7	305	109	597	166	889	202	1181	227	1473	246	1765	260	2057	271	3882	308
75	50	0	0	0	0	146	52	438	122	730	166	1022	197	1314	219	1606	236	1898	250	3723	296
60	50	0	0	0	0	69	25	361	100	653	148	945	182	1237	206	1529	225	1821	240	3646	289
50	50	0	0	0	0	35	12	327	91	619	141	911	175	1203	200	1495	220	1787	235	3612	287
40	50	0	0	0	0	0	0	253	70	545	124	837	161	1129	188	1421	209	1713	225	3538	281
25	50	0	0	0	0	0	0	136	38	428	97	720	139	1012	169	1304	192	1596	210	3421	272
0	50	0	0	0	0	0	0	0	0	253	57	545	105	837	139	1129	166	1421	187	3246	258
100	40	0	0	0	0	284	101	576	160	868	197	1160	223	1452	242	1744	256	2036	268	3861	306
75	40	0	0	0	0	125	45	417	116	709	161	1001	193	1293	216	1585	233	1877	247	3702	294
60	40	0	0	0	0	48	17	340	94	632	144	924	178	1216	203	1508	222	1800	237	3625	288
50	40	0	0	0	0	13	5	305	85	597	136	889	171	1181	197	1473	217	1765	232	3590	285
40	40	0	0	0	0	0	0	232	64	524	119	816	157	1108	185	1400	206	1692	223	3517	279
25	40	0	0	0	0	0	0	115	32	407	93	699	134	991	165	1283	189	1575	207	3400	270
0	40	0	0	0	0	0	0	0	0	231	53	523	101	815	136	1107	163	1399	184	3224	256
100	25	0	0	0	0	185	66	477	133	769	175	1061	204	1353	226	1645	242	1937	255	3762	299
75	25	0	0	0	0	27	9	319	88	611	139	903	174	1195	199	1487	219	1779	234	3604	286
60	25	0	0	0	0	0	0	241	67	533	121	825	159	1117	186	1409	207	1701	224	3526	280
50	25	0	0	0	0	0	0	207	57	499	113	791	152	1083	180	1375	202	1667	219	3492	277
40	25	0	0	0	0	0	0	133	37	425	97	717	138	1009	168	1301	191	1593	210	3418	271
25	25	0	0	0	0	0	0	17	5	309	70	601	115	893	149	1185	174	1477	194	3302	262
0	25	0	0	0	0	0	0	0	0	133	30	425	82	717	119	1009	148	1301	171	3126	248
100	0	0	0	0	0	0	0	120	33	412	94	704	135	996	166	1288	189	1580	208	3405	270
75	0	0	0	0	0	0	0	0	0	253	58	545	105	837	140	1129	166	1421	187	3246	258
60	0	0	0	0	0	0	0	0	0	176	40	468	90	760	127	1052	155	1344	177	3169	252
50	0	0	0	0	0	0	0	0	0	142	32	434	83	726	121	1018	150	1310	172	3135	249
40	0	0	0	0	0	0	0	0	0	68	16	360	69	652	109	944	139	1236	163	3061	243
25	0	0	0	0	0	0	0	0	0	0	0	243	47	535	89	827	122	1119	147	2944	234
0	0	0	0	0	0	0	0	0	0	0	0	68	13	360	60	652	96	944	124	2769	220

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A13: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:25 Longest Winter Period (212 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	2	2	294	147	586	209	878	244	1170	266	1462	281	1754	292	2046	301	2338	308	4163	330
75	100	0	0	140	70	432	154	724	201	1016	231	1308	252	1600	267	1892	278	2184	287	4009	318
60	100	0	0	65	32	357	127	649	180	941	214	1233	237	1525	254	1817	267	2109	277	3934	312
50	100	0	0	31	16	323	115	615	171	907	206	1199	231	1491	249	1783	262	2075	273	3900	310
40	100	0	0	0	0	252	90	544	151	836	190	1128	217	1420	237	1712	252	2004	264	3829	304
25	100	0	0	0	0	138	49	430	120	722	164	1014	195	1306	218	1598	235	1890	249	3715	295
0	100	0	0	0	0	0	0	260	72	552	125	844	162	1136	189	1428	210	1720	226	3545	281
100	75	0	0	111	56	403	144	695	193	987	224	1279	246	1571	262	1863	274	2155	284	3980	316
75	75	0	0	0	0	249	89	541	150	833	189	1125	216	1417	236	1709	251	2001	263	3826	304
60	75	0	0	0	0	174	62	466	129	758	172	1050	202	1342	224	1634	240	1926	253	3751	298
50	75	0	0	0	0	140	50	432	120	724	165	1016	195	1308	218	1600	235	1892	249	3717	295
40	75	0	0	0	0	69	25	361	100	653	148	945	182	1237	206	1529	225	1821	240	3646	289
25	75	0	0	0	0	0	0	247	69	539	123	831	160	1123	187	1415	208	1707	225	3532	280
0	75	0	0	0	0	0	0	76	21	368	84	660	127	952	159	1244	183	1536	202	3361	267
100	60	0	0	62	31	354	126	646	179	938	213	1230	236	1522	254	1814	267	2106	277	3931	312
75	60	0	0	0	0	199	71	491	136	783	178	1075	207	1367	228	1659	244	1951	257	3776	300
60	60	0	0	0	0	124	44	416	116	708	161	1000	192	1292	215	1584	233	1876	247	3701	294
50	60	0	0	0	0	90	32	382	106	674	153	966	186	1258	210	1550	228	1842	242	3667	291
40	60	0	0	0	0	19	7	311	86	603	137	895	172	1187	198	1479	218	1771	233	3596	285
25	60	0	0	0	0	0	0	197	55	489	111	781	150	1073	179	1365	201	1657	218	3482	276
0	60	0	0	0	0	0	0	27	7	319	72	611	117	903	150	1195	176	1487	196	3312	263
100	50	0	0	0	0	277	99	569	158	861	196	1153	222	1445	241	1737	255	2029	267	3854	306
75	50	0	0	0	0	123	44	415	115	707	161	999	192	1291	215	1583	233	1875	247	3700	294
60	50	0	0	0	0	47	17	339	94	631	144	923	178	1215	203	1507	222	1799	237	3624	288
50	50	0	0	0	0	14	5	306	85	598	136	890	171	1182	197	1474	217	1766	232	3591	285
40	50	0	0	0	0	0	0	235	65	527	120	819	157	1111	185	1403	206	1695	223	3520	279
25	50	0	0	0	0	0	0	121	34	413	94	705	136	997	166	1289	190	1581	208	3406	270
0	50	0	0	0	0	0	0	0	0	242	55	534	103	826	138	1118	164	1410	186	3235	257
100	40	0	0	0	0	255	91	547	152	839	191	1131	217	1423	237	1715	252	2007	264	3832	304
75	40	0	0	0	0	100	36	392	109	684	156	976	188	1268	211	1560	229	1852	244	3677	292
60	40	0	0	0	0	25	9	317	88	609	138	901	173	1193	199	1485	218	1777	234	3602	286
50	40	0	0	0	0	0	0	284	79	576	131	868	167	1160	193	1452	213	1744	229	3569	283
40	40	0	0	0	0	0	0	212	59	504	115	796	153	1088	181	1380	203	1672	220	3497	278
25	40	0	0	0	0	0	0	99	27	391	89	683	131	975	162	1267	186	1559	205	3384	269
0	40	0	0	0	0	0	0	0	0	220	50	512	98	804	134	1096	161	1388	183	3213	255
100	25	0	0	0	0	152	54	444	123	736	167	1028	198	1320	220	1612	237	1904	251	3729	296
75	25	0	0	0	0	0	0	290	81	582	132	874	168	1166	194	1458	214	1750	230	3575	284
60	25	0	0	0	0	0	0	215	60	507	115	799	154	1091	182	1383	203	1675	220	3500	278
50	25	0	0	0	0	0	0	181	50	473	108	765	147	1057	176	1349	198	1641	216	3466	275
40	25	0	0	0	0	0	0	110	31	402	91	694	133	986	164	1278	188	1570	207	3395	269
25	25	0	0	0	0	0	0	0	0	288	65	580	112	872	145	1164	171	1456	192	3281	260
0	25	0	0	0	0	0	0	0	0	117	27	409	79	701	117	993	146	1285	169	3110	247
100	0	0	0	0	0	0	0	73	20	365	83	657	126	949	158	1241	182	1533	202	3358	266
75	0	0	0	0	0	0	0	0	0	210	48	502	97	794	132	1086	160	1378	181	3203	254
60	0	0	0	0	0	0	0	0	0	135	31	427	82	719	120	1011	149	1303	171	3128	248
50	0	0	0	0	0	0	0	0	0	101	23	393	76	685	114	977	144	1269	167	3094	246
40	0	0	0	0	0	0	0	0	0	30	7	322	62	614	102	906	133	1198	158	3023	240
25	0	0	0	0	0	0	0	0	0	0	0	209	40	501	83	793	117	1085	143	2910	231
0	0	0	0	0	0	0	0	0	0	0	0	38	7	330	55	622	91	914	120	2739	217

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A14: Predicted Water Supply Deficits and Potential Number of Days Without Water during the Shortest Winter Period (174 Days) under 2050s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	0	0	193	97	485	173	777	216	1069	243	1361	262	1653	276	1945	286	2237	294	4062	322
75	100	0	0	66	33	358	128	650	181	942	214	1234	237	1526	254	1818	267	2110	278	3935	312
60	100	0	0	5	2	297	106	589	164	881	200	1173	226	1465	244	1757	258	2049	270	3874	307
50	100	0	0	0	0	269	96	561	156	853	194	1145	220	1437	240	1729	254	2021	266	3846	305
40	100	0	0	0	0	211	75	503	140	795	181	1087	209	1379	230	1671	246	1963	258	3788	301
25	100	0	0	0	0	117	42	409	114	701	159	993	191	1285	214	1577	232	1869	246	3694	293
0	100	0	0	0	0	0	0	269	75	561	128	853	164	1145	191	1437	211	1729	228	3554	282
100	75	0	0	0	0	256	92	548	152	840	191	1132	218	1424	237	1716	252	2008	264	3833	304
75	75	0	0	0	0	130	46	422	117	714	162	1006	193	1298	216	1590	234	1882	248	3707	294
60	75	0	0	0	0	68	24	360	100	652	148	944	182	1236	206	1528	225	1820	239	3645	289
50	75	0	0	0	0	40	14	332	92	624	142	916	176	1208	201	1500	221	1792	236	3617	287
40	75	0	0	0	0	0	0	274	76	566	129	858	165	1150	192	1442	212	1734	228	3559	282
25	75	0	0	0	0	0	0	181	50	473	107	765	147	1057	176	1349	198	1641	216	3466	275
0	75	0	0	0	0	0	0	41	11	333	76	625	120	917	153	1209	178	1501	197	3326	264
100	60	0	0	0	0	194	69	486	135	778	177	1070	206	1362	227	1654	243	1946	256	3771	299
75	60	0	0	0	0	68	24	360	100	652	148	944	181	1236	206	1528	225	1820	239	3645	289
60	60	0	0	0	0	6	2	298	83	590	134	882	170	1174	196	1466	216	1758	231	3583	284
50	60	0	0	0	0	0	0	270	75	562	128	854	164	1146	191	1438	212	1730	228	3555	282
40	60	0	0	0	0	0	0	212	59	504	115	796	153	1088	181	1380	203	1672	220	3497	278
25	60	0	0	0	0	0	0	119	33	411	93	703	135	995	166	1287	189	1579	208	3404	270
0	60	0	0	0	0	0	0	0	0	271	61	563	108	855	142	1147	169	1439	189	3264	259
100	50	0	0	0	0	99	35	391	109	683	155	975	187	1267	211	1559	229	1851	244	3676	292
75	50	0	0	0	0	0	0	264	73	556	126	848	163	1140	190	1432	211	1724	227	3549	282
60	50	0	0	0	0	0	0	202	56	494	112	786	151	1078	180	1370	202	1662	219	3487	277
50	50	0	0	0	0	0	0	175	49	467	106	759	146	1051	175	1343	197	1635	215	3460	275
40	50	0	0	0	0	0	0	116	32	408	93	700	135	992	165	1284	189	1576	207	3401	270
25	50	0	0	0	0	0	0	23	6	315	72	607	117	899	150	1191	175	1483	195	3308	263
0	50	0	0	0	0	0	0	0	0	175	40	467	90	759	126	1051	155	1343	177	3168	251
100	40	0	0	0	0	71	25	363	101	655	149	947	182	1239	207	1531	225	1823	240	3648	290
75	40	0	0	0	0	0	0	236	66	528	120	820	158	1112	185	1404	207	1696	223	3521	279
60	40	0	0	0	0	0	0	175	49	467	106	759	146	1051	175	1343	197	1635	215	3460	275
50	40	0	0	0	0	0	0	147	41	439	100	731	141	1023	171	1315	193	1607	211	3432	272
40	40	0	0	0	0	0	0	89	25	381	86	673	129	965	161	1257	185	1549	204	3374	268
25	40	0	0	0	0	0	0	0	0	287	65	579	111	871	145	1163	171	1455	191	3280	260
0	40	0	0	0	0	0	0	0	0	147	33	439	84	731	122	1023	150	1315	173	3140	249
100	25	0	0	0	0	0	0	235	65	527	120	819	158	1111	185	1403	206	1695	223	3520	279
75	25	0	0	0	0	0	0	108	30	400	91	692	133	984	164	1276	188	1568	206	3393	269
60	25	0	0	0	0	0	0	47	13	339	77	631	121	923	154	1215	179	1507	198	3332	264
50	25	0	0	0	0	0	0	19	5	311	71	603	116	895	149	1187	175	1479	195	3304	262
40	25	0	0	0	0	0	0	0	0	253	57	545	105	837	139	1129	166	1421	187	3246	258
25	25	0	0	0	0	0	0	0	0	159	36	451	87	743	124	1035	152	1327	175	3152	250
0	25	0	0	0	0	0	0	0	0	19	4	311	60	603	101	895	132	1187	156	3012	239
100	0	0	0	0	0	0	0	0	0	63	14	355	68	647	108	939	138	1231	162	3056	243
75	0	0	0	0	0	0	0	0	0	0	0	228	44	520	87	812	119	1104	145	2929	232
60	0	0	0	0	0	0	0	0	0	0	0	167	32	459	76	751	110	1043	137	2868	228
50	0	0	0	0	0	0	0	0	0	0	0	139	27	431	72	723	106	1015	134	2840	225
40	0	0	0	0	0	0	0	0	0	0	0	81	16	373	62	665	98	957	126	2782	221
25	0	0	0	0	0	0	0	0	0	0	0	0	0	279	47	571	84	863	114	2688	213
0	0	0	0	0	0	0	0	0	0	0	0	0	0	139	23	431	63	723	95	2548	202

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A15: Predicted Water Supply Deficits and Potential Number of Days Without Water during the Longest Winter Period (246 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	94	78	386	193	678	242	970	269	1262	287	1554	299	1846	308	2138	314	2430	320	4255	338
75	100	0	0	208	104	500	179	792	220	1084	246	1376	265	1668	278	1960	288	2252	296	4077	324
60	100	0	0	161	81	453	162	745	207	1037	236	1329	256	1621	270	1913	281	2205	290	4030	320
50	100	0	0	79	40	371	133	663	184	955	217	1247	240	1539	257	1831	269	2123	279	3948	313
40	100	0	0	39	19	331	118	623	173	915	208	1207	232	1499	250	1791	263	2083	274	3908	310
25	100	0	0	0	0	267	95	559	155	851	193	1143	220	1435	239	1727	254	2019	266	3844	305
0	100	0	0	0	0	3	1	295	82	587	133	879	169	1171	195	1463	215	1755	231	3580	284
100	75	0	0	243	122	535	191	827	230	1119	254	1411	271	1703	284	1995	293	2287	301	4112	326
75	75	0	0	65	33	357	128	649	180	941	214	1233	237	1525	254	1817	267	2109	278	3934	312
60	75	0	0	18	9	310	111	602	167	894	203	1186	228	1478	246	1770	260	2062	271	3887	309
50	75	0	0	0	0	228	82	520	145	812	185	1104	212	1396	233	1688	248	1980	261	3805	302
40	75	0	0	0	0	188	67	480	133	772	175	1064	205	1356	226	1648	242	1940	255	3765	299
25	75	0	0	0	0	124	44	416	116	708	161	1000	192	1292	215	1584	233	1876	247	3701	294
0	75	0	0	0	0	0	0	152	42	444	101	736	142	1028	171	1320	194	1612	212	3437	273
100	60	0	0	172	86	464	166	756	210	1048	238	1340	258	1632	272	1924	283	2216	292	4041	321
75	60	0	0	0	0	286	102	578	161	870	198	1162	223	1454	242	1746	257	2038	268	3863	307
60	60	0	0	0	0	239	85	531	147	823	187	1115	214	1407	234	1699	250	1991	262	3816	303
50	60	0	0	0	0	157	56	449	125	741	168	1033	199	1325	221	1617	238	1909	251	3734	296
40	60	0	0	0	0	117	42	409	114	701	159	993	191	1285	214	1577	232	1869	246	3694	293
25	60	0	0	0	0	53	19	345	96	637	145	929	179	1221	203	1513	222	1805	237	3630	288
0	60	0	0	0	0	0	0	81	22	373	85	665	128	957	159	1249	184	1541	203	3366	267
100	50	0	0	157	79	449	161	741	206	1033	235	1325	255	1617	270	1909	281	2201	290	4026	320
75	50	0	0	0	0	272	97	564	157	856	194	1148	221	1440	240	1732	255	2024	266	3849	305
60	50	0	0	0	0	225	80	517	143	809	184	1101	212	1393	232	1685	248	1977	260	3802	302
50	50	0	0	0	0	143	51	435	121	727	165	1019	196	1311	218	1603	236	1895	249	3720	295
40	50	0	0	0	0	102	37	394	110	686	156	978	188	1270	212	1562	230	1854	244	3679	292
25	50	0	0	0	0	38	14	330	92	622	141	914	176	1206	201	1498	220	1790	236	3615	287
0	50	0	0	0	0	0	0	66	18	358	81	650	125	942	157	1234	181	1526	201	3351	266
100	40	0	0	118	59	410	146	702	195	994	226	1286	247	1578	263	1870	275	2162	284	3987	316
75	40	0	0	0	0	232	83	524	146	816	185	1108	213	1400	233	1692	249	1984	261	3809	302
60	40	0	0	0	0	185	66	477	132	769	175	1061	204	1353	225	1645	242	1937	255	3762	299
50	40	0	0	0	0	103	37	395	110	687	156	979	188	1271	212	1563	230	1855	244	3680	292
40	40	0	0	0	0	63	22	355	99	647	147	939	181	1231	205	1523	224	1815	239	3640	289
25	40	0	0	0	0	0	0	291	81	583	132	875	168	1167	194	1459	214	1751	230	3576	284
0	40	0	0	0	0	0	0	26	7	318	72	610	117	902	150	1194	176	1486	196	3311	263
100	25	0	0	35	17	327	117	619	172	911	207	1203	231	1495	249	1787	263	2079	274	3904	310
75	25	0	0	0	0	149	53	441	123	733	167	1025	197	1317	220	1609	237	1901	250	3726	296
60	25	0	0	0	0	102	36	394	109	686	156	978	188	1270	212	1562	230	1854	244	3679	292
50	25	0	0	0	0	20	7	312	87	604	137	896	172	1188	198	1480	218	1772	233	3597	285
40	25	0	0	0	0	0	0	272	76	564	128	856	165	1148	191	1440	212	1732	228	3557	282
25	25	0	0	0	0	0	0	208	58	500	114	792	152	1084	181	1376	202	1668	219	3493	277
0	25	0	0	0	0	0	0	0	0	236	54	528	101	820	137	1112	163	1404	185	3229	256
100	0	0	0	0	0	0	0	283	79	575	131	867	167	1159	193	1451	213	1743	229	3568	283
75	0	0	0	0	0	0	0	105	29	397	90	689	132	981	163	1273	187	1565	206	3390	269
60	0	0	0	0	0	0	0	58	16	350	80	642	123	934	156	1226	180	1518	200	3343	265
50	0	0	0	0	0	0	0	0	0	268	61	560	108	852	142	1144	168	1436	189	3261	259
40	0	0	0	0	0	0	0	0	0	228	52	520	100	812	135	1104	162	1396	184	3221	256
25	0	0	0	0	0	0	0	0	0	164	37	456	88	748	125	1040	153	1332	175	3157	251
0	0	0	0	0	0	0	0	0	0	0	0	191	37	483	81	775	114	1067	140	2892	230

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A16: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:75 Longest Winter Period (228 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	42	35	334	167	626	224	918	255	1210	275	1502	289	1794	299	2086	307	2378	313	4203	334
75	100	0	0	170	85	462	165	754	209	1046	238	1338	257	1630	272	1922	283	2214	291	4039	321
60	100	0	0	126	63	418	149	710	197	1002	228	1294	249	1586	264	1878	276	2170	286	3995	317
50	100	0	0	51	25	343	122	635	176	927	211	1219	234	1511	252	1803	265	2095	276	3920	311
40	100	0	0	13	7	305	109	597	166	889	202	1181	227	1473	246	1765	260	2057	271	3882	308
25	100	0	0	0	0	246	88	538	149	830	189	1122	216	1414	236	1706	251	1998	263	3823	303
0	100	0	0	0	0	2	1	294	82	586	133	878	169	1170	195	1462	215	1754	231	3579	284
100	75	0	0	169	85	461	165	753	209	1045	238	1337	257	1629	272	1921	283	2213	291	4038	321
75	75	0	0	5	3	297	106	589	164	881	200	1173	226	1465	244	1757	258	2049	270	3874	307
60	75	0	0	0	0	253	91	545	152	837	190	1129	217	1421	237	1713	252	2005	264	3830	304
50	75	0	0	0	0	178	63	470	130	762	173	1054	203	1346	224	1638	241	1930	254	3755	298
40	75	0	0	0	0	141	50	433	120	725	165	1017	195	1309	218	1601	235	1893	249	3718	295
25	75	0	0	0	0	81	29	373	104	665	151	957	184	1249	208	1541	227	1833	241	3658	290
0	75	0	0	0	0	0	0	129	36	421	96	713	137	1005	167	1297	191	1589	209	3414	271
100	60	0	0	87	43	379	135	671	186	963	219	1255	241	1547	258	1839	270	2131	280	3956	314
75	60	0	0	0	0	215	77	507	141	799	182	1091	210	1383	230	1675	246	1967	259	3792	301
60	60	0	0	0	0	171	61	463	129	755	172	1047	201	1339	223	1631	240	1923	253	3748	297
50	60	0	0	0	0	95	34	387	108	679	154	971	187	1263	211	1555	229	1847	243	3672	291
40	60	0	0	0	0	58	21	350	97	642	146	934	180	1226	204	1518	223	1810	238	3635	289
25	60	0	0	0	0	0	0	291	81	583	132	875	168	1167	194	1459	215	1751	230	3576	284
0	60	0	0	0	0	0	0	47	13	339	77	631	121	923	154	1215	179	1507	198	3332	264
100	50	0	0	70	35	362	129	654	182	946	215	1238	238	1530	255	1822	268	2114	278	3939	313
75	50	0	0	0	0	198	71	490	136	782	178	1074	207	1366	228	1658	244	1950	257	3775	300
60	50	0	0	0	0	154	55	446	124	738	168	1030	198	1322	220	1614	237	1906	251	3731	296
50	50	0	0	0	0	79	28	371	103	663	151	955	184	1247	208	1539	226	1831	241	3656	290
40	50	0	0	0	0	41	15	333	93	625	142	917	176	1209	202	1501	221	1793	236	3618	287
25	50	0	0	0	0	0	0	274	76	566	129	858	165	1150	192	1442	212	1734	228	3559	282
0	50	0	0	0	0	0	0	30	8	322	73	614	118	906	151	1198	176	1490	196	3315	263
100	40	0	0	24	12	316	113	608	169	900	205	1192	229	1484	247	1776	261	2068	272	3893	309
75	40	0	0	0	0	152	54	444	123	736	167	1028	198	1320	220	1612	237	1904	251	3729	296
60	40	0	0	0	0	108	39	400	111	692	157	984	189	1276	213	1568	231	1860	245	3685	292
50	40	0	0	0	0	33	12	325	90	617	140	909	175	1201	200	1493	220	1785	235	3610	286
40	40	0	0	0	0	0	0	288	80	580	132	872	168	1164	194	1456	214	1748	230	3573	284
25	40	0	0	0	0	0	0	228	63	520	118	812	156	1104	184	1396	205	1688	222	3513	279
0	40	0	0	0	0	0	0	0	0	276	63	568	109	860	143	1152	169	1444	190	3269	259
100	25	0	0	0	0	221	79	513	142	805	183	1097	211	1389	231	1681	247	1973	260	3798	301
75	25	0	0	0	0	56	20	348	97	640	146	932	179	1224	204	1516	223	1808	238	3633	288
60	25	0	0	0	0	13	5	305	85	597	136	889	171	1181	197	1473	217	1765	232	3590	285
50	25	0	0	0	0	0	0	229	64	521	118	813	156	1105	184	1397	205	1689	222	3514	279
40	25	0	0	0	0	0	0	192	53	484	110	776	149	1068	178	1360	200	1652	217	3477	276
25	25	0	0	0	0	0	0	133	37	425	96	717	138	1009	168	1301	191	1593	210	3418	271
0	25	0	0	0	0	0	0	0	0	180	41	472	91	764	127	1056	155	1348	177	3173	252
100	0	0	0	0	0	0	0	124	35	416	95	708	136	1000	167	1292	190	1584	208	3409	271
75	0	0	0	0	0	0	0	0	0	252	57	544	105	836	139	1128	166	1420	187	3245	258
60	0	0	0	0	0	0	0	0	0	208	47	500	96	792	132	1084	159	1376	181	3201	254
50	0	0	0	0	0	0	0	0	0	133	30	425	82	717	119	1009	148	1301	171	3126	248
40	0	0	0	0	0	0	0	0	0	95	22	387	75	679	113	971	143	1263	166	3088	245
25	0	0	0	0	0	0	0	0	0	36	8	328	63	620	103	912	134	1204	158	3029	240
0	0	0	0	0	0	0	0	0	0	0	0	84	16	376	63	668	98	960	126	2785	221

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A17: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:60 Longest Winter Period (217 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	13	10	305	152	597	213	889	247	1181	268	1473	283	1765	294	2057	302	2349	309	4174	331
75	100	0	0	148	74	440	157	732	203	1024	233	1316	253	1608	268	1900	279	2192	288	4017	319
60	100	0	0	106	53	398	142	690	192	982	223	1274	245	1566	261	1858	273	2150	283	3975	316
50	100	0	0	34	17	326	117	618	172	910	207	1202	231	1494	249	1786	263	2078	273	3903	310
40	100	0	0	0	0	291	104	583	162	875	199	1167	224	1459	243	1751	257	2043	269	3868	307
25	100	0	0	0	0	234	84	526	146	818	186	1110	214	1402	234	1694	249	1986	261	3811	302
0	100	0	0	0	0	1	1	293	82	585	133	877	169	1169	195	1461	215	1753	231	3578	284
100	75	0	0	127	63	419	150	711	197	1003	228	1295	249	1587	264	1879	276	2171	286	3996	317
75	75	0	0	0	0	262	94	554	154	846	192	1138	219	1430	238	1722	253	2014	265	3839	305
60	75	0	0	0	0	221	79	513	142	805	183	1097	211	1389	231	1681	247	1973	260	3798	301
50	75	0	0	0	0	148	53	440	122	732	166	1024	197	1316	219	1608	237	1900	250	3725	296
40	75	0	0	0	0	113	40	405	112	697	158	989	190	1281	213	1573	231	1865	245	3690	293
25	75	0	0	0	0	56	20	348	97	640	146	932	179	1224	204	1516	223	1808	238	3633	288
0	75	0	0	0	0	0	0	116	32	408	93	700	135	992	165	1284	189	1576	207	3401	270
100	60	0	0	38	19	330	118	622	173	914	208	1206	232	1498	250	1790	263	2082	274	3907	310
75	60	0	0	0	0	173	62	465	129	757	172	1049	202	1341	224	1633	240	1925	253	3750	298
60	60	0	0	0	0	132	47	424	118	716	163	1008	194	1300	217	1592	234	1884	248	3709	294
50	60	0	0	0	0	60	21	352	98	644	146	936	180	1228	205	1520	223	1812	238	3637	289
40	60	0	0	0	0	24	9	316	88	608	138	900	173	1192	199	1484	218	1776	234	3601	286
25	60	0	0	0	0	0	0	260	72	552	125	844	162	1136	189	1428	210	1720	226	3545	281
0	60	0	0	0	0	0	0	27	7	319	72	611	117	903	150	1195	176	1487	196	3312	263
100	50	0	0	20	10	312	111	604	168	896	204	1188	228	1480	247	1772	261	2064	272	3889	309
75	50	0	0	0	0	155	55	447	124	739	168	1031	198	1323	221	1615	238	1907	251	3732	296
60	50	0	0	0	0	114	41	406	113	698	159	990	190	1282	214	1574	231	1866	246	3691	293
50	50	0	0	0	0	42	15	334	93	626	142	918	176	1210	202	1502	221	1794	236	3619	287
40	50	0	0	0	0	6	2	298	83	590	134	882	170	1174	196	1466	216	1758	231	3583	284
25	50	0	0	0	0	0	0	242	67	534	121	826	159	1118	186	1410	207	1702	224	3527	280
0	50	0	0	0	0	0	0	9	2	301	68	593	114	885	147	1177	173	1469	193	3294	261
100	40	0	0	0	0	262	94	554	154	846	192	1138	219	1430	238	1722	253	2014	265	3839	305
75	40	0	0	0	0	106	38	398	111	690	157	982	189	1274	212	1566	230	1858	244	3683	292
60	40	0	0	0	0	64	23	356	99	648	147	940	181	1232	205	1524	224	1816	239	3641	289
50	40	0	0	0	0	0	0	284	79	576	131	868	167	1160	193	1452	214	1744	229	3569	283
40	40	0	0	0	0	0	0	249	69	541	123	833	160	1125	187	1417	208	1709	225	3534	280
25	40	0	0	0	0	0	0	192	53	484	110	776	149	1068	178	1360	200	1652	217	3477	276
0	40	0	0	0	0	0	0	0	0	251	57	543	104	835	139	1127	166	1419	187	3244	257
100	25	0	0	0	0	159	57	451	125	743	169	1035	199	1327	221	1619	238	1911	251	3736	297
75	25	0	0	0	0	3	1	295	82	587	133	879	169	1171	195	1463	215	1755	231	3580	284
60	25	0	0	0	0	0	0	253	70	545	124	837	161	1129	188	1421	209	1713	225	3538	281
50	25	0	0	0	0	0	0	181	50	473	108	765	147	1057	176	1349	198	1641	216	3466	275
40	25	0	0	0	0	0	0	146	40	438	99	730	140	1022	170	1314	193	1606	211	3431	272
25	25	0	0	0	0	0	0	89	25	381	87	673	129	965	161	1257	185	1549	204	3374	268
0	25	0	0	0	0	0	0	0	0	148	34	440	85	732	122	1024	151	1316	173	3141	249
100	0	0	0	0	0	0	0	33	9	325	74	617	119	909	151	1201	177	1493	196	3318	263
75	0	0	0	0	0	0	0	0	0	168	38	460	88	752	125	1044	154	1336	176	3161	251
60	0	0	0	0	0	0	0	0	0	127	29	419	80	711	118	1003	147	1295	170	3120	248
50	0	0	0	0	0	0	0	0	0	54	12	346	67	638	106	930	137	1222	161	3047	242
40	0	0	0	0	0	0	0	0	0	19	4	311	60	603	100	895	132	1187	156	3012	239
25	0	0	0	0	0	0	0	0	0	0	0	254	49	546	91	838	123	1130	149	2955	235
0	0	0	0	0	0	0	0	0	0	0	0	22	4	314	52	606	89	898	118	2723	216

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A18: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:50 Longest Winter Period (213 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	1	1	293	147	585	209	877	244	1169	266	1461	281	1753	292	2045	301	2337	308	4162	330
75	100	0	0	140	70	432	154	724	201	1016	231	1308	251	1600	267	1892	278	2184	287	4009	318
60	100	0	0	99	49	391	140	683	190	975	222	1267	244	1559	260	1851	272	2143	282	3968	315
50	100	0	0	28	14	320	114	612	170	904	205	1196	230	1488	248	1780	262	2072	273	3897	309
40	100	0	0	0	0	285	102	577	160	869	198	1161	223	1453	242	1745	257	2037	268	3862	307
25	100	0	0	0	0	230	82	522	145	814	185	1106	213	1398	233	1690	248	1982	261	3807	302
0	100	0	0	0	0	1	0	293	81	585	133	877	169	1169	195	1461	215	1753	231	3578	284
100	75	0	0	111	55	403	144	695	193	987	224	1279	246	1571	262	1863	274	2155	284	3980	316
75	75	0	0	0	0	249	89	541	150	833	189	1125	216	1417	236	1709	251	2001	263	3826	304
60	75	0	0	0	0	208	74	500	139	792	180	1084	209	1376	229	1668	245	1960	258	3785	300
50	75	0	0	0	0	138	49	430	119	722	164	1014	195	1306	218	1598	235	1890	249	3715	295
40	75	0	0	0	0	103	37	395	110	687	156	979	188	1271	212	1563	230	1855	244	3680	292
25	75	0	0	0	0	47	17	339	94	631	143	923	178	1215	203	1507	222	1799	237	3624	288
0	75	0	0	0	0	0	0	111	31	403	92	695	134	987	164	1279	188	1571	207	3396	270
100	60	0	0	20	10	312	111	604	168	896	204	1188	228	1480	247	1772	261	2064	272	3889	309
75	60	0	0	0	0	158	56	450	125	742	169	1034	199	1326	221	1618	238	1910	251	3735	296
60	60	0	0	0	0	117	42	409	114	701	159	993	191	1285	214	1577	232	1869	246	3694	293
50	60	0	0	0	0	46	17	338	94	630	143	922	177	1214	202	1506	222	1798	237	3623	288
40	60	0	0	0	0	11	4	303	84	595	135	887	171	1179	197	1471	216	1763	232	3588	285
25	60	0	0	0	0	0	0	248	69	540	123	832	160	1124	187	1416	208	1708	225	3533	280
0	60	0	0	0	0	0	0	19	5	311	71	603	116	895	149	1187	175	1479	195	3304	262
100	50	0	0	1	1	293	105	585	163	877	199	1169	225	1461	244	1753	258	2045	269	3870	307
75	50	0	0	0	0	139	50	431	120	723	164	1015	195	1307	218	1599	235	1891	249	3716	295
60	50	0	0	0	0	99	35	391	109	683	155	975	187	1267	211	1559	229	1851	244	3676	292
50	50	0	0	0	0	28	10	320	89	612	139	904	174	1196	199	1488	219	1780	234	3605	286
40	50	0	0	0	0	0	0	285	79	577	131	869	167	1161	194	1453	214	1745	230	3570	283
25	50	0	0	0	0	0	0	230	64	522	119	814	156	1106	184	1398	206	1690	222	3515	279
0	50	0	0	0	0	0	0	1	0	293	67	585	113	877	146	1169	172	1461	192	3286	261
100	40	0	0	0	0	242	87	534	148	826	188	1118	215	1410	235	1702	250	1994	262	3819	303
75	40	0	0	0	0	89	32	381	106	673	153	965	185	1257	209	1549	228	1841	242	3666	291
60	40	0	0	0	0	48	17	340	94	632	144	924	178	1216	203	1508	222	1800	237	3625	288
50	40	0	0	0	0	0	0	269	75	561	127	853	164	1145	191	1437	211	1729	227	3554	282
40	40	0	0	0	0	0	0	234	65	526	120	818	157	1110	185	1402	206	1694	223	3519	279
25	40	0	0	0	0	0	0	179	50	471	107	763	147	1055	176	1347	198	1639	216	3464	275
0	40	0	0	0	0	0	0	0	0	242	55	534	103	826	138	1118	164	1410	186	3235	257
100	25	0	0	0	0	136	49	428	119	720	164	1012	195	1304	217	1596	235	1888	248	3713	295
75	25	0	0	0	0	0	0	275	76	567	129	859	165	1151	192	1443	212	1735	228	3560	283
60	25	0	0	0	0	0	0	234	65	526	120	818	157	1110	185	1402	206	1694	223	3519	279
50	25	0	0	0	0	0	0	163	45	455	103	747	144	1039	173	1331	196	1623	214	3448	274
40	25	0	0	0	0	0	0	128	36	420	96	712	137	1004	167	1296	191	1588	209	3413	271
25	25	0	0	0	0	0	0	73	20	365	83	657	126	949	158	1241	182	1533	202	3358	266
0	25	0	0	0	0	0	0	0	0	136	31	428	82	720	120	1012	149	1304	172	3129	248
100	0	0	0	0	0	0	0	0	0	290	66	582	112	874	146	1166	172	1458	192	3283	261
75	0	0	0	0	0	0	0	0	0	137	31	429	82	721	120	1013	149	1305	172	3130	248
60	0	0	0	0	0	0	0	0	0	96	22	388	75	680	113	972	143	1264	166	3089	245
50	0	0	0	0	0	0	0	0	0	25	6	317	61	609	102	901	133	1193	157	3018	240
40	0	0	0	0	0	0	0	0	0	0	0	282	54	574	96	866	127	1158	152	2983	237
25	0	0	0	0	0	0	0	0	0	0	0	227	44	519	86	811	119	1103	145	2928	232
0	0	0	0	0	0	0	0	0	0	0	0	0	0	290	48	582	86	874	115	2699	214

Notes: 1. Based on distribution of historic meteorological conditions examined.

Legend	
1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A19: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:40 Longest Winter Period (209 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	0	0	283	141	575	205	867	241	1159	263	1451	279	1743	290	2035	299	2327	306	4152	330
75	100	0	0	132	66	424	151	716	199	1008	229	1300	250	1592	265	1884	277	2176	286	4001	318
60	100	0	0	92	46	384	137	676	188	968	220	1260	242	1552	259	1844	271	2136	281	3961	314
50	100	0	0	22	11	314	112	606	168	898	204	1190	229	1482	247	1774	261	2066	272	3891	309
40	100	0	0	0	0	280	100	572	159	864	196	1156	222	1448	241	1740	256	2032	267	3857	306
25	100	0	0	0	0	226	81	518	144	810	184	1102	212	1394	232	1686	248	1978	260	3803	302
0	100	0	0	0	0	1	0	293	81	585	133	877	169	1169	195	1461	215	1753	231	3578	284
100	75	0	0	96	48	388	138	680	189	972	221	1264	243	1556	259	1848	272	2140	282	3965	315
75	75	0	0	0	0	237	85	529	147	821	187	1113	214	1405	234	1697	250	1989	262	3814	303
60	75	0	0	0	0	197	70	489	136	781	177	1073	206	1365	227	1657	244	1949	256	3774	299
50	75	0	0	0	0	127	45	419	116	711	162	1003	193	1295	216	1587	233	1879	247	3704	294
40	75	0	0	0	0	93	33	385	107	677	154	969	186	1261	210	1553	228	1845	243	3670	291
25	75	0	0	0	0	38	14	330	92	622	141	914	176	1206	201	1498	220	1790	236	3615	287
0	75	0	0	0	0	0	0	106	29	398	90	690	133	982	164	1274	187	1566	206	3391	269
100	60	0	0	2	1	294	105	586	163	878	200	1170	225	1462	244	1754	258	2046	269	3871	307
75	60	0	0	0	0	143	51	435	121	727	165	1019	196	1311	219	1603	236	1895	249	3720	295
60	60	0	0	0	0	103	37	395	110	687	156	979	188	1271	212	1563	230	1855	244	3680	292
50	60	0	0	0	0	34	12	326	90	618	140	910	175	1202	200	1494	220	1786	235	3611	287
40	60	0	0	0	0	0	0	291	81	583	133	875	168	1167	195	1459	215	1751	230	3576	284
25	60	0	0	0	0	0	0	237	66	529	120	821	158	1113	185	1405	207	1697	223	3522	280
0	60	0	0	0	0	0	0	12	3	304	69	596	115	888	148	1180	174	1472	194	3297	262
100	50	0	0	0	0	275	98	567	158	859	195	1151	221	1443	241	1735	255	2027	267	3852	306
75	50	0	0	0	0	124	44	416	116	708	161	1000	192	1292	215	1584	233	1876	247	3701	294
60	50	0	0	0	0	84	30	376	105	668	152	960	185	1252	209	1544	227	1836	242	3661	291
50	50	0	0	0	0	15	5	307	85	599	136	891	171	1183	197	1475	217	1767	232	3592	285
40	50	0	0	0	0	0	0	273	76	565	128	857	165	1149	191	1441	212	1733	228	3558	282
25	50	0	0	0	0	0	0	218	61	510	116	802	154	1094	182	1386	204	1678	221	3503	278
0	50	0	0	0	0	0	0	0	0	286	65	578	111	870	145	1162	171	1454	191	3279	260
100	40	0	0	0	0	223	80	515	143	807	183	1099	211	1391	232	1683	248	1975	260	3800	302
75	40	0	0	0	0	72	26	364	101	656	149	948	182	1240	207	1532	225	1824	240	3649	290
60	40	0	0	0	0	32	11	324	90	616	140	908	175	1200	200	1492	219	1784	235	3609	286
50	40	0	0	0	0	0	0	255	71	547	124	839	161	1131	188	1423	209	1715	226	3540	281
40	40	0	0	0	0	0	0	220	61	512	116	804	155	1096	183	1388	204	1680	221	3505	278
25	40	0	0	0	0	0	0	166	46	458	104	750	144	1042	174	1334	196	1626	214	3451	274
0	40	0	0	0	0	0	0	0	0	233	53	525	101	817	136	1109	163	1401	184	3226	256
100	25	0	0	0	0	115	41	407	113	699	159	991	191	1283	214	1575	232	1867	246	3692	293
75	25	0	0	0	0	0	0	256	71	548	124	840	161	1132	189	1424	209	1716	226	3541	281
60	25	0	0	0	0	0	0	216	60	508	115	800	154	1092	182	1384	203	1676	220	3501	278
50	25	0	0	0	0	0	0	146	41	438	100	730	140	1022	170	1314	193	1606	211	3431	272
40	25	0	0	0	0	0	0	112	31	404	92	696	134	988	165	1280	188	1572	207	3397	270
25	25	0	0	0	0	0	0	57	16	349	79	641	123	933	156	1225	180	1517	200	3342	265
0	25	0	0	0	0	0	0	0	0	125	28	417	80	709	118	1001	147	1293	170	3118	247
100	0	0	0	0	0	0	0	0	0	258	59	550	106	842	140	1134	167	1426	188	3251	258
75	0	0	0	0	0	0	0	0	0	107	24	399	77	691	115	983	145	1275	168	3100	246
60	0	0	0	0	0	0	0	0	0	67	15	359	69	651	108	943	139	1235	162	3060	243
50	0	0	0	0	0	0	0	0	0	0	0	289	56	581	97	873	128	1165	153	2990	237
40	0	0	0	0	0	0	0	0	0	0	0	255	49	547	91	839	123	1131	149	2956	235
25	0	0	0	0	0	0	0	0	0	0	0	201	39	493	82	785	115	1077	142	2902	230
0	0	0	0	0	0	0	0	0	0	0	0	0	0	268	45	560	82	852	112	2677	212

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A20: Predicted Water Supply Deficits and Potential Number of Days Without Water during the 1:25 Longest Winter Period (197 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	0	0	248	124	540	193	832	231	1124	255	1416	272	1708	285	2000	294	2292	302	4117	327
75	100	0	0	106	53	398	142	690	192	982	223	1274	245	1566	261	1858	273	2150	283	3975	315
60	100	0	0	68	34	360	129	652	181	944	215	1236	238	1528	255	1820	268	2112	278	3937	312
50	100	0	0	3	2	295	105	587	163	879	200	1171	225	1463	244	1755	258	2047	269	3872	307
40	100	0	0	0	0	263	94	555	154	847	192	1139	219	1431	238	1723	253	2015	265	3840	305
25	100	0	0	0	0	212	76	504	140	796	181	1088	209	1380	230	1672	246	1964	258	3789	301
0	100	0	0	0	0	1	0	293	81	585	133	877	169	1169	195	1461	215	1753	231	3578	284
100	75	0	0	46	23	338	121	630	175	922	210	1214	233	1506	251	1798	264	2090	275	3915	311
75	75	0	0	0	0	196	70	488	136	780	177	1072	206	1364	227	1656	244	1948	256	3773	299
60	75	0	0	0	0	158	57	450	125	742	169	1034	199	1326	221	1618	238	1910	251	3735	296
50	75	0	0	0	0	93	33	385	107	677	154	969	186	1261	210	1553	228	1845	243	3670	291
40	75	0	0	0	0	61	22	353	98	645	147	937	180	1229	205	1521	224	1813	239	3638	289
25	75	0	0	0	0	10	3	302	84	594	135	886	170	1178	196	1470	216	1762	232	3587	285
0	75	0	0	0	0	0	0	91	25	383	87	675	130	967	161	1259	185	1551	204	3376	268
100	60	0	0	0	0	237	85	529	147	821	187	1113	214	1405	234	1697	250	1989	262	3814	303
75	60	0	0	0	0	95	34	387	108	679	154	971	187	1263	211	1555	229	1847	243	3672	291
60	60	0	0	0	0	57	20	349	97	641	146	933	179	1225	204	1517	223	1809	238	3634	288
50	60	0	0	0	0	0	0	284	79	576	131	868	167	1160	193	1452	214	1744	229	3569	283
40	60	0	0	0	0	0	0	252	70	544	124	836	161	1128	188	1420	209	1712	225	3537	281
25	60	0	0	0	0	0	0	201	56	493	112	785	151	1077	179	1369	201	1661	218	3486	277
0	60	0	0	0	0	0	0	0	0	282	64	574	110	866	144	1158	170	1450	191	3275	260
100	50	0	0	0	0	217	77	509	141	801	182	1093	210	1385	231	1677	247	1969	259	3794	301
75	50	0	0	0	0	75	27	367	102	659	150	951	183	1243	207	1535	226	1827	240	3652	290
60	50	0	0	0	0	37	13	329	91	621	141	913	176	1205	201	1497	220	1789	235	3614	287
50	50	0	0	0	0	0	0	264	73	556	126	848	163	1140	190	1432	211	1724	227	3549	282
40	50	0	0	0	0	0	0	231	64	523	119	815	157	1107	185	1399	206	1691	223	3516	279
25	50	0	0	0	0	0	0	180	50	472	107	764	147	1056	176	1348	198	1640	216	3465	275
0	50	0	0	0	0	0	0	0	0	261	59	553	106	845	141	1137	167	1429	188	3254	258
100	40	0	0	0	0	160	57	452	126	744	169	1036	199	1328	221	1620	238	1912	252	3737	297
75	40	0	0	0	0	18	7	310	86	602	137	894	172	1186	198	1478	217	1770	233	3595	285
60	40	0	0	0	0	0	0	273	76	565	128	857	165	1149	191	1441	212	1733	228	3558	282
50	40	0	0	0	0	0	0	207	58	499	113	791	152	1083	181	1375	202	1667	219	3492	277
40	40	0	0	0	0	0	0	175	49	467	106	759	146	1051	175	1343	198	1635	215	3460	275
25	40	0	0	0	0	0	0	124	34	416	95	708	136	1000	167	1292	190	1584	208	3409	271
0	40	0	0	0	0	0	0	0	0	205	47	497	96	789	131	1081	159	1373	181	3198	254
100	25	0	0	0	0	43	15	335	93	627	143	919	177	1211	202	1503	221	1795	236	3620	287
75	25	0	0	0	0	0	0	193	54	485	110	777	149	1069	178	1361	200	1653	218	3478	276
60	25	0	0	0	0	0	0	156	43	448	102	740	142	1032	172	1324	195	1616	213	3441	273
50	25	0	0	0	0	0	0	90	25	382	87	674	130	966	161	1258	185	1550	204	3375	268
40	25	0	0	0	0	0	0	58	16	350	80	642	123	934	156	1226	180	1518	200	3343	265
25	25	0	0	0	0	0	0	7	2	299	68	591	114	883	147	1175	173	1467	193	3292	261
0	25	0	0	0	0	0	0	0	0	88	20	380	73	672	112	964	142	1256	165	3081	245
100	0	0	0	0	0	0	0	0	0	151	34	443	85	735	123	1027	151	1319	174	3144	250
75	0	0	0	0	0	0	0	0	0	9	2	301	58	593	99	885	130	1177	155	3002	238
60	0	0	0	0	0	0	0	0	0	0	0	264	51	556	93	848	125	1140	150	2965	235
50	0	0	0	0	0	0	0	0	0	0	0	198	38	490	82	782	115	1074	141	2899	230
40	0	0	0	0	0	0	0	0	0	0	0	166	32	458	76	750	110	1042	137	2867	228
25	0	0	0	0	0	0	0	0	0	0	0	115	22	407	68	699	103	991	130	2816	223
0	0	0	0	0	0	0	0	0	0	0	0	0	0	196	33	488	72	780	103	2605	207

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

Table A21: Predicted Water Supply Deficits and Potential Number of Days Without Water during the Shortest Winter Period (144 Days) under 2080s Climate Regime

Percentage Probability of Exceedance		Daily Consumption Rate (m^3)																			
		1200		2000		2800		3600		4400		5200		6000		6800		7600		12600	
Snow Accumulation[1]	Rainfall Runoff[1]	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water	Water Supply Deficit (ML)	Number of Days Without Water
100	100	0	0	102	51	394	141	686	190	978	222	1270	244	1562	260	1854	273	2146	282	3971	315
75	100	0	0	0	0	290	103	582	162	874	199	1166	224	1458	243	1750	257	2042	269	3867	307
60	100	0	0	0	0	262	94	554	154	846	192	1138	219	1430	238	1722	253	2014	265	3839	305
50	100	0	0	0	0	214	76	506	141	798	181	1090	210	1382	230	1674	246	1966	259	3791	301
40	100	0	0	0	0	191	68	483	134	775	176	1067	205	1359	226	1651	243	1943	256	3768	299
25	100	0	0	0	0	153	55	445	124	737	168	1029	198	1321	220	1613	237	1905	251	3730	296
0	100	0	0	0	0	0	0	290	81	582	132	874	168	1166	194	1458	214	1750	230	3575	284
100	75	0	0	0	0	129	46	421	117	713	162	1005	193	1297	216	1589	234	1881	247	3706	294
75	75	0	0	0	0	25	9	317	88	609	138	901	173	1193	199	1485	218	1777	234	3602	286
60	75	0	0	0	0	0	0	289	80	581	132	873	168	1165	194	1457	214	1749	230	3574	284
50	75	0	0	0	0	0	0	241	67	533	121	825	159	1117	186	1409	207	1701	224	3526	280
40	75	0	0	0	0	0	0	218	60	510	116	802	154	1094	182	1386	204	1678	221	3503	278
25	75	0	0	0	0	0	0	180	50	472	107	764	147	1056	176	1348	198	1640	216	3465	275
0	75	0	0	0	0	0	0	25	7	317	72	609	117	901	150	1193	175	1485	195	3310	263
100	60	0	0	0	0	0	0	288	80	580	132	872	168	1164	194	1456	214	1748	230	3573	284
75	60	0	0	0	0	0	0	184	51	476	108	768	148	1060	177	1352	199	1644	216	3469	275
60	60	0	0	0	0	0	0	156	43	448	102	740	142	1032	172	1324	195	1616	213	3441	273
50	60	0	0	0	0	0	0	109	30	401	91	693	133	985	164	1277	188	1569	206	3394	269
40	60	0	0	0	0	0	0	85	24	377	86	669	129	961	160	1253	184	1545	203	3370	267
25	60	0	0	0	0	0	0	47	13	339	77	631	121	923	154	1215	179	1507	198	3332	264
0	60	0	0	0	0	0	0	0	0	185	42	477	92	769	128	1061	156	1353	178	3178	252
100	50	0	0	0	0	0	0	261	73	553	126	845	163	1137	190	1429	210	1721	226	3546	281
75	50	0	0	0	0	0	0	157	44	449	102	741	143	1033	172	1325	195	1617	213	3442	273
60	50	0	0	0	0	0	0	130	36	422	96	714	137	1006	168	1298	191	1590	209	3415	271
50	50	0	0	0	0	0	0	82	23	374	85	666	128	958	160	1250	184	1542	203	3367	267
40	50	0	0	0	0	0	0	58	16	350	80	642	124	934	156	1226	180	1518	200	3343	265
25	50	0	0	0	0	0	0	21	6	313	71	605	116	897	149	1189	175	1481	195	3306	262
0	50	0	0	0	0	0	0	0	0	158	36	450	87	742	124	1034	152	1326	174	3151	250
100	40	0	0	0	0	0	0	187	52	479	109	771	148	1063	177	1355	199	1647	217	3472	276
75	40	0	0	0	0	0	0	83	23	375	85	667	128	959	160	1251	184	1543	203	3368	267
60	40	0	0	0	0	0	0	56	16	348	79	640	123	932	155	1224	180	1516	199	3341	265
50	40	0	0	0	0	0	0	8	2	300	68	592	114	884	147	1176	173	1468	193	3293	261
40	40	0	0	0	0	0	0	0	0	276	63	568	109	860	143	1152	169	1444	190	3269	259
25	40	0	0	0	0	0	0	0	0	239	54	531	102	823	137	1115	164	1407	185	3232	256
0	40	0	0	0	0	0	0	0	0	84	19	376	72	668	111	960	141	1252	165	3077	244
100	25	0	0	0	0	0	0	34	9	326	74	618	119	910	152	1202	177	1494	197	3319	263
75	25	0	0	0	0	0	0	0	0	222	50	514	99	806	134	1098	161	1390	183	3215	255
60	25	0	0	0	0	0	0	0	0	194	44	486	93	778	130	1070	157	1362	179	3187	253
50	25	0	0	0	0	0	0	0	0	146	33	438	84	730	122	1022	150	1314	173	3139	249
40	25	0	0	0	0	0	0	0	0	123	28	415	80	707	118	999	147	1291	170	3116	247
25	25	0	0	0	0	0	0	0	0	85	19	377	73	669	112	961	141	1253	165	3078	244
0	25	0	0	0	0	0	0	0	0	0	0	223	43	515	86	807	119	1099	145	2924	232
100	0	0	0	0	0	0	0	0	0	0	0	0	0	285	48	577	85	869	114	2694	214
75	0	0	0	0	0	0	0	0	0	0	0	0	0	181	30	473	70	765	101	2590	206
60	0	0	0	0	0	0	0	0	0	0	0	0	0	154	26	446	66	738	97	2563	203
50	0	0	0	0	0	0	0	0	0	0	0	0	0	106	18	398	59	690	91	2515	200
40	0	0	0	0	0	0	0	0	0	0	0	0	0	82	14	374	55	666	88	2491	198
25	0	0	0	0	0	0	0	0	0	0	0	0	0	45	7	337	50	629	83	2454	195
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	182	27	474	62	2299	182

Notes: 1. Based on distribution of historic meteorological conditions examined.

1234	Winter Water Consumption Exceeds Maximum Available Active Winter Storage
4567	Total Annual Supplementation Exceeds Maximum Available Active Winter Storage
	Low Risk Water Supply Deficit
	High Risk Water Supply Deficit
	Extreme Risk Water Supply Deficit

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