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St. Mary River Irrigation District

Chin Reservoir Expansion Project

Supplemental Information Request #1



Appendices: Volume 2

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APPENDIX 1.2

Hydrological Modelling to Evaluate Changes in Streamflow Availability in the St. Mary River Watershed (WaterSMART 2023)

waterSMART
Water Management Solutions

St. Mary River
Irrigation District

Hydrological Modelling to Evaluate Changes in Streamflow Availability in the St. Mary River Watershed

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Executive Summary

The St. Mary River Irrigation District (SMRID) is exploring the impacts of climate change on the watershed and the water supply to their system. Previous work has been completed to develop the St. Mary Operations and Planning (SOAP) model and to assess options for expanding the Chin Reservoir storage capacity and the addition of irrigation acres. SMRID engaged WaterSMART Solutions Ltd. (WaterSMART) to model and evaluate climate change impacts on water quantity and the future hydrologic conditions. This is relevant for the proposed Chin Reservoir Expansion project, as well as the whole SMRID system.

The goal of this study was to provide a quantitative characterization of surface water availability across the SMRID project area and to evaluate how availability is likely to change under different climate change scenarios. To meet these objectives, a process-based hydrological model was developed using the Raven Hydrological Modelling Framework to simulate all the inflows to the St. Mary Reservoir.

Future climate change scenarios were generated from statistically downscaled climate scenarios obtained from Environment and Climate Change Canada (ECCC) under two ensemble scenarios with two representative concentration pathways (RCPs). RCP 4.5 corresponds to a scenario where carbon emissions stabilize by 2040, while RCP 8.5 represents a scenario with minimal greenhouse gas emission mitigation.

The results are broken down into three levels: 1) running the model of the watershed with only the climate change water supply data and no change in reservoir size or irrigated acres; 2) running the model of the watershed with climate change and the Chin Reservoir expansion included (two expanded volumes); and 3) running the model of the watershed with climate change, the expanded reservoir, and additional irrigation acres.

The results show that climate change is likely to have a substantial effect on the timing and magnitude of runoff generation. The future climate change scenarios evaluated here suggest air temperatures and annual precipitation are projected to increase for watersheds contributing to the St. Mary and Waterton reservoirs. This analysis suggests water supply will likely increase under these scenarios and the region will also likely be more prone to mid-summer drought. Earlier onset of snowmelt and warmer air temperatures are likely to result in an earlier freshet and lower late summer streamflow. Changing seasonality with climate change is likely to lead to a more volatile water supply, particularly in less snowmelt-dominated sub-basins, making the region more prone to droughts. This dynamic is exacerbated by continued glacier retreat, particularly for the St. Mary River.

The results from the analysis with climate change and the Chin Reservoir expansion (two expanded volumes) show that the expansion storage is a benefit for the SMRID because it allows more water to be stored from the increased inflow to the system on an annual scale. The results suggest that there will likely be higher annual water supply for the SMRID in the future and the Chin Reservoir is able to maintain higher storage volumes. These scenarios suggest there is no increased risk of water shortages to the irrigators from the expanded reservoir and climate change, even with additional irrigated acres.

The study results demonstrate that under climate change conditions, including examining two RCPs and two glacier cover scenarios, the water supply to the SMRID will be sufficient to fill the current volume of Chin Reservoir and there are no years where shortages to irrigators are projected to be over 2 inches an

acre. The results also indicate that under climate change and with the expanded Chin Reservoir (two volume scenarios), the water supply to SMRID will be sufficient to fill either of the expanded storage volumes of Chin Reservoir and there are no years where shortages to irrigators are projected to be over 2 inches an acre. The results demonstrate that under climate change conditions, with the expansion of Chin Reservoir storage and the additional water demand from irrigation, the water supply to the SMRID will be sufficient to fill the Chin Reservoir and there are no years where shortages to irrigators are projected to be over 2 inches per irrigated acre.

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1.0 Introduction

1.1 Current Context

The St. Mary River Irrigation District (SMRID) is exploring the impacts of climate change on their system. Previous work has been completed to develop the St. Mary Operations and Planning (SOAP) model and to assess options for optimization of the system, specifically the expansion of the Chin Reservoir (an additional 75,511 or 103,500 acre-feet) and addition of irrigable acres (an additional 46,500 acres) they service. The SMRID work includes changes through both efficiency gains in the system which will be completed in the next five to ten years and then additional storage in the reservoir which is planned to be completed after 2028. An environmental impact assessment (EIA) has been requested by the regulator as a part of the Chin Reservoir expansion. This requires the SMRID to demonstrate that the development will not have a significant impact on water quantity in the watershed. As part of this work and to plan for the future hydrologic conditions under which the project will operate, an evaluation of climate change impacts on water quantity is necessary.

1.2 Study Goals

The goal of this study is to provide a quantitative characterization of surface water quantity across the St. Mary Irrigation District project area and to evaluate how it is expected to change under climate change scenarios. To meet these objectives, we developed a process-based hydrological model using the Raven Hydrological Modelling Framework (Craig et al., 2020; Chernos et al., 2017) to simulate the streamflow and other hydroclimatic variables across all watersheds with inflows to the St. Mary Reservoir. The Raven Hydrological Modelling Framework is an open-source, flexible modelling platform that incorporates land cover, climate, and water withdrawals for the region of interest and as such allows for the easy modification of these components, providing opportunity to analyze hydrologic conditions under a variety of potential scenarios. In addition, since the model is process-based, it accounts for the underlying hydrologic processes that determine streamflow, and as such can be used to provide simulations under a variety of scenarios as well as provide detailed information on other hydroclimatic variables, such as snowpack and evapotranspiration, and therefore provide explanations for why changes in hydrologic conditions occur in the model. This information can be important for diagnosing changing hydrologic conditions as well as better informing future management actions.

To meet the objectives of this study, the following steps were taken:

- Develop a climate and land use driven streamflow model for the St. Mary, Waterton, and Belly River watersheds. This hydrological model will be at a spatial and temporal scale suitable to investigate several scenarios with changing climate and to provide inflows to the SOAP Model.
- Use the developed hydrological model to characterize streamflow and important hydroclimatic indicators across the study area, including at un-gauged locations.
- Run the developed hydrological model under a climate change scenario to evaluate the potential effects of climate change on hydrologic indicators in the study area.

These steps will produce a hydrological model that accurately simulates streamflow and associated hydrologic processes making it an effective tool for characterizing current hydroclimatic conditions and evaluating hydrologic conditions under future climate. In addition, the hydrological model can be paired with other models that require streamflow simulations, such as water management models. This tool will ultimately help managers make more informed decisions and can be linked to other initiatives in the region, including models identifying high value aquatic habitat, areas of potential aquatic vulnerability and resiliency, water availability forecasts, and environmental flow needs.

2.0 Study Area

The area considered in this study is all inflows to the St. Mary Reservoir, located in southwestern Alberta, north of Cardston, AB. This study area consists of three major watersheds: the Waterton River, the Belly River, and the St. Mary River. The reservoir is in the St. Mary River watershed, which originates in the Rocky Mountains of Glacier National Park, Montana, USA. Additional inflows to the St. Mary Reservoir include the Waterton River, which originates in Glacier National Park, MT and Waterton National Park, AB, and the Belly River, which originates in Glacier National Park, MT. Water from the Waterton River flows into the St. Mary Reservoir via a diversion out of the Waterton Reservoir, while a portion of the Belly River is diverted into the St. Mary Reservoir near Glenwood, AB.

The study area consists of two major biogeoclimatic zones: mountainous headwaters and grasslands (Baldwin et al., 2019). The headwaters of the three watersheds are mountainous, consisting of high relief and high elevations (ranging from 1,500 m to > 3,000 m). Highest elevations (>2,500 m) consist of Cordilleran Alpine Tundra, as well as glaciers, primarily in the headwaters of the St. Mary River. Cordilleran Montane Forest covers mid-to-high elevations, primarily below the tree line (1,800 – 2,500 m), where the land cover is dominated by coniferous forests (primarily Lodgepole pine and Engelmann spruce with Subalpine spruce at higher elevations) with some open shrubland, primarily in avalanche paths and valley bottoms, and grasslands.

The Rocky Mountain Foothills Parkland zone marks the transition out of the Rocky Mountain headwaters. This elevation band (1,300 – 1,500 m) transitions from Rocky Mountain montane forest into temperate grasslands and consists of mixed and sometimes deciduous (aspen) forest stands, grasslands, and some agricultural lands (both livestock grazing and crops). In addition, this zone contains several large lakes, including Waterton Lake, Saint Mary Lake, and Lower Saint Mary Lake. East of the Rocky Mountains, the study area transitions into a low relief and low elevations (1,100 m to 1,300 m). This region is classified as the Rocky Mountain Foothills Fescue Grassland and consists primarily of native grasslands and agricultural areas. The area contains several smaller urban centers, including Cardston, AB and the Waterton and St. Mary reservoirs.

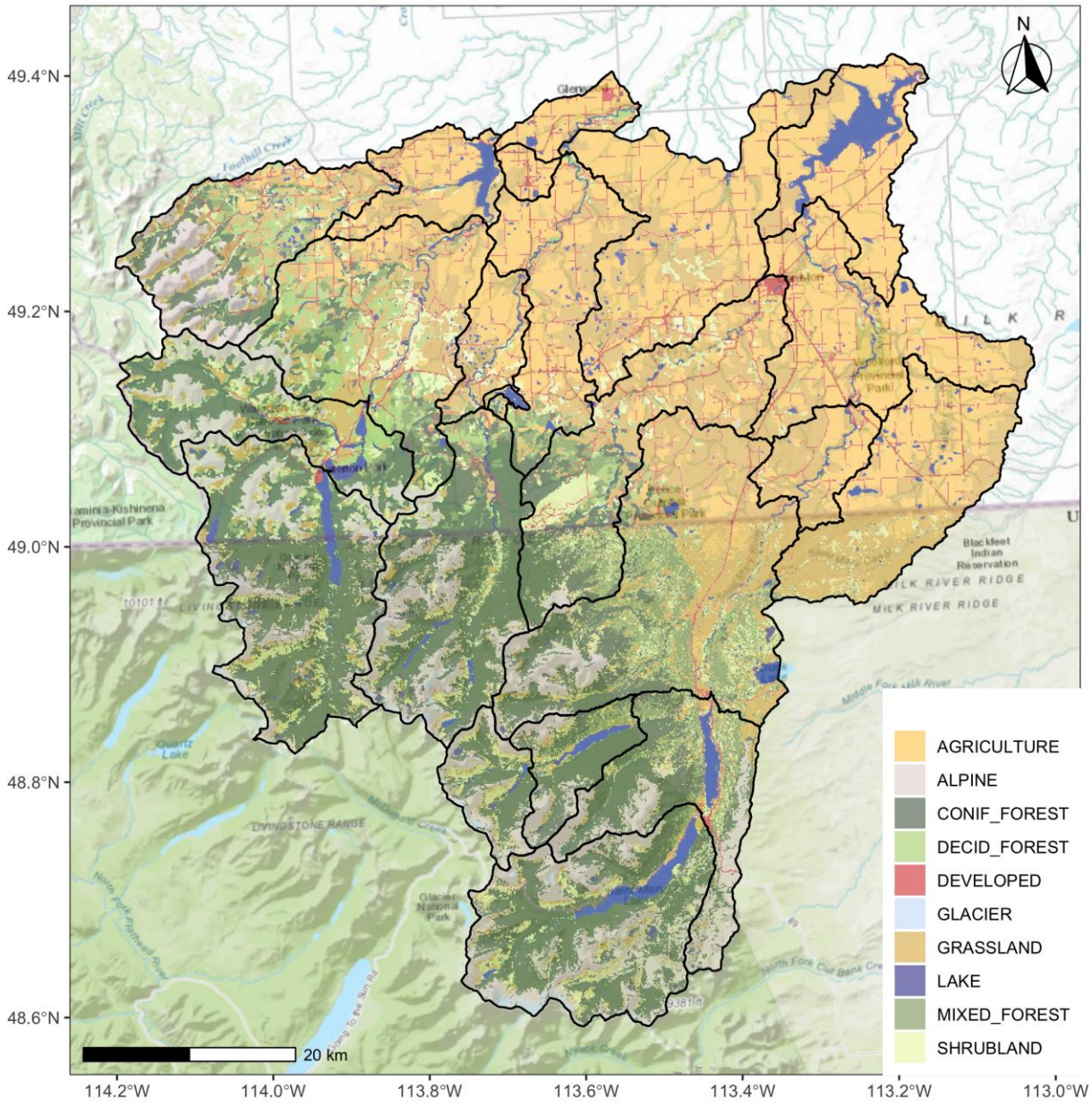


Figure 1. Land cover map of the study area, delineated by sub-basins included in the hydrological model.

3.0 Methods

3.1 Model Formulation

3.1.1 Hydrological Model

The semi-distributed hydrological model used in this study is an adapted version of the HBV-EC model, emulated within the Raven Hydrological Modelling Framework version 3.5 (Craig et al., 2020). The model simulates streamflow and other hydro-climatic variables (i.e., snowmelt, evaporation) at a daily timestep. The model spatially distributes daily minimum and maximum air temperature, precipitation, and relative humidity from all weather stations across the study region. The model simulates major hydrological processes including canopy interception, snow accumulation and melt, evaporation, soil infiltration, percolation, and baseflow, as well as surface runoff. Major processes are described below, while a comprehensive discussion of model algorithms can be found in Bergström (1992), Jost et al. (2012), and Chernos et al. (2020).

In the hydrological model, water inputs occur as precipitation, which are partitioned into rain or snow following the HBV linear transition based on air temperature. Precipitation interception by the forest canopy is estimated as a function of Leaf-Area Index (LAI; Craig et al., 2020; Hedstrom and Pomeroy, 1998). Snowmelt is calculated using a spatially corrected temperature index model, which accounts for aspect, slope, and day length (Jost et al., 2012, Craig et al, 2020). Snow can additionally sublimate from prairie areas following Kutchment and Gelfan (1996). Potential evapotranspiration is calculated using the Priestley–Taylor equation and varies between vegetation types. Once water infiltrates the three-layer soil, it moves downwards through percolation and upwards through capillary rise. Soil water becomes surface runoff (i.e., streamflow) through (faster) interflow and (slower) baseflow pathways.

3.2 Data Sources

3.2.1 Model Forcing Data

To run the hydrological model configurations used in this study, daily air temperature (maximum and minimum, °C) and precipitation (mm/day) are required. These data, along with relative humidity, were collected from DayMet (Thornton et al., 2018) using the Single Pixel Extraction Tool to obtain observations from 1980-2021 at a 1/8th degree resolution over the study area. In total the model has 33 weather stations. Since DayMet data are based on a 1x1 km grid cell, reference elevations are obtained for each data point and are used to correct observations to HRU elevations using specified lapse rates within the hydrological model. Since HRUs are at much higher resolution, spatial interpolation between weather stations uses Inverse Distance Weighting.

Future climate change scenarios were generated from statistically downscaled climate scenarios obtained from Environment and Climate Change Canada (ECCC, 2021) under two representative concentration pathways (RCPs). RCP 4.5 corresponds to a scenario where carbon emissions stabilize by 2040, while RCP 8.5 represents a scenario with minimal greenhouse gas emission mitigation. These scenarios applied the median projection from an equal-weighting ensemble forecast of 24 General Circulation Models (GCM)

from the Coupled Model Inter-comparison Project Phase 5 (CMIP5) from 2021-2100. Projections among climate models can vary because of differences in their underlying representation of earth system processes. Thus, the use of a multi-model ensemble approach has been demonstrated in recent scientific literature to provide better projected climate change information (Zhang et al., 2019, ECCC, 2021).

Daily future weather was generated by first bias-correcting projected climate values by calculating the change between simulated future air temperature and precipitation and historical (simulated). Each future month and year were then matched with a proxy month from the baseline (observed) period. These scaling factors for each month and year (i.e., fractional difference in precipitation and absolute difference in air temperature between the proxy and scenario) were then used to correct the daily observed record for each climate scenario (Figure 2).

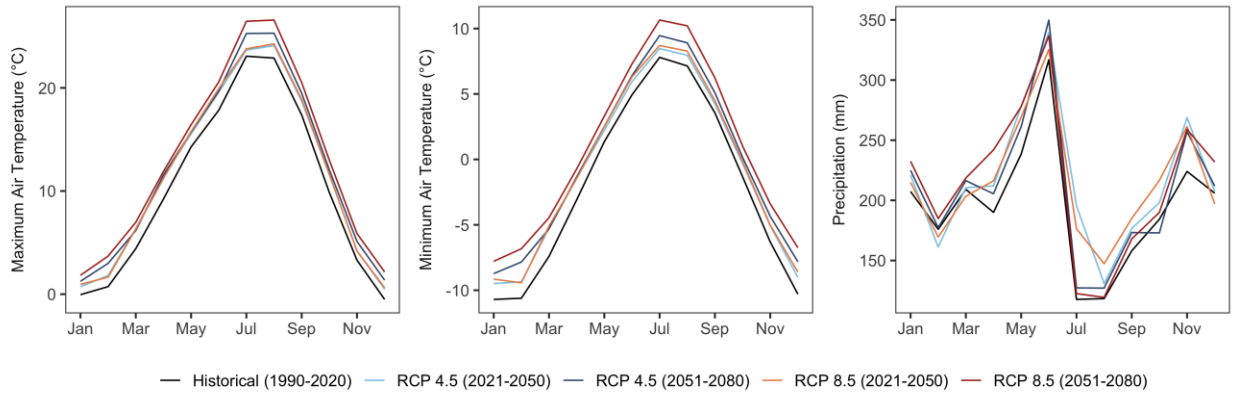


Figure 2. Monthly average climate variables averaged over the study area.

3.2.2 Spatial Discretization

The study area was divided into watersheds, and within each watershed sub-basins, to provide model outputs at major points of interest, calibrate and verify model performance at hydrometric gauges, and to characterize hydroclimatic heterogeneity in the study area. Sub-basin delineation was based on incorporating major tributaries in the system, major lakes or reservoirs (i.e., Waterton Lake, Sherburne Lake, Lower Saint Mary Lake, Waterton Reservoir, St. Mary Reservoir), the location of hydrometric gauges, and major diversions.

The study area was further discretized into hydrological response units (HRUs) based on the unique overlay of elevation bands, hillshade, land cover, and sub-basin. We derived 100 m elevation bands using the Canadian Digital Elevation Data digital elevation model (DEM; Natural Resources Canada, 2016). Hillshade is calculated using the `hillshade` function in the R `raster` package (Hijmans, 2020), which incorporates the slope and aspect of each grid cell. Land cover was obtained from Alberta Biodiversity Monitoring Institute (ABMI) Wall to Wall Land Cover Inventory (ABMI, 2020). We further aggregated land cover into the following classes: Agriculture, Alpine, Shrubland, Grassland, Mixed Forest, Deciduous Forest, Coniferous Forest, Lake, Developed, and Glacier. Since glacier coverage was lumped with snow covered areas (at the time of satellite image acquisition) in the ABMI product, glacier coverage was over-estimated and therefore glacier coverage was manually digitized using Google Earth imagery as of 2020.

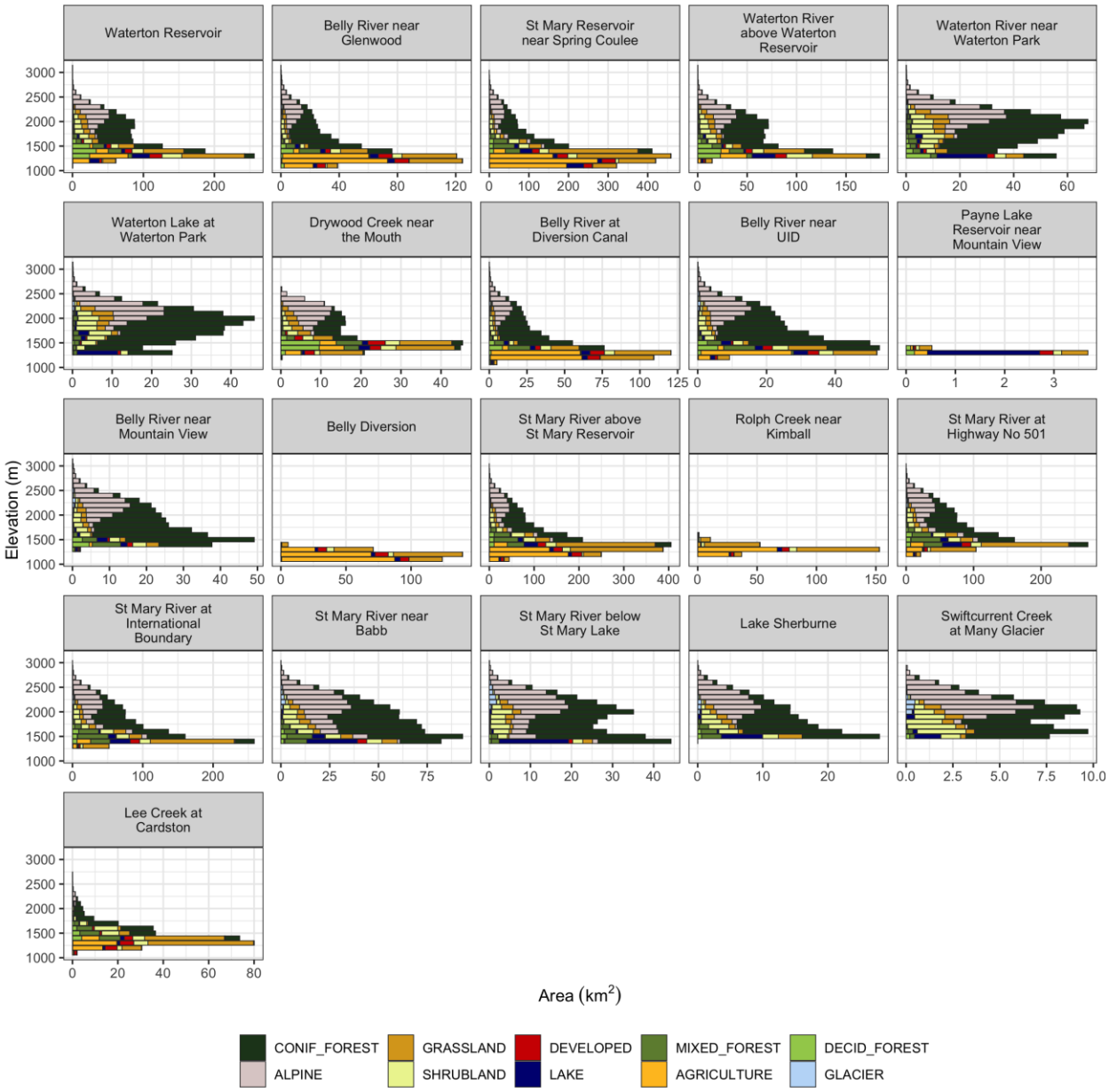


Figure 3. Hypsometric profiles of all sub-basins in the hydrological model, classified by land cover.

3.2.3 Model Calibration/Verification Data

Weather/climate and hydrometric observations were gathered from publicly available data sources to calibrate and verify the hydrological model. This process is essential to ensure that the model is providing accurate results, to constrain uncertainty, and to ensure proper process-representation. Hydroclimatic data were available from several public data sources. Weather stations were available from several networks, including Environment Canada (EC), United States Geologic Survey (USGS), and Alberta Environment and Parks (AEP). Weather data, including air temperature, precipitation, snowfall, and snow water equivalent were obtained for all weather stations in or nearby the study area. In addition, periodic (roughly monthly) snow surveys were available across the study area and are collected and maintained

by Environment and Climate Change Canada (ECCC, Fang et al., 2017).

Streamflow (m^3/s) data were obtained from Water Survey of Canada (WSC) and USGS hydrometric stations in the study area with long-term records (Table 1). In addition, the model was further calibrated and verified using daily air temperature and precipitation observations from regional weather stations and snow water equivalent observations obtained from snow pillow and snow survey sites (Table 13).

Table 1. Sub-basins used in the hydrological model, with Water Survey of Canada (WSC) and USGS (MT) hydrometric gauges listed. Data Types include discharge (Q) and water level (H). Sub-basins without a Station Number did not have publicly available hydrometric observations. Shaded sub-basins were used in model calibration and verification.

Sub-basin Name	Station Number	Data Type	Regulated	Drainage Area (km^2)
Drywood Creek near the Mouth	05AD010	Q	N	239
Waterton Lake at Waterton Park	05AD025	H	N	403
Waterton River near Waterton Park	05AD003	Q	N	613
Waterton River above Waterton Reservoir	-	-	Y	952
Waterton Reservoir	05AD026	H	Y	1,270
Belly River near Mountain View	05AD005	Q	N	319
Payne Lake Reservoir near Mountain View	05AD940	H	Y	-
Belly River near UID	-	-	Y	394
Belly River at Diversion Canal	-	-	Y	602
Belly River near Glenwood	05AD041	Q	Y	653
Belly Diversion	-	-	Y	-
Lee Creek at Cardston	05AE002	Q	N	312
Swiftcurrent Creek at Many Glacier	05014500_MT	Q	N	81
Lake Sherburne	05AE036	H	Y	166
St. Mary River below St. Mary Lake	-	-	N	340
St. Mary River near Babb	05017500_MT	Q	Y	719
St. Mary River at International Boundary	05AE027	Q	Y	1,210
St. Mary River at Highway No 501	05AE043	Q	Y	1,320
Rolph Creek near Kimball	05AE005	Q	N	222
St. Mary River above St. Mary Reservoir	-	-	Y	2,026
St. Mary Reservoir near Spring Coulee	05AE025	H	Y	2,290

3.3 Reservoir Operations and Diversions

Since much of the flow in the study area is affected by diversions and lakes, some of which have control structures, these operations are incorporated into the hydrological model at a rudimentary level. While most waterbodies/lakes are treated as simple depression storage within the model that release water at a specified rate relative to storage, treating a waterbody as a reservoir in Raven allows the model to more explicitly model the mass balance of the lake and account for flow attenuation along the main channel, as well directly accounting for human interventions such as water withdrawals, control structures, and management directives, such as minimum flow requirements (EFNs), target outflows, and maximum/minimum water levels. In total, seven water bodies are treated as reservoirs within the hydrological model (Table 2).

Table 2. Waterbodies treated as reservoirs explicitly within the hydrological model. Model parameters Weir Coefficient and Crest Width control the rate of water release with lower values corresponding to a more attenuated outflow.

Lake Name	Sub-Basin	Max Depth (m)	Lake Area (km^2)	Weir Coeff	Crest Width (m)
Saint Mary Lake	St. Mary River below St. Mary Lake	91	15.88	0.6	10
Lower Saint Mary Lake	St. Mary River near Babb	40	8.78	0.6	15
Lake Sherburne	Lake Sherburne	33	5.99	0.6	5
Waterton Lake	Waterton Lake at Waterton Park	101	10.10	0.6	15
Payne Lake	Payne Lake Reservoir near Mountain View	7.3	2.28	0.6	5
Waterton Reservoir	Waterton Reservoir	20	8.05	0.6	5
St. Mary Reservoir	St. Mary Reservoir near Spring Coulee	56	37.50	0.6	5

Given the outputs from this model will be treated as inflows to a water management model, only operations on constructed reservoirs in the headwaters of the study area and/or for locations upstream of a hydrometric gauge used in model calibration/verification were implemented. Operations on these reservoirs are as follows:

- St. Mary Lake, Lower St. Mary Lake, and Waterton Lake are assumed to be natural lakes, with no flow limits or operations.
- Water management was not considered for Waterton Reservoir, St. Mary Reservoir, or Payne Lake since they are downstream of any hydrometric station used to calibrate model parameters.
- Lake Sherburne operations were approximated using information provided on the US Bureau of Reclamation website (https://www.usbr.gov/projects/index.php?id=158). This included a minimum stage of 1441.49 m and a maximum stage of 1459.38 m. Target stages were developed to mimic the operations of the observed water levels, where storage is increased in the spring, targeting highest water levels in late June, and lowering water levels to provide additional streamflow throughout the late summer months.

The study area contains several major diversions which impact flows and transfer water between watersheds. These diversions are all downstream of hydrometric stations used for model calibration and therefore not represented in the hydrological model but are noted here.

- Water is diverted from the Waterton Reservoir towards the St. Mary Reservoir.
- Some flow from the Belly River is diverted into Payne Lake, which is then diverted into the St. Mary River watershed.
- Some flow from the Belly River is diverted into Cochrane Lake, north of Hill Spring and downstream of the Belly Diversion.
- At Spring Glen Park, a portion of the Belly River is diverted into the Belly Diversion and ultimately conveyed into the St. Mary Reservoir. In the hydrological model, the drainage area of this diversion canal (Belly Diversion) is treated as a contributing area to the St. Mary Reservoir.

At Babb, MT (downstream of the hydrometric station), a portion of the St. Mary River is diverted into the Milk River watershed (outside of the study area).

3.4 Model Calibration

To optimize model representation of key hydrologic processes and streamflow, model parameters were calibrated in a stepwise manner following Chernos et al. (2017) and originally adapted from Stahl et al. (2008). First, air temperature and precipitation lapse rates were calibrated to regional weather stations, then snowmelt parameters are modified to follow empirical values obtained from regional snow surveys and pillows. Finally, vegetation interception and soil routing parameters are calibrated to streamflow observations. Final calibrations were completed by a combination of manual methods and automated calibration. Automated calibration of parameters was completed using OSTRICH calibration software (Matott, 2017), using the Dynamically Dimensioned Search (DDS) algorithm to finalize parameter values. Model parameters were calibrated to hydrometric records which were not regulated. This included sites in the Waterton River, Belly River, and upper St. Mary River watersheds, both on mainstems and tributaries. Model calibration was done over the 2010-2020 period and model performance was verified over the remaining record for sub-basins used in model calibration and all available records for other sites. Additional caution was used in evaluating model performance to regulated sites, particularly St. Mary River near Babb where upstream regulation is more uncertain.

While calibration was able to constrain the value of most model parameters, some parameters are relatively insensitive, such that changing their value does not substantially alter streamflow simulations. In some cases, this is because the model parameter does not affect a dominant hydrologic process in the watershed (for example, capillary rise). In other cases, particularly, for land cover specific model parameters, the parameter is insensitive because little of that land cover type exists in the sub-basin. For example, since relatively little of the study area is covered by deciduous forest, we cannot calibrate the interception parameters for this land cover class effectively. In these cases, model parameters were finalized to ensure conceptual and physical realism (i.e., to ensure Deciduous stands intercept more rainfall than Coniferous stands, but less snow).

3.5 Model Scenarios

Since the hydrological model is a process-based model that incorporates land cover and climate directly, the model is well suited to investigate scenarios with varying climatic and land cover conditions to evaluate hydrologic changes. In total, this study considers:

- 3 climate conditions:
  - *Current*: climatic conditions over the 1991-2020 period
  - *RCP 4.5*: projected climatic conditions over the 2021-2050 and 2051-2080 periods
  - *RCP 8.5*: projected climatic conditions over the 2021-2050 and 2051-2080 periods
- 2 land cover conditions:
  - *Historical (2020)*: land cover condition as of the year 2020 held static
  - *No Glaciers*: the 2020 land cover condition, with all glacierized areas converted to ‘Alpine’

Combinations of land cover conditions, climate conditions, and Chin Reservoir and irrigation Expansion conditions were run in the hydrological model and are listed in Table 3. The scenario names in Table 3 include reference to “Scenario 1” and “Scenario 3,” which are the two scenarios from the previous WaterSMART modelling project titled “Modelling for Chin Reservoir and Irrigation Expansion” that were selected by the SMRID Main Canal Technical Committee to include in this analysis (WaterSMART Solutions

Ltd., 2022). "Scenario 1" represents an expansion of Chin Reservoir maintaining the original full supply level (FSL) and totalling additional 75,511 acre-feet of storage, and "Scenario 3" represents an expansion of Chin Reservoir with a higher FSL, thereby having additional storage volume of 103,500 acre-feet.

Table 3. Model scenarios considered in this study.

Scenario Name	Climate	Land Cover	Chin Expansion	Irrigation Expansion
Historical Current	Current	Historical (2020)	-	-
Future RCP 4.5	RCP 4.5	Historical (2020)	-	-
Future RCP 4.5 No Glaciers	RCP 4.5	No Glaciers	-	-
Future RCP 8.5	RCP 8.5	Historical (2020)	-	-
Future RCP 8.5 No Glaciers	RCP 8.5	No Glaciers	-	-
Future RCP 4.5 Scenario 1 (Chin Expansion)	RCP 4.5	Historical (2020)	75, 511 AF	None
Future RCP 4.5 Scenario 3 (Chin Expansion)	RCP 4.5	Historical (2020)	103, 500 AF	None
Future RCP 4.5 No Glaciers Scenario 1 (Chin Expansion)	RCP 4.5	No Glaciers	75, 511 AF	None
Future RCP 4.5 No Glaciers Scenario 3 (Chin Expansion)	RCP 4.5	No Glaciers	103, 500 AF	None
Future RCP 8.5 Scenario 1 (Chin Expansion)	RCP 8.5	Historical (2020)	75, 511 AF	None
Future RCP 8.5 Scenario 3 (Chin Expansion)	RCP 8.5	Historical (2020)	103, 500 AF	None
Future RCP 8.5 No Glaciers Scenario 1 (Chin Expansion)	RCP 8.5	No Glaciers	75, 511 AF	None
Future RCP 8.5 No Glaciers Scenario 3 (Chin Expansion)	RCP 8.5	No Glaciers	103, 500 AF	None
Future RCP 4.5 Scenario 1	RCP 4.5	Historical (2020)	75, 511 AF	10%
Future RCP 4.5 Scenario 3	RCP 4.5	Historical (2020)	103, 500 AF	10%
Future RCP 4.5 No Glaciers Scenario 1	RCP 4.5	No Glaciers	75, 511 AF	10%
Future RCP 4.5 No Glaciers Scenario 3	RCP 4.5	No Glaciers	103, 500 AF	10%
Future RCP 8.5 Scenario 1	RCP 8.5	Historical (2020)	75, 511 AF	10%
Future RCP 8.5 Scenario 3	RCP 8.5	Historical (2020)	103, 500 AF	10%
Future RCP 8.5 No Glaciers Scenario 1	RCP 8.5	No Glaciers	75, 511 AF	10%
Future RCP 8.5 No Glaciers Scenario 3	RCP 8.5	No Glaciers	103, 500 AF	10%

3.6 Hydrologic Indicators

To characterize the hydrologic and climatic conditions in the study area, several hydroclimatic indicators were extracted from the hydrological model. These indicators were chosen because they are a driver of streamflow, capture an important hydrologic process in the watershed, and/or represent an important period of the year for ecosystem and aquatic health. These indicators are described in Table 4 and are all calculated annually and averaged over a 30-year period (1991-2020, 2021-2050, 2051-2080).

Table 4. Hydroclimatic indicators derived from the hydrological model.

Variable	Description
Air Temperature (°C)	The average air temperature in degrees Celsius.
Precipitation (mm)	The total precipitation, expressed as a depth of water.
Percent Snowbound (%)	The percent of years where the ground was snow covered at the end of the month (calculated for March, April, and May).
Potential Evapotranspiration	The total annual potential evapotranspiration, representative of the

(mm/year)	amount of water that could be lost to the atmosphere and vegetation if a sufficient water source were available.
Runoff (mm)	The total water released from a point on the landscape that becomes streamflow, expressed as a depth of water.
Mean Annual Flow (m^3/s)	The average streamflow over the year.
Aug-Sept Low Flow (m^3/s)	The average streamflow over the late summer (Aug-Sept); this is typically a period where low flows most limit aquatic habitat, lead to water quality degradation and higher water temperatures.
July-Aug Days above 11% MAD (days)	The number of days in July and August above 11% of the mean annual discharge (MAD). The mean annual discharge is calculated over the 1991-2020 period without water use.
Sept Days above 20% MAD (days)	The number of days in September above 20% of the mean annual discharge (MAD). The mean annual discharge is calculated over the 1991-2020 period without water use.
2-year Peak Flow (m^3/s)	The estimated 1-in-2-year peak daily average streamflow; this indicator can lead to increased erosion, turbidity, and damage to infrastructure.
Peak Flow Timing (day of year)	The Julian day of year streamflow where the maximum annual streamflow is reached.

4.0 Results

4.1 Model Parameterization

Model parameterization relied on a combination of calibration using independent weather and snowpack data and conceptual understanding site specific water balances. A comprehensive list of model parameters is provided in Table 5.

Table 5. Final model parameters used in the hydrological model.

Process	Description	Parameter	Value	Units
Orographic Corrections	Adiabatic Lapse Rate	Alapse	6.5	°C/km
	Precipitation Lapse Rate	Plapse (winter)	8.0	mm/day/km
	Precipitation Lapse Rate	Plapse (summer)	2.0	mm/day/km
Rain-Snow Partitioning	Transition Temperature	Snw1	3.0	°C
	Mixed-Range	Snw2	2.0	°C
Snowmelt	Global Snowmelt Factor	K_factor	3.0	mm/ °C /day
	Forest correction (Conif)	Forest_corr	0.80	fraction
	Forest correction (Mixed)	Forest_corr	0.85	fraction
	Forest correction (Decid)	Forest_corr	0.90	fraction
	Aspect/Slope correction	Acor	0.2	fraction
	Minimum Melt (winter)	Min_melt	0.5	mm/ °C/day
	Refreeze factor	Refreeze	2.0	mm/ °C/day
Glacier Melt	Glacier (Ice) Melt	Kglacier	1.75	fraction

	Minimum Glacier Melt	kgMin	0.05	unitless
	Glacier Storage Coeff	gstorage	1.25	unitless
	Glacier AG	gag	0.5	unitless
Leaf Area Index*	Conif Forest	Forest_LAI	3.5	unitless
	Decid Forest	ForestD_LAI	4.5	unitless
	Mixed Forest	ForestM_LAI	4.5	unitless
	Grassland/Agriculture	Grass_LAI	2.5	unitless
	Shrubland	Shrub_LAI	2.5	unitless
Vegetation/Canopy Coverage	Conif Forest	Conif_Cov	0.70	fraction
	Decid/Mixed Forest	ForestD_Cov	0.90	fraction
	Shrubland	Shrub_Cov	0.50	fraction
	Agriculture	Agr_Cov	0.80	fraction
Evapotranspiration Corrections	Conif Forest	Conif_PT	0.80	unitless
	Mixed/Decid Forest	ForestY_PT	1.25	unitless
	Grassland/Agriculture	Grass_PT	1.75	unitless
	Developed	Devel_PT	2.0	unitless
Infiltration	HBV Beta	HBV_B0	0.05	unitless
Percolation	Soil 1	Perc1	2.0	mm/day
Capillary Rise	Surface Soil	Cap0	4.0	mm/day
Baseflow	Lake Release	LakeR	0.20	unitless
	Soil 1 K	Base_K1	0.075	unitless
	Soil 1 N	Base_N1	1.25	unitless
	Soil 2 N	Base_N2	1.50	unitless
	Soil 2 Max Rate	Base_MAX2	5.0	mm/day

**Indicates maximum annual LAI value; Shrub/Wetland, Disturbed Forest, and Grassland values vary seasonally with lower values during the winter.*

Notable parameter values include that snow in forested areas is assumed to melt at a slower rate than open areas (0.70 in Coniferous Forest, 0.90 in Deciduous Forest). Although maximum annual leaf-area-index (LAI) values are higher in Deciduous Forest relative to other forest classes, it varies seasonally with winter values half their summer value, reflecting that much of recently disturbed forests consist of deciduous plants. Evaporation rates varied by land cover type as well. The default rate for open areas in the Priestley Taylor routine is 1.26, but in arid environments this rate is typically higher. In this model the coefficient is 1.75 in agricultural or grassland areas, with higher values in Developed land cover classes, and was lower in Coniferous Forest (0.80).

4.2 Model Performance

4.2.1 Hydroclimatic Simulation

Simulated daily air temperature, total monthly precipitation, and daily SWE closely followed observed values from the independent weather stations in the study region (Table 14). Daily maximum air temperatures had r^2 values between 0.97 and >0.99 and biases of less than 12% in most cases; notably most sites have a small positive bias (i.e., air temperatures are over-estimated). Monthly precipitation r^2 values ranged from 0.42 to 0.94, with most sites over 0.80, and biases ranging from -34% to 3%, with most sites with absolute biases of less than 10%.

Snow water equivalent was well simulated across the study area, with r^2 values ranging from 0.44 to 0.93,

with most sites above 0.70 (Figure 4). Percent biases ranged from -48% to 3%, with most sites with absolute biases of less than 30%. Notably, SWE is well reproduced at snow pillow Flattop Mountain, located just outside (south and west of) the Waterton and Belly headwaters (r^2 = 0.93, PBIAS = -29%) and Many Glacier Snotel, located in the St. Mary River headwaters (r^2 = 0.87, PBIAS = 3%). Conversely, SWE is underestimated at the snow survey sites nearby to Many Glacier Snotel (r^2 = 0.63-0.74, PBIAS = -32 to -48%); however, few of these sites have more than a single value for the year. SWE is substantially over-estimated at snow survey sites Lee Creek Q (r^2 = 0.44, PBIAS = 178%), though it should be noted peak SWE at this site is quite low, rarely greater than 150 mm (w.e).

It should be noted that these weather stations (particularly EC stations) are likely not fully independent since some are likely inputs into the DayMet grid used in this study. In addition, there is a strong precipitation gradient in the region along the mountains along the Continental Divide. Areas close to the divide experience much higher precipitation than areas just to their east. Representing the spatial extent of this gradient is difficult due to the lack of weather stations in this mountainous region and the steep gradient, and therefore additional uncertainty exists in the spatial distribution of hydroclimatic conditions in this area within the model.

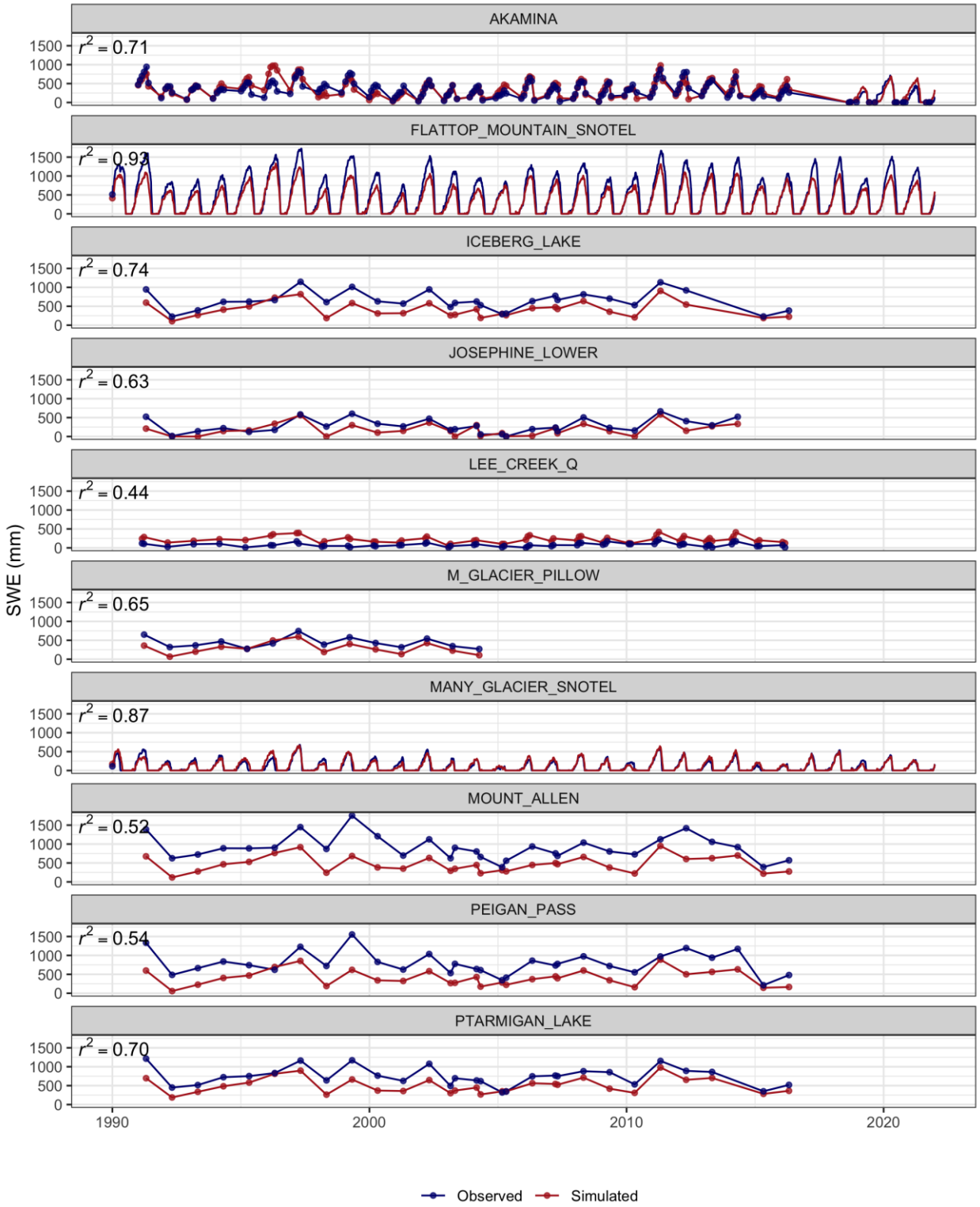


Figure 4. Simulated and observed snow water equivalent at independent verification sites in the study area.

4.2.2 Streamflow Simulations

Streamflow simulations demonstrated relatively good performance in reproducing observations from

hydrometric gauges across the Nicola River watershed (Table 6). Hydrological model performance in reproducing streamflow and water level was evaluated using the Nash-Sutcliffe Efficiency (NSE), ranging up to 1 (perfect simulation) to negative infinity. The logarithmic NSE (logNSE) was also used since it emphasizes performance at low flow values. Performance was strongest in the upper Nicola River and Coldwater River sub-basins and lowest in Guichon Creek. While performance was evaluated at all available hydrometric stations, additional caution is required evaluating model performance for regions with regulated flow, particularly in Guichon Creek, where mining, inter-basin diversions, and reservoir operations have heavily modified natural flow regimes. Model performance in individual sub-regions is shown below in greater detail.

Table 6. Daily streamflow performance statistics for the hydrological model for the calibration (2010-2020) and verification periods. NSE is the Nash-Sutcliffe Efficiency, logNSE is the logarithmic NSE, KGE is the Kling-Gupta Efficiency, and PBIAS is the percent bias.

Site	Period	NSE	logNSE	KGE	PBIAS
Belly River near Mountain View	Calibration	0.81	0.81	0.82	-2.1%
Belly River near Mountain View	Verification	0.79	0.77	0.79	-4.9%
Drywood Creek near the Mouth	Calibration	0.53	0.69	0.52	-7.4%
Drywood Creek near the Mouth	Verification	0.51	0.75	0.46	-0.5%
Lee Creek at Cardston	Calibration	0.52	0.64	0.36	18.3%
Lee Creek at Cardston	Verification	0.58	0.67	0.41	12.9%
St. Mary River near Babb*	Calibration	0.88	0.87	0.88	-1.8%
St. Mary River near Babb*	Verification	0.80	0.84	0.8	-3.7%
Swiftcurrent Creek at Many Glacier	Calibration	0.79	0.80	0.72	-22.5%
Swiftcurrent Creek at Many Glacier	Verification	0.75	0.71	0.66	-26.7%
Lake Sherburne*^	Verification	0.33	0.28	0.29	-3.3%
Waterton River near Waterton Park	Calibration	0.89	0.82	0.82	-13.3%
Waterton River near Waterton Park	Verification	0.84	0.84	0.81	-11.7%
Waterton Lake at Waterton Park^	Verification	0.84	0.82	0.75	-0.1%

**Denotes hydrometric gauge is regulated and affected by significant upstream regulation/water usage.*
^Denotes water level comparison, rather than streamflow.

Model performance is relatively strong in the hydrological model, reproducing streamflow in all major watersheds with a considerable accuracy (Figure 5, Table 6). Performance was strongest at major rivers in the study area (Belly River, St. Mary River, Waterton River), where NSE values ranged from 0.79 – 0.89, with comparable KGE and log-NSE values. Biases for major rivers were generally low (<15% absolute bias). Performance was lower on smaller, more arid tributaries, such as Drywood and Lee Creek, where NSE values ranged from 0.51 to 0.58 and modest positive biases (over-estimated streamflow) were produced. Likewise, the model under-estimated streamflow in Swiftcurrent Creek, though this site has lake attenuation effects. Likewise, downstream Lake Sherburne has little bias, but modest to poor NSE value (0.33) for water level, though this site is regulated, and water management could not be fully constrained by a simple rule curve. Water levels are well reproduced in Waterton Lake, with no bias.

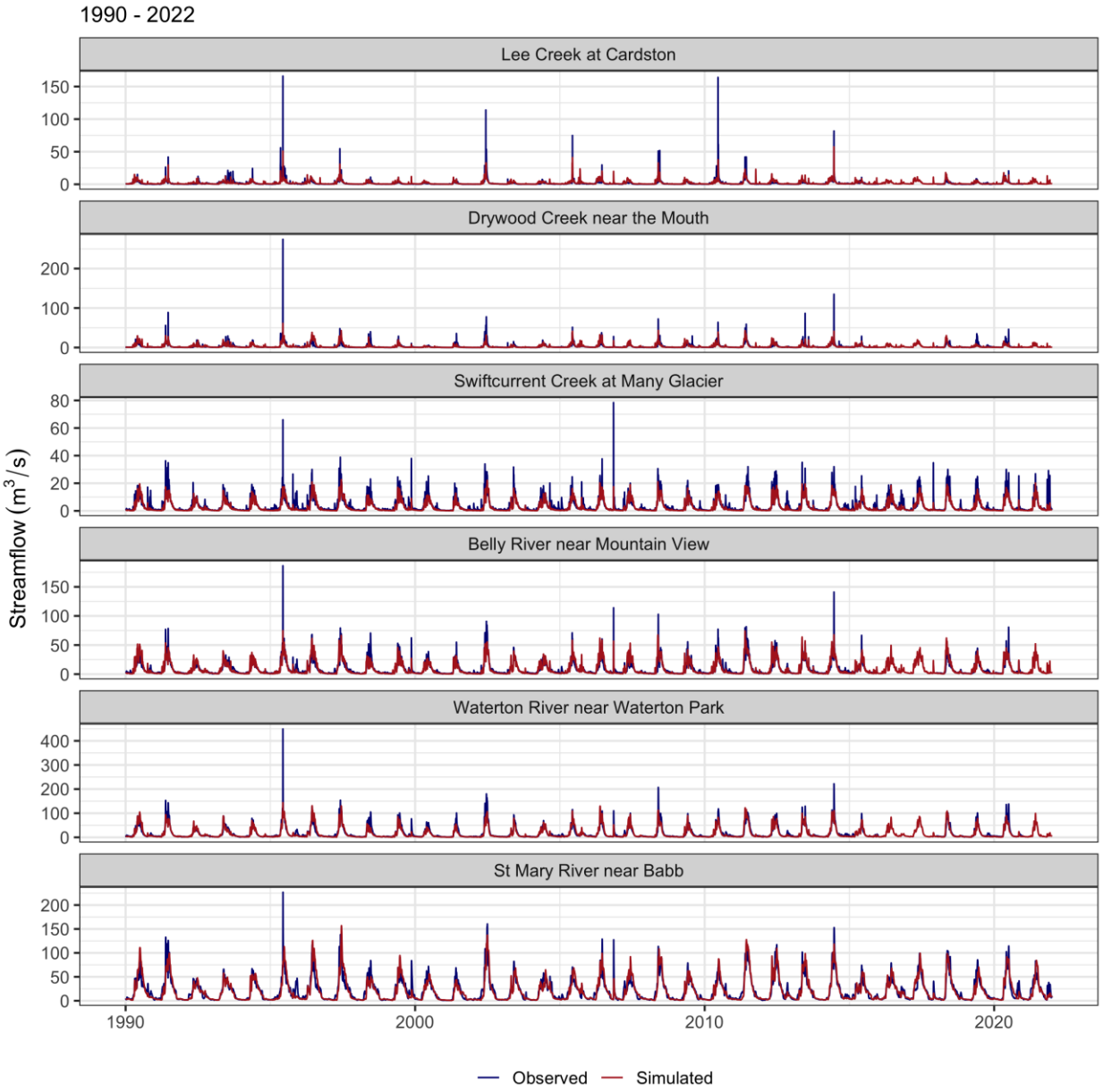


Figure 5. Daily observed and simulated streamflow for the calibration sub-basins used in this study.

Model performance is strongest for average hydrometric conditions (Figure 6). The model does a good job representing snowmelt-driven spring freshet, with modest underestimates at Swiftcurrent Creek, and an over-estimate of April streamflow at lower elevation Lee Creek. Low flows are generally well represented in the model, except at Swiftcurrent Creek, where they are under-estimated; particularly in the fall season where rainfall-driven spikes in streamflow are not captured by the model. Flows in the St. Mary River near Babb are regulated, which reflects part of the longer late summer recession curve relative to other watersheds. It should also be noted that glacier coverage is higher in the St. Mary River, and therefore late summer flows are also supplemented by glacial melt.

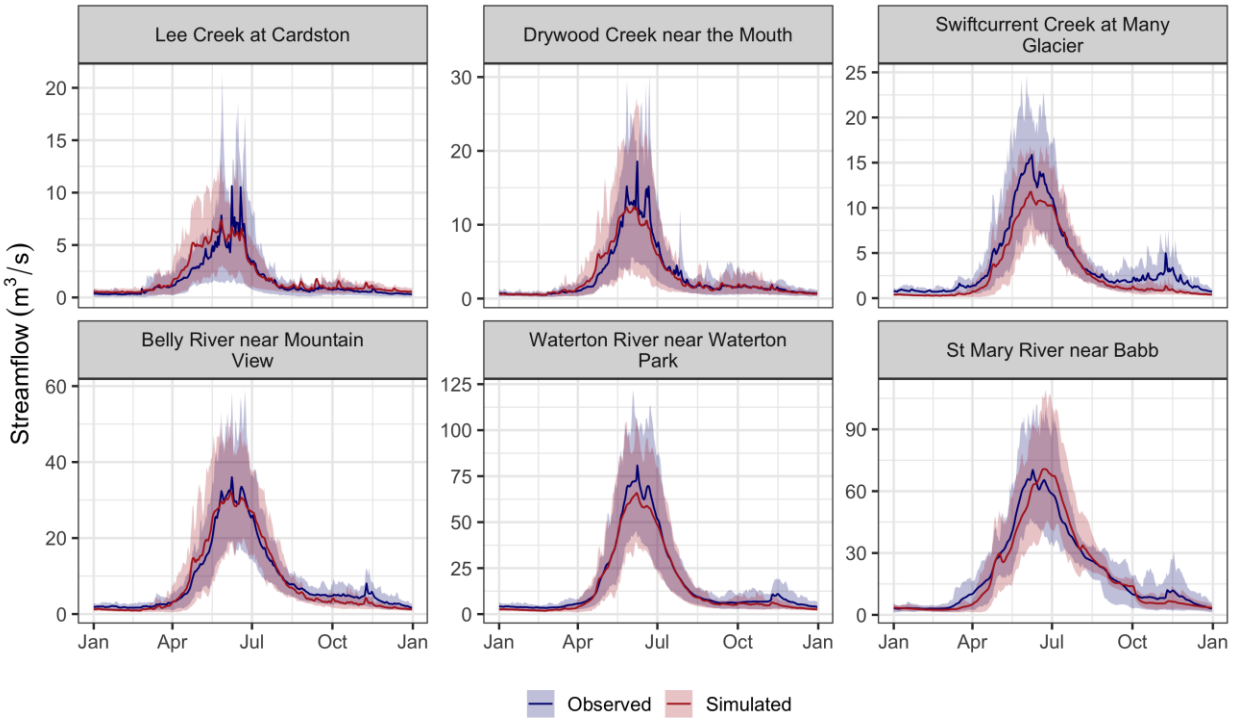


Figure 6. Average hydrographs for six hydrometric stations used in model calibration. Solid lines correspond to averages for the 1991-2020 period while shaded areas correspond to the 10-90% quantiles.

4.3 Current Hydroclimatic Conditions

4.3.1 Climate

Air temperatures are highest at lowest elevations and in further eastern portions of the study area (Figure 22). Average annual air temperatures are lowest at higher elevations, where alpine areas experience values below 0°C. Annual precipitation similarly has a large gradient, with lower elevation, more easterly areas experiencing approximately 500 mm/year on average. By comparison, higher elevations along the Continental Divide in the west of the study area experience over 2000 mm/year in some areas. The large gradient in air temperatures and precipitation in the study area leads to substantial variability in snowpack accumulation (Figure 7). The peak winter snowpack is shallow (< 100 mm w.e.) along the prairie reaches in the east of the study area. Conversely, the winter snowpack in higher elevations in the mountains routinely exceeds 1000 mm, particularly at highest elevations and in glacierized areas.

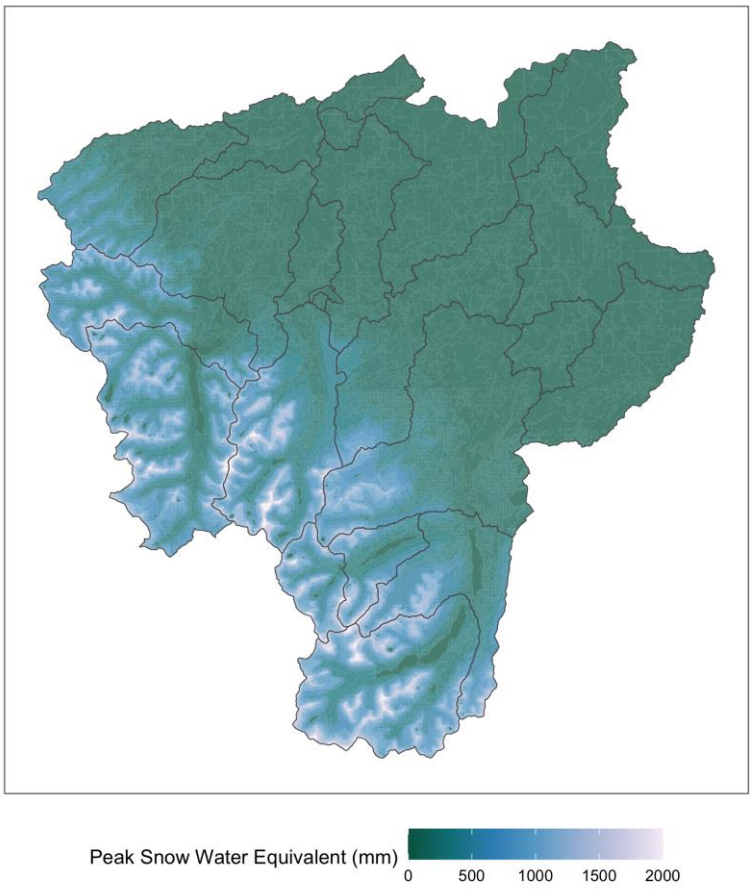


Figure 7. Peak snow water equivalent (mm w.e.) over the Historical (1991-2020) period.

4.3.2 Streamflow and Runoff

Streamflow in the study area follows a snowmelt dominated pattern. Streamflow is low during the winter months where air temperatures are cold, and precipitation falls as snow. Flows rise quickly in the spring in conjunction with the onset of melt of the winter snowpack. This melt occurs earlier in the spring further east and at lower elevations; lower elevation sub-basins, such as Lee Creek and Drywood Creek begin to see freshet in April and May, while the headwaters of the Waterton, St. Mary, and Belly rise in May and June. Peak flows typically occur in June, where larger rainfall events coincide with peak snowmelt driven freshet. Streamflow decreases through the rest of the summer and into the fall. In areas with glaciers, glacial melt provides additional streamflow inputs throughout the late summer. By late October, precipitation again falls mostly as snow, and little new inputs to streamflow are generated until the following spring. This snowmelt dominated trend is more pronounced in higher elevation and major tributaries, while at lower elevation sub-basins, particularly those on the prairies, such as Rolph Creek and Lee Creek, the winter snowpack is lower, and therefore snowmelt signal is less pronounced.

The steep climatological gradients in air temperature, precipitation, and snowpack lead to a dynamic where much of the water in the major rivers originate along the western, mountainous portions of the study area (Figure 8). Runoff exceeds 1500 mm/year along higher elevation areas the headwaters of the St. Mary, Belly, and Waterton River watersheds, due to a combination of high precipitation rates and deep

winter snowpack. Conversely, runoff is very low (<100 mm/year) along the more arid prairie portions of the study area, while some particularly arid areas can effectively have no runoff at an annual timescale. Runoff is comparatively high in reservoirs and lakes because all precipitation becomes runoff once it reaches the surface. However, it should be noted that much of this water will evaporate over the course of the year, and depending on storage dynamics, these bodies of water could be net sinks of water in the system.

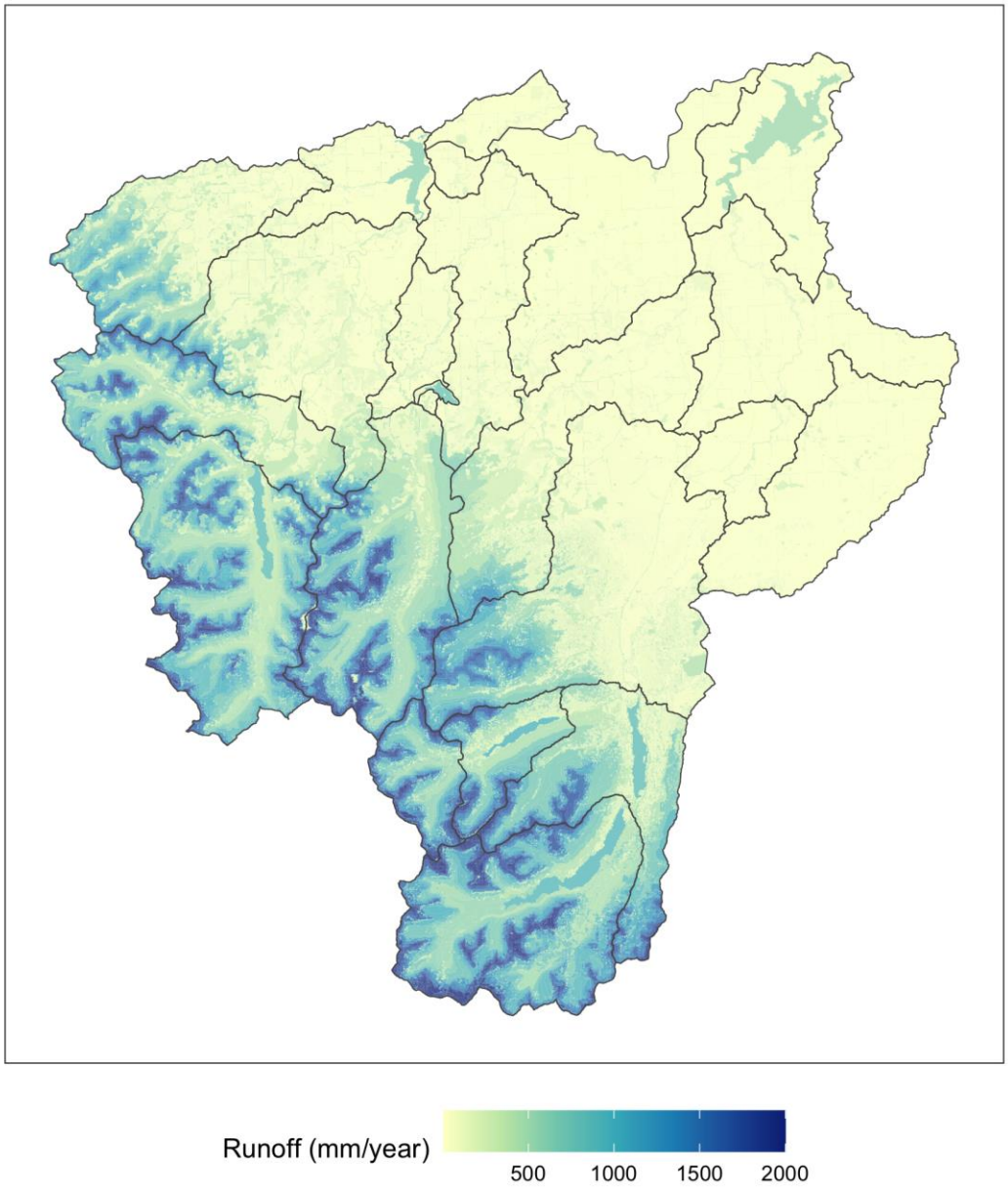


Figure 8. Average annual runoff (mm/year) under the Historical (1991-2020) period.

4.4 Future Hydroclimatic Conditions

4.4.1 Annual Changes

Under the future climate change scenarios, annual precipitation is projected to increase substantially in the study area (Figure 9). By 2021-2050, annual precipitation is projected to increase by roughly 100 mm/year relative to the 1991-2020 period along the western and northern portions of the watershed, primarily in the Waterton River watershed. Increases are greatest at lower elevations, due predominantly to the increase occurring mostly during the summer months, when convective storms have a less defined elevational gradient. By 2051-2080, annual precipitation is projected to decrease relative to 2021-2050. Relative to 1991-2020, annual precipitation is still projected to increase by approximately 100 mm/year, with greater increases under the RCP 8.5 scenario.

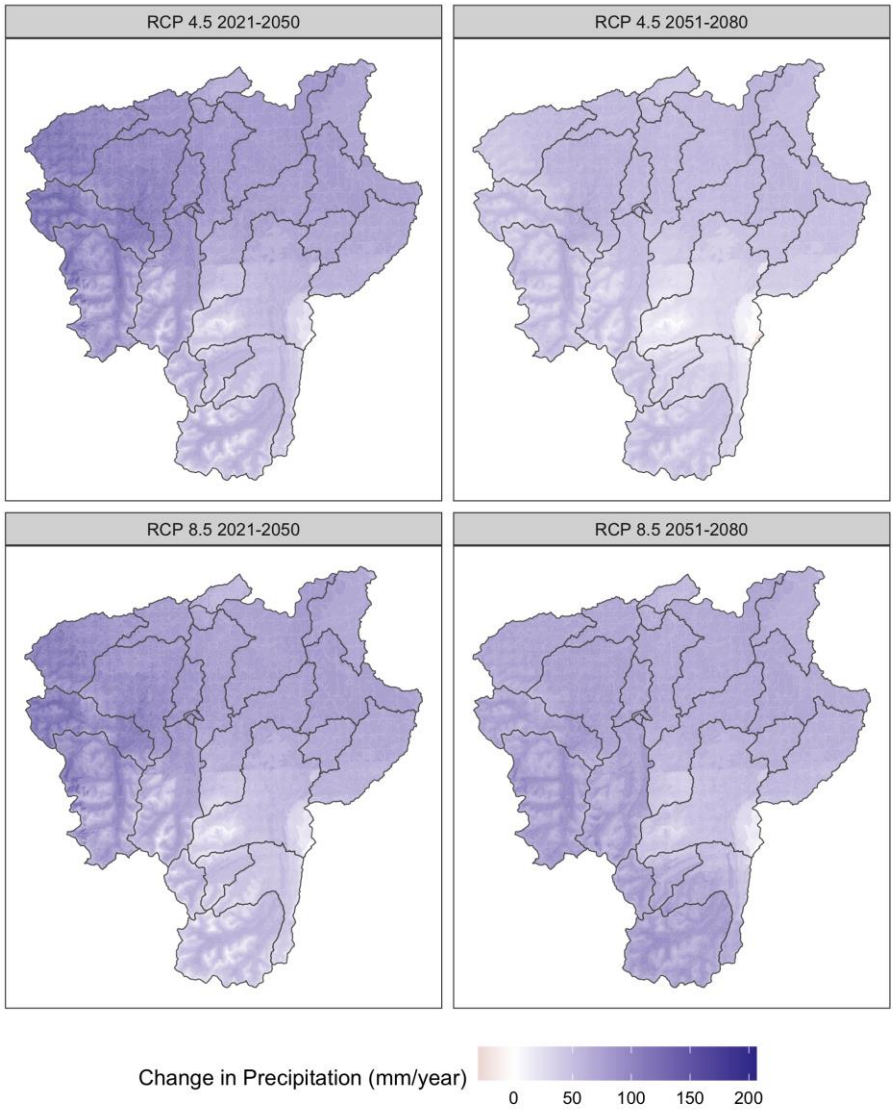


Figure 9. Change in average annual precipitation under the future climate change scenario for two future 30-year periods relative to the 1991-2020 historical period.

Although annual precipitation is projected to increase substantially across much of the study area, the winter snowpack is projected to decrease in all areas except on the prairie, where only small increases are projected (Figure 10). Decreases in SWE are greatest in absolute terms in the mountains, at mid to high elevations. This is due to a substantial increase in air temperatures in the climate change scenarios (1-3°C) leading to less precipitation falling as snow, more periodic winter snowmelt events, and earlier spring snowmelt. These factors are projected to be exacerbated further into the future, with greater reductions in peak SWE under the 2051-2080 period and the RCP 8.5 scenario.

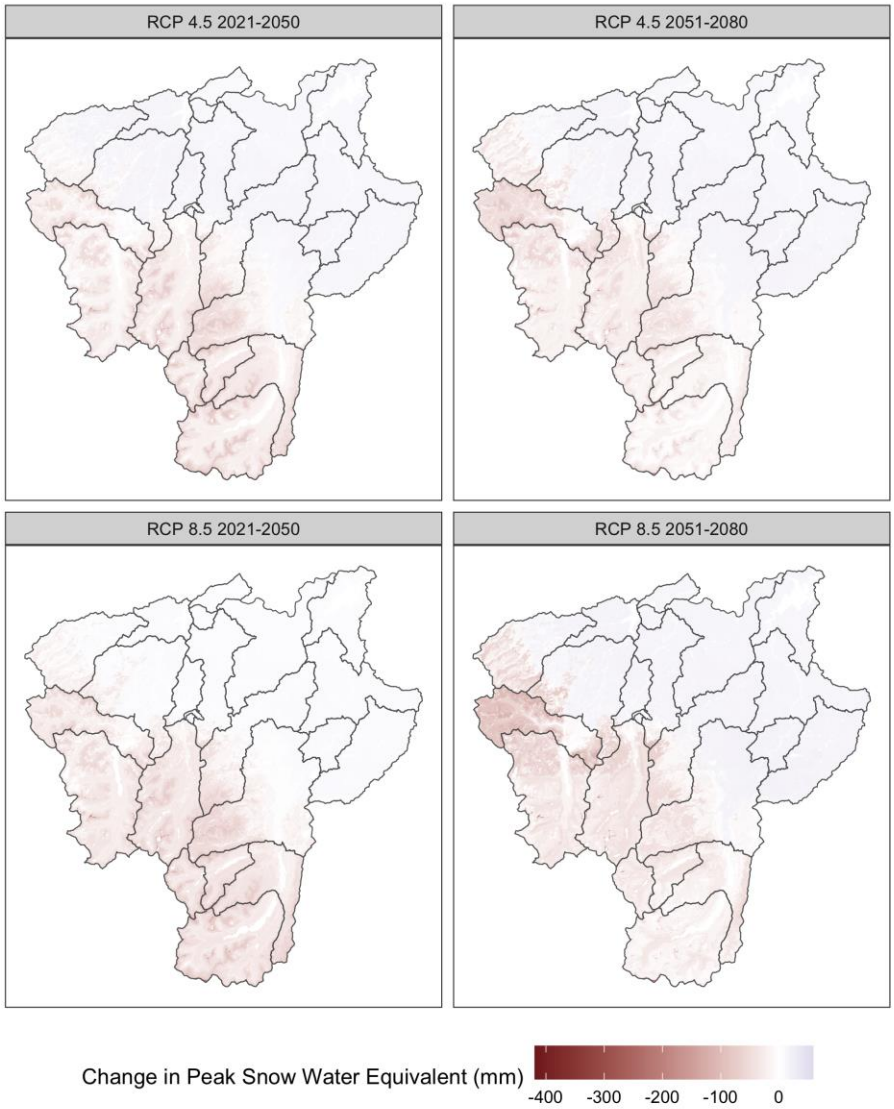


Figure 10. Change in average peak annual snow water equivalent under the future climate change scenario for two future 30-year periods relative to the 1991-2020 historical period.

At an annual timescale, runoff (mm/year) is projected to increase moderately across the study area, with decreases projected for higher elevation areas in the St. Mary and Belly River watersheds (Figure 11). Increases of 50-100 mm/year are projected for many areas. Local increases of up to 200 mm/year are projected for some high elevation glacierized areas where accelerated melt is anticipated over the coming

decades. Overall, this increase in runoff is greatest further into the future and under the RCP 8.5 scenario. This increase in runoff reflects the increase in summer rainfall projected in the coming decades. This translates into a net increase in water in some watersheds, even despite concurrent increases in evapotranspiration.

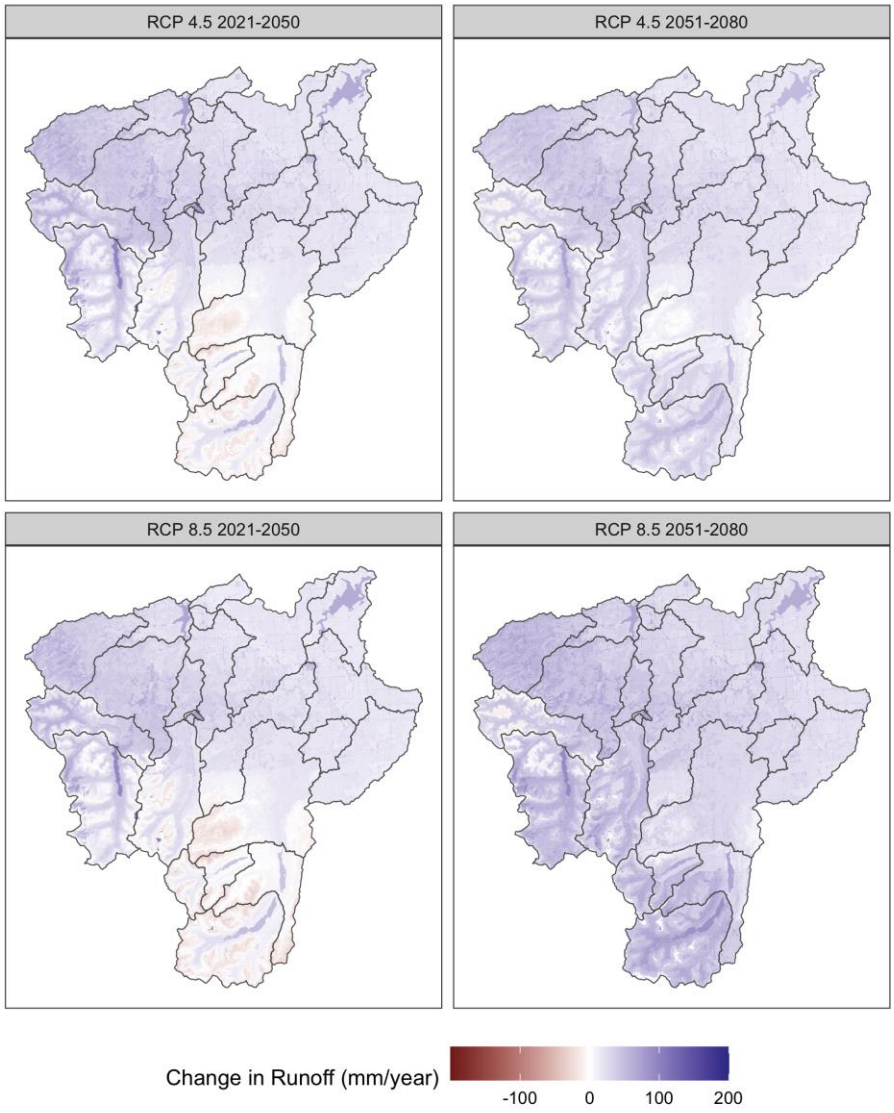


Figure 11. Change in average annual runoff under the future climate change scenario for two future 30-year periods relative to the 1991-2020 historical period.

4.4.2 Streamflow Changes

With increasing air temperatures and increasing precipitation, earlier snow disappearance, and increased evapotranspiration in the watershed, the timing and magnitude of streamflow in major tributaries is projected to change (Figure 12). In all tributaries, this dynamic is projected to lead to earlier freshet, as snowmelt begins earlier in the spring. In most cases, although the peak SWE is projected to decrease in some parts of the region, increased precipitation at lower elevations seems to counteract this and peak flows are projected to remain relatively stable into the future. Late summer flows show substantial

decreases under the No Glacier land cover scenarios, particularly in the St. Mary River, where glacier contributions are currently most significant. In all cases, these changes in seasonality are projected to be more severe further into the future (2051-2080). Finally, flows are projected to increase in the fall months. This is due to an increase in precipitation during this period, paired with warmer air temperatures leading to a greater portion of this precipitation falling as rain, rather than snow, and therefore contributing to streamflow at the time of the storm rather than accumulating as snow and melting the following spring.

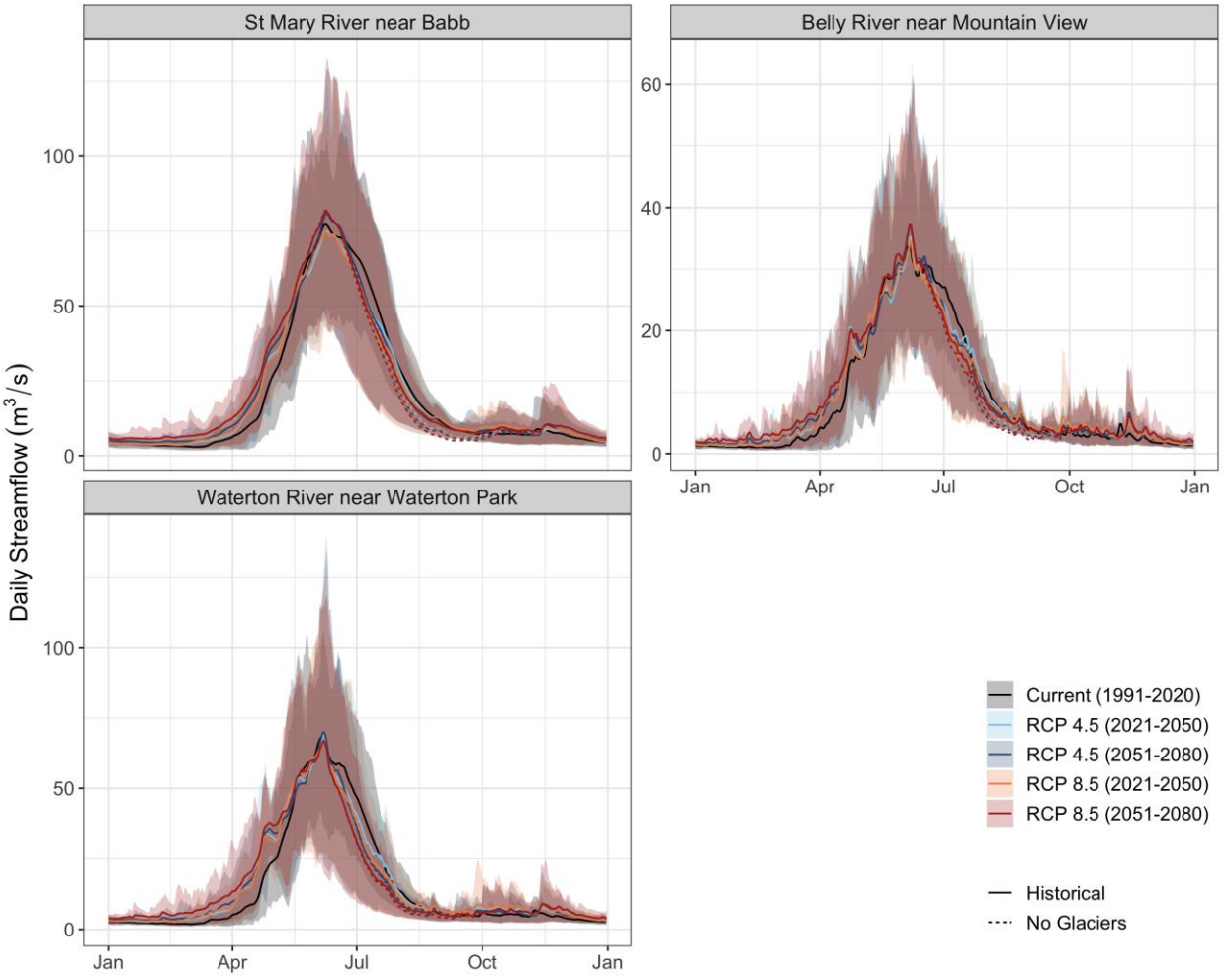


Figure 12. Daily hydrographs for major study area watersheds under current and future periods under the Historical and No Glaciers land cover scenarios. Solid line corresponds to average streamflow while shaded areas correspond to 10-90% quantiles.

4.5 Changes in Hydroclimatic Indicators

The effects of a changing land cover and climate each affect streamflow in isolation. However, the magnitude and timing of the watershed's hydrologic response to these changes can have overlapping effects that amplify or negate this response. This dynamic emphasizes the importance of considering the cumulative impact of these changes to better understand how conditions may change in the future and how to best manage the watershed for greatest resiliency. Below we provide results from three major watersheds in the study area to illustrate how key hydrologic indicators are projected to change under

each scenario. All consequence tables are also provided as a digital appendix.

In the Waterton River, future conditions are likely to yield greater flow at an annual timescale, but with important changes in the seasonality of water availability (Table 7). Mean Annual Flow is projected to increase over both future periods, with increases ranging from 8-12%, with little difference between climate scenario and negligible differences between land cover scenarios. Likewise, the 2-year Peak flow is projected to see a small increase over the coming decades, with modest decreases over the latter half of the century, and negligible changes between land cover scenarios. Peak flows are projected to occur on average 3.2 days earlier under RCP 4.5 and 1.1 days later under RCP 8.5 over the 2021-2050 period, with little change over the latter half of the century. More significant changes in Mean Aug-Sept Flow are projected, with an increase of 8% over the 2021-2050 period under the Historical land cover scenario. This increase in late summer flow is predominantly attributable to increased glacier melt due to higher air temperatures, and under the No Glacier scenario, this increase is negated. Over the latter half of the century, decreases of 3-13% are projected with current glacier coverage, but decreases are 12-23% without glacier coverage. Consequently, a higher percentage of days below thresholds of mean annual discharge (MAD) are projected to decrease under the No Glacier scenarios.

Table 7. Hydrologic Change Consequence Table for the Waterton River watershed. All changes are relative to the Historical (2020) land cover with Current (1991-2020) climate.

Hydrologic Change Consequence Table

Waterton Reservoir

LandCover	Climate	Mean Annual Flow	2-year Peak Flow	Mean Aug-Sept Flow	Peak Flow Timing	July-Aug Days above 11% MAD	Sept Days above 20% MAD
2021-2050							
Historical	RCP 4.5	12%	4%	8%	-3.2 days	0.0 days	-0.3 days
Historical	RCP 8.5	11%	4%	8%	1.1 days	0.0 days	-0.6 days
No Glaciers	RCP 4.5	11%	4%	1%	-3.2 days	0.0 days	-2.4 days
No Glaciers	RCP 8.5	10%	4%	1%	1.1 days	0.0 days	-3.0 days
2051-2080							
Historical	RCP 4.5	9%	–0%	–3%	0.3 days	0.0 days	-1.9 days
Historical	RCP 8.5	12%	–2%	–13%	-0.4 days	0.0 days	-0.8 days
No Glaciers	RCP 4.5	8%	–0%	–12%	0.3 days	-0.4 days	-4.9 days
No Glaciers	RCP 8.5	11%	–2%	–23%	-0.4 days	-0.1 days	-4.4 days

All indicators reflect the change in indicator average relative to Historical (1991-2020).

In the Belly River, future conditions are likely to yield marginally greater flow at an annual timescale, but with substantial reductions in flow during the late summer months with continued glacier retreat (Table 8). Like in the Waterton River, Mean Annual Flow is projected to increase over both future periods, with increases ranging from 3-11%, with little difference between climate scenarios, but modest reductions under the No Glacier land cover scenario. The 2-year Peak flow is projected to see a small increase in the future (7-9%) with negligible changes between climate and land cover scenarios. Peak flows are projected to occur on average 5.3 days later under RCP 4.5 over the 2021-2050 period, and 1.0 to 15.6 days later over the latter half of the century, reflecting a more rainfall-driven peak flow regime in the watershed. More significant changes in Mean Aug-Sept Flow are projected, with an increase of 7-9% over the 2021-2050 period and decrease of up to 6% over the 2051-2080 period under the Historical land cover scenario. However, under the No Glacier scenarios, Aug-Sept flows decrease 12-32%, a sizeable decrease in late summer water availability.

Table 8. Hydrologic Change Consequence Table for the Belly River watershed. All changes are relative to the Historical (2020) land cover with Current (1991-2020) climate.

Hydrologic Change Consequence Table

Belly River at Diversion Canal

LandCover	Climate	Mean Annual Flow	2-year Peak Flow	Mean Aug-Sept Flow	Peak Flow Timing	July-Aug Days above 11% MAD	Sept Days above 20% MAD
2021-2050							
Historical	RCP 4.5	7%	9%	7%	5.3 days	0.0 days	0.0 days
Historical	RCP 8.5	6%	7%	9%	3.0 days	0.0 days	0.0 days
No Glaciers	RCP 4.5	3%	9%	–14%	5.3 days	0.0 days	-1.1 days
No Glaciers	RCP 8.5	3%	7%	–12%	3.0 days	0.0 days	-1.9 days
2051-2080							
Historical	RCP 4.5	7%	8%	1%	15.6 days	0.0 days	0.0 days
Historical	RCP 8.5	11%	7%	–6%	1.0 days	0.0 days	0.0 days
No Glaciers	RCP 4.5	3%	8%	–22%	15.6 days	0.0 days	-3.4 days
No Glaciers	RCP 8.5	7%	7%	–32%	0.9 days	0.0 days	-2.9 days

All indicators reflect the change in indicator average relative to Historical (1991-2020).

In the St. Mary River, future conditions are likely to yield marginally higher flow at an annual timescale, but with substantial reductions in flow during the late summer months with continued glacier retreat (Table 9). Like in the Waterton and Belly rivers, Mean Annual Flow is projected to increase over both future periods, with increases ranging from 2-14%, with greater increases under RCP 8.5 and further into the future, and modest reductions under the No Glacier land cover scenario. The 2-year Peak flow is projected to see negligible changes in the future, with little difference between climate and cover scenarios. Peak flows are projected to occur approximately 4-12 days earlier on average, with greater changes over the latter half of the century, reflecting an earlier snowmelt in a strongly snowmelt driven peak flow regime in the watershed. More significant changes in Mean Aug-Sept Flow are projected, with a decrease of 0-3% over the 2021-2050 period and decrease from 3-8% over the 2051-2080 period under the Historical land cover scenario. However, under the No Glacier scenarios, late summer flows decrease 8-18%; a sizeable decrease in late summer water availability.

Table 9. Hydrologic Change Consequence Table for the St. Mary River watershed. All changes are relative to the Historical (2020) land cover with Current (1991-2020) climate.

Hydrologic Change Consequence Table

St Mary Reservoir near Spring Coulee

LandCover	Climate	Mean Annual Flow	2-year Peak Flow	Mean Aug-Sept Flow	Peak Flow Timing	July-Aug Days above 11% MAD	Sept Days above 20% MAD
2021-2050							
Historical	RCP 4.5	6%	–0%	0%	-3.7 days	0.0 days	0.0 days
Historical	RCP 8.5	5%	–3%	–3%	-6.2 days	0.0 days	0.0 days
No Glaciers	RCP 4.5	3%	–1%	–8%	-3.8 days	0.0 days	0.0 days
No Glaciers	RCP 8.5	2%	–3%	–11%	-6.8 days	0.0 days	0.0 days
2051-2080							
Historical	RCP 4.5	9%	3%	–3%	-5.3 days	0.0 days	0.0 days
Historical	RCP 8.5	14%	7%	–8%	-12.0 days	0.0 days	0.0 days
No Glaciers	RCP 4.5	6%	3%	–12%	-8.9 days	0.0 days	0.0 days
No Glaciers	RCP 8.5	10%	7%	–18%	-12.1 days	0.0 days	0.0 days

All indicators reflect the change in indicator average relative to Historical (1991-2020).

4.6 Effects on water supply for the SMRID

4.6.1 Base Scenarios

The base scenarios were used to evaluate the effects of climate change for Chin Reservoir under current storage (total capacity 168,000 acre-feet) conditions.

The results from the base scenarios suggest an increase in annual water runoff is likely to result in higher annual water supply for the SMRID, with higher storage volumes being maintained in Chin Reservoir relative to historical climate. Figure 13**Error! Reference source not found.** shows the Chin Reservoir storage volume over the year, averaged across all the years in the 2022-2100 period. Figure 13 suggests there is no discernable change in storage regardless of the emissions pathway or the landcover scenario with and without glaciers.

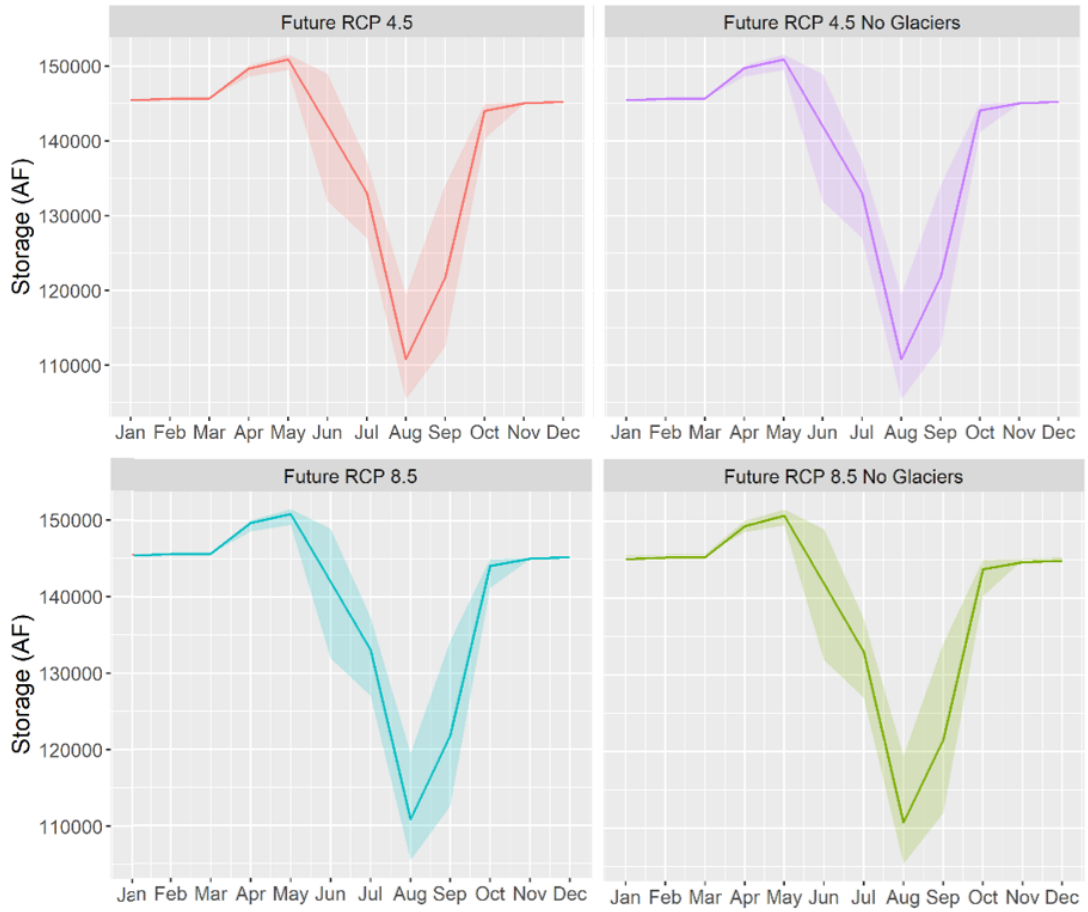


Figure 13. Modelled Chin Storage volume throughout the year under the RCP 4.5 and RCP 8.5 climate scenarios, and with and without glaciers for the 2022-2100 period. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

Table 10 shows the number of years in the modelled time series where there is a deficit in terms of the water demand (in inches per acre) relative to the water delivered that year. The results show that in the base scenarios all 78 years in the assessment (2022 to 2100) have negligible water deficits per acre in the SMRID due to an increase in annual runoff. No shortages are greater than 2 inches of water less than demanded per acre.

Table 10. Modelled deficit range in number of years for RID, TID and SMRID with the effects of climate change inflows (2022 to 2100).

Modelled deficit range (inches)	Historical 4.5	Historical 4.5 No Glacier	Historical 8.5	Historical 8.5 No Glacier
0 to 2	78	78	78	78
2 to 4	0	0	0	0
4 to 6	0	0	0	0

Modelled deficit range (inches)	Historical 4.5	Historical 4.5 No Glacier	Historical 8.5	Historical 8.5 No Glacier
6 to 8	0	0	0	0

4.6.2 Chin Expansion

Climate change effects on the Chin Reservoir were evaluated under two expansion scenarios (Scenario 1 includes expansion by 75,511 ac-ft and Scenario 3 by 103,500 ac-ft). The potential effect of climate change on Chin Reservoir storage is shown in Figure 14,

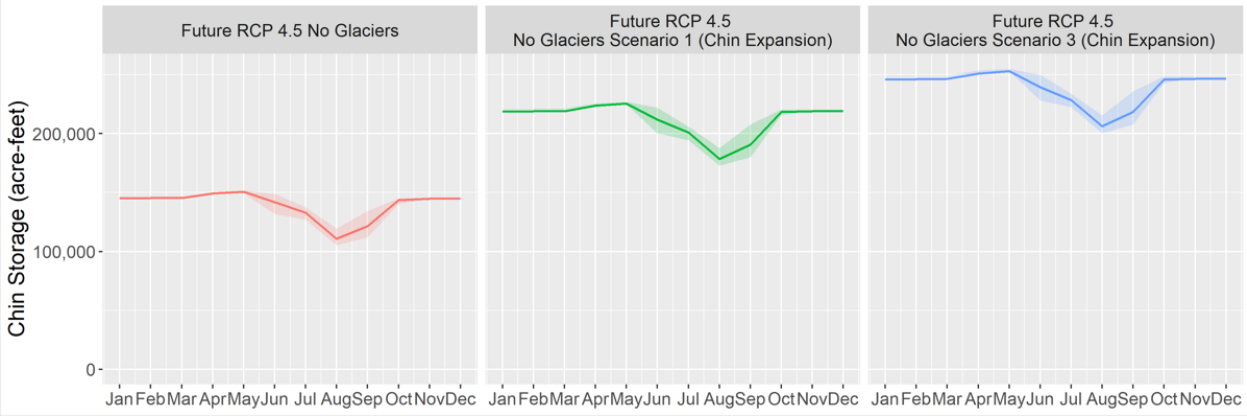


Figure 15, Figure 16, and Figure 17. These figures show the averaged volume of the Chin Reservoir over the course of a year. The results in Figure 14 and Figure 15 show the volume of the reservoir under climate change RCP 4.5 and then the same but with the Chin Reservoir expansion of two sizes, Scenario 1 and Scenario 3. Figure 14 shows the results modelled with historical glacier coverage, while Figure 15 shows the results without glaciers.

Figure 16 and Figure 17 show the average volume of the reservoir under climate change RCP 8.5, and then the same but with the Chin Reservoir expansion of two sizes, Scenario 1 and Scenario 3. These scenarios suggest sufficient water is likely for the Chin Reservoir expansion.

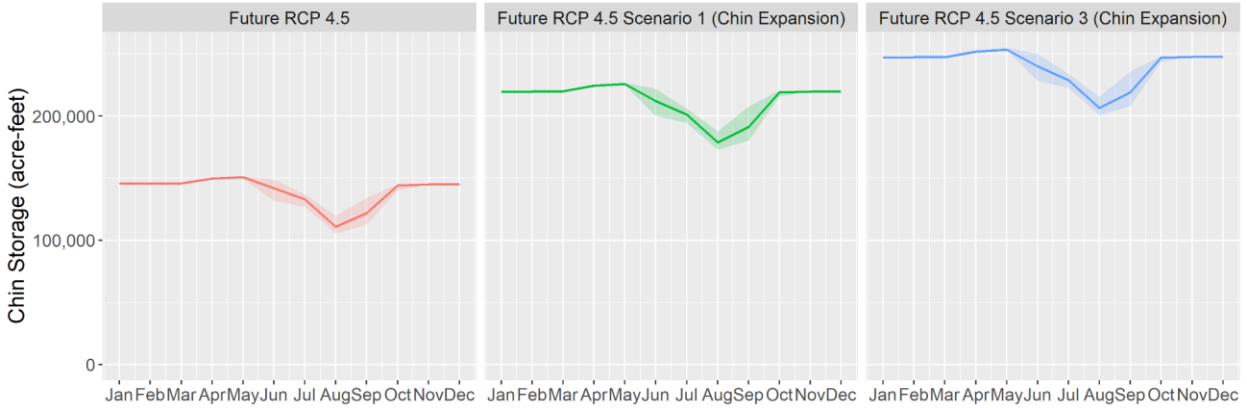


Figure 14. Modelled Chin Storage volume throughout the year under the RCP 4.5 climate scenario and historical

glacier coverage for the 2022-2100 period with additional Chin storage, Scenario 1 and Scenario 3. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

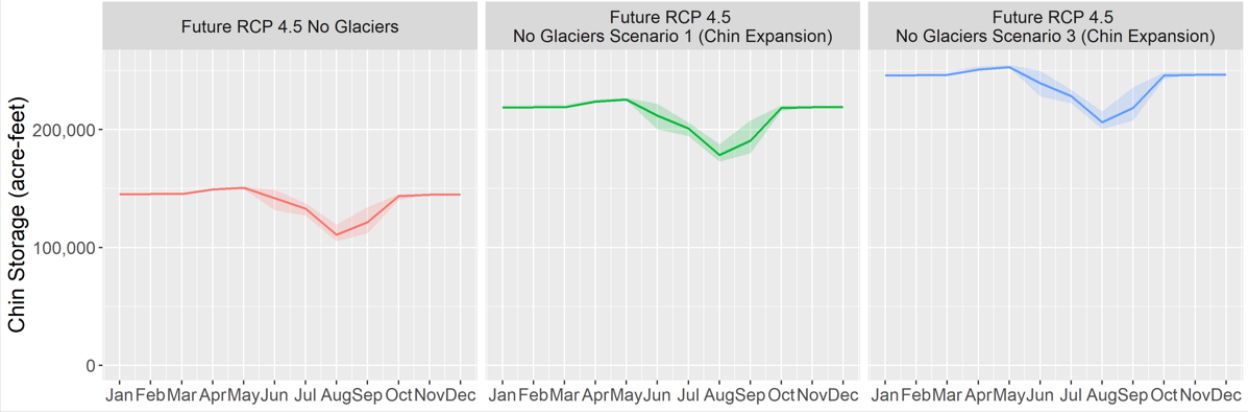


Figure 15. Modelled Chin Storage volume throughout the year under the RCP 4.5 climate scenario and no glacier scenario for the 2022-2100 period with additional Chin storage, Scenario 1 and Scenario 3. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

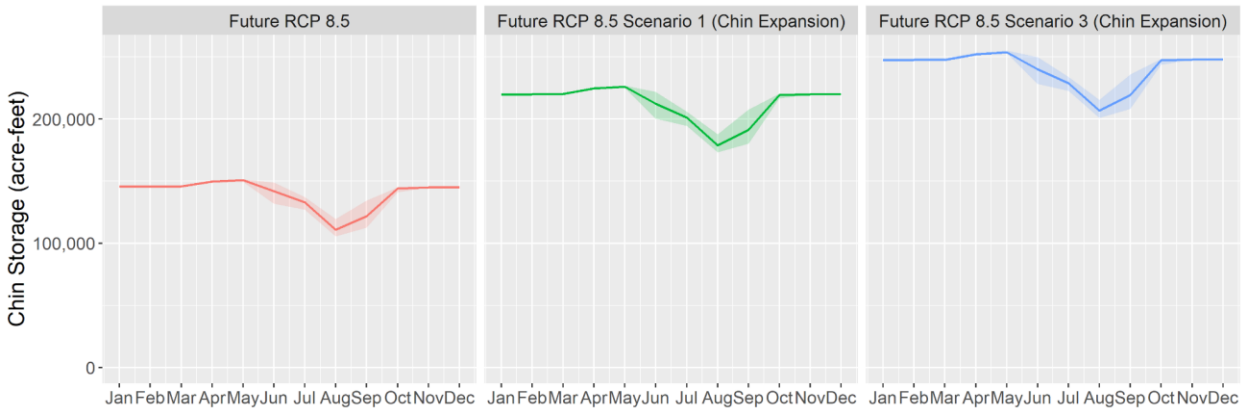


Figure 16. Modelled Chin Storage volume throughout the year under the RCP 8.5 climate scenario and historical landcover for the 2022-2100 period with additional Chin storage, Scenario 1 and Scenario 3. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

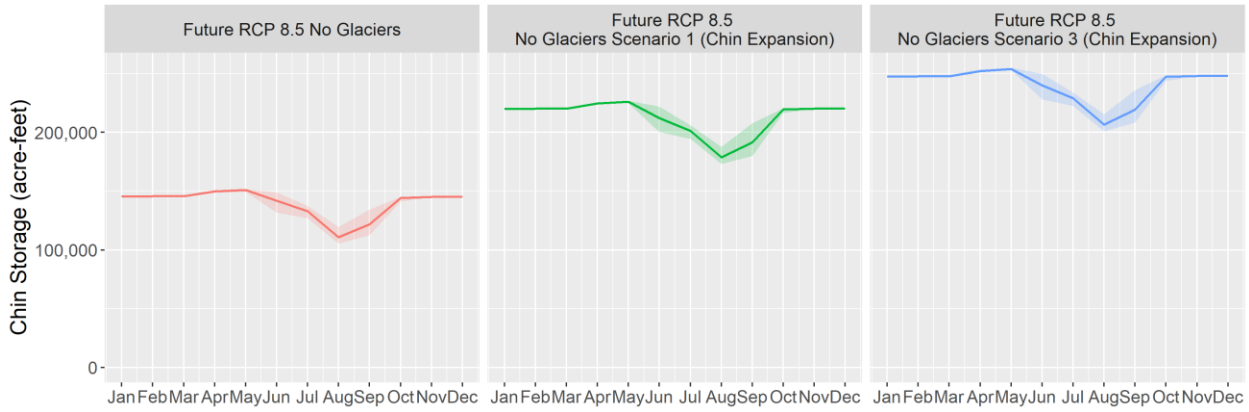


Figure 17. Modelled Chin Storage volume throughout the year under the RCP 8.5 climate scenario and no glacier scenario for the 2022-2100 period with additional Chin storage, Scenario 1 and Scenario 3. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

Table 11 shows the number of years in the simulated time series where there is a deficit in terms of the water demand (in inches per acre) relative to the water delivered that year. This provides an indication of any increased water shortage experienced by irrigators in the SMRID. The results show that neither expansion of the Chin Reservoir (Scenario 1 or Scenario 3) changes the number or size of water deficits. All 78 years in the assessment (2022 to 2100) have negligible water deficits per acre in the SMRID. No shortages are greater than 2 inches of water less than what is demanded per acre, which is the same as the base case.

Table 11. Modelled deficit range in number of years for RID, TID and SMRID with the effects of climate change inflows (2022 to 2100) and the additional storage in Chin Reservoir, Scenario 1 and Scenario 3.

Model Deficit Range (inches)	Base case	Scenario 1	Scenario 3	Base case	Scenario 1	Scenario 3	Base case	Scenario 1	Scenario 3	Base case	Scenario 1	Scenario 3
	Historical RCP 4.5			Historical RCP 4.5			No Glacier RCP 8.5			No Glacier RCP 8.5		
0 to 2	78	78	78	78	78	78	78	78	78	78	78	78
2 to 4	0	0	0	0	0	0	0	0	0	0	0	0
4 to 6	0	0	0	0	0	0	0	0	0	0	0	0
6 to 8	0	0	0	0	0	0	0	0	0	0	0	0

4.6.3 Chin Expansion and Increased Irrigated Acres

The final set of scenarios layered additional demands into the model, along with the climate change projections for water supply and the Chin Reservoir expansion of storage. The irrigation water demand was increased overall by 10% as a rough simulation for climate change impacting demand, and 46,500

additional irrigated acres were added to the SMRID system. The potential effect on water storage from the combination of climate change, the Chin Reservoir expansion, and increased irrigated acres is shown in Figure 18, Figure 19, Figure 20 and Figure 21. The graphs in Figure 18 and Figure 19 compare how the storage in the expanded Chin Reservoir responds under climate change scenario RCP 4.5 with and without glacier coverage.

The graphs in Figure 20 and Figure 21 compare how the storage in the expanded Chin Reservoir responds under climate change scenario RCP 8.5 with and without glacier coverage.

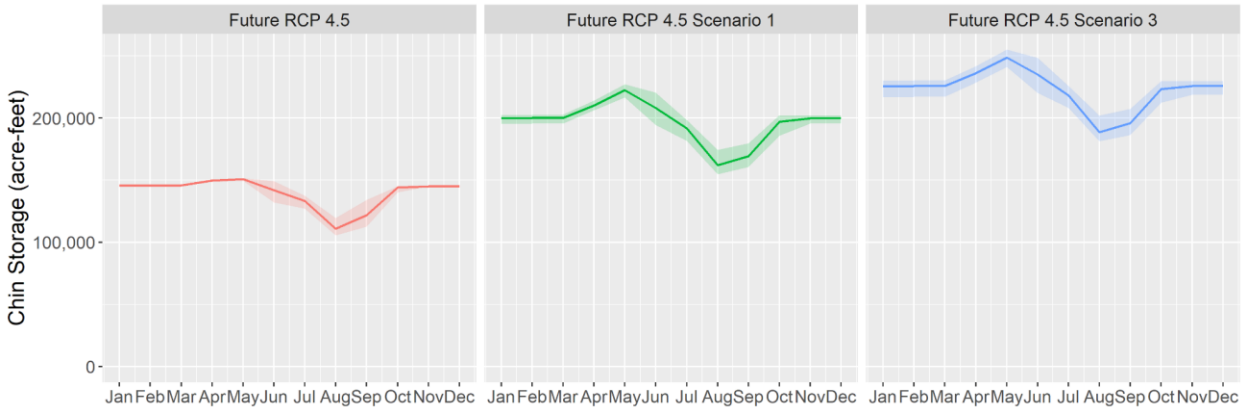


Figure 18. Chin Storage under the RCP 4.5 climate scenario and historical glacier coverage for the 2022-2100 period with additional Chin Reservoir storage, Scenario 1 and Scenario 3, with irrigation expansion. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

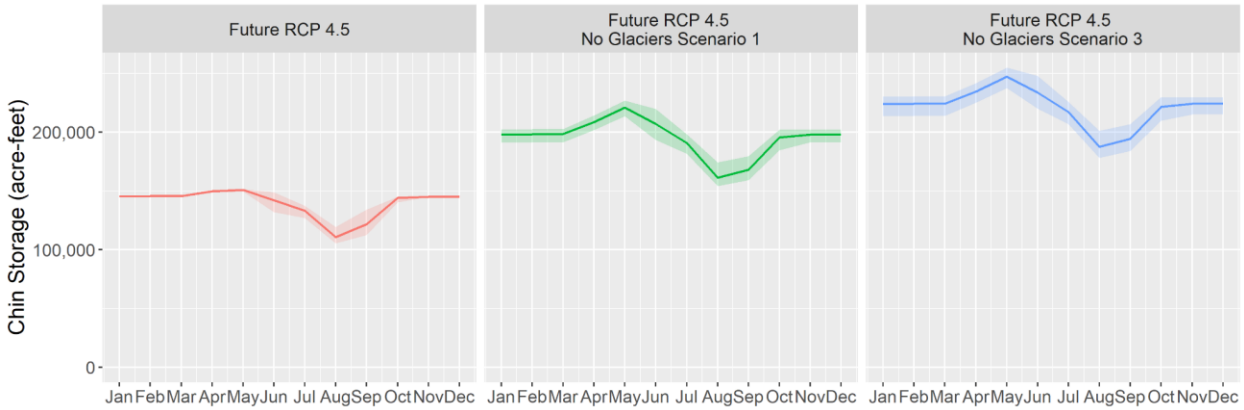


Figure 19. Chin Storage under the RCP 4.5 climate scenario and no glacier scenario for the 2022-2100 period with additional Chin Reservoir storage, Scenario 1 and Scenario 3, with irrigation expansion. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

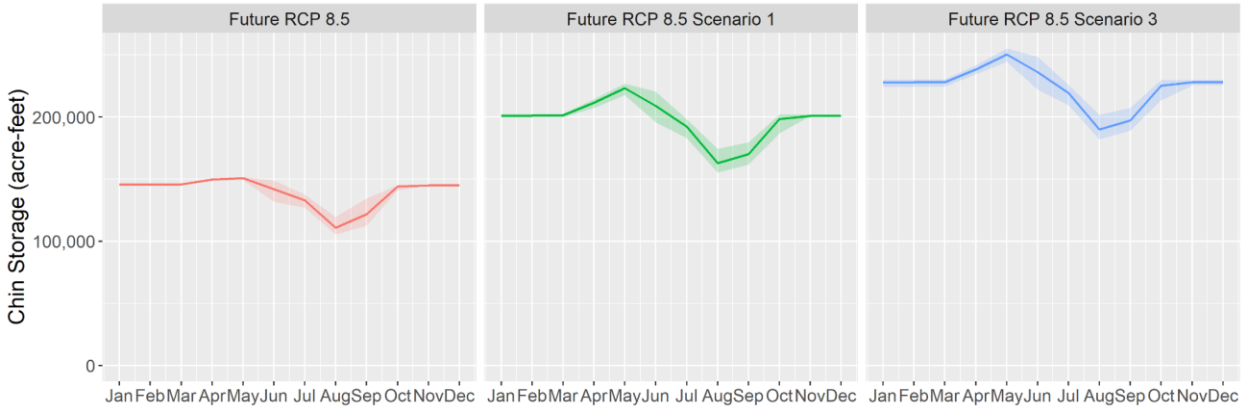


Figure 20. Chin Storage under the RCP 8.5 climate scenario and historical glacier coverage for the 2022-2100 period with additional Chin Reservoir storage, Scenario 1 and Scenario 3, with irrigation expansion. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

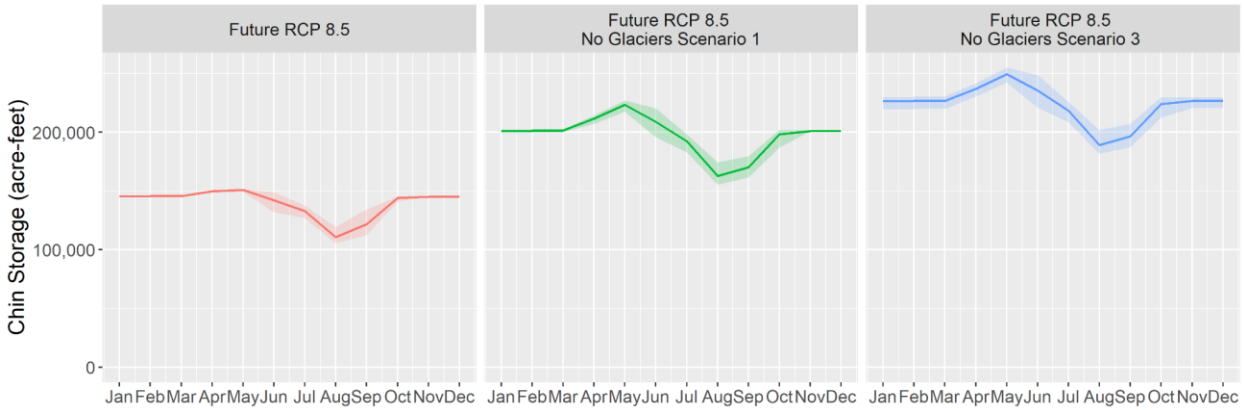


Figure 21. Chin Storage under the RCP 8.5 climate scenario and no glacier scenario for the 2022-2100 period with additional Chin Reservoir storage, Scenario 1 and Scenario 3, with irrigation expansion. The solid coloured line is the average from all 78 years, and the shaded colour shows the range of storage volumes.

The deficit frequency under the modelled scenarios for the SMRID, RID and TID are shown in Table 12. These results suggest an increase in annual water supply is likely to support the SMRID to consistently deliver water to their users given that shortages are maintained within the 0-2 inch deficit category. It is important to note that this analysis did not explicitly evaluate the effects of increased evapotranspiration on crop water use or water stress and does not infer crops would not be stressed under warmer climatic conditions.

Table 12. Modelled deficit range for RID, TID and SMRID impacted by the climate change inflows, Chin Reservoir expansion, and irrigated acre expansion (2022 to 2100).

Model Deficit Range (inches)	Base case	Scenario 1	Scenario 3	Base case	Scenario 1	Scenario 3	Base case	Scenario 1	Scenario 3	Base case	Scenario 1	Scenario 3
	Historical RCP 4.5			Historical RCP 4.5			No Glacier RCP 8.5			No Glacier RCP 8.5		
0 to 2	78	78	78	78	78	78	78	78	78	78	78	78
2 to 4	0	0	0	0	0	0	0	0	0	0	0	0
4 to 6	0	0	0	0	0	0	0	0	0	0	0	0
6 to 8	0	0	0	0	0	0	0	0	0	0	0	0

4.6.4 What we learn from comparing the results

The results in the previous sections (4.6.1, 4.6.2, and 4.6.3) are laid out with the same format of graphs and in a sequence that enables comparison.

The most obvious overall conclusion is that the results show increased storage in the Chin Reservoir in Scenarios 1 and 3. This is a positive outcome for the SMRID Chin Reservoir expansion project. The results are similar between the scenarios because in the model the SMRID system is operated for all the scenarios with the same restrictions and rules based on the real-world regulatory conditions. The results between the climate scenarios of 4.5 and 8.5, or between the situations of glacier cover and no-glacier cover are similar; this comparison indicates the water management system overall can accommodate those changes.

The results in 4.6.1 demonstrate that under climate change conditions, including examining two RCP's and two glacier cover scenarios, the water supply to the SMRID is likely to be sufficient to fill the current volume of Chin Reservoir, and shortages to irrigators are not likely to increase under these scenarios.

The results in 4.6.2 demonstrate that under the climate change scenarios evaluated, and with the expanded Chin Reservoir (two volume scenarios), the water supply to SMRID is likely to be sufficient to fill either of the expanded storage volumes of Chin Reservoir, and shortages to irrigators are not likely to increase under these scenarios.

The results in 4.6.3 demonstrate that under the climate change scenarios evaluated, with the expansion of Chin Reservoir storage and the additional water demand from irrigation, the water supply to the SMRID is likely to be sufficient to fill the Chin Reservoir, and shortages to irrigators are not likely to increase under these scenarios.

When comparing these modelling results, we observe that averaged over the modelled timeframe, climate change scenarios used are not likely to result in water scarcity on an annual scale. This suggests the expanded Chin Reservoir could be fully utilized and there are not likely to be greater shortages to SMRID irrigators. Increasing the irrigation water demand by 10% in the SMRID is also shown to not result

in shortages for SMRID irrigators with the reservoir expansion.

5.0 Discussion and Limitations

5.1 Model Uncertainty

Overall, the model shows strong process-representation, and streamflow simulations generally match observations to a good degree in all three watersheds. This model performance gives confidence that the model can be useful to provide reliable simulations at ungauged sub-basins and can simulate the effect of changing climate and land cover. However, like all models, there are several sources of uncertainty that should be highlighted.

The hydrological model shows very strong performance reproducing streamflow in snowmelt dominated headwater watersheds, but performs worse in more arid, rainfall-driven sub-basins. In this study area, streamflow consists largely of water that originates in these headwater systems, meaning in aggregate model simulations at reservoir inflows closely match naturalized inflows. However, complications with prairie watersheds, such as non-contributing areas, complex soil dynamics, and variable rates of snow redistribution make accurate predictions of these more arid environments difficult to constrain, particularly under climate change scenarios where these factors are further complicated by changing weather patterns. Additional certainty is required to evaluate changes in these prairie sub-basins.

Given the study goals, this hydrological model has been purpose-build to examine average conditions and has not been specifically calibrated and developed to reproduce extreme high flow events (i.e., large flood events). These extreme events are difficult to reproduce, and it is likely that the model under-simulates the magnitude of the largest peak flows on record for several reasons. Extreme peak flows typically occur by the concurrence of a high rate of snowmelt (or otherwise very wet antecedent conditions) and extreme rainfall. While the model does a good job of simulating the timing and magnitude of snowmelt, extreme rainfall events are difficult to capture because they are spatially variable, and often the most intense rainfall occurs far from a weather station, leading to an underestimate in precipitation and/or a dampening effect on the spatially distributed rainfall simulation.

The hydrological model simulations assume a static land cover. As model scenarios demonstrate, glacier coverage is an important component of late-summer streamflow, particularly in the St. Mary River. Glaciers in the Rocky Mountains of Montana and southern Alberta have experienced substantial retreat over the last century. Since the 19th century, every glacier in Glacier National Park, MT has decreased in area (Martin-Mikle & Fagre, 2019) while glacier cover in the central and southern Canadian Rocky Mountains (Canada) has decreased by 30% between 1919 and 2006 (Tennant et al., 2012). Warming air temperatures are likely to accelerate this retreat over the coming decades, leading to less glacier coverage and fewer glacial contributions to streamflow. As such, it is likely that the model under-estimates late-summer streamflow prior to 2020 (i.e., the year of the glacier coverage layer used in this study), with more consequential under-estimates further into the past. Likewise, considering future conditions with current glacier extents is likely to over-estimate late-summer water availability in the coming decades.

The hydrological model does not account for major diversions, inter-basin transfers, or water use, these are accounted for in the SOAP model. While these factors do not affect flow in the headwaters, further

downstream they have a considerable effect on the streamflow and water levels, particularly in the St. Mary River and Belly River systems. Simulations from the hydrological model should be roughly equivalent to a historical streamflow record, except for operations at Lake Sherburne in the St. Mary River headwaters. This is important and does not reflect entitlement flows in the future. This could be further evaluated in future work.

5.2 Changing Streamflow Timing

Overall, changes in water availability at an annual scale are projected to remain relatively stable, with small increases in some watersheds/sub-basins. However, this annual scale obfuscates changes in seasonal pattern which could be important for water availability and impact water management decisions. In the future, streamflow is projected to increase across the study area in the spring, with the earlier onset of snowmelt. The corollary to this is that there is likely to be a longer post-snowmelt low-flow period in these watersheds. Once the winter snowpack has been depleted, streamflow is dependent on inputs from ephemeral rainfall events and groundwater. These sources are more volatile than snowmelt, making these watersheds more prone to droughts and summer low flow conditions. This dynamic could be mitigated, at least in part, by water storage facilities (i.e., reservoirs), provided they have the capacity and availability to store water earlier in the spring and potentially for a longer period.

6.0 Conclusions

A hydrological model was developed to simulate the Waterton, Belly, and St. Mary River watersheds and estimate inflows to the St. Mary Reservoir. The model shows good performance at reproducing streamflow and other hydroclimatic variables across the watershed, indicating good process representation. The hydrological model was used to evaluate how climate change is likely to impact hydroclimatic conditions in the study area. Findings from these scenarios are as follows:

- Model simulations demonstrate that there is a steep hydroclimatic gradient, and most streamflow in the study area originates from the deep snowpack and high precipitation in the mountainous headwaters of the study area. Conversely, little runoff is generated in eastern arid prairie reaches which may be subject to water stress without irrigation.
- Under future climate change, air temperatures and annual precipitation are projected to increase across the watershed. These changing hydroclimatic conditions are projected to lead to increased runoff at an annual timescale, providing more reliable water to support irrigation if water can be stored. A change in streamflow timing is projected due to earlier snowmelt, and subsequently lower late summer streamflow. This dynamic is exacerbated by continued glacier retreat, particularly in the St. Mary River. This poses a challenge for the aquatic environment.
- Changing seasonality with climate change is likely to lead to a more volatile water supply, particularly in less snowmelt-dominated sub-basins, making the region more prone to droughts. This dynamic could be mitigated, at least in part, by water storage facilities (i.e., reservoirs), provided they have the capacity and availability to store water earlier in the spring and potentially for a longer period.

- The effects of changing glacier coverage and climate each affect streamflow in isolation. The magnitude and timing of the watershed's hydrologic response to these changes can have critical overlapping effects that amplify or negate this response. This dynamic emphasizes the importance of considering the cumulative impact of these changes to better understand how conditions may change in the future and how to best manage the watershed for greatest resiliency.
- The study results show averages that indicate climate change is likely to result in an increase in annual water supply – this suggests the expanded Chin Reservoir is likely to have adequate supply.
- Increasing the irrigation water demand in the SMRID is shown to not increase shortages for SMRID irrigators when done in combination with the Chin Reservoir expansion. It is important to acknowledge this is a limited analysis and did not use the Irrigation Demand Model.
- The effect of increasing water supply and increasing storage is positive, demonstrated by a lack of water deficit (shortage) for the SMRID, TID, and RID under all scenarios.
- Higher air temperatures could result in crop stress that has not been evaluated here. Some crops are more prone to damage or stress leading to low yields under heat-wave conditions. This could be considered and assessed in future studies.

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Appendix A Hydroclimatic Datasets

Table 13. Weather stations and snow surveys/pillows used to verify model performance. Networks used include AEP (Alberta Environment), EC (Environment Canada), and MT-USGS (United States Geologic Survey – Montana Branch).

Station Name	ID	Network	Longitude	Latitude	Elevation (m)
FLATTOP MOUNTAIN SNOTEL	13A19S	MT-USGS	-113.86	48.80	1,920
AKAMINA	ALE-05AD803	AEP	-114.05	49.03	1,800
PTARMIGAN LAKE	ALE-05AE807	AEP	-113.72	48.83	1,770
MOUNT ALLEN	ALE-05AE806	AEP	-113.68	48.77	1,740
ICEBERG LAKE	ALE-05AE804	AEP	-113.72	48.83	1,710
PEIGAN PASS	ALE-05AE805	AEP	-113.70	48.77	1,680
CHIEF CUSTOMS WATERTON	05AE819	AEP	-113.66	49.00	1,620
POLL HAVEN AFS	27030	EC	-113.60	49.03	1,615
LEE CREEK "Q"	ALE-05AE814	AEP	-113.60	49.05	1,500
WATERTON LAKES RED ROCK	05AD805	AEP	-114.03	49.13	1,500
M GLACIER PILLOW	ALE-13A27	AEP	-113.67	48.80	1,494
MANY GLACIER SNOTEL	13A27S	MT-USGS	-113.67	48.80	1,494
JOSEPHINE LOWER	ALE-05AE808	AEP	-113.67	48.78	1,490
LEE CREEK 99	05AE817	AEP	-113.55	49.00	1,490
ST. MARY RANGER STATION AT ST. MARY'S	05AE808	MT-USGS	-113.43	48.74	1,412
CARWAY	2219	EC	-113.38	49.00	1,354
BULLHORN HEADWATERS	45749	EC	-113.55	49.15	1,326
MOUNTAIN VIEW VILLAGE	27199	EC	-113.59	49.13	1,308
GOAT HAUNT	05AD806	MT-USGS	-113.89	48.96	1,290
WATERTON PARK GATE	26850	EC	-113.81	49.13	1,289
HILL SPRING	2258	EC	-113.63	49.29	1,183
CARDSTON	26971	EC	-113.29	49.20	1,136
ST. MARY RESERVOIR	45727	EC	-113.11	49.36	1,128
BULLHORN COULEE RESERVOIR	45747	EC	-113.36	49.30	1,115
GLENWOOD	45748	EC	-113.52	49.33	1,074

Table 14. Meteorological verification statistics for independent weather station and snow pillow/survey stations considered in this study. N corresponds to the number of observations, PBIAS to the percent bias, and r2 to the pearson correlation coefficient.

Site	Maximum Air Temperature			Snow Water Equivalent			Monthly Precipitation		
	N	*PBIAS*	r^2	*N*	*PBIAS*	r^2	*N*	*PBIAS*	r^2
AKAMINA	-	-	-	1108	15.2	0.71	41	1.5	0.75
BULLHORN COULEE RESERVOIR	1938	8.5	0.99	-	-	-	66	-9.5	0.92
BULLHORN HEADWATERS	2059	11.2	0.99	-	-	-	66	2.9	0.66
CARDSTON	9883	6.9	0.99	-	-	-	263	3.1	0.90
CARWAY	7543	7.8	0.97	-	-	-	245	-14.6	0.88
CHIEF CUSTOMS WATERTON	-	-	-	-	-	-	379	1.2	0.64
FLATTOP MOUNTAIN SNOTEL	11317	18.9	0.98	11688	-29.1	0.93	384	-30.3	0.83
GLENWOOD	2225	11.1	0.99	-	-	-	82	-1.2	0.92
GOAT HAUNT	-	-	-	-	-	-	331	-34.5	0.42
HILL SPRING	2240	9.2	0.98	-	-	-	87	-8.7	0.94
ICEBERG_LAKE	-	-	-	28	-35.9	0.74	-	-	-
JOSEPHINE_LOWER	-	-	-	28	-35.9	0.63	-	-	-
LEE CREEK 99	-	-	-	-	-	-	378	7.1	0.72
LEE_CREEK_Q	-	-	-	56	177.9	0.44	-	-	-
M_GLACIER_PILLOW	-	-	-	14	-33.4	0.65	-	-	-
MANY GLACIER SNOTEL	11655	7.4	0.98	11688	2.6	0.87	383	-36.1	0.56
MOUNT_ALLEN	-	-	-	30	-47.9	0.52	-	-	-

MOUNTAIN VIEW VILLAGE	5926	7.2	0.97	-	-	-	214	-20.9	0.91
PEIGAN_PASS	-	-	-	30	-48.2	0.54	-	-	-
POLL HAVEN AFS	2420	9.8	0.98	-	-	-	86	0.2	0.89
PTARMIGAN_LAKE	-	-	-	29	-32.3	0.70	-	-	-
ST. MARY RESERVOIR	2394	11.6	1.00	-	-	-	84	1.0	0.89
WATERTON LAKES RED ROCK	-	-	-	-	-	-	372	-0.3	0.70
WATERTON PARK GATE	9477	7.2	0.99	-	-	-	310	3.3	0.81

Appendix B Historical Climate Maps

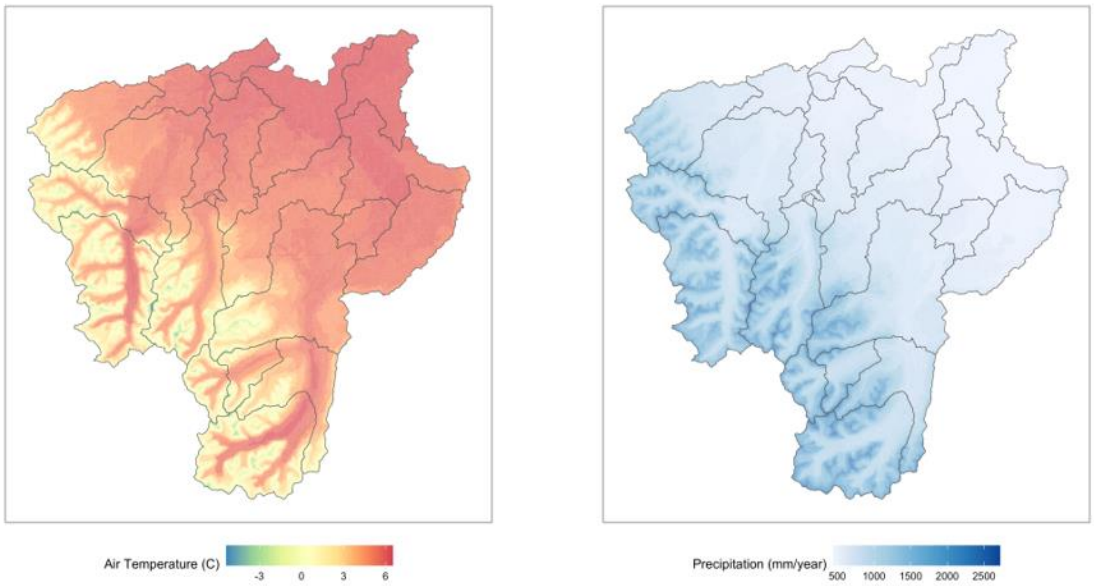


Figure 22. Average annual air temperature (C) and precipitation (mm/yr) for the Historical (1991-2020) period.

APPENDIX 2.1

Adaptive Water Management and Operations with the Southern Tributaries Technical Memorandum (SMRID 2025)

SMRID
ST. MARY RIVER IRRIGATION DISTRICT

TECHNICAL MEMORANDUM

Date: June 27, 2025

To: David Westwood, CPA, General Manager
Trevor Helwig, P.Eng., Technical Services Manager

From: Travis Geremia, P.Eng., Infrastructure Engineer

Subject: Adaptive Water Management and Operations within the Southern Tributaries

1 Introduction

The St. Mary River Irrigation District (SMRID) submitted the Environmental Impact Assessment for the proposed Chin Reservoir Expansion Project (the Project) in July 2024. Supplemental Information Requests (SIR) #1 was received in November 2024. Many of the SIR questions were related to a computer simulation of the water supply and water management system. This analysis was performed to quantitatively assess the feasibility of the Project, the potential Project impacts, and the potential risks to the Project. The simulation was done using computer models, which are described in the Technical Memorandum (WaterSMART, June 2025) accompanying the SIR response. Real-world operations of the region are more adaptive than a computer model is able simulate. This memorandum has been prepared to provide additional context for those unfamiliar with the region's water management infrastructure and the regular operational activities of the various water management operators.

1.1 Definitions

For clarity, the following definitions are provided:

- The Southern Tributaries: broadly describes the Waterton, Belly, and St. Mary Rivers, that are tributaries of the Oldman River.
- AGI Headworks: The complex network of diversion structures, conveyance channels, and reservoirs owned and operated by Alberta Agriculture and Irrigation (AGI) for the purpose of supplying water to several irrigation districts, the Blood Tribe Agricultural Project, and other water users in the region.
- The St. Mary Project: The combined network of all AGI and irrigation district infrastructure existing south of the Oldman and South Saskatchewan rivers in Southern Alberta.

2 Understanding the Regional System

The headwaters of the Southern Tributaries begin in the Rocky Mountains, within Waterton Lakes National Park, Alberta and Glacier National Park, Montana.

Beginning in the 1800s, river withdrawals in the Southern Tributaries have occurred via a complex network of government-owned diversion structures, impoundments, and conveyance canals as shown on Figure 2.3 – Regional Water Management System in the Southern Tributaries, attached. The Southern Tributaries supply several irrigation districts, namely Mountain View Irrigation District, Southwest Irrigation District, United Irrigation District, Magrath Irrigation District, Raymond Irrigation District, Raymond Irrigation District, St. Mary River Irrigation District, and the Blood Tribe Agricultural Project, as illustrated on the below Figure 1.

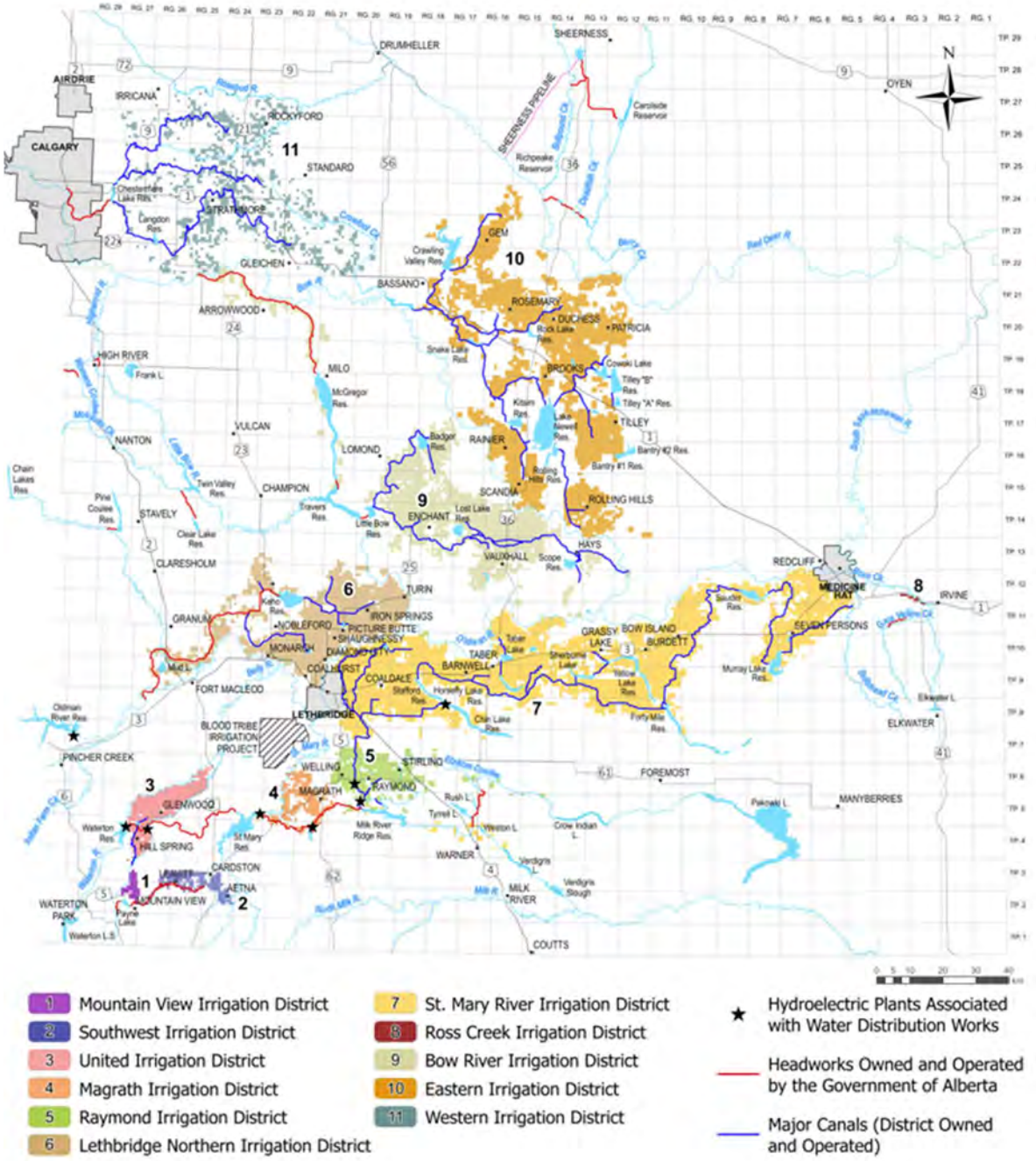


Figure 1: Irrigation Districts of Alberta (AGI 2024)

2.1 The Southern Tributaries Watershed

The Waterton River and Drywood Creek watersheds feed into the Waterton Reservoir, an on-stream reservoir owned and operated by AGI. Water captured at the Waterton Reservoir is either discharged to the Waterton River or diverted to the Waterton-to-St. Mary (WSTM) conveyance canal. During periods of high flow, when the Waterton Reservoir exceeds design storage volumes, excess water is discharged via the Chute Spillway into the Waterton River, as pictured in Figure 2, below.



Figure 2: Waterton Reservoir During a Period of High Flow (AENV 2004)

The WSTM conveyance canal, which is owned and operated by AGI, is supplied by the irrigation low-level outlet located on the east embankment of the Waterton Dam. The WSTM flows in an easterly direction and augments diversions occurring at the Belly River Diversion.

The Belly River begins at Helen Lake at the foot of Mount Merrit (ORSWP 2010) in Glacier National Park, Montana. After crossing the Canada-USA border, a portion of flow is diverted into Payne Lake, comprising the headworks of both Mountain View Irrigation District and the Southwest Irrigation District via a diversion structure located roughly 9.0 km southwest of Mountain View, Alberta. A second diversion located on the Belly River approximately 5.0 km south of Hillspring, Alberta, diverts flow into Miami Creek, forming the headworks of the United Irrigation District. The WSTM canal meets the Belly River at the Belly River Diversion Dam, roughly 5.8 km southwest of the town of Glenwood, Alberta, which is pictured below as Figure 3. Flows from the Waterton Reservoir combine with diversions occurring at the Belly River Diversion, which is then conveyed to the St. Mary Reservoir in the WTSM canal.



Figure 3: Belly River Diversion (AENV 2004)

Immediately upstream of the St. Mary Reservoir, irrigation water for the Blood Tribe Agricultural Project (BTAP) is diverted from the WSTM Canal by a canal turnout adjacent to HWY 505. All three diversions on the Belly River are owned and operated by AGI.

The headwaters of the St. Mary River begin in Glacier National Park, Montana, where melt water flows through the Upper and Lower St. Mary Lakes, or via Lake Sherburne, an onstream reservoir owned and operated by the US Bureau of Reclamation (USBR). Discharges meet in the St. Mary River near the town of Babb, Montana. Roughly 1.0 km Southeast of Babb. The combined flows in the St. Mary River meet the St. Mary Diversion, owned and operated by the USBR, which diverts a portion of the St. Mary River flow into the USBR's St. Mary Canal System. Operation of the USBR St. Mary Diversion structure is regulated by the International Joint Commission (IJC) under the Boundary Waters Treaty of 1909 and the IJC Order of 1921, which govern the apportionment and measurement of water crossing the international boundary. Beginning in 2024 the St. Mary Diversion structure has started rehabilitation by the USBR, as shown in the below Figure 4 illustration, with an expected completion date in 2027 or 2028.



Figure 4: Conceptual USBR St. Mary Diversion Project (MRJBC 2025)

The remaining flows continue along the route of the St. Mary River before meeting the St. Mary Reservoir, located roughly 15 km northeast of Cardston, Alberta.

The on-stream St. Mary Reservoir, owned and operated by AGI, receives flows from the St. Mary River and the WSTM conveyance canal. Water stored by the St. Mary Reservoir is diverted via the irrigation low level outlet located on the southeast abutment of the St. Mary Dam to the WSTM conveyance canal supplying Milk River Ridge Reservoir (MRRR). Water is also discharged via the combined low-level outlet and TransAlta hydro facility to the St. Mary River. During high flow events, when the reservoir exceeds its operational capacity, excess water is discharged over a chute spillway into the St. Mary River, as pictured in Figure 5 below.

Roughly 2.0 km northeast of Spring Coulee, Alberta, water from the WSTM canal is diverted into the headworks of the Magrath Irrigation District via a turnout structure owned and operated by AGI.



Figure 5: St. Mary Reservoir (AENV 2004)

The WSTM canal continues carrying diverted water eastward to Jensen Reservoir, a flow-through reservoir with minor storage capacity, and onwards to the MRRR. The MRRR, operated by AGI, releases water into the SMRID main canal. The outlet of MRRR represents the demarcation between SMRID- and AGI-owned infrastructure. Along the SMRID main canal, the Raymond Irrigation District (RID) receives water from a canal turnout operated by SMRID and RID operators. There are several other smaller diversion structures along the SMRID main canal that supply RID open channels and buried pipelines.

SMRID, AGI, and upstream water users work collaboratively to fulfill regional water demands throughout the operating season. However, it is important to note that the operation of the onstream infrastructure and diversion rates are ultimately controlled by AGI, which manages the flow based on operational needs and regulatory constraints, such as the provincial apportionment requirements with Saskatchewan and the Water Conservation Objectives within Waterton, Belly, and St. Mary Rivers downstream from AGI onstream reservoirs.

2.2 Dynamic Water Management Actions

The annual water cycle begins in the headwater mountains generally within Waterton Lakes National Park and Glacier National Park, with the accumulation of snow roughly through the months of October to June. Throughout this time, automated snow weather stations (snow pillows) located within the headwater mountains record and transmit real-time data regarding the amount of potential runoff that has accumulated as snow. Onstream flow measurement gauges report active discharge from these headwaters. The snow pillows and onstream flow gauging instruments are owned and operated by Alberta Environment and Protected Areas (EPA). Additionally, manual snow coarse readings can be taken, though the occurrence of manual readings is understood to be infrequent due to labour requirements.

The transmitted data is used by AGI staff to predict the volume of water that can realistically be captured by the AGI onstream reservoirs during the coming freshet; this is referred to as the watershed yield. AGI determines the total water supply available for the coming irrigation season by combining the anticipated watershed yield and the carry over storage throughout the St. Mary Project (SMP) from the previous season. In approximately February or March, AGI calculates projected water availability and provides individual reports of the supply forecast to the various irrigation districts operating within the Southern Tributaries.

The SMRID board and operations managers review the provided water supply forecast and use it to determine the appropriate farm gate allocation for the district. The farm gate allocation is defined as a volume of water individual users can draw to irrigate their irrigated acreage. The farm gate allocation is a measure of inches of water that can be applied per acre and is expressed as inches of irrigation. The SMRID board of directors determines the farm gate allocation through risk-informed discussions that consider the anticipated needs of irrigators, while balancing the understanding that carry over storage at the end of an irrigation season is desirable for the beginning of the next season. Most irrigators would suggest that a farm gate allocation of 16" per acre is ideal, while statistically over the years ranging from 2000-2021 the average annual gross diversion of the amalgamated SMRID is 13".

Throughout the winter months, AGI operators communicate regularly with SMRID operations managers. Weekly meetings between the two operations groups begin prior to the irrigation season and take place throughout the irrigation season. The discussions during these meetings focus on forecasts of irrigation demand, anticipated inflows into the headworks reservoirs, weather, anticipated crop requirements, and other water demands. Additionally, the operations groups communicate regularly by email and telephone. These regular communications allow for dynamic operation of the AGI and SMRID infrastructure and adjustments to the flows of the conveyance canals occur daily. During periods of low irrigation demand, there may be opportunities to strategically fill reservoirs.

Though the SMRID holds the most senior license in the Southern Tributaries system and therefore retains the right to call for priority above other junior license holders, this action has never been carried out. AGI water managers generally fill water orders of the upstream junior license holders prior to SMRID due to beneficial geographic proximity to the AGI headworks, even during years with low water availability. AGI operators are also responsible to maintain flows in the rivers downstream of the AGI reservoirs, in accordance with operating approval requirements.

Water users within the SMP are the beneficiaries of years of experience and knowledge transfer between the AGI and SMRID operators. The dynamic management of the SMP infrastructure and operator experience is critical in managing the effects of floods and droughts experienced within the Southern Tributaries.

Based on experience, there is sufficient storage and water availability within the SMP reservoirs to meet irrigation needs during a year of severe drought, assuming reservoir winter storage targets are generally met in the year prior. Depending on the following year's

watershed yield, a second year of drought would result in water shortages, that would require various proactive strategies to mitigate the worst impacts of a multiyear drought.

3 Years of Limited Water Supply

The SMRID acknowledges that irrigation is only one of many water uses in the watershed, and that water for basic human needs, livestock, and ecological flows takes precedence over irrigation needs, as demonstrated during the droughts of 2001 and 2024. In response SMRID, along with the irrigation districts in the Southern Tributaries, re-affirmed a formal commitment that irrigation will come after basic needs for water are met through the *Human Use of Water and Livestock Sustenance Declaration* included as Appendix A.

The SMRID Board of Directors and operational managers apply a forward-looking strategy in the allocation of irrigation water to its users. In times of limited watershed yield, various water saving strategies are implemented such that adequate carry over storage remains in the SMP reservoirs for the following season. The alternative strategy would be to regularly deplete the SMP reservoirs of carry over storage, jeopardizing the following year's spring startup, which is considered a worse outcome than restricting water allocation in the year prior.

The various administrative strategies, described in detail below, are the primary tools that are used at the SMRID's discretion.

3.1 Farm Gate Allocation

In years where the anticipated watershed yield is limited, as extrapolated from snow measurement data, the SMRID Board may set a reduced farm gate allocation. The SMRID Board is intentionally cautious when setting the beginning farm gate allocation, recognizing the value of carry over storage for the next season. Restricted farm gate allocations have the added benefit of encouraging prudent irrigation practices at the farm level. Depending on precipitation patterns and reservoir storage, the farm gate allocation may be increased, provided carry over storage would not be jeopardized.

3.2 Preseason Communication

Years of restricted water supply are anticipated using the organization's experience and real-time snow and reservoir monitoring technologies. Combined with early watershed yield forecasts from AGI, the SMRID will take proactive steps to communicate to its users that the farm gate allocation will be restricted, early in the months of March and April. SMRID irrigators armed with this information are encouraged to consider the reduced farm gate allocations when selecting the crops they choose to grow that year. Cereal crops (wheat, barley, oats, etc) and pulse crops (peas, beans, lentils, etc.), which require less irrigation water, can be planted in place of higher water requirement crops. Reducing overall demand for irrigation water depending on the scale at which these crops are planted.

3.3 Enable Allocation Trading

Individual irrigators who are members of the SMRID are allowed to trade water allocation with one another and within their respective farming operations. Irrigators will transfer the year's allocation from fields which require less irrigation, to crops with higher water needs on the open market. This strategy encourages responsible use, because it creates a monetary value on the allocated water. As described in the prior section, allocation trading also encourages planting of crops requiring less irrigation water, further encouraging the shift of the irrigated crop mix away from being primarily focused on high water demanding crops.

3.4 Startup and Shutdown Dates

In the beginning and ending weeks of an irrigation season, a larger proportion of irrigation water is spilled through the SMRID's open channel conveyance system. This is a result of design minimum flows required to operate the open channel conveyance network being greater than the irrigation usage. Irrigation water spilled to the rivers is not credited towards the SMRIDs total annual withdrawals. Adjusting the districts startup and shut down dates reduces depletion of stored water in SMP reservoirs, by reducing the shoulder seasons when the open channel design minimum flows exceed irrigation demand.

3.5 Restriction on Water Use Types

In addition to supplying water for irrigation during the standard growing season, the SMRID supplies water for other types of water use. Some examples of this are annual agreements (specific water supply agreements for a limited time and purpose) and fall irrigation (irrigation after the main crop is harvested). When natural water supply is limited, the SMRID can decide to restrict these types of water uses as a way of conserving water.

4 2024 Case study

The drought experienced in 2023 and the poor snowfall accumulation over the 2023/24 winter provides a recent example of the collaborative actions taken between AGI and the SMRID to manage the effects of drought.

In fall 2023 reservoir winter storage targets were not met. In addition, the 2023/24 snow accumulation in the mountain headwaters was low. This meant that the predicted watershed yield for the 2024 irrigation season was low, which was reflected in the early AGI allocation forecasts for 2024 that were communicated to the SMRID.

Following the Government of Alberta's lead, the SMRID participated in water sharing agreements that balanced the needs of communities and other junior license holders within the Southern Tributaries and Oldman River watershed. SMRID effectively agreed to forgo its senior license entitlement, in favour of meeting the needs of junior license holders, water conservation objectives, and apportionment agreements. The years of experience offered by AGI and SMRID operators was valuable in the development of these agreements.

The AGI allocation forecasts for 2024 indicated that a farm gate allocation of 8" was appropriate, roughly half of the ideal allocation as viewed by the industry. Recognizing that 8" of irrigation would result in poor performance of the standard irrigated crop mix, the SMRID promptly communicated the expected farm gate allocation to irrigators. Early communication of this limited water supply allowed irrigators to change their crop mix to favour drought tolerant crops. Additionally, SMRID irrigators have the ability to transfer water allocations from crops requiring less water to higher value crops, generally with higher water needs, either within their farming operations or by trading with other irrigators within the SMRID.

Fortunately, timely and substantial precipitation events took place over the spring/summer of 2024, alleviating the worst effects of drought. The SMRID slightly increased the farm gate allocation to 9" and prioritized the replenishment of the SMP reservoirs. AGI and SMRID operators worked closely to prioritize which reservoirs to fill within the SMP, while balancing irrigation needs.

By October 2024, winter reservoir targets were generally met throughout the SMP. The SMRID's March 31, 2025 Water Supply Update, illustrates a combined storage of 515,500 ac-ft, roughly 63% of total storage, representing the carry over storage from 2024 to 2025. The snowfall accumulation during the 2024/2025 winter is remarkably similar to the snowfall accumulation from 2023/24. The additional carry over reservoir storage has allowed AGI's water supply forecasts to significantly improve, enabling the SMRID to set a farm gate allocation of 12" for 2025. Comparing the farm gate allocation of 12" vs. 8" the previous year highlights the role that storage in both AGI and SMRID reservoirs plays in improving resilience in times of limited water supply.

5 References

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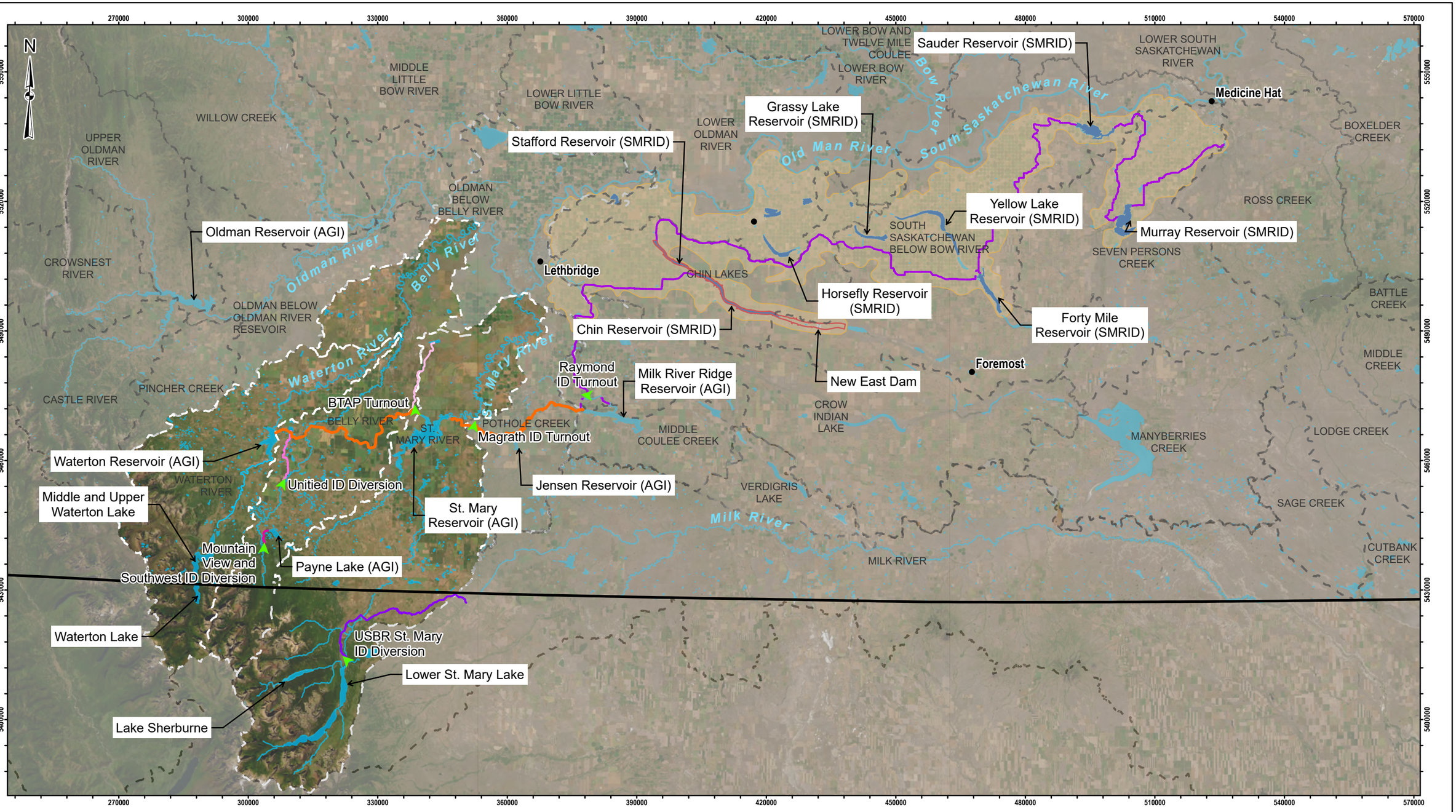
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SMRID
ST. MARY RIVER IRRIGATION DISTRICT

FIGURES

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Legend

- Place Names
- Irrigation District Turnout/Diversion
- WTSM Canal
- SMRID Main Canal
- Mountain View and Southwest ID Canal
- United ID Canal
- BTAP Canal
- USBR St. Mary Canal
- Proposed Dam Location
- Local Study Area (LSA)
- Regional Study Area (RSA)
- SMRID Infrastructure
- Water Feature
- Watershed Boundary
- National Boundary

0 30 Kilometres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: EARTHSTAR GEOGRAPHICS
4. SMRID = SAINT MARY RIVER IRRIGATION DISTRICT
5. ID = IRRIGATION DISTRICT
6. BTAP = BLOOD TRIBE AGRICULTURAL PROJECT
7. WTSM = WATERTON TO ST. MARY
8. WATERSHED DATA SOURCE: ALBERTA ENVIRONMENT AND PARKS, USGS

CLIENT: SMRID

Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT SIR#1 RESPONSE DOCUMENT

TITLE: REGIONAL WATER MANAGEMENT SYSTEM IN THE SOUTHERN TRIBUTARIES WATERSHED

SCALE 1:850,000 | PROJECT No. A03701E05 | FIG No. 2.3

File: \\int.klohn.com\Proj\Data\AICGY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\ChinReservoir_TBRFigures_220802\ChinReservoir_TBRFigures_221114.aprx Creator: : HManandyan

SMRID
ST. MARY RIVER IRRIGATION DISTRICT

APPENDIX A

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Human Use of Water and Livestock Sustenance Declaration

The Alberta Irrigation Districts Association,

Whose membership is composed of all Alberta Irrigation Districts, each duly constituted under the Alberta Irrigation Districts Act;

Reaffirming the Human Use of Water and Livestock Sustenance Declaration dated December 6, 2010 declare the following:

WHEREAS the member districts of the Alberta Irrigation Districts Association have been granted by the Government of Alberta water licences of considerable quantity for irrigation under the principle of prior allocation; and

WHEREAS the member districts of the Alberta Irrigation Districts Association have prior right to that licensed water relative to the right of most of the licensees in the area of the Province of Alberta surrounding the irrigation districts, and

WHEREAS the members of the Alberta Irrigation Districts Association recognize that water is vital to sustain human health and well-being, and that of livestock, and

WHEREAS drought conditions are recurrent in southern Alberta as a result of variability of the weather;

THEREFORE, the member districts of the Alberta Irrigation Districts Association agree to the following:

That in the case of water shortage due to drought conditions that can occur in southern Alberta, the member districts of the Alberta Irrigation Districts Association assure, within their right to control, the following:

i) that water required for the basic needs of humans, as defined by the World Health Organization[i] for "Optimal access service level," and for livestock sustenance will take priority over any water use for irrigation, and

ii) that the member districts will participate in water sharing with other licence holders in good faith so that sufficient water can be distributed for basic human use and for sustenance of livestock.

Dated the 5 day of November, 2018

Richard Phillips, Chair

[i] Howard, G. And Bartram, J. 2003. p. 22. Domestic water quantity, service, level and health. World Health Organization.

APPENDIX 4.1

Technical Memorandum Regarding Chin Reservoir Expansion Project Supporting SIR Response (WaterSMART 2025)

A Hazen Company
waterSMART
Water Management Solutions

Technical Memorandum

July 10, 2025

To: David Westwood, General Manager, SMRID

From: Brie Nelson, Project Manager
Alison Regan, Regional Water Resources Lead
P. Kim Sturgess, C.M., P.Eng., FCAE, President

Technical Memorandum Regarding Chin Reservoir Expansion Project Supporting SIR Response

Background

The St. Mary River Irrigation District (SMRID) submitted an Environmental Impact Assessment (EIA) for the proposed Chin Reservoir Expansion Project in July 2024. A number of supplemental information requests (SIRs) were received regarding the EIA in November 2024. This technical memorandum provides details that respond to the SIRs related to the modelling work completed by WaterSMART Solutions Ltd. (WaterSMART).

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Models Simulating the River System and Operations

In 2022/2023, the SMRID engaged WaterSMART Solutions Ltd. (WaterSMART) and subconsultant MacDonald Hydrological Consultants Ltd. (MacHydro), to conduct a series of modelling projects to support them in evaluating the benefits and risks of a potential expansion of the Chin Reservoir and addition of irrigation acres. Two existing surface water simulation models that capture reservoir operations, water withdrawals, water license priorities, and IOs/WCOs were used to evaluate the potential reservoir expansion and added water demand.

South Saskatchewan River Operational Model (SSROM)

The SSROM results were used for responding to SIRs regarding impacts to the Oldman River and the South Saskatchewan River, including SIR number 4, 97, 146, 149, and 150.

The SSROM was built using the Operational Analysis and Simulation of Integrated Systems (OASIS) platform. More information about the OASIS platform can be found on the Hazen and Sawyer website, at: https://www.hazenandsawyer.com/articles/oasis-modeling-for-water-people.

The SSROM is a comprehensive, daily, mass balance surface water model of the South Saskatchewan River Basin (SSRB). It was collaboratively constructed through numerous Working Group projects between 2008 and 2016. The initial model development was done for the Government of Alberta (GoA), Alberta Innovates, irrigation districts, municipalities, and other funders, to assess climate vulnerability and sustainable water management in the SSRB. Each of the major sub-basins (Red Deer, Bow, Oldman & Southern Tributaries) were individually modelled and analyzed before being combined to form the SSROM for the full SSRB[1].

The SSROM programming represents typical operations as provided by Working Group participants [2] including Alberta Agriculture and Irrigation (AGI) and the irrigation districts at the time of the model development. For further information please refer to 2016 report “Climate Vulnerability and Sustainable Water Management in the South Saskatchewan River Basin Project”, which can be found here 2015 Climate Vulnerability and Sustainable Water Management in the SSRB Project - Canada WaterPortal.

The SSROM uses historical weekly naturalized inflow data from Alberta Environment and Protected Areas (AEPA) for the years 1928 to 2009 for all areas of the SSRB except for St. Mary River. The SSROM uses a data series for the St. Mary River representing entitlement flows[3], which is adapted from

[1] The SSROM was updated in 2022 and 2024, however given that the modelling work to develop the SOAP Model occurred before either of these were completed, the 2016 version was used for the EIA and the SIR responses to be consistent.

[2] Working Groups were made up of subject matter experts from a variety of organizations including provincial government departments (e.g. AGI, AEPA), municipalities (e.g. City of Lethbridge, City of Medicine Hat, Town of Taber, Town of Cardston), irrigation districts (e.g. SMRID, RID, LNID, TID, UID), research institutions (e.g. Alberta Innovates, University of Lethbridge), watershed planning and advisory councils (e.g. Oldman Watershed Council and South East Alberta Watershed Alliance), and private companies (e.g. AMEC, SouthGrow).

[3] Entitlement flows refer to the flow that Canada is entitled to under the Boundary Waters Treaty (1909), which governs the sharing of international streams between Canada and the United States (US). The Boundary Waters

the naturalized inflow data from the Alberta Government. Historically, Alberta has received more water than its entitlement allows because Montana lacks diversion and storage infrastructure to take and use its full allocation. It is not known if and when the US might take the full allotment of water to which it is entitled in the St. Mary system, which would reduce the amount that is available to Alberta. Entitlement flows in the St. Mary River are approximately 30% less than observed historical flows. The SSROM uses a conservative approach of assuming only the IJC flow to which Alberta is entitled was received, not the flow that has historically been received.

The water demand data used in the SSROM is provided by the GoA from the Water Resource Management Model (WRMM) and the Irrigation Demand Model (IDM) as appropriate, and in some cases scaled down to more accurately represent water use or replaced by actual use data at the discretion of some participating stakeholders. The proper licence priority was applied for large irrigation districts, including SMRID. The SSROM is based on the existing water allocation system in Alberta, and the water licenses issued at the time of model development.

SMRID OASIS Analysis and Planning (SOAP) Model

The SMRID OASIS Analysis and Planning SOAP Model was used to respond to SIRs regarding impacts to the upstream canals and reservoirs (St. Mary, Waterton, and Milk River Ridge reservoirs), to flow and storage in SMRID canals and reservoirs, and to the Southern Tributaries rivers immediately downstream of where the water is diverted for the SMRID water licences. The SIR responses relying on information from the SOAP Model include SIR number 4, 7, 94, 97, 98, 141, 146, 150, and others.

In 2022, the SOAP Model was developed from the SSROM to provide more detail and specificity within the SMRID's area of operations. While the SSROM also simulates SMRID's operations, the SOAP Model was designed to be a tool for the SMRID to explore possible actions and operational changes to support their planning processes. The SOAP Model enables rapid analysis of options specific to the SMRID.

The portion of the SSROM that covers the SMRID area and the water supply system to SMRID was used as the foundation for the SOAP Model. This focused geography allows for a more detailed representation of local operations. The SOAP Model's geographic boundaries range from the Waterton Reservoir to Medicine Hat (see Figure 1).

Treaty and the subsequent 1921 IJC Order established the terms and conditions for water sharing with Montana and are relevant to the St. Mary River system.

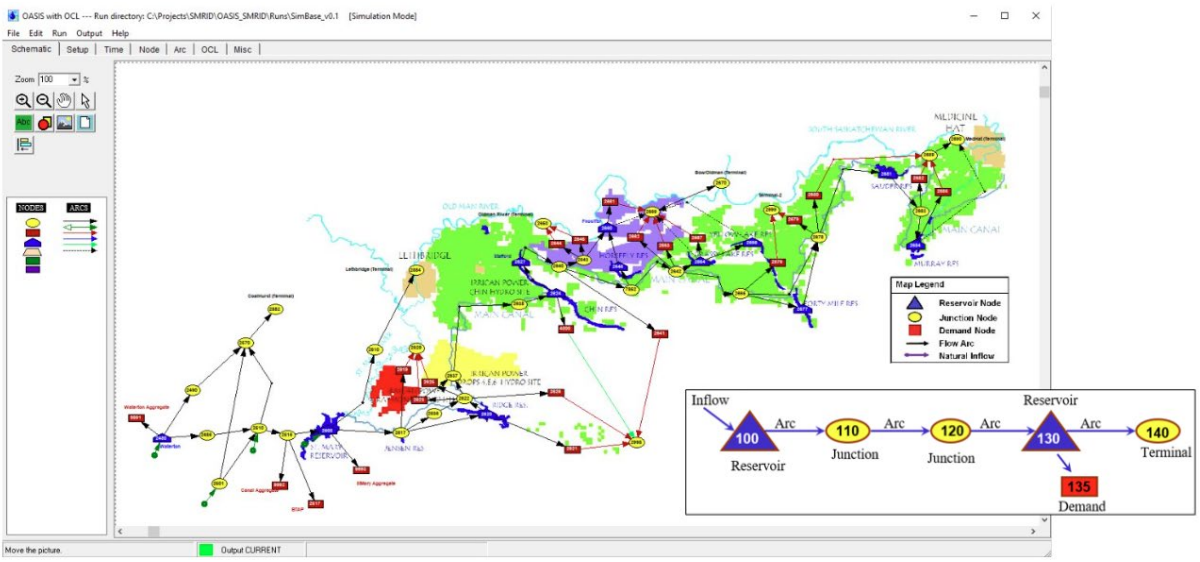


FIGURE 1: SOAP Model schematic. Reservoirs are shown as blue polygons, withdraws as red rectangles, junctions/points of interest as yellow circles, conveyance as connecting arrows, and hydrologic inflows as green arrows.

Because it was built from the SSROM, the programming of the SOAP Model reflects typical operational practices as provided by AGI and the irrigation districts at the time of development.

Similar to the SSROM, the SOAP Model uses historical naturalized inflow data from AEPA for the years 1928 to 2009 but applies current system operations to test historical hydrologic conditions against a variety of infrastructure or operational alternatives. This distinction is important, as no single year in the model exactly replicates historical observations. For example, the output for 1935 does not represent what actually occurred that year but instead simulates how current operations would respond if 1935 dust bowl hydrology were to recur today.

Key SOAP Model Assumptions and Limitations

- The inflow data used in all river systems in the SOAP Model except the St. Mary River is historic naturalized flow data provided by AEPA.
    - The inflow data used for the St. Mary River is historical observed flow data, which was provided by AEPA.
- The SOAP Model operates on a daily timestep and enforces mass-balance across the system (water in = water out for each time step and node).
    - Smaller timestep events, like intense hourly rainfall, are averaged out across a day. Sub-daily concerns are outside the scope of this model and analysis.
- The SOAP Model is designed as a planning tool for understanding operational and hydrological processes, as opposed to hydraulics, groundwater, or rainfall-runoff. The model does not include water quality.

- Shortages in the SOAP Model are defined as a non-delivery of water to existing demands.
- The Chin Reservoir rule curves have been adjusted to allow the expanded reservoir to make use of newly available storage, but the expanded Chin Reservoir is expected to be operated in alignment with the rules for the existing reservoir. See details in the section below "Operation of Chin Reservoir."
    - When modelling the Chin Reservoir Expansion Project, the Storage-Area-Elevation curves and the upper and lower curves are changed directly in proportion to the increase in Full Supply Level (FSL) and useable storage. This also increases the winter carry over level in the Chin Reservoir.
- Irrigation demand data was provided by AGI from their IDM.
- Canal capacities were not changed in this assessment. In actual operations, the regulated capacity of SMRID canal infrastructure, water licences, and diversion timing vary and may constrain available volumes.

Model Simulation of Chin Reservoir Expansion

Both the SSROM and SOAP Model were used to assess impacts from the Chin Reservoir Expansion Project (the Project) in order to respond to SIRs. The following sections describe details of how the Chin Reservoir is represented in the models, including the water balance, operations, and modelled scenarios.

Chin Reservoir Water Balance

The Chin Reservoir is an off-stream irrigation reservoir feeding a canal system. The water balance for the reservoir represented by the model is predominantly canal inflow and outflow. Please see the SIR responses for SIR number 7 and 160 for the Chin Reservoir water balance.

Within the SOAP Model, the Chin Reservoir receives inflow from the main canal, discharges water to Stafford reservoir, receives precipitation that lands on the reservoir surface, and loses water to evaporation. The model does not include surface water runoff from the surrounding area (local drainage) or interaction with groundwater beneath the reservoir (such as seepage), which are likely to be small compared to the inflows and outflows included in the model. The direct precipitation of an intense two-hour rainfall storm event, for example, will be captured in the model as part of net evaporation, but the resulting local runoff will not. Therefore, the model results are conservative and appropriate for the purpose of identifying limitations and impacts to the water supply for the Project from the Southern Tributaries River system.

Operation of the Chin Reservoir

Figure 2 presents the current operational rule curve for the existing Chin Reservoir. The operational FSL is 861.4 m (in meters above sea level), and the water level at dead storage is 845.96 m.

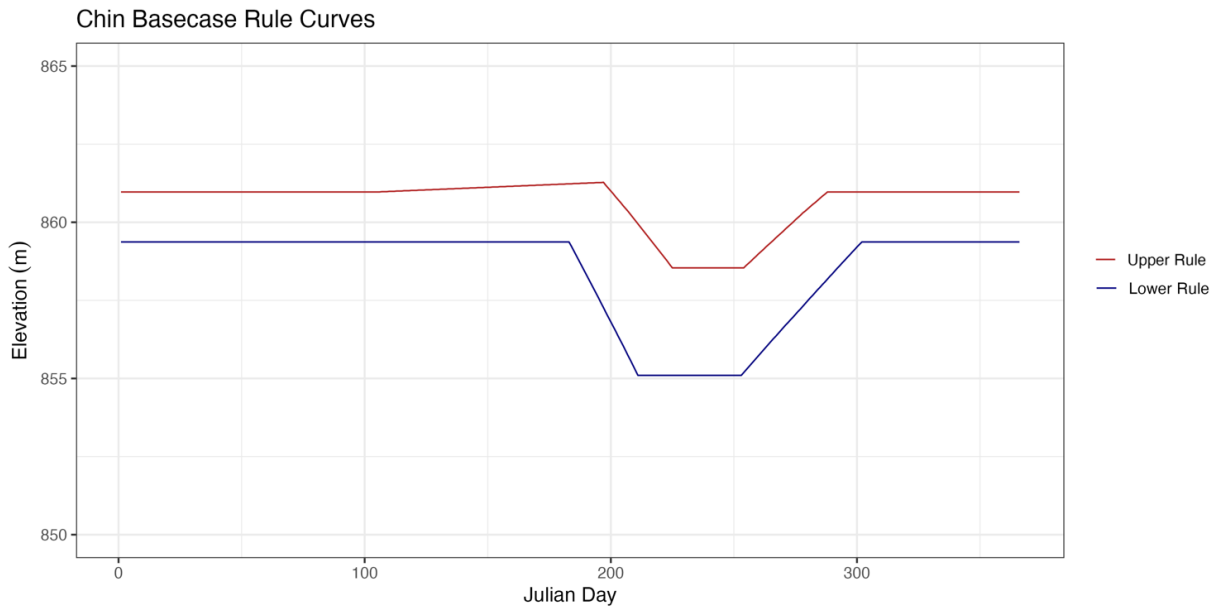


FIGURE 2: Upper (red) and Lower (blue) rule curves (m) for the existing Chin Reservoir represented in the SOAP Model. The upper rule curve was provided by SMRID.

The operational rule curve for the expanded reservoir is currently assumed to follow the same seasonality as the existing Chin Reservoir. The expanded Chin Reservoir will have a maximum storage water level of 864 m and a water level at dead storage of 845.96 m. Figure 3 presents the operational rule curve for the expanded Chin Reservoir under the modelled scenario for the Project.

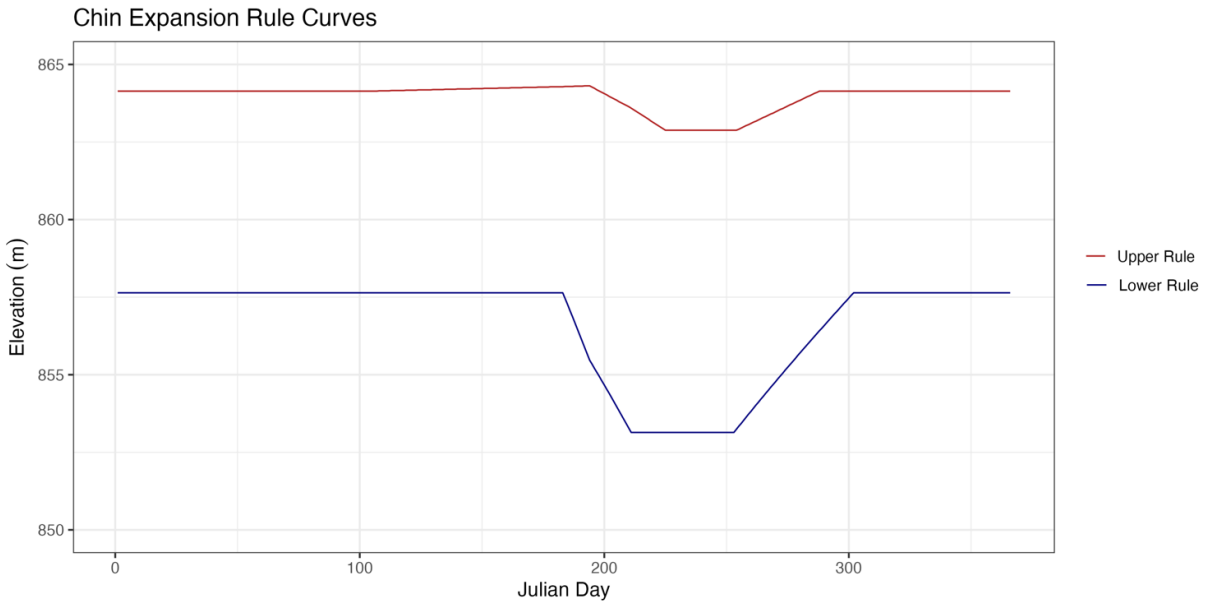


FIGURE 3: Upper (red) and Lower (blue) rule curves (m) for the expanded Chin Reservoir represented in the SOAP Model.

It is important to note that the rule curves provide the upper and lower boundaries. SMRID operators ultimately manage all their reservoirs according to actual weather conditions and irrigation demand, which vary considerably from year to year. In the model, the Chin Reservoir water level is lowered when irrigation demand necessitates water being released, when water is demanded for other water users and when water needs to be relocated to other storage in the system.

The SMRID manages their system through close coordination with AGI operators, who release water into the district system from the St. Mary and Waterton reservoirs through a series of canals, gates, and intermediate reservoirs. Chin Reservoir levels are adjusted based on the anticipated water availability, projected demand, and risk mitigation factors (e.g. such as flood risk management). Operators generally manage Chin Reservoir on a seasonal schedule as follows:

- Chin Reservoir is filled each year in the spring or early summer when runoff water is available and diverted from the headworks via the main canal to the reservoir.
- Chin Reservoir is drawn down through the summer if there is high irrigation demand.
    - Irrigation demand, as represented in the IDM, is 90% of "ideal crop demand." The SOAP Model does not adjust this demand even if water availability is expected to be constrained.
- In cases of extreme drought, the reservoir could be drawn down to the lowest possible water level, which is the dead storage level at 845.96 m above sea level. SMRID has never drawn down Chin Reservoir this low historically, but it has gotten into the low 850's late in the

summer during recent dry years. For example, a level of 850.5 m was reached mid-August 2021 during the most extreme hot period of recent history and part of a muti-year drought. The drawdown process is typically slow and occurs over the course of the summer. The lowest drawdown level over the past 40 years of data was slightly lower than 849 m, which was reached at the end of the operating season in October 2001, another muti-year drought. Storage from the Oldman, Waterton, and St. Mary reservoirs can be used in SSROM to meet apportionment at the Alberta-Saskatchewan border, as per the Master Apportionment Agreement.

Ideally, after peak irrigation demand there is still capacity to transfer water from headworks reservoirs, and Chin Reservoir is re-filled to the SMRID's target winter levels.

Chin Reservoir Expansion Analysis Modelling Study Alternatives

Both the SSROM and SOAP Model were used to assess impacts from the Project and subsequently to respond to SIRs.

Basecase Scenario

The Basecase scenario represents the system as it is currently (without the Project) and represents the consequences of not building the Chin Reservoir Expansion Project. This scenario simulates current operations of facilities on, and withdrawals from, the Waterton, Belly, and St. Mary River systems, including major off-stream canals and storage reservoirs. It includes the actual irrigated acreage in SMRID, including Taber Irrigation District (TID) and Raymond Irrigation District (RID), and the model programming represents typical operation as provided by AGI and the irrigation districts at the time of model development.

Chin Reservoir Expansion Project Scenario

The Project was developed into a model scenario with specific changes relative to the Basecase scenario. This scenario contains the same assumptions and constraints as Basecase, but with the following changes:

- 46,500 irrigated acres increase across the SMRID
- 127,665 CDM storage increase in Chin Reservoir
- FSL (full supply level) for Chin Reservoir set to 864 m above sea level
- Higher winter carry over for Chin Reservoir
- Extend diversion season from Milk River Ridge Reservoir one week earlier and one week later than Basecase

Figure 4 below shows the storage area elevation curve used in the SOAP Model to represent the expanded Chin Reservoir.

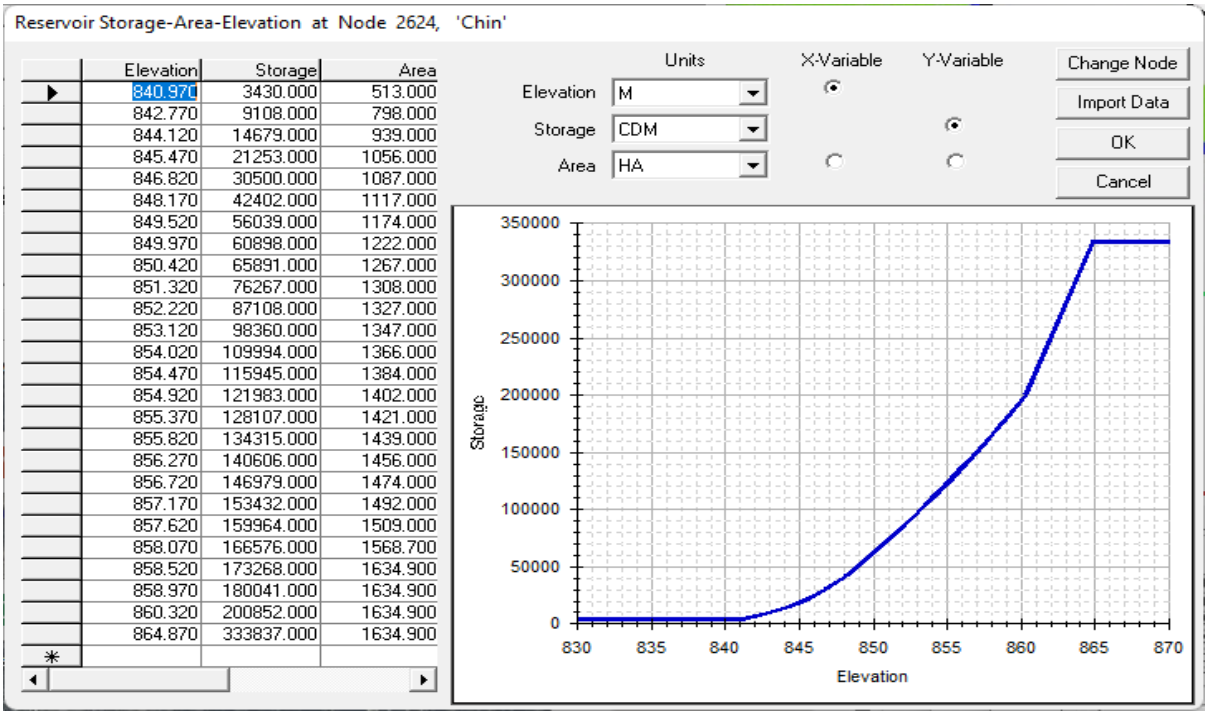


FIGURE 4: Expansion modelling scenario Storage Area Elevation visualization of the Chin Reservoir expansion in the SOAP Model. Storage volume is shown in cubic decameters (CDM).

Closing

This technical memorandum is intended to supplement the information in the SIR response document provided by SMRID. There are no model results included here because they are in the SIR response document for each specific SIR that the results are directly relevant to.

In summary, modelling was done to assess impacts from the Project using two water mass-balance models representing water management operations in the SMRID region (the SOAP Model) and the wider South Saskatchewan River watershed (the SSROM). The model programming represents typical operations provided by AGI and SMRID and uses crop demand data from the IDM. The models use historical naturalized inflow data from 1928 to 2009 with current system operations, and minimum flows in the Southern Tributary rivers (WCOs) are maintained consistently between the SSROM and the SOAP models and between the two modelled scenarios. An understanding of the potential impacts of the Project is achieved by using these models to compare a scenario that represents the system without the Project, and a scenario with the changed infrastructure and operations which represents the Chin Reservoir Expansion Project.

APPENDIX 6.1

Updated Concordance Table

SECTION 1 – PUBLIC ENGAGEMENT AND INDIGENOUS ENGAGEMENT

Numbering		Terms	Location in EIA	Location in SIRs
A		Document the public engagement program implemented for the Project including:	Volume 1: Section 1.13	SIR#1 Question 44
	a	a list of meetings and the specific comments or issues raised at the meetings;		SIR#1 Question 43
	b	a list of other consultation methods including communication via websites, radio, television, newspaper, and the intended audience reached;		SIR#1 Questions 44 and 45
	c	a description and documentation of concerns and issues expressed by the public, SMRID's analysis of those concerns and issues and the actions taken to address those concerns and issues; and		SIR#1 Questions 49 and 50
	d	a description of how the public input was incorporated into the Project development, impact mitigation and monitoring.		
B		Document the Indigenous consultation program implemented for the Project including:	Volume 1: Section 1.14	SIR#1 Questions 43 and 48
	a	a list of meetings and the specific comments or issues raised at the meetings;		SIR#1 Questions 46, 48, and 49
	b	a description and documentation of concerns and issues expressed by Indigenous communities and groups, SMRID's analysis of those concerns and issues, and the actions taken to address those concerns and issues;		SIR#1 Question 47
	c	a description of how Indigenous values are considered in the framework of decision making;		SIR#1 Question 51
	d	how Indigenous knowledge helped shape project development, impact mitigation, monitoring and reclamation; and		SIR#1 Questions 43 and 46
	e	the consultation undertaken with Indigenous communities and groups with respect to traditional ecological knowledge and traditional use of land and water.		
C		Describe plans to maintain the public engagement and Indigenous consultation process following completion of the EIA report to ensure that the public and Indigenous peoples will have an appropriate forum for expressing their views on the ongoing development, operation, and reclamation of the Project.	Volume 1: Section 1.14	SIR#1 Question 43
D		Provide the presentation materials and associated documents (e.g., agendas, minutes, briefings) used for public meetings and Indigenous consultations.	Volume 1: Section 1.14	SIR#1 Question 49

SECTION 2 – PROJECT DESCRIPTION

Numbering		Terms	Location in EIA	Location in SIR#1
2.1		**Overview**		
A		Provide a brief project description in sufficient detail to provide context for the EIA, including:	Volume 1: Section 1	
	a	proponent information;	Volume 1: Section 1.2.1	
	b	the need for the Project and why this project was chosen over other projects;	Volume 1: Section 1.9, Section 2.2	SIR#1 Question 1
	c	roles of various government departments and agencies and non-governmental organizations;	Volume 1: Section 1.11	SIR#1 Question 20
	d	which communities would benefit from the Project; and	Volume 3	
	e	the development plan and schedule.	Volume 1: Section 2.5	SIR#1 Question 8
B		Describe how the Project links to and realizes the outcomes of the Alberta Irrigation Modernization Program.	Volume 1: Section 1.9, Section 1.13.2	SIR#1 Questions 20, 38, and 44 SIR#1, Appendix 44.2 SIR#1, Appendix 49.4

Numbering		Terms	Location in EIA	Location in SIR#1
C		Describe the benefits of the Project, including jobs created, local training, employment and business opportunities, and royalties and taxes generated that accrue to:	Volume 3	SIR#1 Question 65
	a	the Proponent;		
	b	local and regional communities, including Indigenous communities;		
	c	the local authority;		
	d	Alberta; and		
	e	Canada.		
D		Describe the priority rights of SMRID for the licensed allocation of water in comparison to upstream users, and how decisions are made with respect to annual diversions from the source of the SMRID water supply (i.e., Milk River Ridge Reservoir).	Volume 1: Section 1.2.1	SIR#1 Question 93 SIR#1, Appendix 2.1
E		Describe how the existing Chin Reservoir affects downstream users, including junior license holders, municipal and industrial uses, and Indigenous communities. Discuss:	Volume 1: Section 1.14, Section 2.2,	SIR#1 Questions 14 and 146
	a	past and existing contracts that SMRID has entered into with non-irrigators to supply water for domestic, commercial, or industrial uses; and	Volume 1: Section 1.13 Volume 4: Water Quality TBR, Section 2.2.1	
	b	whether alternative (non-irrigation) water contracts have been explored for water above current SMRID requirements up to SMRID total license allocation.		
F		Detail historic and planned water conservation practices adopted by SMRID and the outcomes on the water balance, including:	Volume 1: Section 1.1.3, Section 1.2.1	SIR#1, Appendix 2.1
	a	total water volume realized through efficiency gains over the past ten years;		
	b	how past water savings gained through efficiency improvements are currently stored and/or returned to natural systems; and		
	c	a description of the need for additional storage considering past and future gains realized through conservation and efficiency practices.		
G		Discuss the current need for the Project including:	Volume 1: Section 1.1, Section 1.1.3, Section 1.4, Section 1.5, Section 1.6, Section 1.7, Section 1.9,	SIR#1 Question 1
	a	the need for drought mitigation and climate resiliency;		
	b	rural and regional economic development objectives;		
	c	changes in agricultural practices on lands using the water supply from SMRID and on lands currently without a secure water supply; and		
	d	enhancement of public recreational opportunities.	Section 1.2.2	
H		Describe and provide maps and/or drawings of the components of the Project, including, but not limited to:	Volume 1: Section 2	SIR#1 Questions 2, 7, 21, 92, and 241 SIR#1, Appendix 1.1 SIR#1, Appendix 2.1
	a	the proposed dam structure;		
	b	existing East Dam;		
	c	existing infrastructure, leases, and clearings;		
	d	proposed facilities, buildings and infrastructure (e.g., pipelines and utilities);		
	e	temporary structures;		
	f	transportation and access routes;		
	g	containment structures;		
	h	sources of aggregate resources, borrow material and other construction material and locations of any stockpiles that will be developed if known;		
	i	waste and debris storage area and disposal sites;		

Numbering		Terms	Location in EIA	Location in SIR#1
	j	borrow pits;		
	k	the water supply system, and the existing Waterton-St. Mary Headworks System;		
	l	water conveyance structures;		
	m	reservoirs;		
	n	total potential areas to be flooded in extreme (e.g., 1 in 100-year and 1 in 300-year) flood scenarios; and		
	o	water wells/intakes, pipelines, and storage structures.		
I		Discuss the alternatives for the Project and the rationale for not selecting the identified alternatives.	Volume 1: Section 2.2	SIR#1 Question 206
J		Discuss the implications of a delay in proceeding with the Project, or any phase of the Project, or not going ahead with the Project.	Volume 1: Section 1.4 to Section 1.9 and Volume 4	SIR#1 Question 8
K		Discuss the overall positive and negative economic, environmental, and social impacts of the Project.	Volume 4	
L		Provide the adaptive management approach that will be implemented throughout the life of the Project. Include how monitoring, mitigation and evaluation were incorporated.	Volume 2 Summarized in Appendix I	SIR#1 Question 8 Refer to Terms in Section 8 and 11, below
M		Provide a list of commitments SMRID has made. This would include any mitigation, monitoring and operational commitments made as part of this assessment.	Volume 2 Summarized in Appendix I	SIR#1 Question 8 Refer to Terms in Section 8 and 11, below
2.2		**Constraints**		
A		Discuss the process and criteria used to identify constraints to development, and how the Project was designed to accommodate those constraints. Including the following:	Volume 1: Section 1.10, Section 1.13, Section 1.2.1	SIR#1 Question 20
	a	any applicable *Alberta Land Stewardship Act* Regional Plan, sub-regional plan;		
	b	any approved water management plan enacted under the *Water Act*;		
	c	watershed plan;		
	d	apportionment agreement with downstream provinces, and how the apportionment commitments are met;		SIR#1 Questions 2, 45, 98, and 149 SIR#1, Appendix 2.1
	e	management plan implemented by Watershed Planning and Advisory Councils and/or Watershed Stewardship Groups;		
	f	applicable municipal plans;		SIR#1 Question 20
	g	the Government of Alberta Rural Economic Development Action Plan;		
	h	Indigenous traditional land and water use;		SIR#1 Questions 83, 84, 85, and 86
	i	land use policies and resource management initiatives that pertain to the Project;		
	j	the environmental setting;	Volume 4	
	k	results of project-specific and regional monitoring; and		
	l	potential for changes in the regulatory regime.		
B		Describe the process and criteria used and options considered to select sites for project components, including:	Volume 1: Section 2	SIR#1, Appendix 1.1
	a	the dam;		
	b	water conveyance structures;		
	c	the source of water;		
	d	borrow sites; and		
	e	material disposal sites, including materials from the existing East Dam.		

Numbering		Terms	Location in EIA	Location in SIR#1
C		Provide a list of project components for which locations will be determined later. Discuss the selection criteria that will be used to determine the specific location of these.	Volume 1: Section 2	SIR#1 Question 66
D		Describe the potential effects of raising the full supply level on the West Dam, Chin Chute, Chin Power Plant, Chin conduits, and the Stafford Reservoir.	Volume 1: Section 2.7 Volume 2: Section 2.8	
E		Describe roads, pipelines, well sites, power lines, or other infrastructure that may be affected by the Project.		SIR#1 Questions 11, 24, 68, 103, and 198
F		Document communication with the owner of the infrastructure regarding potential impacts and relocation requirements and other measures required to mitigate permanent or short-term impacts.		
G		Describe proposed protection, relocation, or reconstruction of infrastructure and measures proposed to mitigate impacts during construction.		
H		Describe public lands that may overlap with the Project.	Volume 2: Section 2.8	SIR#1 Questions 20, 65, 69, and 197
I		Describe the cumulative effects of the Project in combination with any other activities in the Regional Study Area.	Volume 2	
2.3		**Regional and Cooperative Efforts**		
A		Discuss SMRID's involvement in regional and cooperative efforts to address environmental and socio-economic issues associated with regional development.	Volume 1: Section 1.10, Section 1.13 Volume 3	SIR#1 Questions 6 and 20
B		Describe opportunities for sharing infrastructure (e.g., access roads, utility corridors, water infrastructure) with other resource development stakeholders. Provide rationale where these opportunities will not be implemented.	Volume 1: Section 2.7 Volume 2: Section 2.8	SIR#1 Questions 6, 9, 10, 11, 20, 22, 24, 44 and 69
C		Discuss potential cooperation with other parties regarding water related infrastructure and management including, but not limited to, water supply, water intakes, pipelines, water storage and withdrawals, flow monitoring and reporting and ecological monitoring.	Volume 1: Section 2.7 Volume 2: Section 2.8	SIR#1 Question 6 SIR#1, Appendix 2.1
2.4		**Transportation Infrastructure**		
A		Assess the geotechnical impacts of the Project on rate of retrogression and overall stability of the Highway 36 Chin Coulee landslide (identified as site S005 in Transportation and Economic Corridors' Geohazard Risk Management Program).	Volume 2: Section 5.1	SIR#1 Question 72
B		Describe the potential effects of raising the full supply level on the Highway 36 causeway.	Volume 2: Section 5.1	SIR#1 Question 24
C		Discuss the potential impacts of the Project to Highway 36, as well as the bridge crossing the Chin Reservoir, including:	Volume 2: Section 5.1	SIR#1 Questions 24, 68, and 69 SIR#1, Appendix 1.1
	a	freeboard impacts, wave/wind run-up impacts, ice impacts, bank erosion impacts, scour impacts, and structural capacity; and		
	b	conceptual solutions to address any adverse effects. Include a cost assessment that considers initial costs and predicted operation and maintenance costs.		
D		Prepare a Traffic Impact Assessment as per the latest Transportation and Economic Corridors' Traffic Impact Assessment Guidelines, including the following:	Volume 2: Section 5.2	SIR#1 Question 71 SIR#1, Appendix 71.1
	a	describe and map the Project boundary, internal road network, and any existing or proposed access location to/from the provincial highway system;		
	b	discuss the options considered for the proposed highway access locations and provide rationale for selecting the preferred option;		
	c	discuss compatibility of the preferred option with Transportation and Economic Corridors' future highway plans;		

Numbering		Terms	Location in EIA	Location in SIR#1
	d	describe existing and future background traffic and development traffic, and consider the cumulative effects from other existing and planned developments that are or will be using the same highways and highway accesses;		
	e	consider the potential traffic impacts for all stages of the Project (e.g., construction, operations, expansion, shutdown, etc.), and determine any necessary improvements to maintain the safe operations of the highway intersection and access road infrastructure; and		
	f	provide a schedule for undertaking the necessary improvements prior to commencing the Project.		
E		Describe any project infrastructure (e.g., utilities and facilities that cross or in close proximity to a provincial highway) that may impact the provincial highways, and any effects from the Project (e.g., smoke, dust, light, noise, precipitation, etc.) that may impact the highway users, and provide solutions.		SIR#1 Questions 24, 52-57, and 87-91
F		Provide a summary of any discussions with Alberta Transportation and Economic Corridors in regard to the Project and its traffic impacts.		SIR#1 Questions 24 and 71
G		If the Project involves the transport of dangerous goods by trucks, include the following:		SIR#1 Question 71 SIR#1, Appendix 71.1
	a	state the classes, divisions, and characteristics of the dangerous goods; and		
	b	state where the dangerous goods will be transported to.		
2.5		**Air Emissions Management**		
A		Discuss the selection criteria used, options considered, and rationale for selecting mitigation measures to minimize air emission and ensure air quality management.	Volume 2: Section 3.1 Volume 2, Appendix 14: HHRA	SIR#1 Questions 87, 88, 89, and 218
B		Provide emission profiles (type, rate, and source) for the Project's construction and operating emissions including point and non-point sources, area, mobile and fugitive emissions. Discuss:		SIR#1 Questions 3 and 90
	a	odorous and visible emissions from the Project;		SIR#1 Questions 3, 91, and 215
	b	greenhouse gas emissions during all stages of the Project. Identify the primary sources and provide calculations;		
	c	amount and nature of criteria air contaminants emissions; and		
	d	control technologies and mitigative measures used to reduce emissions.		SIR#1 Questions 88 and 218
2.6		**Dam Safety**		
A		Describe how the Project will adhere to the Alberta Dam and Canal Safety Directive and include:	Volume 1: Section 2 Volume 2: Section 4.2.1	SIR#1 Question 6 SIR#1, Appendix 1.1
	a	the Project components and scope;		
	b	the overall approach for design and technical specification;		
	c	any hypotheses and assumptions used;		
	d	data collection methods, models and studies;		
	e	the degree of uncertainty, reliability and sensitivity of models used to reach conclusions; and		
	f	any gaps in knowledge and understanding related to key conclusions, including steps to address these gaps.		
B		Describe the physical characteristics of the proposed reservoir, including:		SIR#1, Appendix 1.1
	a	normal operating range;		
	b	spatial extent/overlap into other tributaries, if any;		
	c	surface area at the maximum normal reservoir level;		
	d	normal operating water volume; and		
	e	the volume between the maximum normal reservoir level and the minimum normal reservoir level.		
C		Describe the consequence classification of the Project and its appurtenant structures.		SIR#1, Appendix 1.1

Numbering		Terms	Location in EIA	Location in SIR#1
D		Describe preliminary design of the proposed structures, including:	Volume 1: Section 2	SIR#1, Appendix 1.1
	a	characteristics of the proposed site, including field and lab test results and geotechnical properties;		
	b	principal dimensions of the structures and related works including spillway/ outlet structures;		
	c	anticipated quantities of materials required for construction;		
	d	seepage control and drainage provisions for both the dam and rim of the proposed reservoir extension;		SIR#1 Questions 106 and 113 SIR#1, Appendix 1.1
	e	stability under usual and unusual loading conditions; and		SIR#1, Appendix 1.1
	f	freeboard requirements.		
E		Describe expected performance of the dam and its appurtenant structures during and after extreme weather events (e.g., floods, earthquakes, etc.) including:	Volume 1: Section 2 Volume 2: Section 4.2.1	SIR#1 Question 224 SIR#1, Appendix 1.1
	a	ability of the structures (e.g., earth dams, diversions, flow control) to withstand those events and potential challenges and mitigation measures;		
	b	potential challenges that could impact the safety of the proposed structures; and		
	c	proposed measures to mitigate challenges identified.		
F		Describe construction activities of the proposed structures including:		SIR#1, Appendix 1.1
	a	site clearing and grubbing;		
	b	construction and operation of any temporary structures required (e.g., cofferdam, river diversion, etc.) if any;		
	c	excavation and stockpiling of suitable material, including drilling, blasting, sorting and screening in rock quarries, and moisture conditioning of impervious material;		
	d	excavated slope stabilization and foundation preparation;		
	e	placing impervious lining and erosion protection;		
	f	installation of instrumentation, mechanical and electrical equipment; and		
	g	testing and commissioning.		
G		Describe decommissioning, removal and/or reclamation of the existing or temporary structures including:		
	a	removal of temporary structures (e.g., coffer dams etc.); and		
	b	breach/removal of any existing structures.		
H		Describe the operation of structures including:	Volume 1: Section 2.3, Section 2.4, Section 2.6	
	a	approach used for first filling of the reservoir;		
	b	debris management during reservoir filling;		
	c	shoreline stabilization during reservoir filling, including potential impacts with higher reservoir water levels on the reservoir shoreline;		
	d	operation, maintenance and surveillance needs for safe operation of the structures;		
	e	expected fluctuations in the reservoir and its impacts; and		
	f	approach to manage the reservoir in usual and unusual conditions.		
I		Provide details regarding potential accidents or malfunctions, including:	Volume 2: Section 4.2.1	
	a	identification of potential accidents and malfunctions that could occur during all stages of the Project's construction (e.g., cofferdam leakage or failure or other dam safety incidents);		

Numbering			Terms	Location in EIA	Location in SIR#1
	b		description of the effects of a failure by tabulating the flow arrival time at downstream of the structures until the estimated contents of the reservoir are within the estimated 100-year flood level; and		
	c		assessment of the potential for cascade failure and the impacts of such a cascade failure if there are other dam or canal structures located downstream.		
2.7			**Water Management**		
2.7.1			**Water Supply**		
A			Describe the water supply requirements for the Project as it relates to the source of water for the reservoir, including:	Volume 1: Sections 1.4 to 1.10 Volume 2: Section 2.2, Section 2.3 Volume 3	SIR#1 Questions 2, 4, 7, 29, 41, 95, 96, 138, 139, 140, 141, and 160 SIR#1, Appendix 2.1
	a		the water requirements and sources for normal operation of the reservoir. Identify the volume of water to be diverted from each source;		
	b		the variability in the amount of water required on an annual and seasonal basis as the Project is implemented;		
	c		the expected water balance prior to and resulting from the Project including, but not limited to:		
		i	total annual diverted volumes of water,		
		ii	volume of water lost from canals and reservoirs,		
		iii	volume of return flows,		
		iv	licensed volumes used for other purposes than irrigation (e.g., agricultural and industrial water convenance agreements),		
		v	volume of remaining license water available for crop use, and		
		vi	volumes of consumptive use;		
	d		a complete water balance for the reservoir (including existing and proposed using historical hydrologic data [especially watershed natural runoff yield and natural flow]);		
	e		a discussion of assumptions made or methods chosen to arrive at the water balances; and		
	f		the expected cumulative effects on water losses/gains resulting from the Project's operations.		
B			Describe the water supply requirements for the Project as it relates to process and/or potable water needs during construction, operation and/or decommissioning, including:	Volume 1: Sections 1.4 to 1.10 Volume 2: Section 2.2, Section 2.3 Volume 3	SIR#1 Question 16
	a		the process water, potable water, and non-potable water requirements and basin water supply sources for construction and normal operation of the reservoir. Identify the volume of water to be withdrawn from each Source and potential changes in the operation of upstream water supply reservoirs;		
	b		potable water treatment systems for all stages of the Project;		
	c		type, quantity, and process of potable water treatment chemicals used; and		
	d		measures for ensuring efficient use of water such as water use minimization, recycling, conservation, and technological improvements.		
2.7.2			**Surface Water**		
A			Describe the surface water management strategy for all stages of the Project, including:	Volume 1: Section 2 Volume 2: Section 2.2, Section 2.3	
	a		plan for diverting water during decommissioning of the existing East Dam and subsequent filling of the expanded reservoir upon completion of the new dam;		SIR#1, Appendix 1.1
	b		design factors considered, such as:		
		i	site drainage,		

Numbering			Terms	Location in EIA	Location in SIR#1
		ii	run-on management,		
		iii	road run-off,		
		iv	erosion/sediment control,		
		v	geotechnical stability concerns,		
		vi	surface water protection and groundwater interaction,		SIR#1 Question 13
		vii	waterbody dewatering,		
		viii	groundwater seepage, and	Volume 1: Section 2 Volume 2: Section 2.3	SIR#1 Question 106
		ix	flood protection;	Volume 1: Section 2 Volume 2: Section 2.2, Section 4.2.1	
	c		permanent or temporary alterations or realignments of watercourses, waterbodies, and wetlands (including the relevance of the Alberta Wetland Policy); and	Volume 2: Section 2.6	
	d		the pre- and post-disturbance alignment and condition of ephemeral and permanent streams, wetlands and waterbodies including those created by the Project.		
B			Describe and map roadway, pipeline, powerline and other utility crossings of watercourses, wetlands, or waterbodies.	Volume 2 Volume 4	
2.7.3			**Wastewater Management**		
A			Describe the types and characteristics of wastewater that will be generated during the Project.	Volume 1: Section 2 Volume 2: Section 2.2, Section 2.3	SIR#1 Question 16
B			Describe the wastewater management strategy for each wastewater type generated during all stages of the Project, including:		
	a		the criteria used, options considered and rationale for the selection of wastewater treatment and wastewater disposal and a discussion of why the other options were not chosen;		
	b		the proposed mitigation and monitoring measures (water management and wastewater management treatment systems) to protect water quality; and		
	c		design of facilities that will collect, treat, store and release wastewater streams.		
2.8			**Waste Management**		
A			Describe the types and characteristics of waste that will be generated during all stages of the Project.	Volume 1: Section 2.5 Volume 2: Sections 2.1 to 2.7	SIR#1 Question 16
B			Discuss the selection criteria used, options considered, and rationale for waste disposal during construction and decommissioning. Include:		
	a		the location and availability of on- and off-site waste disposal; and		
	b		site suitability from a water quality protection perspective, geotechnical perspective and with regard to existing and potential human activities.		
C			Characterize and quantify the anticipated dangerous goods, hazardous, non-hazardous, and recyclable wastes generated by all phases of the Project, and describe:		
	a		the composition and volume of specific waste streams and discuss how each stream will be managed; and		
	b		plans for pollution prevention, waste minimization, recycling, and management to reduce waste quantities for all stages of the Project.		
D			Describe the nature and amount of on-site hydrocarbon storage. Discuss containment and other environmental protection measures.		
2.9			**Conservation and Reclamation**		

Numbering		Terms	Location in EIA	Location in SIR#1
A		Provide a conceptual conservation and reclamation plan for all phases of the Project. Describe and map as applicable:	Volume 2: Section 2.5 Volume 2: Section 2.6 Map Figure 2.5.1 Map Figure 2.6.1 Map Figures 2.8.9 – 2.8.14 Map Figures 2.8.15 – 2.8.20 Map Figures 2.8.22 – 2.8.27 Volume 2, Appendix 8	SIR#1 Questions 5, 12, 199, 200, and 201
	a	borrow pits;		
	b	waste material disposal sites;		
	c	temporary roadways or utility corridors;		
	d	any other disturbance;		
	e	current land use and capability and proposed post-development land use and capability;		
	f	anticipated timeframes for completion of reclamation stages including an outline of the key milestone dates for reclamation and how progress to achieve these targets will be measured;		
	g	constraints to reclamation such as timing of activities, availability of reclamation materials and influence of natural processes and cycles including natural disturbance regimes;		
	h	a revegetation plan for the disturbed terrestrial, riparian, and wetland areas;		
	i	reclamation material salvage, storage areas, and handling procedures; and		
	j	existing and final reclaimed site drainage plans.		
B		Discuss, from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and wildlife habitat, the expected success of establishment and recovery, and the expected differences in the resulting communities.	Volume 2: Section 2.6, Section 2.7 Map Figures 2.7.2a – 2.7.2d	
C		Describe how SMRID considered the use of progressive reclamation in project design and reclamation planning.	Volume 2, Appendix 8	
D		Discuss uncertainties related to the conceptual reclamation plan.		SIR#1 Question 199

SECTION 3 – ENVIRONMENTAL ASSESSMENT

Numbering		Terms	Location in EIA	Location in SIR#1
3.1		**Air Quality and Noise**		
3.1.1		**Baseline Information**		
A		Identify residences or other facilities that could be affected by air emissions, dust, noise or vibration from construction, operation, and decommissioning.	Volume 2: Section 3.1, Section 3.3	SIR#1 Question 52 SIR#1, Appendix 52.1
B		Discuss baseline air quality conditions including appropriate ambient air quality parameters and baseline noise conditions.		
C		Discuss baseline soil drifting from the footprint of the reservoir during current reservoir draw-down.	Volume 2: Section 2.5	SIR#1 Question 19
3.1.2		**Impact Assessment**		
A		Identify construction and operational components of the Project that have the potential to increase noise levels or affect air quality.	Volume 2: Section 2.5, Section 3.1, Section 3.3	SIR#1 Questions 53, 54, 55, 90, and 239 SIR#1, Appendix 52.1
B		Discuss the nature, severity, extent, and duration of activities likely to produce noise, vibration, dust, or affect air quality that could impact residences, livestock, other facilities or receptors during construction and operation.		SIR#1 Question 52, 88, and 89 SIR#1, Appendix 52.1
C		Assess the probability of soil drifting during reservoir draw-down from the expanded reservoir.		SIR#1 Question 19
D		Discuss the frequency, severity, and potential impacts of dust generation.		SIR#1 Question 87
E		Describe how air quality, dust, and noise impacts resulting from the Project will be mitigated.		SIR#1 Questions 8, 16, 54, 56, 87, 88, 218

Numbering		Terms	Location in EIA	Location in SIR#1
F		Discuss the Project's relative contribution to cumulative effects on regional air quality and noise.		SIR#1 Questions 52 and 55 SIR#1, Appendix 52.1
3.2		**Hydrogeology**		
3.2.1		**Baseline Information**		
A		Provide an overview of the existing geologic and hydrogeologic setting. Document new hydrogeological investigations, including methodologies, analysis, results, and interpretations undertaken as part of the EIA, and:	Volume 4: Hydrogeology TBR	SIR#1 Questions 114, 121, 122, and 127 SIR#1, Appendix 105.1
	a	present regional and project area geology to illustrate depth, thickness and spatial extent of lithology, stratigraphic units, and structural features; and		
	b	describe and review the geology of the region and project area, including both surficial and bedrock units (both aquifer and non-aquifer units).		
B		Present regional and project area hydrogeology describing:		SIR#1 Questions 14, 42, 105, 107, 108, 114, 123, 124, 125, 126, 128, 129, 130, 131, 132, and 241 SIR#1, Appendix 105.1
	a	the major aquifers, aquitards and aquicludes (quaternary and bedrock), their spatial distribution, properties, hydraulic connections between aquifers, hydraulic heads, gradients, groundwater flow directions and velocities, include maps and cross sections;		
	b	the chemistry of groundwater aquifers including baseline concentrations of major ions, metals and hydrocarbon indicators;		
	c	the potential groundwater discharge zones, potential sources and zones of groundwater recharge, areas of groundwater-surface water interaction and areas of quaternary aquifer-bedrock groundwater interaction; and		
	d	an inventory of water well development and groundwater use.		
C		Provide a detailed review and inventory with site reconnaissance for the entire project area to determine what boreholes are present, including:		SIR#1 Questions 102, 104, 106, 110, 111, and 133
	a	a determination of which party will be responsible for the cost of decommissioning and if replacement is required. Identify where the new wells will be installed;		
	b	an outline of how decommissioning will be completed. Identify what regulatory authorizations are required for the replacement of existing water wells; and		
	c	details of the compensation requirements if new wells cannot be installed.		
D		Describe the potential for current seeps or flows from watercourses (permanent and intermittent) bringing overland agricultural contaminated runoff into the current channel or the proposed reservoir expansion.		SIR#1 Questions 106 and 134
3.2.2		**Impact Assessment**		
A		Describe project components and activities that have the potential to affect groundwater resource quantity and quality at all stages of the Project.	Volume 2: Section 2.1	
B		Describe the nature and significance of the potential project impacts on groundwater with respect to:		SIR#1 Question 113
	a	inter-relationship between groundwater and surface water in terms of surface water quantity and quality;		
	b	implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands;		SIR#1 Question 135
	c	changes in groundwater quality, quantity, and flow;		SIR#1 Question 112
	d	conflicts with other groundwater users, and proposed resolutions to these conflicts;		SIR#1 Question 135

Numbering		Terms	Location in EIA	Location in SIR#1
	e	groundwater protection including reclaiming wells in the Project area prior to construction of the Project;		SIR#1 Question 103
	f	potential implications of seasonal variations;		SIR#1 Question 135
	g	groundwater withdrawal for project operations, including expected alterations in the groundwater flow regime during and following project operations; and		
	h	a discussion of the groundwater vulnerability below the proposed reservoir expansion and along the meltwater valley channel.		SIR#1 Question 135
C		Detail the proposals, and/or mitigation strategies to protect the potential contamination of groundwater aquifers.		SIR#1 Questions 102, 108, 109, 110, 111, 115, 116, 117, and 136
D		Discuss the Project's relative contribution to cumulative effects on regional groundwater with respect to:		SIR#1 Question 137
	a	changes in regional groundwater quality and quantity; and		
	b	conflicts with regional groundwater users.		
3.3		**Hydrology**		
3.3.1		**Baseline Information**		
A		For the local and regional study areas:	Volume 4: Hydrology TBR	SIR#1 Questions 29, 142, 143, and 154
	a	describe the rationale used to define the local and regional study areas considering the location and range of probable project and cumulative effects;		
	b	provide maps illustrating the boundaries of the local and regional study areas;		
	c	describe meteorological conditions;		
	d	describe and map the surface hydrology; and		
	e	describe the sediment yield.		
B		Provide an inventory of surface water users who have existing approvals, permits or licenses in the local and regional study areas, including traditional agricultural and household users.		SIR#1 Questions 14 and 161
C		Describe baseline surface water quantity characteristics, including:		SIR#1 Questions 29, 155, 156, 157, 158 SIR#1, Appendix 1.1
	a	seasonal variation, low, average, and peak flows for watercourses; and		
	b	low, average, and peak levels and trends for the waterbodies impacted by the Project.		
3.3.2		**Impact Assessment**		
A		Identify project activities that may affect surface water during all stages of the Project, including site preparation, construction, operation, decommissioning and reclamation.	Volume 2: Section 2.2	
B		Discuss potential hydrological changes (in terms of quantity, extent, and duration) to watersheds due to the project implementation, including changes in:		SIR#1 Questions 139, 140, 144, 148
	a	surface and near-surface drainage conditions;		
	b	channel regime (during minimum, average and peak flows);		
	c	water levels in water bodies and water courses;		
	d	evaporation, transpiration and seepage amounts;		
	e	sediment transport and yield; and		
	f	open-water surface areas.		
C		Describe the extent of hydrological changes that will result from potential changes to groundwater and surface water movement, and:		

Numbering		Terms	Location in EIA	Location in SIR#1
	a	include changes and timing of those changes to the quantity of surface flow and water levels in watercourses (during minimum, average and peak flows) and water levels in waterbodies, and wetlands;		SIR#1 Questions 4, 147, 150
	b	assess the potential impact of alterations in flow and water levels on local or regional hydrology and identify temporary and permanent alterations or disturbances;		SIR#1 Question 151 SIR#1, Appendix 2.1
	c	assess changes in runoff rates and volumes before, during and after construction of the Project; and		SIR#1 Question 41
	d	identify changes in erosion including changes in sedimentation in watercourses resulting from the Project.	Volume 2: Section 2.2, Section 2.5	SIR#1 Question 224
D		Describe how water conservation objectives may be adversely affected with the development of the Project.	Volume 2: Section 2.2	SIR#1 Questions 2, 4, 145, 151, 188, and 189
E		Describe the impacts on other surface water users resulting from the Project. Identify any potential water use conflicts.		SIR#1 Question 146
F		Discuss how potential impacts of temporary and permanent roads on wetland hydrology will be minimized and mitigated.		
G		Describe mitigation measures to address surface water quantity impacts during all stages of the Project including:		SIR#1 Questions 14 and 147 SIR#1, Appendix 2.1
	a	alteration in flow regimes;		
	b	potential flood events; and		
	c	potential water use conflict.		
H		Discuss the Project's relative contribution to cumulative effects on regional water quantity (e.g., timing, volume, peak and minimum flow rates of water courses, waterbody levels).		SIR#1 Question 141
I		Discuss the impact of low flow conditions and in-stream flow needs on water supply and water and wastewater management strategies.		SIR#1 Questions 4, 145, and 151
3.4		**Surface Water Quality**		
3.4.1		**Baseline Information**		
A		Describe the baseline water quality of water courses and water bodies (current Chin Reservoir and downstream (natural or man-made) bodies of water). Discuss the effects of seasonal and flow variations, other controlling factors, and temporal and spatial trends. Include water quality for high flow events (1 in 20-year and 1 in 100-year and 1 in 300- year) under current conditions. Consider appropriate water quality parameters (e.g., metals, nutrients, pesticides, temperature, BOD/TOC, bacteria, aquatic and benthic invertebrates, aquatic plants, algae, dissolved oxygen, etc.) Provide a summary of existing information available from literature review(s).	Volume 4: Surface Water Quality TBR	SIR#1 Questions 17, 163, 165, 166, 167, 168, 169, 191, 194, 195, and 196 SIR#1, Appendix 17.1
B		Describe and map the current point and identify non-point sources in the Project area.		SIR#1 Questions 236 and 240
C		Describe all the current water uses of the Chin Reservoir (e.g., flood storage, fish habitat, hydroelectric, municipal discharge, recreation, etc.)		
3.4.2		**Impact Assessment**		
A		Identify project activities that may affect surface water during all stages of the Project (including site preparation, construction, operation, maintenance, decommissioning and reclamation). Determine the local and regional extent of potential impacts as well as their frequency, duration, magnitude, and seasonality.	Volume 2: Section 2.3	SIR#1 Questions 170 and 195

Numbering			Terms	Location in EIA	Location in SIR#1
B			Describe and predict the potential impacts of the Project (during site preparation, construction, operation, maintenance decommissioning and reclamation) on surface water quality of the current Chin Reservoir and downstream (natural or manmade) bodies of water using modelling or other scientifically defensible approach, including:	Volume 2: Section 2.3	SIR#1 Questions 15, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, and 195
	a		changes in water quality that may exceed the Environmental Quality Guidelines for Alberta Surface Waters, the Canadian Water Quality Guidelines, the Federal Environmental Quality Guidelines or mainstem reaches in the Surface Water Quality Management Framework included as part of the South Saskatchewan Regional Plan;		SIR#1 Questions 171 and 172
	b		changes in concentrations, loading amounts, and timing of key water quality parameters including routine parameters that could impact the current Chin Reservoir and downstream (natural or manmade) bodies of water, including:		SIR#1 Questions 15, 171, and 173
		i	impacts on their use as a drinking water supply, recreation, agriculture, domestic use, aesthetics, and other water uses,		
		ii	potential implications to water quality on the current Chin Reservoir and downstream (natural or manmade) bodies of water due to the water drawn during the initial filling of the Project,	Volume 2: Section 2.3	SIR#1 Questions 13, 171, and 174
		iii	potential implications to aquatic resources (e.g., aquatic and benthic invertebrates, biota, vegetation, algae, biodiversity, habitat),		SIR#1 Questions 171 and 175
		iv	changes in water quality due to seasonal and flow variation,		SIR#1 Questions 171 and 176
		v	groundwater and surface water interactions,	Volume 2: Section 2.1	SIR#1 Questions 171 and 177
		vi	changes in the quality of surface water runoff,	Volume 2: Section 2.3	SIR#1 Questions 171 and 178
		vii	implications to the health and extent of riparian lands,	Volume 2: Section 2.6	SIR#1 Questions 171 and 179
		viii	impacts in the event of a catastrophic failure of the structure, and	Volume 2: Section 4.2	SIR#1 Questions 171 and 180
		ix	impact on creek banks during flood events;		SIR#1 Questions 171 and 181
	c		the level of uncertainty derived from the models and tools used in the analysis; and	Volume 2: Section 2.3	SIR#1 Questions 171 and 182
	d		any limitations of expected water quality on municipal/domestic use, recreational use, fisheries, stock watering or other uses.	Volume 2: Section 2.3, Section 3	SIR#1 Questions 171 and 183
C			Describe the water quality expected in the Project and downstream (natural or manmade) bodies of water. Include water quality for high flow events (1 in 20-year and 1 in 100- year and 1 in 300-year) under expected reservoir conditions.	Volume 2: Section 2.3 Volume 2, Appendix 14 SIR#1 Question 17	SIR#1 Questions 166 and 195
D			Describe the potential and implications for metals (e.g., lead, arsenic, cadmium, selenium, and mercury) methylation in the Project to:		SIR#1 Questions 15, 17, and 184
	a		enter the aquatic food chain, including downstream in the Project and downstream (natural or manmade) bodies of water; and		
	b		impact treatment of water from the Project and downstream (natural or manmade) bodies of water for drinking water purposes.		
E			Describe the potential and implications for organic carbon and nutrient management in the Project, based on the proposed operating regime to:		SIR#1 Question 185
	a		impact treatment of water the Project and downstream (natural or manmade) bodies of water for drinking water purposes (e.g., disinfection by-products); and		
	b		impact productivity of aquatic vegetation (e.g., macrophyte, algae).		

Numbering		Terms	Location in EIA	Location in SIR#1
F		Describe the potential and implications for cyanobacteria/microcystin in the proposed Chin Reservoir to:		SIR#1 Question 213
	a	impact treatment of water from the Project and downstream (natural or manmade) bodies of water for drinking water purposes; and		
	b	impact recreation of the Project and downstream (natural or manmade) bodies of water.		
G		Describe the potential and implications for release and contamination of hydrocarbons and associated materials from pipelines and other oil and gas infrastructure, farm infrastructure and/or contaminated surface soil or subsoil in the area, on water quality and aquatic environment.		
H		Describe mitigation measures to address surface water quality impacts during all stages of the Project including:	Volume 2: Section 2.3, Section 3	SIR#1 Questions 186 and 195
	a	alteration in flow regimes;		
	b	potential flood events;		
	c	potential water use and operations conflicts; and		
	d	increased loading of water quality parameters of concern.		
I		Provide a summary of the management plan to prevent or reduce impacts to surface water, and a spill response plan should an accidental release occur.	Volume 2: Section 2.3, Section 3, Section 4	SIR#1 Questions 187 and 190
J		Discuss the contribution of the Project to cumulative effects on water quality, including downstream (natural or manmade) bodies of water, and discuss the implications to the South Saskatchewan Region - Surface Water Quality Management Framework and any other regional initiatives.	Volume 2: Section 2.3	SIR#1 Questions 188 and 195
K		Discuss the impact of low flow conditions and in-stream flow needs on water quality and water and wastewater management strategies.		SIR#1 Questions 189 and 195
3.5		**Aquatic Ecology**		
3.5.1		**Baseline Information**		
A		Describe and map the fish, fish habitat, and other aquatic resources (e.g., aquatic, and benthic invertebrates) for water bodies and watercourses and other waters affected by the Project that may provide habitat for fish. Describe the species composition, distribution, relative abundance, quantitative population estimates, seasonal movement trends, and general life history parameters.	Volume 4: Aquatic Ecology TBR	
B		Identify fish species that are:		
	a	listed as “at Risk, May be at Risk and Sensitive” in the *General Status of Alberta Wild Species* (Alberta Environment and Protected Areas);		
	b	listed as threatened or ‘Endangered’ under the *Alberta Wildlife Act*;		
	c	listed as ‘Threatened’ or ‘Endangered’ under Schedule 1 the federal *Species at Risk Act*;		
	d	listed as ‘Threatened’ or ‘Endangered’ by Committee on the Status of Endangered Wildlife in Canada (COSEWIC); and		
	e	species of cultural significance.		
C		Quantitatively describe the current extent of aquatic habitat. Describe and map fish habitat and aquatic resources in water bodies and watercourses and identify:		
	a	key indicator fish species and provide the rationale and selection criteria used;		
	b	habitat used by fish, whether seasonally or year-round, for water bodies and watercourses and other connected water bodies that may provide habitat for fish, including critical or sensitive areas such as spawning, rearing, and over-wintering habitats;		

Numbering		Terms	Location in EIA	Location in SIR#1
	c	water quality parameters in water bodies and watercourses that may affect suitability for fish; and		
	d	current and potential use of the fish resources by Indigenous peoples or sport fisheries.		
3.5.2		**Impact Assessment**		
A		Describe and assess the potential impacts of the Project to fish, fish habitat, and other aquatic resources, including but not limited to:	Volume 2: Section 2.4	
	a	change in habitat suitability and availability during construction and operation of the Project;		
	b	survival of eggs and fry, chronic or acute health effects, and increased stress on fish populations from release of contaminants, sedimentation, flow alterations, temperature and habitat changes;		
	c	changes to riparian areas that could affect aquatic biological resources and productivity;		
	d	changes to benthic invertebrate communities that may affect food quality and availability for fish;		
	e	the potential for increased fragmentation of aquatic habitat;		
	f	potential water quality and quantity changes;		
	g	acidification and/or eutrophication;		
	h	groundwater-surface water interactions; and	Volume 2: Section 2.1	
	i	potential for thermal plumes to affect aquatic habitat.		SIR#1 Question 18
B		Identify the key indicator fish species and provide the rationale and selection criteria used.	Volume 2: Section 2.4	
C		Discuss the design, construction, and operational factors including specific diversion and reservoir operations that will be incorporated into the Project to minimize impacts to fish and fish habitat and protect aquatic resources.		
D		Identify plans proposed to offset a reduction in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat protection.		
E		Discuss the potential impacts of new water control structures on seasonal fish movements relative to baseline conditions.		
F		Discuss the potential effects on fish and fish habitat during the filling of the expanded reservoir and decommissioning of the existing East Dam.		
G		Discuss the potential for aquatic invasive species to occur and the potential for the Project to affect occurrence or distribution of these species. Describe measures to monitor for and remove aquatic invasive species should they be encountered during project works.		
H		Discuss the potential increase in fishing pressures that could arise from the improved access from the Project in the region and how the sport fishery could change.		
I		Identify plans proposed to offset any loss in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat including the development of a no net loss fish habitat objective.		
J		Describe the effects of surface water withdrawals and water diversions including the impacts to:		
	a	St. Mary, Oldman, Waterton, and Belly Rivers; and		
	b	cumulative effects on fish, fish habitat and other aquatic resources.		
K		Discuss changes in the aquatic environment with predicted climate change scenarios, with and without the Project in the local and regional study areas.		SIR#1 Questions 18 and 139
3.6		**Terrain and Soils**		
3.6.1		**Baseline Information**		

Numbering			Terms	Location in EIA	Location in SIR#1
A			Describe and map the terrain and soil resources, including:	Volume 4: Soils and Terrain TBR	SIR#1 Question 202
	a		surficial geology and topography;		
	b		soil types and their distribution;		
	c		soils that could be affected by the Project;		
	d		specific locations of erosion sensitive and saline-sodic soils; and		
	e		an inventory of geohazards, such as erosion, landslides, floods etc.		
3.6.2			**Impact Assessment**		
A			Describe project activities and other related issues that could affect soil quality (e.g., wetting/drying/rewetting of soil, salinization, silt accumulation, soil crusting, compaction, anaerobic decomposition of organic matter, contaminants) and:	Volume 2: Section 2.5	SIR#1 Question 203
	a		indicate the amount (ha) of surface disturbance from the Project construction, operation, and decommissioning activities;		
	b		indicate the size and location of soil types and land capability classes that will be disturbed;		
	c		describe potential sources of soil contamination (e.g., industry infrastructure and activities, agricultural infrastructure and activities, contaminated sites, etc.), along with the appropriate remedial measures;		
	d		describe the impact of the Project on soil types and reclamation suitability and the approximate volume of soil materials that are salvaged for reclamation. Discuss constraints or limitations to achieving vegetation/habitat reclamation based on anticipated soil conditions (e.g., compaction, contaminants, salinity, soil moisture, nutrient depletion, erosion, etc.);		
	e		discuss potential changes to the rate and type of soil erosion;		
	f		discuss potential changes to slope instability, wind erosion, and other geohazards; and		
	g		discuss the relevance of changes for the local landscape on biodiversity, productivity, ecological integrity, aesthetics, and future use.		
B			Discuss the potential impacts caused by the mulching and storing woody debris considering, but not limited to, vulnerability to fire, degradation of soil quality and increased footprint.		
C			Provide a mitigation plan including:		
	a		possible measures to minimize surface disturbance;		
	b		possible actions to mitigate effects of constraints or limitations to habitat reclamation;		
	c		possible actions to address impacts to land capability; and		
	d		any other measures to reduce or eliminate the potential impacts that the Project may have on soil capability and/or quality and include:		
		i	soil mapping and typical profiles,		
		ii	losses of agricultural soils,		
		iii	erosion issues, and		
		iv	characteristics related to handling, reclamation of site disturbances.		
3.7			**Vegetation**		
3.7.1			**Baseline Information**		
A			Describe and map the vegetation communities, native grasslands, wetlands, wetland habitat, riparian lands, rare plants, invasive species, and communities of rare and scarce distribution. Identify the occurrence, relative abundance and distribution and identify any species that are:	Volume 4: Vegetation and Wetlands TBR	

Numbering		Terms	Location in EIA	Location in SIR#1
	a	listed as “at Risk, May be at Risk and Sensitive” in the *General Status of Alberta Wild Species* (Alberta Environment and Protect Areas);		
	b	listed as threatened or ‘Endangered’ under the *Alberta Wildlife Act*;		
	c	listed as ‘Threatened’ or ‘Endangered’ under Schedule 1 of the federal *Species at Risk Act*;		
	d	listed as ‘Threatened’ or ‘Endangered’ by COSEWIC;		
	e	species tracked by the Alberta Conservation Information Management System (ACIMS) as being SU, S1, S2, S3;		
	f	rare ecological communities as tracked by ACIMS; and		
	g	traditionally used species.		
B		Discuss the potential of each ecosite phase or ecological range site to support rare plant species, plant species of cultural significance, and plant communities of limited distribution. Consider their importance for local and regional habitat, rare plant habitat and the hydrologic regime.		
C		Describe the regional relevance of landscape units that are identified as rare.		
D		Describe and quantify the current extent of habitat fragmentation.		
E		Describe and quantify the local and regional relevance of native grassland, and:		
	a	discuss the distribution and relative abundance of native grassland units;		
	b	discuss locations and size of native grassland units;		
	c	characterize the flora and fauna of the native grassland units; and		
	d	evaluate and discuss native grassland integrity.		
3.7.2		**Impact Assessment**		
A		Identify the area of each vegetation community mapped, including various native grassland plant communities, that would be permanently lost due to the Project.	Volume 2: Section 2.6	
B		Identify and quantify areas that will be temporarily lost to the Project and will be reclaimed (e.g., access routes).		
C		Discuss the predicted changes to upland, native grassland, riparian, and wetland habitats resulting from increased fragmentation.		
D		Identify areas that will be avoided during construction.		
E		Discuss the potential project impacts on rare plants, endangered species, or rare ecological communities, and describe any required regulatory authorizations and/or possible mitigation plans/strategies needed to address these impacts.		
F		Describe and assess the potential impacts of the Project on vegetation communities considering:		
	a	both temporary (include timeframe) and permanent impacts;		
	b	the potential for introduction and colonization of weeds and non-native invasive species and how those species will be managed;		
	c	potential increased fragmentation and loss of upland, native grassland, riparian and wetland habitats;		
	d	implications of vegetation changes for other environmental resources (e.g., terrestrial and aquatic habitat diversity and quantity, water quality and quantity, erosion potential); and		
	e	the species that will be used in reclaiming areas disturbed during construction and for erosion control and site stabilization.		SIR#1 Question 205

Numbering		Terms	Location in EIA	Location in SIR#1
G		For temporary disturbances, discuss from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and the expected differences in the resulting vegetative community structures.		
H		Describe how the Alberta Wetland Policy was considered in the assessment of impacts, including but not limited to:		SIR#1 Questions 204, 205, 206, and 207
	a	avoidance, minimization, reclamation or replacement of wetlands in accordance with the Alberta Wetland Mitigation Directive;		
	b	temporary and permanent alterations (direct and indirect) to wetlands classified under the Alberta Wetland Classification System;		
	c	any expected changes in wetland class or type and cause for this change; and		
	d	consideration of cumulative effects in the watershed to wetlands.		
I		Discuss the effect of a loss or development of wetlands and riparian areas, including how the loss or development will affect land use.		SIR#1 Question 208
J		Discuss the regional significance of the indirect effects of the conversion of native grassland pasture to tame pasture or cultivated lands with an increase in water availability.		SIR#1 Question 209
3.8		**Wildlife and Wildlife Habitat**		
3.8.1		**Baseline Information**		
A		Describe and map current and potential wildlife resources (amphibians, reptiles, birds, and terrestrial and aquatic mammals). Describe species relative abundance, distribution and their use and potential use of habitats. Also identify species that are:	Volume 4: Wildlife and Wildlife Habitat TBR	SIR#1 Questions 211 and 212
	a	listed as “at Risk, May be at Risk and Sensitive” in the *General Status of Alberta Wild Species* (Alberta Environment and Protected Areas);		
	b	listed as threatened or ‘Endangered’ under the Alberta *Wildlife Act;*		
	c	listed as ‘Threatened’ or ‘Endangered’ under Schedule 1 of the federal *Species at Risk Act;*		
	d	listed as ‘Threatened’ or ‘Endangered’ by COSEWIC;		
	e	migratory bird species listed under the *Migratory Birds Convention Act*, and		
	f	species of cultural significance.		
B		Describe and map existing wildlife habitat and habitat disturbance including assessment activities. Identify habitat disturbances that are related to existing and approved projects.		
3.8.2		**Impact Assessment**		
A		Describe and assess the potential impacts of the Project to wildlife, wildlife habitats, and biodiversity considering:	Volume 2: Section 2.7	
	a	how the Project will affect wildlife relative abundance, habitat availability, habitat fragmentation, mortality, movement patterns, and distribution for all stages of the Project, including a prediction of future use due to habitat alteration;		
	b	how improved or altered access may affect wildlife, including future prediction of wildlife use and movements, potential obstruction of movements, and increased vehicle wildlife collisions;		
	c	how altered habitat conditions (loss, change, fragmentation) may effect wildlife and biodiversity values. Consider habitat change (e.g., riparian), the availability of habitat and the influence of anthropogenic features and infrastructure on wildlife movements and predator-prey relationships;		

Numbering		Terms	Location in EIA	Location in SIR#1
	d	the contribution of the Project to changes in regional biodiversity and the impact to local and regional ecosystems;		
	e	potential effects on wildlife resulting from changes to air and water quality, including both acute and chronic effects to animal health;		
	f	how the risk to wildlife and habitat can be managed, including the use of setbacks; and		
	g	the resilience and recovery capabilities of wildlife populations and habitats to disturbance.		
B		Provide a strategy and mitigation plan to avoid or minimize effects on wildlife and wildlife habitat for all stages of the Project considering:		
	a	consistency of the plan with applicable regional, provincial and federal wildlife habitat objectives and policies;		
	b	a schedule for the return of habitat capability to areas temporarily affected by the Project;		
	c	the use of setbacks to protect habitat and connectivity of habitat for species of conservation concern;		
	d	anticipated access controls or other management strategies to protect wildlife during construction and operation;		SIR#1 Question 210
	e	measures to prevent human-wildlife encounters and consequent destruction of wildlife; and		
	f	habitat fragmentation and habitat connectivity resulting from linear features (e.g., above ground canals, roads etc.) and other project infrastructure and activities.		
C		Identify opportunities for habitat creation or enhancement which may occur as a result of the Project.		
D		Identify the key wildlife and habitat indicators used to assess project impacts. Discuss the rationale for their selection.		
3.9		**Climate Change**		
3.9.1		**Baseline Information**		
A		Describe climate norms and variability as they relate to agricultural productivity in the Project area.	Volume 1: Sections 1.4 to 1.8	SIR#1 Questions 1, 79, 80, 81, 94, 95, 138, 139, 155, 156, 157, and 158 SIR#1, Appendix 1.2
B		Identify elements of the Project that are sensitive to changes or variability in climate parameters, including frequency and severity of extreme weather events and discuss the potential impacts over the life of the Project.		
3.9.2		**Impact Assessment**		
A		Describe and assess the greenhouse gas emissions during construction, operation, and decommissioning phases of the Project.	Volume 1: Sections 1.4 to 1.8, Volume 3	SIR#1 Question 3
B		Estimate the impacts of the Project to carbon sequestration capacity, including impacts on sequestration in soil and water systems across the expanded reservoir.		
C		Discuss the benefits and consequences of the Project on the affected area with regards to its ability to counteract climate change impacts and the associated risks.		SIR#1 Questions 1, 79, 80, 81, 94, 95, 138, and 139 SIR#1, Appendix 1.2
D		Evaluate the feasibility of the Project under scenarios of climate change, including and explanation of:		
	a	how drier conditions would affect the long-term viability of local agriculture with and without the Project;		
	b	how potential adverse effects of excess rainfall events will be mitigated by the Project; and		
	c	how changes to the volume and timing of spring runoff and river flows may affect the supply of water from the St. Mary's River and/or the Milk River Ridge Reservoir and the risks posed to water availability for the Chin Reservoir.		
E		Review and discuss potential changes in local climate under multiple climate projections, and:		

Numbering		Terms	Location in EIA	Location in SIR#1
	a	identify representative climate change scenarios that reflect a full range of future climate variability (e.g., wet and dry conditions); and		
	b	evaluate relative changes in climate indices (e.g., annual/seasonal precipitation and temperature) between baseline and future periods.		
F		Describe potential effects of climate change on water demands and supply, including:		
	a	changes in water demand for irrigation;		
	b	potential changes in flow and impacts on downstream watercourses and waterbodies; and		
	c	a description of adaptations (e.g., reservoir operation) to climate change for sustainable water resource management.		
3.10		**Land Use and Management**		
3.10.1		**Baseline Information**		
A		Describe and map the ownership status of the subject lands, including lands owned by the Crown, local municipalities, and patented lands. Describe and map the current land uses in the Project area, including private land, Crown land dispositions, and Crown land reservations.	Volume 2: Section 2.8	SIR#1 Questions 197 and 198 SIR#1, Appendix 1.1
B		Describe and map the existing land and resource uses and potential conflicts that exist considering oil and gas development, renewable energy production, agriculture, tourism, Indigenous uses, and outdoor recreational activities.		
C		Identify and map unique sites or special features such as Parks and Protected Areas, Heritage Rivers, Historic Sites, Environmentally Significant Areas, culturally significant sites, and other designations (e.g., World Heritage Sites, Ramsar Sites, Internationally Important Bird Areas).		
D		Identify land use policies and resource management initiatives that pertain to the Project and discuss how the Project will be consistent with the intent of these initiatives.		SIR#1 Question 20
E		Describe and map land clearing activities, showing the timing of the activities.		
F		Describe existing access control measures.		
3.10.2		**Impact Assessment**		
A		Identify the potential impacts of the Project on land uses, including:	Volume 2: Section 2.8	
	a	unique sites or special features;		
	b	effects caused by changes in public access, including secondary effects related to increased hunter, angler and other recreational access, and access to traditional use sites;		
	c	the implications of relevant land use policies and resource management initiatives for the Project, including constraints to development; and		
	d	the anticipated changes (type and extent) to the topography, elevation, and drainage pattern within the Project area.		
B		Identify existing private land uses that would be impacted by the Project and describe the:		SIR#1 Questions 22, 106, and 198
	a	area of land affected and the nature of the impact;		
	b	opportunities for mitigation and compensation, including the cost of implementation; and		
	c	procedures that will be followed in compensating landowners for lands required for the Project and for associated damages or disturbances.		
C		Discuss possible mitigation strategies to address:		
	a	the need for, and plans to address, access management during and after project operations (public, traditional use);		

Numbering		Terms	Location in EIA	Location in SIR#1
	b	the process for addressing the needs of other land users in the Project area; and		
	c	project effects that may lead to changes in land use.		
D		Provide a fire control plan highlighting:	Volume 2: Section 4.2.2	SIR#1 Question 237
	a	fire prevention, detection, reporting, and suppression measures, including proposed fire equipment; and		
	b	measures taken to ensure continued access for firefighters to adjacent wildland areas.		

SECTION 4 – HISTORIC RESOURCES

Numbering		Terms	Location in EIA	Location in SIR#1
4.1		**Baseline Information**		
A		Provide a brief overview of the regional historic resources setting, including a discussion of the relevant archaeological, historic and palaeontological records.	Volume 1: Section 1.1 to Section 1.3 Volume 2: Section 2.9	SIR#1 Questions 73 and 75
B		Describe and map known historic resource sites in the Project area, considering:	Volume 2: Section 2.9	SIR#1 Questions 76, 77, and 78
	a	site type and assigned Historic Resource Values; and		
	b	existing site-specific *Historical Resources Act* requirements.		
C		Provide an overview of previous Historic Resources Impact Assessments that have been conducted within the Project area, including:		
	a	a description of the spatial extent of previous assessment relative to the Project area, noting any assessment gap areas; and		
	b	a summary of *Historical Resources Act* requirements and/or clearances that have been issued for the Project to date.		
D		Identify locations within the Project area that are likely to contain previously unrecorded historic resources. Describe the methods used to identify these areas.		
E		Describe consultation with Alberta Arts, Culture and Status of Women concerning the program and schedule of *Historical Resources Act* requirements for the Project, including:		SIR#1 Question 74
	a	any historic resources issues raised during consultation on the Project; and		
	b	any *Historical Resources Act* programs required to evaluate and mitigate the impacts on historic resources.	To be determined by HRMB	
4.2		**Impact Assessment**		
A		Provide a summary of the results of any Historic Resources Impact Assessments that have been conducted for the Project.	Volume 2: Section 2.9	
B		Describe the Project components and activities, including all ancillary activities, that have the potential to affect historic resources at all stages of the Project.	Volume 1: Section 1.1 to Section 1.3 Volume 2: Section 2.9	
C		Describe the nature and magnitude of the potential project impacts on historic resources, considering:	Volume 2: Section 2.9	
	a	effects on historic resource site integrity; and		
	b	implications for the interpretation of the archaeological, historic and palaeontological records.		

SECTION 5 – TRADITIONAL ECOLOGICAL KNOWLEDGE AND TRADITIONAL LAND USE

Numbering		Terms	Location in EIA	Location in SIR#1
A		If consultation with Indigenous groups reveals traditional use areas and spiritual sites within lands affected by the Project, provide:	Volume 1: Section 1.14	SIR#1 Questions 43 and 82
	a	a map and description of traditional land use areas including fishing, hunting, trapping, water use (e.g., for drinking, cooking and navigation) and nutritional, medicinal, or cultural plant harvesting by affected Indigenous peoples (if the Indigenous community or group is willing to have these locations disclosed); and		
	b	a map of cabin sites, spiritual sites, cultural sites, graves and other traditional use sites considered historic resources under the *Historical Resources Act* (if the Indigenous community or group is willing to have these locations disclosed), as well as traditional trails and resource activity patterns.		
B		Discuss the species, abundance and availability of vegetation, fish and wildlife used for food, traditional, medicinal, and cultural purposes in the identified traditional land use areas, considering all project related impacts.	Volume 2: Section 2.6, Section 2.7; Volume 4: Vegetation and Wetlands TBR, Section 3.4; Volume 4: Wildlife TBR, Section 2.3.1, Section 3.1.1, Appendix II (Table II-4)	SIR#1 Questions 43, 82, 83, 84, 85, 86, and 232
C		Discuss access for traditional uses during all stages of the Project.	Volume 1: Section 1.14	SIR#1 Questions 43 and 83
D		Describe how TEK and Traditional Land Use information was incorporated into the Project, EIA development, the conservation and reclamation plan, monitoring and mitigation.		SIR#1 Questions 43 and 84
E		Determine the impacts of the Project on traditional, medicinal, and cultural land use and identify possible mitigation strategies.		SIR#1: Questions 43 and 86

SECTION 6 – PUBLIC HEALTH AND SAFETY

Numbering		Terms	Location in EIA	Location in SIR#1
6.1		**Public Health**		
A		Describe aspects of the Project's activities and emissions during construction and operation that may have implications for public health or the delivery of regional health services.	Volume 1: Sections 1.13 and 1.14 Volume 2: Section 3 Volume 2, Appendix 14: HHRA	SIR#1 Question 43
B		Conduct a human health risk assessment following guidance from Alberta Health for project components that have implications for public health and describe the results.		SIR#1 Questions 91, 213, 217, 218, 219, 220, 221, 222, and 223
C		Document health concerns raised by stakeholders during consultation on the Project.		SIR#1 Questions 23, 44, and 214
D		Document health concerns identified by Indigenous communities or groups resulting from impacts of existing development and of the Project, specifically on their traditional lifestyle. Include an Indigenous receptor type in the assessment.		SIR#1 Questions 23, 43, 46, 48, and 214
E		Describe mitigation plans for adverse impacts to public health resulting from the Project.		SIR#1 Questions 8 and 214
6.2		**Public Safety**		
A		Describe aspects of the Project that may have implications for public safety. Specifically:	Volume 2: Section 4	SIR#1 Questions 21 and 187
	a	describe the emergency response plan including public notification protocol and safety procedures to ensure public safety and minimize adverse environmental effects, including emergency reporting procedures for spill containment and management;		

Numbering		Terms	Location in EIA	Location in SIR#1
	b	document any safety concerns raised by stakeholders during consultation on the Project and the actions taken to address those concerns;		SIR#1 Questions 21 and 44
	c	describe how local residents will be contacted during an emergency and the type of information that will be communicated to them;		SIR#1 Question 21
	d	describe the existing agreements with area municipalities or industry groups such as safety cooperatives, emergency response associations, regional mutual aid programs and municipal emergency response agencies or other industry partner emergency response/spill response agreements; and		
	e	describe the potential safety impacts resulting from higher regional traffic volumes.		SIR#1 Question 71 SIR#1, Appendix 71.1
B		Discuss mitigation plans to safeguard workforce and public safety for the construction and operation of the Project.		SIR#1, Appendix 71.1

SECTION 7 – SOCIO-ECONOMIC ASSESSMENT

Numbering		Terms	Location in EIA	Location in SIR#1
7.1		**Baseline Information**		
A		Describe the existing socio-economic conditions in the region and in the communities in the region.	Volume 3	
B		Describe factors that may affect existing socio-economic conditions including:		SIR#1 Question 64
	a	population changes;		
	b	workforce requirements for all stages of the Project, including a description of when peak activity periods will occur;		
	c	planned accommodations for the workforce for all stages of the Project. Discuss the rationale for their selection;		
	d	the SMRID's policies and programs regarding the use of local, regional and Alberta goods and services;		
	e	the Project schedule; and		
	f	the overall engineering and contracting plan for the Project.		
C		Describe the socio-economic contribution of current agricultural operations (irrigated and non-irrigated) in the local and regional study areas including:		SIR#1 Question 26
	a	historic and current livestock operations;		
	b	historic and current cropping patterns;		
	c	historic and current irrigated acreages; and		
	d	other agricultural uses (e.g., greenhouses).		
D		Describe the current impacts of drought on agricultural operations in the local and regional study area including:		SIR#1 Questions 32 and 40
	a	revenue losses (e.g., productivity loss and forced timing of sale of products);		
	b	drought-related costs (e.g., emergency water supply, and trucking of livestock and feed);		
	c	impacts to operations (e.g., forced herd reduction);		
	d	costs related to drought recovery; and		
	e	long term community impacts.		

Numbering		Terms	Location in EIA	Location in SIR#1
E		Describe the process used to establish rates ($/unit water) for supplying water to irrigated crop producers, and include:	Volume 3	
	a	current water rates (2020-2022); and		
	b	forecast water rates following the Project.		
F		Describe the socio-economic impacts of the current wetlands within the Project area.	Volume 3	
7.2		**Impact Assessment**		
A		Describe the socio-economic impacts of construction and operation of the Project on:	Volume 3	SIR#1 Question 65
	a	land owners;		
	b	agricultural productivity;		
	c	local and regional infrastructure and community services;		
	d	availability and quality of health care services;		
	e	local training, employment and business opportunities;		
	f	housing;		
	g	recreational activities; and		
	h	First Nations and Métis (e.g., traditional land use and social and cultural implications).		
B		Provide a discussion as to which communities will benefit from the Project.		
C		Discuss opportunities to work with Indigenous communities and groups, other local residents, and businesses regarding employment, training needs and other economic development opportunities arising from the Project.		SIR#1 Question 64
D		Provide the estimated total project cost, including a breakdown for engineering and project management, equipment and materials, and labour for both construction and operation stages, including maintenance of the Project. Indicate the percentage of expenditures expected to occur in the region, Alberta, Canada, outside of Alberta, and outside of Canada.		
E		Provide an estimate of the costs and benefits of providing livestock watering facilities supported from the Project as it relates to improved range management and livestock production.		
F		Provide an estimate of the Project's impact on current irrigators (e.g., increased output, more stable output, increased demand, water rates) and impact on average annual farm income.		
G		Provide details on the total number of existing and new irrigable acres to be serviced by the Project, including the costs and benefits of expanding irrigable acres.		SIR#1 Questions 5 and 27
H		Discuss considerations made by irrigation districts when evaluating requests to add new irrigated parcels.		SIR#1 Question 5
I		Provide an estimate of the nature and cost of the development of recreational infrastructure.		
J		Provide a benefit/cost analysis of the Project, including costs of construction, operation, and maintenance, increase value of agricultural production, indirect and induced benefits (livestock production, food processing etc.), recreational activities and sport fisheries. Present a sensitivity analysis of assumptions used to generate these values.		SIR#1 Questions 25, 27, 28, 35, 36, 37, 38, 39, 60, 61, 62, and 63
K		Identify non-quantifiable benefits and costs expected during the life of the Project. Discuss how these might affect the overall project benefit/cost analysis.		SIR#1 Question 59
L		Provide an estimate of the wetland losses and gains related to the Project and the economic costs and benefits considering Alberta's current wetland policy.		

SECTION 8 – MITIGATION MEASURES

Numbering	Terms	Location in EIA	Location in SIR#1
A	Discuss mitigation measures planned to avoid, minimize, or eliminate the potential impacts for all stages of the Project.	Volume 2 Volume 2: Appendix I Volume 2, Appendix 14: HHRA	SIR#1 Questions 8, 11, 21, 54, 56, 65, 71, 88, 106, 108, 113, 115, 116, 119, 135, 136, 141, 150, 151, 152, 164, 184, 185, 186, 190, 193, 198, 210, and 218 SIR#1, Appendix 2.1 SIR#1, Appendix 71.1 SIR#1, Appendix 164.1
B	Identify the mitigation objectives for each associated impact and describe those mitigation measures that will be implemented. Provide rationale for their selection, including a discussion on the effectiveness of the proposed mitigation.		

SECTION 9 – RESIDUAL IMPACTS

Numbering	Terms	Location in EIA	Location in SIR#1
A	Describe and characterize the residual impacts of the Project following implementation of SMRID's mitigation measures and SMRID's plans to manage those residual impacts.	Volume 2 Volume 2: Appendix I	SIR#1 Questions 3, 8, 52, 65, 68, 87, 135, 162, 170, 172, 173, 175, 177, 178, 186, 188, 208, and 213

SECTION 10 – ACCIDENTS AND MALFUNCTIONS

Numbering	Terms	Location in EIA	Location in SIR#1
A	Describe the potential challenges that could impact the safety of the proposed structures and proposed mitigation measures (e.g., during excavations, during reservoir filling, debris management, operations, maintenance and surveillance philosophy, performance under extreme weather events [floods, tornados, etc.], emergency preparedness and response, etc.).	Volume 2: Section 4	

SECTION 11 – MONITORING

Numbering		Terms	Location in EIA	Location in SIR#1
A		Describe the surface water quality monitoring program that will be implemented to assess the future impacts of construction and operation (including maintenance) of the expanded reservoir and decommissioning of the existing East Dam. Consider appropriate water quality parameters (e.g., metals, nutrients, pesticides, temperature, BOD/TOC, bacteria, aquatic and benthic invertebrates, aquatic plants, algae, dissolved oxygen, etc.) and their spatial (e.g., lateral and depth) and temporal (e.g., seasonal) flow variations.	Volume 2 Volume 2: Appendix I	SIR#1 Questions 8, 164, 167, 168, 171, 184, 187, 190, 193, 213, 214, 217, and 222 SIR#1, Appendix 164.1
B		Describe SMRID's current and proposed monitoring programs, including:	Volume 2 Volume 2: Appendix I	SIR#1 Questions 8, 56, 105, 106, 115, 118, 119 152, 178, 184, 186, and 187
	a	how the monitoring programs will assess any project impacts and measure the effectiveness of mitigation plans. Discuss how SMRID will address any project impacts identified through the monitoring program;		
	b	how SMRID will contribute to current and proposed regional monitoring programs;		

Numbering		Terms	Location in EIA	Location in SIR#1
	c	monitoring performed in conjunction with other stakeholders, including Indigenous communities and groups;		
	d	new monitoring initiatives that may be required as a result of the Project;		
	e	regional monitoring that will be undertaken to assist in managing environmental effects and improve environmental protection strategies;		
	f	how monitoring data will be disseminated to the public, Indigenous communities, or other interested parties; and		
	g	how the results of monitoring programs and publicly available monitoring information will be integrated with SMRID's environmental management system.		

APPENDIX 6.2

2018 Chin Reservoir Dam Safety Review – Chin 1 Dam (West) and Chin 2 Dam (East) (Matrix 2019)

2018 CHIN RESERVOIR DAM SAFETY REVIEW
CHIN 1 DAM (WEST) AND CHIN 2 DAM (EAST)
CHIN RESERVOIR

Report Prepared for:
ST. MARY RIVER IRRIGATION DISTRICT

Prepared by:
MATRIX SOLUTIONS INC.
WITH TETRA TECH INC.

Version 1.0
February 2019
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2018 CHIN DAM SAFETY REVIEW

CHIN NO. 1 (WEST) AND CHIN NO. 2 (EAST)

CHIN RESERVOIR

Report prepared for St. Mary River Irrigation District, February 2019

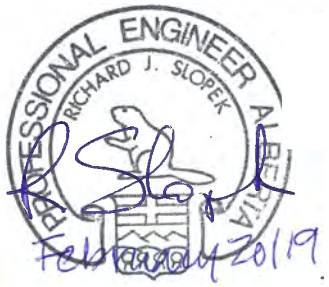
Geotechnical Review



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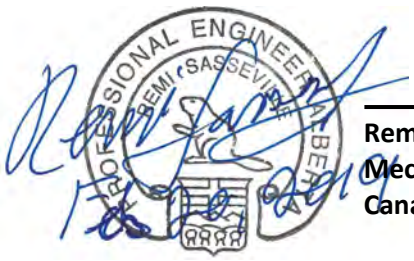
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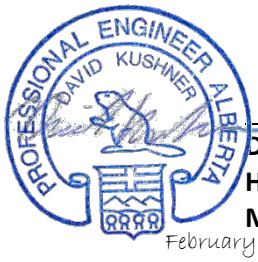
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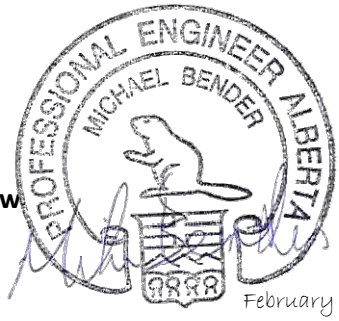
Dam Safety Management System Review



David Kushner, P.Eng.
Hydrotechnical Engineer
Matrix Solutions Inc.

February 20, 2019

Hydrotechnical Review
Overall Dam Safety Review



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APEGA Permit to Practice
Permit No. P5540

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DISCLAIMER

Matrix Solutions Inc. certifies that this report is accurate and complete and accords with the information available during the project. Information obtained during the project or provided by third parties is believed to be accurate but is not guaranteed. Matrix Solutions Inc. has exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this report.

This report was prepared for St. Mary River Irrigation District. The report may not be relied upon by any other person or entity without the written consent of Matrix Solutions Inc. and of St. Mary River Irrigation District. Any uses of this report by a third party, or any reliance on decisions made based on it, are the responsibility of that party. Matrix Solutions Inc. is not responsible for damages or injuries incurred by any third party, as a result of decisions made or actions taken based on this report.

VERSION CONTROL

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V0.1	25-Jan-2019	Draft	23637-553 Chin DSR 2019-01-25 Draft v0.1.docx	Issued to client for review
V1.0	19-Feb-2019	Final	23637-553 Chin DSR Final 2019-02-19 final V1.0.docx	Issued to client

EXECUTIVE SUMMARY

The following report documents a Dam Safety Review (DSR) of the St. Mary River Irrigation District (SMRID) Chin facility, by Matrix Solutions Inc. (Matrix) and Tetra Tech (including Canadian Projects, a Tetra Tech company). The DSR included both the Chin 1 dam (west) and Chin 2 dam (east), situated at either end of the Chin Coulee where irrigation water is stored along the SMRID main canal. The assessments included: hydrotechnical, geotechnical, structural, and electrical & mechanical aspects of the facility. The dam safety management systems were also reviewed.

The dams are earth embankment structures that were originally constructed in 1952 by the Prairie Farm Rehabilitation Administration (PFRA). The catchment area for the dams is a relatively small 247 km^2 along the south shoreline, plus the SMRID main canal which normally discharges to the reservoir via the 11 MW Chin Hydro facility. Chin 1 dam has a gated low-level outlet structure with five conduits to Stafford Reservoir. There are no spillways. The conduit structures initially settled after construction, and have been the focus of numerous repairs over the years. A major refurbishment of the conduits was undertaken in 1982. Other changes have included electrical upgrades for remote operation of the gates, and minor repairs to the riprap erosion protection at Chin 2 dam.

Previous DSRs were completed in 1986, 1995 (Chin 1 dam only), 2002/2003, and 2013. This latest DSR is intended to satisfy the dam safety requirements of completing a DSR every 5 years due to a high consequence of dam failure. Both dams of the Chin facility have a Very High dam safety consequence classification resulting from potential loss of life downstream of Chin 1 dam, and from potential loss of pre-contact cultural resources downstream of Chin 2 dam where compensation is not practical. A re-classification of the Chin 2 dam to a lower consequence rating may be possible if SMRID can achieve clarity on the condition and value of the downstream cultural resources. However, this re-classification would likely not impact SMRID's operation of the facility because the Chin 1 dam would still have a Very High consequence classification.

This DSR identified the following two dam safety deficiencies, both of which should be considered non-critical (i.e., not imminent threats to dam failure):

1. The Chin facility cannot accommodate the inflow design flood (IDF). The IDF has a peak flow of 495 m^3/s and a total inflow volume of 52,240 dam^3 (52.24 million m^3), which is larger than the 37,945 dam^3 flood storage between the full supply level (861.36 m) and the minimum crest elevation of the Chin 1 dam (863.56 m). The outlet conduits provide some capacity to release water during a flood, but the capacity is similar to the expected canal inflow along the SMRID main canal. Therefore, the IDF will need to be temporarily stored in the reservoir.

2. The Chin dams may also be susceptible to seismic loadings, based on the updated Fifth Generation Seismic Hazard Model for Canada, implemented in 2015. A more detailed assessment is needed to understand the likely performance of the dams under seismic loading.

There are other non-conformances (i.e., non-compliance issues) for the dams related to the required documentation: the Emergency Preparedness Plan (EPP) has not been updated since 2001; an Emergency Response Plan (ERP) has not been developed; a Flood Action Plan (FAP) has not been developed; and the Operation, Maintenance and Surveillance (OM&S) manual has not been developed. These are all requirements of the Alberta Dam and Canal Safety Directive.

The DSR also describes a number of recommendations for additional repairs plus best management practices to be implemented, in addition to the above deficiencies and non-conformances. The additional recommendations should be considered by SMRID but are not required. The highest priority recommendations are:

1. Repair the gates, thimbles, and the broken stem bracket for Gate 2.

2. Install road barriers along Range Road 182 near the control building to prevent vehicles from crashing into the gate controls and other instrumentation.

3. Minor electrical system repairs, including covers for control panel openings, tagging the cables for future troubleshooting, and removing/capping unused wiring.

This summary highlights the key findings of the DSR. The DSR is intended to be representative of conditions at the Chin facilities at the time of the inspection, which occurred on November 13 and November 14 in 2018; at which time the project team inspected the embankment structures, the electrical controls, the five gates and outlet conduits, and nearby areas. The project team was unable to inspect the underwater inlet to the gated conduits. The DSR also relied on available information provided by SMRID such as the previous DSRs, the original design drawings, the original gate rating curves, a partial test of the gate operations, piezometer instrumentation data, and available information from surveys that were arranged by SMRID.

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1 INTRODUCTION

1.1 Scope of Work

The St. Mary River Irrigation District (SMRID) retained Matrix Solutions Inc. (Matrix) to complete a dam safety review (DSR) for the Chin Reservoir. The work was performed in general accordance with the work plan issued to SMRID on October 4, 2018, per the standards outlined in the Canadian Dam Safety Association's (CDA) Dam Safety Guidelines (CDA 2013) and as per the Alberta Dam and Canal Safety Directive (the Directive; GoA 2018).

The DSR scope of work included both of the Chin Reservoir containment structures (Chin 1 and Chin 2), with the following specific activities:

- review of available information, including previous dam safety documents, the Emergency Preparedness Plan (EPP) and the Operation, Maintenance and Surveillance (OM&S) Manual
- inspection of the dams and conduits
- completion of a site inspection report
- assessment of the hydrotechnical, geotechnical, electrical & mechanical aspects of the dams, and the structural elements such as the Outlet Structure
- assessment of the potential failure modes
- identification of dam safety deficiencies and non-conformities
- additional recommendations

This DSR report is based on a site inspection, the available information listed in Appendix A, on selected assessments for hydrotechnical, geotechnical, structural, and electrical & mechanical systems, an assessment of the dam safety management systems, and on credible potential failure modes for the dam. This report also provides an updated master deficiency list and master non-conformity list.

1.2 Project Description and Key Parameters

The Chin Reservoir is located about 45 km east of Lethbridge, Alberta (Appendix B Figure 1). The reservoir consists of two earth fill dams, Chin 1 dam on the western reservoir boundary and Chin 2 dam on the eastern boundary. Both dams are publicly accessible: Chin 1 along Range Road 182; Chin 2 along a private road at the end of Range Road 161.

The reservoir is situated along the SMRID main Canal about 60 km downstream of Raymond Reservoir and immediately upstream of Stafford Reservoir. The main function of the Chin Reservoir is to provide irrigation water for the SMRID Main Canal. The Main Canal is controlled by SMRID, and it flows into the Chin Reservoir near the Chin 1 dam.

An Outlet Structure at Chin 1 releases water to the Stafford Reservoir where it is then directed to the downstream Main Canal flowing east toward other irrigation water supply facilities. The Outlet Structure has five gated conduits. The gate house is fenced with controlled access. Neither dam has an emergency spillway.

Two other small conveyance structures are situated near the dams:

- A drainage culvert near the Chin 1 left abutment (south) for local drainage from a coulee into the reservoir, with a ditch plug preventing outflow to the downstream side of the dam.
- A source water intake for the Skiff Water Co-op Ltd. consisting of two buried intakes and a buried pipe to a pump house downstream of Chin 2, with the pipe buried outside of the dam embankment.

Instrumentation for monitoring seepage and settlement exists at the Chin 1 dam, but has not been maintained. There is no instrumentation at the Chin 2 dam.

A summary of the key parameters pertaining to the Chin Reservoir and structures is provided in Table A though Table C. Recent surveys of the dam crests and the conduits are included in Appendix C. Selected record drawings (as-constructed drawings) from the original construction in 1952 and the 1982 major upgrades are included in Appendix D.

TABLE A Summary of Chin Reservoir Parameters

Parameter		Source	Comments / Assumptions
Drainage area (total or gross)	247 km^2	Matrix 2017	Measured using LiDAR15
Drainage area (effective)	204.3 km^2	Matrix 2017	Measured using LiDAR15, including 16.3 km^2 for the reservoir surface area.
Dam Safety Consequence Classification	Very High	Matrix 2017	Based on Chin 1 dam.
Inflow Design Flood (IDF) volume	52,240 dam^3	Matrix 2017	IDF = 2/3 between 1,000 year flood and PMF, based on previous PMF estimate, local hydrology and climate data for 1,000 year flood hydrograph.
IDF peak flow	495 m^3/s	Matrix 2017	IDF = 2/3 between 1,000 year flood and PMF.
Probable Maximum Flood (PMF) peak flow	669 m^3/s	Matrix 2017	
Full Supply Level (FSL) in summer	861.36 m asl	AECOM 2013	Original full supply level = 862.27 m asl
Winter FSL	860.61 m asl	AECOM 2013	Original full supply level = 862.27 m asl
Reservoir area at summer FSL	1,570 ha	ASRD 2002	
Reservoir volume at summer FSL	217,679 dam^3	ASRD 2002	Based on bathymetry completed in 2002, included in Appendix E.
Flood storage above summer FSL	37,945 dam^3	Matrix 2017	As measured from FSL to the minimum dam crest elevation along the Chin 1 dam.
Maximum reservoir length	24.7 km	ASRD 2002	
Maximum width	0.87 km	ASRD 2002	
Canal inlet capacity for the design capacity / bankfull conditions[1]	65/126 m^3/s	AECOM 2013	Design capacity/bankfull capacity of the SMRID canal. A concrete chute outlet structure also discharges from the canal to the Chin Reservoir and is located at the south side of the reservoir approximately 800 m upstream of Chin 1 Dam (West).

1. Main canal inflow is normally discharged to the Chin Reservoir via the 11 MW Chin Hydro Facility

TABLE B Summary of Chin 1 Dam (West) Parameters

Parameter		Source	Comments / Assumptions
Dam Safety Consequence Classification	Very High	Matrix 2017	Loss of life expected to be more than 10 people.
Dam structure	Zoned Earth Fill	Klohn 2002	
Top of dam as designed	864.24 m asl	Klohn 2002	Above sea level (asl)
Top of dam minimum elevation	863.56 m asl	2015 Survey provided by SMRID	Appendix C Figure 3.
Crest width	12.2 m	PFRA 1955	Drawing included in Appendix D.
Crest length	400 m	Klohn 2002	
Toe of dam invert elevation	842.94 m asl	LiDAR 15 provided by SMRID	Minimum outside toe-of-dam elevation
Maximum Height	21.3 m	Klohn 2002	
Upstream slope: - Slope above bench - Slope below bench - Top width of bench - Top of bench elevation	 2.75H:1V 5H:1V 9.1 m 855.0 m asl	PFRA 1955	Drawing in Appendix D.
Downstream slope: - Slope above bench - Slope below bench - Top width of bench - Top of bench elevation	 2H:1V to 2.5H:1V 4H:1V 7.9 m 855.0 m asl	PFRA 1955	Drawing in Appendix D.
Emergency spillway	None		
Outlet Structure capacity to Stafford Reservoir	74 m^3/s	AECOM 2013	Capacity assumes SMRID will not fully open the outlet gates. Actual capacity with gates fully open is 110 m^3/s.
Stafford Reservoir FSL downstream of the Chin Outlet Structure	846.58 m asl	AECOM 2013	Summer operating level.
Outlet Structure gates	5 slide gates	AECOM 2013	Rotork IQ actuators
Conduit dimensions - Conduits 1 and 5 (HxW) - Conduits 2, 3 and 4 (HxW)	 1.22 x 1.56 m 1.22 x 1.93 m	PFRA 1955	
Conduit settlement	1.0 m	2018 Survey provided by SMRID	Maximum settlement from 1952 to 2018, located 9 m downstream of the gates.
Dam access	Public		Range Road 182.
Gatehouse security	Fence, padlock		

TABLE C Summary of Chin 2 Dam (East) Parameters

Parameter		Source	Comments / Assumptions
Dam Safety Consequence Classification	Very High	Matrix 2018	Assuming loss of known and unknown downstream cultural heritage sites.
Dam structure	Homogenous earth fill	AECOM 2013	
Top of dam as designed	865.0 m asl	WPL 2003	
Top of dam minimum elevation	864.16 m asl	2017 Survey provided by SMRID	Appendix C Figure 4.
Crest width	9.1 m	2017 Survey provided by SMRID	
Crest length	564 m	WPL 2003	
Toe of dam invert elevation	851.9 m asl	2017 Survey	Minimum outside toe-of-dam elevation
Maximum height	12.3 m	2017 Survey	By Ventus Geospatial on July 31, 2017
Upstream slope: - Slope above bench - Slope below bench - Top width of bench - Top of bench elevation	 3H:1V 5H:1V 9.1 m 857.1 m asl	PFRA 1955	Drawing in Appendix D.
Downstream slope: - Slope above bench - Slope below bench - Top width of bench - Top of bench elevation	 2H:1V 4H:1V 4.1 m 857.1 m asl	PFRA 1955	Drawing in Appendix D.
Emergency spillway	None		
Outlet	None		
Other	Water intake		Source water intake on north bank; buried pipe through native fill (not through the dam embankment) to a pump house downstream of the dam.
Dam access	Semi-Private		Private road with uncontrolled gate

1.3 History of the Dams

The Chin Reservoir was constructed in 1955 by the Prairie Farm Rehabilitation Administration (PFRA) to provide additional storage capacity for cropland irrigation water in southeastern Alberta. Both Chin 1 dam (west) and Chin 2 dam (east) are earth embankment dams, with Chin 1 as a zoned earth fill structure, and Chin 2 as a homogeneous earth fill structure. The Chin Reservoir and both dams are now owned, operated, and maintained by the SMRID.

A summary of previous studies and maintenance follows. A timeline of the dam history is shown on the attached Figures 2A and 2B (Appendix B). Further details of the history and maintenance of specific elements are discussed in the appropriate sections later in this report.

The classification and flood handling capacity for the reservoir has changed over time. The first recorded dam consequence classification occurred in 1986, along with the inflow design flood (IDF) set to the Probable Maximum Flood (PMF). The classification and IDF have changed over time as follows:

- 1986: Dam hazard potential classification = Significant/High; IDF = PMF = 583 m^3/s peak flow, 102,000 dam^3 volume (PFRA 1986)
- 2000: Dam consequence classification = Very high; IDF = PMF (Klohn 2000)
- 2012: Dam consequence classification = Extreme; IDF = PMF = 722 m^3/s peak flow, 79,000 dam^3 (AECOM 2012)
- 2017: Dam consequence classification = Very high; IDF = 2/3 PMF = 669 m^3/s peak flow, 52,240 dam^3 (Matrix 2017)

The original full supply level (FSL) of the reservoir was 862.27 m. PFRA lowered the FSL of the reservoir to the current FSL of 861.36 m following the 1986 DSR that concluded that the reservoir cannot accommodate the IDF. The most recent studies also conclude that the reservoir cannot accommodate the current IDF (Matrix 2017, 2018).

Shortly after construction of the dams, the Outlet Structure settled by about 1 m, resulting in vertical cracking in the conduits. A large crack about 50 mm wide developed in all five (5) conduits at a location approximately 9 m downstream of the gates, with smaller cracks developing at other locations within the conduits.

Major rehabilitation of the Outlet Structure and upgrades to the operating system occurred in 1982. Cracks within the conduits were pressure grouted, galvanized plates were installed over the large cracks (9 m downstream of the gates) and the downstream outlet structure (which had settled and pulled away from the conduits) was replaced with a new stilling basin. A control building and concrete deck was constructed, electric gate actuators were installed (previously manual) and a semi-automatic control system was installed. These works resulted in the operating capacity of the Outlet Structure upgraded from 51 m^3/s to 74 m^3/s, assuming that the operating capacity would be limited to a partial opening of the gates.

Major reconditioning of the five Outlet Structure gates occurred in 1993. This work included welding on cover plates where the thimbles were eroding, repair of the gate 1 stem block and replacement of gates 1, 2 and 4 with Armco 55-10 heavy duty cast iron gates. Gates 2 and 5 were reconditioned and re-installed in conduits 3 and 5, respectively (AECOM 2013).

Since 2013, there have been several relatively minor repairs and maintenance including gate reconditioning (welding of pitting), various repairs to the cracks in the conduits, repairs to the gate actuators, and repairs to the irrigation inlet to the reservoir (the Chin Chute).

Other maintenance has included road grading and riprap repairs on Chin 2 dam in 2012 (approximate date).

1.4 Previous Dam Safety Review Findings

Previous DSRs for the Chin Reservoir consist of the following:

- 1986 by PFRA
- 1995 by Klohn-Crippen for Chin 1 dam only
- 2002 by Klohn-Crippen for Chin 1 dam only
- 2003 by Williams Projects Engineering for Chin 2 dam only
- 2013 by AECOM

A summary of the DSRs and recommendations are shown on Figures 2A and 2B (Appendix B). Recommendations from the 2013 DSR are summarized below:

- The existing facilities are inadequate to accommodate the IDF. A means to safely handle the IDF should be provided (PFRA 1986, Klohn 1995, Klohn 2002, AECOM 2013).

- Perform a detailed dam hazard assessment and hydrology review (i.e., update the IDF) (PFRA 1986, Klohn 1995, Klohn 2002).

- Perform a Chin 2 dam break inundation study and update the dam consequence classification (AECOM 2013).

- Prepare an OM&S manual (PFRA 1986, Klohn 1995, Klohn 2002, AECOM 2013).

- Place additional riprap on the upstream slope of Chin 1 where the riprap is thin (Klohn 1995).

- Re-activate the standpipe piezometers that were observed to be plugged, and resume collection of data (Klohn 1995, Klohn 2002).

- Replace all five (5) gates at the next available opportunity (AECOM 2013).

- Stabilize the erosion gully downstream of the Chin 2 dam (WPL 2003).
- Continue the conduit inspection program (AECOM 2013).
- Repair the cover plates in the conduits (9 m downstream of the gates) (AECOM 2013).
- Repair the erosion on the downstream left abutment of Chin 1 and install a cattle fence (AECOM 2013).

1.5 Studies Undertaken Since the Previous Dam Safety Review

Since 2013, the dam consequence classification and the IDF for the Chin 1 dam have been updated (Matrix 2017). A dam break inundation study has also been completed for the Chin 2 dam (Matrix 2018). As a result of these studies, the dam consequence classification was downgraded from Extreme to Very High because the dam break scenario expected loss of life (LOL) of 15 people downstream of Chin 1 is less than the guideline for an Extreme classification. The subsequent dam break study downstream of Chin 2 similarly allowed for a dam consequence classification of Very High, but it was due to the potential unrecoverable loss of downstream archeological sites that have not yet been investigated.

These same studies also evaluated potential options to handle the updated IDF. SMRID has not yet implemented a strategy to handle the IDF.

2 SITE INSPECTION

The site inspection for this DSR was completed on November 13 and 14, 2018. The dams were inspected on November 13, and the conduits were inspected on November 14. A conduit inspection report was provided to SMRID on November 16, 2018 and a full site inspection report was provided on November 28, 2018. The inspection reports and photographs are included in Appendix F.

3 DAM SAFETY REVIEW

This DSR provides an assessment of the following hazards in the next sections:

- hydrotechnical assessment for both Chin 1 and Chin 2 dams
- geotechnical assessment for both Chin 1 and Chin 2 dams
- structural assessment for the Chin 1 dam Outlet Structure conduit and gates
- electrical and mechanical assessments for the Chin 1 dam gate control systems

3.1 Hydrotechnical Assessment

3.1.1 Dam Consequence Classification

The most recent studies assigned a dam safety consequence classification of Very High to both of the Chin Reservoir structures, based on the 2013 CDA Guidelines (Matrix 2017 and 2018). The 2013 CDA Guidelines and the Alberta Dam and Canal Safety Directive requirements for dam consequence classification are similar and both result in a consequence classification of Very High.

The consequence classification of Very High for Chin 1 is based on an interpretation of a dam break assessment (Klohn 2002), with an estimated incremental LOL of 15 people. The Very High category corresponds to LOL between 10 and 100 people. Other consequence categories (i.e., infrastructure, economic, environmental and cultural losses) were assigned a lower classification.

The Very High consequence classification was assessed as part of this DSR by verifying the number of residences immediately downstream of Chin 1 where a residential development continues to grow. The development has a single road access from the dam, limiting the potential egress opportunities during an emergency.

The previous consequence classification assumed 30 residences immediately downstream of Chin 1 (Matrix 2017). During the DSR site inspection, 19 permanent homes and 21 portable recreation homes were observed – for a total of 41 residences. This small difference results in a slight increase to the estimated LOL from 15 to 16 people, but it does not result in reclassification of the dam safety category because the LOL is less than 100 people. Therefore, a classification of Very High is appropriate for the Chin 1 dam.

The Chin 2 dam was originally classified as “Low” during the 2003 DSR (WPL 2003), and then as “High” during the 2013 DSR (AECOM 2013). More recently, a classification of “Very High” was recommended for Chin 2 based on a dam break inundation study (Matrix 2018). The study estimated that a breach of Chin 2 would result in the potential loss or disturbance of high value pre-contact cultural resources where compensation is not practical. Other consequence categories (i.e., economic, environmental, and incremental loss of life) were assigned a lower classification.

The Chin 2 dam consequence classification of Very High allows for a consistent IDF for the reservoir compared to the Chin 1 dam safety classification. However, the Chin 2 classification uses conservative assumptions for the value of pre-contact cultural resources, and conservatively assumes that all of the cultural resources would be eroded and lost during a dam break failure. Further consultation with local First Nations may result in a lesser classification. This future reclassification would not affect the overall consequence classification of the reservoir facility for the purposes of an IDF.

Overall, it is reasonable to operate the Chin Reservoir facility as a Very High consequence dam based on the potential loss of life downstream of Chin 1, which is also the lower of the two dams by 0.4 m.

3.1.2 Inflow Design Flood

The IDF has evolved over the life of the Chin Reservoir facility. The most recent IDF was developed from the current dam consequence classification of Very High (Matrix 2017). The IDF is therefore defined as 2/3 between the 1:1,000 year return period flood and the PMF. The IDF has a peak flow of 495 m^3/s for a summer storm and a volume of 52,240 dam^3.

The IDF volume should be considered as the governing factor for handling a large flood because there is no emergency spillway.

The basis for the IDF is:

- PMF peak inflow of 669 m^3/s adjusted from the previous DSR (AECOM 2013) by accounting for a slightly smaller drainage area as measured from LiDAR topography.

- 1:1,000 year return period flood peak of 149 m^3/s extrapolated from 40 years of record at the nearby Prairie Blood Coulee Environment Canada gauging station (05AD035), which is located about 50 km west of the Chin watershed and has a similar watershed topography (prairie) and size (about 200 km^2).

- An assumed hydrograph shape from the June 2010 flood at the nearby Prairie Blood Coulee, the largest recorded flood.

- Precipitation directly on the reservoir of 358 mm, an estimate of rainfall accumulation 2/3 between the 1:1,000 year 2-day rainfall and the Probable Maximum Precipitation (PMP). The 1:1,000 year rainfall was estimated from the Lethbridge climate station using about 100 years of data. The summer PMP was based on the Hershfield statistical method (AECOM 2012).

- The IDF does not include canal inflow, which must be accounted separately.

The IDF was assessed in terms of the reasonability tests presented in the previous study (Matrix 2017), which used the modified Creager Diagram plus a multiplication factor between 4 and 7 for the 1:100 year flood (AT 2004) to verify that the PMF (i.e., the primary governing factor for the IDF) is within a reasonable range. In both cases, the PMF peak flow was within 10% of the expected/typical PMF for regional rivers.

The IDF assumed that the PMF would be due to a summer storm because the summer PMF was estimated to have a larger volume and peak flow compared to a spring snowmelt PMF (AECOM 2013). The spring snowmelt PMF would also allow more time to release the volume through the Outlet Structure because the runoff would occur over a longer period of time.

Overall, the most recent IDF update to 52,240 dam^3 is a reasonable basis to proceed for dam safety purposes.

3.1.3 Freeboard

The freeboard requirements for the IDF were updated in 2017 (Matrix 2017), including wind speeds in Lethbridge, wave setup, and wave runup for the required 1:2 year wind event. The reported freeboard requirements are:

- 0.57 m for Chin 1 dam
- 1.20 m for Chin 2 dam, higher due to prevailing winds

The freeboard estimates are based on standard calculation methods and the recommended freeboard is reasonable.

3.1.4 Erosion Protection

The slope protection along the upstream slope for both dams has been in place since the dams were constructed, and have only required minor repairs to date. The existing condition of the slope protection riprap was observed as:

- Chin 1 dam:
    - Upstream slope (water side) - the riprap is generally a non-uniform mixture of rock and concrete debris, including oversized boulders and undersized rock with a few bare patches where individual boulders may have been plucked out by ice.
    - Downstream slope (land side) – there is a well-developed grass cover providing good erosion protection.
- Chin 2 dam:
    - Upstream slope – the riprap is generally in good condition, but with a relatively wide range of particle sizes; “dished” sections have been repaired where the face of the dam is no longer uniform near the middle of the dam face (circa 2012).
    - Downstream slope - there is a well-developed grass cover providing good erosion protection.

Other signs of erosion consist of minor gullying due to road drainage and disturbances initiated by cattle. There is also an old gully noted by previous DSRs about 50 m downstream of the Chin 2 dam (near the right abutment), but the gully appears to be a relic of local drainage and cattle grazing.

The previously observed and repaired “dished” sections of riprap along the upstream face of Chin 2 were likely due to the flushing of underlying fines between the voids in the larger rock. This suggests that there may not be sufficient gravel bedding (or geotextile) between the large rock riprap and the

general dam fill. However, the “dishing” in the past appears to be minor and can likely be resolved with regular maintenance.

Overall, there are no major issues related to erosion protection along the upstream face of each dam. The minor gullying along the dam crest is likely due to poor road grading, and the “dishing” at Chin 2 is likely due to poor initial placement of gravel bedding when the dam was constructed. Neither of these issues currently threaten the dam.

3.1.5 Gate Rating Curves

SMRID operates on the assumption that the gates are sufficient to safely release 74 m^3/s during an emergency (without fully opening the gates). Rating curves for the gates describe the expected release rate for each of the five conduits depending on the gate opening, and depending on downstream tailwater. The rating curves are copies from an old report, but they cannot be properly referenced. The rating curves are included in Appendix E.

The rating curves suggest that SMRID can release up to 110 $^3/s$ (about 4,000 cfs) during an emergency, assuming backwater from Stafford Reservoir at FSL. The accuracy of the rating curves was not verified in the field but is consistent with a simplified calculation of flow through on orifice.

3.1.6 Flood Handling

The flood handling capacity of the Chin Reservoir facility was evaluated most recently in 2017 (Matrix 2017). The assessment concluded that Chin 1 would overtop during an IDF event, and that the operating capacity of the Outlet Structure was not sufficient to release the surplus water. The Chin 1 dam is about 0.6 m lower than Chin 2 as measured from the minimum dam crest elevation.

The 2017 assessment included a flood routing analysis that assumed a summer starting elevation at FSL, the IDF hydrograph described earlier, and canal inflow. The canal was assumed to be flowing at the 65 m^3/s design capacity at the beginning of the IDF event, then flowing at the bankfull capacity of 126 m^3/s after 36 hours. It was further assumed that the canal inflow would return to the design capacity 3.5 days after the start of the IDF event (i.e., after the precipitation has ended and the peak inflow is nearly past). In other words, it assumed that the canal does not breach.

It is reasonable to conclude that Chin 1 would overtop during an IDF (and potentially Chin 2 as well), because the Outlet Structure operating capacity of 74 m^3/s is similar to the inflow design capacity of the canal. Therefore, most of the IDF volume would need to be stored in the reservoir to avoid overtopping. The IDF volume is about 52,000 dam^3, and the available flood storage below the top of the dam is only about 38,000 dam^3 (i.e., 38 million m^3).

In summary, the Chin Reservoir facility cannot handle the IDF.

3.2 Geotechnical Assessment

The CDA Guidelines identify the following general geotechnical hazards for consideration:

- deformation
- hydraulic fracturing
- seepage
- piping
- internal erosion
- slope instability
- static and dynamic liquefaction

Other geotechnical hazards might also be identified for a specific structure.

3.2.1 Geotechnical Background

The Chin Reservoir and its dams are located in a large, glacial meltwater channel eroded through glacial till and sedimentary bedrock of the Foremost Formation. The dams were constructed over large thicknesses of alluvial deposits present on the coulee bottom. Some clay till was encountered at the abutments of both dams. A drilling investigation at the discharge basin of the Outlet Structure in Chin 1 encountered extensive deposits of till-textured materials interpreted to be colluvium from slumping of the till deposits on the adjacent right abutment of the dam.

The alluvial deposits at the coulee bottom were typically identified as soft, medium plastic, silty clay with a variable content of fine sand and a trace of medium grained sand. The embankment fill for both dams was derived predominantly from borrow pits excavated in the alluvial clay on the coulee bottom adjacent to the dam sites. Atterberg Limits from construction and subsequent investigations indicate that the alluvial clay ranged from low plastic to high plastic. Pockets of sand or silty sand, likely associated with channel deposits, were encountered in the alluvial deposits. The alluvium deposits were found to be up to about 38 m thick at Chin 1 and were not penetrated at up to 23 m depth across much of the coulee bottom beneath Chin 2.

Foundation settlements approaching 2 m have been observed at Chin 1. Settlements at Chin 2 have been less carefully observed but appear to have exceeded about 1 m. Construction of the dams was staged over four years at Chin 1 and over two years at Chin 2 to allow time for settlement to proceed and excess foundation pore pressures to dissipate during construction. Although much of the settlement occurred during and over a few years after construction, the settlement of both dams is likely continuing at a slow rate due to secondary consolidation of the foundation alluvium.

The settlement of the dams is understood to have exceeded that anticipated during design. The crest elevations at both dams are understood to be lower than their design levels of Elevation 864.2 m and 865.0 m for Chin 1 and Chin 2, respectively. Current crest low point elevations are understood to be at

approximately Elevations 863.6 m and 864.2 m for Chin 1 and Chin 2, respectively. The operation level of the Chin Reservoir has been reduced from the design FSL of Elevation 862.3 m to a FSL of 861.36 m. The lower operating level is understood to be provided, in part, to allow the safe routing of the design flood considering the settled levels of the dam crests.

Some fill placement for crest augmentation is known to have been carried out at Chin 2. The fill placement on the Chin 2 crest has been primarily intended to address concerns with traffic support and rut repair on that crest, which has exhibited persistent issues with pooling of surface water and rutting under minor traffic loading. Re-grading of the crest of Chin 2 to drain to the upstream slope has been a recurring recommendation of dam safety reviews and inspections but it is not clear that necessary grade adjustments have been attempted. Gravel surfacing placed on the Chin 2 crest appears to become rapidly "lost" in the embankment's clay fill. It is understood that some pit run gravel fill was placed on the Chin 2 crest in 2014, likely to help support surfacing gravel. Despite this work, little evidence of surfacing gravel was evident on the dam crest at the time of the site inspection for this DSR. It is considered likely that improved drainage of surface water from the dam crest, along with continued use of relatively coarse, well-graded gravel surfacing, would improve the support of traffic on the crest and reduce the need for ongoing addition of gravel surfacing material. The grading of Chin 2's crest should be augmented to ensure reliable drainage of surface water, preferably to the upstream slope of the dam.

Some fill placement for crest augmentation has likely also been carried out at Chin 1. A county road is now present on the Chin 1 crest and necessary grading and gravel placement for traffic support is likely provided on a routine basis. Issues have been noted with ridges left by grading operations on the Chin 1 crest edges. The potential for such ridges to be left is exacerbated by fences, guard rails, cable barriers, and other obstructions installed on or near the crest edges. The ridges trap water on the crest and should be removed or breached every few metres to allow crest drainage without excessive concentration of flows (particularly onto the downstream slope).

Settlement has also impacted the Outlet Structure at Chin 1. The reinforced concrete outlet structure was not built with articulation joints as is commonly done to allow for expected deformations associated with embankment construction. Instead, the Chin Reservoir outlet was constructed as a monolithic structure with a longitudinal joint at mid-height along the five-barrel conduit. The longitudinal joint was intended to reduce the strain in the structure associated with bending imposed by differential settlements. Substantial cracking of the conduit structure occurred soon after construction. The damage appears to have been concentrated near the middle of the dam where extension strains and bending are typically largest.

From a geotechnical perspective the cracking of the conduit is a concern because it will tend to allow seepage out of the conduit upstream of the flow control gates and into the conduit downstream of the gates (Seepage into the conduit upstream of the flow control gates could also occur under high flow conditions). Seepage out of the conduit upstream of the gates will tend to increase pore pressures in the

surrounding embankment. Seepage into the conduit could be accompanied by piping of embankment fill into the conduit, which has been observed in the past and was addressed by pressure grouting around the conduit. Increased seepage gradients in the embankment are likely to be associated with conduit cracks allowing seepage out of the conduit upstream of the gates and/or seepage into the conduit downstream of the gates.

An array of piezometers was installed during construction and extended along both sides of the conduit. The intent of the array was that readings of these piezometers could be interpreted to warn of crack formation at times when visual inspection of the structure would be impractical. It is not obvious that monitoring of these piezometers has been particularly effective in this regard and many of them have become non-functional.

The cracks in the Outlet Structure have been repaired on an ongoing basis over the life of the structure and it is recommended that the repair of the cracks be continued on a high priority basis. Cracks in the conduit as fine as 0.1 mm to 0.2 mm could allow excessive to continuing erosion of embankment fill into the conduit.

Both dams were constructed generally as homogenous embankments with zoning provided only in the installation of drainage measures and upstream erosion protection. The embankment fill, which was derived primarily from alluvial clay borrowed from the coulee bottom, appears to be suitable for use as low permeability fill.

Seepage cut-off trenches were excavated into the foundations of both dams beneath the upstream side of the dam crest and backfilled with embankment fill. The trench depths were up to about 3.7 m and 3 m at Chin 1 and Chin 2, respectively. The trenches were intended to address preferential seepage paths that might be provided by desiccation cracks in the top of the alluvial clay foundation, and would also cut off seepage in shallow channel deposits of sand, if present. Excavation of the cut-off trench through the former stream channel near the left abutment of Chin 1 was found to be challenging (this channel was likely enlarged by excavation to some extent in the past to enhance its flow capacity). The very soft, saturated soil at the channel base was first covered with some embankment fill to provide a working platform and then the cut-off trench excavation was attempted with a dragline. “As-constructed” drawings appear to indicate that the cut-off trench depth in native soil was probably only about 1 m in the stream channel area. Since desiccation cracks would not have been as much of a concern at the channel location as at other locations on the coulee bottom, there might have been less concern with the cut-off depth in this area. Channel deposits, which are relatively likely at shallow depths in the foundation area near the stream channel, would probably not have been effectively blocked by the seepage cut-off trench at that location and could be exacerbating foundation seepage in the former stream channel area.

There has been some speculation that clay in the embankment fill could be dispersive. This might relate to a general observation that the alluvial deposits and embankment fill at the sites appear to be relatively prone to erosion by flowing water. Observations supporting this concern include the following:

- significant erosion of the thalweg of a side coulee adjacent to the right abutment of Chin 2
- formation of some erosion pipes from areas where water pooled on the Chin 2 crest to the downstream slope (presumably, the pipe outlets do not appear to have been definitively located)
- the formation of a large erosion scour around the inlet to the Chin 1 Outlet Structure

The small erosion pipes at Chin 2 appear to have resulted from seepage following preferential seepage paths formed by weathering or by shallow slumps on the relatively steep, 2H:1V grade on the upper portion of the downstream slope. While the formation of these pipes likely resulted in no significant peril for the dam, it underscores the need to prevent the pooling of water on the dam crest. A similar small erosion pipe may have been identified by SMRID in 2015 near the upstream edge of Chin 1, but has not been noted in subsequent inspections. Vigilance should be maintained to identify and repair such piping features.

The large erosion scour around the inlet to the Outlet Structure was first noticed when the reservoir was drawn down during a drought in 1993. It is not apparent that any evidence of piping along the structure was identified, however, the choice of concrete fine aggregate (sand) to backfill the eroded area suggests that this may have been a concern. Much of the sand fill appears to have eroded out of the scour by the time it was re-exposed in 2001. Again in 2001, there were no indications reported that piping along the structure was occurring. In 2001 the scour was repaired with compacted clay fill covered by bedding gravel and riprap. The SMRID attributes the erosion scour under consideration to a whirlpool that forms near the intake when large flows are passed through the Outlet Structure. Low water levels will exacerbate the whirlpool formation. The area around the intake has not been inspected since the repairs were completed in 2001. The area near the intake should be inspected to confirm the adequacy of the repairs completed in 2001.

The issue of potentially dispersive clay fill was reviewed in some detail by D.S. Matheson, P.Eng., in a report dated January 2008 that dealt with installation of replacement piezometers in the West Dam. Matheson concludes that the embankment fill at the West Dam is not dispersive. The embankment fill at the East Dam is similar and is also unlikely to be dispersive. The potential dispersive nature of the foundation soils and embankment fill at the dams has not been further investigated by this DSR.

The alluvium-sourced embankment fill used in the embankments might simply be more prone to erosion compared to fill material sourced from clay till deposits, which are more commonly used for embankment dam construction in Southern Alberta and would provide reference experience. The till material likely includes more coarse sand, gravel, and cobble size materials than the alluvial clays and this granular content likely helps the till-sourced clay fill to resist erosion and to leave a protective lag of granular material where erosion does occur.

Drainage measures were provided in both dams. The Chin 1 drainage measures include:

- A chimney drain at least 0.6 m thick constructed in a stepped configuration immediately downstream of a line projected at 1.5H:1V from the designated embankment centreline and extending from roughly 4 m below the downstream edge of the crest to original grade under the downstream slope of the dam.

- A blanket drain approximately 0.6 m thick extending near original grade from the bottom of the chimney drain to the downstream toe of the dam (the blanket drain also extends beneath fill placed in the former stream channel but probably not beneath the fill initially placed to form a working platform).

- A trench drain about 4 m deep along the downstream toe of the dam with a perforated pipe installed near the trench bottom. It appears that the trench drain discharges to both sides of both the canal downstream of the Outlet Structure and the former stream channel.

- Sand filled boreholes along the downstream toe of the dam.

The drainage fill used in Chin 1 is reported to have been a sand and gravel fill (sand fill was likely used in the boreholes along the dam toe). Review of the drainage fill gradations reported relative to the reported embankment fill gradations indicates that the drainage fill would be filter-compatible with all but the very finest samples of embankment fill that was tested.

The Chin 2 drainage measures include:

- A blanket drain approximately 0.6 m thick extending near original grade from a line projected at 1.5H:1V from the designated embankment centreline to the downstream toe of the dam.

- A trench drain up to about 3.7 m deep along the downstream toe of the dam. It appears that the trench drain discharges to grade along the dam's downstream toe.

- Boreholes filled with drainage fill along the upstream end of the blanket drain.

The Chin 2 drainage fill is reported to have been a sand and gravel fill. Review of the drainage fill gradations reported relative to embankment fill gradations reported indicates that the coarsest drainage fill would be filter-compatible with all but the very finest samples of embankment fill tested and the average gradation of the drainage fill would be filter-compatible with all of the reported embankment fill gradations.

Grout curtains were not installed in the dam abutments, but the blanket drains appear to have been extended some distance up the abutment slopes. Seepage along the downstream groins of the dams is generally not reported, likely due to the presence of clay soil at the abutments, except at the Chin 2 dam

right abutment where bedrock is probably exposed to the reservoir upstream of the dam at elevations above 860 m (approx.). Seepage is reported to flow to the right abutment when the reservoir rises above 860 m. No turbid seepage has been noted to occur in the area; however, it is recommended that a filtered drain with flow measurement capability be installed to safely intercept all the seepage flows reporting to the abutment area, to allow monitoring to better detect potential turbid effluent, and to allow flow rates to be tracked against time and compared to the reservoir level.

The embankments appear to have been constructed with minimal difficulties beyond some issues with uniform moisture conditioning of the fill. The embankments are understood to have generally performed well with little need for significant maintenance or repairs other than normal riprap augmentation at both dams and crest repairs at Chin 2. The embankments have also performed well during periods when the reservoir has been drawn down significantly. No adverse impacts to the dams or reservoir slopes have been reported during these drawdown periods.

Issues that prevented the successful excavation for the original outlet stilling basin underscore the potential for weak, saturated foundation soils to impact embankment stability during and soon after construction. The drainage measures and construction staging implemented were adequate to provide for sufficient dissipation of foundation pore pressures to avoid problems with embankment instability at the end of construction. A stilling basin was constructed at the outlet in 2002 at which time temporary shoring adequate to support the excavation slopes and prevent heave of the excavation base was provided.

3.2.2 Deformation

Significant deformations occurred during and after construction of both Chin Coulee Dams. Deformation is an issue in relation to maintaining the crests of water retention structures at suitable levels and it appears that the crests of both dams are lower than their design levels but this has been offset by a reduction in operating level from the design FSL.

Differential settlements can lead to cracking of embankments and the potential for damage to discharge structures such as low-level outlets incorporated into the embankment. Surveying, measurements of joints and cracks, and inspections are relied upon to help evaluate deformation or damage to discharge structures.

As noted previously, the Outlet Structure has been impacted by deformations related to embankment construction loading and foundation consolidation. Periodic maintenance and repair of the structure has been necessary to repair the cracks that could lead to embankment fill loss into the conduit. Regular inspection of the conduit to identify new or reopened cracks for prompt repair continues to be recommended.

Survey monitoring of important locations on dams, such as crest areas, is generally used to ensure that suitable elevations are provided or restored, if necessary. Crest elevation changes might occur due to

disturbance by traffic and road grading. Surveying should be carried out at least once in each DSR cycle to check the crest elevations of both dams under consideration herein. Crest augmentation has been carried out at Chin 2 but it is not clear whether the Chin 1 dam crest has been raised.

A culvert is provided on the left abutment of Chin 1 to carry road ditch flow from the downstream side of the crest to discharge on the armoured upstream slope of the dam. The elevation of this culvert should be checked to ensure that it will not allow water from the reservoir to flow to the downstream side of the dam before overtopping is imminent elsewhere as well.

Settlement gauges at the Chin 1 dam are understood to be decommissioned and abandoned.

The crests of water retention structures should be graded to shed water, usually to the upstream slope but crest crowning with some drainage flowing to a well-vegetated downstream slope is also acceptable and is probably appropriate at Chin 1. Some crest surface maintenance (grading and traffic support enhancements) are understood to be carried out periodically for Chin 2 but the measures implemented to date have not provided a long-term solution and further maintenance and repair remains necessary. Crest surface maintenance work should include survey to ensure that the crests are maintained no lower than their required elevation and are properly sloped to prevent pooling of water. This is primarily a concern at Chin 2, but should also be checked for Chin 1, particularly in regard to ridges left by grading operations due to the presence of fences and other obstructions at the sides of the crest.

Deformations can also be strong indicators of other issues in relation to a dam's performance such as slope instability, piping, or internal erosion. Careful observation of dams and dam sites to identify deformations is always an important component of dam surveillance and should continue to be an important component of the surveillance of the Chin Coulee structures.

3.2.3 Hydraulic Fracturing

Deformation plays an important role in the possible development of hydraulic fracturing. Zones of relatively stiff soil, or structures which generally exhibit much stiffer deformation response than surrounding soils, might attract loading (stress) away from nearby zones of softer soil with larger deformation responses to loading, potentially resulting in stress conditions in the softer zones that are low enough that they can be exceeded by applied hydraulic pressures resulting in hydraulic fracturing. Hydraulic fracturing can seriously degrade the performance of low permeability seepage control components.

Considering the moderately sloping foundation geometry, the flexible and consistent embankment fill used, provision of filtered drainage, and the good performance of the Chin Coulee water retention structures over 60 years of operation, hydraulic fracturing is not considered to be a significant hazard.

The Outlet Structure might result in some increased potential for hydraulic fracture because the stiff structure will tend to decrease stress levels in the adjacent soils. Filtered drainage measures are

provided to help safely drain seepage along the structure. A diaphragm of filter material entirely surrounding a nearly 40 m length of the outlet conduit's downstream end.

3.2.4 Seepage

Seepage is a normal occurrence associated with earthfill, water retention structures. Seepage quantity and quality need to be acceptable. There are no indications that the seepage quantities at the Chin dams are unacceptably high.

Chin 1 dam foundation seepage likely reports to the outlet channel near the right abutment and the old stream channel near the left abutment. Embankment seepage is also likely collected and transported to these areas by the drainage measures constructed in the dam. There is no means available to monitor or measure the seepage flows at the West Dam. Periods of low water level in the Stafford Reservoir should be used to facilitate inspection and assessment of seepage conditions downstream of Chin 1 in the former stream channel and the Outlet Structure discharge canal. These inspections should check for evidence of unfiltered seepage egress, piping initiation, turbid seepage, sand boils, blockage of drain outlets, and any other unexpected or unfavourable conditions.

An unusual detail exists at the upstream toe of Chin 1 where a gravel filled sump was constructed to ensure a connection between any relatively pervious deposits in the old stream channel and the coulee bottom upstream of the dam. This detail appears to have been intended to allow foundation drainage during construction but it does not appear that this sump/relief drain was deactivated after construction. The sump provides a reservoir connection shortening the foundation seepage path length in this area by over 60 m. Capping the reservoir end of the sump might reduce foundation seepage and pore pressure somewhat and could be considered the next time the Chin Reservoir is drawn down. If significant concerns develop regarding embankment foundation seepage in the former stream channel area, the complete deactivation of this drain should be planned and implemented.

Foundation and embankment seepage at Chin 2 formerly discharged to a shallow swale at the downstream toe of the dam and was measured at a weir before discharging into the former borrow pit on the left side of the coulee bottom downstream of the dam. It is reported that, although some wet areas are intermittently evident along the downstream toe of the dam, there has been no flow in the swale for a number of years. It is likely that sedimentation in the reservoir due to shoreline erosion is acting to blanket the reservoir bottom (including the upstream borrow pit areas) and reduce seepage quantities. Seepage from the reservoir is now likely to discharge primarily to the water-filled borrow pits on the coulee bottom a short distance downstream of the dam. There is no active monitoring of the water level in the downstream borrow pits or the flow rate in the stream channel beyond the pits. Monitoring of the flow rate downstream of the borrow pits would provide an indication of changes in seepage and is recommended. If there is no flow downstream of the borrow pits under dry conditions, then the water levels in the ponds should be monitored. Rising pond levels would indicate increasing seepage flow in the coulee bottom deposits.

3.2.5 Piping and Internal Erosion

Piping can initiate when seepage results in particle migration from a dam, its foundation, or an abutment. When the particle displacement occurs at an interface between two materials, the process is referred to as internal erosion and the eroded material might be redeposited within the structure. The piping might progress upstream along a susceptible pathway until the reservoir is breached. These processes could result in the development of sink holes or embankment instability potentially leading to loss of containment. Internal erosion might allow elevated pore pressures to be transmitted toward the downstream slope, potentially resulting, ultimately, in embankment slope failures and loss of containment.

The filtered drainage, including a chimney drain, is expected to be generally effective in controlling the potential for piping through the Chin 1 embankment where piping is most likely to occur at cracks in the Outlet Structure. Piping to such cracks should be avoided by prompt repair of all cracks found in the structure.

The silty clay embankment fill used at both dams has been assessed by others and found to be non-dispersive. The alluvium-sourced clay fill material is, however, probably more prone to piping and erosion than clay till-sourced embankment fill. The hydraulic gradient along the seepage paths where pipes appear to have formed from pools of water on the Chin 2 dam crest would have been about 1/2.3, so it appears that piping of the embankment fill readily occurs at this seepage gradient.

Unfiltered seepage gradients with the reservoir level near the dam crest level (passing a large flood) of roughly 1/4 to the downstream slope above the bench on Chin 2 and 1/6.5 over the chimney drain at Chin 1 are estimated. Taking 1/7 (approximately 1/3 of 1/2.3 to provide a factor of safety) as the maximum safe gradient for unfiltered seepage through the embankments and comparing this to the calculated seepage gradients through the upper portions of the embankments with a reservoir level near the crest levels indicates a hazard of piping with elevated reservoir levels, particularly at Chin 2 where there is no filtered chimney drain. This hazard will be exacerbated by weathering and cracking near the crest related to factors such as wetting-drying cycles, frost action, and deformation.

There is some potential for piping of susceptible foundation soils at both dams based on the estimated seepage gradients in the foundations where unfiltered seepage egress probably occurs and is likely expressed at downstream submerged locations in the old stream channel near Chin 1 and in the borrow pits near Chin 2. The seepage egress at these submerged locations is not filtered and cannot be readily observed for evidence of piping. The seepage gradients to these locations are estimated at approximately 1/8.5 at Chin 1and 1/12 at Chin 2 (for silty sand channel deposits the safe seepage gradient is about 1/25).A similar hazard could exist at the West Dam outlet canal depending on the extent and effectiveness of filtration material provided in the stilling basin and canal.

The reduction of seepage reporting to the downstream toe of Chin 2 has been attributed to reservoir siltation. This observation could, however, also be explained by formation of one or more foundation

seepage pipes leading to the ponds in the downstream borrow pits. Potential foundation piping could be addressed by lengthening seepage paths, providing enhanced drainage measures for filtered seepage egress, and/or by improved surveillance to check for indications of increasing seepage quantities.

Internal erosion within embankment dams is readily preventable in design and construction by ensuring filter compatibility between adjacent materials, particularly at drains and likely seepage egress points. As discussed previously, the drainage materials used at both Chin 1 and Chin 2 appear to be reasonably filter-compatible with the embankment fill. At both dams, some internal erosion of the very finest embankment fill into the drainage zones could occur but this is considered to be a negligible hazard.

The hazard of internal erosion might be increased somewhat by potential segregation of the relatively broadly graded drainage materials used; however, since zoned drains with separate filter and drainage materials were not provided, the implications of minor segregation that is likely to have occurred are also considered to be negligible.

Filter compatibility is sometimes not adequately addressed by upstream erosion protection designs, leaving the potential for internal erosion of embankment fill through the bedding, or of the bedding material, through the riprap on the upstream slopes of the embankments. At this site, the “facing gravel” (assumed to be riprap bedding) appears to be reasonably compatible with the embankment fill but might lack sufficient coarse gravel content in some cases to be filtered by the riprap. Repairs or placement of additional erosion protection areas should include placement of suitable bedding and transition materials, as necessary, and should provide for careful riprap placement to minimize gaps between riprap pieces.

Near the Chin 2 right abutment, there is some potential for embankment fill and/or erodible bedrock to be displaced by seepage through fractures and other discontinuities. Such flow appears to occur when reservoir levels are above 860 m. As previously recommended, a filtered drain should be installed to safely intercept all the seepage flows reporting to the abutment area, to allow monitoring to better detect potential turbid effluent, and to allow flow rates to be tracked against time and reservoir level.

Monitoring of a dam for evidence of piping and internal erosion issues (turbid seepage flows, increasing seepage, depressions, or sinkholes) is an appropriate component of the operations and management plan. Potential seepage egress areas should be monitored as part of surveillance activities for signs of turbidity, erosion, boils, increased seepage, etc. The areas observed should include the downstream abutments and valley bottom near the dam.

3.2.6 Slope Instability

The coulee slopes above the reservoir were observed from the dam sites during the site visit and no evidence of significant instability of the reservoir slopes was noted nor has such been reported. The stability of the reservoir slopes has not been further assessed by this DSR.

Slope instability is a geotechnical hazard applicable to the embankment dams under consideration. The stability of the dam embankment slopes has been assessed as part of previous dam safety assessment work. The results of a stability assessment depend significantly of the material strength parameters used, which are generally somewhat subjective in their determination. Parameters used in selected previous assessments are summarized in the following table.

The 2013 DSR applied a reduced strength in a lower portion of the foundation at Chin 1, however, the deeper material did not impact the analysis results since the foundation strengths applied substantially exceeded the embankment strength applied.

The most reasonable parameters employed are considered to be those from the work reported in 2003 and 2007. The moderate effective stress friction angles, in the range of 25˚ to 30˚, appear to be reasonable for a silty, medium plastic clay. Disregarding effective cohesion (set to 0 kPa) may be somewhat conservative but low values are considered suitable for long-term stability analysis particularly when considering fill or near-normally consolidated native clay.

TABLE D Previous Stability Analysis Parameter Summary

Parameter		Wet Unit Weight (kN/m^3)			Effective Friction Angle			Effective Cohesion (kPa)		
Dam	**DSR Year:**	**1986**	**2003/2007**	**2013**	**1986**	**2003/2007**	**2013**	**1986**	**2003/2007**	**2013**
1	Fill	18.4	19	20	30˚	30˚	24.8˚	10	0	5
	Foundation	19.3	19	20	32˚	25˚	32˚	0	0	7
2	Fill	18.9	20	20	32˚	28˚	24.8˚	10	0	5
	Foundation	20.6	20	20	34˚	28˚	32˚	0	0	7

The following table summarizes selected key stability analysis factor of safety results for the maximum sections of the dams reported by previous DSR work. CDA Guideline target minimum factors of safety against instability are also included in the table for reference.

TABLE E Selected Key Stability Analysis Factors of Safety Previously Reported

DSR Year:		1986		2007	2003	2013		Target
Failure	**Dam:**	**Chin 1**	**Chin 2**	**Chin 1**	**Chin 2**	**Chin 1**	**Chin 2**	**CDA**
Downstream Steady State		2.3	2.4	1.65	2.2	1.88	1.91	1.5
Downstream Pseudo-Static				1.45 (0.04g)	1.8 (0.05g)	1.24 (0.1g)	1.2 (0.1g)	1.0
Upstream Steady State						2.66	2.59	
Upstream Rapid Drawdown		1.8	1.8	1.3	1.5	1.14	1.27	1.2-1.3
Upstream Pseudo-Static						1.36 (0.1g)	1.35 (0.1g)	1.0

The previous stability analysis results are generally favourable, with only an upstream rapid drawdown result for Chin 1 presented in the 2013 report falling below CDA Guidelines. That analysis did not include the stabilizing effect of the riprap and bedding gravel on the upstream slope, which could improve the

calculated factor of safety under rapid drawdown. The marginally low factor of safety is not considered to be a matter of concern, because Chin 1 has performed well through drawdown events since construction, and an embankment failure under rapid drawdown conditions is unlikely to lead directly to loss of reservoir containment.

Previous stability assessments under seismic conditions have considered horizontal seismic coefficients of 0.1 (i.e., horizontal seismic acceleration of 0.1 g) or less. An updated assessment indicates that using a horizontal seismic coefficient of 0.25 in a pseudo-static analysis would be more appropriate. This horizontal seismic coefficient represents the peak ground acceleration (PGA) between an annual exceedance probability of 1/2475 and 1/10,000, as recommended by current CDA Guidelines for the assessment of dams with 'Very High' consequence classifications. The PGA values were extrapolated from a 2015 National Building Code seismic hazard calculation for the approximate location of the Chin Reservoir multiplied by a factor of 1.72 representing the effect of an estimated "E" Site Class. Use of PGA to assess an embankment dam is relatively conservative but is appropriate for a screening-level assessment.

The stability of the dams under seismic conditions should be reviewed considering the updated seismic coefficient. Reassessment of Chin 1 is undertaken herein since a favourable result for that dam would also suggest a favourable result for the smaller Chin 2 based on its lower height and the results of previous analyses.

Computational assessment of the Chin 1 embankment stability is presented below considering the design embankment configuration at its maximum height section (designated Section AA in previous work), where the greatest potential for slope instability is expected to exist. The slope stability analysis was undertaken using a limit equilibrium approach implemented in Slope/W (Version 8.15). Trial failure surfaces used were circular arcs, however, the failure surfaces were generally adjusted using the software's optimization routine to help account for the potential geometry of realistic failure surfaces, which tend to be constrained by geometric considerations and zones of relatively weak or strong material.

The stability analyses presented herein include estimates of embankment pore pressures and foundation pore pressures considering piezometer readings (increased to the "review" levels as detailed in Section 3.2.10) and the general configuration of the dam, including the expected influence of the reservoir, the tailwater level (Stafford Reservoir), and the embankment drainage measures. Two piezometric lines, one for the embankment and one for the foundation, are used in the analyses. The embankment drainage measures have been assumed to be reasonably effective in lowering the foundation pore pressures. Although the available piezometer data is not adequate to confirm this assumption, it is consistent with the approach taken by previous stability assessments and is considered reasonable.

The foundation piezometric line for steady state seepage applies the normal reservoir level at Elevation 861.4 m upstream of the dam and to the downstream end of the gravel filled sump at this section under the upstream toe of the dam. The embankment piezometric line for steady state seepage applies the normal reservoir level at the upstream face of the dam and then drops to reflect the piezometric levels measured in the embankment. A modest upward gradient from the foundation to the embankment and drains is applied, consistent with available measurements. The gradients of both the embankment and foundation piezometric lines decrease under the dam's downstream slope reflecting the influence of the drainage measures. Near the downstream toe of the dam (at the upstream end of former stream channel remnant) the piezometric lines match the applied tailwater level at Elevation 846.6 m.

The pore pressure distributions under maximum reservoir conditions (taken as matching the top of the dam), are adapted from the anticipated steady state condition by assuming rapid response in the embankment beneath the reservoir and a rapid transition to steady state seepage in the foundation under the increased reservoir head and an assumed increase in the tailwater level to Elevation 848 m.

The reservoir is assumed to be reasonably capable of being lowered rapidly to Elevation 848 m. The pore pressure distribution under rapid drawdown conditions in the current analysis is adapted from the anticipated steady state condition by assuming a saturated ground response beneath the reservoir, drainage of the upstream erosion protection materials, and little drainage of the general embankment fill or foundation. This pore pressure distribution is conservative.

Soil parameters used in the current assessment of Chin 1 are summarized in the following table.

TABLE F Stability Analysis Effective Stress Material Parameters

Material	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Impervious Fill	19	28	1
Foundation Clay	19	25	1
Upstream Slope Protection	18	38	0

The stability analysis results for Chin 1 are summarized in the following table.

TABLE G Stability Analysis Results for Chin 1 (Maximum Section)

Slope	Seepage Condition	Other Constraint	Factor of Safety		
			CDA Guideline	Previous DSR Result	Current Result
Downstream	Reservoir at Maximum	Overall Slope	1.0 (Implied)	Not Reported	1.7
Downstream	Steady State	Overall Slope	1.5	1.9	1.8
Downstream	Steady State	Shallow, Upper Slope	1.5	1.5	1.2
Downstream	Steady State	Seismic (Pseudo-Static), Overall Slope	1.0	Not Reported	0.7 (0.25 g)
Downstream	Steady State	Seismic (Pseudo-Static), Shallow, Upper Slope	1.0	1.2 (0.1 g)	Not Assessed
Upstream	Steady State	Overall Slope		2.7	2.4
Upstream	Steady State	Shallow, Upper Slope		2.2	1.6
Upstream	Steady State	Seismic (Pseudo-Static), Overall Slope	1.0	Not Reported	0.7 (0.25 g)
Upstream	Steady State	Seismic (Pseudo-Static), Shallow, Upper Slope	1.0	1.4 (0.1 g)	Not Assessed
Upstream	Rapid Drawdown	Overall Slope	1.2 to 1.3	Not Reported	1.3
Upstream	Rapid Drawdown	Shallow, Upper Slope	1.2 to 1.3	1.1	1.1

The graphical output from the slope stability analysis software is attached in Appendix G for each condition analyzed and noted above.

The stability analysis results indicate that the Chin 1 slopes satisfy the CDA Guideline target minimum factors of safety against instability for all anticipated conditions except the following:

- A shallow failure of the upper portion of the downstream slope under steady state seepage conditions. Such a shallow failure is not considered a significant hazard as it would not lead directly to loss of reservoir containment and could be readily repaired as a maintenance matter.

- A shallow failure of the upper portion of the upstream slope under rapid drawdown conditions. Such a failure is not considered a significant hazard as it would not lead directly to loss of reservoir containment, furthermore, the dam has been subjected to reservoir drawdown in the past with no significant issues with stability of the upstream slope reported.

- The pseudo-static assessment of embankment stability with a horizontal seismic coefficient of 0.25 yields a factor of safety less than 1, which indicates a need for more detailed assessment of the expected embankment performance under the applicable Earthquake Design Ground Motion.

A detailed assessment of the expected performance of the dams under seismic loading is beyond the scope of this assessment. A preliminary assessment of the likely upper limit of permanent seismic

displacement of Chin 1, at its maximum section, indicates that about 0.3 m of movement could be expected provided that significant strain softening of the embankment and foundation does not occur. This deformation would likely be tolerable for the embankments with suitable follow up inspections and repairs. The Outlet Structure might, however, be damaged significantly by seismic deformation, which could lead to loss of reservoir containment.

3.2.7 Static and Dynamic Liquefaction

Static and dynamic liquefaction are both phenomena wherein the strength of a saturated soil is suddenly and dramatically reduced. Both phenomena are primarily an issue with loose soils composed of silt and sand and typically do not occur in cohesive soils or compacted fills.

Case histories of static liquefaction generally involve submarine slopes, hydraulic fills, or unusually loose fills that are being or have been submerged. No cases of static liquefaction involving natural alluvial or lacustrine deposits have been identified by the DSR team. In the two cases known by the DSR team where non-hydraulic fills experienced static liquefaction, both failed upon first submergence. While static liquefaction, with a suitable trigger (likely seismic) or other external loading, cannot be definitively ruled out, it is considered to be a very minor hazard. The DSR review team does not consider static liquefaction to be a significant hazard for consideration in the review of the Chin Coulee Dams.

If loose, granular material, that is potentially prone to dynamic liquefaction, is present in the foundation of a dam, such susceptible soils would need to be present over a significant area and at a fairly shallow depth for embankment failure to result. The available foundation assessment data indicates that such an extensive, shallow, granular deposit is not present at either site. Although dynamic liquefaction is not considered to be significant hazard for the Chin Coulee Dams, detailed site investigations could be undertaken to further check for indications of potentially susceptible deposits. Such investigations could be a component of the detailed assessment of the expected embankment performance under the applicable Earthquake Design Ground Motion.

3.2.8 Other Geotechnical Issues

The CDA Guidelines require the impervious core of a dam to be protected from freezing and do not permit reservoir levels to be raised above the top of the impervious core, even temporarily, unless it can be shown that the dam will not be endangered by the raised reservoir level. Concerns in this regard are related to embankment fill piping concerns at elevated reservoir levels as discussed previously in this report. Crest settlements exacerbate this issue.

Taking the top of the core at the likely depth of frost penetration (estimated at about 2.0 m on an exposed crest) and applying the reservoir level limit at that point suggests reservoir level limits of 0.4 m and 0.8 m above FSL for Chin 1 and Chin 2, respectively. Rigorously applying these limits would significantly reduce the allowable reservoir level during flood events and the available capacity of the Chin Reservoir to impound a flood event.

The Chin Reservoir Dams do not satisfy these CDA Guidelines and the likelihood of failure at elevated reservoir levels associated with flood conditions is increased as a result. It is recommended that the downstream slopes of Chin 1 and Chin 2 be monitored on an ongoing basis during any event where the water level exceeds FSL by more than 0.4 m and 0.8 m, respectively, so that appropriate protective measures can be implemented, as necessary, in response to observed seepage, piping, or instability on the downstream slopes of the dams. Planning for this monitoring, as well as suitable response and protective measures, should be documented in emergency preparation and response plans. Suitable protective measures are likely to commence with construction of a weighted filter using filter fabric and drainage gravel and might progress to a controlled breach at a favourable location. Suitable response measures are likely to include warning of downstream stakeholders to allow them to implement measures to mitigate the consequences of dam failure.

3.2.9 Instrumentation and Monitoring Schedule

SMRID engineers generally complete documented inspections at the dams annually and this annual inspection includes review of the Outlet Structure, downstream of the flow control gates. SMRID operators are understood to visit Chin 1 daily during the irrigation season and weekly in the winter. Operators visit Chin 2 less frequently since there is no operations equipment at that dam. Chin 2 is understood to be visited every week to two weeks in the irrigation season but only monthly or bi-monthly in the winter.

The annual inspections of the embankments by staff engineers is considered adequate. It is recommended that the annual inspection of the Outlet continue to reduce the potential for cracks to go unrepaired for a significant length of time and, potentially, allow soil loss from the embankment. It is recommended that the Outlet Structure upstream of the gate well be inspected to identify cracks for repair at least once every three years unless piezometer monitoring indicates the need for earlier inspection.

As previously noted, the area around the inlet to the Outlet Structure should be inspected to confirm the adequacy of the repairs implemented in that area, and in particular to check for sinkholes.

Routine site surveillance by operators is acceptable provided that substantial attention is paid to site conditions during these visits. It is recommended that site inspections by operations staff be carried out at least bi-weekly throughout the year and that these inspections be documented on the same frequency using a simple checklist confirming that no changed or unexpected conditions were present.

Some geotechnical instrumentation was installed at Chin 1 and Chin 2 at the time of construction. All of the instrumentation at Chin 2 has failed or been lost, with the exception of a seepage flow monitoring weir at the outlet of the dam toe seepage collection ditch; however, it is understood that no flow has been observed in the past several years. At Chin 1, some piezometers installed during construction remain functional and several standpipe piezometers were installed in 2007 to replace lost or failed

instruments. Settlement gauges installed in Chin 1 at the time of construction are understood to have been abandoned and decommissioned.

Dam crest elevations should be monitored by survey to ensure that they remain above the minimum required level. Dam crest surveys should be carried out at least once in each DSR cycle.

It is recommended that some piezometers be installed at Chin 2 to allow better assessment of pore pressures and seepage gradients in the embankment and foundation.

The available piezometers at Chin 1 are considered adequate for the monitoring of pore pressures in the embankment; however, uncertainty remains in regard to the seepage gradients in the foundation of the dam. Installation of additional piezometers in the Chin 1 foundation is recommended beneath the downstream bench near the Outlet Structure and the former stream channel.

A review of recent piezometer readings at Chin 1 is provided in the next subsection of this report. The piezometers at Chin 1 are read annually by the SMRID, typically in the spring or early summer; this reading frequency is considered to be the minimum acceptable frequency and should be augmented by additional readings any time the reservoir rises above FSL or is lowered by more than about 2 m.

The piezometer monitoring data is plotted by the SMRID for review and the plots are generally suitable; however, some instruments are not included in the plots and these should be added.

The usefulness of instrumentation monitoring and data collection and its value to detect changing conditions is vastly diminished if timely, critical review of the data is not carried out. It is difficult to assess the level of internal review applied by the SMRID to the instrumentation data. It is recommended that review and approval of surveillance data be documented. Procedures for collecting, checking, presenting, and reviewing instrumentation data should be included in an OM&S Manual.

As previously noted, a filtered drain should be installed to safely intercept all the seepage flows reporting to the right abutment of Chin 2 when the reservoir level is above about Elevation 860 m. This drain should be monitored to detect potential turbid effluent, and to allow flow rates to be tracked against time and reservoir level.

The water levels in the ponds (borrow pits) downstream of the Chin 2 should be monitored to detect changes that could indicate increased seepage from the reservoir. Similarly, any flow on the coulee base downstream of the ponds should be measured for the same purpose. These monitoring activities should be carried out following periods of reasonably dry climatic conditions with the reservoir at a reasonably consistent level.

3.2.10 Chin 1 Piezometer Data Review

Chin 1 piezometer monitoring data was provided by the SMRID for review. The monitoring data was presented in a Microsoft Excel Workbook. The workbook included a plot of the data from the

replacement (RP – Series) piezometers installed in 2007. An additional plot was prepared by the review team showing the data for functional piezometers in the array of piezometers installed around the Outlet Structure gatewell at the time of construction. The piezometer data plots are presented in Appendix G.

The array of piezometers installed at the time of construction around the Outlet Structure gatewell are intended to detect disruption of seepage patterns and thus provide an indication of developing issues with the structure, such as cracking. The readings of these instruments appear to indicate some variability and no clear pattern of head distribution; this suggests that the proximity of the various instruments to cracks in the conduit could be a significant factor in their readings. A head increase could indicate the opening of a crack upstream of the flow control gates and a head decrease could indicate the opening of a crack downstream of the flow control gates. As such, elevated head readings reported at the locations of Piezometers R4 and L1 between 2013 and 2015 should have been taken to indicate a potential cracking issue upstream of the gates. Conduit repairs were conducted between 2014 and 2015 but it does not appear that any cracking upstream of the gates was repaired.

Although inspection of the conduits is likely the best means to find (and facilitate repair of) cracks, it is not feasible to inspect the conduits, particularly upstream of the gatewell, much of the time. It is therefore recommended that the array of piezometers installed around the gatewell continue to be monitored for changes that could indicate the formation or opening of cracks. The possibility of clearing or repairing instruments in this group that have become blocked or difficult to read or employing an alternative reading system, such as a flexible coaxial cable, should be investigated.

The remaining (functional) piezometers in Chin 1 are located generally along four lines from right to left as follows: right of the Outlet Structure, left of the Outlet Structure, at the typical dam section (also referred to as Section B-B), and at maximum section (also referred to as Section A-A).

The piezometers installed approximately beneath the upstream edge of the dam crest are as follows:

- RP 3 and 4 are located right of the conduit in the lower part of the embankment fill and at the embankment-foundation interface, respectively. These piezometers give similar readings except that RP 4 appears more sensitive to reservoir fluctuations. An upward trend in the readings of these instruments in 2017 and 2018 might indicate increased conduit leakage upstream of the gates. These piezometers indicated a head of 856.0 m in 2018 and this level could be taken as a review level since it is about 1 m above the recent typical levels.

- RP 1 and 2 are located left of the conduit at the embankment-foundation interface and in the middle part of the embankment fill, respectively. These piezometers give similar readings. These piezometers indicated heads of 853.8 m and 853.6 m, respectively, in 2018. A review level of 855 m is suggested for these instruments.

- RP 13 and 14 are located near Section BB in the lower part of the embankment fill and at the embankment-foundation interface, respectively. RP 13 is consistently dry indicating a piezometric level below Elevation 851.2 m. RP 14 indicated a head of 851.2 m in 2018 but has been somewhat higher in the past, which suggests a modest upward seepage gradient. Review levels of 851.5 m and 852 m, respectively, are suggested for these instruments.

- RP 9 and 10 are located near Section AA in the lower part of the embankment fill and at the embankment-foundation interface, respectively. These piezometers give readings roughly 1 m apart with the lower installation indicating the higher head and, therefore, a modest upward seepage gradient. These piezometers indicated heads of 852.2 m and 853.2 m, respectively, in 2018. Review levels of 853 m and 854 m, respectively, are suggested for these instruments.

Piezometers RP 5, 6, and 7 were installed approximately beneath the downstream edge of the dam crest right of, over, and to the left of the Outlet Structure conduit respectively. RP 5 and 7 are likely near the embankment-foundation interface and RP 6 is in the embankment fill. RP 5 indicated a head of 849.4 m in 2018 and the other two piezometers are consistently dry indicating piezometric levels below roughly 851 m and 848 m for RP 6 and RP 7, respectively. Review levels of 850 m, 851 m, and 849 m, respectively, are suggested for these instruments.

The piezometers installed near the upstream edge of the bench at approximately Elevation 855 m on the downstream slope of Chin 1 are as follows:

- CP 26 and RP 8 are located right and left of the conduit, respectively, in the embankment foundation. These piezometers indicated heads of 847.7 m and 847.4 m, respectively, in 2018. A review level of 848 m is suggested for these instruments as this level would suggest that the drainage diaphragm around the downstream end of the Outlet Structure conduit could be running near its full level.

- RP 15 is located near Section BB in the foundation but intersects the blanket drain, the bottom of which appears to be near Elevation 849.5 m. In 2018, RP 15 was dry, indicating a piezometric level below about 848.2 m. RP 15 last indicated a water level in 2014 at Elevation 848.4 m. A review level of 849.5 m is recommended, which would indicate that the drain is likely beginning to flow in this area.

- RP 11 and CW 5 are located near Section AA (CW 5 is likely near the downstream edge of the bench) and both probably indicate the drain head level in this area. These piezometers indicated heads of 847.5 m and 847.4 m, respectively, in 2018. A review level of 848.5 m is suggested for these instruments.

Piezometer RP 16 is located just beyond the downstream toe of the dam at Section BB and indicated a head of 847.0 m in 2018. A review level of 848 m, well below grade, is suggested for this instrument.

Piezometer RP 12 is located on Section AA near the toe of the 4H:1V lower embankment slope on the upstream part of the fill placed in the old stream channel. This piezometer indicated a head of 847.4 m in 2018; this level appears to be higher than the water level downstream in the channel, which might indicate some flow interference at the blanket drain outlet. A review level of 848 m is suggested for this instrument, about 1 m below grade.

3.3 Structural Assessment

3.3.1 History of Structural Elements

Chin Dam No. 1 (West) includes a 5-bay Outlet Structure. The Outlet Structure structure consists of an inlet structure, five monolithic reinforced cast-in-place conduits, a gatewell structure with five cast iron gates operated by Rotork electric actuators, an outlet structure and a single stilling basin with basin blocks as well as a light-weight concrete block control building.

The Outlet Structure is constructed as an integral part of Chin Dam No. 1 therefore an independent stability assessment is not warranted as it is dependent on the embankment dam stability.

The conduits are 146 m long and are numbered 1 to 5 from north to south. Conduits 1 and 5 measure 1,220 mm high x 1,560 mm wide and Conduits 2 to 4 measure 1,220 mm high x 1,930 mm wide. The gate well structure is 67 m downstream of the intake structure and is located at the upstream edge of the dam crest.

Construction of the first Chin Dam No. 1, began in 1952 and was completed over a 4-year period. It was designed to undergo significant settlement, but shortly after the embankment was complete, tension cracks caused the monolithic conduit structure to break completely through at two locations. The result was a 50 mm tension crack developed at station 0+078 (~9 meters downstream of the gate well structure) and a smaller crack which formed at station 0+070 (~3 meters downstream of the gate well structure).

These two major cracks, along with other minor cracks were repeatedly pressure grouted in 1956, 1961, 1963, and 1966 as settlement continued to cause the grout to fail and, in some instances, embankment fill material piped into the conduit. These cracks are monitored on a regular basis and settlement has diminished over the years. Between 1981 and 1983 several repairs and retrofits were carried out on Chin Dam No. 1. The cast iron gates were replaced on Conduits 1, 2, and 4, with Armco 55-10 heavy duty cast iron gates and were reconditioned on Conduits 3 and 5. The manual operators were replaced with electric Rotork actuators and a control building was constructed adjacent to the hoists.

The original outlet had settled 300 mm lower than the conduit structure and pulled away about 200 mm. It was replaced with a new outlet structure and stilling basin in 1982. The embankment was tested for voids near major cracks by drilling probes in the sides and bottoms of the conduits. The 50 mm tension crack at station 0+078 was re-grouted and covered with a 300 mm wide x 6 mm thick

galvanized plate and fastened with 19 mm diameter x 114 mm long cadmium plated Hilti Kwik bolts. Numerous smaller cracks were filled with grout that had elastic properties in anticipation of future settlement.

In 1997, Extensometers were installed on the roof of Conduits 1 and 5 to measure ongoing differential settlement. In 2001 a cofferdam was constructed upstream of the dam to allow the installation of a concrete apron and additional riprap around the inlet structure.

3.3.2 Previous Dam Safety Reviews

The PFRA DSR assessment noted that the concrete was in good condition following the grouting and repairs by UMA between 1981 and 1983. However, there was some minor seepage through hairline cracks and at the corners of the gates. Additionally, the plates installed over the tension cracks at station 0+078 had to be repaired after one season and the PFRA recommended the plates be recessed flush with the conduit walls. The report concluded that there were "no problems, unsafe conditions, or defects requiring immediate remedial action to ensure the safety of the dam" but that the differential settlement would likely continue and the cracking in the concrete should be monitored on an annual basis.

The 1995 report by Klohn-Crippen indicates that the conduits and the gate well were generally in good condition and all five actuators and gates were functional. The only issues identified were the condition of cover plates over the large cracks (presumably at station 0+078 m), potential increases in seepage through existing cracks, and susceptibility to piping failure (based on low weighted-creep ratios). There was some indication that the control building had settled relative to the gate well, but it was not considered a dam safety issue. The downstream riprap and stilling basin were described as in good condition and the backfill was tight against the structure. The report notes that the outlet structure had settled 10 mm and separated 10 mm relative to the end of the conduits (approximately 15 mm on diagonal), but the water stop at the joint should be capable of handling at least 25 mm of separation.

In 2002, Klohn-Crippen reported that the gate wells and gates were in good condition. The gates performed satisfactorily and there was very little leakage during the inspection. The outlet structure had settled a notable amount, but the magnitude of the settlement was similar to what was observed in 1995 and the water stop was still intact. The riprap above the water level at the intake (i.e., the riprap placed in 2001) was in excellent condition.

The most recent DSR was completed in 2013 by AECOM. It describes the considerable vertical cracking in all conduits but notes that the concrete was not spalling. The gates on all conduits failed to seal properly and Gates 3 and 5 were leaking a considerable amount. The resulting high-pressure water jet had caused noticeable wire-draw erosion in the gate frames. The report also notes that the extensometer movements had slowed relative to previous measurements. It was recommended that the gates should be repaired, and the conduit cracks be monitored but these issues were not of immediate concern with respect to the stability of the structure.

3.3.3 SMRID Maintenance after 2013

Documentation for inspections occurring in 2013, 2015, 2016 and 2017 were provided by SMRID. Several deficiencies were noted in the 2013 SMRID inspection and the 2013 DSR, including damage to the cast iron gates, damage to the steel plates covering the main tension crack at station 0+078 and scour in the concrete downstream of the gates. Subsequently, repairs were made to the gate thimbles and 3M metal seam sealer was applied to repair minor pitting on gates 2, 3, and 5. The steel plates covering the tension crack at station 0+078 were replaced in Conduits 1, 2, and 5. Additionally, grout was used to fill smaller cracks at several locations in each conduit and the scour cavities in the floor of the conduits downstream of the gates. An area of concern was noted upstream of Gate 1 but was not addressed at the time.

In general, inspections conducted since 2013 have found the conduits and gates to be in fair to good condition. Notable exceptions include the following:

- some pitting on Gates 1, 2, 4, and 5 (2018)
- the guides on Gate 5 are corroded and the side seals are in poor condition (2018)
- substantial leakage from Gates 3 and 5 (2017)
- several bolts are missing from the tension crack plate at station 0+078 in Conduit 1
- delaminating grout upstream of all gates (2018)
- cracked gate stem guide on Gate 2 (2018)
- concrete honeycombing in Conduit 2 (2018), Conduit 3 (2016, 2017), and Conduit 4 (2016, 2017)
- the outlet structure constructed in 1982 has settled and separated relative to the outlet end of the conduits

Gate, conduit, and outlet structure observations made between 2013 and 2018 are summarized in Tables I1 to Table I6 in Appendix I.

3.3.4 Site Inspection Observations

The gate well structure and the stilling basin were inspected from the deck by CPL on November 13, 2018 and the conduit inspection was carried out by Matrix on November 14, 2018. The site inspection report is provided in Appendix F.

From the deck, only a small portion of the gate well structure was visible for inspection through the grating. However it generally appeared to be in good condition with only some minor temperature cracks visible. The deck concrete is uneven with numerous concrete topping pours visible and the upstream portion of the deck appears to be sloping downwards toward the reservoir side.

The stilling basin also appeared to be in good condition again with only minor temperature cracking visible. However, the stilling basin built in 1982 has apparently settled by over 50 mm and moved apart by about 25 mm relative from the original conduit structure. It is uncertain when this movement

occurred. There are water stops between the two structures and the upper portion visible from the surface appears to be intact. The water stops used at these joints allow for vertical and horizontal differential movement between the structures as they are not embedded in the 1952 conduit structure.

There are no monitoring survey pins located on the gate well structure or the stilling basin to indicate when movements may have occurred or whether there is any continued movement. Therefore, it is recommended that monitoring pins be installed on both the deck of the gate well structure and the stilling basin and conduit structure.

Inspections since the 2013 DSR, including the 2018 inspection, are summarized in Appendix I in Tables I1 to I6. In general, the 2018 inspection did not identify any notable changes from previous inspections indicating that there are no apparent immediate concerns relative to dam safety. However, the gates are starting to show wear and a program should be put in place to carry out maintenance and/or replacement of the gates which are now some 36 years old.

3.4 Electrical & Mechanical Assessment

3.4.1 History of Electrical & Mechanical Systems

All outlet controls were originally operated manually. The original gates were cast gates linked to manual operators on the dam and all gates were installed in concrete gate wells. The bottom monolithic section of the spillway conduits includes all gates, thimbles, and guides. The gate wells are approximately 15 m deep above the gates, they rest on the bottom monolithic section and are inset in a socket type connection with dowels. This detail was likely designed to allow for the movement expected during the planned settlement of the dam and conduits. The gate operators are resting on a concrete curb over the gate wells. Grating protects the gate well opening other than gaps for the actuators. Vent pipes are 100 mm diameter and are embedded in the gate well concrete to provide air intake to the conduits downstream of all gates.

Per the 1995 DSR report, the original gates remained in operation until 1973, after which the gates started to leak. Gate 3 was sealed off and Gate 1 later failed due to thimble or gate breakage. Both gates remained inoperative up to 1982, at which point serious pitting on thimbles and damage were observable on all gates. Gate 3 was broken and flange back gate thimbles were broken on Gates 1 and 4, and one flange back gate thimble was badly pitted on Gate 2.

The Outlet Structure was repaired and upgraded in 1982, including the conduits and gates. The capacity of the structure was increased from 51 m^3/s to 74 m^3/s with the addition of a new outlet structure and stilling basin. Gates 1, 2, and 4 were replaced with new Armco 55-10 heavy duty cast iron gates. The gates were discarded except for Gate 2 which was reconditioned and reused to replace Gate 3, and Gate 5 was reconditioned and re-installed. Manual gate operators were also replaced with Rotork electric

actuators. It is assumed that the initial electro-mechanical control system was installed in an adjacent small control building.

Since the 1982 repairs, Gate 1 broke at the stem block (unknown year) and pitting was observed on all lower corners of all thimbles. In 1993, during dewatering of the reservoir, Gate 1 was repaired, and cover plates were welded over the pitted thimbles. New concrete was also placed up to 10 m upstream of the gates in eroded areas. Several wedge blocks were missing or loose and had to be replaced. All wedge blocks were welded to the thimbles.

All five gates have been operational since the 1982 repair work. Leakage in 1995 was indicated as 'very little.'

The original electro-mechanical control system was replaced around 2005 with a PLC-based control system with automatic and remote functions via Human-Machine Interface (HMI). It is assumed the remote water level sensors for Chin (Sonic probe) and Stafford (pressure) for Reservoir level monitoring, as well as new Rotork IQ actuators and electrical wiring were installed at the same time. The program in the PLC allows for automatic control of the Stafford Reservoir water level, calculated flow indication, limit settings on gate operation and movement (one per 8 hrs), and remote status to the central SCADA system. Gate position sensors, independent of the Rotork, are installed on each gate. The control panel internal UPS looks to provide about 1 hour of instrument and communication power.

In 2013, AECOM reported that the actuator on Gate 5 was tripping on high torque when operated, indicating possible deterioration of the brass nut of the actuator or gate guide issues. The nut had not been replaced for 8 years after the Rotork installation and may have been at 'the point of failure.' SMRID operators indicated that this was a common issue and now the brass nuts are replaced as part of a regular maintenance program. This maintenance activity should be added to the OM&S manual.

Several other items identified by AECOM in 2013 include:

- All gates failed to properly seal; two gates had significant leakage that had caused noticeable erosion in the cast iron gate frame and surrounding concrete.
- The Stafford Reservoir level sensor appeared sensitive to waves causing false, and unnecessary, automatic gate operations.
- The gear box of the Gate 5 actuator was damaged at some point by an apparent truck impact.
- Significant deflection of the actuator support I-beams was noted when in operation.

3.4.2 Previous Dam Safety Reviews

Conclusions and recommendations in the 1995 Klohn-Crippen DSR regarding the mechanical and electrical equipment included mainly inspection requirements:

- Inspect downstream gate faces each fall.
- Conduct diver and camera inspections of upstream side of the gates every two years.
- Install bulkheads, dewater and inspect the entire conduits and gates at the five-year intervals.

These activities should be identified in the OM&S Manual.

The 2002 Klohn-Crippen DSR did not discuss mechanical and electrical equipment, likely because gate operation was not tested during the inspection. A recommendation was made in this DSR to check the alignments of the gate thimble, guides, and stem blocks as possible movement is possible between the lower conduit section and the gate well.

The 2013 AECOM DSR provided the following recommendations for the mechanical and electrical equipment:

- Obtain O&M manuals and record drawings for the site including a wiring diagram.
- Remove redundant cabling and secure exposed wiring.
- Tag cabling and install cable tray were required.
- Seal holes in the control panel.
- Consider the operational benefit of installing an auxiliary generator connection point.
- Reset control limits and clean gate seats.
- Update the PLC controls to allow:
    - remote settings of the Stafford Reservoir level set point
    - automatic gate control based on flow
    - holding gate in place (to avoid frequent movement)
- Initiate a three-month maintenance routine to exercise the gates with full actuator strokes from local control to monitor signs of wear and lubricate the mechanism.
- Initiate a five-year maintenance routine to overhaul drive systems (brass nuts) and inspect and clean debris from the gates system.

3.4.3 SMRID Maintenance after 2013

Since the Outlet Structure repairs in 1982, there have been more frequent inspections of the conduits and gates, generally occurring every one or two years by SMRID staff.

The gate thimbles were repaired in 2013 with the bottom and side plates either replaced or covered with new plates.

In 2015, the Gate 4 Rotork actuator was very noisy and it was turned off until it was serviced. It is unknown what the issue was and if any specific maintenance or repair was required to return the gate into service.

In 2016, oil in all the Rotork actuators was replaced. Actuator drive nuts and bearings were also replaced on Gates 1 to 4, but there is no indication that this was done on Gate 5 at the same time. Gates were seated, which assumes that closed position settings were adjusted in the PLC.

Inspection Reports indicate that all gates have been leaking over the years, even after the 2013 repairs. On some gates, the leakage occurred simultaneously from both sides and the bottom. Ash seems to be used when the gates are closed for the winter to achieve a proper seal on the gates during the non-operational winter months.

When checked, vent pipes were clear. It was noted that the vent on Gate 5 seemed to be noisier than for the other gates. This could not be verified during the site inspection as the conduits were dewatered.

3.4.4 Site Inspection Observations

The electrical and mechanical equipment generally appeared in good condition. All gates were operated in the dry via the local PLC HMI. The operation of Gate 1 was witnessed and was observed to operate smoothly under “no-load condition.” The remaining gates were opened while the inspection team conducted the inspection of the downstream works. The control panel indicated that all five gates were in the open position at the end of the inspection and as observed the next day during the conduit inspection conducted by Matrix on November 14, 2018. SMRID confirmed that all gates operated without any issues.

The electrical and control system is in the adjacent control building and generally appears to be in good condition. As noted in previous DSRs, openings in the front of the panel from the original electro-mechanic controls have not all been covered properly and only duct tape was used to cover the last large opening. These openings need to be covered properly as per the Alberta electrical code requirements.

New wires installed during the control system replacement around 2005 do not show signs of wear or damage. Inside cable runs are relatively short and supported locally on rails, while longer outside cable runs are better protected in cable trays. It does not appear that any electrical or control cables are tagged. There are also several older cables which are not in service within the control building that can be removed.

A single level sensor / transducer provides reservoir level information for the Chin Reservoir and one for the Stafford Reservoir. Based on the previous DSRs, the Stafford level sensor appears sensitive to wave action even though it is a pressure sensor, which should naturally filter the level. It could be a loose transducer mount or other issue. The cause of this should be investigated and repaired if necessary to prevent false level indications and excessive gate adjustments.

Secondary power to operate the gates is provided by a power drill (stored inside the control panel) and a portable generator. All gate operators can also be manually adjusted via a handwheel permanently mounted on each actuator. There is no permanent generator connected nor is there a connection point for a temporary auxiliary generator.

During the conduit inspection by Matrix, the following key observations were made relative to the gates:

- Gate seals appeared to generally be in good condition. As the conduits were dewatered no observations of gate leakage were able to be made. This should be done under the next watered-up condition.

- The Gate 2 lowest stem guide is cracked and has broken-off the concrete anchors.

- Pitting is visible on all gates, with some heavier pitting on underside of Gate 3 and along the bottom thimble corners of Gate 4.

- Gate 5 side guides are heavily corroded and rusted near the bottom on both sides. SMRID indicated that the guides should be fixed this year. The gate side seals near the bottom were also in poor condition.

Automatic control of the gates is based on the water level of the Stafford Reservoir located downstream of the Chin Dam. Therefore, during flood conditions, the gates may need to be adjusted manually to obtain the desired discharge and Chin Reservoir level.

4 DAM SAFETY MANAGEMENT SYSTEM REVIEW

4.1 Emergency Management Plan

An emergency management plan is required for all dams with a dam consequence rating of significant, high, very high or extreme (GoA 2018). In the case of a dam with a consequence rating of high, very high or extreme, the emergency management plan must consist of the following documents.

- an EPP
- an Emergency Response Plan (ERP)
- a Flood Action Plan (FAP)

The following is a review of these plans.

4.1.1 Emergency Preparedness Plan

An EPP is a public document intended for use by external agencies, and should contain sufficient information for development of emergency response plans in the event of a dam failure or passage of a major flood. An EPP should outline roles and responsibilities of the various responders, describe the associated hazards, and list the notifications to be issued. An EPP is a requirement of the Alberta Dam and Canal Safety Directive (GoA 2018) for Very High consequence dams.

SMRID has the following EPP documentation:

- Chin 1 dam (West) EPP was prepared by UMA in 2001:
    - no updates since 2001
    - no record that the EPP was distributed to the relevant responders (included a distribution table but the table was not filled out)
    - the list of hazardous conditions (impacts) due to dam breach is out-of-date (e.g., flood maps missing houses immediately downstream of the dam)
    - contact information is out-of-date
    - Alberta River and Flood Forecast details are out-of-date
    - the dam consequence classification has been superseded
    - communication procedures may no longer be valid (e.g., procedure states that all written communication should be faxed)
- Chin 2 dam does not have an EPP.

In summary, an EPP for the Chin Reservoir facility exists but is out-of-date.

4.1.2 Emergency Response Plan

An ERP is an internal document for SMRID to document specific step-by-step procedures for handling various emergencies such as a dam breach. An ERP is a requirement of the Alberta Dam and Canal Safety Directive (GoA 2018) for Very High consequence dams such as Chin.

An ERP is not available for the two dams at Chin Reservoir.

4.1.3 Flood Action Plan

An FAP provides specific flood handling procedures. The procedures are intended to address the range of possible conditions during a flood, including the progression of triggers for intervention and the operating choices that may be limited by the timing of events. An FAP is a requirement of the Alberta Dam and Canal Safety Directive (GoA 2018) for Very High consequence dams such as Chin.

An FAP is not available for the Chin Reservoir. During the site inspection interviews, SMRID staff were able to describe some of the flood handling procedures that they would likely use but these procedures have not been documented or tested.

4.2 Operation Maintenance and Surveillance Manual

An OM&S Manual is intended to document the regular maintenance procedures, normal operating procedures, and surveillance requirements. An OM&S Manual is a requirement of the Alberta Dam and Canal Safety Directive (GoA 2018) for Very High consequence dams.

An OM&S Manual was not available for the Chin Reservoir. SMRID operating staff are trained and have staff redundancy in place to maintain the dams and to operate the structure with a degree of reliability, but the procedures have not been documented or fully tested.

Numerous recommendations are provided in this report to assist the SMRID in the surveillance of the dams and should be incorporated into an OM&S Manual. The summary in Section 6.3 is a representative list of OM&S Manual recommendations, but additional suggestions are included in the dam safety assessment sections.

5 FAILURE MODE ASSESSMENT

A brief failure mode assessment was conducted to highlight the possible range of credible dam failure modes at the Chin Reservoir. These are summarized below in terms of:

- overtopping of the dam(s) during a flood
- piping failure of the Chin 1 dam by rupture of the monolithic conduit structure
- undermining of the Outlet Structure
- gate equipment failure

5.1 Flood Overtopping of the Dam(s)

Containment of the Chin Reservoir at the Chin 1 dam (west) and Chin 2 dam (east) is expected to be overtopped during the IDF, and potentially during lesser flood events. A detailed assessment of the overtopping likelihood has not been completed for lesser events, but a previous study assessed the possible performance of a future spillway structure at the Chin 2 dam, whereby a spillway with a crest elevation of 862.0 m would spill about 10 m^3/s during the estimated 1:1,000 year flood event (Matrix 2018). Therefore, a 1:1,000 year event has the potential to begin overtopping the Chin 1 dam, depending on canal inflow and the timing of gate operations at the Chin 1 dam.

Overtopping would occur at the Chin 1 dam, which has a minimum crest elevation that is 0.6 m lower than the Chin 2 dam (based on survey data from 2015 at Chin 1 and 2017 at Chin 2). The overtopping location would be near the gate house and Outlet Structure.

Overtopping of the dam could result in dam failure due to headcut erosion. The overtopping flow would be near the Outlet Structure where the dam crest is low and the flow may be concentrated to one or two drainage paths around the Outlet Structure. Erosion along the side of the concrete structure may then accelerate uphill until a large gully forms. The gully may eventually breach the top of the dam.

During extreme flood events, SMRID has limited flood handling options for controlling the Chin Reservoir level:

- The upstream canal releases from the Milk River Ridge Reservoir (MRRR) may be stopped during an emergency, provided that MRRR does not have a dam safety issue.

- The Outlet Structure can be used to release water to the Stafford Reservoir, but the release rate may be similar to uncontrolled canal inflow resulting from local drainage along the canal.

- A controlled breach of the canal upstream of the Chin Reservoir may be used to prevent additional canal inflow, but this may not prevent overtopping because the local drainage IDF for Chin Reservoir is sufficient to fill and overtop the reservoir.

5.2 Piping Failure by Rupture of the Monolithic Conduit Structure

Propagation of cracks or further settlement of the conduits could jeopardize the integrity of the concrete conduits and could result in embankment material piping through the conduit to the outlet structure, creating a void in the embankment and undermining the stability of Chin 1 dam. The development of a large tension crack or spalling / honeycombing of the concrete are two potential mechanisms for this type of failure to be initiated.

However, tension crack expansion / development is considered unlikely as the settlement of the structure has slowed in recent years and existing cracks have been observed to be somewhat stable

year-over-year. Degradation of the concrete integrity could result from erosion of the concrete during discharge conditions especially immediately downstream of the gates where erosion has been previously noted. Maintaining clear air vents is a requirement as cavitation damage could occur if the air vents are plugged.

5.3 Undermining of the Outlet Structure

Scour at the toe of the stilling basin or separation between the Outlet Structure and the monolithic conduit structure could undermine the stability of the stilling basin, resulting in erosion of the embankment fill material at the toe of the dam. This could destabilize the toe of the dam and result in a piping type failure.

The stilling basin was submerged at the time of the inspection; therefore, it was not possible to assess the condition of the toe of the dam at this location. However, significant scour downstream of the stilling basin would likely cause the outlet structure to settle and separate more from the conduit structure. The stilling basin has settled slightly since construction but has been relatively stable since the Klohn-Crippen inspection in 1995 so it is likely that the stilling basin is performing adequately and protecting the toe of the dam from scour.

As aforementioned, the Outlet Structure has settled and separated from the conduit structure, but the separation is within the documented capability of the water stop that prevents water from undermining the embankment fill behind the outlet structure.

5.4 Gate Equipment Failure

Improper operation or failure of the gate or hoist equipment during a flood condition could result in the inability to adequately discharge flow through the Outlet Structure which could result in water levels cresting over the top of the dam in an extreme flood event (see also Overtopping of the Dam).

6 RECOMMENDATIONS

The Water (Ministerial) Regulation and the Alberta Dam and Canal Safety Directive define the following:

- A critical safety deficiency is a hazardous condition that has the potential to lead to an imminent failure.
- A safety deficiency (non-critical) is a hazardous condition that has the potential to develop into a critical safety deficiency over time.
- A non-conformance is a non-compliance with the Alberta Water Act, the Water (Ministerial) Regulation, or the Directive.

The dam owner must maintain a master list of all safety deficiencies and non-conformities.

6.1 Safety Deficiencies

The Chin Reservoir facility and its two dams have two safety deficiencies. First, the reservoir facilities are not adequate to accommodate the IDF without overtopping the dam. Second, the screening-level assessment provided in this DSR indicates that the dam may not satisfy the seismic criteria. The updated Master Deficiencies List is provided in Table H.

6.2 Non-Conformances

Two non-conformances exist. First, the Emergency Management Plan (EMP) has not been updated, and does not include the required ERP or FAP. Secondly, the OM&S Manual has not been completed. This OM&S manual would include a variety of procedures and measures that, if implemented, would satisfy many of the additional recommendations in this dam safety review. The updated Master Non-Conformances List is provided in Table I.

6.3 Additional Recommendations

There are a number of additional recommendations described throughout this report that are not currently considered a safety deficiency or non-conformance. These recommendations are summarized in Table J. Many of the recommendations are related to operation, maintenance and surveillance of the dams and would pro-actively address issues that may eventually lead to a safety issue.

The recommendations are focused on activities not already implemented by SMRID, and prioritized in terms of 1) high priority, 2) secondary priority, and 3) best management practices (BMPs).

A key consideration is the expected lifespan of the Outlet Structure and conduits given that the structure is 67 years old and has needed frequent repairs to cracks. Continued inspections of the Outlet Structure are recommended as a high priority; although, the structural site assessment did not identify an imminent threat to the dam and there is no foreseeable limit to the integrity of the Outlet Structure.

TABLE H Deficiencies List

No.	Safety Deficiency	Recommendation	Priority Rating	Existing Status	Updated Status	Comment[1]
D1	The existing facilities are inadequate to accommodate the Inflow Design Flood (IDF).	A means to safely handle the IDF should be provided (additional storage, spill capacity or combination thereof). For example construction of an emergency overflow weir on Chin 2 dam (East).	1 Non-critical	An assessment options was completed in 2018 (Matrix Solutions Inc. *Chin 2 Dam Proposed Spillway and Assessment of Dam Breach Inundation and Consequence Classification*. July 2018). SMRID is considering the recommendations and is currently pursuing funding sources.	January 2019: added to table.	Under current conditions, the reservoir could overtop Chin 1 dam (West) during a 1:1,000 year flood depending on canal inflow the timing of gate operations at the Chin 1 dam. E.g., there is approximately a 0.1% probability of a flood occurring in any given year that would overtop Chin 1 dam (West). Note that the Chin 2 dam (East) crest is 0.6 m higher that the Chin 1 dam crest.
D2	The dams may not satisfy the seismic criteria and may not perform as needed during an earthquake.	A detailed assessment, including a site investigation and laboratory testing program is needed to better estimate the likely performance of the dams under seismic loading.	2 Non-critical	The 2018 Dam Safety Review included a screening-level assessment of the Chin 1 dam embankment during the design seismic event. The assessment indicates a basis for concern.	January 2019: added to table.	Dynamic liquefaction might occur in the dam foundations during the design earthquake event but only if susceptible soils are present. Dynamic liquefaction is not considered to be a significant hazard for the Chin dams, but a site investigation is needed to confirm that susceptible soils are not present.

1. Comments should also state if previous deficiencies have been addressed comprehensively and can be removed from the list.
2. A critical safety deficiency is a hazardous condition that has the potential to lead to an imminent failure.
3. A safety deficiency (non-critical) is a hazardous condition that has the potential to develop into a critical safety deficiency over time.
4. St. Mary River Irrigation District (SMRID).

TABLE I Non-Conformances List

No.	Non-Conformance	Recommendation	Priority Rating	Existing Status	Updated Status	Comment[1]
N1	An Emergency Management Plan (EMP) has not been completed for the Chin Reservoir and structures.	Prepare an ERP and FAP in accordance with the Directive and CDA Guidelines. The EPP is dated 2001 and should be updated including with current impacts (new development downstream of Chin 1 dam) and in accordance with the Directive and CDA Guidelines.	1	An EPP is available but is out-of-date.	January 2019: added to table.	Per the Directive, an EMP comprised of an EPP, ERP, and a FAP is required for a dam with a consequence rating of high, very high or extreme. Chin 1 (West) and Chin 2 (East) dams have a consequence rating of Very High.
N2	An Operation, Maintenance and Surveillance (OM&S) Manual has not been completed for the Chin Reservoir and structures.	Prepare an OM&S Manual in accordance with the Alberta Dam and Canal Safety Directive and CDA Guidelines.	2	An OM&S is not available.	January 2019: added to table.	Per the Directive, an OM&S is required for a dam with a consequence rating of significant, high, very high or extreme. Chin 1 (West) and Chin 2 (East) dams have a consequence rating of Very High.

1. Comments should also state if previous non-conformances have been addressed comprehensively and can be removed from the list.
2. A non-conformance is a non-compliance with the Alberta Water Act, the Water (Ministerial) Regulation, or the Alberta Dam and Canal Safety Directive (the Directive).
3. St. Mary River Irrigation District (SMRID).

TABLE J Additional Recommendations

ID	Priority	Dam	Short Description	Recommendation
1	1 (High)	Chin 1 (West)	Gate replacement and repairs	Repair the gates and thimbles, including the broken stem bracket on Gate 2.
2	1	Chin 1 (West)	Road barriers	Install road barriers to mitigate the potential for damage from passing traffic near the fence by the control building and instrumentation along the dam crest.
3	1	Chin 1 (West)	Electrical system maintenance	Properly cover the openings in the control panels, tag the electrical and controls cabling for future troubleshooting, remove and properly cap all unused wiring.
4	2 (Secondary)	Chin 1 (West)	Inspect the area around the submerged Outlet Structure inlet for erosion or sinkholes	The area around the Outlet Structure inlet should be inspected to check for any evidence of sinkholes or similar depressions potentially associated with piping.
5	2	Chin 1 (West)	Outlet Structure inspections and repairs	Cracks in the conduit are detected and repaired on a high priority basis. The structure downstream of the gates should be inspected annually and the portion upstream of the gates should be inspected at least once every three years. The importance of inspecting the Outlet Structure at Chin 1 should be emphasized in the OM&S Manual.
6	2	Chin 1 (West)	Install Outlet Structure survey pins	Given the settlement of the Outlet Structure, monitoring pins should be installed at the gate well structure and the stilling basin to monitor potential movement or settlement in the future.
7	2	Chin 1 (West)	Survey left abutment culvert and ditch plug	The elevation of the culvert and ditch plug should be surveyed to confirm the conditions for which uncontrolled flow may be possible from the dam to the downstream abutment face. It is possible that the culvert level is lower than the minimum dam crest elevation near the gate house.
8	2	Chin 1 (West)	Cap the gravel filled sump on the upstream end	Consider capping the reservoir end of the gravel filled sump at the upstream toe in the old stream channel may improve resistance against seepage, which could result in foundation piping.
9	2	Chin 1 (West)	Install piezometers	Consider installing additional piezometers to allow better assessment of foundation pore pressures and seepage gradients beneath the downstream portion of the dam.
10	2	Chin 2 (East)	Install piezometers	Consider installing piezometers to allow better assessment of pore pressures and seepage gradients in the embankment and foundation.
11	2	Chin 2 (East)	Install filtered drain on right abutment.	Seepage is reported to flow to the right abutment downstream of the East Dam when the reservoir rises above Elevation 860 m. Consider installing a filtered drain to safely intercept the seepage reporting to the abutment area and facilitate monitoring.
12	2	Chin 1 (West) & Chin 2 (East)	Install secondary water level sensors	Consider installing secondary water level sensors to provide redundant signal for detection of sensor failure and allow continuous safe operation.
13	3 (BMPs)	Chin 1 (West) & Chin 2 (East)	Ensure riprap bedding is installed during riprap repairs	Inspection and maintenance of the riprap erosion protection on the upstream slopes of the dams is expected to be necessary on an ongoing basis. Repairs or placement of additional erosion protection areas should include placement of suitable bedding and transition materials, as necessary, and should provide for careful riprap placement to minimize gaps between riprap pieces.
14	3	Chin 1 (West)	Resume readings of the piezometer array near the Outlet Structure gatewell	For the piezometers in the array installed during construction near the Outlet Structure gatewell, the possibility of clearing or repairing those that have become difficult to read. Implement an alternative reading system, such as a flexible coaxial cable.

ID	Priority	Dam	Short Description	Recommendation
15	3	Chin 1 (West) & Chin 2 (East)	Dam crest survey	Survey the crest elevation of the dams every 5 years.
16	3	Chin 1 (West)	Road grading	Grader ridges on the crest of the West Dam tend to cause surface water to pool on the crest. The ridges should be removed or breached at frequent intervals to allow drainage and avoid significant concentration of runoff flows.
17	3	Chin 2 (East)	Road grading	The dam crest should be graded to drain to the upstream slope. This will reduce the potential for pooling of water on the crest and for damage due to traffic under wet conditions.
18	3	Chin 1 (West) & Chin 2 (East)	Monitor for small piping erosion features from water on the dam crest	Small piping features have previously developed from drainage of surface water pools along the dam crest. Vigilance is required to ensure such features are detected and repaired prior to progressive erosion.
19	3	Chin 1 (West) & Chin 2 (East)	Monitor for seepage during high reservoir levels (reservoir levels more than 0.4 m and 0.8 m above FSL for Chin 1 and Chin 2, respectively).	During high reservoir levels, significant seepage and piping issues may occur through the frost impacted and erosion prone upper portions of the dams. If adverse performance is detected, suitable measures should be implemented to protect the dam and downstream stakeholders should be warned so measures to mitigate dam failure consequences can be initiated. Equipment and materials (including filter fabric and drainage gravel) necessary to address indications of adverse performance should be on-hand for use.
20	3	Chin 1 (West)	PLC input, alarm testing and setting	Complete testing and re-calibration of the PLC inputs and alarms to confirm proper operation and remote status. This would include gate positions and water levels. Log all changes and tests completed.
21	3	Chin 1 (West)	Observe gate operations	Operate all gates to full capacity each year during high flow and record operation performance under “full-load condition.”
22	3	Chin 1 (West)	Monitor seepage to the old downstream channel and outlet canal during low Stafford Reservoir levels	Seepage from the dam foundation and embankment drains to the old stream channel and outlet canal near the left and right sides of the coulee bottom, respectively. This is the most likely location where boils and/or turbid seepage flow from foundation piping may be expressed. Periods of low water level in the Stafford Reservoir should be used to facilitate inspection and assessment of seepage.
23	3	Chin 2 (East)	Monitor seepage to the downstream borrow pits	Seepage reporting to the downstream toe of the dam has largely dried up in recent years and this is attributed to reservoir siltation, but could still occur as piping to the water-filled borrow pits downstream of the dam. Channel flow downstream of the pits or, if none, the water levels in the pits should be monitored to confirm decreasing seepage flows.

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APPENDIX A
Available Information

AVALIABLE INFORMATION

Dam Safety Reviews

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APPENDIX B
Figures

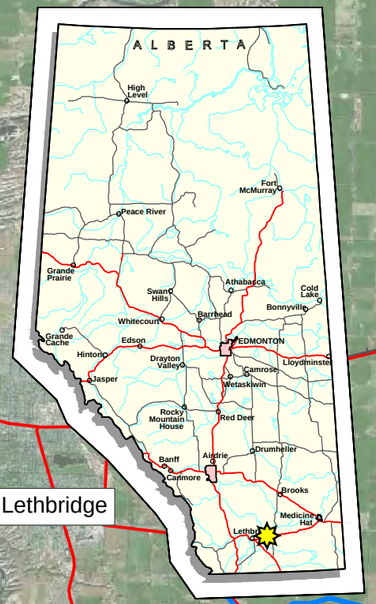
Plot 11 = Tabloid (L)

Easting (m)

370000 375000 380000 385000 390000 395000 400000 405000 410000 415000 420000 425000 430000 435000 440000

Northing (m)

5520000 5515000 5510000 5505000 5500000 5495000 5490000 5485000



Lethbridge

Taber

Old Man River

Dam Breach Direction of Flow

Chin

SMRID Main Canal

Stafford Reservoir

Chin 1

Chin Reservoir

Chin 2

Cross Catchment Area
247 km²

SMRID Main Canal

3 4 5 36 61 72

N

Flow Direction
Catchment Area
3 Highway (IHS data)
72 Township Road (IHS Data)
CPR Rail Line (IHS Data)

1 : 200,000 metres
2000 0 2000 4000
UTM83-12

Note: Figure(s) must be used in conjunction with the attached report and is subject to the limitations and conditions stated in the report.

Reference: July 2011 aerial photograph captured from Bing Imagery © Microsoft Corporation.

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

St. Mary River Irrigation District
2018 Chin Reservoir Dam Safety Review

Location Plan

Date:	Project:	Submitter:	Reviewer:
December 2018	23637-SP-18	D. Kushner	M. Bender

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Figure 1

F:\23637\Drafting\20181023637-SP-18.dwg - LOC - Friday, January 27, 2017 4:24:26 PM - Patrice Cantin

1955: PFRA completed construction of Chin 1 (West) and Chin 2 (East) dams.

(PFRA 1986)

1968: St. Mary River Irrigation District was formed

(PFRA 1986)

1955: Settling and significant cracking of the concrete occurred in all conduits. Largest crack was 9 m downstream of the gates (50 mm wide) where the conduit structure was broken through completely.

(PFRA 1986)

1981: Dissipation structure movement

- North side wall was 300 mm lower than the conduit structure
- Dissipation structure pulled away from the conduits by about 200 mm
- Both side walls fractured and backfill had been washed away

(PFRA 1986)

1980: Dissipation structure pulled away from the conduits by about 100 mm

(PFRA 1986)

1979: Gate 1 failed and was sealed (inoperative)

(PFRA 1986)

1973: Gate 3 developed considerable leakage and was sealed (inoperative)

(PFRA 1986)

1986: DSR PFRA – Chin 1 and 2

- Dam Hazard Potential Classification: Significant / High
- Chin 1 does not pass the IDF (IDF = PMF)
- Provide a means to meet the IDF
- Perform a detailed dam hazard assessment
- Prepare an OMS Manual
- Provide all weather access to Chin 2
- Inspect the outlet structure every 2 years
- Inspect cracks in the conduits semi-annually
- Repair the cover plates installed 9 m downstream of the gates
- Inspect Chin 1 abutments semi-annually for settlement
- Monitor the erosion gully downstream of Chin 2
- Monitor the seepage at the right (south) abutment of Chin 2

(PFRA 1986)

1982: Design capacity of LLO increased from 51 to 74 m^3/s

(PFRA 1986)

1986: PFRA established:

- The PMF (and IDF) as 583 m^3/s and 102,000 dam^3
- The Dam hazard Potential Classification as Significant / High

(PFRA 1986)

1955 1960 1965 1970 1975 1980 1985 1990 1995

1956: Conduit repairs

- Large cracks were pressure grouted

(PFRA 1986)

1961: Conduit repairs

- Large cracks in the conduits re-opened to about 16 mm
- Cracks were pressure grouted

(PFRA 1986)

1963: Scour hole downstream of the LLO

- Repaired, backfilled, re-sloped and grouted riprap installed

(PFRA 1986)

1966: Conduit repairs

- Large cracks in the conduits re-opened to 1.5 mm
- Cracks were pressure grouted

(PFRA 1986)

1963: Conduit repairs

- Large cracks in the conduits re-opened and 2.5 m^3 of soil flowed into the conduit
- Cracks were pressure grouted
- Conduit barrels upstream of the gates were gunnited (coated with concrete)

(PFRA 1986)

1982: LLO and gate rehabilitation

- Repair of conduits and gates (all gates operational again)
- Replacement of outlet structure with new stilling basin
- Pressure grouted the large cracks in conduits (9 m downstream of the gates)
- Installed galvanized plates over the large cracks

(PFRA 1986)

1982: Operating System Upgrades

- Control building and concrete deck constructed
- Semi-automatic control system installed
- Gates upgraded with electric actuators (previously manual)
- Chain-link fence installed around the top of the gate wells

(PFRA 1986)

1986: FSL reduced from 862.27 m to 861.36 m (estimated year)

(AECOM 2013)

1990: First SMRID annual inspection records

- Annual inspections continued every year to present

1993: Gate Reconditioning and Replacement

- Reservoir was partially dewatered
- Replacement of gates 1,2 and 4 with new Armtec 55-10 cast iron gates
- Gate 2 and 5 were reconditioned and re-installed in conduits 3 and 5, respectively

(Klohn 1995)

LLO = Low Level Outlet
FSL = Full Supply Level
EPP = Emergency Preparedness Plan
IDF = Inflow Design Flood
PMF = Probable Maximum Flood
OMS = Operations Maintenance and Surveillance
PFRA = Prairie Farm Rehabilitation Administration

References: Matrix 2019. 2018 Chin Reservoir Dam Safety Review. Appendix E.

LEGEND

- MAJOR MILESTONES
- MAJOR ISSUES
- LLO & GATES CONSTRUCTION / MAINENANCE
- OTHER CONSTRUCTION / MAINTENANCE
- DAM SAFTEY REVIEW RECOMENDATIONS

REVISION

No.	DATE	DESCRIPTION	BY
1	2018-12-03	Final Issued to Client	DK

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

St. Mary River Irrigation District
Chin Reservoir Dam Safety Review

Timeline
1955 to 1995

Date:	Project:	Technical:	Reviewer:	Drawn:
December 2018	166861-23637-535	D. Kushner	M. Bender	D. Kushner

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Figure 2A

"F:\25185\522\Construction\Monitoring\6. Exceedances\Nov 23 to 30-2018 Ref 347050"

1995: DSR Klohn Crippen – Chin 1 (West)
- Dam Consequence Classification: Significant / High
- Chin 1 does not pass the IDF (IDF = PMF)
- Provide a means to meet the IDF
- Perform a detailed dam hazard assessment
- Prepare an Emergency Preparedness Plan
- Prepare an OMS Manual
- Parametric stability analysis of Chin 1 Dam
- Interpret settlement gauges every 5 years
- Re-activate plugged standpipe piezometers
- Monitor two small holes on the downstream slope
- Repair and regrade areas of significant surface erosion
- Place additional riprap on the upstream slope of Chin 1 where the riprap is thin
- Maintain regular inspection of the conduits and outlet structure

(Klohn 1995)

2002: DSR Klohn Crippen – Chin 1 (West)
- Dam Consequence Classification: Very High
- Chin 1 does not pass the IDF (IDF = PMF)
- Provide a means to meet the IDF
- Perform a detailed dam hazard assessment
- Review the PMF and IDF
- Prepare an EPP
- Prepare an OMS Manual
- Re-activate plugged standpipe piezometers
- Survey of the dam crest elevation and several cross sections
- Conduit repairs required: exposed reinforcing, repairs on the major cracks
- Repair the culvert at the left abutment or provide erosion protection
- Maintain regular inspection of the conduits and outlet structure

(Klohn 2002)

2003: DSR William Projects Limited – Chin 2 (East)
- Dam Consequence Classification: Low (Chin 2)
- Review the PMF and IDF
- Continue annual inspections
- Conduct a Dam Safety Review in 7 years
- Repair the small erosion tunnels on the dam crest and downstream slope
- Regrade and gravel the dam crest and provide positive drainage to the upstream side
- Place riprap on upstream slope where riprap is thin near the abutments
- Stabilize the erosion gully downstream of the dam
- Repair the potholes on the dam access road (north of the dam)

(WPL 2003)

2013: DSR AECOM – Chin 1 and 2
- Dam Consequence Classification: Extreme
- Chin 1 does not pass the IDF (IDF = PMF)
- Provide a means to meet the IDF
- Perform an Inundation study downstream of Chin 2
- Complete an OMS Manual
- Upgrades to allow more remote operation
- General maintenance on the control building
- Regular gate maintenance program
- Replace the gates
- Consider replacing the conduit structure
- Continue conduit inspection program
- Repair the cover plates (9 m d/s of the gates)
- Continue monitoring instrumentation data
- Repair erosion on downstream left abutment of Chin 1 and install cattle fence

(AECOM 2013)

2017: Dam Hazard Classification and IDF Study
- Chin 1 Dam Consequence Classification: Very High, IDF = 2/3 PMF
- PMF = 669 m^3/s
- IDF = 495 m^3/s, 52,240 m^3

(Matrix 2017)

2018: Chin 2 Dam Break Inundation Study
- Chin 2 Dam Consequence Classification: Very High

(Matrix 2018)

1996: Chin 1 Parametric Stability Analysis

(Klohn 1996)

2000: Chin 1 Dam Break Inundation Study
- Dam Consequence Classification changed to Very High
- IDF = PMF

(Klohn 2000)

2010: Flood of Record (June 17-23)
- Estimated peak daily inflow to Chin Reservoir: 50 m^3/s
- Peak outflow from Stafford Reservoir: 23 m^3/s
- Peak Chin Reservoir level: 861.92 m
- Peak Stafford Reservoir level: 846.94 m

2013: Dam Consequence Classification Updated to Extreme, IDF = PMF

(AECOM 2013)

2012: Hydrology Study
- PMF = 722 m^3/s, 79,000 dam^3

(AECOM 2012)

1995 2000 2005 2010 2015 2018

1997: Extensometers installed on the conduit ceiling in conduits 1 and 3

(Klohn 1995)

2001: EPP completed for Chin 1

2001: Houses built downstream of Chin 1 (West)

2001: Upgrade and repairs of the LLO Intake
- Cofferdam constructed across the inlet
- Repair of the erosion and scour around the inlet
- Construction of a concrete apron upstream of the inlet
- Additional riprap placed around and over the inlet structure

(SMRID Inspection 2001)

2004: Conduit 3 repairs
- Replaced floor plate (at crack 9 m downstream of gate)
- Grouted and feathered from plates to conduit walls

(SMRID Inspection 2004)

2010: Conduit 5 repairs
- Steel plate was missing (at the large crack 9 m downstream of the gate)
- Crack was grouted, no new plates were installed

(SMRID Inspection 2013)

2012: Chin 2 dam maintenance
- Surfacing along dam crest road
- Scarping of upstream face observed resulting in "dishing" of riprap
- Repaired upstream riprap (estimated year)

(SMRID Inspection 2012)

2012: Installed culvert at Chin 1 left abutment

(SMRID Inspection 2012)

2013: Conduit repairs
- Repair steel gate thimbles in gates 3 and 5
- Repair pitting by welding gates 1,2 and 4
- Repair scour in concrete immediately downstream of gates
- Replace damaged steel covers (9 m downstream of gates) in conduits 1, 2 and 5
- Grouting of other cracks in all conduits

(SMRID Inspection 2014)

2016: Repairs to gate actuators
- Drive nuts and bearings replaced in actuators 1 to 4

(SMRID Inspection 2016)

2015: Repairs to irrigation inlet to Chin Reservoir
- Repaired large area on bottom slab, cut out slab and poured new concrete
- Grouted pitted or eroded areas of concrete
- Repaired cracks with flexible grout

(SMRID Inspection 2015)

LLO = Low Level Outlet
FSL = Full Supply Level
EPP = Emergency Preparedness Plan
IDF = Inflow Design Flood
PMF = Probable Maximum Flood
OMS = Operations Maintenance and Surveillance
PFRA = Prairie Farm Rehabilitation Administration

References: Matrix 2019. 2018 Chin Reservoir Dam Safety Review. Appendix E.

LEGEND
- MAJOR MILESTONES
- MAJOR ISSUES
- LLO & GATES CONSTRUCTION / MAINENANCE
- OTHER CONSTRUCTION / MAINTENANCE
- DAM SAFTEY REVIEW RECOMENDATIONS

REVISION			
1	2018-12-03	Final Issued to Client	DK
No.	DATE	DESCRIPTION	BY

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

St. Mary River Irrigation District
Chin Reservoir Dam Safety Review

Timeline 1995 to 2018

Date:	Project:	Technical:	Reviewer:	Drawn:
December 2018	166861-23637-535	D. Kushner	M. Bender	D. Kushner

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Figure 2B

"F:\25185\522\Construction\Monitoring\6. Exceedances\Nov 23 to 30-2018 Ref 347050"

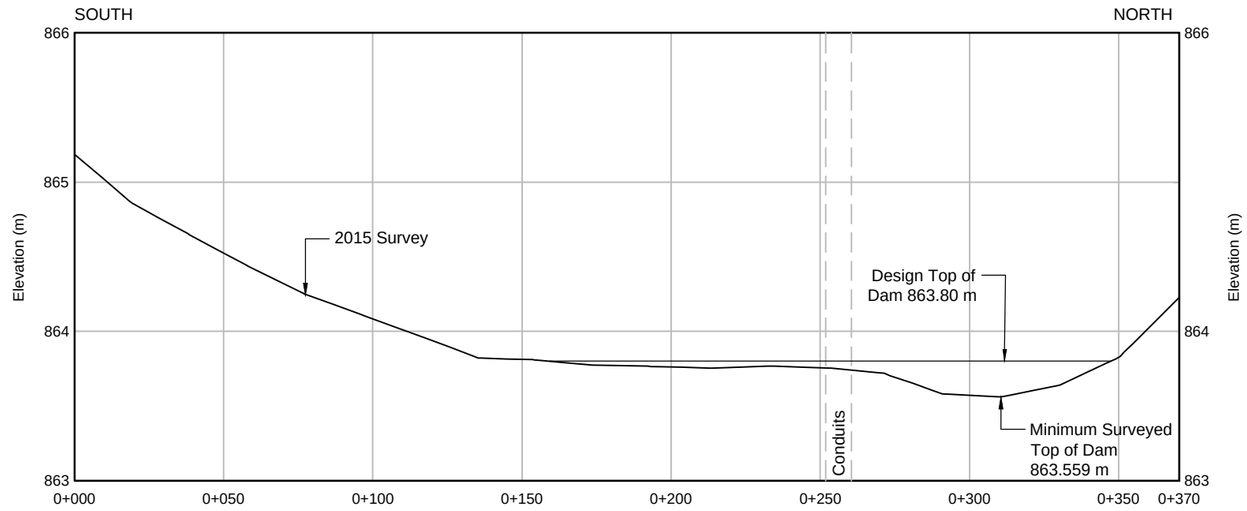
APPENDIX C
Surveys

APPENDIX D
Dam Crest Surveys
Figures 3 and 4

Plot 1:1 = Tabloid (L)



Detailed Plan View
Scale 1:7500



A — **Profile**
Horizontal Scale 1:2000
Vertical Scale 1:40

1:40 Meters
0.4 0 0.4 0.8
UTM83-12

1:2000 Meters
20 0 20 40
UTM83-12

1:7500 Meters
75 0 75 150
UTM83-12

Note: Figure(s) must be used in conjunction with the attached report and is subject to the limitations and conditions stated in the report.

Reference: July 2011 aerial photograph captured from Bing Imagery © Microsoft Corporation.

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

St. Mary River Irrigation District
2018 Chin Reservoir Dam Safety Review

Chin 1 Dam Profile

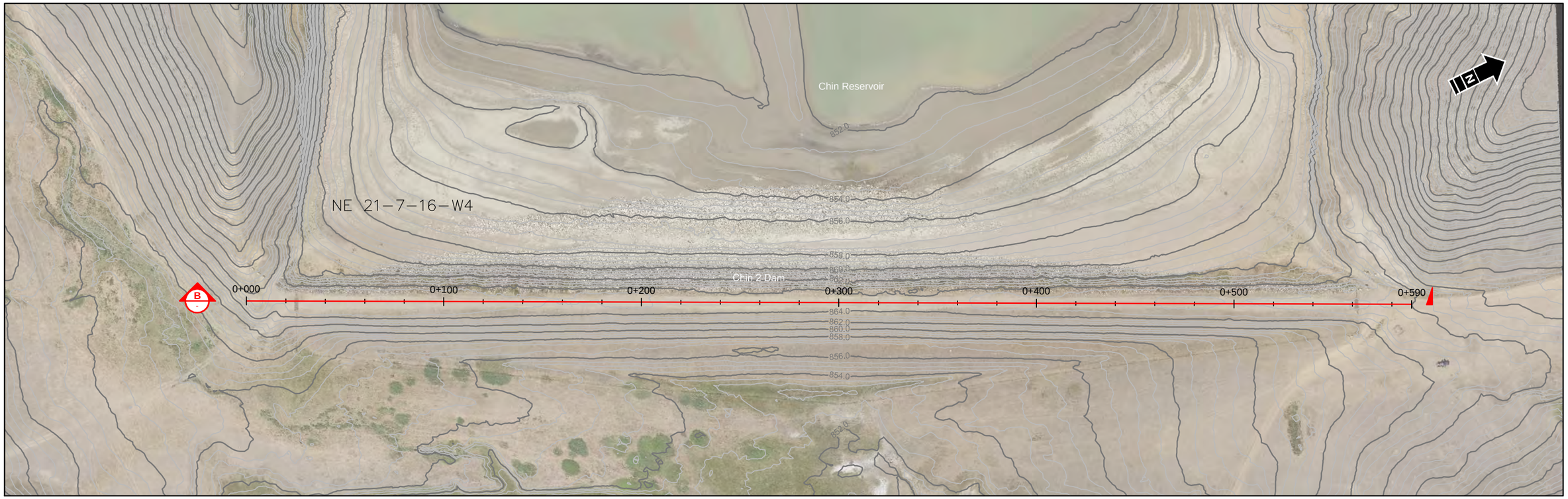
Date:	Project:	Submitter:	Reviewer:
December 2018	23637-SP-18	D. Kushner	M. Bender

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

Figure 3

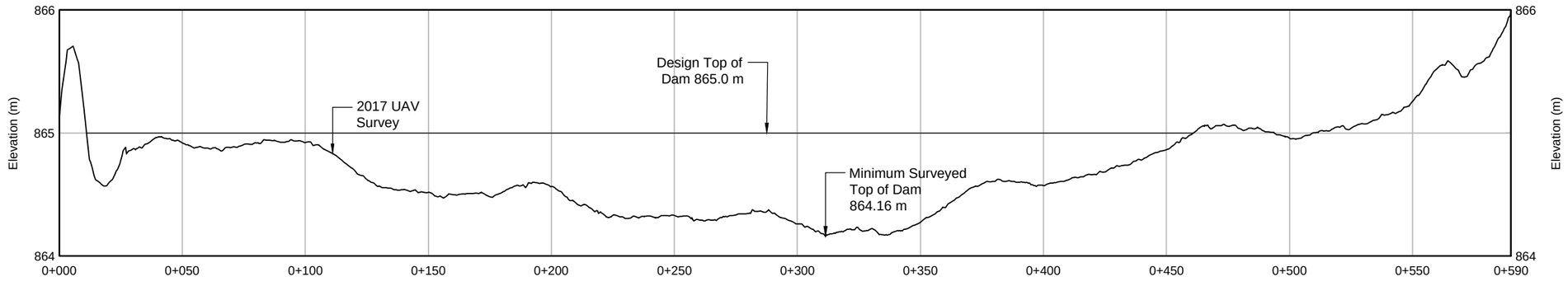
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Plot 1:1 = Tabloid (L)



Detailed Plan View

Scale 1:2000



B - Profile

Horizontal Scale 1:2000
Vertical Scale 1:40

1:40 Meters
0.4 0 0.4 0.8
UTM83-12

1:2000 Meters
20 0 20 40
UTM83-12

Reference: July 2017 UAV Image and surface contours by Ventus Geospatial. Design dam elevation from As-Built Plan no. 27555-L-C575 provided by Client.

Note: Figure(s) must be used in conjunction with the attached report and is subject to the limitations and conditions stated in the report.

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

St. Mary River Irrigation District
2018 Chin Reservoir Dam Safety Review

Chin 2 Dam Profile

Date:	Project:	Submitter:	Reviewer:
December 2018	23637-SP-18	D. Kushner	M. Bender

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

Figure 4

F:\23637\Drafting\20182\23637-SP-18.dwg - PROF-CH2 - Wednesday, January 23, 2019 9:11:58 AM - David Williamson

APPENDIX D
Conduit Settlement Surveys 1952 to 2018

5 Sheets

LEGEND

SPOT ELEV.'S TAKEN FEB. 17/82 , CONDUIT No. 1 (NORTH) ℄ OF FLOOR

NOTE:
REFER TO FIGURE No. 11 OF REPORT ON THE PERFORMANCE OF CHIN DAM No. 1 ST. MARY IRRIGATION PROJECT, MAY 8, 1970 BY GOVERNMENT OF CANADA PFRA ENGINEERING SERVICE.

PROFILES SHOWN THUS TAKEN FROM FLOOR BOLTS :

MARCH /84 – CONDUIT No.1

NOTE:
ELEV.'S TAKEN IN 1982 WERE SURVEYED AT THE CENTER LINE OF THE CONDUITS AND NOT ON THE BOLTS.

TO OBTAIN ORIGINAL PFRA ELEVATIONS FROM GEODETIC METRIC SUBTRACT 0.026, DIVIDE BY 0.3048 AND SUBTRACT 31.96.

STA. 0+000 = CONDUIT INLET (STA. 12+50 Ft. PFRA) FIG. 11 METERS TO FEET DIVIDE BY 0.3048.

NOTE:
PLOTS PRIOR MARCH 11/98 HAVE BEEN SCALED AND REPLOTTED FROM UMA DRAWING TITLED: CONDUIT SETTLEMENT – CHIN RESERVOIR OUTLET STRUCTURE
UMA PROJECT No. 1758–013–01, DRAWING W1579, REV 2

NOTE:
SURVEYS AFTER AND INCLUDING NOV. 16/98 MAY BE MORE ACCURATE DUE TO A BETTER LIGHTING SYSTEM.

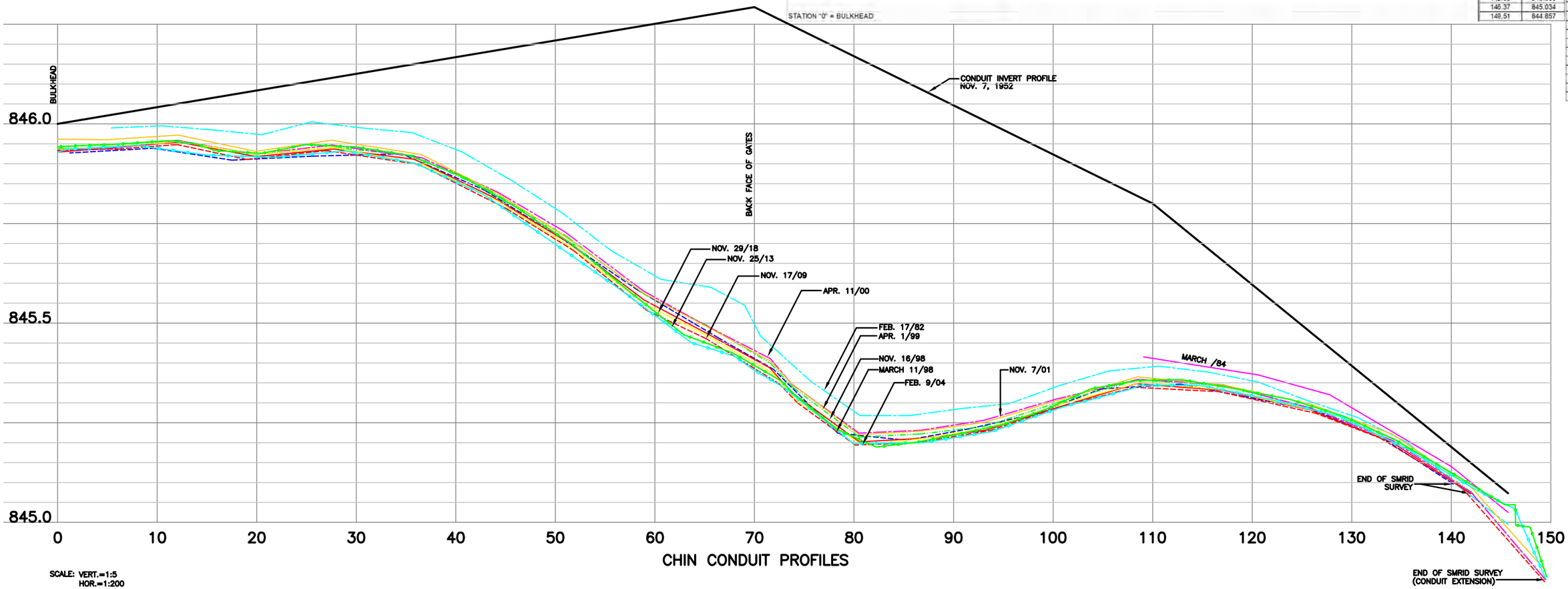
BENCH MARK : ASCM # 78162, ELEV = 919.676
LATERAL TOLERANCE : +/– 150 mm FROM CONDUIT CENTER LINE

FLOOR ℄ SURVEYED BY SMRID MARCH 11/98, CONDUIT No.1 – NO ICE ON FLOOR
FLOOR ℄ SURVEYED BY SMRID NOV. 16/98, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID APR. 1/99, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID APR. 11/00, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID NOV. 7/01, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID FEB. 9/04, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID NOV. 17/09, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID NOV. 25/13, CONDUIT No.1
FLOOR ℄ SURVEYED BY SMRID NOV. 29/18, CONDUIT No.1

CONDUIT #1

READING #1		READING #2		READING #3		READING #4		READING #5		READING #6		READING #7		READING #8		READING #9		READING #10	
FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)	
11-Mar-98		16-Nov-98		1-Apr-99		11-Apr-00		7-Nov-01		9-Feb-04		15-Dec-05		17-Nov-09		25-Nov-13		14-Nov-18	
STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.
1.26	845.927	0.00	845.929	0.00	845.939	0.00	845.933	0.00	845.962	0.00	845.935	0.00	845.933	0.00	845.934	0.00	845.928	0.10	845.943
9.66	845.939	4.80	845.939	4.94	845.94	4.86	845.937	4.83	845.960	5.06	845.943	5.08	845.935	6.04	845.937	0.87	845.936	5.90	845.949
17.53	845.909	12.21	845.954	12.10	845.959	12.04	845.958	12.11	845.972	12.23	845.956	12.20	845.949	12.01	845.948	7.95	845.946	11.15	845.958
25.65	845.919	19.95	845.918	19.87	845.923	19.88	845.924	19.89	845.931	19.81	845.924	19.91	845.915	18.96	845.911	14.86	845.922	14.02	845.949
34.58	845.925	27.70	845.937	27.73	845.941	27.56	845.947	27.53	845.959	27.61	845.941	27.65	845.938	27.02	845.933	21.83	845.916	15.79	845.933
42.90	845.834	35.85	845.911	35.77	845.92	36.59	845.915	36.54	845.923	36.67	845.898	36.51	845.898	36.31	845.898	28.90	845.932	20.49	845.926
50.51	845.715	43.60	845.818	43.38	845.833	44.25	845.828	44.23	845.825	44.25	845.806	44.33	845.799	45.17	845.786	35.94	845.901	24.95	845.948
58.24	845.584	51.27	845.703	51.12	845.718	50.89	845.730	51.07	845.716	51.23	845.695	51.28	845.692	51.83	845.682	42.78	845.823	29.94	845.942
66.40	845.463	58.92	845.558	58.96	845.572	58.88	845.580	58.93	845.574	59.04	845.547	58.98	845.538	59.18	845.532	49.77	845.702	35.30	845.921
71.94	845.384	65.24	845.474	65.16	845.495	65.10	845.494	65.09	845.493	65.12	845.470	65.26	845.460	65.14	845.461	56.69	845.581	40.74	845.867
78.39	845.224	71.53	845.388	71.61	845.399	71.59	845.411	71.64	845.404	71.79	845.376	71.80	845.368	72.47	845.348	63.64	845.451	46.04	845.791
85.30	845.206	73.79	845.325	73.84	845.339	73.79	845.346	73.75	845.348	74.19	845.306	74.22	845.296	74.32	845.300	67.98	845.417	51.82	845.699
91.65	845.235	80.52	845.202	80.54	845.214	80.51	845.224	80.50	845.220	80.83	845.194	80.69	845.182	80.12	845.194	69.90	845.383	57.26	845.583
98.16	845.272	86.88	845.211	86.77	845.222	86.68	845.231	86.74	845.229	86.87	845.210	86.56	845.196	86.29	845.200	72.97	845.338	62.89	845.471
104.92	845.335	93.17	845.231	93.18	845.241	93.05	845.256	93.13	845.251	93.52	845.237	93.51	845.226	93.75	845.231	79.99	845.197	67.81	845.425
112.81	845.347	100.40	845.288	100.43	845.301	100.43	845.310	100.43	845.306	100.95	845.288	100.80	845.294	100.47	845.288	86.98	845.200	72.68	845.355
119.20	845.316	108.34	845.348	108.48	845.357	108.59	845.359	108.50	845.365	108.90	845.352	108.67	845.353	108.19	845.339	93.88	845.228	73.97	845.322
126.22	845.281	117.14	845.331	116.91	845.344	117.08	845.345	117.02	845.345	117.29	845.332	117.08	845.340	116.66	845.328	100.89	845.289	78.32	845.233
133.34	845.208	125.85	845.282	125.77	845.288	125.83	845.287	125.84	845.297	126.14	845.281	126.14	845.293	126.34	845.274	107.86	845.335	82.22	845.189
140.23	845.096	134.036	845.201	134.19	845.21	134.12	845.205	134.12	845.221	ice	ice	134.04	845.220	132.81	845.212	108.66	845.344	86.27	845.201
		141.946	845.072	142.018	845.076	142.02	845.074	142.00	845.088	ice	ice	141.88	845.099	140.98	845.089	114.72	845.344	90.58	845.222
				149.45	844.856	149.45	844.857	149.38	844.881	ice	ice	ice	ice	149.37	844.851	121.76	845.309	94.89	845.245
																128.80	845.266	99.32	845.284
																135.66	845.183	103.79	845.335
																142.58	845.060	108.45	845.356
																146.37	845.034	112.926	845.358
																149.51	844.857	118.34	845.335
																		123.729	845.309
																		129.194	845.266
																		134.357	845.207
																		139.772	845.128
																		145.381	845.044
																		146.424	845.044
																		146.45	844.993
																		147.913	844.988
																		149.59	844.863

STATION "0" = BULKHEAD



SCALE: VERT.=1:5
HOR.=1:200

ST. MARY RIVER IRRIGATION DISTRICT	
CHIN RESERVOIR OUTLET STRUCTURE	
CONDUIT SETTLEMENT CONDUIT 1	
DRAWN J. MARTHALLER	SURVEY B. WEILER
SCALE AS SHOWN	
DATE NOVEMBER/2018	
	DWG. NO. CC 5 – 1

LEGEND

NOTE:
REFER TO FIGURE No. 11 OF REPORT ON THE PERFORMANCE OF CHIN DAM No. 1 ST. MARY IRRIGATION PROJECT, MAY 8, 1970 BY GOVERNMENT OF CANADA PFRA ENGINEERING SERVICE.

NOTE:
ELEV.'S TAKEN IN 1982 WERE SURVEYED AT THE CENTER LINE OF THE CONDUITS AND NOT ON THE BOLTS.

TO OBTAIN ORIGINAL PFRA ELEVATIONS FROM GEODETIC METRIC SUBTRACT 0.026, DIVIDE BY 0.3048 AND SUBTRACT 31.96.

STA. 0+000 = CONDUIT INLET (STA. 12+50 Ft. PFRA) FIG. 11 METERS TO FEET DIVIDE BY 0.3048.

NOTE:
PLOTS PRIOR MARCH 11/98 HAVE BEEN SCALED AND REPLOTTED FROM UMA DRAWING TITLED: CONDUIT SETTLEMENT – CHIN RESERVOIR OUTLET STRUCTURE
UMA PROJECT No. 1758–013–01, DRAWING W1579, REV 2

NOTE:
SURVEYS AFTER AND INCLUDING NOV. 16/98 MAY BE MORE ACCURATE DUE TO A BETTER LIGHTING SYSTEM.

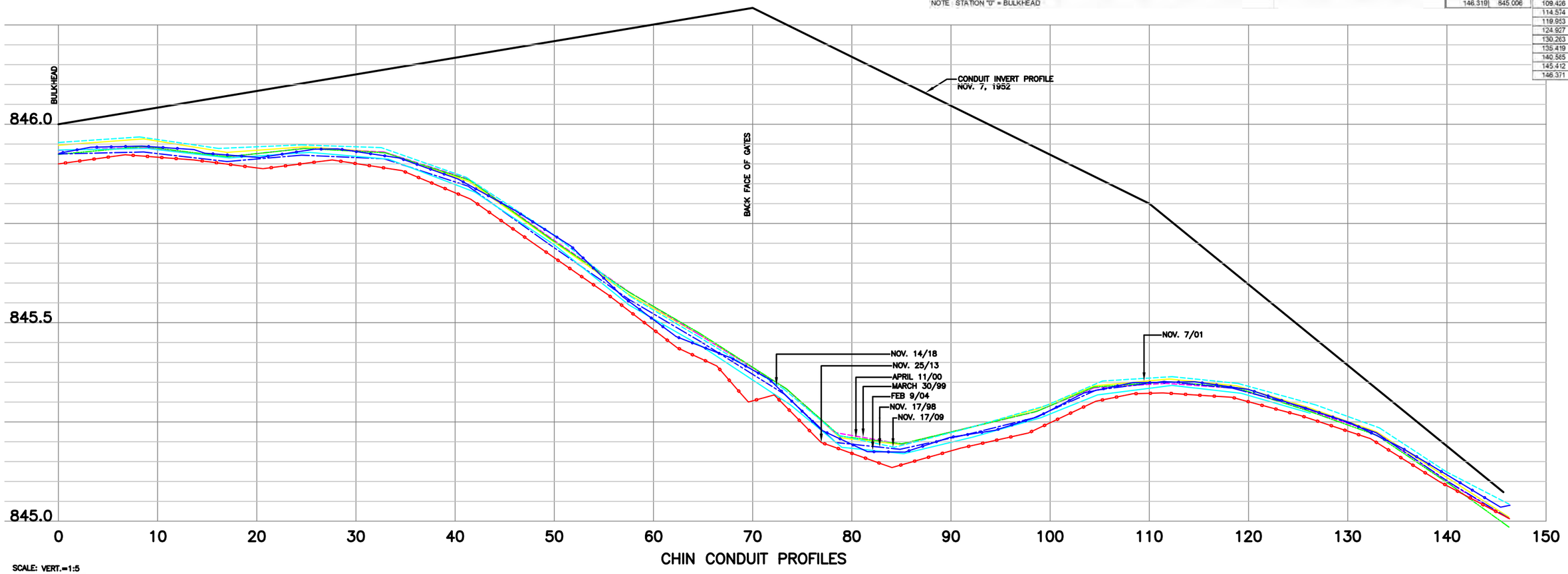
BENCH MARK : ASCM # 78162, ELEV = 919.676
LATERAL TOLERANCE : +/– 150 mm FROM CONDUIT CENTER LINE

FLOOR ℄ SURVEYED BY SMRID NOV. 17/98, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID MAR. 30/99, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID APR. 11/00, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID NOV. 7/01, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID FEB. 9/04, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID NOV. 17/09, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID NOV. 25/13, CONDUIT No.2
FLOOR ℄ SURVEYED BY SMRID NOV. 14/18, CONDUIT No.2

CONDUIT #2

READING #1		READING #2		READING #3		READING #4		READING #5		READING #6		READING #7		READING #8	
FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)	
17-Nov-98		30-Mar-99		11-Apr-00		7-Nov-01		9-Feb-04		17-Nov-09		25-Nov-13		14-Nov-18	
STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.
0.00	845.925	0.00	845.934	0.00	845.924	0.00	845.947	0.00	845.960	0.00	845.954	0.000	845.900	0.100	845.927
8.58	845.930	8.61	845.942	8.57	845.944	8.60	845.963	8.90	845.964	8.16	845.968	6.734	845.923	3.236	845.942
17.00	845.906	16.95	845.917	16.99	845.918	16.99	845.929	17.21	845.940	16.15	845.939	13.670	845.910	8.410	845.945
24.50	845.922	24.69	845.939	24.90	845.939	24.89	845.943	25.31	845.954	24.48	845.948	20.620	845.888	13.683	845.936
32.83	845.913	32.62	845.930	32.94	845.928	32.96	845.929	33.28	845.937	32.55	845.941	27.604	845.910	14.781	845.927
41.31	845.844	41.32	845.862	41.47	845.859	41.45	845.855	41.99	845.854	41.14	845.866	34.650	845.883	20.301	845.916
49.28	845.701	49.44	845.717	49.47	845.714	49.47	845.712	50.01	845.721	50.09	845.719	41.576	845.811	25.814	845.937
57.56	845.558	57.51	845.578	57.46	845.578	57.40	845.573	57.51	845.570	57.69	845.566	48.525	845.689	28.168	845.938
64.57	845.455	64.47	845.472	64.68	845.473	64.68	845.469	64.94	845.464	64.58	845.464	55.434	845.570	34.337	845.915
73.19	845.320	73.31	845.335	73.42	845.333	73.42	845.333	73.80	845.318	73.03	845.334	62.381	845.437	40.287	845.882
78.38	845.198	78.51	845.223	78.82	845.214	78.84	845.210	79.00	845.211	78.89	845.216	66.380	845.391	46.025	845.783
84.86	845.181	85.07	845.194	85.04	845.195	85.03	845.193	85.22	845.195	84.28	845.186	69.567	845.300	51.673	845.693
91.40	845.217	91.70	845.235	91.91	845.236	91.92	845.236	92.25	845.237	91.55	845.233	72.175	845.318	56.920	845.565
98.35	845.260	98.45	845.275	98.70	845.277	98.67	845.282	99.09	845.286	99.56	845.291	76.919	845.198	62.288	845.465
104.62	845.330	104.45	845.336	104.42	845.338	104.48	845.341	104.78	845.343	105.27	845.353	84.044	845.135	67.834	845.411
111.46	845.352	111.64	845.347	112.06	845.351	112.01	845.358	112.29	845.367	112.29	845.364	90.993	845.184	71.648	845.356
118.39	845.335	118.64	845.335	118.80	845.336	118.78	845.341	119.28	845.347	118.63	845.347	97.798	845.222	76.961	845.229
125.70	845.286	125.79	845.281	125.98	845.278	125.96	845.287	126.23	845.297	126.74	845.293	104.601	845.302	81.567	845.175
132.85	845.223	132.94	845.222	132.96	845.216	132.91	845.225	ice	ice	133.19	845.235	108.347	845.321	85.357	845.174
140.28	845.097	140.32	845.095	140.27	845.093	140.26	845.106	ice	ice	139.66	845.124	111.420	845.323	89.880	845.211
146.20	845.008	146.21	845.007	146.28	844.985	146.27	845.010	ice	ice	146.26	845.043	118.326	845.312	94.454	845.229
												125.365	845.265	98.764	845.263
												132.279	845.208	103.387	845.323
												139.274	845.099	108.341	845.349
												146.319	845.006	109.426	845.349
														114.574	845.351
														119.953	845.332
														124.927	845.291
														130.263	845.248
														135.419	845.185
														140.565	845.108
														145.412	845.035
														146.371	845.040

NOTE : STATION "0" = BULKHEAD



SCALE: VERT.=1:5
HOR.=1:200

ST. MARY RIVER IRRIGATION DISTRICT	
CHIN RESERVOIR OUTLET STRUCTURE	
CONDUIT SETTLEMENT CONDUIT 2	
DRAWN J. MARTHALLER	SURVEY B.WEILER
SCALE AS SHOWN	
DATE NOVEMBER/2018	
	DWG. NO. CC 5 – 2

LEGEND

NOTE:
REFER TO FIGURE No. 11 OF REPORT ON THE PERFORMANCE OF CHIN DAM No. 1 ST. MARY IRRIGATION PROJECT, MAY 8, 1970 BY GOVERNMENT OF CANADA PFRA ENGINEERING SERVICE.

NOTE:
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STA. 0+000 = CONDUIT INLET (STA. 12+50 Ft. PFRA) FIG. 11
METERS TO FEET DIVIDE BY 0.3048.

NOTE:
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UMA PROJECT No. 1758–013–01, DRAWING W1579, REV 2

NOTE:
SURVEYS AFTER AND INCLUDING NOV. 16/98 MAY BE MORE ACCURATE DUE TO A BETTER LIGHTING SYSTEM.

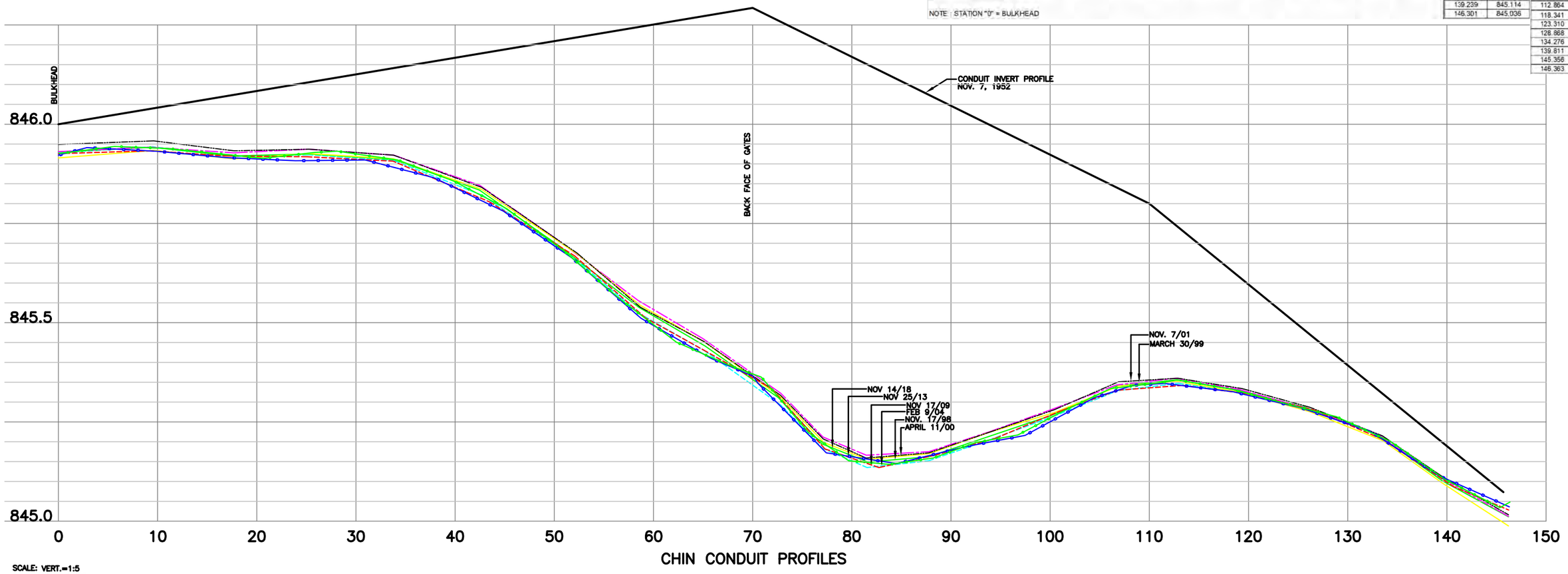
BENCH MARK : ASCM # 78162, ELEV = 919.676
LATERAL TOLERANCE : +/– 150 mm FROM CONDUIT CENTER LINE

FLOOR C SURVEYED BY SMRID NOV. 17/98, CONDUIT No.3
FLOOR C SURVEYED BY SMRID MAR. 30/99, CONDUIT No.3
FLOOR C SURVEYED BY SMRID APR. 11/00, CONDUIT No.3
FLOOR C SURVEYED BY SMRID NOV. 7/01, CONDUIT No.3
FLOOR C SURVEYED BY SMRID FEB. 9/04, CONDUIT No.3
FLOOR C SURVEYED BY SMRID NOV. 17/09, CONDUIT No.3
FLOOR C SURVEYED BY SMRID NOV. 25/13, CONDUIT No.3
FLOOR C SURVEYED BY SMRID NOV. 14/18, CONDUIT No.3

CONDUIT #3

READING #1		READING #2		READING #3		READING #4		READING #5		READING #6		READING #7		READING #8	
FLOOR C.L. (SMRID) 17-Nov-98		FLOOR C.L. (SMRID) 30-Mar-99		FLOOR C.L. (SMRID) 11-Apr-00		FLOOR C.L. (SMRID) 7-Nov-01		FLOOR C.L. (SMRID) 9-Feb-04		FLOOR C.L. (SMRID) 17-Nov-09		FLOOR C.L. (SMRID) 25-Nov-13		FLOOR C.L. (SMRID) 14-Nov-18	
STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.
0.00	845.930	0.00	845.931	0.00	845.915	0.00	845.949	0.00	845.928	0.00	845.926	0.000	845.922	0.100	845.926
9.44	845.942	9.24	845.942	9.61	845.934	9.61	845.958	9.51	845.943	9.27	845.933	2.868	845.941	5.658	845.944
17.50	845.920	17.65	845.928	17.72	845.913	17.71	845.933	17.78	845.919	16.92	845.920	9.855	845.932	10.958	845.939
25.25	845.925	25.19	845.937	25.30	845.926	25.29	845.937	25.26	845.923	25.12	845.918	16.882	845.916	16.028	845.926
33.85	845.911	33.82	845.922	33.77	845.913	33.79	848.922	33.78	845.909	33.73	845.907	23.911	845.908	20.650	845.914
42.46	845.834	42.48	845.846	42.58	845.836	42.68	845.841	42.84	845.820	43.50	845.804	30.930	845.910	25.901	845.929
50.40	845.895	50.21	845.711	52.36	845.672	52.31	845.675	52.31	845.656	52.06	845.668	37.886	845.865	28.107	845.932
58.51	845.539	58.45	845.556	58.65	845.544	58.67	845.539	58.63	845.522	59.20	845.512	44.858	845.781	34.187	845.910
65.22	845.441	64.97	845.460	65.11	845.452	65.12	845.452	65.17	845.429	65.13	845.430	51.792	845.663	39.752	845.858
72.60	845.311	72.84	845.322	72.85	845.312	72.81	845.317	72.84	845.292	71.93	845.334	58.744	845.511	45.221	845.787
76.95	845.195	77.09	845.212	77.18	845.198	77.12	845.207	77.01	845.184	77.28	845.182	65.799	845.410	51.003	845.680
81.61	845.149	81.46	845.166	81.52	845.156	81.45	845.159	81.54	845.135	82.73	845.135	67.903	845.388	56.552	845.561
87.74	845.162	87.77	845.175	87.80	845.170	87.76	845.172	87.73	845.152	88.52	845.167	70.042	845.365	62.304	845.451
93.89	845.214	93.98	845.226	93.88	845.224	93.88	845.224	93.91	845.205	94.51	845.209	70.548	845.347	67.883	845.390
100.08	845.266	100.13	845.281	100.49	845.274	100.45	845.281	100.53	845.266	101.19	845.279	77.429	845.172	70.865	845.363
106.89	845.340	106.88	845.343	106.88	845.340	106.89	845.351	106.81	845.329	106.83	845.333	84.514	845.145	75.648	845.223
112.75	845.356	112.70	845.380	112.86	845.352	112.89	845.360	112.93	845.347	113.40	845.342	91.511	845.188	79.694	845.152
118.97	845.330	119.02	845.332	119.32	845.324	119.34	845.334	119.36	845.324	119.87	845.321	97.473	845.216	83.806	845.143
125.69	845.287	125.95	845.284	126.17	845.276	126.17	845.287	ice	ice	126.72	845.279	104.451	845.311	88.202	845.159
133.13	845.216	133.22	845.216	133.53	845.203	133.49	845.215	ice	ice	133.54	845.206	108.345	845.342	92.486	845.198
139.51	845.102	139.29	845.111	139.47	845.097	139.49	845.113	ice	ice	140.67	845.087	111.498	845.347	96.741	845.217
146.22	845.011	146.21	845.012	146.21	844.988	146.213	845.016	ice	ice	146.23	845.028	118.427	845.326	101.219	845.276
												125.323	845.285	106.092	845.334
												132.210	845.227	111.135	845.349
												139.239	845.114	112.864	845.356
												146.301	845.036	118.341	845.332
														123.310	845.299
														128.868	845.263
														134.276	845.201
														139.811	845.105
														145.356	845.034
														146.363	845.048

NOTE : STATION "0" = BULKHEAD



SCALE: VERT.=1:5
HOR.=1:200

ST. MARY RIVER IRRIGATION DISTRICT	
CHIN RESERVOIR OUTLET STRUCTURE	
CONDUIT SETTLEMENT CONDUIT 3	
DRAWN J. MARTHALLER	SURVEY B. WEILER
SCALE AS SHOWN	
DATE NOVEMBER/2018	
	DWG. NO. CC 5 – 3

LEGEND

NOTE:
REFER TO FIGURE No. 11 OF REPORT ON THE PERFORMANCE OF CHIN DAM No. 1 ST. MARY IRRIGATION PROJECT, MAY 8, 1970 BY GOVERNMENT OF CANADA PFRA ENGINEERING SERVICE.

NOTE:
ELEV.'S TAKEN IN 1982 WERE SURVEYED AT THE CENTER LINE OF THE CONDUITS AND NOT ON THE BOLTS.

TO OBTAIN ORIGINAL PFRA ELEVATIONS FROM GEODETIC METRIC SUBTRACT 0.026, DIVIDE BY 0.3048 AND SUBTRACT 31.96.

STA. 0+000 = CONDUIT INLET (STA. 12+50 Ft. PFRA) FIG. 11 METERS TO FEET DIVIDE BY 0.3048.

NOTE:
PLOTS PRIOR MARCH 11/98 HAVE BEEN SCALED AND REPLOTTED FROM UMA DRAWING TITLED: CONDUIT SETTLEMENT – CHIN RESERVOIR OUTLET STRUCTURE UMA PROJECT No. 1758–013–01, DRAWING W1579, REV 2

NOTE:
SURVEYS AFTER AND INCLUDING NOV. 16/98 MAY BE MORE ACCURATE DUE TO A BETTER LIGHTING SYSTEM.

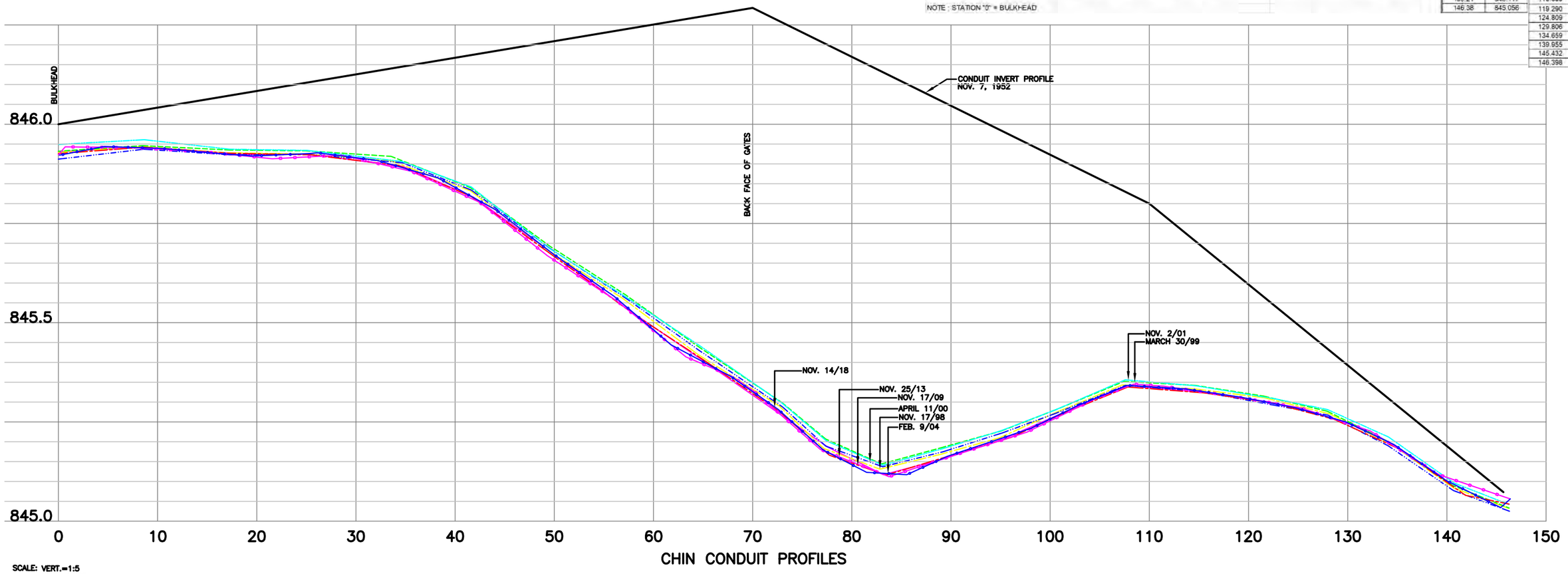
BENCH MARK : ASCM # 78162, ELEV = 919.676
LATERAL TOLERANCE : +/– 150 mm FROM CONDUIT CENTER LINE

FLOOR C SURVEYED BY SMRID NOV. 17/98, CONDUIT No.4
FLOOR C SURVEYED BY SMRID MAR. 30/99, CONDUIT No.4
FLOOR C SURVEYED BY SMRID APR. 11/00, CONDUIT No.4
FLOOR C SURVEYED BY SMRID NOV. 2/01, CONDUIT No.4
FLOOR C SURVEYED BY SMRID FEB. 9/04, CONDUIT No.4
FLOOR ℄ SURVEYED BY SMRID NOV. 17/09, CONDUIT No.4
FLOOR ℄ SURVEYED BY SMRID NOV. 25/13, CONDUIT No.4
FLOOR ℄ SURVEYED BY SMRID NOV. 14/18, CONDUIT No.4

CONDUIT #4

READING #1		READING #2		READING #3		READING #4		READING #5		READING #6		READING #7		READING #8	
FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)	
17-Nov-98		30-Mar-99		11-Apr-00		02-Nov-01		09-Feb-04		17-Nov-09		25-Nov-13		14-Nov-18	
STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.
0.00	845.929	0.00	845.932	0.00	845.912	0.04	845.949	0.00	845.931	0.00	845.926	0.00	845.923	0.100	845.922
8.48	845.944	8.50	845.946	8.60	845.937	8.66	845.961	8.62	845.942	8.58	845.942	0.88	845.943	4.642	845.944
17.00	845.928	17.30	845.935	17.33	845.923	17.26	845.937	17.41	845.923	17.17	845.927	7.62	845.941	10.400	845.939
24.92	845.925	24.91	845.933	25.13	845.924	25.07	845.934	25.15	845.925	25.38	845.923	14.58	845.931	16.351	845.926
33.53	845.908	33.54	845.919	34.67	845.903	34.66	845.906	34.79	845.893	34.32	845.896	21.57	845.913	19.577	845.920
41.56	845.832	41.57	845.840	41.64	845.834	41.82	845.842	41.85	845.816	41.62	845.818	28.57	845.922	25.297	845.926
49.44	845.681	49.53	845.693	49.57	845.687	49.51	845.687	49.74	845.678	49.70	845.672	35.49	845.882	26.089	845.928
56.90	845.561	57.19	845.570	57.31	845.560	57.32	845.563	57.41	845.533	58.18	845.519	42.42	845.804	32.123	845.909
64.48	845.420	64.56	845.439	64.61	845.430	64.66	845.442	64.85	845.407	65.00	845.407	49.29	845.689	38.244	845.865
72.89	845.290	72.94	845.299	73.00	845.288	72.93	845.298	73.07	845.264	72.65	845.273	56.35	845.554	44.111	845.784
77.17	845.183	77.36	845.207	77.37	845.189	77.45	845.202	77.61	845.186	77.74	845.166	63.26	845.414	49.888	845.673
82.84	845.131	82.99	845.144	83.12	845.137	83.15	845.141	83.19	845.117	83.46	845.116	57.88	845.365	56.048	845.566
88.92	845.168	89.17	845.186	89.23	845.175	89.22	845.183	89.27	845.157	89.93	845.165	70.04	845.329	61.790	845.444
94.88	845.210	95.05	845.227	95.15	845.222	95.08	845.228	95.21	845.206	96.06	845.211	76.81	845.181	67.831	845.364
100.71	845.275	100.50	845.260	100.81	845.272	100.69	845.262	100.78	845.267	101.44	845.273	83.76	845.112	72.600	845.281
107.25	845.343	107.45	845.352	107.58	845.342	107.57	845.356	107.67	845.342	107.83	845.336	90.71	845.169	77.132	845.179
114.54	845.333	114.84	845.342	114.85	845.328	114.71	845.341	114.99	845.326	115.63	845.323	97.64	845.224	81.488	845.123
121.57	845.311	121.51	845.315	122.60	845.292	122.69	845.308	123.01	845.297	122.33	845.298	104.62	845.309	85.536	845.117
128.21	845.270	127.92	845.277	128.02	845.267	127.96	845.281	ice	ice	128.59	845.257	108.42	845.345	89.709	845.164
134.58	845.191	133.88	845.203	134.07	845.190	134.11	845.212	ice	ice	135.20	845.182	111.43	845.340	93.807	845.198
140.73	845.083	140.58	845.090	140.66	845.077	140.72	845.096	ice	ice	141.88	845.085	118.39	845.315	98.089	845.234
146.25	845.032	146.28	845.033	146.309	845.025	146.263	845.042	ice	ice	146.28	845.043	125.30	845.285	102.769	845.291
												132.28	845.227	107.778	845.342
												139.21	845.117	113.658	845.333
												146.38	845.056	119.290	845.312
														124.809	845.285
														129.806	845.250
														134.659	845.193
														139.955	845.102
														145.432	845.034
														146.398	845.056

NOTE : STATION "0" = BULKHEAD



SCALE: VERT.=1:5
HOR.=1:200

ST. MARY RIVER IRRIGATION DISTRICT	
CHIN RESERVOIR OUTLET STRUCTURE	
CONDUIT SETTLEMENT CONDUITS 4	
DRAWN J. MARTHALLER	SURVEY B. WEILER
SCALE AS SHOWN	
DATE NOVEMBER/2018	
	DWG. NO. CC 5 – 4

LEGEND

SPOT ELEV.'S TAKEN FEB. 17/82 , CONDUIT No. 5 (SOUTH) ℄ OF FLOOR

NOTE:
REFER TO FIGURE No. 11 OF REPORT ON THE PERFORMANCE OF CHIN DAM No. 1 ST. MARY IRRIGATION PROJECT, MAY 8, 1970 BY GOVERNMENT OF CANADA PFRA ENGINEERING SERVICE.

PROFILES SHOWN THUS TAKEN FROM FLOOR BOLTS : MARCH 29/56 – CONDUIT No.5
DEC. /67 – CONDUIT No.5
MARCH /84 – CONDUIT No.5

NOTE:
ELEV.'S TAKEN IN 1982 WERE SURVEYED AT THE CENTER LINE OF THE CONDUITS AND NOT ON THE BOLTS.

TO OBTAIN ORIGINAL PFRA ELEVATIONS FROM GEODETIC METRIC SUBTRACT 0.026, DIVIDE BY 0.3048 AND SUBTRACT 31.96.

STA. 0+000 = CONDUIT INLET (STA. 12+50 Ft. PFRA) FIG. 11 METERS TO FEET DIVIDE BY 0.3048.

NOTE:
PLOTS PRIOR MARCH 11/98 HAVE BEEN SCALED AND REPLOTTED FROM UMA DRAWING TITLED: CONDUIT SETTLEMENT – CHIN RESERVOIR OUTLET STRUCTURE
UMA PROJECT No. 1758–013–01, DRAWING W1579, REV 2

NOTE:
SURVEYS AFTER AND INCLUDING NOV. 16/98 MAY BE MORE ACCURATE DUE TO A BETTER LIGHTING SYSTEM.

BENCH MARK : ASCM # 78162, ELEV = 919.676
LATERAL TOLERANCE : +/– 150 mm FROM CONDUIT CENTER LINE

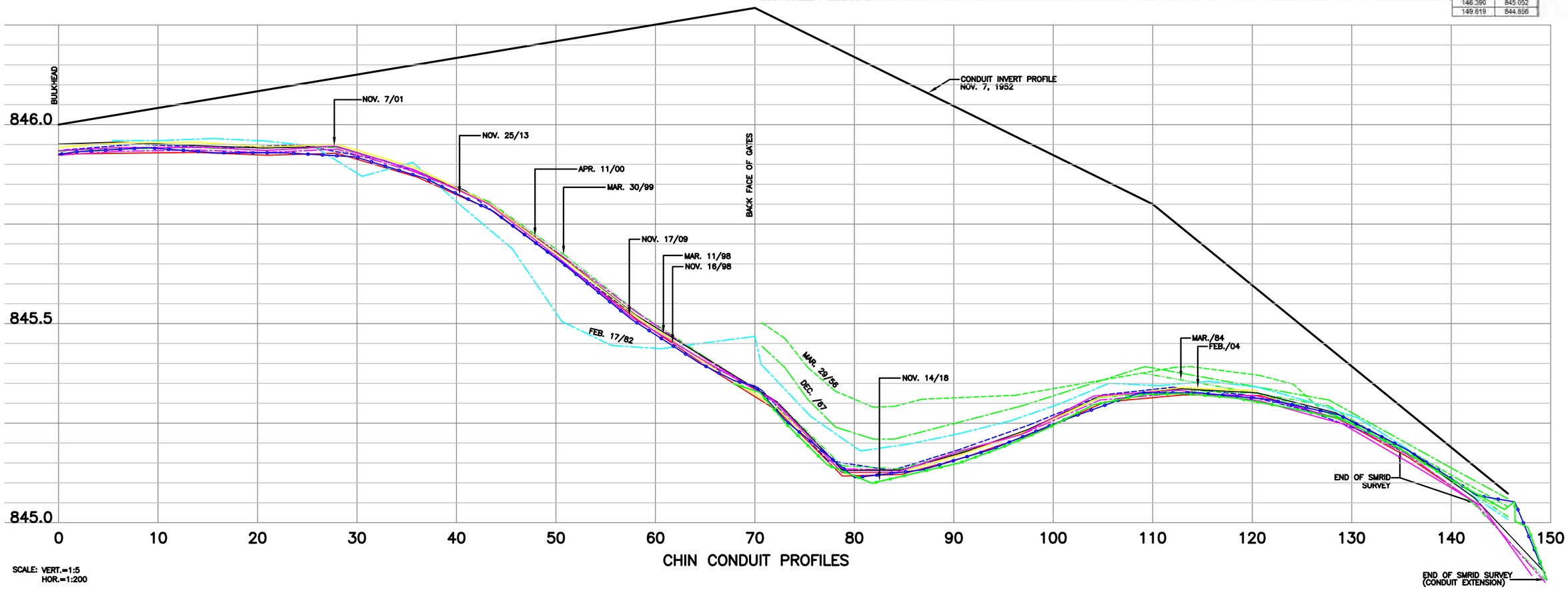
FLOOR ℄ SURVEYED BY SMRID MARCH 11/98, CONDUIT No.5
– CONDUIT No. 5 WAS NOT PROFILED FROM STA. 0+135–0+145.7 DUE TO ICE ON THE FLOOR.

FLOOR ℄ SURVEYED BY SMRID NOV 16/98, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID MAR. 30/99, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID APR. 11/00, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID APR. 7/01, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID FEB. 9/04, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID NOV. 17/09, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID NOV. 25/13, CONDUIT No.5
FLOOR ℄ SURVEYED BY SMRID NOV. 14/18, CONDUIT No.5

CONDUIT #5

Reading #1		Reading #2		Reading #3		Reading #4		Reading #5		Reading #6		Reading #7		READING #8		READING #9		READING #10	
FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)		FLOOR C.L. (SMRID)	
11-Mar-98		16-Nov-98		30-Mar-99		11-Apr-00		7-Nov-01		9-Feb-04		15-Dec-05		17-Nov-09		25-Nov-13		14-Nov-18	
STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV.	STATION	ELEV	STATION	ELEV
1.18	845.936	0.00	845.926	0.00	845.933	0.000	845.923	0.000	845.951	0.000	845.943	0.000	845.932	0.00	845.934	0.00	845.925	67.840	845.349
8.64	845.951	6.23	845.928	5.96	845.938	5.977	845.933	5.929	845.956	6.014	845.954	6.006	845.948	5.87	845.942	1.61	845.931	70.507	845.327
16.54	845.941	13.91	845.930	13.92	845.942	13.993	845.936	14.019	845.947	14.154	845.955	14.159	845.950	14.98	845.943	8.85	845.942	73.106	845.249
24.91	845.949	20.89	845.923	20.56	845.935	20.602	845.930	20.577	845.941	20.858	845.944	20.351	845.944	20.89	845.935	15.81	845.929	77.276	845.145
33.39	845.910	27.96	845.928	27.89	845.943	28.010	845.938	27.959	845.945	28.019	845.950	27.948	845.948	27.72	845.946	22.79	845.929	81.777	845.099
41.49	845.835	36.04	845.868	35.72	845.886	35.716	845.882	35.698	845.887	35.698	845.893	35.780	845.888	35.64	845.887	29.81	845.919	86.384	845.126
49.90	845.680	43.42	845.786	43.27	845.806	43.228	845.803	43.270	845.802	43.343	845.801	43.141	845.801	43.19	845.801	36.83	845.865	90.575	845.150
58.10	845.530	50.86	845.649	50.93	845.671	50.892	845.665	50.975	845.660	51.036	845.657	50.820	845.660	50.50	845.660	43.78	845.781	94.734	845.188
66.08	845.394	58.07	845.512	57.95	845.533	58.070	845.529	58.045	845.521	58.104	845.518	57.957	845.523	57.38	845.519	50.69	845.651	99.146	845.234
71.35	845.333	64.93	845.396	64.97	845.416	65.056	845.411	65.021	845.414	65.234	845.393	65.170	845.398	65.18	845.403	57.52	845.512	104.014	845.296
78.03	845.156	72.34	845.260	72.26	845.302	72.287	845.299	72.262	845.303	72.286	845.287	72.469	845.264	71.85	845.308	64.49	845.400	109.262	845.322
84.44	845.131	78.79	845.117	78.74	845.143	78.759	845.135	78.803	845.131	78.855	845.124	78.886	845.127	78.73	845.126	67.89	845.357	113.207	845.324
91.17	845.183	84.69	845.121	84.56	845.135	84.657	845.132	84.693	845.132	84.631	845.125	84.591	845.130	84.26	845.127	73.05	845.257	118.333	845.343
98.32	845.246	91.36	845.166	90.91	845.179	90.936	845.176	90.976	845.177	91.066	845.174	91.067	845.178	90.66	845.160	80.03	845.113	123.773	845.288
105.66	845.321	98.25	845.226	97.24	845.229	97.235	845.226	97.266	845.232	97.363	845.230	97.249	845.228	96.83	845.222	86.95	845.133	129.056	845.259
112.68	845.340	105.18	845.303	104.65	845.314	104.688	845.308	104.599	845.316	104.647	845.315	104.425	845.315	104.05	845.318	93.90	845.185	134.297	845.194
119.66	845.322	113.14	845.321	112.72	845.332	112.859	845.326	112.834	845.336	112.803	845.339	112.648	845.337	112.45	845.333	100.66	845.256	139.991	845.108
126.21	845.282	120.81	845.319	120.47	845.325	120.476	845.318	120.505	845.326	120.503	845.331	120.449	845.333	120.72	845.306	107.73	845.318	145.360	845.033
133.07	845.217	128.68	845.260	128.42	845.289	128.384	845.264	128.387	845.276	ice	ice	128.222	845.293	129.08	845.248	108.82	845.326	146.397	845.053
135.52	845.183	135.78	845.163	135.59	845.174	135.598	845.171	135.567	845.183	ice	ice	135.453	845.201	135.74	845.151	114.76	845.326	146.419	845.003
		142.53	845.048	142.24	845.048	142.370	845.050	142.339	845.062	ice	ice	ice	ice	143.09	845.041	121.74	845.309	147.692	844.989
		149.58	844.845	149.45	844.857	149.450	844.850	149.437	844.874	ice	ice	ice	ice	148.10	844.867	128.688	845.271	149.559	844.858
																135.849	845.182		
																142.610	845.068		
																146.390	845.052		
																149.819	844.856		

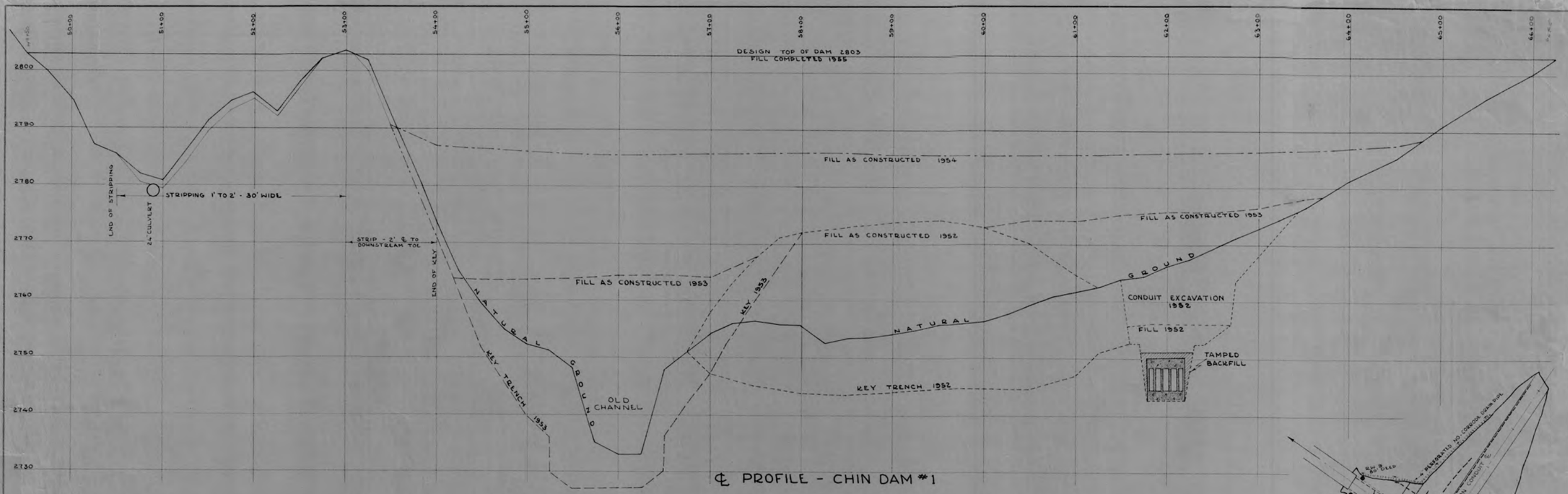
NOTE : STATION "0" = BULKHEAD



SCALE: VERT.=1:5
HOR.=1:200

ST. MARY RIVER IRRIGATION DISTRICT	
CHIN RESERVOIR OUTLET STRUCTURE	
CONDUIT SETTLEMENT **CONDUIT 5**	
DRAWN J. MARTHALLER	SURVEY B. WEILER
SCALE AS SHOWN	
DATE NOVEMBER/2018	
	DWG. NO. CC 5 – 5

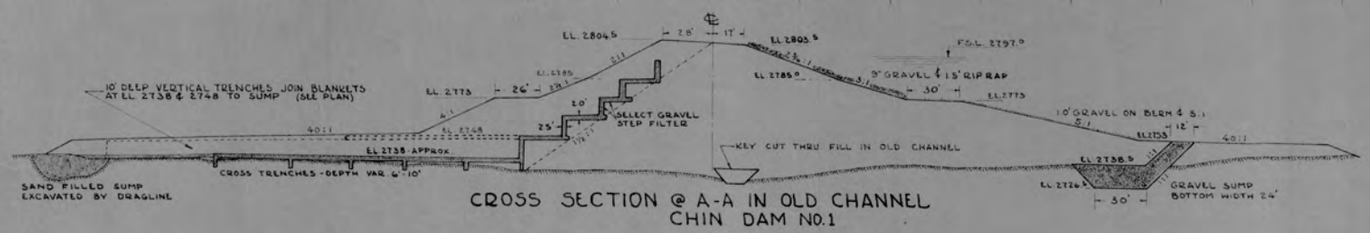
APPENDIX D
Drawings



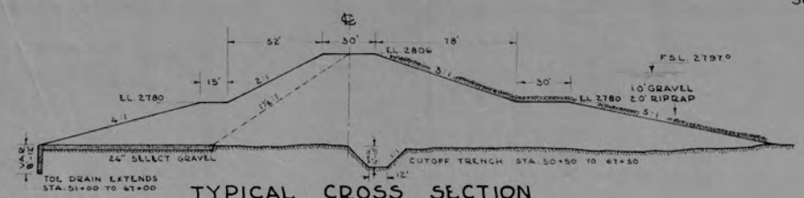
℄ PROFILE - CHIN DAM #1



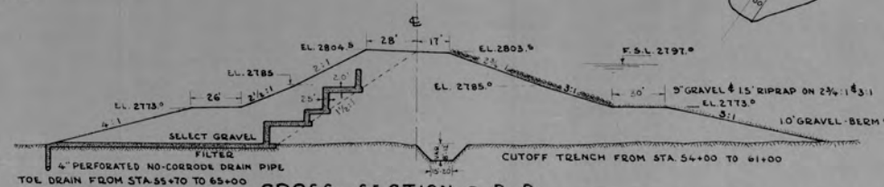
℄ PROFILE - CHIN DAM #2



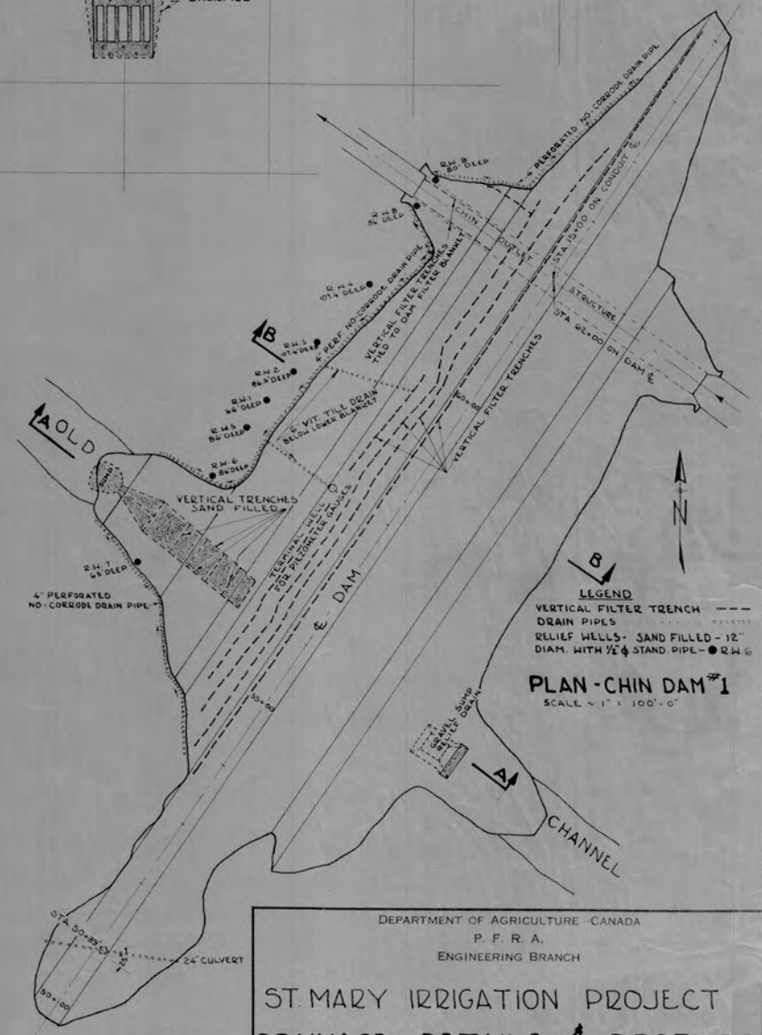
CROSS SECTION @ A-A IN OLD CHANNEL
CHIN DAM NO.1
SCALE - 1"=40'-0"



TYPICAL CROSS SECTION
CHIN DAM NO. 2
SCALE - 1" = 40'-0"



CROSS SECTION @ B-B
CHIN DAM NO. 1
SCALE - 1"=40'-0"



LEGEND
VERTICAL FILTER TRENCH ---
DRAIN PIPES .....
RELIEF WELLS - SAND FILLED - 12" DIAM. WITH ½" ℄ STAND PIPE - ● R.W.#

PLAN - CHIN DAM #1
SCALE - 1" = 100'-0"

NOTES:
1. ALL ELEVATIONS SHOWN ARE IRRIGATION ELEVATIONS: TO OBTAIN GEODETIC ADD 3196 FT.
2. FOR FURTHER DETAILS SEE PLANS #27555-L-C574, C573, C560, C561, C562, C563, C564, C567, C569.

DEPARTMENT OF AGRICULTURE CANADA
P. F. R. A.
ENGINEERING BRANCH

ST. MARY IRRIGATION PROJECT

DRAINAGE DETAILS & PROFILES CHIN DAMS #1 & #2

DIVISION #7

AS CONSTRUCTED 1952-1956

SCALE - AS SHOWN | DATE - MARCH 1959 | SHEET

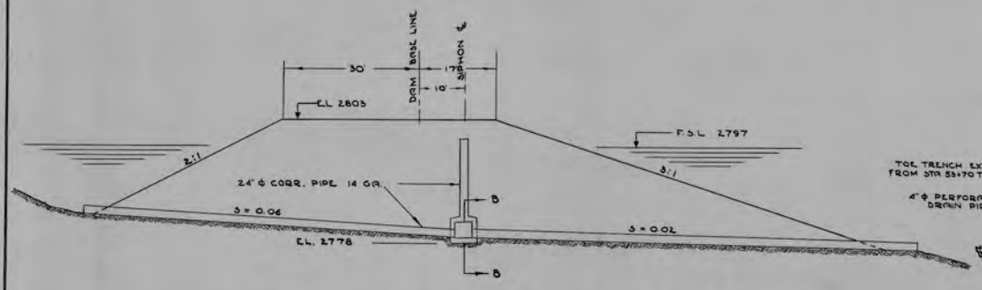
SUBMITTED BY: [signature] DATE:
APPROVED BY: C.M. Wilson SUPT. ENGINEER DATE:

DESIGNED BY:
DRAWN BY: L.W.
TRACED BY: M.L.V.
CHECKED BY: G.G.C.
CONSTRUCTED BY: - R.M.J.

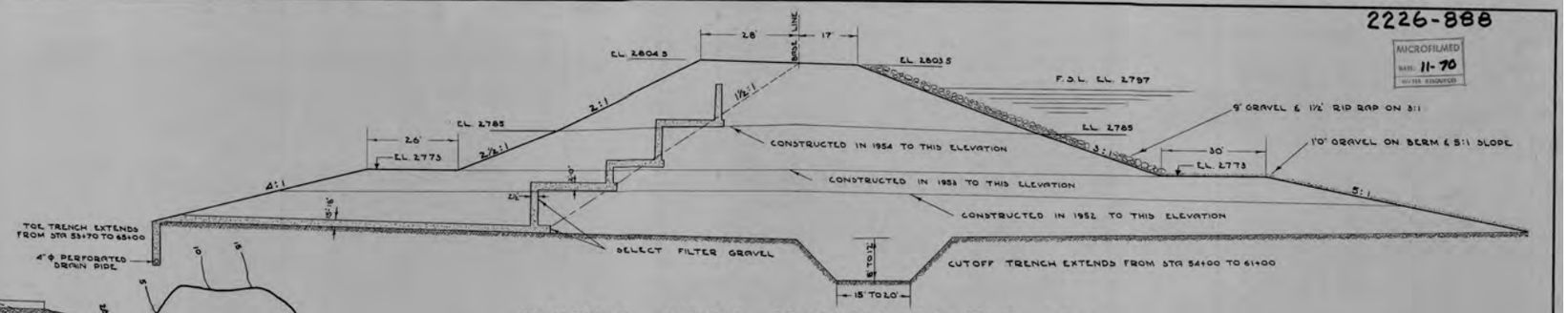
PLAN NO. 27555-L-C575

C99104

2226-888
MICROFILMED
DATE: 11-70



SECTION A-A THROUGH CULVERT
SCALE 1/16" = 1'-0"



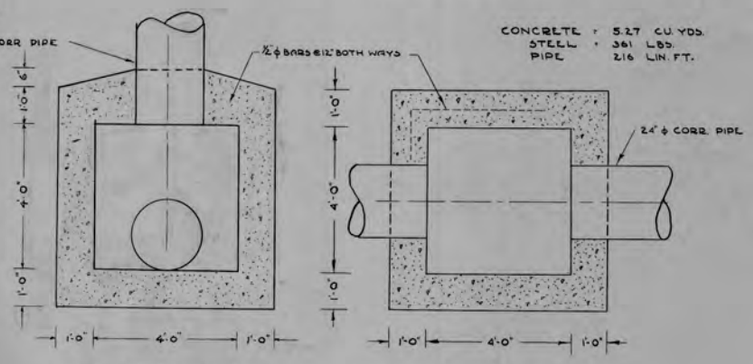
TYPICAL CROSS SECTION OF THE DAM
SCALE 1 INCH = 20 FEET

SCHEDULE OF CONSTRUCTION CHIN DAM #1

YEAR	EARTH FILL CU/YDS	FILTER GRAVEL TONS	FACING GRAVEL TONS
1952	95,279	10,758	—
1953	129,649	15,909	4,965
1954	123,510	6,591	2,542
1955	93,190	5,355	9,679
TOTAL	441,628	38,613	17,206

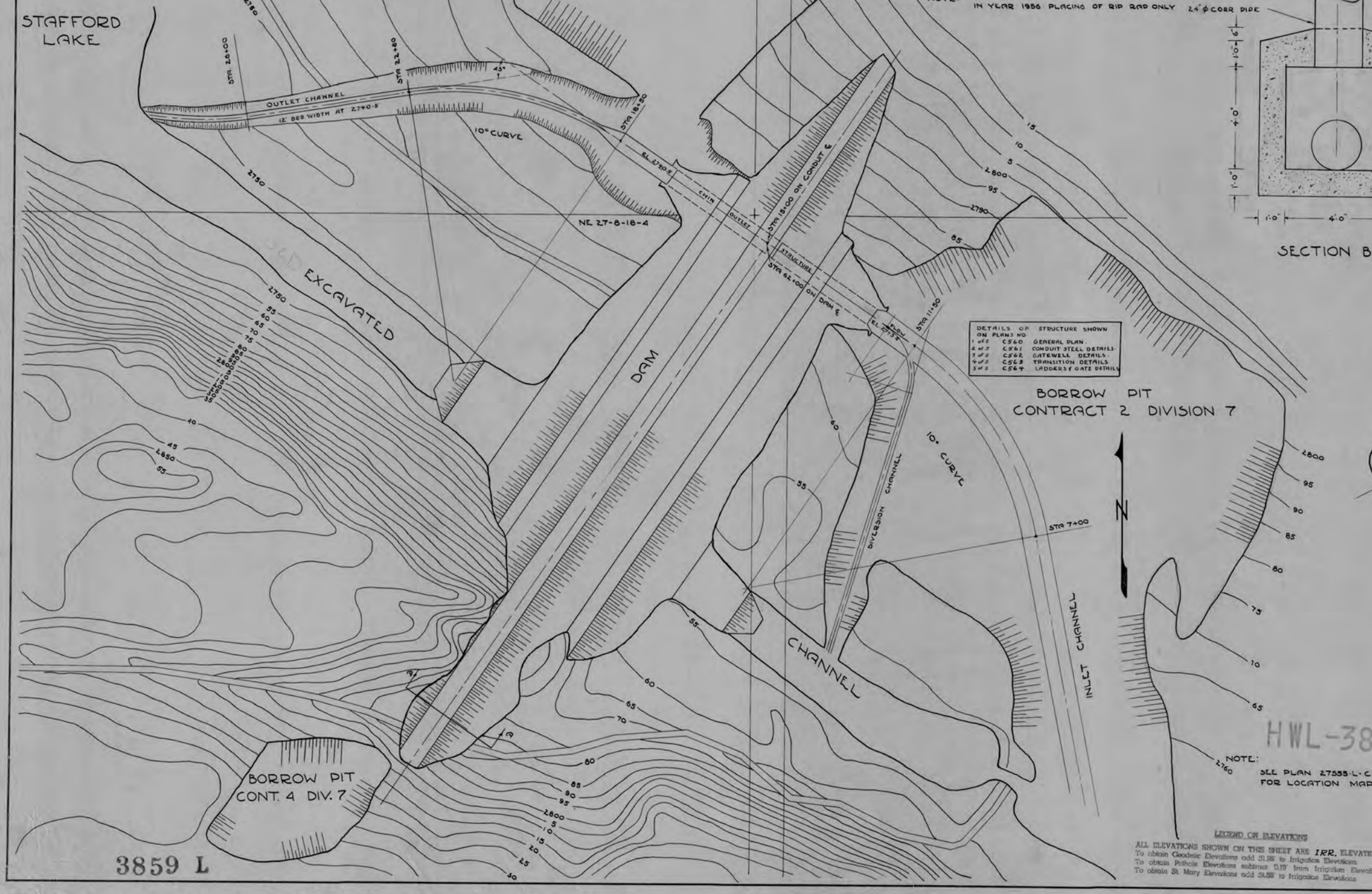
NOTE:
IN YEAR 1956 PLACING OF RIP RAP ONLY

STATION	LEFT SHOULDER ELEVATION	DISTANCE FROM BASE LINE	RIGHT SHOULDER ELEVATION	DISTANCE FROM BASE LINE
49+50 — 53+75	2803	31 FEET	2803	18.5 FEET
54+00	2804	29 FEET	2803	18.5 FEET
55+00 — 61+00	2804.5	28 FEET	2803.5	17.0 FEET
62+00 — 66+50	2804	29 FEET	2803	18.5 FEET



CONCRETE : 5.27 CU YDS.
STEEL : 361 LBS.
PIPE : 216 LIN. FT.

SECTION B-B PLAN
SCALE : ½" = 1'-0"

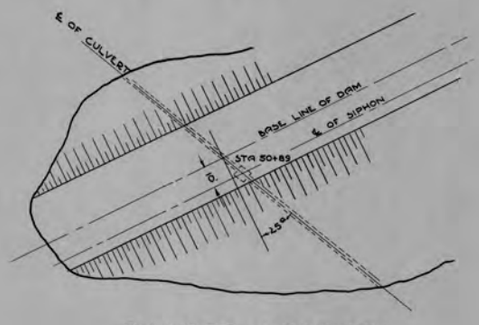


DETAILS OF STRUCTURE SHOWN ON PLANS NO		
1 of 5	C560	GENERAL PLAN
2 of 5	C561	CONDUIT STEEL DETAILS
3 of 5	C562	GATEWELL DETAILS
4 of 5	C563	TRANSITION DETAILS
5 of 5	C564	LADDERS & GATE DETAILS

BORROW PIT
CONTRACT 2 DIVISION 7

NOTE:
SEE PLAN 27555-L-C 574
FOR LOCATION MAP

LEGEND ON ELEVATIONS
ALL ELEVATIONS SHOWN ON THIS SHEET ARE IRR. ELEVATIONS
To obtain Geodetic Elevations add 31.98' to Irrigation Elevations.
To obtain Pothole Elevations subtract 0.19' from Irrigation Elevations.
To obtain St. Mary Elevations add 31.88' to Irrigation Elevations



CULVERT LOCATION
SCALE 1" = 40'

NOTE:
EARTH FILL FROM STA 49+50 TO STA 53+00
AND CULVERT WERE CONSTRUCTED IN 1955

SCALE REFERENCE ONE INCH

DEPARTMENT OF AGRICULTURE—CANADA
P. F. R. A.
ENGINEERING BRANCH

ST. MARY IRRIGATION PROJECT
CHIN DAM # 1
DIVISION 7
AS CONSTRUCTED 1952 - 1956

IN N.E. Qr. SECTION 27-8-18-4

SCALE 1" = 100' DATE FEBRUARY 1956 SHEET 1 OF 1

SUBMITTED BY: H. L. Stanley
DATE:
APPROVED BY: G. H. Wenno, CHIEF ENGINEER
DATE: APR. 1958

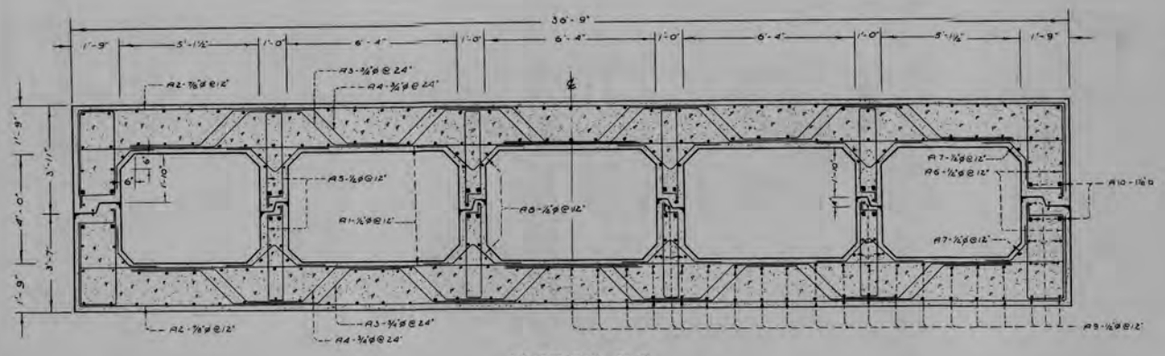
DESIGNED BY:
DRAWN BY: A. K
TRACED BY: A. K
CONSTRUCTED BY:
CHECKED BY: R.W.J

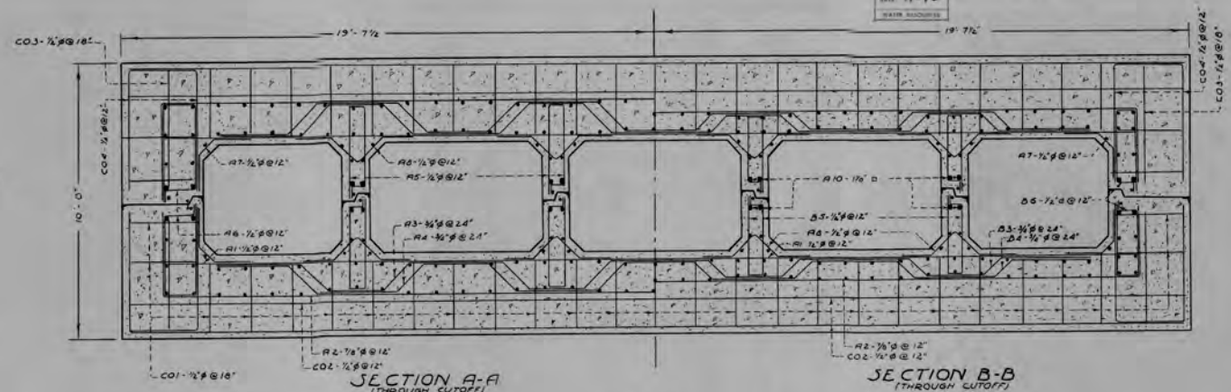
PLAN No 27555-L-C 573

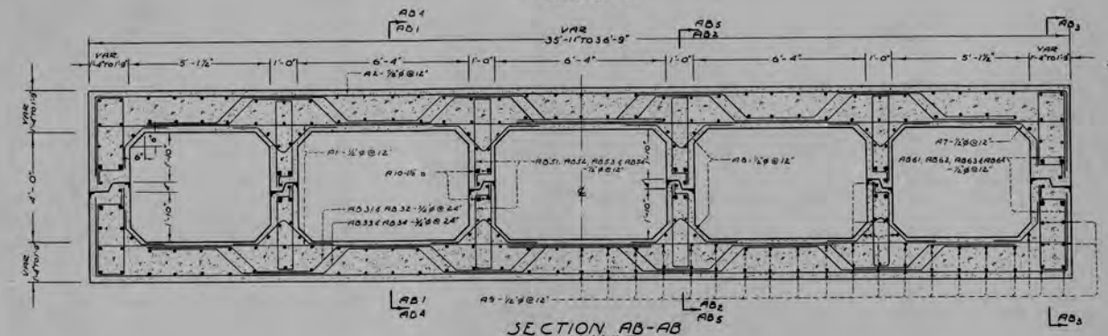
HWL-3859

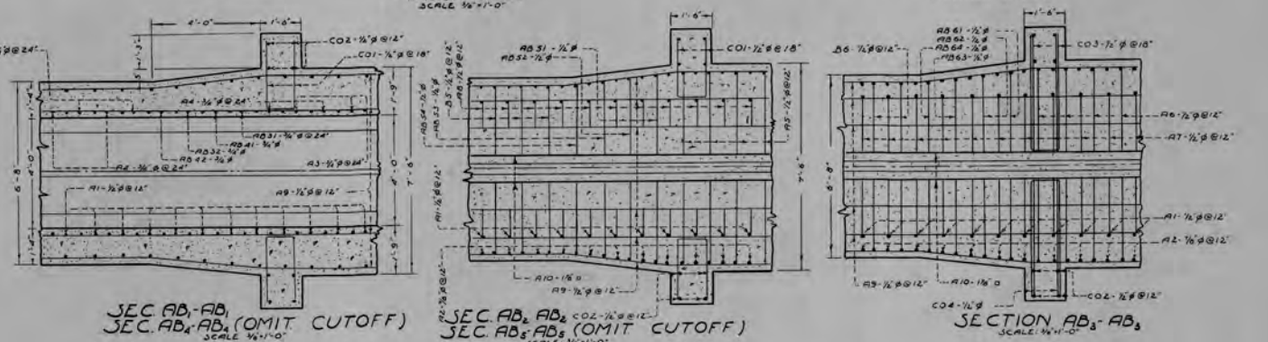
MICROFILMED DATE 11-70 WATER RESOURCES

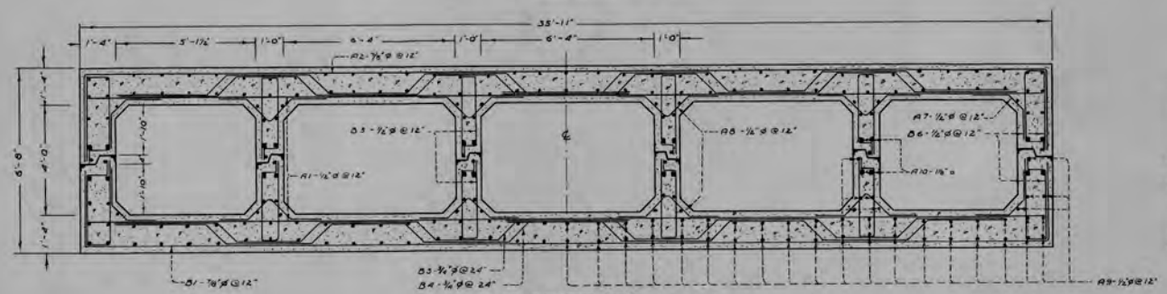
2226-881

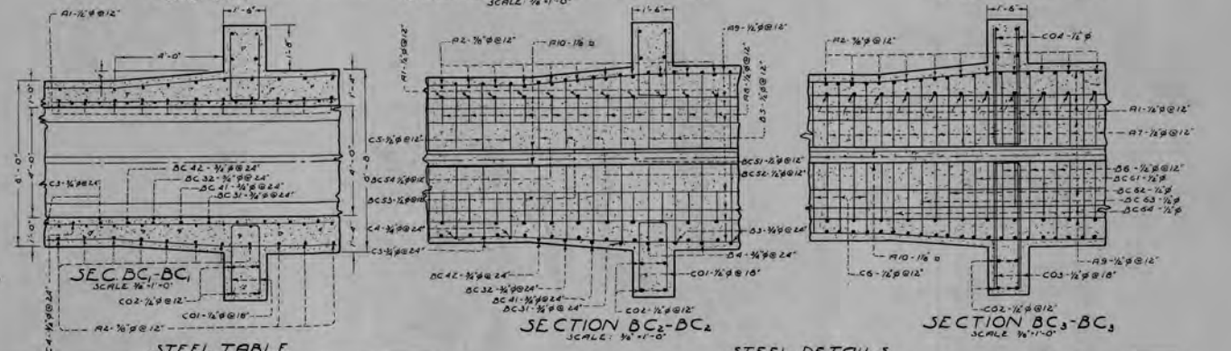


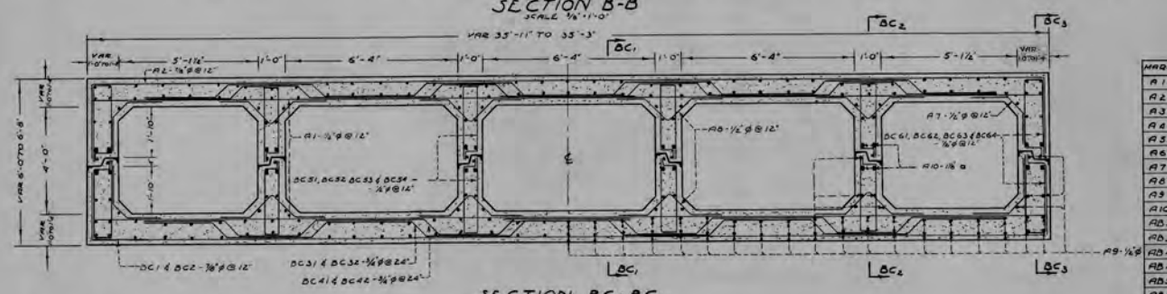










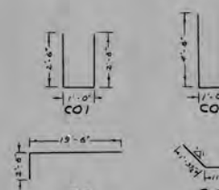


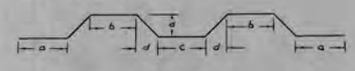
STEEL TABLE

MARK	SIZE	SPACE	SHAPE	LENGTH	NO	WEIGHT	LOCATION
A1	1/2"ϕ	12"	STRAIGHT	20'-0"	1810	24181.8	ALL SECTIONS
A2	7/8"ϕ	12"	SEE DETAIL	22'-0"	1810	61392.0	ALL SECTIONS
A3	3/4"ϕ	24"	DO	20'-0"	248	7448.9	SEC. A-A
A4	3/4"ϕ	24"	DO	20'-0"	244	7325.9	DO
A5	1/2"ϕ	12"	DO	8'-0"	932	8301.2	DO
A6	1/2"ϕ	12"	DO	9'-6"	496	3147.6	DO
A7	1/2"ϕ	12"	DO	3'-6"	1844	4311.3	SECS A-A, B-B, C-C, AB-AB & BC-BC
A8	1/2"ϕ	12"	DO	5'-0"	3686	12317.3	SECS A-A, B-B, C-C, AB-AB & BC-BC
A9	1/2"ϕ	12"	STRAIGHT	57555 L/ft	—	45186.8	ALL SECTIONS
A10	1 1/8" □	VAR.	DO	11924 LINFT	—	51309.0	DO
AB31	3/4"ϕ	24"	SEE DETAIL	20'-0"	8	240.3	SEC AB-AB
AB32	3/4"ϕ	24"	DO	20'-0"	8	240.3	DO
AB41	3/4"ϕ	24"	DO	20'-0"	8	240.3	DO
AB42	3/4"ϕ	24"	DO	20'-0"	8	240.3	DO
AB51	1/2"ϕ	12"	DO	7'-10 3/8"	16	84.4	DO
AB52	1/2"ϕ	12"	DO	7'-8 1/4"	16	82.2	DO
AB53	1/2"ϕ	12"	DO	7'-5 3/4"	16	79.9	DO
AB54	1/2"ϕ	12"	DO	7'-3 1/8"	16	77.7	DO
AB61	1/2"ϕ	12"	DO	9'-3 1/2"	8	49.6	DO
AB62	1/2"ϕ	12"	DO	8'-10 1/2"	8	47.4	DO
AB63	1/2"ϕ	12"	DO	8'-5 7/8"	8	45.2	DO
AB64	1/2"ϕ	12"	DO	8'-0 1/2"	8	43.0	DO
B3	3/4"ϕ	24"	DO	18'-0"	299	8085.9	SEC. B-B
B4	3/4"ϕ	24"	DO	19'-0"	302	8618.6	DO
B5	1/2"ϕ	12"	DO	7'-2"	1216	3821.7	DO
B6	1/2"ϕ	12"	DO	7'-10"	608	3181.2	DO
BC31	3/4"ϕ	24"	DO	17'-0"	8	204.3	SEC. BC-BC
BC32	3/4"ϕ	24"	DO	17'-0"	7	178.3	DO
BC41	3/4"ϕ	24"	DO	16'-0"	8	216.3	DO
BC42	3/4"ϕ	24"	DO	19'-0"	6	162.3	DO
BC51	1/2"ϕ	12"	DO	7'-1"	16	75.7	DO
BC52	1/2"ϕ	12"	DO	6'-11"	16	73.9	DO
BC53	1/2"ϕ	12"	DO	6'-9"	16	72.1	DO
BC54	1/2"ϕ	12"	DO	6'-7"	16	70.4	DO
BC61	1/2"ϕ	12"	DO	7'-6"	8	40.9	DO
BC62	1/2"ϕ	12"	DO	7'-4"	8	33.1	DO
BC63	1/2"ϕ	12"	DO	7'-0"	8	37.4	DO
BC64	1/2"ϕ	12"	DO	6'-8"	8	35.6	DO
C3	3/4"ϕ	24"	DO	17'-0"	337	8604.5	SEC C-C
C4	1/2"ϕ	24"	DO	17'-0"	336	6630.5	DO
C5	1/2"ϕ	12"	DO	6'-6"	2028	8805.6	DO
CO1	1/2"ϕ	18"	DO	6'-0"	270	1082.2	CUTOFFS - DOWELS
CO2	1/2"ϕ	12"	STRAIGHT	20'-0"	40	534.4	30 LONGITUDINALS
CO3	1/2"ϕ	18"	SEE DETAIL	10'-0"	20	133.6	30 DOWELS
CO4	1/2"ϕ	12"	DO	11'-6"	40	307.3	30

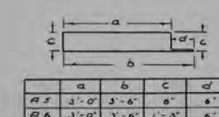
TOTAL: 318407.6

STEEL DETAILS
NOT TO SCALE





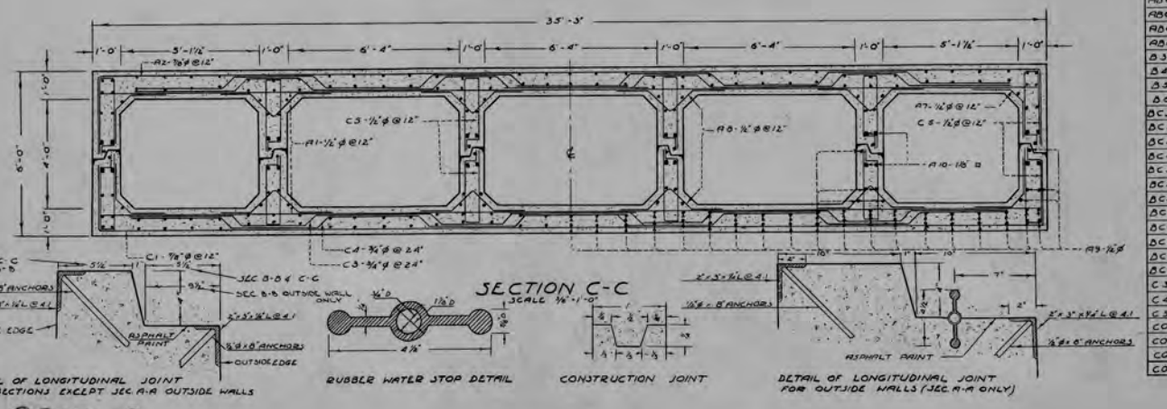
	a	b	c	d
A3	3'-0½"	2'-0"	2'-10"	1'-3"
A4	2'-6½"	3'-0"	1'-10"	1'-3"
AB31	3'-1½"	2'-0"	2'-11½"	1'-2⅜"
AB32	3'-0½"	2'-0"	3'-4½"	11⅞"
AB41	3'-3½"	3'-0"	1'-3½"	1'-1⅞"
AB42	3'-2⅜"	3'-0"	2'-6½"	10⅝"
B3	2'-9½"	2'-0"	3'-8"	10"
B4	2'-9½"	3'-0"	2'-8"	10"
BC31	2'-8½"	2'-0"	3'-3"	9⅞"
BC32	2'-6½"	2'-0"	3'-11"	8⅞"
BC41	2'-5½"	3'-0"	2'-10"	8"
BC42	2'-7½"	3'-0"	3'-0"	8"
C3	3'-1½"	2'-0"	3'-11"	6"
C4	2'-7½"	3'-0"	2'-11"	6"



	a	b	c	d
A5	3'-0"	3'-6"	6"	6"
A6	3'-0"	3'-6"	1'-3"	6"
AB51	2'-11⅜"	3'-5⅛"	4"	6"
AB52	2'-10⅜"	3'-4⅛"	6"	6"
AB53	2'-8⅜"	3'-2⅛"	8"	6"
AB54	2'-7⅜"	3'-1⅛"	6"	6"
AB61	2'-11⅜"	3'-5⅛"	1'-2⅜"	6"
AB62	2'-10⅜"	3'-4⅛"	1'-1⅜"	6"
AB63	2'-8⅜"	3'-2⅛"	11⅜"	6"
AB64	2'-7⅜"	3'-1⅛"	10⅜"	6"
B5	2'-7"	3'-1"	6"	6"
B6	6'-7"	3'-1"	10"	6"
BC51	2'-6⅛"	3'-0⅛"	6"	6"
BC52	2'-5⅛"	2'-11⅛"	6"	6"
BC53	2'-4⅛"	2'-10⅛"	6"	6"
BC54	2'-3⅛"	2'-9⅛"	6"	6"
BC61	2'-6⅛"	3'-0⅛"	9⅛"	6"
BC62	2'-5⅛"	2'-11⅛"	8⅛"	6"
BC63	2'-4⅛"	2'-10⅛"	7⅛"	6"
BC64	2'-3⅛"	2'-9⅛"	6⅛"	6"
C5	2'-3"	2'-9"	6"	6"

LEGEND ON ELEVATIONS

ALL ELEVATIONS SHOWN ON THIS SHEET ARE IRR. ELEVATIONS
To obtain Geodetic Elevations add 5183 to Irrigation Elevations.
To obtain Potable Elevations subtract 019 from Irrigation Elevations.
To obtain St. Mary Elevations add 3988 to Irrigation Elevations.



3852 L

HWL-3852

SCALE REFERENCE ONE INCH

DEPARTMENT OF AGRICULTURE—CANADA
P. F. R. A.
WATER DEVELOPMENT BRANCH

ST. MARY IRRIGATION PROJECT
CHIN OUTLET STRUCTURE
CONDUIT STEEL DETAILS
AS CONSTRUCTED 1952

SCALE AS SHOWN DATE DECEMBER 1955 SHEET 2 OF 5

SUBMITTED BY _____ DATE _____
APPROVED BY _____ DATE _____ CHIEF ENGINEER
DESIGNED BY J.T.D. R.S.
DRAWN BY A.K.
TRACED BY A.K.
CONSTRUCTED BY
CHECKED BY R.W.J.

PLAN No. 27555-LC561

2226-882

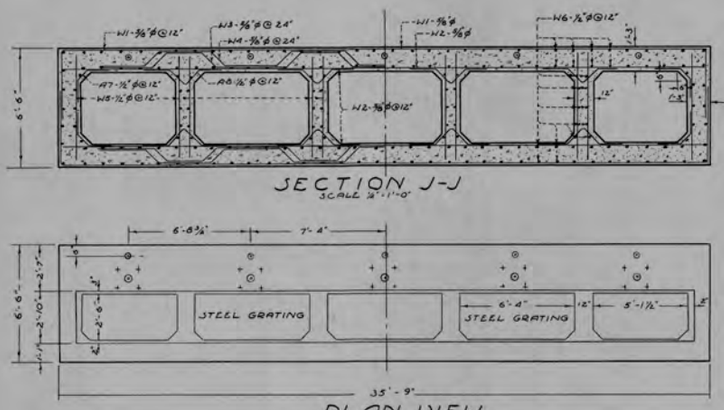
MICROFILM DATE 11-70

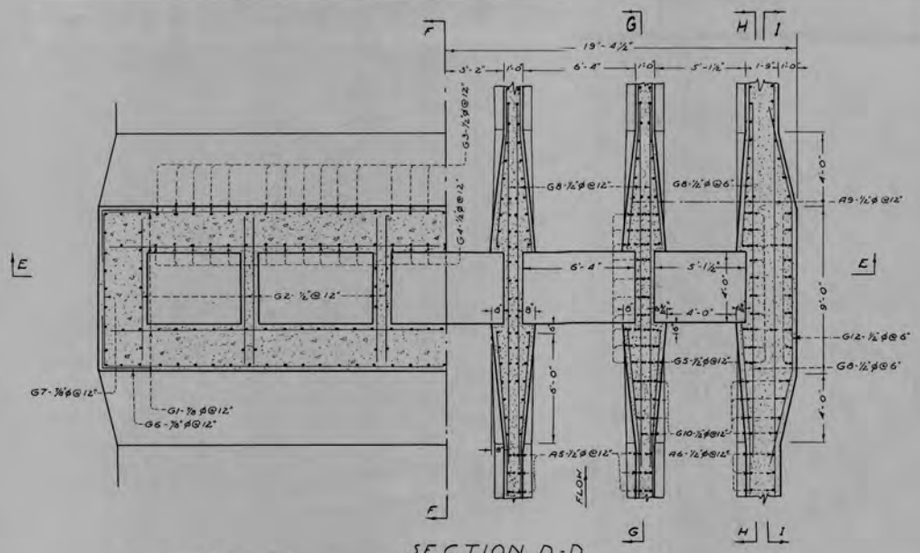
AS CONSTRUCTED STEEL TABLE

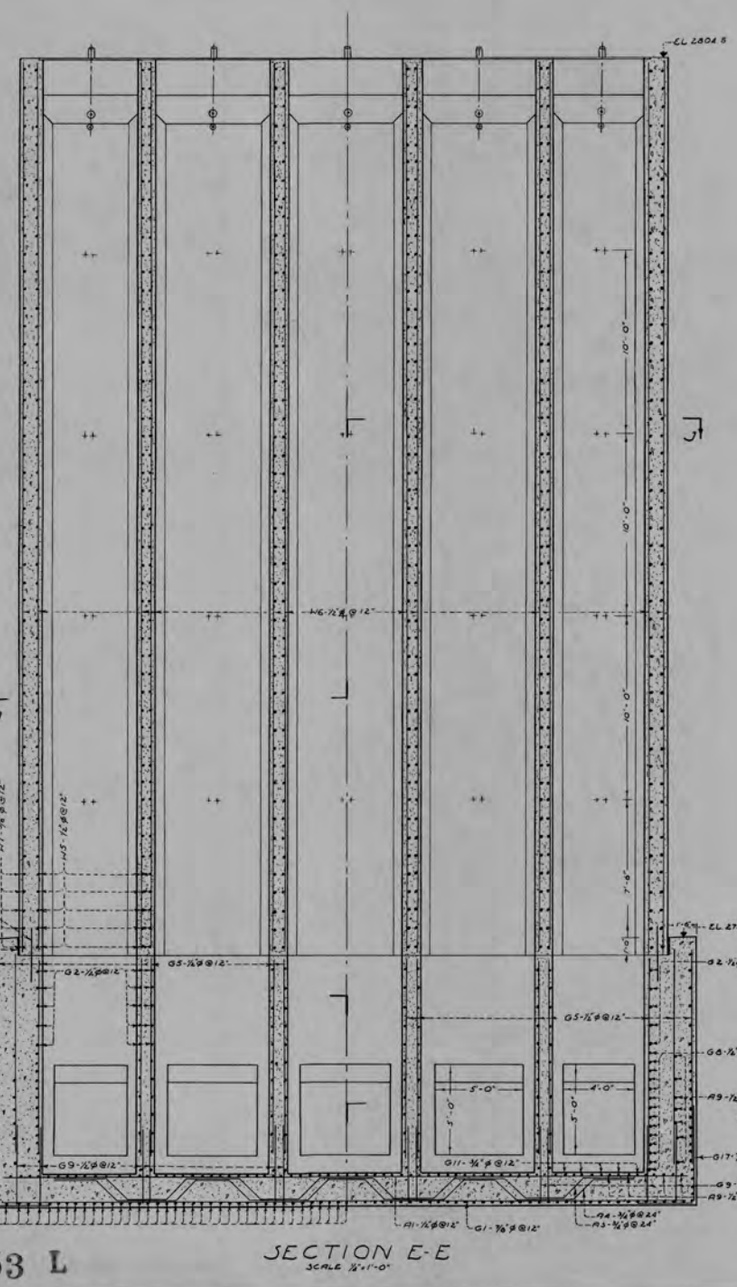
MARK	SIZE	SPACE	SHAPE	LENGTH	NO	WEIGHT	LOCATION
A1	½ ø	12"	STRAIGHT	20'-0"	48	641.3	SEC. F-F
A3	⅜ ø	24"	SEE DETAIL	20'-0"	4	120.2	" "
A4	⅜ ø	24"	" "	20'-0"	6	180.2	" "
A7	½ ø	12"	" "	3'-6"	196	458.2	WELL SEC. J-J
A8	½ ø	12"	" "	5'-0"	392	1309.3	" " "
A9	½ ø	12"	STRAIGHT	27'LALLIN FT	—	1819.6	SEC. F-F
G1	⅜ ø	12"	"	20'-0"	104	4251.3	SEC. F-F & D-D
G2	⅜ ø	12"	"	8'-6"	50	265.9	SEC. D-D, G-G & H-H
G3	½ ø	12"	"	6'-6"	58	251.8	SEC. D-D & F-F
G4	½ ø	12"	SEE DETAIL	6'-6"	58	251.8	" " " "
G5	½ ø	12"	STRAIGHT	10'-9"	184	1321.3	SEC. D-D, E-E, F-F, G-G, H-H & I-I
G6	⅜ ø	12"	SEE DETAIL	6'-0"	24	294.3	SEC. D-D
G7	⅜ ø	12"	STRAIGHT	8'-6"	12	206.5	SEC. D-D & E-E
G8	½ ø	6" & 12"	"	20'-0"	84	1122.3	ALL GATE SECTIONS
G9	½ ø	12"	"	4'-6"	264	793.6	SHELLS SEC. E-E, F-F, G-G, H-H & I-I
G10	½ ø	12"	"	5'-6"	116	426.2	SEC. D-D, F-F, G-G, H-H & I-I
G11	½ ø	12"	SEE DETAIL	16'-0"	37	889.4	ALL GATE SECTIONS
G12	½ ø	6"	" "	20'-0"	109	1443.2	" " "
G13	⅜ ø	—	" "	20'-0"	4	120.2	SEC. F-F
G14	⅜ ø	—	" "	20'-0"	4	120.2	" "
G15	⅜ ø	—	" "	20'-0"	4	120.2	" "
G16	⅜ ø	—	" "	20'-0"	4	120.2	" "
G17	⅜ ø	12"	"	8'-6"	34	290.7	SEC. E-E & I-I
G18	½ ø	12"	STRAIGHT	20'-0"	48	1441.9	SEC. F-F
W1	½ ø	12"	SEE DETAIL	27'-0"	195	3491.6	SEC. J-J, E-E & F-F
W2	½ ø	12"	STRAIGHT	20'-0"	202	4213.7	" " " " "
W3	⅜ ø	24"	SEE DETAIL	17'-0"	52	922.0	SEC. J-J & E-E
W4	⅜ ø	24"	" "	17'-0"	48	851.1	" " "
W5	½ ø	12"	STRAIGHT	6'-0"	490	1963.9	SEC. J-J & F-F
W6	½ ø	12"	"	6085LBS FT	—	6085.0	SEC. J-J, E-E & F-F
W7	½ ø	12"	SEE DETAIL	9'-6"	30	190.4	SEC. F-F - HOIST SUPPORT

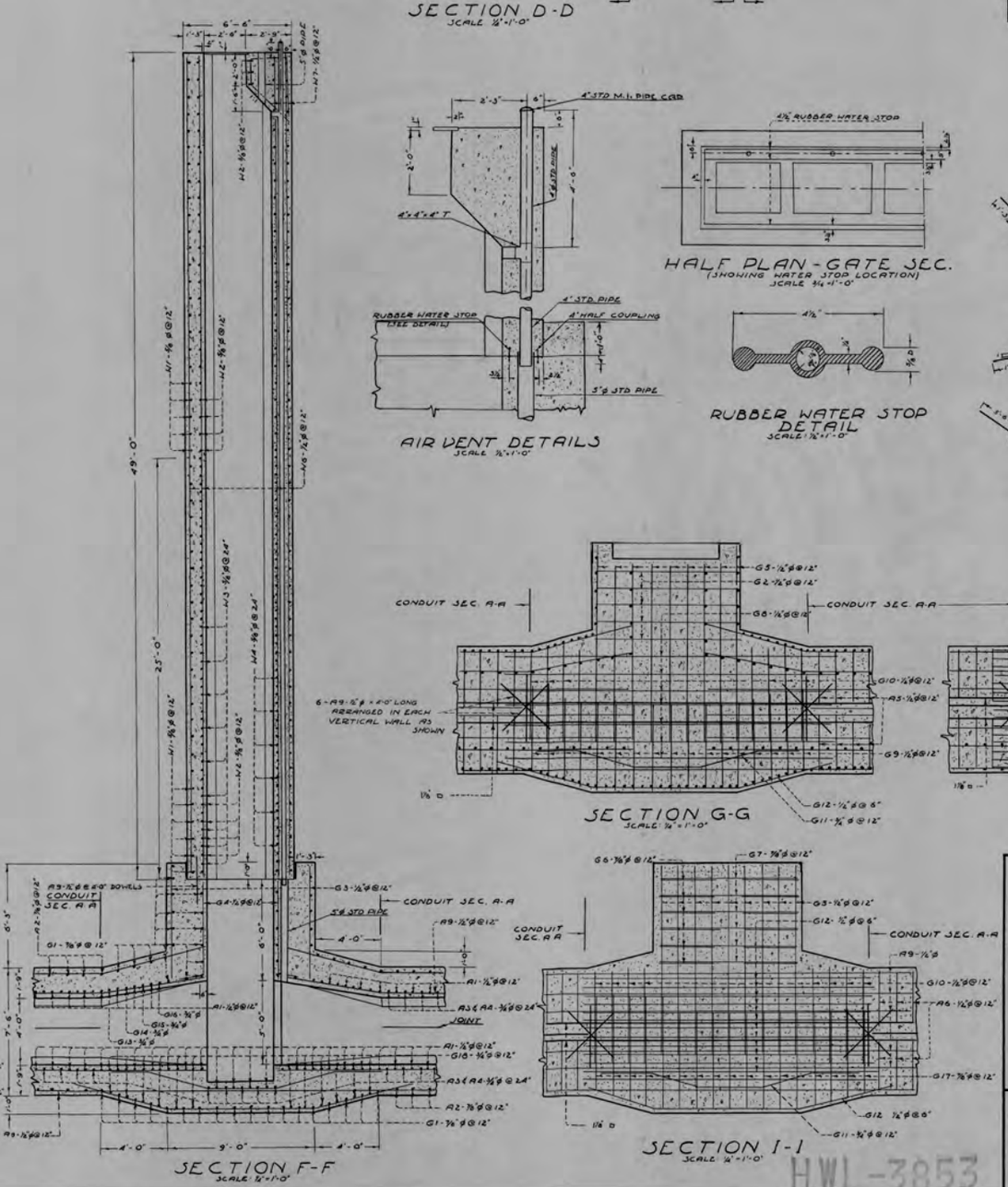
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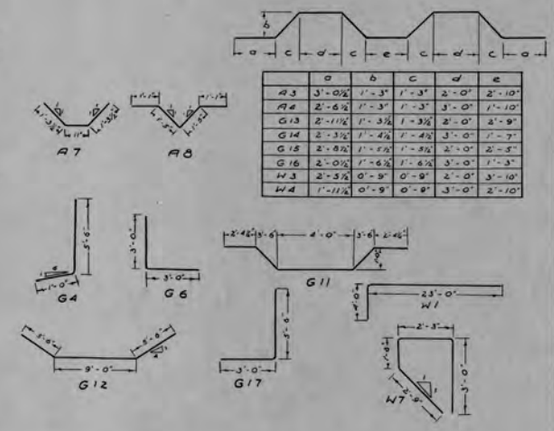
STEEL DETAILS
NOT TO SCALE



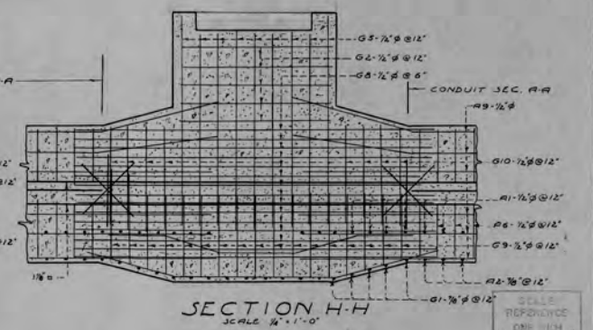








	a	b	c	d	e
A3	3'-0½"	1'-3"	1'-3"	2'-0"	2'-10"
A4	2'-6½"	1'-3"	1'-3"	3'-0"	1'-10"
G13	2'-11⅞"	1'-3½"	1'-3½"	2'-0"	2'-9"
G14	2'-3½"	1'-4½"	1'-4½"	3'-0"	1'-7"
G15	2'-8½"	1'-5½"	1'-5½"	2'-0"	2'-5"
G16	2'-0½"	1'-6½"	1'-6½"	3'-0"	1'-3"
W3	2'-3½"	0'-9"	0'-9"	2'-0"	3'-10"
W4	1'-11⅝"	0'-9"	0'-9"	3'-0"	2'-10"



DEPARTMENT OF AGRICULTURE—CANADA
P. F. R. A.
WATER DEVELOPMENT BRANCH

ST. MARY IRRIGATION PROJECT
CHIN OUTLET STRUCTURE
GATE WELL DETAILS
AS CONSTRUCTED 1952

SCALE AS SHOWN DATE DECEMBER 1955 SHEET 3 OF 5.

SUBMITTED BY _____ DATE _____

APPROVED BY _____ CHIEF ENGINEER DATE _____

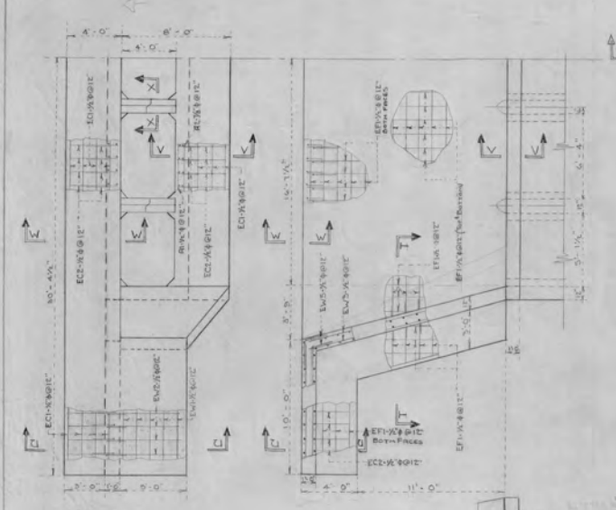
DESIGNED BY J.T.D. & R.J.
DRAWN BY A.K.
TRACED BY A.G.
CONSTRUCTED & CHECKED BY R.W.J.

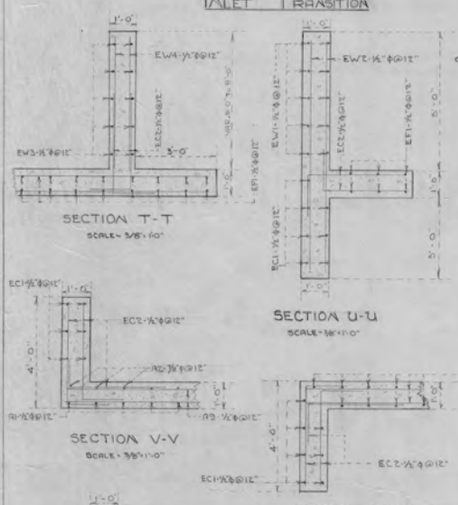
PLAN No 27555L-C562

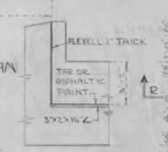
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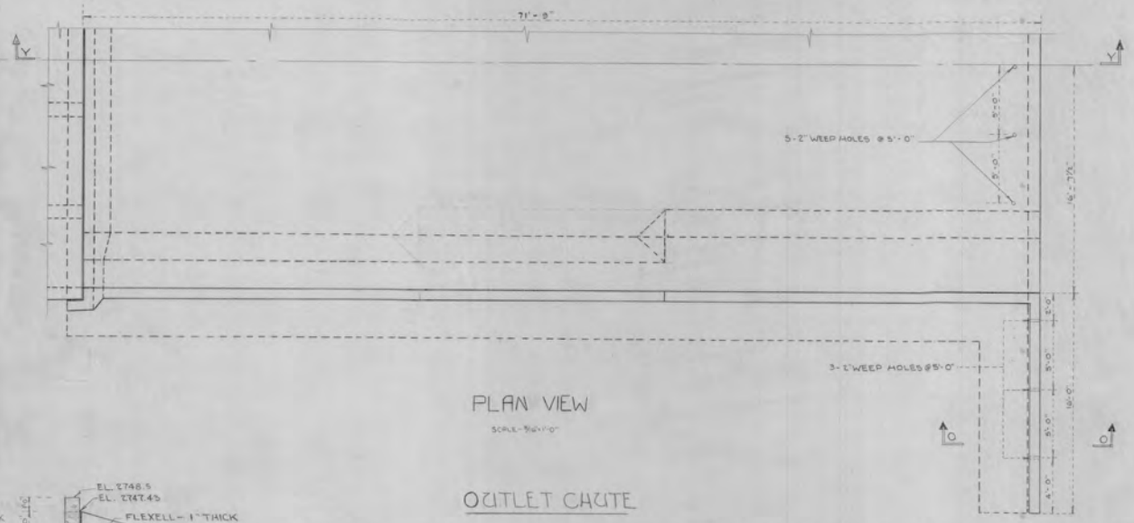
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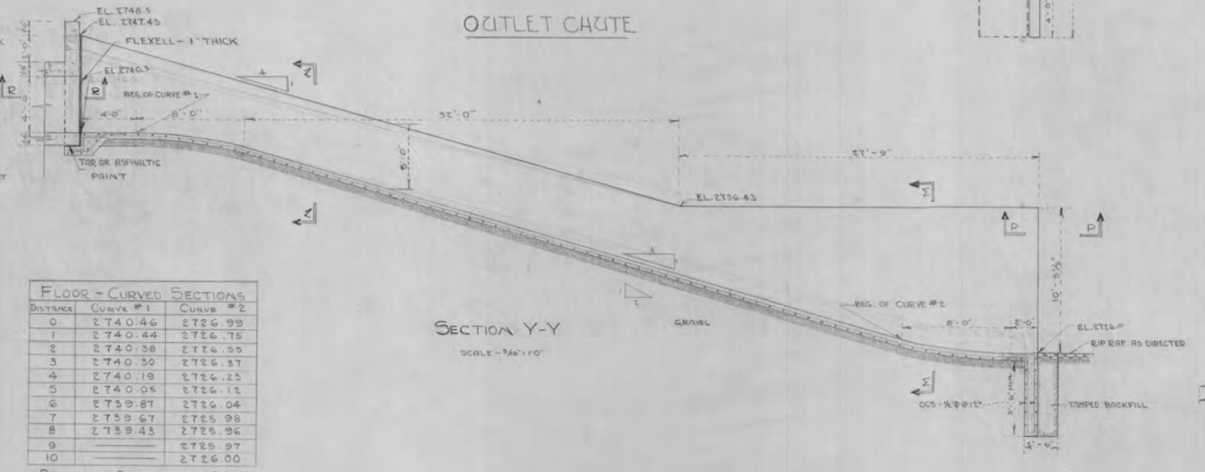
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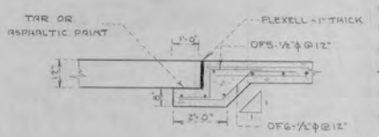


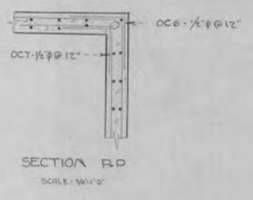


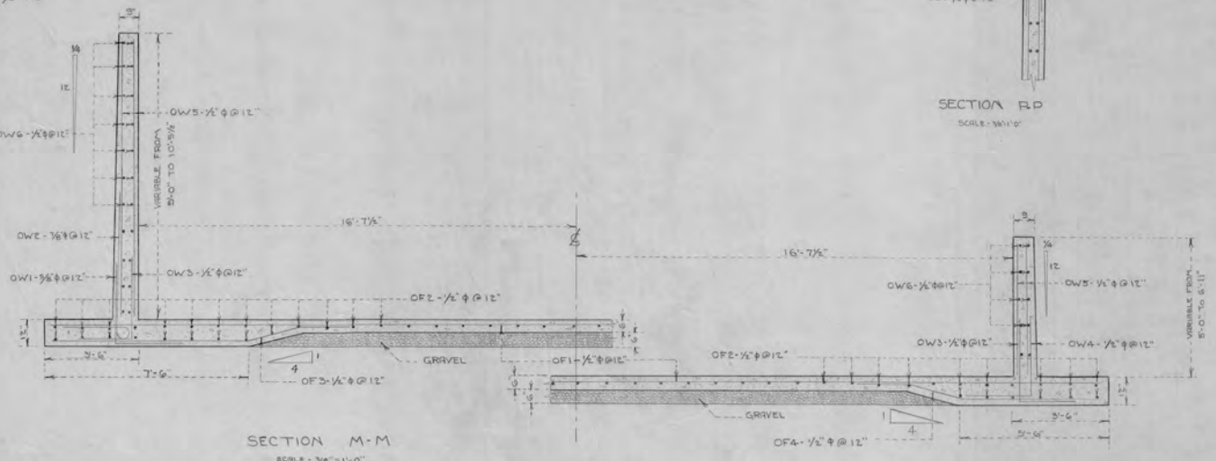
FLOOR - CURVED SECTIONS		
DISTANCE	CURVE #1	CURVE #2
0	2740.46	2726.99
1	2740.44	2726.75
2	2740.38	2726.55
3	2740.30	2726.37
4	2740.19	2726.25
5	2740.05	2726.12
6	2739.87	2726.04
7	2739.67	2725.98
8	2739.43	2725.96
9		2725.97
10		2726.00

RADIUS OF CURVATURE = 34.4'

APPROXIMATE QUANTITIES		
ITEM	QUANTITY	UNIT
INLET TRANSITION		
CONCRETE	49.0	CU. YDS.
REINFORCING STEEL	4778.4	LBS.
RIP - RAP	30.0	CU. YDS.
GRAVEL	20.0	CU. YDS.
OUTLET CHUTE		
CONCRETE	153.5	CU. YDS.
REINFORCING STEEL	15,700.2	LBS.
RIP - RAP	60.0	CU. YDS.
GRAVEL	75.0	CU. YDS.





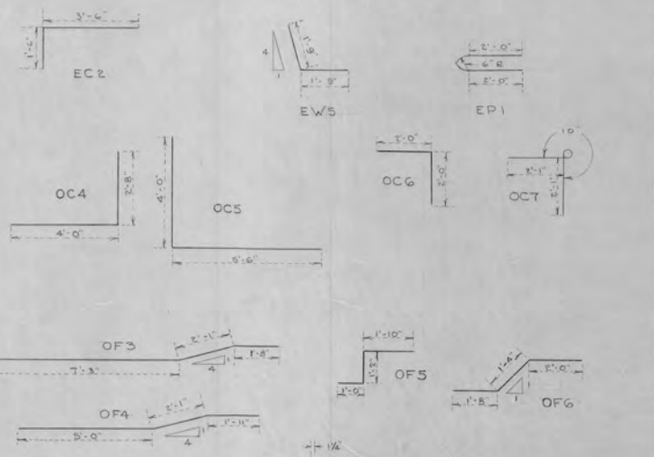


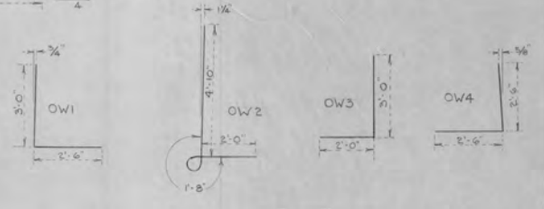
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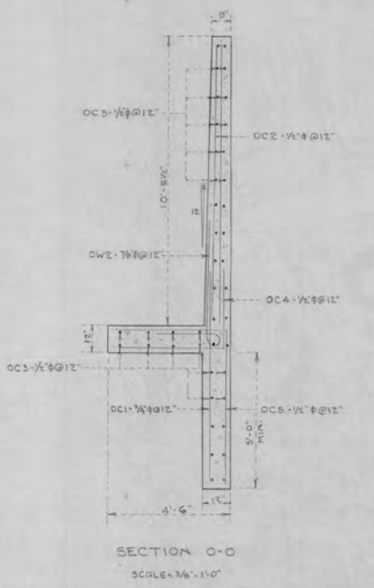
2" CHAMFER STRIPS ON ALL EXPOSED CONCRETE EDGES

ALL CUTOFFS ARE TO BE EXCAVATED AND FORMED TO A MINIMUM DEPTH OF 2'-6" BELOW THE SURFACE SLAB AND TO THICKNESS AS SHOWN. ADDITIONAL WIDTH OF EXCAVATED TRENCH IS TO BE BACKFILLED WITH HAND TAMPED CLAY. IF SHEET PILING IS REQUIRED A MIN. CUTOFF DEPTH OF 3'-0" MUST BE USED.

REINFORCING STEEL TABLE							
MARK	SIZE	SHAPE	SPCG.	LENGTH	NO.	WEIGHT	LOCATION
INLET TRANSITION							
EF1	½" ϕ	STRAIGHT	12"	3500 L.FT.		2204.4	FLOOR BOTH FACES BOTH DIRECTION
EC1	½" ϕ	do.	12"	720 L.FT.		481.0	CUTOFF & HEADWALLS HORIZ.
EC2	½" ϕ	SEE DETAIL	12"	5'-0"	327	1095.5	CUTOFF WALL & HEADWALL VERT.
EW1	½" ϕ	STRAIGHT	12"	9'-6"	20	126.9	WING WALL HORIZ.
EW2	½" ϕ	do.	12"	8'-6"	40	227.1	WING WALL VERT.
EW3	½" ϕ	do. (Var)	12"	400 L.FT.		267.2	TRANSITION WALL HOR.
EW4	½" ϕ	do.	12"	400 L.FT.		267.2	do do VERT.
EW5	½" ϕ	SEE DETAIL	12"	3'-6"	20	46.8	CORNER TIES
EP1	½" ϕ	do.	12"	5'-0"	16	53.4	PIER NOSE HOR.
EP2	½" ϕ	STRAIGHT	12"	1'-8"	8	8.9	do do VERT.
TOTAL						4778.4	
OUTLET CHUTE							
OC1	¾" ϕ	STRAIGHT	12"	6'-0"	34	306.4	CUTOFF WALL
OC2	½" ϕ	do	12"	10'-0"	68	454.2	do do
OC3	½" ϕ	do.	12"	2300 LIN.FT.		1536.4	do do
OC4	½" ϕ	SEE DETAIL	12"	6'-8"	34	151.5	do do
OC5	½" ϕ	do.	12"	9'-6"	100	634.6	do
OC6	½" ϕ	do.	12"	4'-0"	22	58.8	SEC. P-P
OC7	½" ϕ	do.	12"	5'-0"	22	73.5	do.
OF1	½" ϕ	STRAIGHT	12"	3350 LIN.FT.		2237.8	SECS. M-M & N-N
OF2	½" ϕ	do.	12"	4700 LIN.FT.		3139.6	do do
OF3	½" ϕ	SEE DETAIL	12"	11'-0"	58	426.2	SEC. M-M
OF4	½" ϕ	do	12"	9'-0"	88	529.1	SEC. N-N
OF5	½" ϕ	do	12"	4'-0"	50	133.6	SEC. R-R
OF6	½" ϕ	do	12"	5'-0"	50	167.0	do.
OW1	5/8" ϕ	do	12"	5'-6"	56	321.2	SECS. M-M
OW2	⅝" ϕ	do	12"	9'-0"	92	1692.4	SECS. M-M & O-O
OW3	½" ϕ	do.	12"	5'-0"	74	247.2	SECS. M-M & N-N
OW4	½" ϕ	do	12"	5'-0"	46	153.6	SEC. N-N
OW5	½" ϕ	STRAIGHT	12"	2170 LIN.FT.		1449.6	SECS. M-M & N-N
OW6	½" ϕ	do.	12"	2170 LIN.FT.		1449.6	do do.
TOTAL						15700.2	







DEPARTMENT OF AGRICULTURE - CANADA
P.F.R.A.
WATER DEVELOPMENT BRANCH

ST. MARY - MILK RIVER PROJECT
CHIN CONDUIT OUTLET STRUCTURE
DETAIL PLAN OF INLET TRANSITION & OUTLET CHUTE

SCALE - AS SHOWN | DATE - NOV. 1951 | SHEET

SUBMITTED BY: J.A. Blakeman — DATE: [illegible]
APPROVED BY: — DATE:

DESIGNED BY: R.S. & R.B.G.
DRAWN BY: M.L.K. & R.B.G.
TRACED BY: M.L.K.
CHECKED BY: R.S. & J.T.O.

PLAN No. 27555-L-568

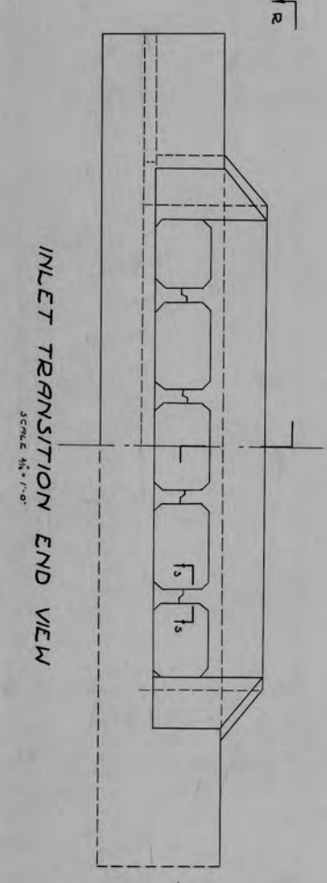
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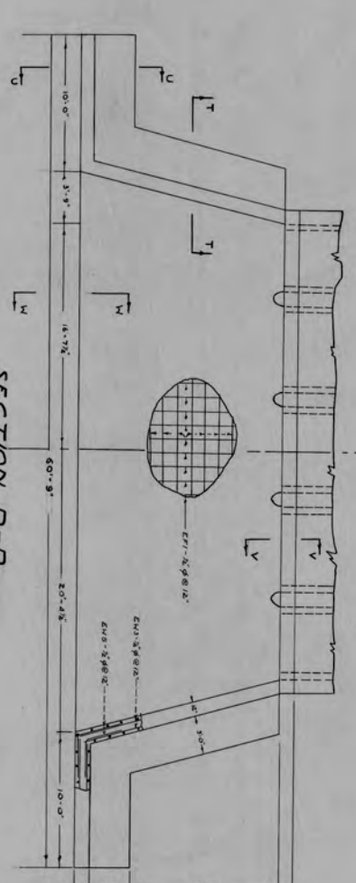
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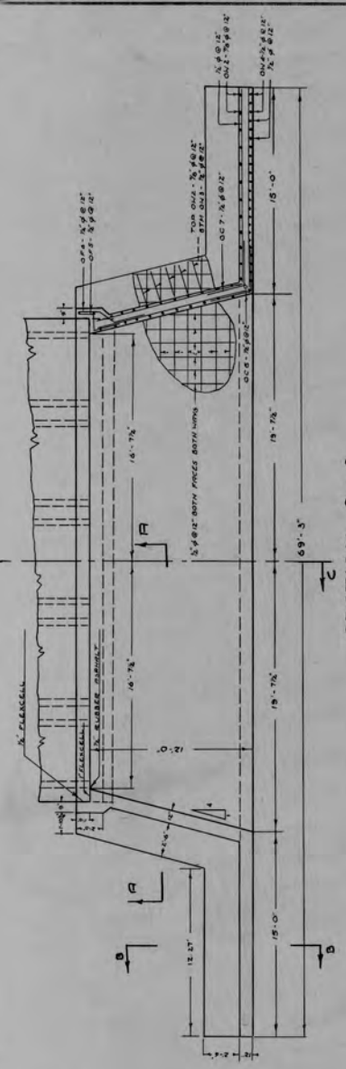
DATE 11-70 WATER RESOURCES

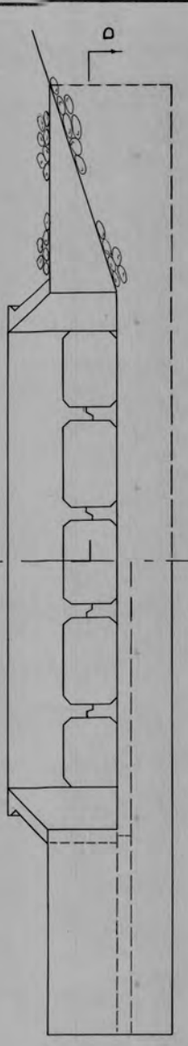
AS CONSTRUCTED STEEL TABLE

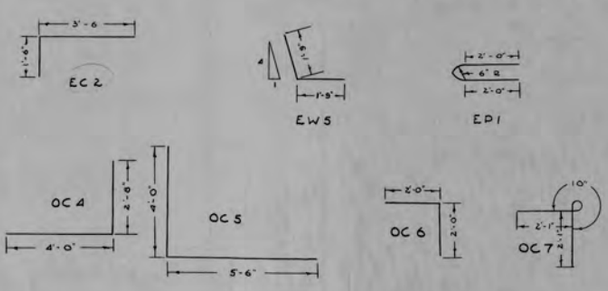
MARK	SIZE	SPCG	SHAPE	LENGTH	No	WEIGHT	LOCATION
INLET TRANSITION							
EF1	½" ϕ	12"	STRAIGHT (LONG)	3300 L FT		2204.4	FLOOR-BOTH FACES, BOTH DIRECTIONS
EC1	½" ϕ	12"	DO	720 L FT		481.0	CUTOFF & HEADWALLS HORIZ.
EC2	½" ϕ	12"	SEE DETAIL	5'-0"	327	1095.5	CUTOFF WALL & HEADWALL-VERT.
EW1	½" ϕ	12"	STRAIGHT	9'-6"	20	126.9	WING WALL HORIZONTAL
EW2	½" ϕ	12"	DO	8'-6"	40	227.1	WING WALL VERTICAL
EW3	½" ϕ	12"	DO (VAR)	400 L FT		267.2	TRANSITION WALL HORIZ.
EW4	½" ϕ	12"	DO	400 L FT		267.2	DO DO VERT.
EW5	½" ϕ	12"	SEE DETAIL	3'-6"	20	46.8	CORNER TIES
ED1	½" ϕ	12"	DO	5'-0"	16	53.4	PIER NOSE HORIZONTAL
ED2	½" ϕ	12"	STRAIGHT	1'-8"	8	8.9	DO DO VERTICAL
TOTAL 4778.4#							
OUTLET CHUTE (SEE NOTE)							
OC1	¾" ϕ	12"	STRAIGHT	6'-0"	34	306.4	CUTOFF WALL
OC3	½" ϕ	12"	DO	560 L FT		374.1	DO DO
OC4	½" ϕ	12"	SEE DETAIL	6'-8"	34	151.5	DO DO
OC5	½" ϕ	12"	DO	9'-6"	100	634.6	DO
TOTAL 1466.6#							
OUTLET TRANSITION							
OW2	⅞" ϕ	12"	SEE DETAIL	9'-0"	58	1067.0	WALL BACKFACE - SEC. A-A & B-B
OW3	½" ϕ	12"	DO	5'-0"	24	80.0	WALL TO FOOTING - SEC. A-A
OW4	½" ϕ	12"	DO	5'-0"	30	100.0	WINGWALL TO FOOTING - SEC. B-B
OC6	½" ϕ	12"	DO	4'-0"	10	27.0	CORNER TIES SEC. D-D
OC7	½" ϕ	12"	DO	5'-0"	10	33.0	DO DO DO
OF5	½" ϕ	12"	DO	4'-0"	50	134.0	EXPANSION JOINT - SEC C-C & D-D
OF6	½" ϕ	12"	DO	5'-0"	50	167.0	DO DO DO DO
STOCK	½" ϕ	12"	STRAIGHT	4800 L FT	—	3206.0	SLAB, WALLS & CUTOFF
TOTAL 4814.0#							

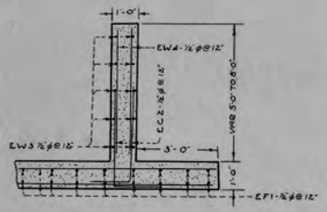


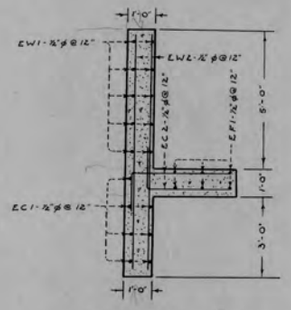


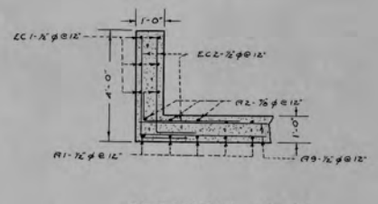


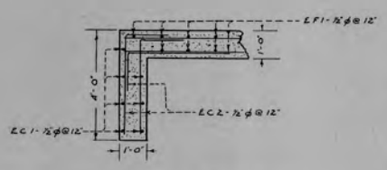


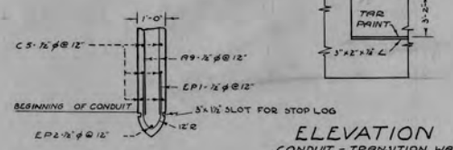


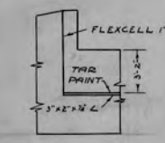


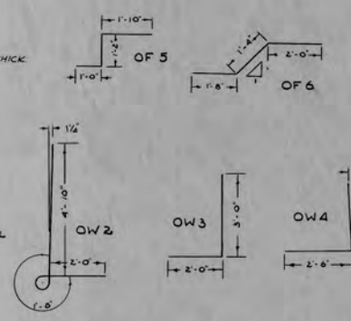


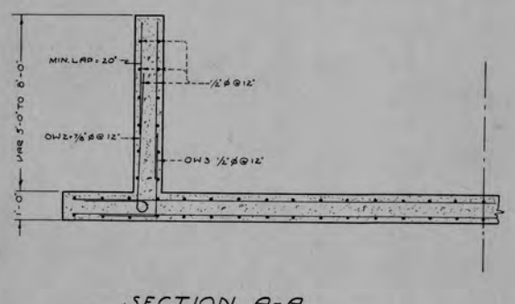


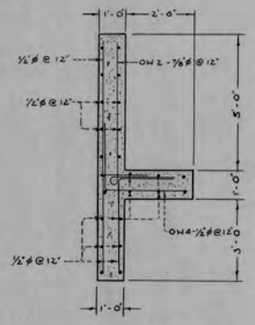


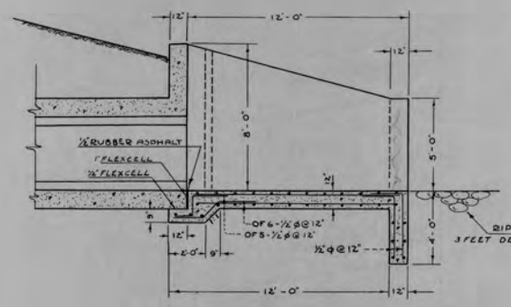












AS CONSTRUCTED QUANTITIES		
ITEM	QUANTITY	UNIT
INLET TRANSITION		
CONCRETE	44.45	CU. YDS
REINFORCING STEEL	4778.4	LBS
OUTLET CHUTE (SEE NOTE)		
CONCRETE	24.07	CU. YDS.
REINFORCING STEEL	1466.6	LBS
FOUNDATION PREPARATION	10.5	CU YDS
HAND EXCAVATION	2.07	CU. YDS
GRAVEL	2560.0	CU YDS
OUTLET TRANSITION		
CONCRETE	46.19	CU YDS
REINFORCING STEEL	4814.0	LBS
RIP RAP	439.5	CU YDS

NOTE:
THE OUTLET CHUTE (SEE PLAN 27555-L-563) WAS OMITTED DUE TO FOUNDATION CONDITIONS, AND THE OUTLET TRANSITION SUBSTITUTED. THE DECISION TO CHANGE WAS MADE AFTER THE SHEET PILING, REINFORCING STEEL AND CONCRETE FOR THE OUTLET CUTOFF WALL AND FOOTING FOR THE CHUTE WERE PLACED.

SCALE REFERENCE ONE INCH

DEPARTMENT OF AGRICULTURE—CANADA
P. F. R. A.
WATER DEVELOPMENT BRANCH

ST. MARY IRRIGATION PROJECT
CHIN CONDUIT OUTLET STRUCTURE
DETAIL OF PLAN
INLET & OUTLET TRANSITION
AS CONSTRUCTED 1952

SCALE AS SHOWN DATE DECEMBER 1955 SHEET 4 OF 5.

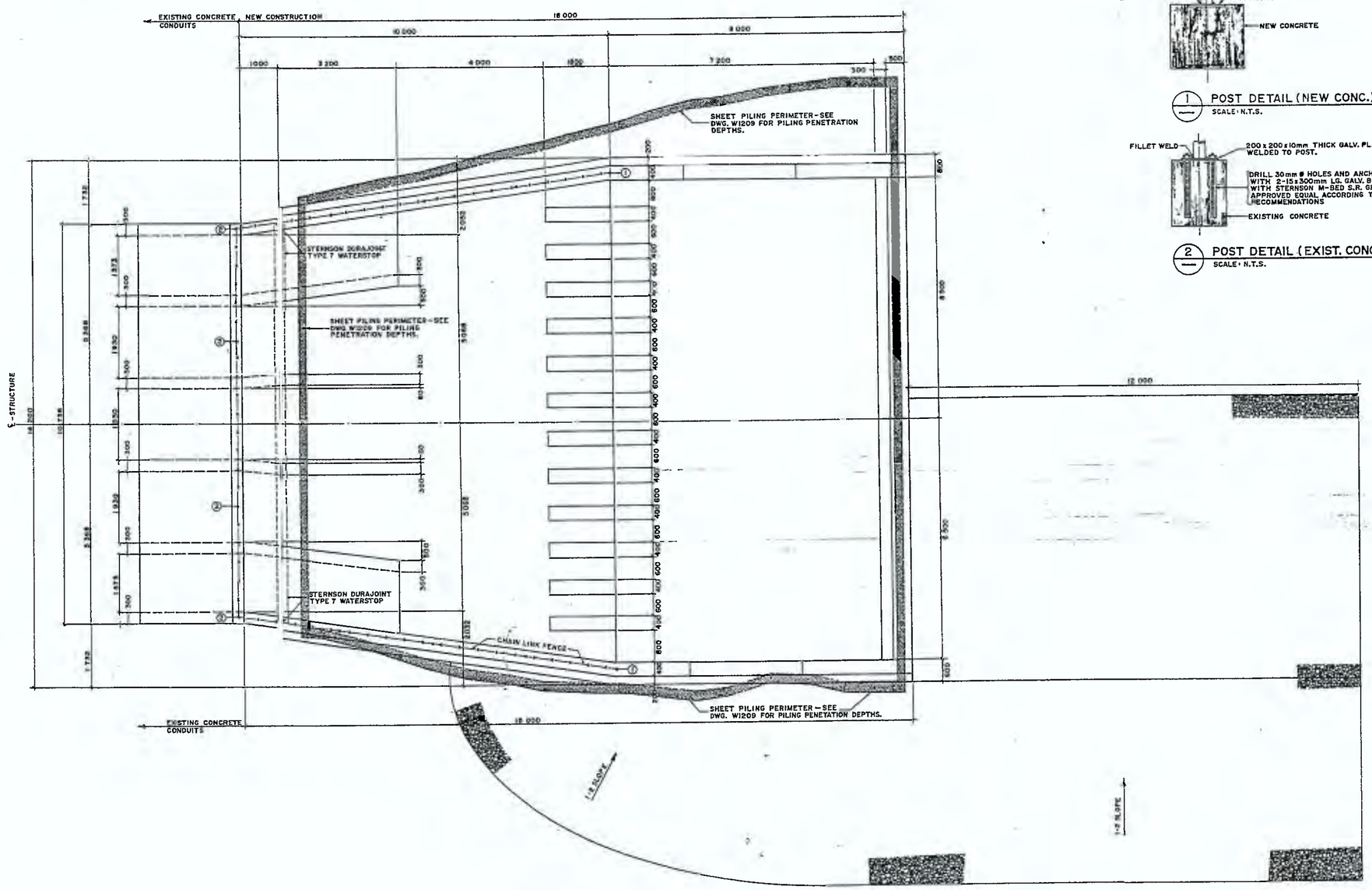
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DATE
APPROVED BY CHIEF ENGINEER
DATE APR 1956

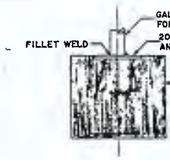
DESIGNED BY R.S.E. 280
DRAWN BY A.K.
TRACED BY A.K.
CONSTRUCTED & CHECKED BY R.W.J.

PLAN No 27555-L-C563

3854 L

HWL-3854





1 POST DETAIL (NEW CONC.)
SCALE: N.T.S.

2 POST DETAIL (EXIST. CONC.)
SCALE: N.T.S.

GENERAL NOTES

FOUNDATION CONCRETE 15 MPa
SLAB CONCRETE 30 MPa
WALL CONCRETE 35 MPa
CONCRETE AIR CONTENT 4-7 %
MAXIMUM SLUMP 80mm
RIPRAP — SOUND CLEAN FIELDSTONE
100% LESS THAN 700mm
50% LESS THAN 450mm
20% GREATER THAN 300mm
ALL MISCELLANIOUS STEEL GRADE 44W AS PER C.S.A 840.20,040.21
ALL CONCRETE TYPE 50

RECORD DRAWING
DATE May 6/82 SIGNED [signature] PROJECT SUPERVISOR

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF ALBERTA
PERMIT NUMBER P 02375
UNDERWOOD McLELLAN LTD.
PERMIT

REV	D	M	S	REVISION DESCRIPTION	DRN	SUPV	CHK	ENG
0	7	9	82	RECORD DRAWING	R.C.S.		A.S.	J.P.	J.P.

Underwood McLellan Ltd.
Consulting Engineers and Planners
Lethbridge, Alberta

PROFESSIONAL ENGINEERS ALBERTA
ENGINEER

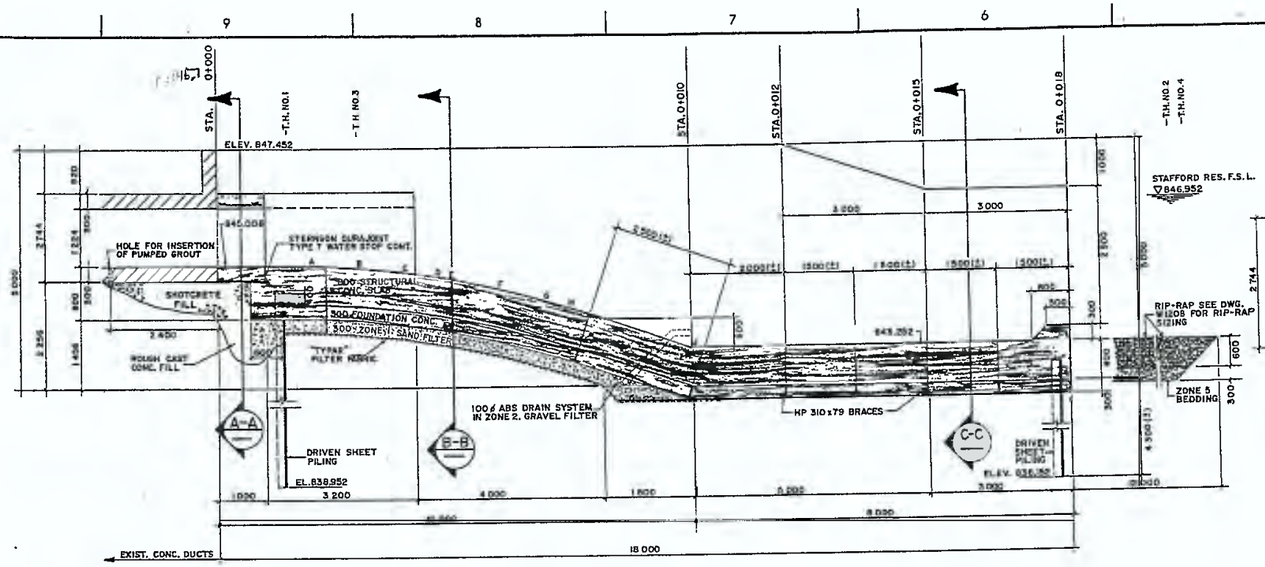
ST. MARY RIVER IRRIGATION DISTRICT

CHIN RESERVOIR OUTLET STRUCTURE

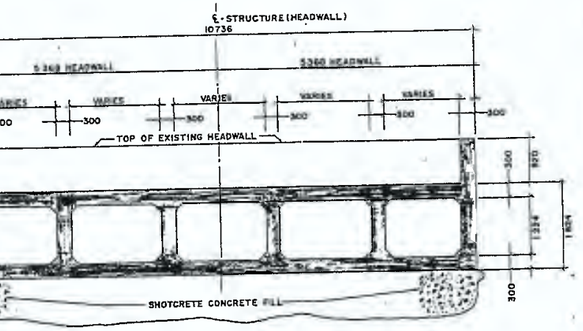
STILLING BASIN

PLAN AND DETAILS

the uma group	JOB NUMBER	DRAWING	REV
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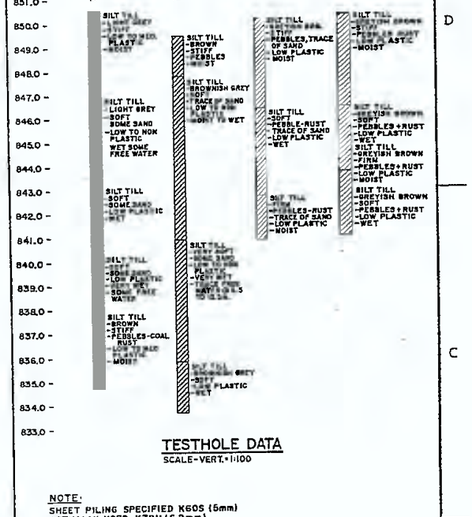


CENTERLINE PROFILE
SCALE • 1:50



A-A SECTION – STA. 0+000.
SCALE • 1:50

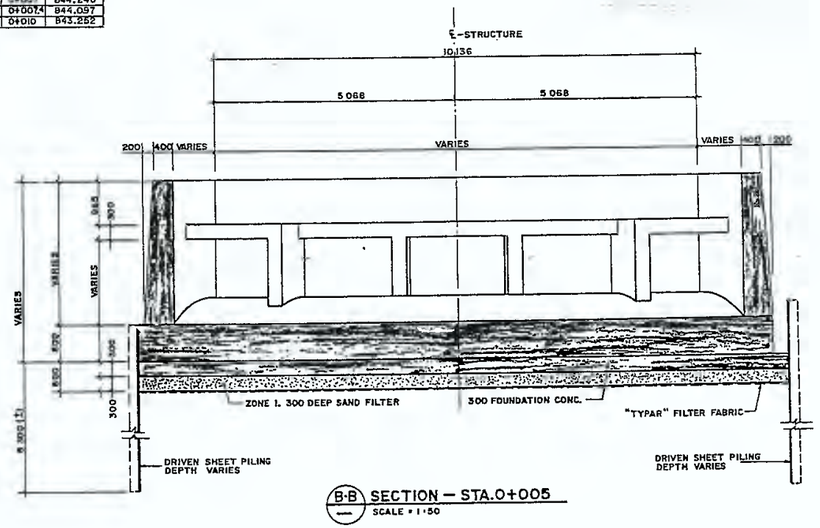
NOTE:
ALL ELEVATIONS ARE REFERENCED FROM INVERT ELEVATION OF CENTRE CONDUIT (845.008) ESTABLISHED FROM ALBERTA ENVIRONMENT B.M. A82-028 ELEVATION (863.024) ON FEB. 19, 1983.



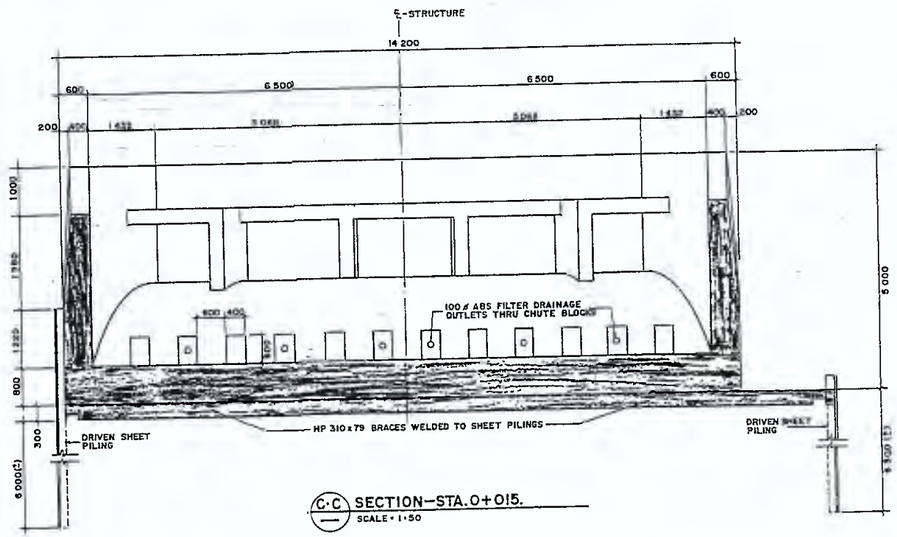
TESTHOLE DATA
SCALE-VERT.• 1:100

NOTE:
SHEET PILING SPECIFIED K60S (5mm) ACTUALLY USED K79U (6.2mm)

SPOT ELEV. SCHEDULE		
POINT	STATION	ELEVATION
A	0+002	845.008
B	0+005	844.978
C	0+006	844.886
D	0+0047	844.780
E	0+005	844.734
F	0+006	844.520
G	0+007	844.246
H	0+007.4	844.057
J	0+010	843.252



B-B SECTION – STA.0+005
SCALE • 1:50



C-C SECTION – STA.0+015.
SCALE • 1:50

RECORD DRAWING
DATE May 7/90

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF ALBERTA
PERMIT NUMBER P 00375
UNDERWOOD McLELLAN LTD.
PERMIT

REV	D	M	Y	REVISION DESCRIPTION	DRN	SUPV	DES	CHK	ENG
0	8	9	82	RECORD DRAWING	R.C.S		A.S.	J.P.	J.P.

Underwood McLellan Ltd.
Consulting Engineers and Planners
Lethbridge, Alberta

PROFESSIONAL ENGINEER ALBERTA
ENGINEER

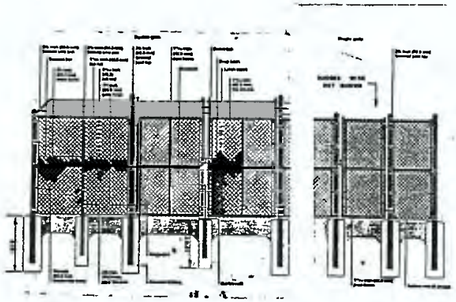
ST. MARY RIVER IRRIGATION DISTRICT

CHIN RESERVOIR OUTLET STRUCTURE

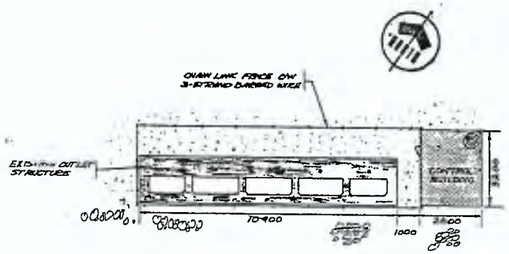
STILLING BASIN

CROSS-SECTIONS

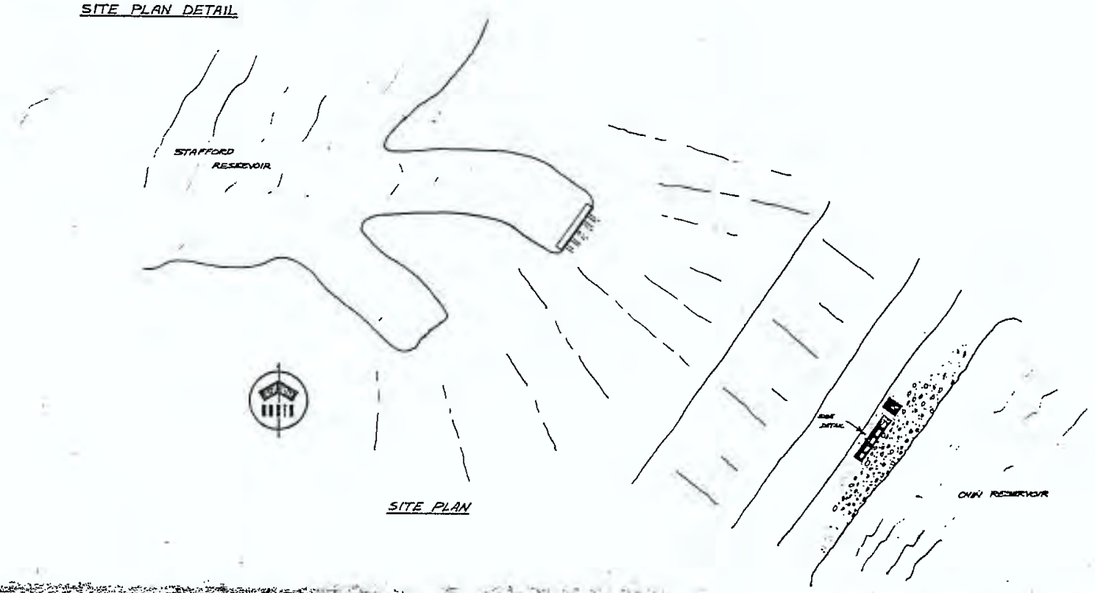
the uma group	JOB NUMBER 2507-1758-013-01	DRAWING W1209	REV 0



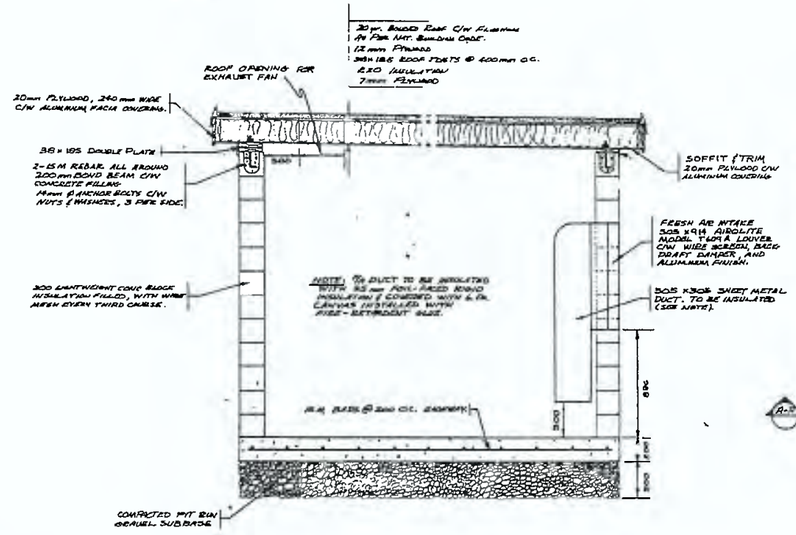
TYPICAL GATE DETAIL



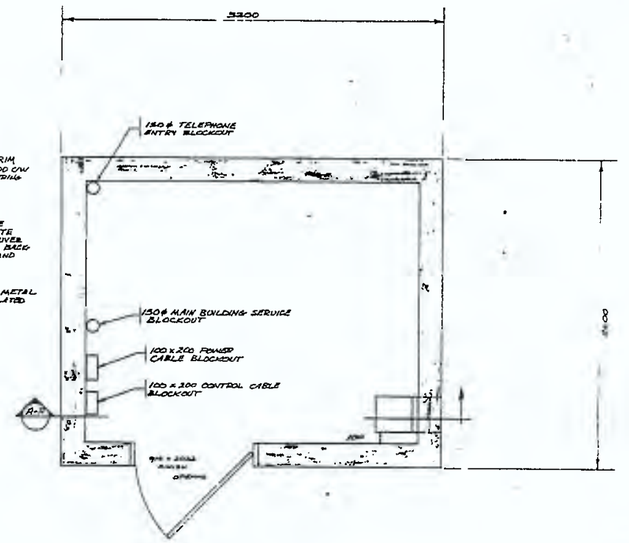
SITE PLAN DETAIL



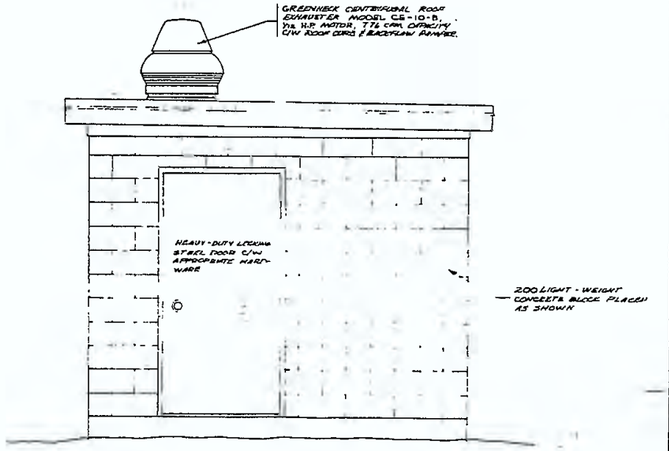
SITE PLAN



A-A SECTION



CONTROL BUILDING FLOOR PLAN



ELEVATION

PAINT SPECIFICATIONS

INTERIOR - BAPCO - MEADOW GREEN

EXTERIOR - BAPCO - SAND BEIGE WITH BAPCO - ACORN BROWN FLASHING & TRIM

PAINT SPECIFICATIONS

INTERIOR: BAPCO - Meadow Green

EXTERIOR: BAPCO - Sand Beige with Acorn Brown Flashing and Trim

RECORD DRAWING
DATE 4/09/83 SIGNED [signature] PROJECT SUPERVISOR

METRIC

No.	REVISION	DATE	BY

No.	DATE	REMARKS
2	JULY '83	RECORD DRAWING
1	APR. 2/'83	FOR CONSTRUCTION

PROFESSIONAL ENGINEER ALBERTA

ST. MARY RIVER IRRIGATION DISTRICT

CHIN DAM OPERATORS & CONTROLS

CONTROL BUILDING

PLANS, SECTION, & DETAILS

N.E. 1/4 of 27-8-18-W. 4th

Underwood McLellan Ltd.
Consulting Engineers and Planners
Calgary, Alberta
the UMA group

DESIGN W.F., E.G., M.A.M.	
DRAWN K.L.V.	
CHECKED W.F., E.G., D.	
SCALE NOT TO SCALE	
	DATE APRIL 2, 1983
	JOB 1988-018-00-WF
	SHEET
	DRAWING W0220
	ISSUE 2

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS AND GEOPHYSICISTS OF ALBERTA
PERMIT NUMBER P 02375
UNDERWOOD McLELLAN LTD.

APPENDIX E
Rating Curves

Bathymetry of
Chin Lakes

Scale 1 : 20 000

500 0 500 1000 1500

Metres

Contours (Intervals are approximately 1.0 metres below FSL: 861.36)

Intermediate

Index

Boat Launch Site

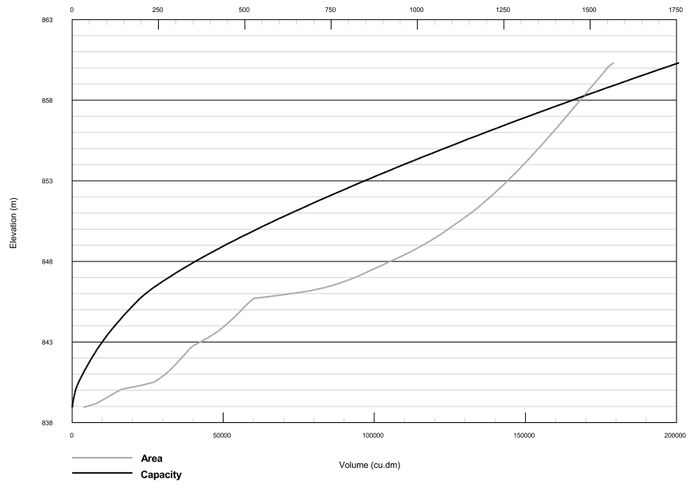
Shoreline from OrthoPhoto
Water level: 860.32m
Date: 05/28/98

Bathymertic Survey performed during August 28, 2002, average water level : 858.52 m)

Disclaimer: This map is not intended for navigational purposes. Information as depicted is subject to change, therefore, the Government of Alberta assumes no responsibility for discrepancies at time of use.

Produced by Resource Information Unit, Alberta Sustainable Resource Development, Southeast Region, Lethbridge, March 2004.

Area / Capacity Curve



Lake Morphometry

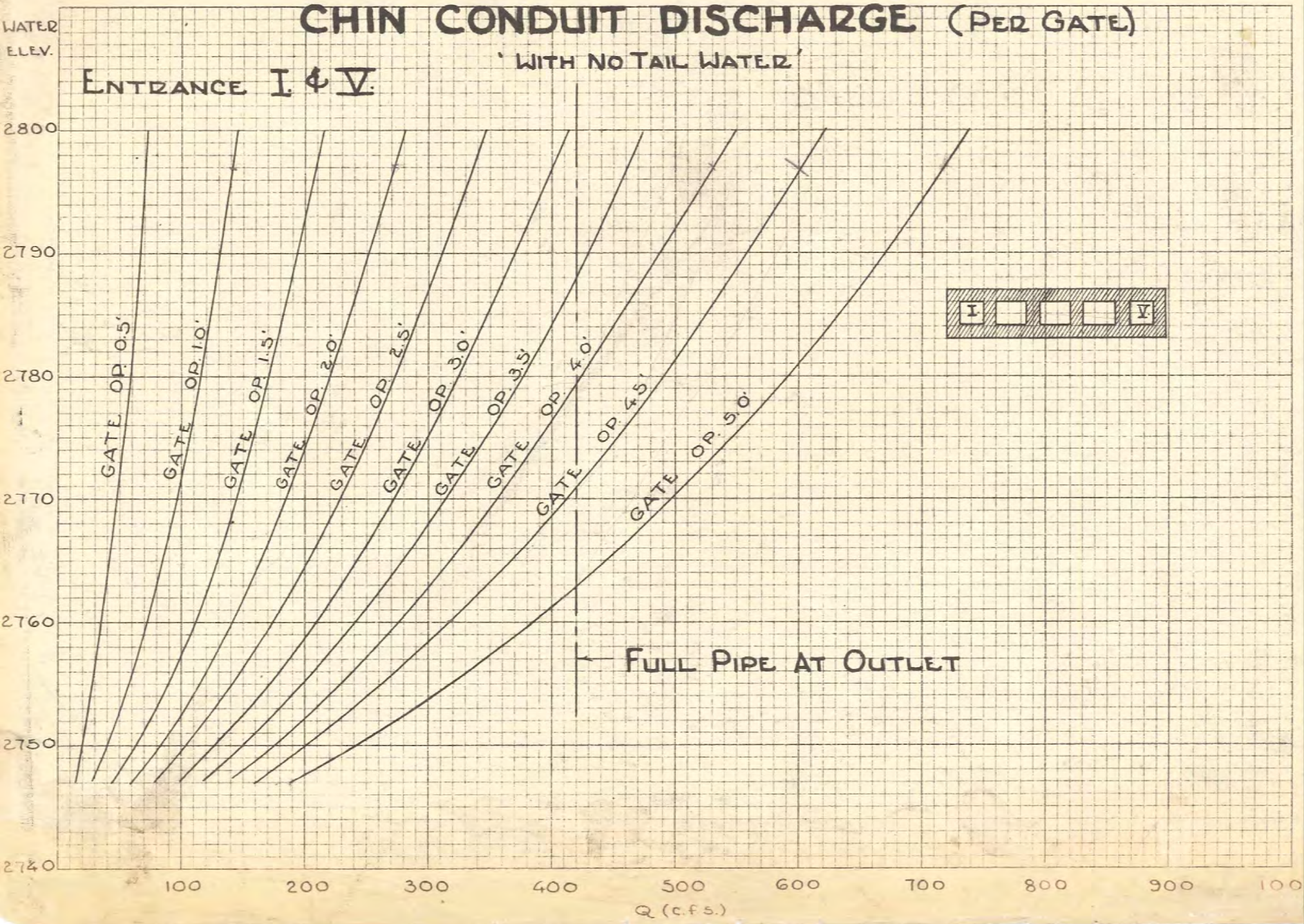
Location:	**Twp. 7 & 8 Rge. 16, 17 & 18 W 4**
Area (shoreline):	**1568.97 Hectares**
Volume:	**200851.98 cubic decametres**
Shoreline Length:	**66.2 kilometres (including islands)**
Shoreline Development Factor:	**4.71**
Maximum Length:	**24.7 kilometres**
Maximum Width:	**0.87 kilometres**
Mean Width:	**0.24 kilometres**
Maximum Depth:	**22.64 metres**
Mean Depth:	**12.80 metres**
Elevation:	**860.32**
Date of Impoundment:	**Initially 1920's - Enlarged in 1952**

Colour/Depth Scale

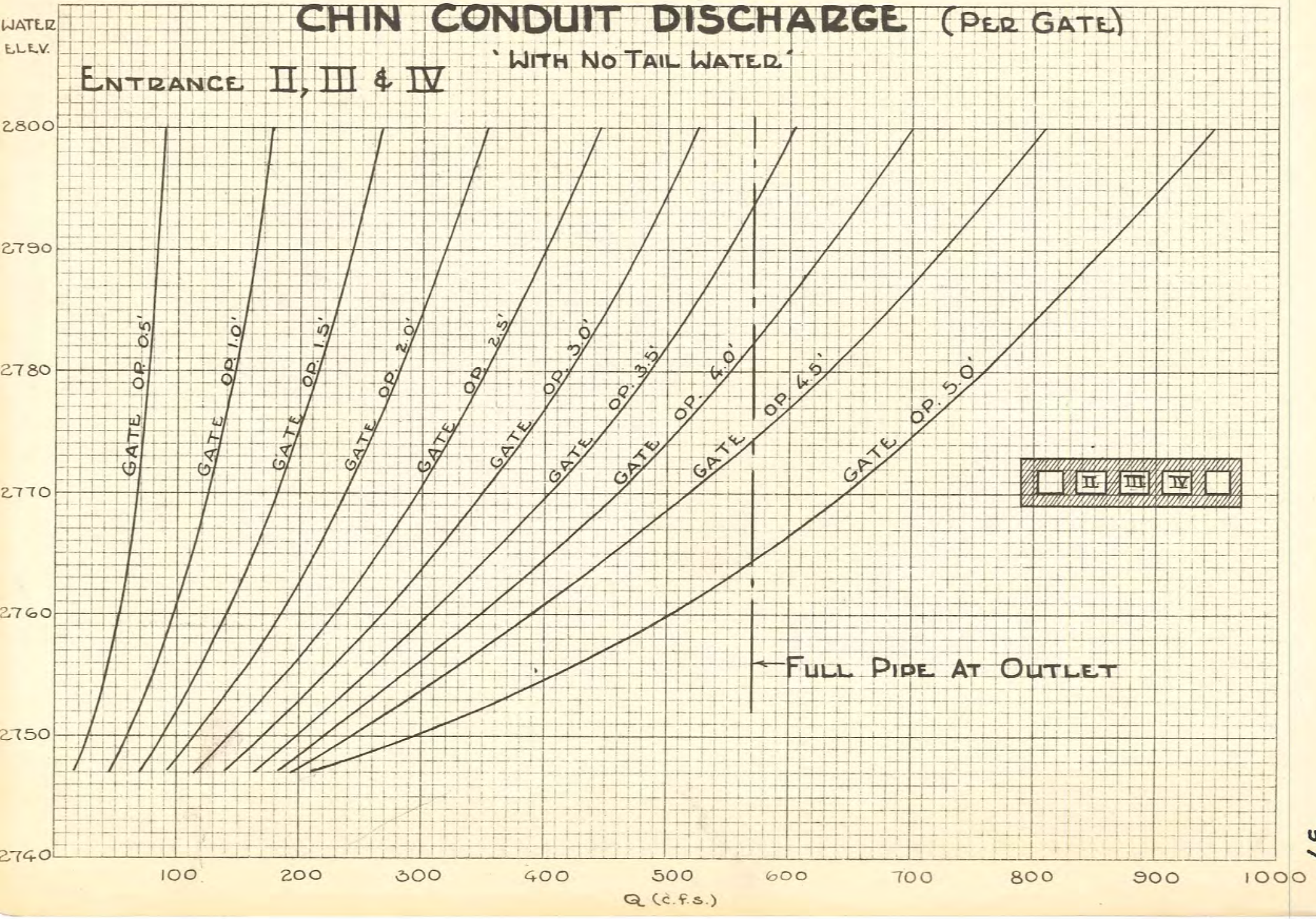
F.S.L. 861.36

Area (ha)	Volume (cu.dm)	Elevation (m)	
1568.71	200851.98	860.32	1m Shoreline Level
1552.86	197322.38	860.10	
1545.21	193828.45	859.87	
1536.46	190351.72	859.64	
1527.52	186894.68	859.42	2m
1518.59	183457.75	859.20	
1509.48	180040.92	858.97	
1500.48	176644.59	858.75	
1491.70	173268.50	858.52	3m
1482.63	169912.17	858.29	
1473.74	166576.26	858.07	
1464.86	163260.34	857.85	
1456.00	159964.41	857.62	
1447.12	156688.41	857.39	4m
1438.66	153432.38	857.17	
1429.58	150195.39	856.95	
1420.61	146978.83	856.72	
1411.76	143782.46	856.50	5m
1402.48	140606.01	856.27	
1393.49	137450.43	856.04	
1384.15	134315.08	855.82	
1374.97	131200.73	855.60	6m
1365.62	128107.04	855.37	
1356.03	125034.40	855.14	
1346.57	121983.33	854.92	
1336.94	118953.54	854.70	
1327.44	115945.41	854.47	7m
1317.67	112958.67	854.25	
1307.77	109993.92	854.02	
1297.90	107051.43	853.79	
1287.74	104131.17	853.57	8m
1277.07	101233.75	853.35	
1266.58	98360.33	853.12	
1255.97	95510.52	852.89	
1244.86	92684.59	852.67	
1233.65	89883.67	852.45	9m
1222.34	87107.96	852.22	
1210.67	84357.69	852.00	
1198.79	81633.68	851.77	
1186.35	78936.41	851.54	10m
1173.67	76267.12	851.32	
1160.02	73626.36	851.10	
1145.95	71016.32	850.87	
1131.77	68437.92	850.64	
1117.32	65891.43	850.42	11m
1102.18	63377.46	850.20	
1087.37	60897.54	849.97	
1071.90	58450.97	849.75	
1055.64	56039.19	849.52	12m
1038.46	53664.01	849.29	
1021.13	51327.47	849.07	
1002.14	49029.92	848.85	
982.35	46775.12	848.62	
961.11	44564.83	848.39	13m
938.93	42402.33	848.17	
915.55	40289.73	847.95	
893.42	38229.73	847.72	
870.52	36219.53	847.50	14m
847.50	34260.85	847.27	
824.01	32353.97	847.04	
798.04	30499.94	846.82	
766.77	28704.34	846.60	15m
731.73	26979.10	846.37	
681.79	25332.71	846.14	
606.43	23798.66	845.92	
524.94	22434.18	845.70	
513.24	21253.06	845.47	16m
502.43	20098.26	845.25	
492.51	18967.80	845.02	
482.26	17859.65	844.79	
471.21	16774.55	844.57	17m
460.16	15714.33	844.35	
448.37	14678.97	844.12	
436.30	13670.14	843.89	
422.69	12688.47	843.67	
407.62	11737.42	843.45	18m
389.64	10820.27	843.22	
371.33	9943.58	843.00	
350.29	9108.09	842.77	
339.04	8319.93	842.54	19m
329.99	7557.09	842.32	
320.65	6814.60	842.10	
310.88	6093.13	841.87	
301.11	5393.63	841.64	
291.25	4716.14	841.42	20m
280.45	4060.83	841.20	
268.54	3429.82	840.97	
254.63	2825.60	840.75	
238.65	2252.69	840.52	21m
198.28	1715.72	840.29	
142.91	1269.58	840.07	
124.53	948.04	839.85	
106.50	667.85	839.62	22m
88.23	428.22	839.39	
69.08	229.71	839.17	
33.00	74.26	838.95	
0.33	0.00	838.72	

NO. 359-5 10 X 10 to the inch.
MADE IN U.S.A.
KEUFFEL & ESSER CO.



NO. 359-5 10 × 10 to the inch.
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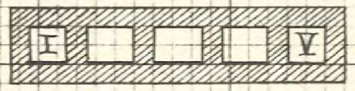


NO. 359-5 10 × 10 to the inch.
MADE IN U. S. A.
KEUFFEL & ESSER CO.

CHIN CONDUIT DISCHARGE (PER GATE)

'WITH TAIL WATER'

ENTRANCE I & V



GATE OP. 0.5'
GATE OP. 1.0'
GATE OP. 1.5'
GATE OP. 2.0'
GATE OP. 2.5'
GATE OP. 3.0'
GATE OP. 3.5'
GATE OP. 4.0'
GATE OP. 4.5'
GATE OP. 5.0'

H = HEADWATER ELEV. - TAIL WATER ELEV.

H

0 10 20 30 40 50 60

0 100 200 300 400 500 600 700 800 900 1000

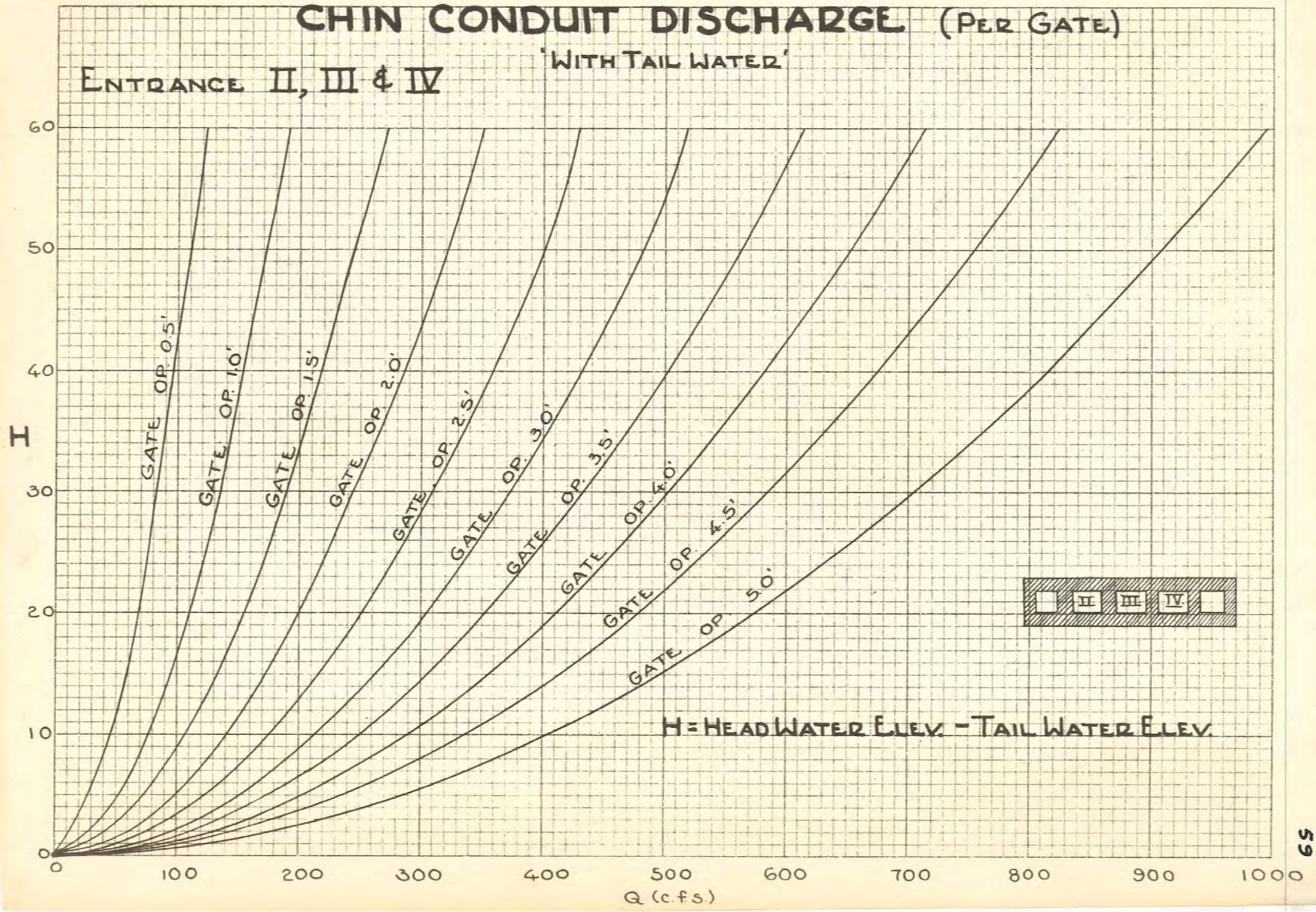
Q (c.f.s.)

KEUFFEL & ESSER CO.

CHIN CONDUIT DISCHARGE (PER GATE)

'WITH TAIL WATER'

ENTRANCE II, III & IV



APPENDIX F
Inspection Reports

APPENDIX F
2018 Dam Safety Inspection Report

PROJECT NAME	**CHIN RESERVOIR DAM SAFETY REVIEW**		
CLIENT	St. Mary River Irrigation District (SMRID)	**REPORT DATE**	November 28, 2018
LOCATION	Chin 1: SE ¼ 34-8-18 W4M Chin 2: SE ¼ 26-7-16 W4M	**PREPARED BY**	David Kushner, P.Eng. Michael Bender, Ph.D., P.Eng. Allen Veenland, P.Eng Richard Slopek, P.Eng Remi Sasseville, P.Eng
INSPECTION DATE	November 13 & 14, 2018		
WEATHER	Nov 13: Cloudy / Sunny, 5 / 8 °C Nov 14: Cloudy / Sunny, 5 / 11 °C Some snow cover		

1 INSPECTION TEAM

Name - Title	Company	Dates Attended
David Kushner, P.Eng.	Matrix Solutions Inc.	November 13 & 14, 2018
Michael Bender, Ph.D., P.Eng.	Matrix Solutions Inc.	November 13 & 14, 2018
Richard Slopek, P.Eng.	Canadian Projects Limited	November 13, 2018
Remi Sasseville, P.Eng.	Canadian Projects Limited	November 13, 2018
Kevin Wisener, P.Eng.	Canadian Projects Limited	November 13, 2018
Allen Veenland, P.Eng	Tetra Tech	November 13, 2018
Travis Geremia, Project Manager, P.Eng.	SMRID	November 13 & 14, 2018
Scott Marose – Irrican Operator	SMRID	November 13 & 14, 2018
Peter Peters – Water Supervisor	SMRID	November 13, 2018
Robb Slusar – Dam Safety & Construction Technologist	SMRID	November 13, 2018
Alan Mills – Irrican Operator	SMRID	November 14, 2018
Jan Tamminga – Manager of Operations	SMRID	Interviewed at SMRID office
Trevor Helwig, P.Eng. – District Engineer	SMRID	Interviewed at SMRID office

2 CHIN 1 DAM (WEST)

2.1 Dam Crest

Condition	Observation
Surface Cracking/ Scarps	• Road crest forms a public rural road (Township Road 182). • The road surface on dam crest was in good condition with no visually evident signs of surface cracking or scarps (Photo 1).
Horizontal Alignment	• The existing dam crest profile appeared straight and uniform (Photo 1).
Settlement	• No indication of settlement observed.

Depression/Sinkhole	• None observed. Some minor potholes related to traffic and road maintenance.
Ruts and/or Puddles	• County road on dam crest is graveled and maintained. Left of outlet structure minor ponding of surface water noted due to grading ridge (Photo 2).
Surface Protection	• Gravel road along crest.
Vegetation	• None observed directly on crest.
Animal Burrow	• None observed.
Other	• The fenced gates and instrumentation along the dam crest are relatively unprotected from public safety risks such as damage from passing motorists or road grader.

2.2 Upstream Slope

Condition	Observation
Slope Stability	• No indications of instability observed (Photo 3).
Slope Protection	• Riprap is generally a non-uniform mixture of rock and debris with some out-of-spec oversized boulders and concrete rubble (Photo 4, Photo 5 and Photo 6). • Some patches of predominantly finer riprap noted in typical reservoir fluctuation zone (Photo 5). • Few locations with exposures of base gravel were noted (Photo 6). • Riprap on upper slope, above typical reservoir fluctuation zone appears to have been placed ad-hoc and many patches with no visible riprap were observed; this may relate to repair of past erosion events (Photo 7 and Photo 8).
Erosion	• Small number of locations where individual boulders may have been plucked by ice. • No indications of current erosion activity observed.
Depression/Sinkhole	• None observed.
Vegetation	• Grass and bushes growing amongst riprap, particularly on upper slope (Photo 9). • There are a few small trees near the shoreline (Photo 10).
Animal Burrows	• None observed.
Other	• Minor bits of concrete debris noted along the dam crest (Photo 11).

2.3 Downstream Slope

Condition	Observation
Slope Stability	• No indications of instability observed.
Slope Protection	• Covered with a thick, well-developed grass cover which provides good erosion protection (Photo 12 and Photo 13).
Erosion	• No eroded areas were visually evident on the downstream slope of the dam with the exception of some areas along the abutments (see abutments Section).
Depression/Sinkhole	• None observed.
Vegetation	• Slope is grass covered. A few weeds were noted but nothing of significant concern.
Animal Burrow	• None observed.
Seepage	• No evidence of seepage egress on downstream slope observed (Photo 12).
Other	• N/A.

2.4 Downstream Toe

Condition	Observation
Surface Condition	• Grading appears reasonably smooth and regular (Photo 14).
Movement	• No evidence of movement observed
Leakage	• None observed.
Toe Drainage	• A toe ditch is present along most of the dam length. Its base is likely close to the ground water level but with no standing water or evidence of seepage flows along the ditch. Some vegetation noted indicates possible shallow groundwater locally beneath the ditch (Photo 15).
Seepage	• Seepage likely reports to the channel downstream of the outlet structure and to the old channel near the left side of the coulee bottom.
Vegetation	• Generally grass covered. Some cattails at the upstream end of old channel at the left side of the coulee bottom suggest seepage egress in that area (Photo 16).
Depression / Sinkhole	• None observed.

Animal Burrow	• None observed.
Others	• At least 40 residences are situated from 100 to 700 m downstream of the dam and the conduits, 19 permanent homes and 21 camper trailers (RVs) with space for more RVs during peak summer season. There is only one egress option for residents which is close to the dam and may not be possible during a dam failure.

2.5 Right Abutment (North)

Condition	Observation
Surface Protection – Upstream	• Coverage of riprap is sparse (Photo 17).
Surface Protection – Downstream	• Downstream abutment is covered with grass (Photo 18).
Interface – Abutment / Shoreline	• Some shoreline erosion is occurring on the upstream, right abutment although a small amount of erosion protection appears to have been placed (Photo 11). • Closer to the dam, there is an area that appears to be used as a boat launch but is not graded and surfaced as a formal boat launch (Photo 11).
Movement	• Some slumping might be occurring as part of the reservoir rim erosion but no specific examples were observed.
Erosion	• Small 300 mm diameter culvert at right upstream abutment. An eroded swale is forming along the groin of the upstream abutment (Photo 17).
Depression/Sinkhole	• None observed
Vegetation	• Right upstream and downstream abutment areas are generally grass covered with a few trees also noted (Photo 11 and Photo 18).
Animal Burrow	• None observed.
Slope Stability	• No evidence of significant slope instability observed.
Other	• N/A.

2.6 Left Abutment (South)

Condition	Observation
Surface Protection – Upstream	• Coverage of riprap was sparse (Photo 3).
Surface Protection – Downstream	• Downstream abutment is covered with grass (Photo 19).
Interface – Abutment / Shoreline	• Some shoreline erosion is occurring on the upstream, left abutment.
Movement	• Some shallow slumping might be occurring on the upstream left abutment near the dam (Photo 20).
Erosion – Left Abutment	• Left downstream abutment shows disturbance from cattle activity and signs of erosion from surface runoff (Photo 19 and Photo 21). 600 mm culvert near left downstream abutment drains from a small coulee west and downstream of the left abutment to the reservoir. A ditch block was installed between the depression and the downstream abutment (Photo 22). • Some minor erosion is occurring on the upstream groin (Photo 3 and Photo 24).
Depression/Sinkhole	• None observed.
Vegetation	• Generally, grass covered where not eroded or disturbed by cattle activity.
Animal Burrow	• None observed.
Slope Stability	• As noted above, some possible shallow slope movement upstream of dam. Downstream abutment slope is irregular and locally steep but recent slope movement activity was not observed.
Other	• N/A.

2.7 Instrumentation

Condition	Observation
Piezometer	• Some standpipe piezometers consisting of capped steel pipes were noted and additional standpipes are likely present beneath instrument covers that were also observed. (Photo 25)
Deformation Monitoring	• A manhole related to an abandoned settlement monitoring system was observed (Photo 26).

2.8 Outlet Structure

Condition	Observation
Type	• Five (5) x 1.2 m high x 145 m long gated concrete conduits, with a gate well near the dam center-line. Outlet energy is dissipated at a cast-in-place concrete stilling basin. • Conduits are numbered 1 to 5 from the right (north) to the left (south). • Conduits 1 and 5 are 1.5 m wide. • Conduits 2 to 4 are 1.9 m wide. • No trashracks at the inlet. • Bulkhead slots at upstream end of conduits.
Gates - refer to conduit inspection report for further details and photos.	
Type	• Cast steel slide gates with the following dimensions. • Gate 1: 1.5 m high x 1.2 m wide • Gate 2: 1.5 m high x 1.5 m wide • Gate 3: 1.7 m high x 1.7 m wide • Gate 4: 1.5 m high x 1.5 m wide • Gate 5: 1.7 m high x 1.4 m wide • Gates 1, 2 and 4 are flush bottom seal type gates (seal flush with the floor of the conduit). • Gates 3 and 5 lower past the floor of the conduit and seal between the face of the gate and the concrete.
Actuators	• The actuators and controls appeared to be in good condition (Photo 27). • A drill to operate the gates in the event of power loss is located within the control cabinet (Photo 28). – See Section 2.9 for further details.
Testing	• The bulkheads were in place during the inspections. Therefore, there was no water in the gate well or against the gates and the gates could not be tested under hydrostatic loads. • Gate 1 was raised from 0.487 m open to 1.237 m open (Photo 29 and Photo 30) in the presence of the inspection team. The gate operated smoothly under no load conditions. • The other four gates were raised from their partially open positions to the raised positions (Photo 31) while the inspection team examined the stilling basin. SMRID operator confirmed all gates were operating properly without any issues.
Seals / Guides	• SMRID noted that majority of gate seals and guides were in acceptable condition. Typical condition shown in Photo 32. • Gate 5 had heavy wear along the side seals and guides (Photo 33).
Stems	• Gate stems were generally corroded with a build-up of precipitate material. • Gate 2 had a broken stem guide (Photo 34).
Conduits - refer to conduit inspection report for further details and photos.	
Concrete Condition	• All conduits had a coating of grout upstream of the gates. In all cases this grout was delaminating with approximately 3ft x 3ft pieces missing 5 m upstream of the gates (Photo 35). • Numerous cracks observed in sides and ceiling. SMRID noted that these cracks were observed and are similar to previous years (Photo 36 and Photo 37). Did not observe very many cracks in the floor (about 50% of floor was visible; the rest was under very murky water). • Concrete appeared to be solid and relatively smooth. Some honeycombing on the ceiling noted maximum 30 to 40 mm deep. Hit these areas with the hammer but did not reveal any larger voids.
Condition of Joints	• A single horizontal joint runs the length of the conduits (Photo 36). The joint had a 5 mm layer of weaker grout / cement that came off with blows from the hammer. A hard layer was underneath.

Movement	• The conduits were surveyed for settlement.
Leakage	• SMRID noted that there was significantly more leakage through the cracks in the concrete last year during the annual inspection. SMRID noted that the reservoir was at a lower elevation (587.54 m) last year. Therefore, it was thought that the leakage was primarily due to surface water drainage from the dam crest and slopes.
Intake Structure	
Concrete Condition	• Intake is submerged and was not inspected. Divers installed bulkheads, however, no report was provided on the intake. A barge was used to install the bulkhead gates (Photo 38).
Condition of Joints	• Not inspected.
Movement	• Not inspected.
Access	• Inspection by divers or during extreme low reservoir levels.
Gate Well	
Concrete Condition	• Deck concrete is not uniform with apparent multiple iterations of patch work having been carried out. There are miscellaneous temperature cracks (Photo 39). The concrete in the gate well shaft appears to be in good condition.
Condition of Joints	• The joint between the shaft and the upstream portion of the deck doesn't show any apparent movement (Photo 27).
Movement	• The deck slab appears to be sloping downwards towards the upstream side.
Air Vents	• Air vents were inspected at each gate well with a borehole camera. All vents were in good condition with no deterioration or separation of the pipes.
Stilling Basin and Wing Walls	
Concrete Condition	• The stilling basin was an addition to the end of the conduits in 1982. Conduits were constructed in 1952. The concrete generally appeared to be in good condition (Photo 40 and Photo 41).
Condition of Joints	• There appears to be some separation between the conduits and the stilling basin structure. The waterstop between the two structures could be seen at the top of the walls. The waterstop is embedded in the stilling basin wall and abuts to the conduit structure wall (Photo 42).
Movement	• There appears to have been some settlement of the stilling basin as there is a vertical offset between the stilling basin and the conduit structure (Photo 43 and Photo 44).
Erosion	• No apparent erosion, although the toe of the structure was submerged.
Outlet Canal (To Stafford Reservoir)	
Bank Condition	• Banks appear smooth, no depressions or signs of sloughing (Photo 45).

Bank Protection	• Riprap bank armor with good coverage and thickness (Photo 45). • Some gravel bedding material may be exposed or some gravel is mixed in with riprap (Photo 46). • Rock sizes vary from 25 mm to 300 mm (Photo 46). • Some concrete debris in riprap.
Erosion	• No erosion observed.
Movement	• Slopes appear stable with no apparent movement.
Other	• N/A.

2.9 Operating Procedures / Electrical / Controls

Condition	Observation
Controls	• Controls are contained in a control room at one end of the intake. The system can be operated remotely with an iPad as well as manually at site. A Programmable Logic Controller with touch screen, installed in 2000, is in the control with multiple display screens to monitor water levels, gate positions, etc.
Reservoir Level Control	• The gates are operated automatically to control the reservoir level to a set point. • There is 1 level transducer that provides the reservoir level to the control system located several kilometers upstream of the dam. There used to be a second water level sensor at the dam but it was damaged by freeze-thaw and not replaced. • In the event of a loss of communications, the operating system is programed to enter manual mode. • Reservoir level is typically set with a 20 cm dead-band.
Gate Operation	• Hoists are electrically activated Rotork hoists with a screw stem. Refer to Outlet Structure Section, for inspection details. • Flow through the gates is calculated using original PFRA rating curves. • Soft limit on gate opening in automatic control is set at 75% capacity and needs manual over-ride to open further. • Operations staff noted they had to increase torque at the higher end but gates open and close smoothly. • There is no set ramping rate requirement to open or close gates slowly for fisheries.
Electrical / Power Systems	• The primary source of power is from an overhead transmission line. • No backup power system (e.g., backup generator). • Backup power for the Rotork hoist equipment is a drill stored in the control room and a portable generator (Photo 28). All gate actuators can be operated manually via a hand wheel mounted on all actuators. • A larger drill is stored at the SMRID office in Lethbridge.

Flood Operation	• Discussed events during the previous largest flood of record at the reservoir. Operators noted that the largest flood in memory was the 2010 flood.
	• Emergency operations are not documented. Some potential actions include:
	  ○ Shut off inflow from the upstream canal (at Raymond).
	  ○ Flow releases through the outlet to Stafford Reservoir (immediately downstream) and then into the SMRID main canal (towards Sauder Reservoir).
	  ○ Operator noted that storm inflows were near to exceeding storage and outflow capacity from Chin and Stafford Reservoirs.

Other	• All gate operations are made by the dam operator, no the supervisor. • Dam operators cover for each other to provide redundancy. • Operating staff indicated that ice forms on the reservoir in the gate well and in the conduits, but winter operation has never been required. • The stilling basin and conduit outlets based on high water marks would be at least partially submerged when Stafford Reservoir is at full supply level.

2.10 Other

Condition	Observation
Signs	• Warning signs on Outlet Structure are not large enough to meet current Canadian Dam Association guidelines.
Fence	• Fence around control building and gate actuators in good condition (Photo 47). • Fence around Outlet Structure in good condition (at the outlet). • SMRID noted that a vehicle had hit the control building fence several years ago but that no damage was caused to the gates or actuators.
Other	• Instrumentation well heads along the dam crest road near the control building are unprotected (Photo 48).

3 CHIN 2 DAM (EAST)

3.1 Dam Crest

Condition	Observation
Surface Cracking/ Scarps	• None observed (Photo 49). • Road surface on the dam crest had been recently (within the past several years) re-surfaced with a layer of granular fill that is potentially non-standard road gravel (Photo 49). • No surface cracking or scarps were observed.
Horizontal Alignment	• Appears straight (Photo 49).
Settlement	• Crest grade corrections are reported to have been carried out; however, some elevation variations are still evident (Photo 49, and Photo 51). • Dam crest appears to be slightly low at both abutments.
Depression/Sinkhole	• See above. • No sinkholes observed.
Ruts and/or Puddles	• Significant ponding and road surface beginning to rut (Photo 49).
Surface Protection	• Inadequate road gravel for regular traffic (Photo 49).
Vegetation	• None observed directly on the crest (Photo 49).
Animal Burrow	• None observed.
Other	• N/A.

3.2 Upstream Slope

Condition	Observation
Slope Stability	• No indications of instability observed.
Slope Protection	• Upstream dam slope had good riprap coverage near center of dam. Riprap coverage decreases towards abutments (Photo 51). • SMRID noted that additional riprap was installed several years prior to fill “dished” sections where riprap face was low. • Some existing locations where “dished” sections continue to develop, likely due to fine-grained soils flushing through the riprap from wave action. • The riprap on the dam’s upstream face is variable in size with riprap generally ranging from 25 mm to 600 mm (Photo 53).

Erosion	• No evidence of erosion observed.
Depression/Sinkhole	• None observed.
Vegetation	• Some small bushes and grass along slope.
Animal Burrows	• None observed.
Other	• A few pieces of debris were noted.

3.3 Downstream Slope

Condition	Observation
Slope Stability	• Some evidence of possible old, shallow slumping was noted on right side of dam. This movement could date back to the time of construction and is considered indicative of the marginal stability of 2H:1V embankment slopes (Photo 53).
Slope Protection	• Slope is protected by grass cover (Photo 55).
Erosion	• No eroded areas were visually evident on the downstream slope of the dam.
Depression/Sinkhole	• A grade irregularity was noted on the left side of the dam. The irregularity is oddly shaped, and evidence of recent movement was not observed. This irregularity is likely as-constructed at the time of crest grade correction.
Vegetation	• Grass, no bushes or trees.
Animal Burrow	• None observed.
Seepage	• A seepage area is visible at the downstream toe at the right (south) abutment. This area was dry at the time of the site visit but is reported to produce an evident flow when the reservoir level is particularly high (Photo 57).
Other	• N/A.

3.4 Downstream Toe

Condition	Observation
Surface Condition	• Original construction created two borrow areas that have filled with water. A stockpile (possibly waste material) is also present downstream of the dam. (Photo 59 and Photo 60).
Movement	• No evidence of movement observed.
Seepage	• None observed.
Toe Drainage	• A shallow drainage collection ditch is provided along the toe of the downstream slope to convey flow to a borrow area downstream of the dam. The ditch bottom is dimpled, likely due to cattle activity, and standing water was noted locally in the ditch. No flow was evident at the time of the site inspection (Photo 57). • Seepage flow measurement weir is in disrepair and has not been used for many years.
Vegetation	• Grades beyond the dam toe are generally vegetated with grasses and small shrubs. (Photo 59 and Photo 60). • Some areas downstream of the dam toe do not appear to have been well reclaimed after construction or have had high use by cattle resulting in locally poor vegetation cover (Photo 61). • Wetland vegetation growth on the upstream side of the pond in the right borrow pit likely indicates some seepage egress to that area (Photo 60).
Depression / Sinkhole	• None observed
Animal Burrow	• None observed
Others	• N/A.

3.5 Right Abutment (South)

Condition	Observation
Surface Protection – Upstream	• Coverage of riprap appears sparse (Photo 62).
Surface Protection – Downstream	• Downstream abutment is covered with grass (Photo 57).
Interface – Abutment/Shoreline	• The right abutment is formed by a prominent ridge between the Chin Coulee and a side coulee entering just downstream of the dam (Photo 63).
Movement	• None observed.

Erosion	• Significant erosion does not appear to be occurring on the upstream or downstream right groin. • A stable beach area appears to be forming on the groin area in the zone of reservoir fluctuation; this is likely related to material eroded from the reservoir slopes (Photo 62). • Some shoreline erosion along the valley wall near the abutment beach.
Depression/Sinkhole	• None observed.
Vegetation	• The abutment slopes are reasonably vegetated.
Animal Burrow	• None observed.
Slope Stability	• The reservoir is eroding fairly steep slopes on the south (right) side of reservoir but no significant landslides were evident (Photo 64).
Other	• N/A.

3.6 Left Abutment (North)

Condition	Observation
Surface Protection – Upstream	• Coverage of riprap appears sparse (Photo 65).
Surface Protection – Downstream	• Downstream abutment is covered with grass (Photo 66).
Interface – Abutment / Shoreline	• Some beach erosion along reservoir shoreline upstream of the dam is evident (Photo 67).
Movement	• None observed.
Erosion	• Minor erosion is evident on both the upstream and the downstream groins. This erosion is related to runoff from the access road which follows a side coulee down onto the dam crest and frequent vehicle access to the upstream beach area. The groin erosion issues may have been exacerbated by construction disturbance related to a water co-op intake pipeline that is understood to extend around the dam's left abutment. (Photo 51, Photo 65 and Photo 66). • A stable beach area appears to be forming on the groin area in the zone of reservoir fluctuation; this is likely related to material eroded from the reservoir slopes (Photo 67).
Depression/Sinkhole	• None observed.
Vegetation	• The abutment slopes are generally vegetated with grasses where not disturbed by erosion or construction activity.
Animal Burrow	• None observed.

Slope Stability	• No significant landslides were observed on the abutment slopes (Photo 68).
Other	• SMRID noted that a water co-op intake was located near the left abutment. A siphon / pump line is buried and follows a path around the abutment to the downstream side of the dam.

3.7 Instrumentation

Condition	Observation
Piezometer	• None observed.
Slope Inclinometer	• None observed.
Weir	• A seepage measurement weir along the toe ditch is situated near one of the borrow area ponds. The ditch at the weir was dry and the weir is not functioning (damaged). The apparent lack of seepage could be a result of sediment deposition along the upstream slope of the dam.
Deformation Monitoring	• None observed.

4 RESERVOIR SHORELINES AND OTHER ASPECTS

4.1 Reservoir

Condition	Observation
Slope Condition	• The reservoir slopes are somewhat variable with side coulees and significant erosion gullies commonly present (Photo 69).
Surface Protection	• In some areas, the Chin Coulee exhibits apparent inner and outer slopes (Photo 70).
Erosion	• Surface protection against erosion is generally not provided, however, some local erosion protection was observed on the right (north) abutment upstream of the West Dam.
Movement	• Reservoir erosion of coulee slides is evident in most areas along the reservoir.
Vegetation	• Coulee slopes above the areas of erosion along the shoreline are generally grass covered.

4.2 Other Aspects

Condition	Observation
Access Road	• Range Road 182 provides good all-weather access to and across the crest of the Chin 1 Dam (west) (Photo 71 and Photo 72). • The access to the left abutment of the East Dam can likely provide access to the dam by four-wheel-drive vehicles under most weather conditions. (Photo 73) • The access to the right abutment of the East Dam is understood to be a trail of poor quality. • Surveillance of the East Dam may become impractical during wet weather conditions.
Signs	• Dam signage is minimal and likely does not adequately warn the public of the hazards present at the Chin 1 Dam (west) Outlet Structure (Photo 74). Signage does not meet current CDA guidelines.
Fence	• Although the fences are generally in good condition, cattle appear to be allowed access close to and even onto the dams in some areas.

5 PHOTOGRAPHS – CHIN 1 DAM (WEST)

Photographs – Chin 1 Dam (West)



Photo 1: Dam crest looking south towards left abutment. Topped with crushed gravel and graded to provide drainage from the crest.



Photo 2: Minor ponding along upstream crest near outlet structure due to grading ridge.



Photo 3: Left upstream abutment looking down slope. Thicker vegetation cover on upper 5 m of dam. Minimal signs of erosion. No indications of instability observed.



Photo 4: Upstream dam slope near the control building.

Photographs – Chin 1 Dam (West)



Photo 5: Patch of relatively small riprap on upstream slope.



Photo 6: Exposure of gravel bedding beneath riprap on upstream slope.



Photo 7: Riprap protection on upper part of upstream dam slope is variable and sparse.



Photo 8: Patch on upper part of upstream slope where no riprap is visible.

Photographs – Chin 1 Dam (West)



Photo 9: Some vegetation and small bushes along the upstream slope near the crest.



Photo 10: Trees growing on upstream slope.



Photo 11: Right shoreline near abutment. Some erosion evident. Riprap armor along shoreline. No visible armoring near abutment. Gravel / concrete pile on upstream slope (in foreground).



Photo 12: Downstream slope of dam.

Photographs – Chin 1 Dam (West)



Photo 13: Downstream slope of dam.



Photo 14: Downstream toe area.



Photo 15: Downstream toe ditch. Toe has no standing water but some indications of shallow groundwater.



Photo 16: Some seepage likely reports to old channel area downstream of the dam. Some cattails suggest seepage egress in that area.

Photographs – Chin 1 Dam (West)



Photo 17: Right upstream abutment. Coverage of riprap is sparse. Small 300 mm diameter culvert.



Photo 18: Right downstream abutment. No signs of erosion. Thick well established grass cover.



Photo 19: Left downstream abutment shows some signs of erosion from surface runoff (looking down slope).



Photo 20: Left shoreline and abutment.

Photographs – Chin 1 Dam (West)



Photo 21: Left downstream abutment (looking up slope).



Photo 22: Culvert near left abutment drains a small coulee near the left abutment.



Photo 23: Shoreline erosion near left abutment.



Photo 24: Left upstream abutment looking up slope.

Photographs – Chin 1 Dam (West)



Photo 25: Exposed top of standpipe piezometer.



Photo 26: Manhole for access to settlement monitoring system, which is understood to be abandoned.



Photo 27: Rotork actuators and stem covers. The joint between the shaft and the upstream portion of the deck doesn't show any apparent movement.



Photo 28: Drill for emergency operation of the gates is stored in the control cabinet.

Photographs – Chin 1 Dam (West)



Photo 29: Control screen showing initial gate positions at start of inspection.



Photo 30: Control screen showing raised position of Gate 1.



Photo 31: Control screen showing all five gates in raised position.

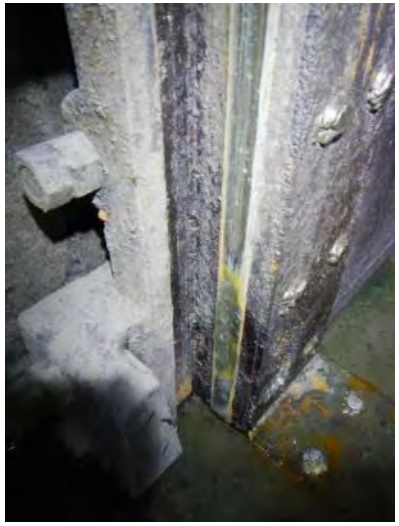


Photo 32: Conduit 1. Upstream / left side of gate. Typical condition of gate seals and guides. SMRID noted that seals and guides were in acceptable condition.

Photographs – Chin 1 Dam (West)



Photo 33: Conduit 5. Side gate guides were heavily corroded and rusted near bottom on both sides. SMRID noted that the guides will be fixed this year. Side seals in poor condition near the bottom on both sides.



Photo 34: Conduit 2. Lowest gate stem guide was cracked and had broken off the concrete anchors. The anchors were bent downwards. The gate stem guide had fallen down and was resting on top of the gate. The gate step guide had fallen down and was resting on top of the gate. Photo shows stem corrosion and build-up of precipitate material.



Photo 35: Conduit 5. Typical condition of conduit upstream of gate well. Note delaminated grout.



Photo 36: Conduit 1. Typical condition of conduit downstream of gate well near stilling basin. Note numerous cracks and signs of seepage in walls and ceiling.

Photographs – Chin 1 Dam (West)



Photo 37: Conduit 1. Example of crack and seepage.



Photo 38: Barge for bulkhead gate installation (photo taken November 4, 2018).



Photo 39: Temperature crack on gatewell deck slab.



Photo 40: Stilling basin and conduit structure showing year of construction.

Photographs – Chin 1 Dam (West)



Photo 41: Surface of outlet structure free of cracks. Energy dissipation blocks in good condition.



Photo 42: Waterstop between conduit structure and stilling basin.



Photo 43: Differential settlement between stilling basin and conduit structure.



Photo 44: Differential settlement between stilling basin and conduit structure.

Photographs – Chin 1 Dam (West)



Photo 45: Outlet channel of outlet. High water mark visible near top of riprap on right bank.



Photo 46: Riprap at outlet channel. Some gravel bedding exposed or some gravel mixed in with riprap.



Photo 47: Control building and gate actuators.



Photo 48: Instrumentation well heads near upstream crest of dam beside public road.

6 PHOTOGRAPHS – CHIN 2 DAM (EAST)

Photographs – Chin 2 Dam (East)



Photo 49: View of dam crest looking north towards left abutment. Crest surface has significant ponding and is beginning to rut.



Photo 50: View of dam from downstream left abutment. Visible undulations to dam crest.



Photo 51: View of dam from upstream left abutment. Visible undulations to dam crest. Vehicle access has resulted in erosion and gullying.



Photo 52: Upstream dam slope with good riprap coverage near center of dam. SMRID noted that additional riprap was installed several years prior. Some small bushes and grass along slope. Riprap coverage decreases towards abutments.

Photographs – Chin 2 Dam (East)



Photo 53: Riprap along upstream slope. Some gravel bedding exposed. Rock sizes range from 25 to 800 mm.



Photo 54: Possible scarp of old, shallow slump on downstream slope of dam.



Photo 55: Downstream slope of dam looking north.



Photo 56: Grading irregularity at top of downstream slope on left side of dam.

Photographs – Chin 2 Dam (East)



Photo 57: Right downstream abutment. SMRID noted that seepage has occurred here in the past. Area was muddy during site investigation but no seepage was observed.



Photo 58: Standing water locally noted in drainage swale along dam toe. Swale bottom disturbance by cattle activity under wet conditions is evident.



Photo 59: Borrow area for original dam construction.

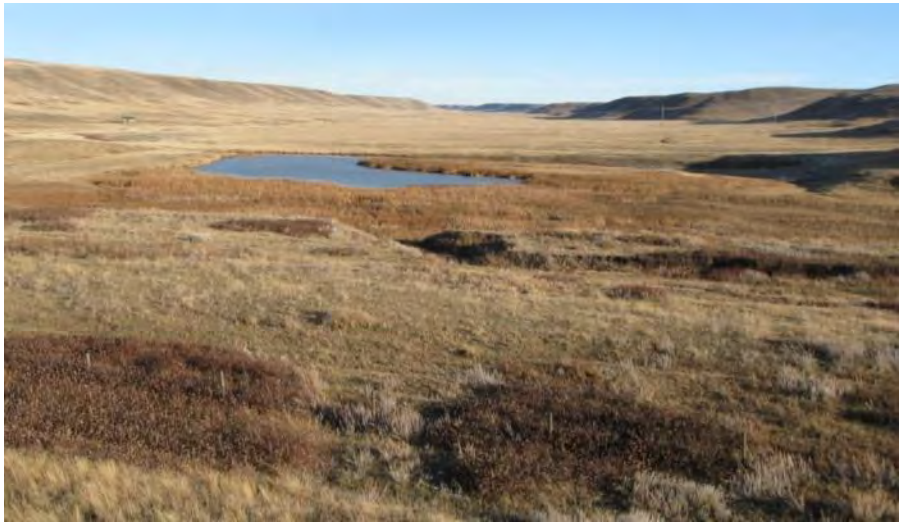


Photo 60: Seepage is likely reporting to the borrow excavations downstream of the dam. Wetland vegetation is evident on the upstream side of the borrow area on the right side of the coulee bottom.

Photographs – Chin 2 Dam (East)



Photo 61: Area beyond downstream toe where construction disturbance appears to have been poorly reclaimed or have had high use by cattle.



Photo 62: Right upstream abutment. Sediment deposition has created a beach area which has become vegetated. Sparse riprap coverage on abutment.



Photo 63: Prominent ridge between dam right abutment and side coulee.



Photo 64: Right shoreline near abutment. The reservoir is eroding fairly steep slopes on the south (right) side of reservoir but no significant landslides were evident. Shallow area of sediment deposition between upstream dam face and reservoir / shoreline area.

Photographs – Chin 2 Dam (East)



Photo 65: Left upstream abutment. Sedimentation has created a beach area. Sparse riprap coverage at the abutment.



Photo 66: Left downstream abutment. Some minor erosion noted along the road leading to the downstream side of the dam.



Photo 67: Left shoreline near abutment. Some signs of erosion from wave action. Shallow area of sediment deposition between upstream dam face and reservoir / shoreline area.



Photo 68: Coulee slope upstream of left abutment.

7 PHOTOGRAPHS – RESERVOIR SHORELINES AND OTHER ASPECTS

Photographs – Reservoir Shorelines and Other Aspects



Photo 69: Coulee slopes exposed above reservoir level.



Photo 70: Coulee side slopes.



Photo 71: County road along north side of Chin 1 Dam.



Photo 72: County road along south side of Chin 1 Dam.

Photographs – Reservoir Shorelines and Other Aspects



Photo 73: Access trail to left abutment of Chin 2 Dam (east). Access in wet conditions is possible with 4 wheel drive vehicles and tracked equipment.



Photo 74: Hazard signage at Chin 1 Dam (west) outlet structure does not meet current CDA guidelines.

APPENDIX F
2018 Conduit Inspection Report

PROJECT NAME	**Chin Reservoir Dam Safety Review**		
CLIENT	St. Mary River Irrigation District (SMRID)	**LOCATION**	SE ¼ 34-8-18 W4M 5504370N, 402340E UTM 12N/WGS84
CONDUITS ENTERED BY (INSPECTION TEAM)	David Kushner, P.Eng. (Matrix) Travis Geremia, P.Eng. (SMRID) Alan Mills (SMRID) Scott Marose (SMRID)	**DATE**	November 16, 2018
		WEATHER	Cloudy / Sunny, 5 / 11 °C
		PREPARED BY	David Kushner, P.Eng.

GENERAL NOTES

- Conduits are numbered 1 through 5 from the right bank (north east) to left bank, respectively.
- No debris observed in conduits 1 through 3. Some debris found in conduit 4 (bottles and one (1) 500 mm long piece of wood). Conduit 5 contained the most debris (bottles, wood, miscellaneous trash).
- Numerous cracks observed in sides and ceiling. TG noted that these cracks were observed and are similar to previous years. TG noted that there was significantly more leakage through the cracks last year. SM noted that the reservoir was at a similar or higher level last year. Therefore, it was thought that the leakage was primarily due to surface water.
- Did not observe very many cracks in the floor (about 50% of floor was visible, the rest was under very murky water)
- All conduits had a coating of grout upstream of the gates. In all cases this grout was delaminating with approximately 3ft x 3ft pieces missing 5 m upstream of the gates.
- Bulkheads all sealed very well and the entrance appeared to be in good condition
- Did not find any voids in the concrete by checking with a hammer. Checked 90% of the cracks in conduit 1. Checked larger cracks in the remaining conduits.
- Concrete appeared to be solid and relatively smooth. Some honeycombing on the ceiling noted maximum 30 to 40 mm deep. Hit these areas with the hammer but did not reveal any larger voids.
- The conduits all had a horizontal joint halfway up the walls. The joint had a 5 mm layer of weaker grout / cement that came off with blows from the hammer. A hard layer was underneath.
- All gates had pitting along the bottom edge to varying degrees.
- SMRID surveyors were onsite surveying the conduits after the inspection team.
- Digital files of higher resolution photographs and video were provided to SMRID, CPL and TetraTech. Video camera did not record portions of the inspection (it is thought that recording was interrupted when the camera was bumped on conduit ceiling).

CONDUIT 1

- Contained notably more cracks than the other conduits.
- Majority of cracks and seepage were on the right side (facing downstream).
- Bottom seal type gate.
- SMRID noted that side and bottom gate seals appeared to be in good condition.
- Pitting visible

CONDUIT 2

- The lowest gate stem guide was cracked and had broken off the concrete anchors. The anchors were bent downwards. The gate stem guide had fallen down and was resting on top of the gate.
- Bottom seal type gate.
- SMRID noted that side and bottom gate seals appeared to be in good condition.

CONDUIT 3

- Bottom gate seal was on face of concrete. Gate seals by lowering past the conduit invert into a gate well (seal is between face of gate and concrete).
- SMRID noted that side gate seals appeared to be in good condition.

CONDUIT 4

- Bottom seal type gate.
- SMRID noted that side and bottom gate seals appeared to be in good condition.

CONDUIT 5

- Notably fewer cracks in conduit 5 compared to conduit 1.
- Conduit 5 did not have metal plates downstream of the gate (other conduits did, see photograph 1-8).
- Bottom gate seal was on face of concrete. Gate seals by lowering past the conduit invert into a gate well (seal is between face of gate and concrete).
- Side gate guides were heavily corroded and rusted near bottom on both sides. SMRID noted that the guides should be fixed this year.
- Side seals of gate near the bottom were in poor condition.
- Air monitor started showing an increase in O_2 levels near the upstream end of the conduit. Discussed with SMRID and decided not to inspect upstream 30 m of the conduit.

Photographs – Conduit 1



Photo 1-1: Near entrance of conduit, note more numerous cracks along right side (facing downstream).



Photo 1-2: Example of crack and seepage. Joint visible to right of crack.

Photographs – Conduit 1



Photo 1-3: Signs of seepage through horizontal joint.



Photo 1-4: Crack along roof of conduit. Appears to be remnants of grout repair.

Photographs – Conduit 1



Photo 1-5: Close up view of crack that had notable seepage. Estimate less than 1 L / minute.



Photo 1-6: Horizontal joints had a 5 mm layer of weaker grout / cement that came off with blows from the hammer. A hard layer was underneath.

Photographs – Conduit 1



Photo 1-7: example of honeycombing along ceiling of conduit.



Photo 1-8: Metal Plate located downstream of gate. Note several bolts were missing and previously welded.

Photographs – Conduit 1

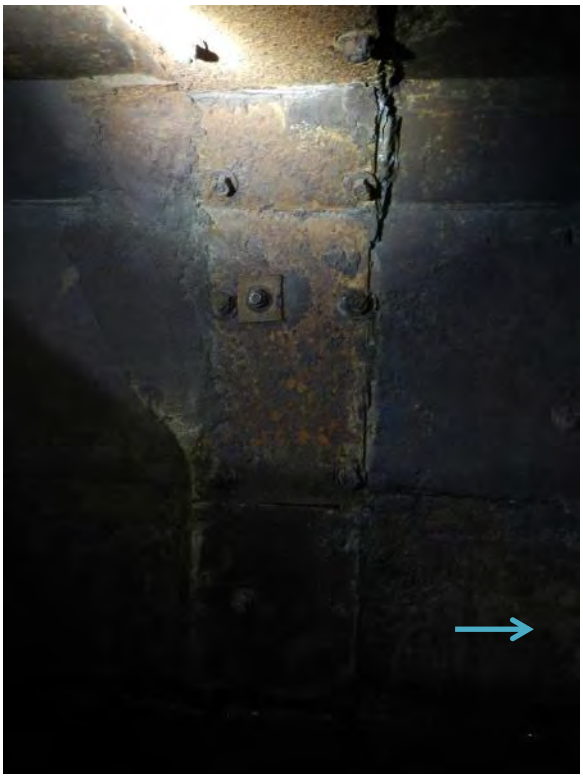


Photo 1-9: Metal Plate located downstream of gate. Note several bolts were missing and previously welded.



Photo 1-10: Bottom sealing surface of gate.

Photographs – Conduit 1



Photo 1-11: Upstream / left side of gate. Note pitting on gate edge. SMRID (TG & AM) noted that side seals were in good condition.



Photo 1-12: Upstream / left side of gate.. SMRID (TG & AM) noted that side seals were in good condition.

Photographs – Conduit 1



Photo 1-13: Pitting noted on left corner of gate edge.



Photo 1-14: Pitting noted on right corner of gate edge.

Photographs – Conduit 1



Photo 1-15: Coating of grout upstream of the gates delaminating.



Photo 1-16: Minor leaking noted through bulkhead (less than 1 L per minute).

Photographs – Conduit 1



Photo 1-17: Downstream face of gate



Photo 1-18: Downstream face of gate

Photographs – Conduit 1



Photo 1-18: Downstream face of gate. Small gap noted under knife edge at right side of gate (facing downstream)

Photographs – Conduit 2



Photo 2-1: Metal Plate located downstream of gate. No missing bolts noted.

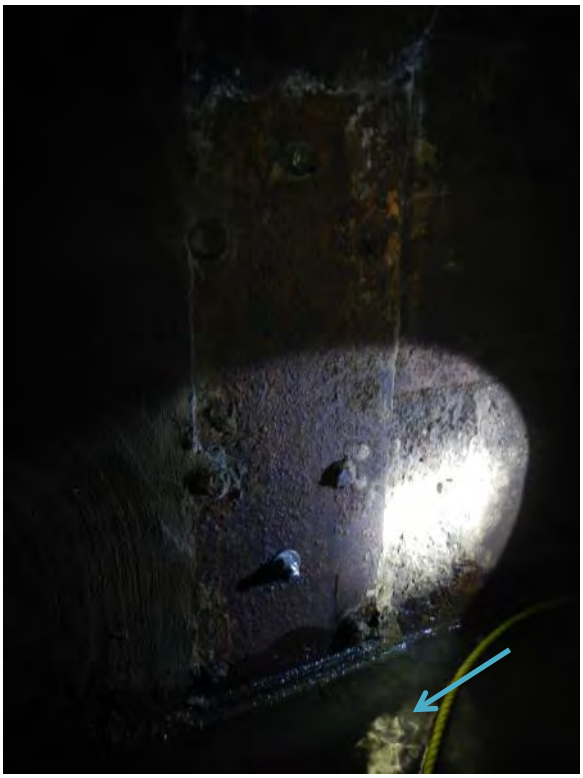


Photo 2-2: Metal Plate located downstream of gate. No missing bolts noted.

Photographs – Conduit 2



Photo 2-3: The lowest gate stem guide was cracked and had broken off the concrete anchors. The anchors were bent downwards. The gate stem guide had fallen down and was resting on top of the gate.



Photo 2-4: Pitting along upstream edge of gate. Sealing edge in good condition (near middle of gate)

Photographs – Conduit 2



Photo 2-5: Previous weld to restore gate. Pitting of gate edge beginning again.



Photo 2-6: Previous weld to restore gate. Pitting of gate edge beginning again.

Photographs – Conduit 2



Photo 2-7: example of honeycombing along ceiling of conduit.



Photo 2-8: Conduit near downstream end. Note there are few cracks in the concrete.

Photographs – Conduit 3



Photo 3-1: Leak from crack in ceiling (approximately 2 L per minute).



Photo 3-2: Metal Plate located downstream of gate. No missing bolts noted.

Photographs – Conduit 3



Photo 3-3: Metal Plate located downstream of gate. No missing bolts noted.



Photo 3-4: Metal Plate located downstream of gate. No missing bolts noted.

Photographs – Conduit 3

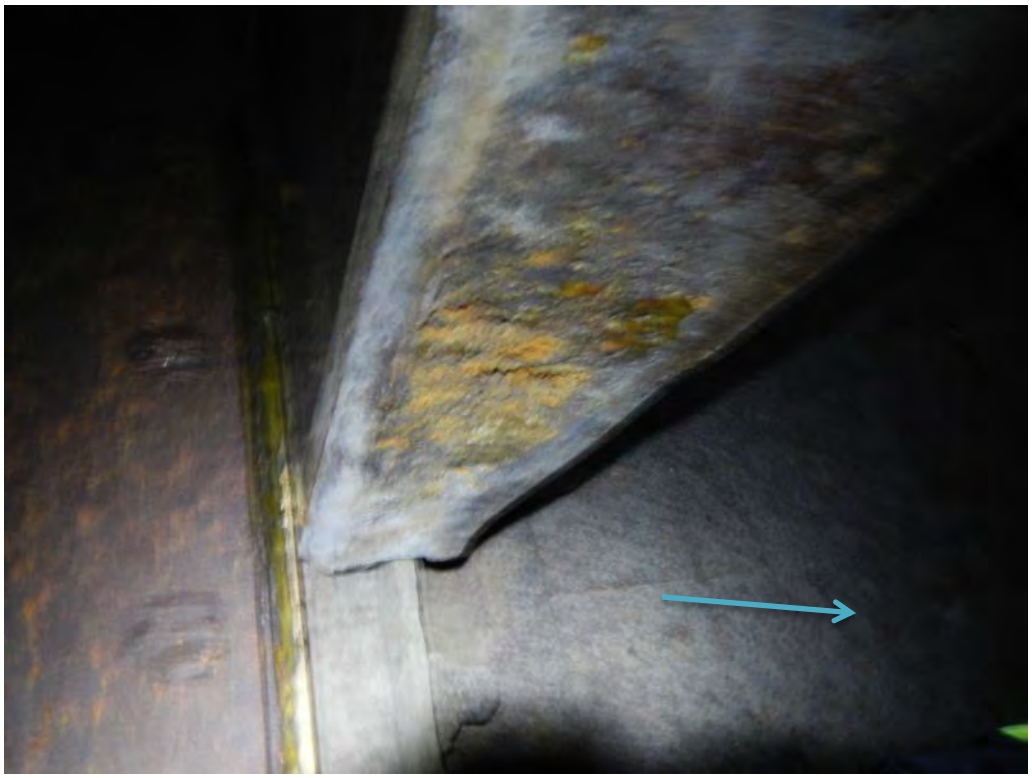


Photo 3-5: Heavy pitting on underside of gate. Knife edge of gate was largely absent of pitting.

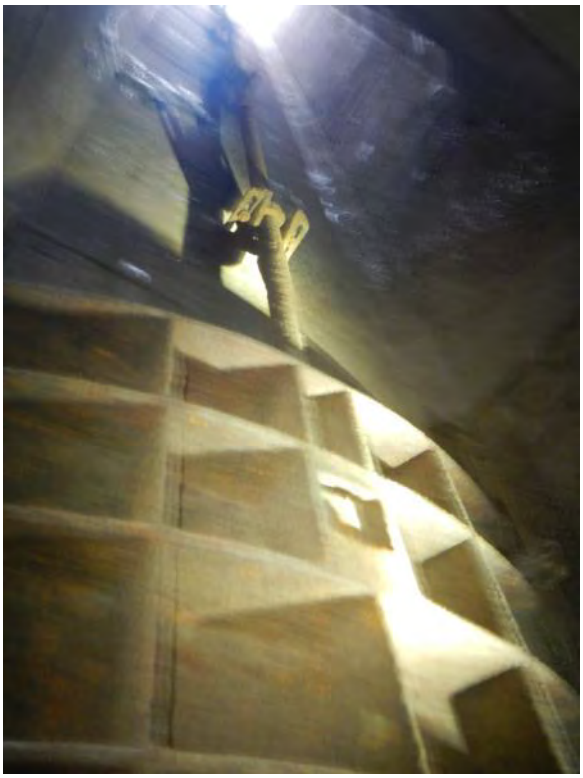


Photo 3-6: Upstream side of gate and stem.

Photographs – Conduit 3



Photo 3-7: SMRID noted that side gate seals appeared to be in good condition.



Photo 3-8: No visible leakage through bulkhead.

Photographs – Conduit 4



Photo 4-1: Metal Plate located downstream of gate. No missing bolts noted.



Photo 4-2: Metal Plate located downstream of gate. No missing bolts noted.

Photographs – Conduit 4



Photo 4-3: Pitting along bottom corner of plate immediately downstream of gate



Photo 4-4: Pitting along bottom corner of plate immediately downstream of gate

Photographs – Conduit 4

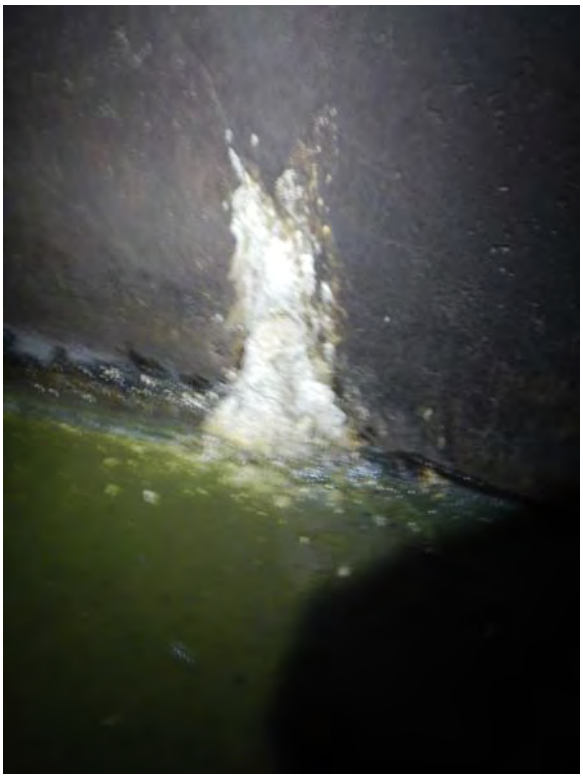


Photo 4-5: Example of cracks that had been sealed (assumed an expanding hydrophilic type sealant).



Photo 4-6: Knife edge of gate with previous welds starting to pit.

Photographs – Conduit 4



Photo 4-7: Knife edge of gate with previous welds starting to pit.

Photographs – Conduit 5



Photo 5-1: Side gate guides were heavily corroded and rusted near bottom on both sides. SMRID noted that the guides should be fixed this year. Side seals in poor condition near the bottom on both sides.

Photographs – Conduit 5

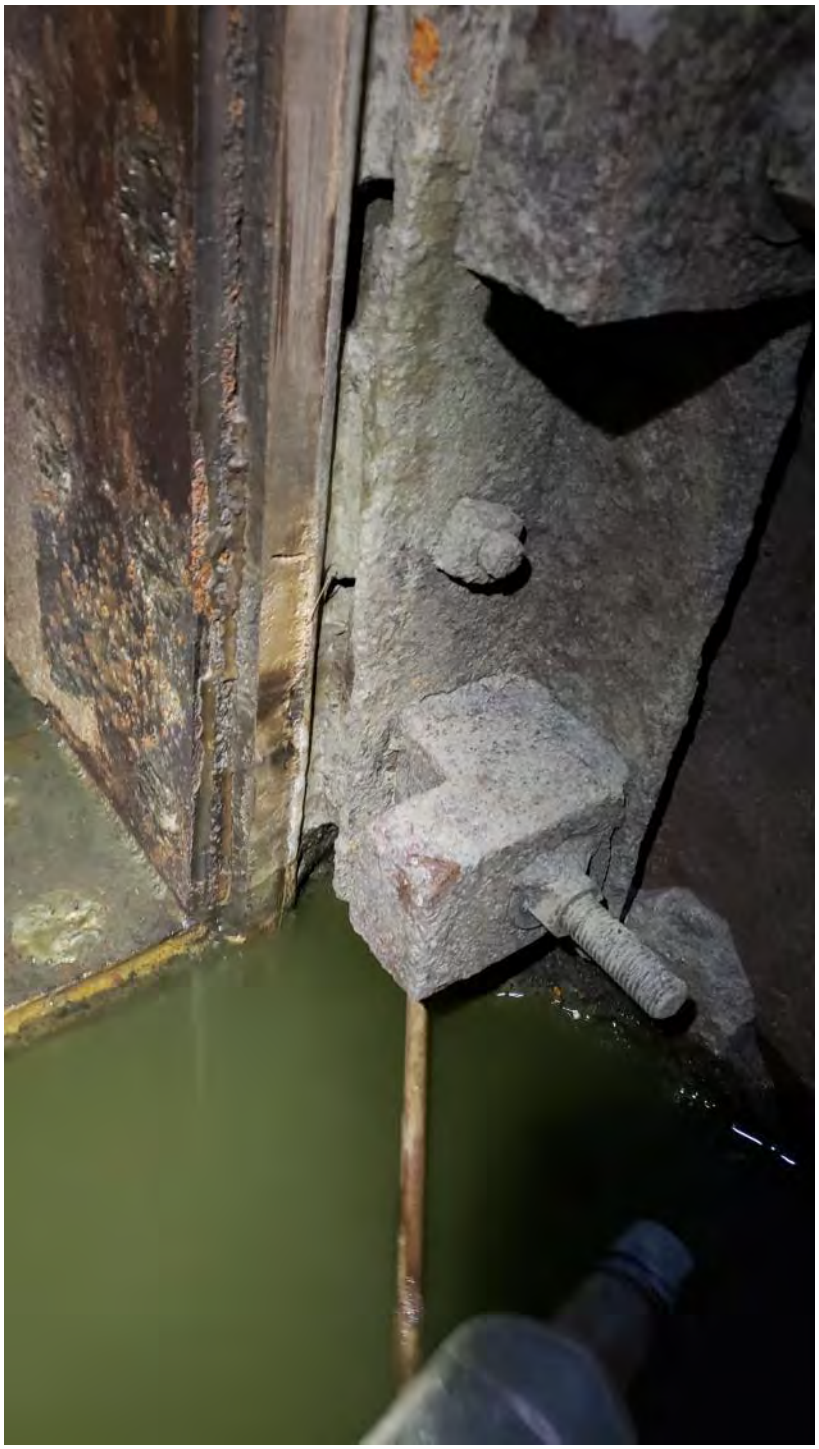


Photo 5-2: Side gate guides were heavily corroded and rusted near bottom on both sides. SMRID noted that the guides should be fixed this year. Side seals in poor condition near the bottom on both sides.

Photographs – Conduit 5



Photo 5-3: Conduit upstream of gate well. Note delaminated grout.

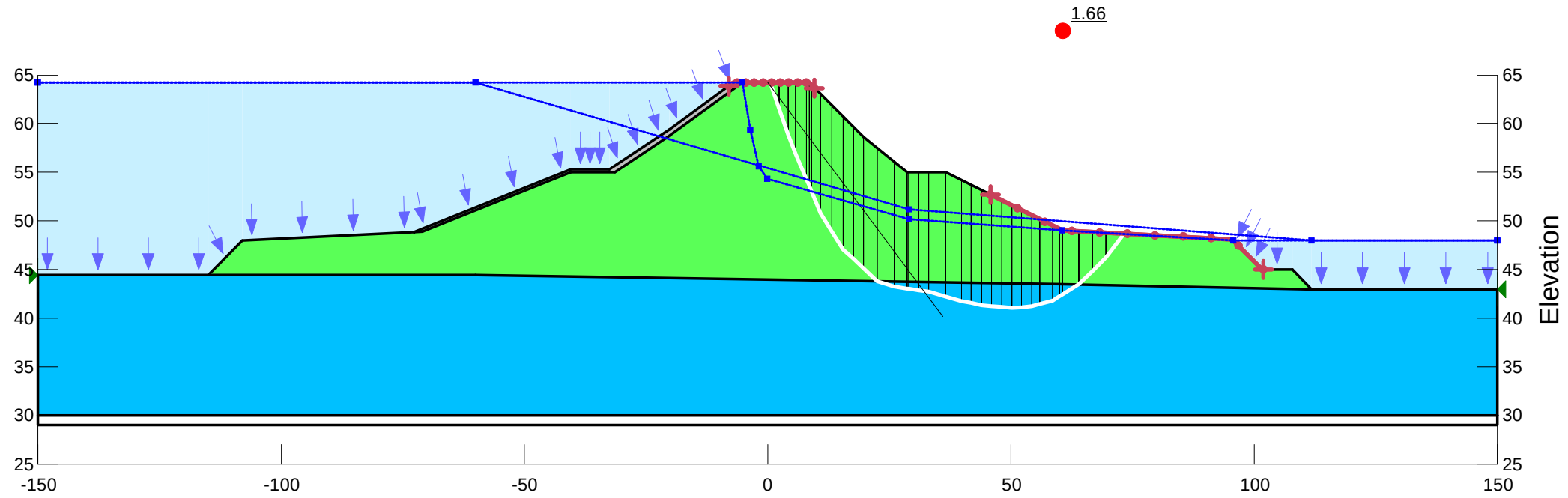


Photo 5-4: Crack in floor upstream of gate well.

APPENDIX G
Geotechnical

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Maximum Reservoir



Materials

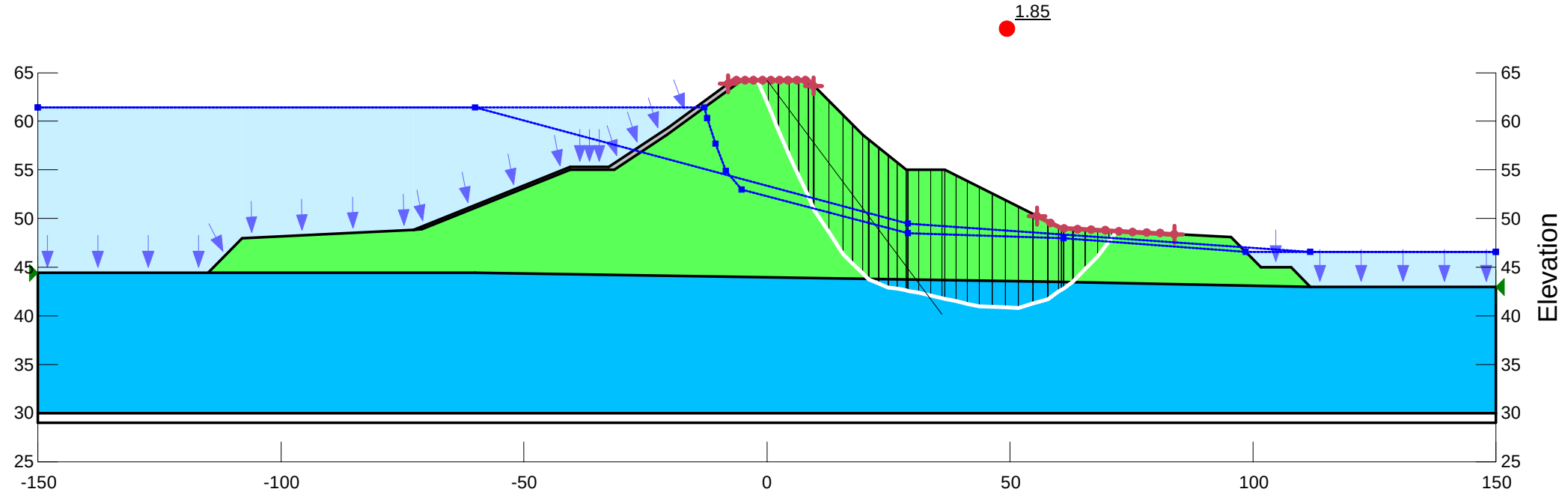
- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Downstream Slope Stability at Maximum Reservoir Level

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Steady State Seepage



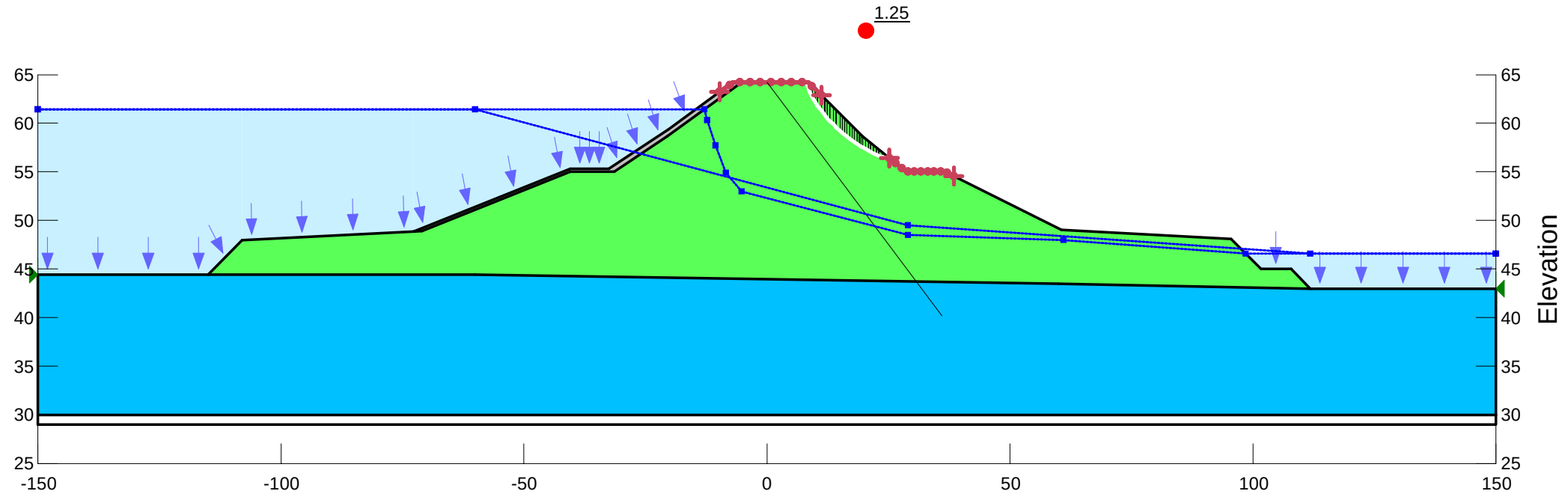
Materials

- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

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Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Steady State Seepage



Materials

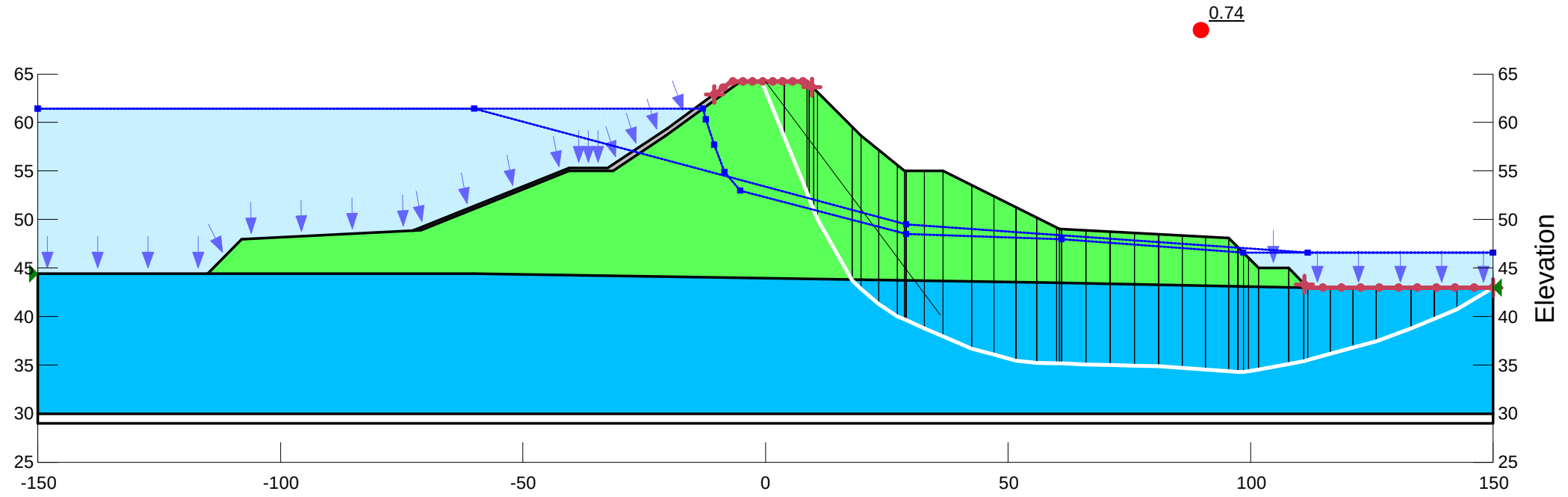
- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Downstream Slope Stability, Shallow, Steady State Seepage

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Seismic Acceleration 0.25g



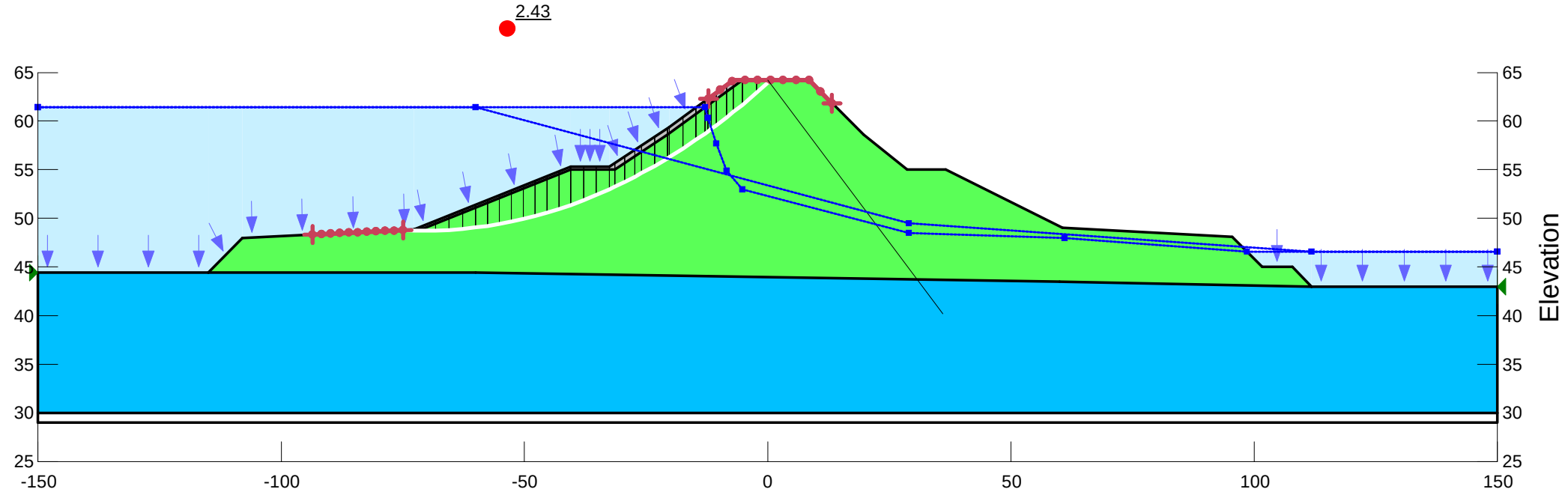
Materials
- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Downstream Slope Stability, Pseudo-Static, Steady State Seepage

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Steady State Seepage



Materials

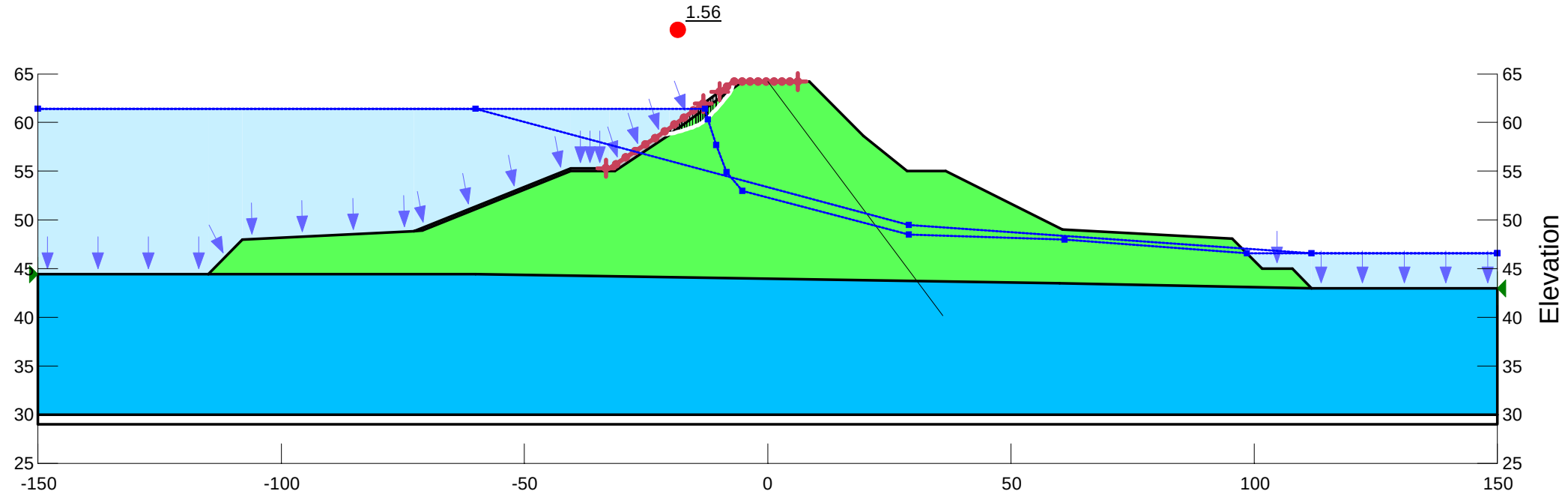
- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Upstream Slope Stability, Steady State Seepage

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Steady State Seepage



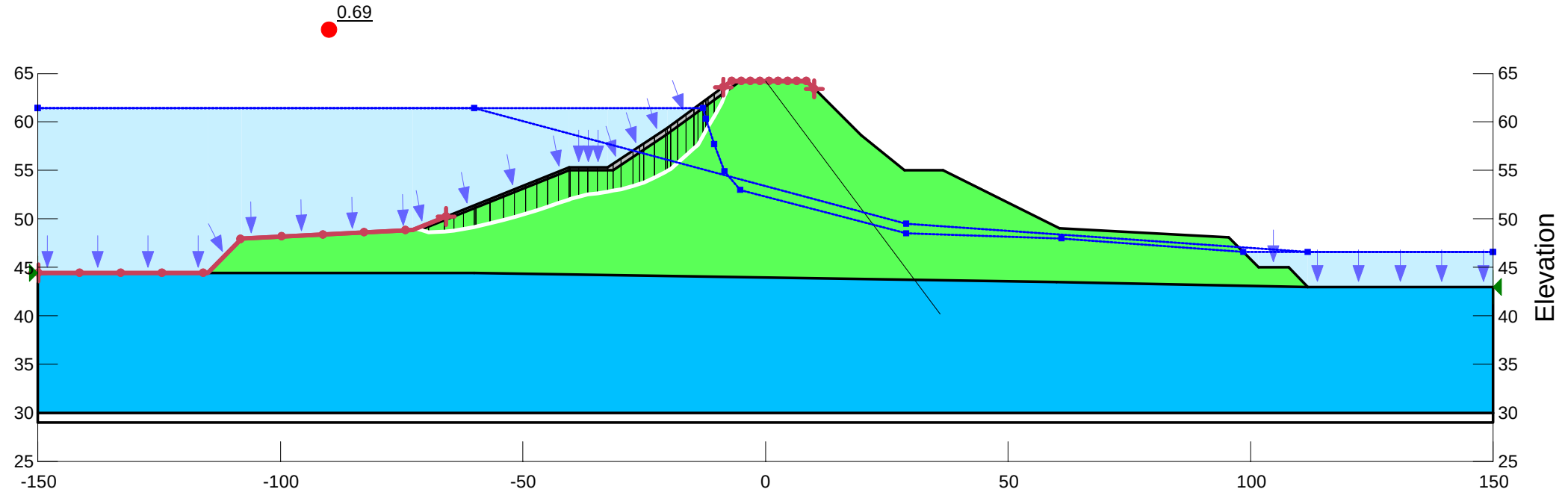
Materials

- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Seismic Acceleration 0.25g



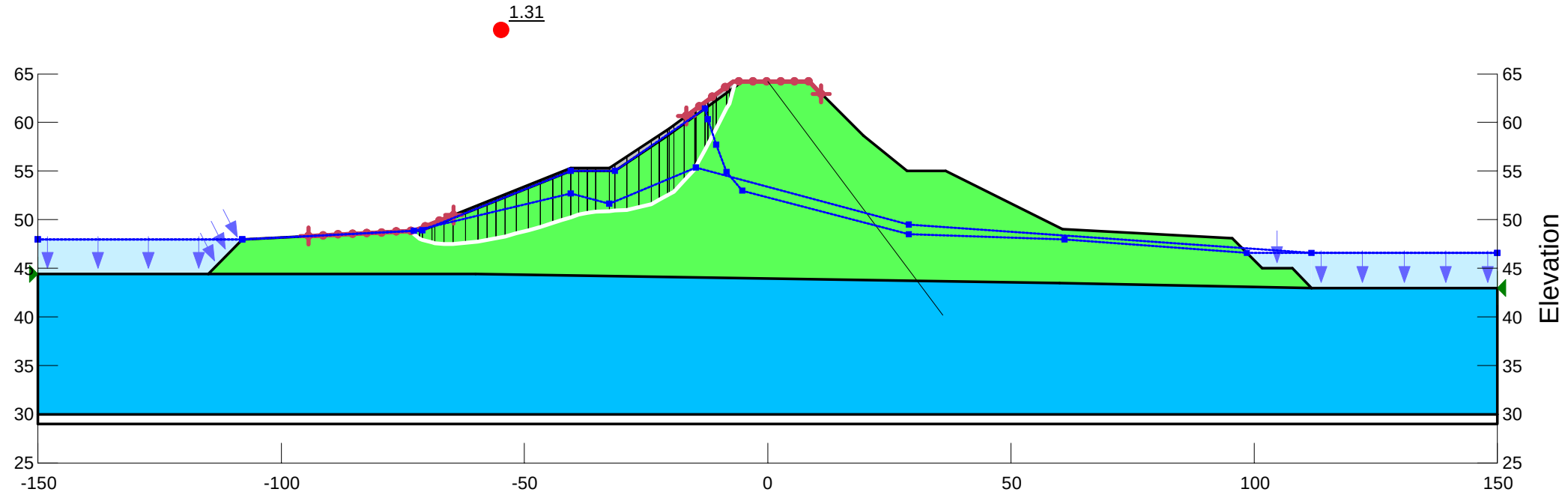
Materials
- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Upstream Slope Stability, Pseudo-Static, Steady State Seepage

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Rapid Drawdown

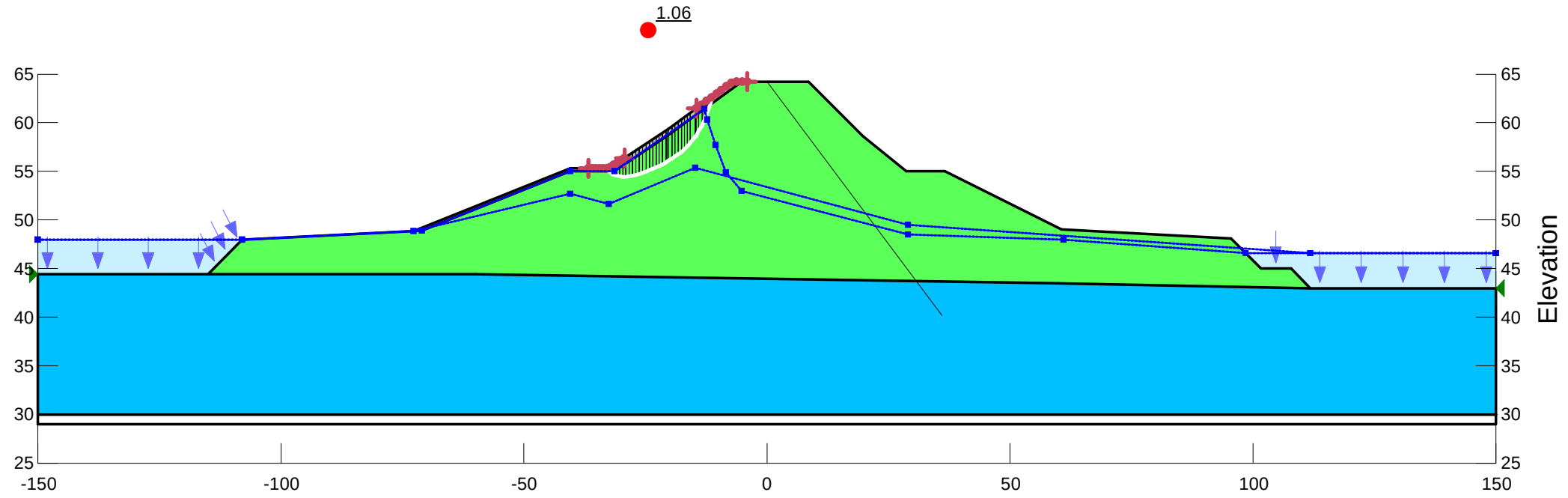


Materials
- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Chin Reservoir Dam No. 1 (West)
2:1 Vertical Exaggeration

Rapid Drawdown



Materials

- Embankment Fill
- Foundation Clay
- Erosion Protection
- Bedrock

Name: Embankment Fill Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 27 ° Piezometric Line: 2
Name: Foundation Clay Unit Weight: 19 kN/m³ Cohesion': 1 kPa Phi': 25 ° Piezometric Line: 1
Name: Erosion Protection Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 38 ° Piezometric Line: 2
Name: Bedrock Piezometric Line: 1

Upstream Slope Stability, Shallow, Rapid Drawdown

Chin Dam 1 - Conduit Piezometers

ELEVATION (M)

863.00
861.00
859.00
857.00
855.00
853.00
851.00
849.00
847.00
845.00

7/Jul/07
7/Jul/08
7/Jul/09
7/Jul/10
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7/Jul/17
7/Jul/18

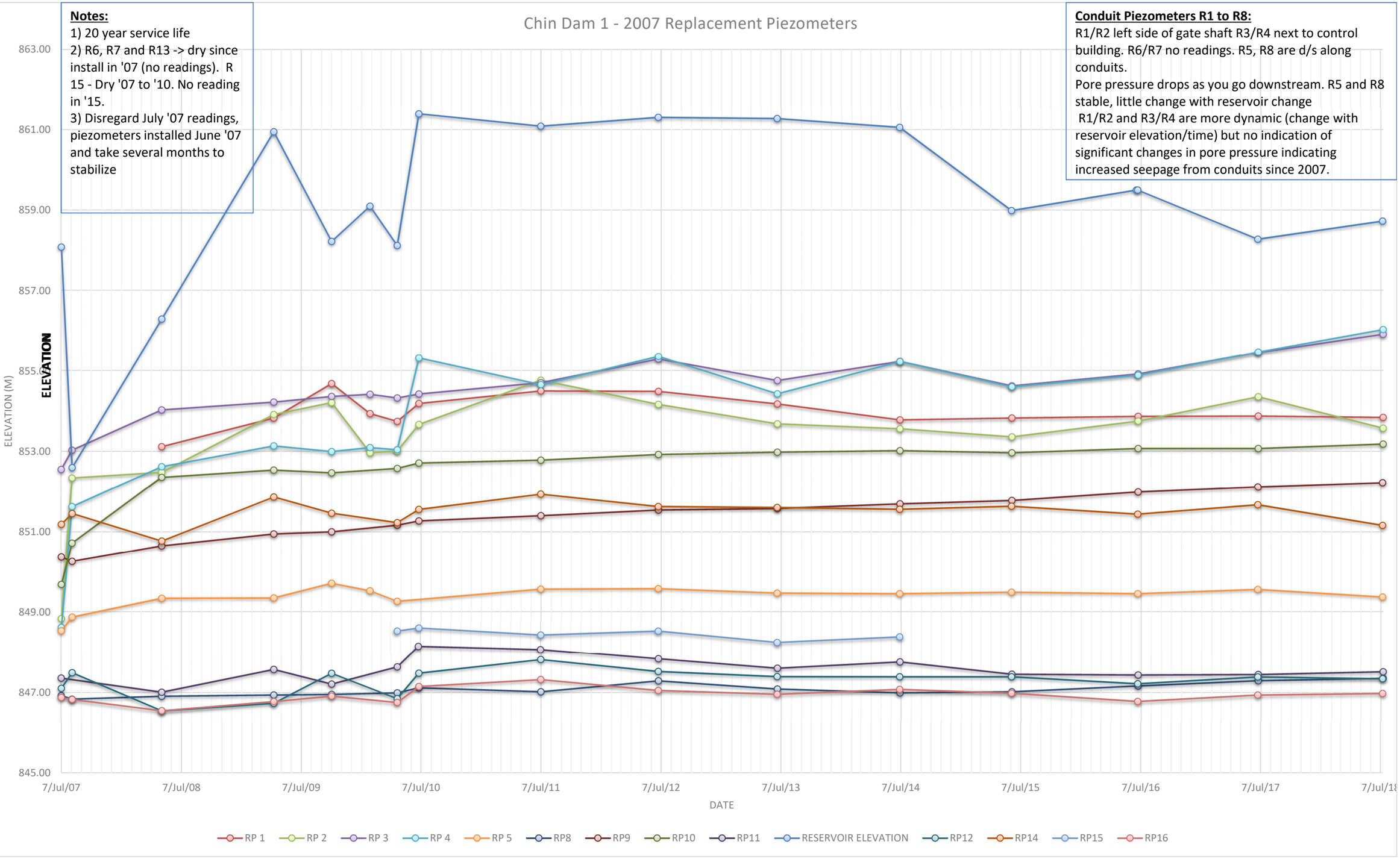
DATE

ELEVATION

L 1
L 5
F 1
B 1
R 2
R 3
R 4
R 5
F 2
RESERVOIR ELEVATION
B 2

Notes:
1) 20 year service life
2) R6, R7 and R13 -> dry since install in '07 (no readings). R 15 - Dry '07 to '10. No reading in '15.
3) Disregard July '07 readings, piezometers installed June '07 and take several months to stabilize

Conduit Piezometers R1 to R8:
R1/R2 left side of gate shaft R3/R4 next to control building. R6/R7 no readings. R5, R8 are d/s along conduits.
Pore pressure drops as you go downstream. R5 and R8 stable, little change with reservoir change
R1/R2 and R3/R4 are more dynamic (change with reservoir elevation/time) but no indication of significant changes in pore pressure indicating increased seepage from conduits since 2007.



APPENDIX H
Hydrotechnical

HYDROTECHNICAL

The Dam Safety Review is based on the Hydrotechnical analysis contained within the following reports.

- Matrix Solutions Inc. (Matrix). 2018. *Chin 2 Dam Proposed Spillway and Assessment of Dam Breach Inundation and Consequence Classification.* July 2018.
- Matrix Solutions Inc. (Matrix). 2017. *Chin Reservoir Dam Consequence Classification and Inflow Design Flood Updates.* August 2017.

APPENDIX I
Structural, Electrical & Mechanical

SUMMARY OF CONDUIT AND GATE INSPECTIONS AND MAINTENACE SINCE 2013

TABLE I1 Conduit 1

Year	I/M	By	Gate & Rotork	Major Crack at Station 0+078	Miscellaneous
2013	I	AECOM	Some leakage through gate seal.	No comments.	Noticeable vertical cracking, very little horizontal cracking, no concrete spalling.
2013	I	SMRID	Good condition.	Plate could use some grouting.	First joint downstream of conduit cracks requires grouting.
	M		Repaired gate thimbles, replaced bottom plate, covered existing side plates with new plate.	N/A	Repaired crack at 10 m d/s of gates with grout.
2015	I	SMRID	Operating. Vent pipe clear.	Not inspected.	Not inspected.
2016	I	SMRID	Leaking on both sides and bottom	Good condition, grout intact on leading edge, plate and bolts in good condition.	Pin gaps: 481.9 mm
	M		Replaced oil in Rotork. Reseated gate. Added ash to help seal gate. Drive nut and bearings replaced.	N/A	N/A
2017	I	SMRID	Thimble in good condition. Gate leaking from both sides.	Grout mostly intact on leading edges of plate.	Pin gaps: 482.9 mm
2018	I	Matrix & TetraTech	Gate seals in good condition. Pitting visible.	Several bolts were missing and previously welded.	Notably more cracks than the other conduits (mostly on right side looking d/s). No concrete spalling (hammer tested). Honeycombing on ceiling of conduit. Delaminating grout upstream of gate well.

TABLE I2 Conduit 2

Year	I/M	By	Gate & Rotork	Major Crack at Station 0+078	Miscellaneous
2013	I	AECOM	No comments.	No comments.	Noticeable vertical cracking, very little horizontal cracking, no concrete spalling.
2013	I	SMRID	Good/fair.	Plates could be replaced or re-grouted.	First joint downstream of conduit cracks requires grouting.
	M		Repaired gate thimbles, replaced bottom plate, covered existing side plates with new plate.	N/A	Repaired crack at 10 m d/s of gates with grout.
2015	I	SMRID	Operating. Vent pipe clear.	Not inspected.	Not inspected.
2016	I	SMRID	Minimal leakage.	Grout intact on leading edges of plate, plate in good condition, bolts in place.	Overall good condition.
	M		Replaced oil in Rotork. Reseated gate. Added ash to help seal gate. Drive nut and bearings replaced.	N/A	N/A
2017	I	SMRID	Some leakage from top of gate.	Grout intact on leading edges of plate, plate in good condition, bolts in place.	Overall good condition.
2018	I	Matrix & TetraTech	The lowest gate stem guide was cracked and had broken off the concrete anchors. Side and bottom gate seals appeared to be in good condition. Some new pitting present.	No missing bolts noted.	No concrete spalling (hammer tested). Few concrete cracks but some honeycombing on ceiling of conduit. Delaminating grout upstream of gate well.

TABLE I3 Conduit 3

Year	I/M	By	Gate & Rotork	Major Crack at Station 0+078	Miscellaneous
2013	I	AECOM	Significant leakage through gate seal.	No comments.	Noticeable vertical cracking, very little horizontal cracking, no concrete spalling.
2013	I	SMRID	Poor – bottom thimble plate is pitted and corroded. Scour holes around thimble require grout.	Plates could be re-grouted.	First joint downstream of conduit cracks requires grouting.
	M		Repaired gate thimbles, replaced bottom plate, covered existing side plates with new plate.	N/A	Repair scoured concrete downstream of gate. Repaired crack at 10 m d/s of gates with grout.
2015	I	SMRID	Operating. Vent pipe clear.	Not inspected.	Not inspected.
2016	I	SMRID	Gate is leaking on both sides.	Grout intact on leading edge of plate, plate and bolts in good condition	Overall good condition. Concrete Honeycomb on roof, dripping.
	M		Replaced oil in Rotork. Reseated gate. Added ash to help seal gate. Drive nut and bearings replaced.	N/A	N/A
2017	I	SMRID	Gate is leaking due to debris caught in gate.	Grout intact on leading edge of plate, plate and bolts in good condition	Overall good condition. Concrete honeycomb on roof dripping.
2018	I	Matrix & TetraTech	Side gate seals appeared to be in good condition. Heavy pitting on underside of gate.	No missing bolts noted.	No concrete spalling (hammer tested). Delaminating grout upstream of gate well.

TABLE I4 Conduit 4

Year	I/M	By	Gate & Rotork	Major Crack at Station 0+078	Miscellaneous
2013	I	AECOM	Noticeable deflection of Gate I-beams supports when operating.	No comments.	Noticeable vertical cracking, very little horizontal cracking, no concrete spalling.
2013	I	SMRID	Fair – small hole formed through bottom of gate seal.	Bolts on plate are missing washers and some are loose. Plates could be re-grouted.	First joint downstream of conduit cracks requires grouting.
	M		Repaired gate thimbles, replaced bottom plate, covered existing side plates with new plate.	N/A	Repaired crack at 10 m d/s of gates with grout.
2015	I	SMRID	Operating. Vent pipe clear. Rotork 4 noisy and turned off until serviced.	Not inspected.	Not inspected.
2016	I	SMRID	Gate is leaking on both sides, top, and bottom corners. Tight operation between 20%-35% open.	Grout still intact on leading edges of the plate. Plate and bolts in good condition.	Overall good condition. Concrete Honeycomb on roof, dripping.
	M		Replaced oil in Rotork. Reseated gate. Added ash to help seal gate. Drive nut and bearings replaced.	N/A	N/A
2017	I	SMRID	Gate is leaking on both sides, top, and bottom corners.	Grout still intact on leading edges of the plate. Plate and bolts in good condition.	Overall good condition. Concrete Honeycomb on roof, dripping.
2018	I	Matrix & TetraTech	Knife edge of gate with previous welds starting to pit. Pitting along bottom corner of plate immediately downstream of gate	No comments.	No concrete spalling (hammer tested). Delaminating grout upstream of gate well.

TABLE I5 Conduit 5

Year	I/M	By	Gate & Rotork	Major Crack at Station 0+078	Miscellaneous
2013	I	AECOM	Noticeable deflection of Gate I-beams supports when operating. Significant leakage through gate seal.	No comments.	Noticeable vertical cracking, very little horizontal cracking, no concrete spalling.
2013	I	SMRID	Poor – gate guides starting to rust. Bottom and side thimble are pitted and metal is corroded. Scour holes require grout.	Good – crack was re-grouted in 2010.	First joint downstream of conduit cracks requires grouting.
	M		Repaired gate thimbles, replaced bottom plate, covered existing side plates with new plate.	N/A	Repair scoured concrete downstream of gate.
2015	I	SMRID	Suction huge compared to others. Rotork very noisy.	Not inspected.	Not inspected.
2016	I	SMRID	Gate has substantial leakage at the bottom.	No comments.	Overall good condition. Concrete repair looks great – no cracks or slumps. Pin gaps 799.2 mm.
	M	SMRID	Replaced oil in Rotork. Reseated gate. Added ash to help seal gate.	N/A	N/A
2017	I	SMRID	Gate has substantial leakage, mostly from bottom.	No comments.	Overall good condition. Concrete repair looks great – no cracks or slumps. Pin gaps 799.5 mm. **New leak 15 m from end of conduit.**
2018	I	Matrix & TetraTech	Side gate guides were heavily corroded and rusted near bottom on both sides. SMRID noted that the guides should be fixed this year. Side seals of gate near the bottom were in poor condition.	No plate present (removed in 2010).	Notably fewer cracks than the other conduits. No concrete spalling (hammer tested). Delaminating grout upstream of gate well. Crack upstream of gate well.

TABLE I6 Miscellaneous

Year	I/M	By	Control Building	Outlet Structure and Stilling Basin
2013	I	AECOM	Concrete pad heaved – door cut at sill added 8 years prior.	Concrete sound with no visible cracks or spalling.
2013	I	SMRID	No comments.	No comments.
2015	I	SMRID	No comments.	Riprap and structure in good condition.
2016	I	SMRID	No comments.	No comments.
2017	I	SMRID		
2018	I	Matrix & TetraTech	Concrete pad for the control building slopes slightly towards the upstream side of the dam.	Some separation between the conduits and the stilling basin structure. Water stop is intact and embedded in the stilling basin wall.

APPENDIX 13.1

Chin Reservoir Expansion – Water Quality Analysis Technical Memorandum (INTERA 2025a)

INTERA Incorporated
8501 Turnpike Drive, #110
Westminster, CO 80031
+1 (720) 318 4725
INTERA.com

TECHNICAL MEMORANDUM

To: Jeffrey Olitch, P.Eng., PE

From: INTERA Incorporated

Date: June 30, 2025

Re: Chin Reservoir Expansion – Water Quality Analysis

1.0 Introduction

INTERA, under subcontract to MPE (a division of Englobe), evaluated the benefits and risks of expanding the Chin Reservoir for the benefit of the St. Mary River Irrigation District (SMRID). The Chin Reservoir Expansion would increase irrigation capacity and water supply reliability within the SMRID, Taber Irrigation District (TID), and Raymond Irrigation District (RID). INTERA's analysis will provide additional information to support the response to supplemental Information (SIR) #1 and the project Environmental Impact Assessment (EIA).

INTERA's analysis describes the water quality expected in the project area and downstream bodies of water, under low and high flow scenarios and under current footprint (base case) and completed expansion reservoir (project case) conditions. This Technical Memorandum describes the potential implications of constituents in the reservoir entering the aquatic food chain, and potential for impacts on treatment of water from the Project and downstream bodies of water for drinking water purposes.

The analysis focuses on assessing the future operating condition of the expanded reservoir compared with existing conditions. INTERA did not analyze a gradual reservoir filling scenario. The evolution of water quality in the expanded portion of the reservoir cannot be precisely characterized through modeling; therefore, we propose that filling will occur in isolation and monitoring will be conducted to inform adaptive management and confirm that adverse effects have been avoided.

2.0 Water Quality Analysis

2.1 Data

INTERA analyzed water chemistry for Chin Reservoir surface water samples to characterize baseline conditions and to serve as an input to evaluate water quality changes due to reservoir expansion. The samples came from multiple sampling events that have occurred in this region (Volume 4: Water Quality Technical Baseline Report), including by SMRID and Klohn Crippen Berger Ltd. (KCB) (**Figures 1** and **2**). The resulting averages for each sample location are presented in **Table 1** and **Table 2**. For results below the limit of detection, we used half of the respective detection limit value as an estimate to represent and graph the values.

For the canal inflow data for Tin, the laboratory analysis method changed the detection limit dramatically, and for the first 2 years, the detection limit was much higher than the rest of the data sampled. Therefore, the first 2 years of available data were excluded from the calculated average for this parameter. The maximum allowable concentration (MAC) for each constituent was assessed based on available guidelines from both the Environmental Quality Guidelines for Alberta Surface Waters (GoA, 2018) and Canadian Council of Ministers of the Environment (CCME, 1999).

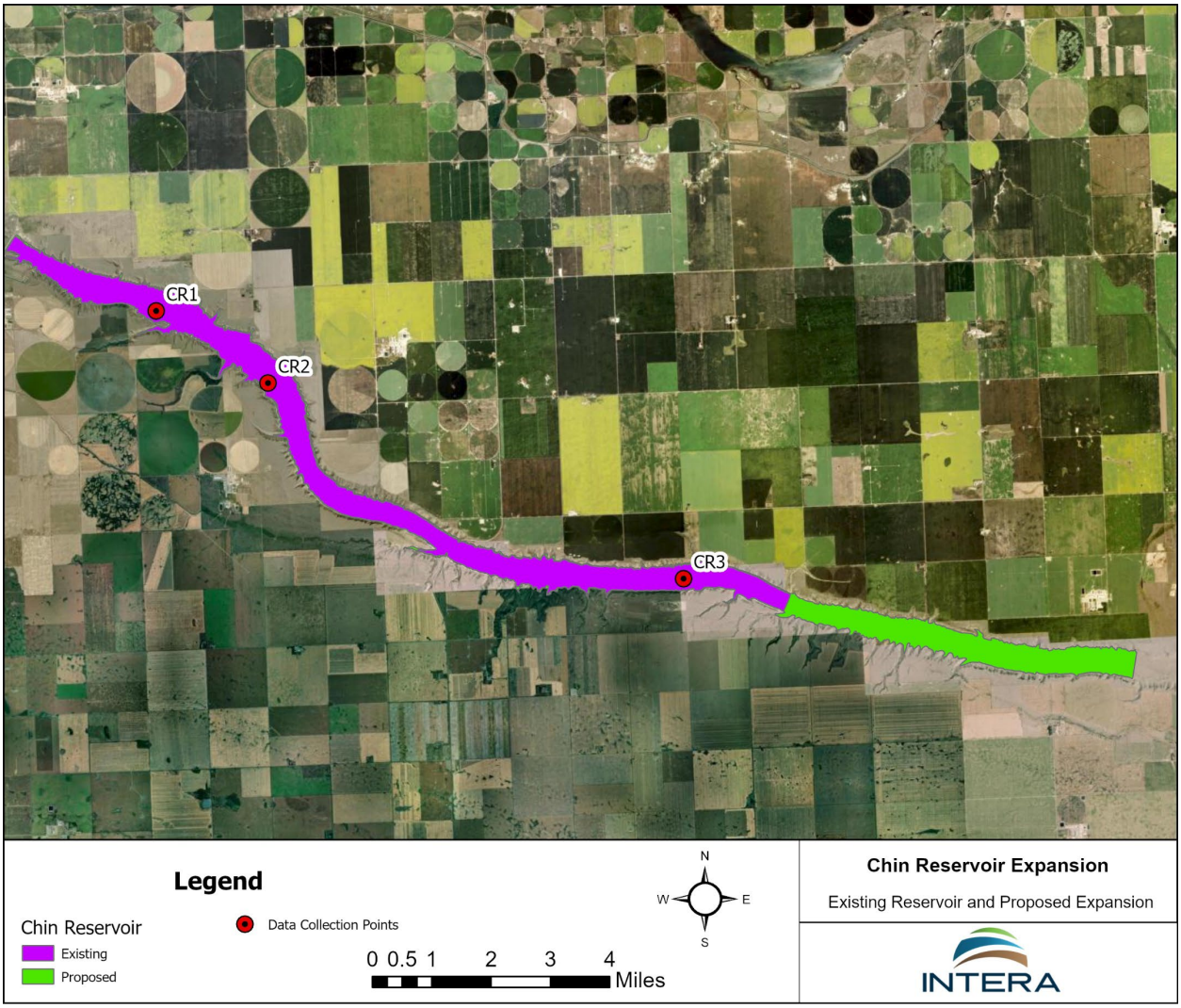


Figure 1. Current and proposed expanded Chin Reservoir, with data collection locations sampled by Klohn Crippen Berger Ltd.

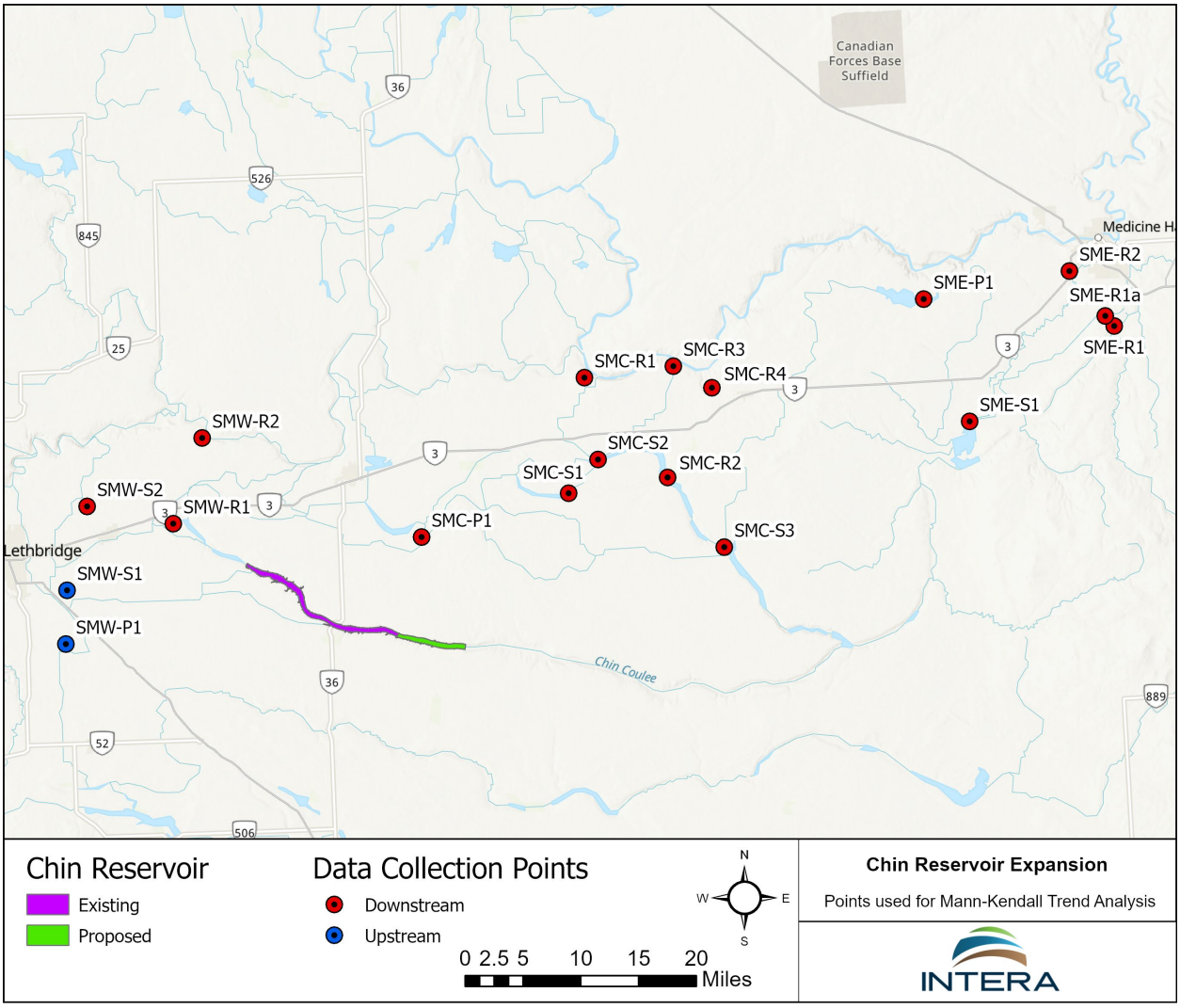


Figure 2. SMRID water quality sampling station locations.

Table 1. Averaged observed metal constituents at various sampling locations.

Metals Constituents	Units	Reservoir (CR1-3) Average	Upstream (SMW-P1) Average	Downstream Average
Silver (Ag)	ug/L	0.0050	0.0623	0.0950
Thallium (Tl)	ug/L	0.0054	0.0321	0.1530
Cadmium (Cd)	ug/L	0.0115	0.0346	0.3940
Bismuth (Bi)	ug/L	0.0250	0.2500	0.3130
Beryllium (Be)	ug/L	0.0367	0.1790	0.7890
Tin (Sn)	ug/L	0.0500	0.5000	0.7080
Lead (Pb)	ug/L	0.0519	0.1340	7.9700
Cobalt (Co)	ug/L	0.0678	0.3630	7.7800
Antimony (Sb)	ug/L	0.1070	0.2640	0.7920
Mercury (Hg)	ug/L	0.1420	0.0522	3.7200
Chromium (Cr)	ug/L	0.2020	0.9520	16.5000
Selenium (Se)	ug/L	0.2680	0.2750	0.6620
Uranium (U)	ug/L	0.7380	0.5430	11.2000
Nickel (Ni)	ug/L	0.8830	0.5790	22.0000
Arsenic (As)	ug/L	0.8880	0.8250	19.5000
Copper (Cu)	ug/L	0.9310	0.9110	20.8000
Vanadium (V)	ug/L	1.1700	0.8710	35.5000
Molybdenum (Mo)	ug/L	1.1900	1.0700	4.1000
Zinc (Zn)	ug/L	1.7500	3.7700	74.4000
Titanium (Ti)	ug/L	1.8400	6.0900	135.0000
Lithium (Li)	ug/L	4.5900	5.2900	190.0000
Boron (B)	mg/L	0.0100	0.0201	2.6400
Manganese (Mn)	ug/L	47.0000	13.9000	338.0000
Aluminum (Al)	mg/L	0.0786	0.2290	14.3000
Iron (Fe)	mg/L	0.0924	0.1870	16.9000
Barium (Ba)	ug/L	113.0000	115.0000	392.0000
Strontium (Sr)	ug/L	131.0000	123.0000	360.0000
Potassium (K)	mg/L	1.0700	0.9380	18.9000
Silicon (Si)	mg/L	1.5100	1.4400	21.5000
Sulfur (S)	mg/L	8.8700	7.9400	20.2000
Sodium (Na)	mg/L	8.9200	6.2500	1450.0000
Magnesium (Mg)	mg/L	13.1000	10.5000	171.0000

Table 2. Averaged observed nonmetal constituents at various sampling locations.

Nonmetals Constituents	Units	Upstream Average	Reservoir Average	Downstream Average
Nitrite (as N)	ug/L	0.0000	5.0000	46.7000
Phosphorus (P)	ug/L	7.0300	5.1100	729.0000
Ammonia, (as N)	ug/L	23.0000	20.6000	142.0000
Nitrate (as N)	ug/L	38.9000	24.6000	100.0000
Nitrate and Nitrite (as N)	ug/L	39.8000	27.3000	110.0000
Total Kjeldahl Nitrogen	mg/L	0.1750	0.1340	3.5000
Total Nitrogen	mg/L	0.2590	0.1500	3.5100
Chloride (Cl)	mg/L	0.8110	0.8490	393.0000
Hydroxide (OH)	mg/L	2.5000	1.8300	1.8300
Carbonate (CO_3)	mg/L	3.2900	2.0700	206.0000
Sulfate (SO_4)	mg/L	19.9000	26.7000	1730.0000
Alkalinity, (as $CaCO_3$)	mg/L	113.0000	135.0000	1420.0000
Hardness (as $CaCO_3$)	mg/L	117.0000	138.0000	763.0000
Bicarbonate (HCO_3)	mg/L	137.0000	163.0000	1380.0000
TDS (Calculated)	mg/L	137	166	4510

An analysis of the spatial distribution of surface water sampling locations, along with the average constituent concentrations at those sites, showed no significant spatial or temporal trends between sampling points within the Reservoir, or within the inflow canal. Refer to the Chin Reservoir Historical Canal Inflow and Modeled Arsenic Trend Analysis Technical Memo for additional information (INTERA 2025a). For conservative reservoir mass balance modeling, we averaged the data from the three Chin Reservoir sample sites. The data from the upstream SMRID sample point, SMW-P1, was averaged to represent typical concentrations for the upstream (inflow) sources.

2.2 Mass Balance Model

INTERA constructed a water quality model of the Chin Reservoir to predict impacts of the reservoir expansion on water quality. This model, constructed as a simple mass balance model, evaluated the Chin Reservoir system as a continually stirred reactor (CSR). A CSR incorporates all elements and then distributes them uniformly throughout the entire system. The mass balance model represents the Chin Reservoir in two distinct ways: (1) as the extent of the current footprint and (2) as the proposed expanded footprint.

We also considered an approach to model an incremental footprint to represent the gradual filling of the reservoir as a short transitional phase with additional terms to represent soil leaching and erosion. However, this was considered to introduce significant uncertainty to the mass balance modeling as insufficient data were available to assess the magnitude of the flux accurately. Given the uncertainty in the process, the adaptive management plan was developed to protect the system and downstream users. The primary mechanism for mitigating the potential for adverse effects on water quality will be to

fill the expanded portion of the reservoir in isolation from the existing reservoir, which will allow for monitoring and adaptive management of water quality within the expanded portion of the reservoir prior to commissioning. Therefore, no modeling was conducted for the filling phase and soil leaching was excluded from the model. Refer to the Adaptive Management Plan for Water Quality Technical Memo for additional information (INTERA 2025b).

The mass balance model analyzes water quality constituents as a conservative substance and models both total and dissolved metals, as well as other non-metal water quality constituents. As a mass balance analysis, the model considers all relevant inflows and outflows to the system. The inflows and outflows were provided from the Hydrologic and Hydraulic model (H&H Model) developed by WaterSMART Water Management Solutions for Chin Reservoir. The inflows and outflows span a range of years from 1928-2010 and contain both high and low flow conditions for the system. The Storm Event Modeling section (Section 2.5) shows the model results and effects of storm events (1:20, 1:100, 1:300) on the system. The theoretical fluxes present in the Chin Reservoir system are illustrated in **Figure 3**. However, the water budget—and consequently the mass balance model—consolidates the physical processes for the flux of constituent mass into a single total inflow and total outflow interaction, as provided by the reservoir inflow and outflow data from the H&H Model. Sections 2.4 and 2.5 discuss how groundwater and basin runoff were isolated and considered using the model.

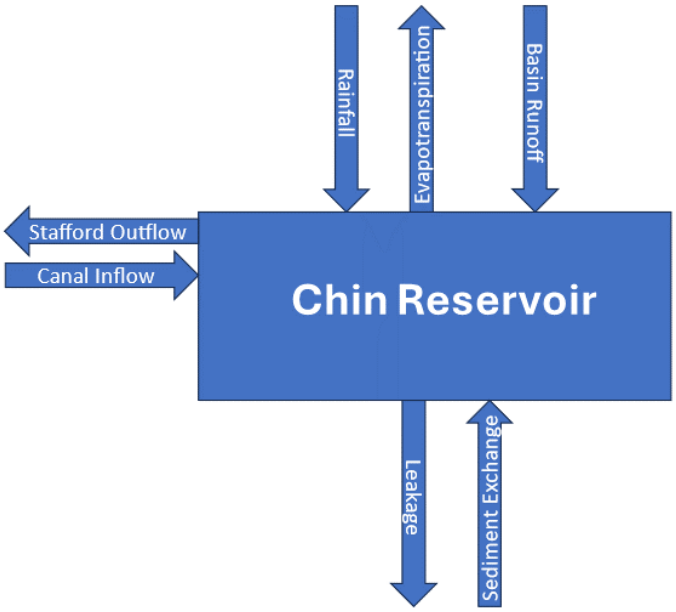


Figure 3. Potential water processes within Chin Reservoir system.

INTERA used the water quality data averaged from previous data collection efforts to define both the initial reservoir concentration and inflow concentrations within the mass balance model. The observed concentrations of constituents at the upstream main canal sampling location (SMW-P1) served in the model as inflow concentrations, while the initial reservoir concentrations were represented by the

average observed reservoir concentration. It is considered appropriate to apply average concentrations because (1) the average preserves mass, (2) trend analysis did not identify significant increasing trends, (3) the reservoir acts as a huge buffering mechanism that absorbs short event-based transients, and (4) there are insufficient data to develop and apply a flow volume weighted function to the inflow concentrations. The model initial reservoir concentrations and inflow concentrations are displayed in **Figure 4** through **Figure 8** and detailed in **Table 3**. The assigned inflow concentrations represent the mass of constituents added to the water in the reservoir. The mass balance modeling was performed for both the current (base case) and expanded reservoir (project case) footprints, with total inflow and storage as input to the mass balance model.

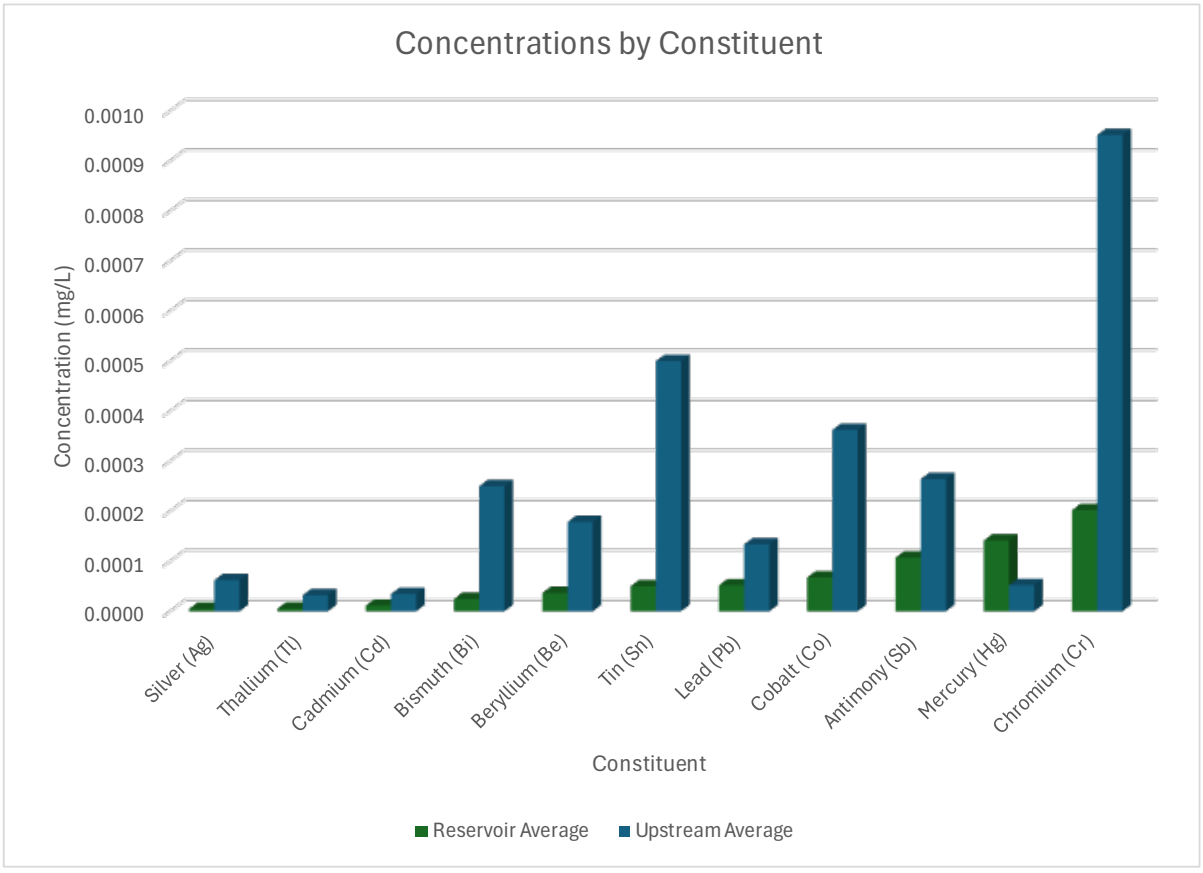


Figure 4. Observed constituent concentrations upstream of and within Chin Reservoir.

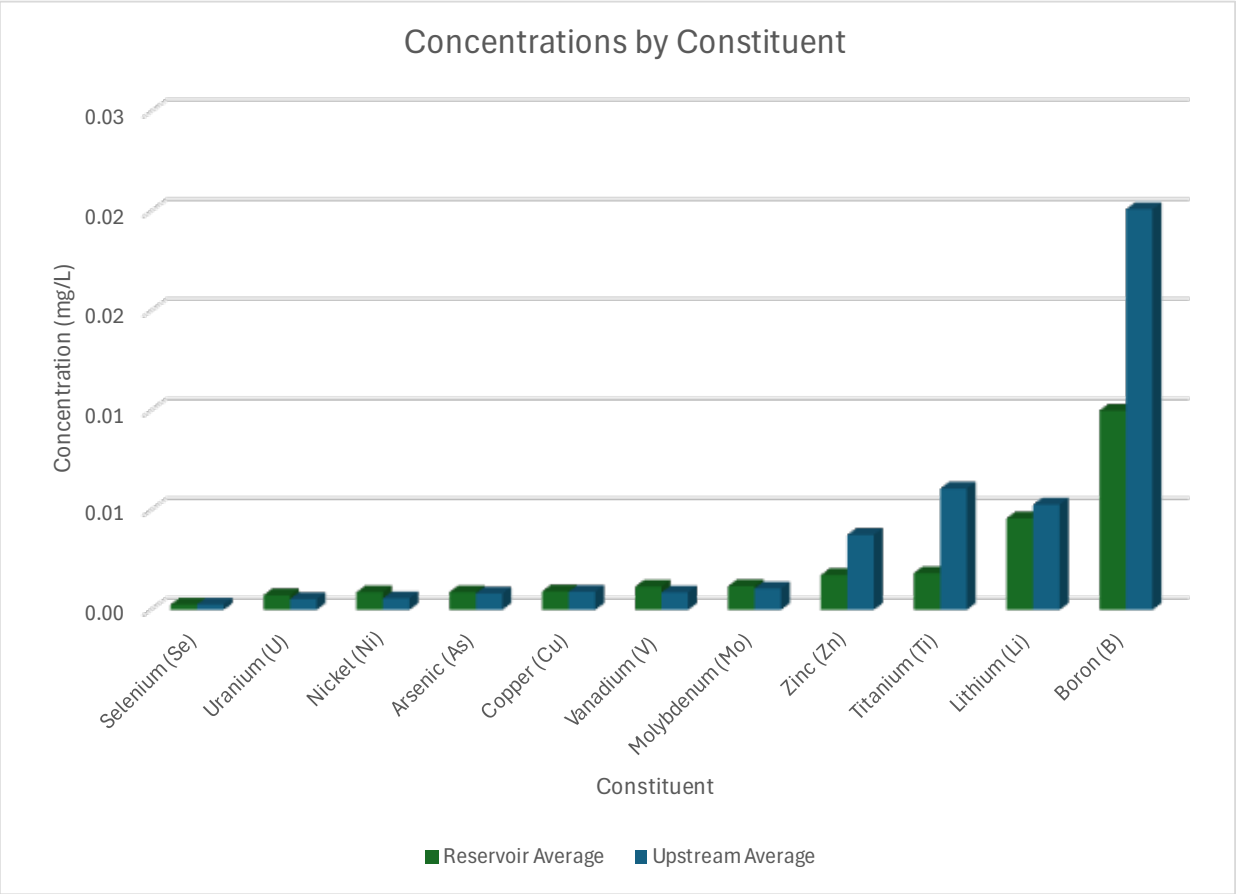


Figure 5. **Observed constituent concentrations upstream of and within Chin Reservoir.**

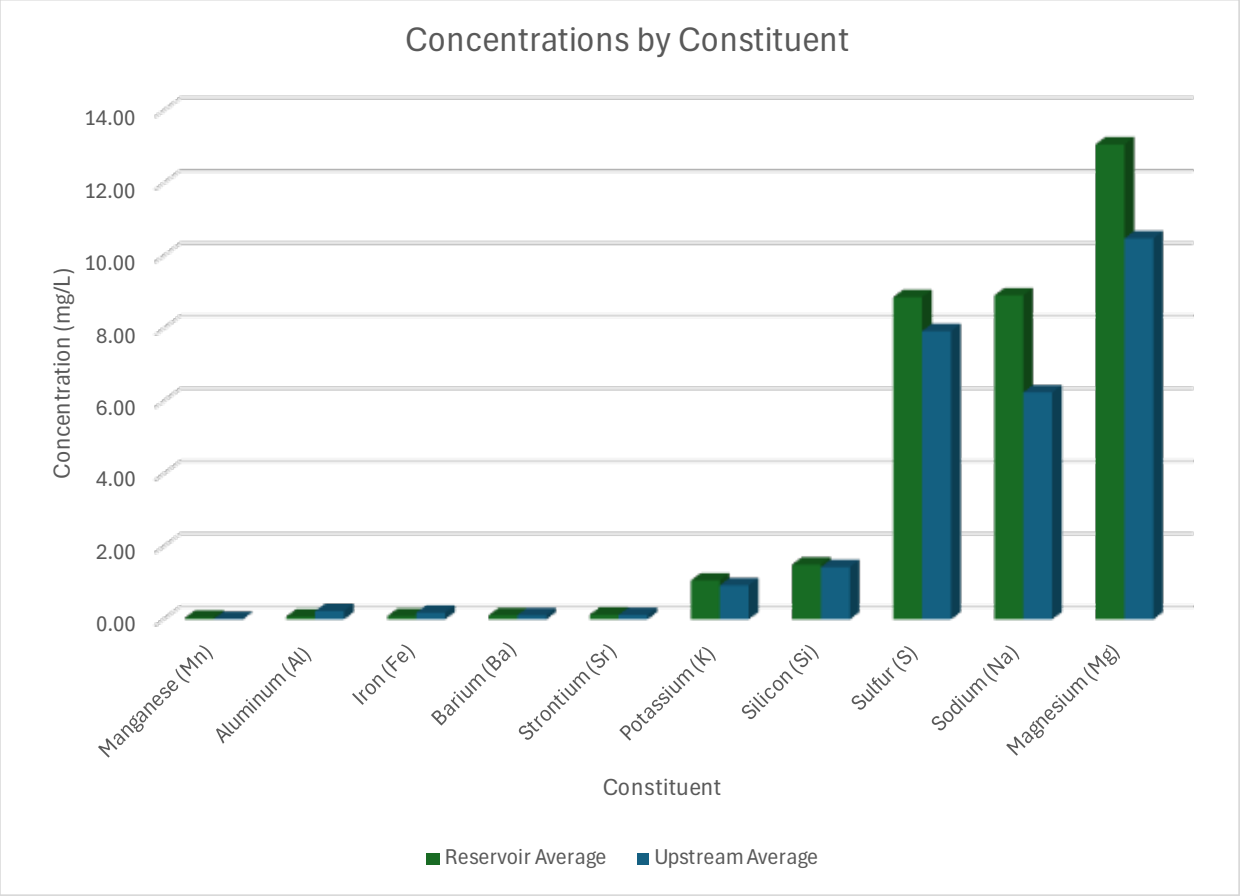


Figure 6. **Observed constituent concentrations upstream of and within Chin Reservoir.**

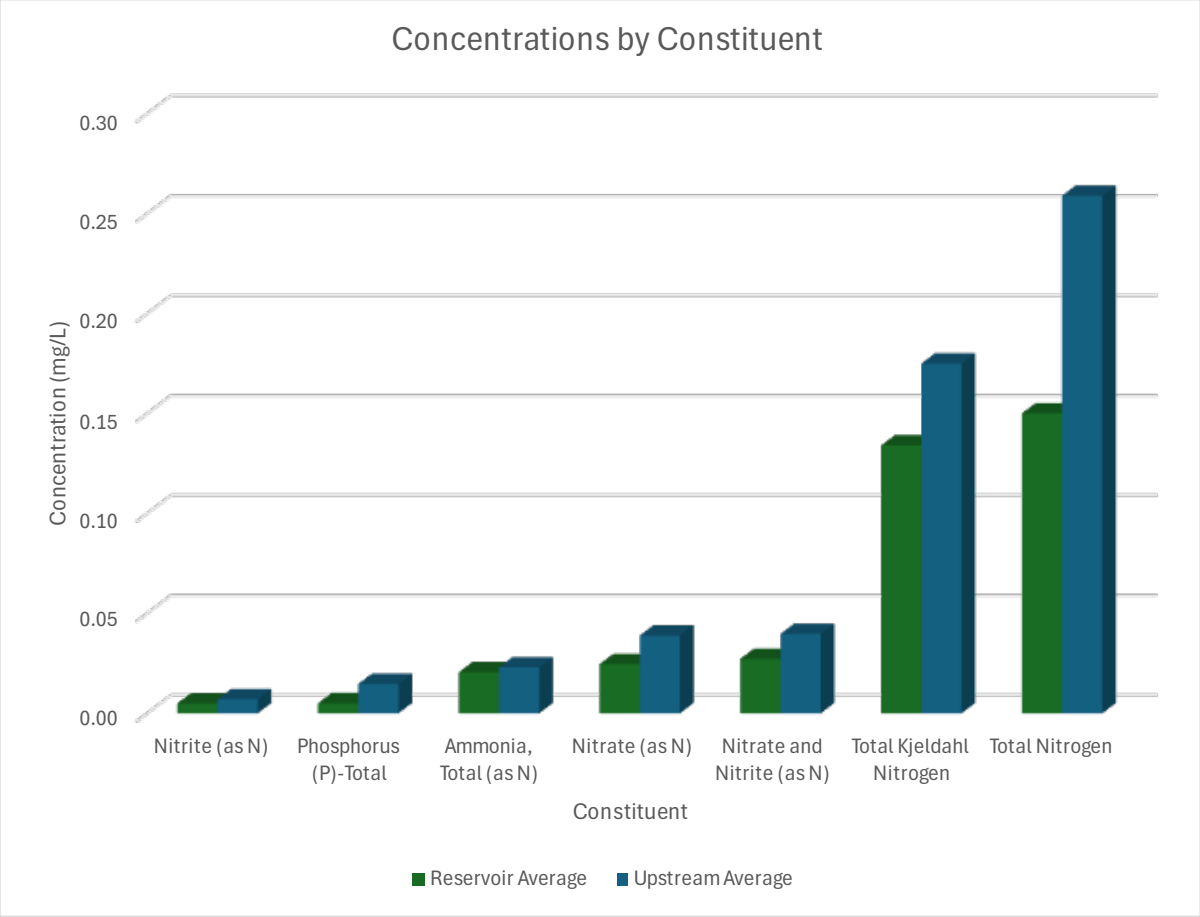


Figure 7. **Observed constituent concentrations upstream of and within Chin Reservoir.**

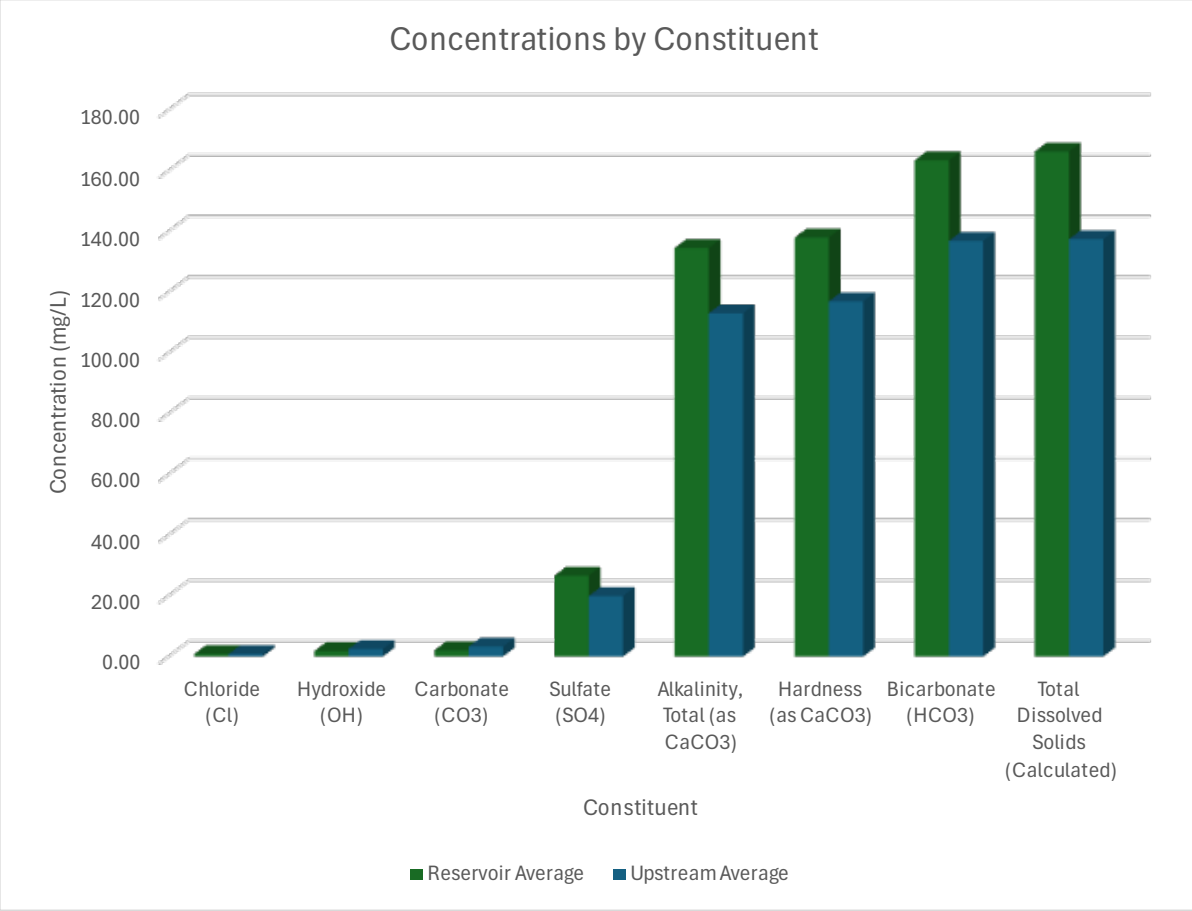


Figure 8. **Observed constituent concentrations upstream of and within Chin Reservoir.**

Table 3. Averaged water quality data used as inputs for the mass balance model.

Constituent (mg/L)	Reservoir Average (used as initial concentration)	Upstream Average (used as inflow concentration)
Silver (Ag)	0.000005000	0.000062321
Thallium (Tl)	0.000005389	0.000032143
Cadmium (Cd)	0.000011494	0.000034643
Bismuth (Bi)	0.000025000	0.000250000
Beryllium (Be)	0.000036667	0.000178571
Tin (Sn)	0.000050000	0.000050000
Lead (Pb)	0.000051944	0.000133929
Cobalt (Co)	0.000067778	0.000362500
Antimony (Sb)	0.000107222	0.000264286
Mercury (Hg)	0.000141588	0.000052179
Chromium (Cr)	0.000202222	0.000951786
Selenium (Se)	0.000268167	0.000275000
Uranium (U)	0.000737722	0.000542857
Nickel (Ni)	0.000882778	0.000578571
Arsenic (As)	0.000888333	0.000825000
Copper (Cu)	0.000930556	0.000910714
Vanadium (V)	0.001167222	0.000871429
Molybdenum (Mo)	0.001187111	0.001071429
Zinc (Zn)	0.001750000	0.003767857
Titanium (Ti)	0.001841111	0.006089286
Lithium (Li)	0.004594444	0.005285714
Boron (B)	0.010000000	0.020107143
Manganese (Mn)	0.046972222	0.013928571
Aluminum (Al)	0.078638889	0.229178571
Iron (Fe)	0.092388889	0.187392857
Barium (Ba)	0.113027778	0.115285714
Strontium (Sr)	0.131333333	0.122900000
Potassium (K)	1.072055556	0.937500000
Silicon (Si)	1.510000000	1.440500000
Sulfur (S)	8.871666667	7.935000000
Sodium (Na)	8.920000000	6.250000000
Magnesium (Mg)	13.077777778	10.487500000
Nitrite (as N)	0.005	0.007031915
Phosphorus (P)	0.005105556	0.014702128
Ammonia, (as N)	0.020561111	0.023046875
Nitrate (as N)	0.024611111	0.03893617

Constituent (mg/L)	Reservoir Average (used as initial concentration)	Upstream Average (used as inflow concentration)
Nitrate and Nitrite (as N)	0.027277778	0.039765957
Total Kjeldahl Nitrogen	0.134055556	0.175
Total Nitrogen	0.150055556	0.258974359
Chloride (Cl)	0.848888889	0.810638298
Hydroxide (OH)	1.833333333	2.5
Carbonate (CO_3)	2.072222222	3.287234043
Sulfate (SO_4)	26.66666667	19.94574468
Alkalinity, (as $CaCO_3$)	134.5555556	113.0702128
Hardness (as $CaCO_3$)	138	116.9787234
Bicarbonate (HCO_3)	163.4444444	136.8723404
TDS (Calculated)	166.3333333	137.4680851

2.3 Pesticides

In addition to metal and non-metal constituents, the mass balance model was also used to analyze pesticide concentration within the Chin Reservoir system. Like the other constituents, pesticide concentration data came from previous sampling events. Of the specific pesticides sampled, the majority were very infrequently detected. From the previous sampling efforts, the only constituent with sufficient datapoints for modeling was 2,4-Dichlorophenoxyacetic acid. The initial model concentrations are shown below in **Table 4.**

Table 4. 2,4-Dichlorophenoxyacetic acid model starting concentrations.

Constituent (mg/L)	Reservoir Average	Upstream Average
2,4-Dichlorophenoxyacetic acid	0.00002862	0.00005724

2.4 Groundwater Contribution

The degree of groundwater contribution to a water system can be difficult to quantify, especially in a large system, as seepage rates can vary over a large area. Additionally, groundwater contributions to systems are often so minor that the groundwater flux is lost in the noise of the reservoir's other boundary conditions. As such, groundwater contributions are often estimated rather than measured, as was the case in the Chin Reservoir model, which used a mass balance approach.

The constituent analysis performed by Stewart and others (2007) evaluated the relative contributions of groundwater and surface water to overall reservoir water quality by using specific conductivity to compare constituent concentrations. This analysis assumed that the observed concentration within the reservoir is derived from two principal inflows: groundwater and surface water. In INTERA's analysis, the relative inflows to the reservoir serve as the weighting mechanism such that the reservoir concentration

is equal to the groundwater concentration times relative groundwater contribution + Canal concentration times (1 – groundwater contribution).

While Stewart and others (2007) focused exclusively on specific conductivity in their analysis, INTERA's analysis for the Chin Reservoir system focused on Sulfates and Total Dissolved Solids (TDS). We selected these constituents due to the large difference between surface water and groundwater concentrations. This examination employed an iterative process to determine the relative groundwater contribution that would result in simulated reservoir concentrations that most closely match observed values in the Chin Reservoir. Note that the model slightly overestimates Sulfates and slightly underestimates TDS, indicating some degree of uncertainty in the estimation process. The constituents examined and their respective final calculated groundwater contributions, as well as the accuracy of those calculations, are shown in **Table 5**. These calculations indicate that the groundwater contribution represents approximately 0.4% of the total inflow to the Chin Reservoir on average. This small inflow would only be significant when the groundwater constituent concentration is significantly different from the canal inflow concentration–such as TDS and Sulfates. However, for most water quality parameters, this proportionately low groundwater contribution has a negligible effect on overall reservoir concentrations.

Table 5. Constituent concentrations and groundwater contributions.

Constituent (mg/L)	Upstream Average Concentration	Reservoir Average Concentration	Shallow Groundwater Average Concentration	Predicted Concentration Assuming a 0.4% GW Contribution	Accuracy of Groundwater Contribution Estimate
Sulfate (SO4)	21.80412	26.66667	1801.66667	28.92357	1.08463
TDS (Calculated)	143.54654	166.33333	3608.33333	157.40569	0.94633

Once we developed an estimate of the proportion of groundwater contribution, we placed the values into the numerical model (described in Section 2.2) to simulate the concentration of various parameters over time and determine the magnitude of the groundwater contribution's impact. As discussed in Section 2.2, the water budget consolidates the physical processes into a predefined total inflow and total outflow interaction (provided by the H&H Model). To represent the groundwater contribution to the system, we separated the total inflow into two datasets: (1) one multiplied by 0.996, representing 99.6% of total inflow derived from canal inflow, and (2) one multiplied by 0.004, representing 0.4% of total inflow derived from groundwater sources.

INTERA used the water quality data averaged from previous data collection efforts to define both the initial reservoir concentration and inflow concentrations within the mass balance model. The model used observed constituent concentrations at upstream observation locations as inflow concentrations and initial concentrations as the average observed reservoir concentration. The groundwater concentration was computed as the average of groundwater observations. The assigned inflow concentrations represent the mass of constituents added to the water in the reservoir by multiplying the respective proportions of contribution by the concentration corresponding to the inflow type (e.g., the inflow multiplied by 0.004 would then be multiplied by the groundwater concentration). INTERA

performed mass balance modeling for both the current and expanded reservoir footprints, with total inflow and storage as input to the mass balance model.

Figure 9 through **Figure 12** show the results for a subset of constituents of both the surface water only model and the groundwater/surface water combined model, compared with observed values in **Table 6**. The combined groundwater/surface water model results are closer to the observed Reservoir values for constituents with large deltas between the groundwater and surface water concentrations, as is the case for Sulfates, than the surface water only model results are for those constituents. However, in constituents with similar values for surface water and groundwater, such as Antimony, there is little difference between accuracy of the surface water only model run and the groundwater/surface water model run to the observed Reservoir values.

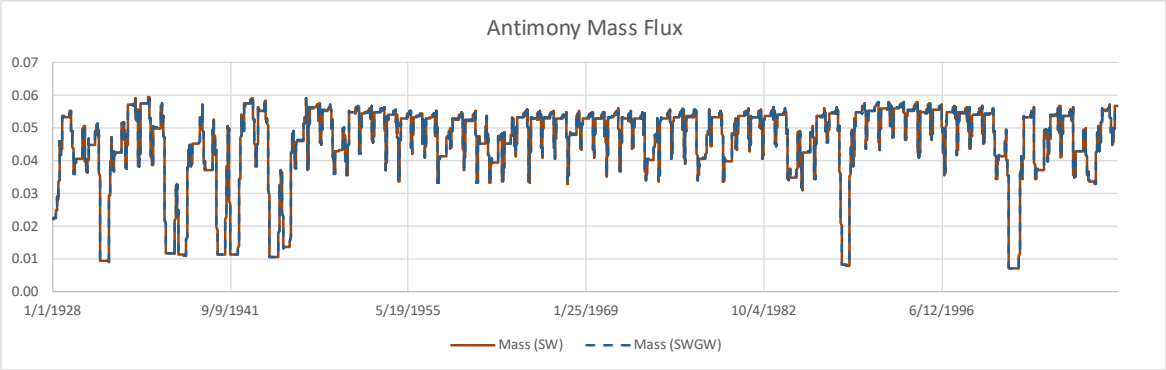


Figure 9. Total Antimony mass flux in both surface water only and groundwater/surface water base footprint models.

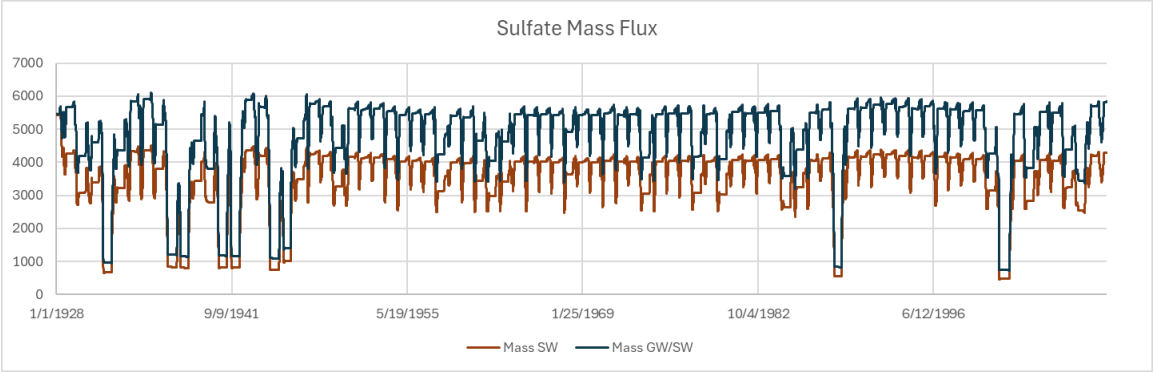


Figure 10. Total Sulfates mass flux in both surface water only and groundwater/surface water base footprint models.

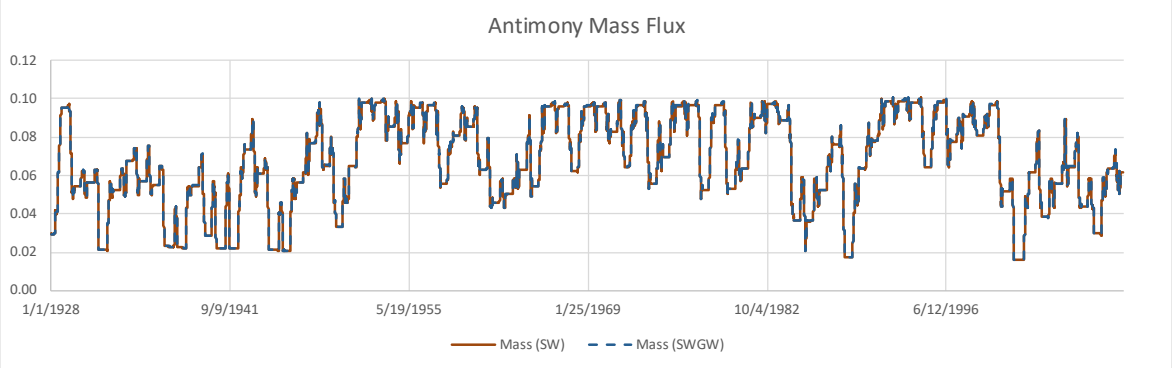


Figure 11. Total Antimony mass flux in both surface water only and groundwater/surface water expanded footprint models.

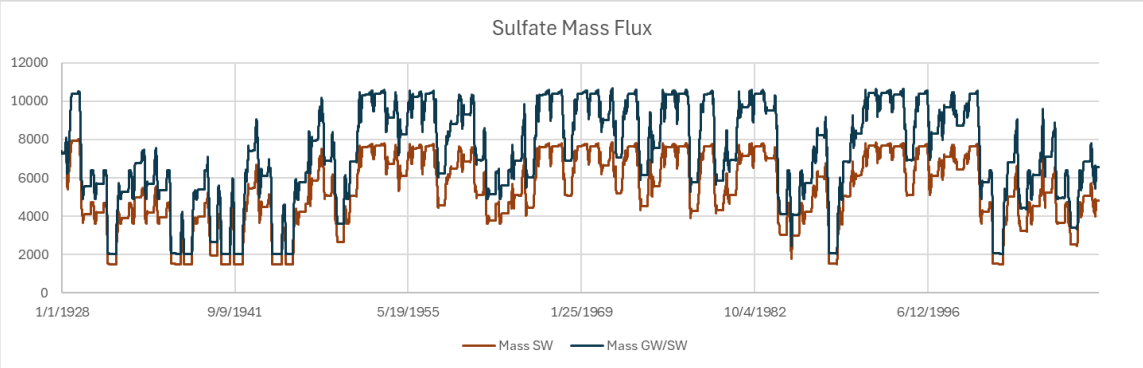


Figure 12. Total Sulfate mass flux in both surface water only and groundwater/surface water expanded footprint models.

Table 6. Comparison of modeled and observed concentrations across model footprints and inflow types.

Constituent (mg/L)	Base Footprint	Expanded Footprint	Initial Reservoir Average	Upstream Average	Downstream Average	Groundwater Average
SW Antimony (Sb)	0.0002622	0.0002632	0.0001072	0.0002643	0.0007917	0.0004333
SW/GW Antimony (Sb)	0.0002640	0.0002639	0.0001072	0.0002643	0.0007917	0.0004333
SW Sulfate (SO_4)	19.9080004	19.9952109	26.6666667	19.9457447	1734.5833333	1801.6666667
SW/GW Sulfate (SO_4)	27.0693449	27.0726108	26.6666667	19.9457447	1734.5833333	1801.6666667

SW = surface water, GW = groundwater

The modeled constituents show that it is possible for groundwater inflows to influence modeled water quality but only when the groundwater and surface water quality are substantially different, such as the case of the Sulfate concentrations between the two inflow types. However, the water quality rarely differs so significantly between inflows. In most cases, such as Antimony, the model results vary little regardless of whether groundwater is included as a separate inflow, given the low groundwater inflow rates. Because the model results would largely remain unchanged when groundwater inflow concentrations are represented separately in the model, we deemed this unnecessary for further modeling efforts.

2.5 Storm Event Modeling

In addition to the varying effects of groundwater contributions to the Chin Reservoir system, INTERA also examined the effects of large-scale rain events, or "design storm." These events are represented in design storm hydrographs to assess the impact of 20-, 100-, and 300-year storm events over both the base and expanded reservoir footprint (**Figure 13** through **Figure 20**). We then incorporated the provided runoff volumes into the mass-balance model by adding two inflows: the local watershed runoff and the direct precipitation. The surface water only model does not represent this additional inflow, so outflows were assumed to remain unchanged and only the inflow was added. This assumption means the design storm response was placed into reservoir storage. We added the design storm into the surface water only model inflow/outflow time series at a high storage condition (i.e., a period of time

during which the water balance is already exhibiting behaviors that would be expected from wet seasons or events). This model used the week of 5/17/2000 to 5/22/2000.

INTERA utilized two methods to add water volume to the model: (1) as increased surface runoff to the reservoir from rain that fell on the surrounding catchment and (2) as rainfall that fell directly onto the reservoir. The model assigned the latter, direct-to-reservoir rainfall a constituent concentration of zero in every run. For the surface runoff to the reservoir, the model assigned two different concentrations to represent high and low concentration scenarios and performed runs for each.

The event mean concentration is unknown for the local basin runoff as there are no sampling stations or available data to characterize runoff water quality. Therefore, we used an uncertainty analysis approach to capture the range of possible concentrations. Varied concentrations included twice the upstream concentration (labeled "high"), and half the upstream concentration (labeled "low"). This dual-modeling run allowed the model to represent more closely the flushing phenomenon common with rainfall events, wherein the first flush of runoff covers a large area and picks up a higher concentration of constituents, but the later portions of the runoff have far lower concentrations, as much of the potential constituent has already been flushed.

As with groundwater contributions (Section 2.4), INTERA performed storm event model runs for a subsection of constituents, namely Antimony and Sulfate. This came to a total of 12 model runs, six for each constituent in both reservoir footprints, representing the high (twice the upstream concentration) and low (half the upstream concentration) concentration values for each of the three storm events. The resulting mass and concentration fluxes for both constituents are shown in **Figure 13** through **Figure 20**.

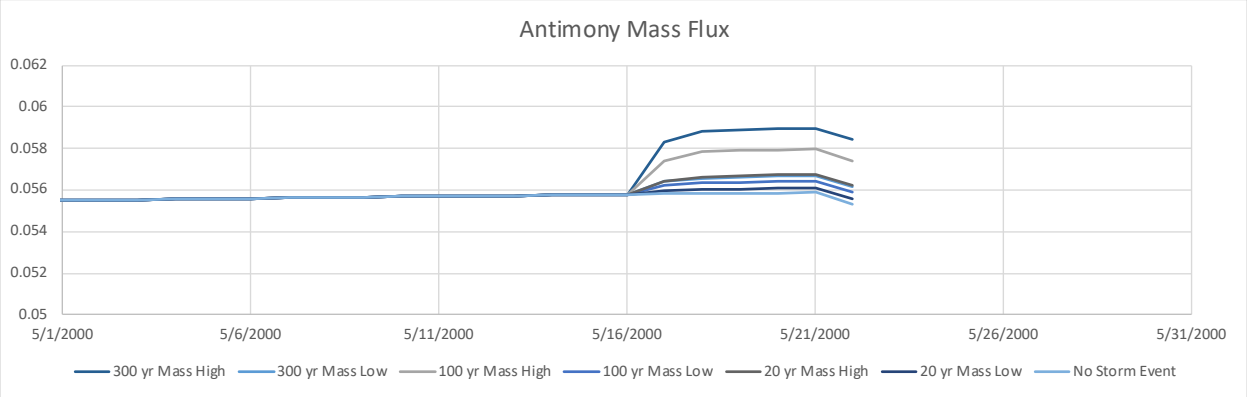


Figure 13. **Modeled Antimony mass flux for each storm event, high and low concentrations, base reservoir footprint.**

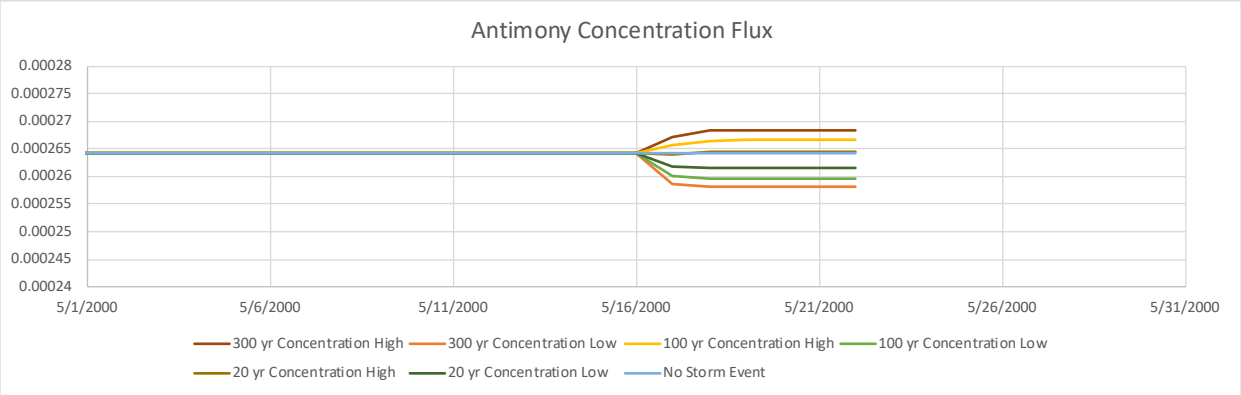


Figure 14. Modeled Antimony concentration flux for each storm event, high and low concentrations, base reservoir footprint.

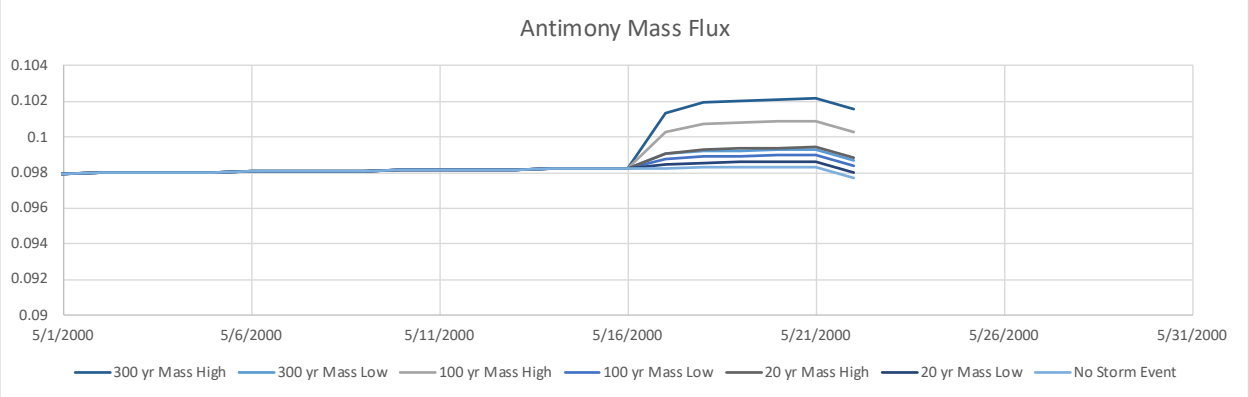


Figure 15. Modeled Antimony mass flux for each storm event, high and low concentrations, expanded reservoir footprint.

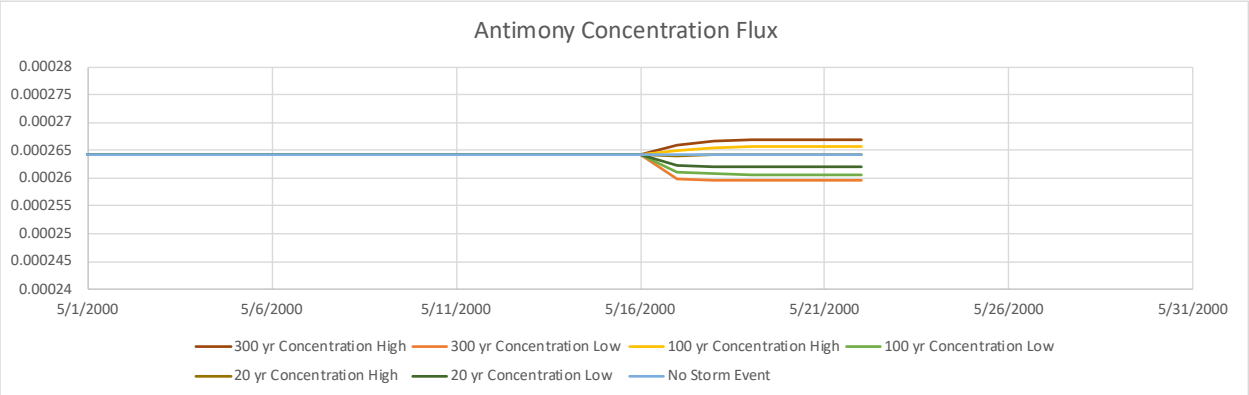


Figure 16. Modeled Antimony concentration flux for each storm event, high and low concentrations, expanded reservoir footprint.

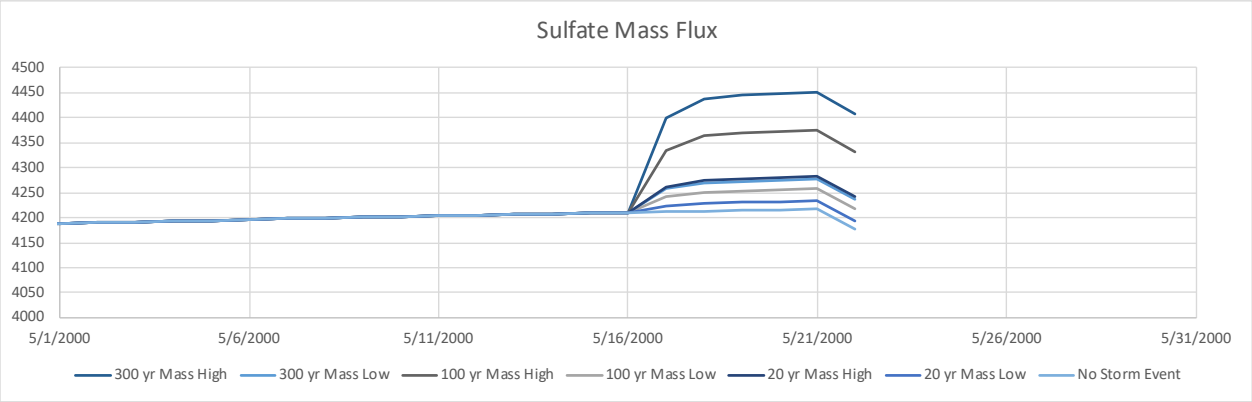


Figure 17. Modeled Sulfate mass flux for each storm event, high and low concentrations, base reservoir footprint.

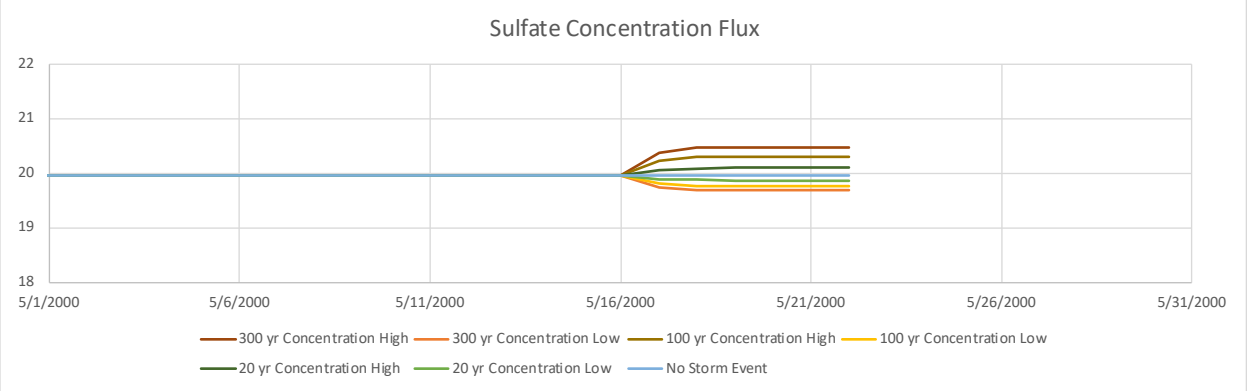


Figure 18. Modeled Sulfate concentration flux for each storm event, high and low concentrations, base reservoir footprint.

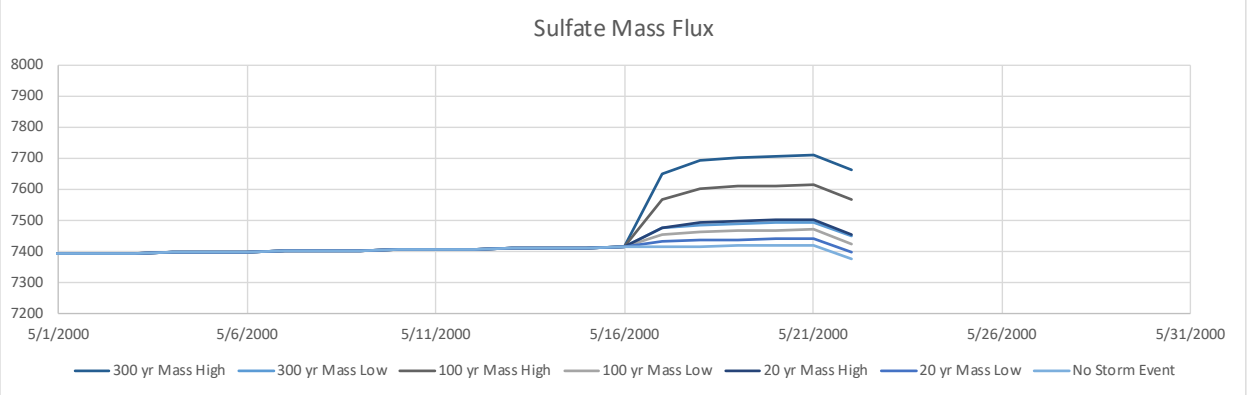


Figure 19. Modeled Sulfate mass flux for each storm event, high and low concentrations, expanded reservoir footprint.

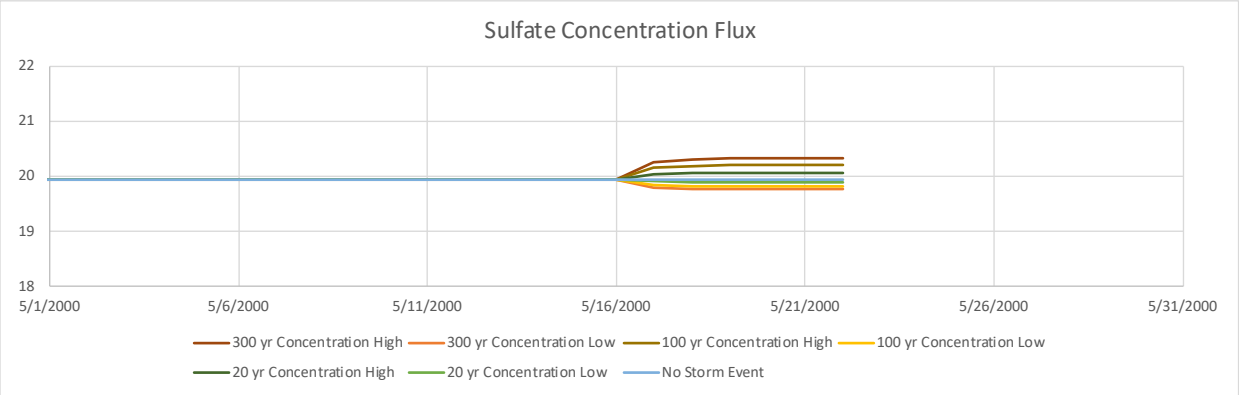


Figure 20. **Modeled Sulfate concentration flux for each storm event, high and low concentrations, expanded reservoir footprint.**

As shown in **Figure 13** through **Figure 20** and in **Table 7**, while the storm events increase the overall mass of constituents in the system, they also introduce clean rainwater, which decreases the concentration of the constituents within the system for many of the events—particularly the low-concentration runs and the expanded footprint models.

Table 7. **Maximum modeled concentrations during storm events (5/17/2000 through 5/22/2000) for base and expanded reservoir.**

Maximum Concentrations over Storm Events	Sulfate Maximum Concentration (mg/L)		Antimony Maximum Concentration (mg/L)	
	Base Footprint	Expanded Footprint	Base Footprint	Expanded Footprint
20-year Low	19.88903707	19.90410041	0.000261722	0.000262
20-year High	20.09780763	20.05379397	0.00026452	0.000264
100-year Low	19.80373619	19.84424922	0.000260009	0.000261
100-year High	20.30671153	20.20011527	0.000266675	0.000266
300-year Low	19.72858316	19.79172915	0.000258619	0.00026
300-year High	20.47510075	20.32084996	0.000268477	0.000267

3.0 Results

INTERA ran the water quality mass balance model (Section 2.2) for both the current footprint of the reservoir and the future expanded reservoir area. The mass balance model assumed conservative substance and a simple continuously stirred reactor. We specified the inflow concentration in the model and calculated outflow concentration using the simulated reservoir concentration.

To test the mixing algorithm, we developed a hypothetical case that initialized the reservoir concentration at 0.0 mg/L and set the inflow to the reservoir to 1.0 mg/L for the year 1928. **Figure 21** displays the simulated concentrations at the end of the first year. The test case demonstrates that the reservoir fully flushes within a single calendar year.

We ran the mass balance model separately for each constituent and for both the base case (existing conditions) and the project case (expanded reservoir) footprints, with the results presented in **Figure 22** through **Figure 26.** Under the given assumptions, we observed only a small difference in concentration between the expanded and current reservoir footprints. In both cases, the reservoir water quality is driven by canal inflow water quality due to the high magnitude of the inflow compared to the total storage.

The modeled average parameter concentrations are detailed in **Table 8** and **Table 9**, and a comparison of the simulated data with the observed dataset is shown in **Table 1**, **Table 2**, and **Figure 27** through **Figure 31**. Further comparisons of the results of modeled scenarios, for both the current and expanded footprints of the model, are shown in **Table 8** and **Table 9.** In all cases, the expanded reservoir exhibits water quality concentrations very similar to the baseline reservoir footprint and to the observed reservoir water quality. The observed (baseline) average parameter concentrations from samples collected in Watercourse 126419 downstream from the existing reservoir are shown in **Figure 27** through **Figure 31** to emphasize that reservoir water quality mirrors canal inflow water quality. The model utilized a conservative approach which assumed no absorption or settling of constituents; the ramifications of which are largely constrained to an overestimation of metals within the reservoir, though they are still below the regulatory limits. The detailed water quality model results are provided in Appendix A.

Table 8. Mass balance model nonmetals concentration results, base and expanded footprints for model period (1928-2010)

Constituent (mg/L)	Base Footprint			Expanded Footprint		
	Min	Max	Average	Min	Max	Average
Nitrite (as N)	0.005018	0.007032	0.007019	0.004958	0.007032	0.007017
Phosphorus (P)-Total	0.005192	0.014702	0.014641	0.005063	0.014702	0.014634
Ammonia, Total (as N)	0.020583	0.023047	0.023031	0.020388	0.023047	0.023028
Nitrate (as N)	0.024739	0.038936	0.038845	0.024404	0.038936	0.038834
Nitrate and Nitrite (as N)	0.027390	0.039766	0.039686	0.027049	0.039766	0.039676
Total Kjeldahl Nitrogen	0.134422	0.175000	0.174738	0.132930	0.175000	0.174703
Total Nitrogen	0.151031	0.258974	0.258000	0.148796	0.258974	0.258198
Chloride (Cl)	0.810638	0.848546	0.810883	0.810638	0.841760	0.810858
Hydroxide (OH)	1.839305	2.500000	2.495740	1.817939	2.500000	2.495192
Carbonate (CO_3)	2.083106	3.287234	3.279470	2.054823	3.287234	3.278546
Sulfate (SO_4)	19.945745	26.606461	19.988691	19.945745	26.442701	19.991546
Alkalinity, Total (as $CaCO_3$)	113.070213	134.363091	113.207502	113.070213	133.425498	113.213711
Hardness (as $CaCO_3$)	116.978723	163.028206	117.275635	116.978723	162.071703	117.296614
Bicarbonate (HCO_3)	136.872340	163.206413	137.042133	136.872340	162.071763	137.049988
TDS (Calculated)	137.468085	166.074759	137.652531	137.468085	164.936385	137.661728

Table 9. Mass balance model metals concentration results, base and expanded footprints for model period (1928-2010)

Constituent (mg/L)	Base Footprint			Expanded Footprint		
	Min	Max	Average	Min	Max	Average
Aluminum (Al)-Total	0.079987	0.229179	0.228217	0.077979	0.229179	0.228113
Antimony (Sb)-Total	0.000109	0.000264	0.000263	0.000106	0.000264	0.000263
Arsenic (As)-Total	0.000825	0.000888	0.000825	0.000825	0.000881	0.000825
Barium (Ba)-Total	0.113048	0.115286	0.115271	0.112079	0.115286	0.115263
Beryllium (Be)-Total	0.000038	0.000179	0.000178	0.000036	0.000179	0.000178
Bismuth (Bi) total	0.000027	0.000250	0.000249	0.000025	0.000250	0.000248
Boron (B)-Total	0.010091	0.020107	0.020043	0.009916	0.020107	0.020035
Cadmium (Cd)-Total	0.000012	0.000035	0.000034	0.000011	0.000035	0.000034
Chromium (Cr)-Total	0.000209	0.000952	0.000947	0.000201	0.000952	0.000946
Cobalt (Co)-Total	0.000070	0.000363	0.000361	0.000067	0.000363	0.000360
Copper (Cu)-Total	0.000911	0.000930	0.000911	0.000911	0.000923	0.000911
Iron (Fe)-Total	0.093240	0.187393	0.186786	0.091613	0.187393	0.186718
Lead (Pb)-Total	0.000053	0.000134	0.000133	0.000052	0.000134	0.000133
Lithium (Li)-Total	0.004601	0.005286	0.005281	0.004556	0.005286	0.005281
Magnesium (Mg)-Total	10.487500	13.054574	10.504052	10.487500	12.967943	10.504986
Manganese (Mn)-Total	0.013929	0.046676	0.014140	0.013929	0.046578	0.014159
Mercury (Hg)-Total	0.000052	0.000141	0.000053	0.000052	0.000140	0.000053
Molybdenum (Mo)-Total	0.001071	0.001186	0.001072	0.001071	0.001177	0.001072
Nickel (Ni)-Total	0.000579	0.000880	0.000581	0.000579	0.000875	0.000581
Potassium (K)-Total	0.937500	1.070850	0.938360	0.937500	1.063052	0.938385
Selenium (Se)-Total	0.000268	0.000275	0.000275	0.000266	0.000275	0.000275
Silicon – (Si)total	1.440500	1.509377	1.440944	1.440500	1.497319	1.440901
Silver (Ag)-Total	0.000006	0.000062	0.000062	0.000005	0.000062	0.000062
Sodium (Na)-Total	6.250000	8.896082	6.267061	6.250000	8.845082	6.268294
Strontium (Sr) total	0.122900	0.131258	0.122954	0.122900	0.130230	0.122952
Sulfur (S) total	7.935000	8.863276	7.940985	7.935000	8.797160	7.941078
Thallium (Tl)-Total	0.000006	0.000032	0.000032	0.000005	0.000032	0.000032
Tin (Sn)-Total	0.000054	0.000500	0.000497	0.000050	0.000500	0.000497
Titanium (Ti)-Total	0.001879	0.006089	0.006062	0.001826	0.006089	0.006059
Uranium (U)-Total	0.000543	0.000736	0.000544	0.000543	0.000732	0.000544
Vanadium (V)-Total	0.000871	0.001165	0.000873	0.000871	0.001157	0.000873
Zinc (Zn)-Total	0.001768	0.003768	0.003755	0.001735	0.003768	0.003754

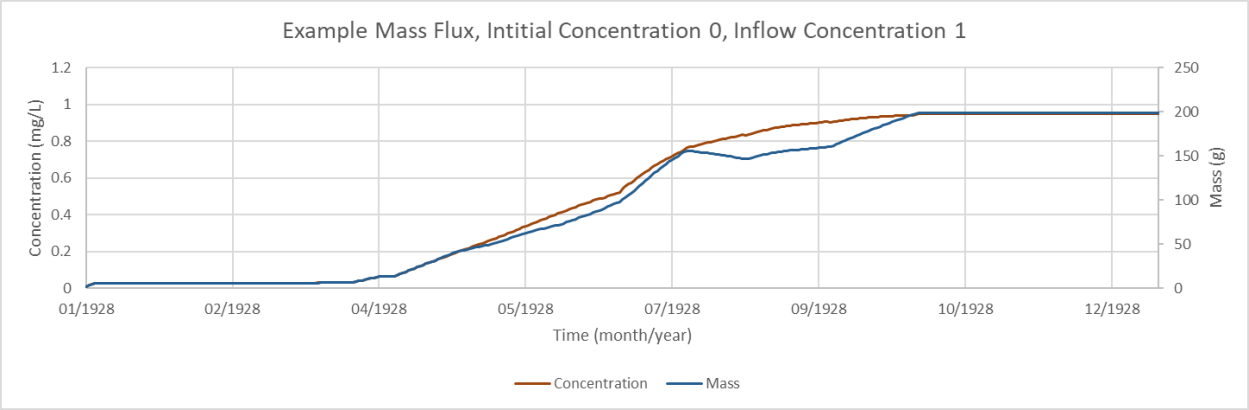


Figure 21. Example of mass flux, 1928-1929.

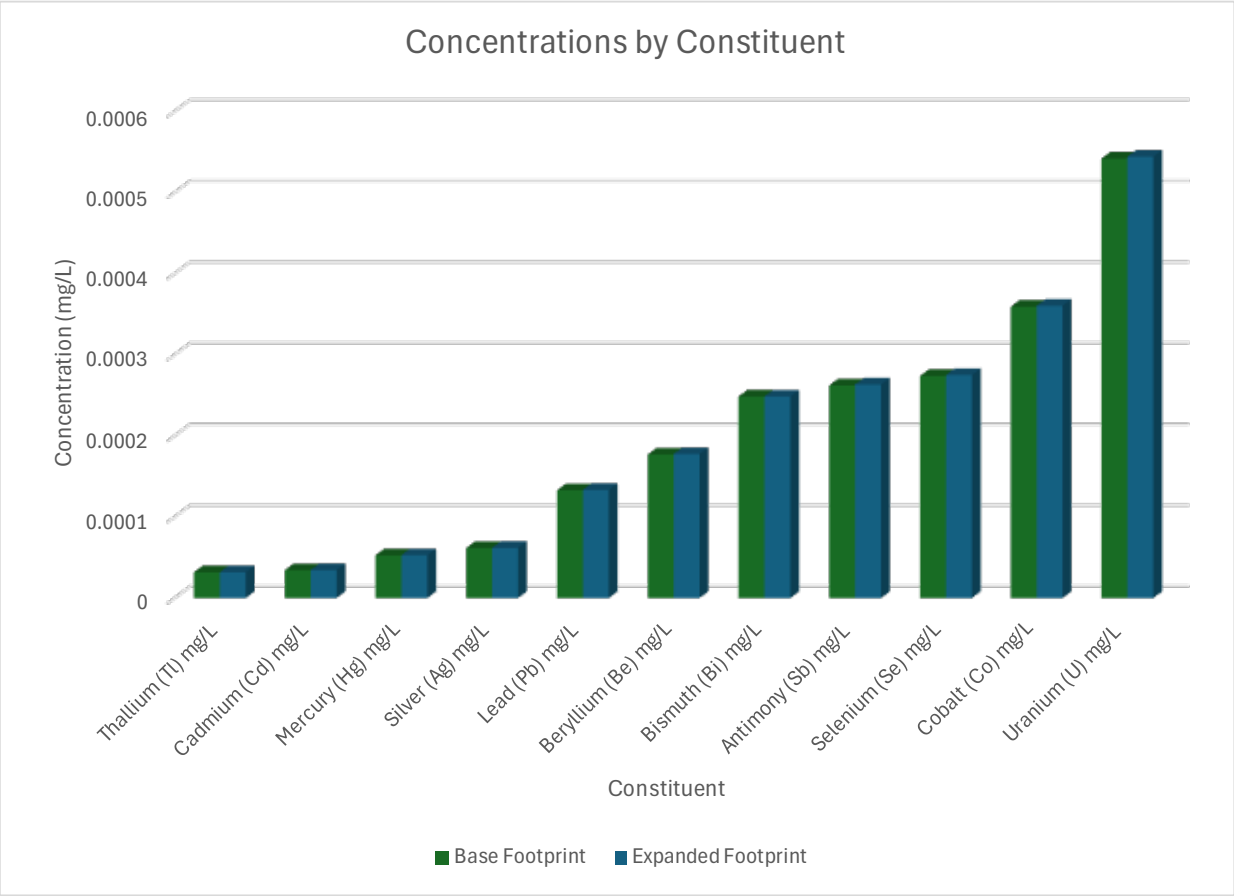


Figure 22. **Average modeled constituent concentrations, base and expanded footprint.**

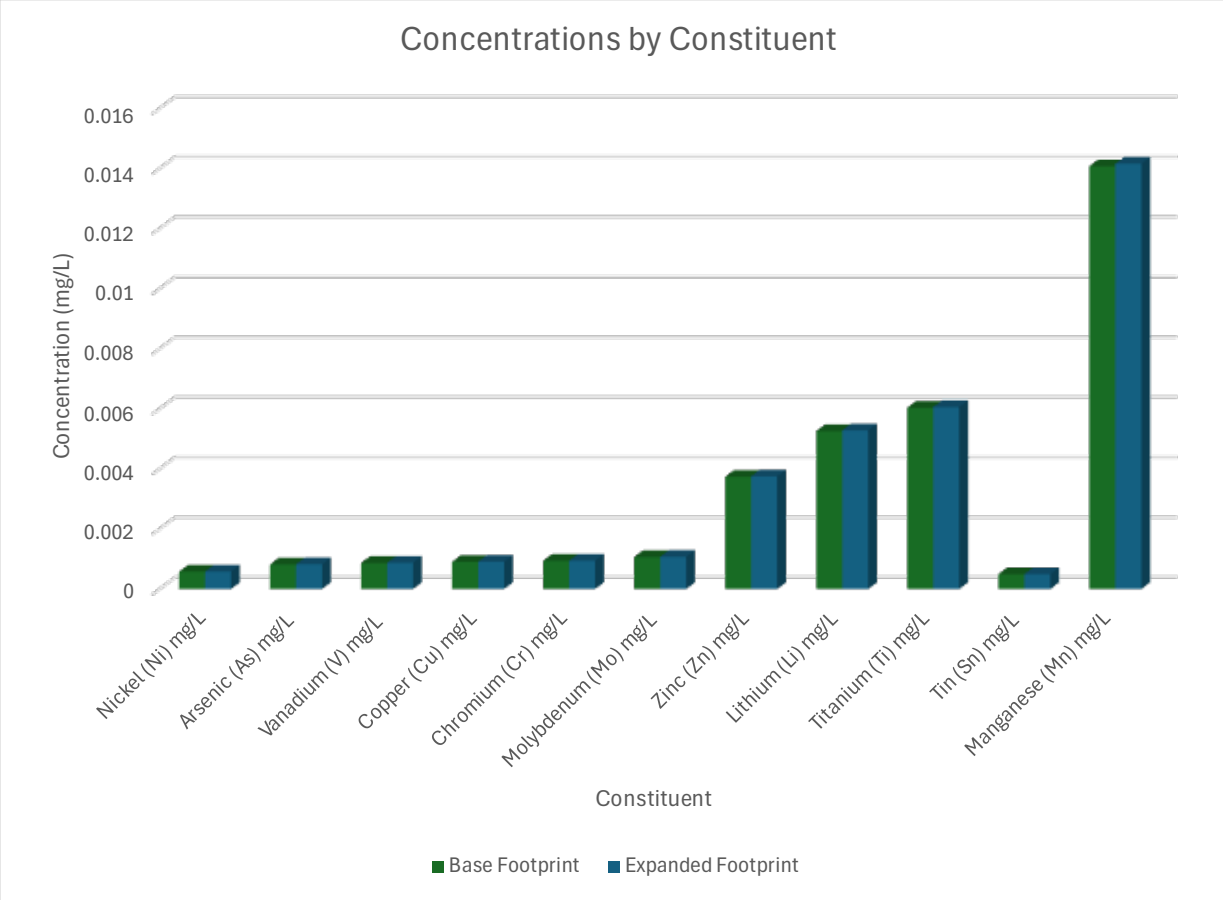


Figure 23. **Average modeled constituent concentrations, base and expanded footprint.**

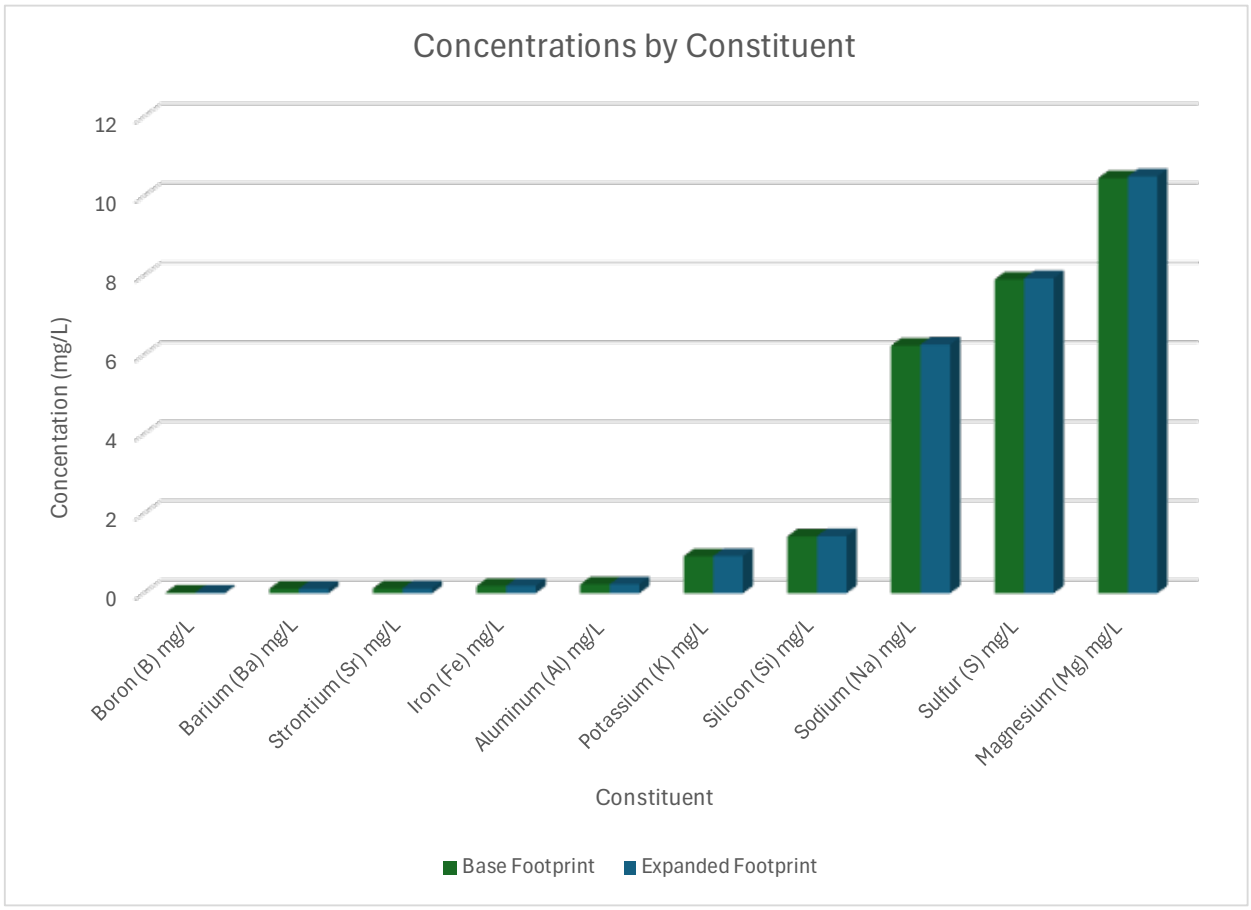


Figure 24. **Average modeled constituent concentrations, base and expanded footprint.**

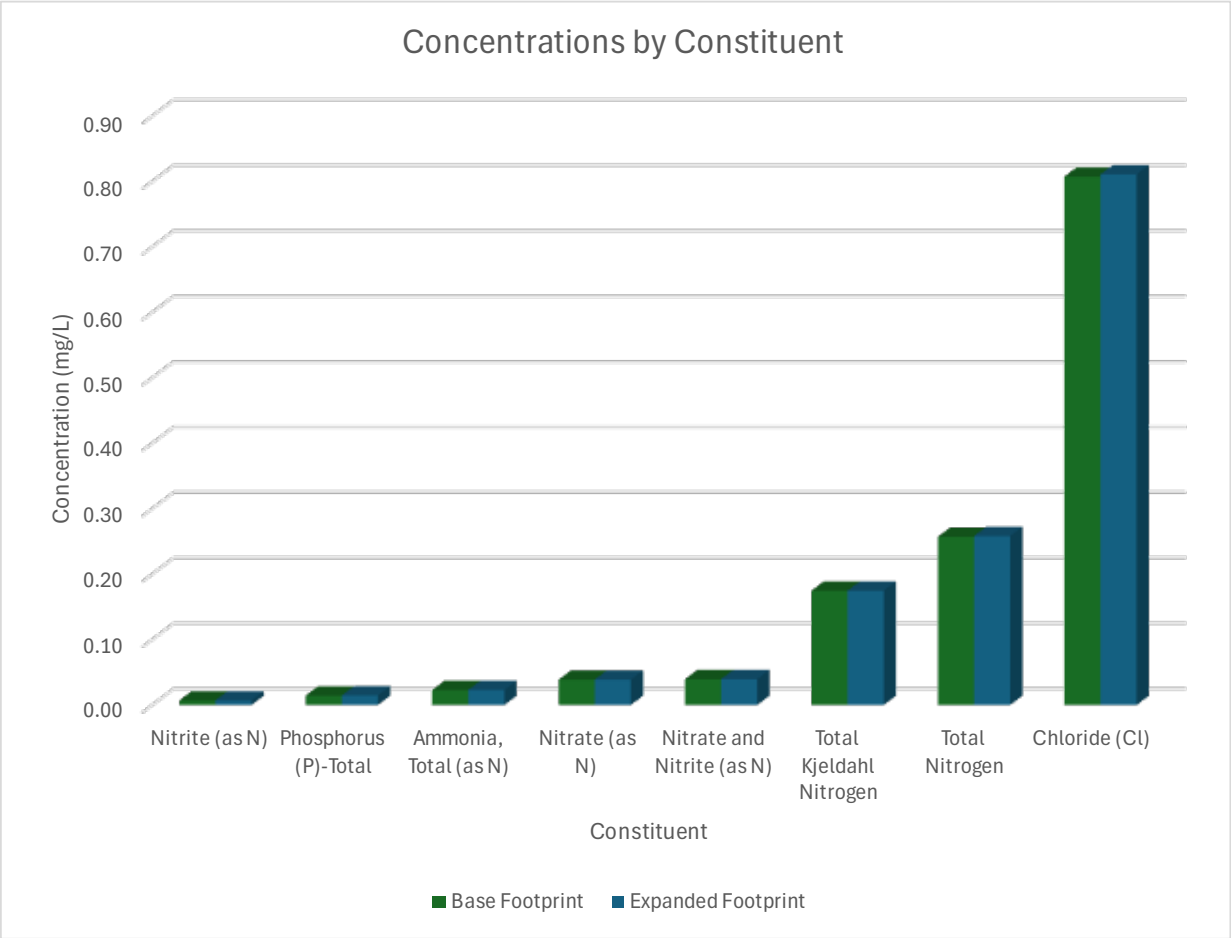


Figure 25. **Average modeled constituent concentrations, base and expanded footprint.**

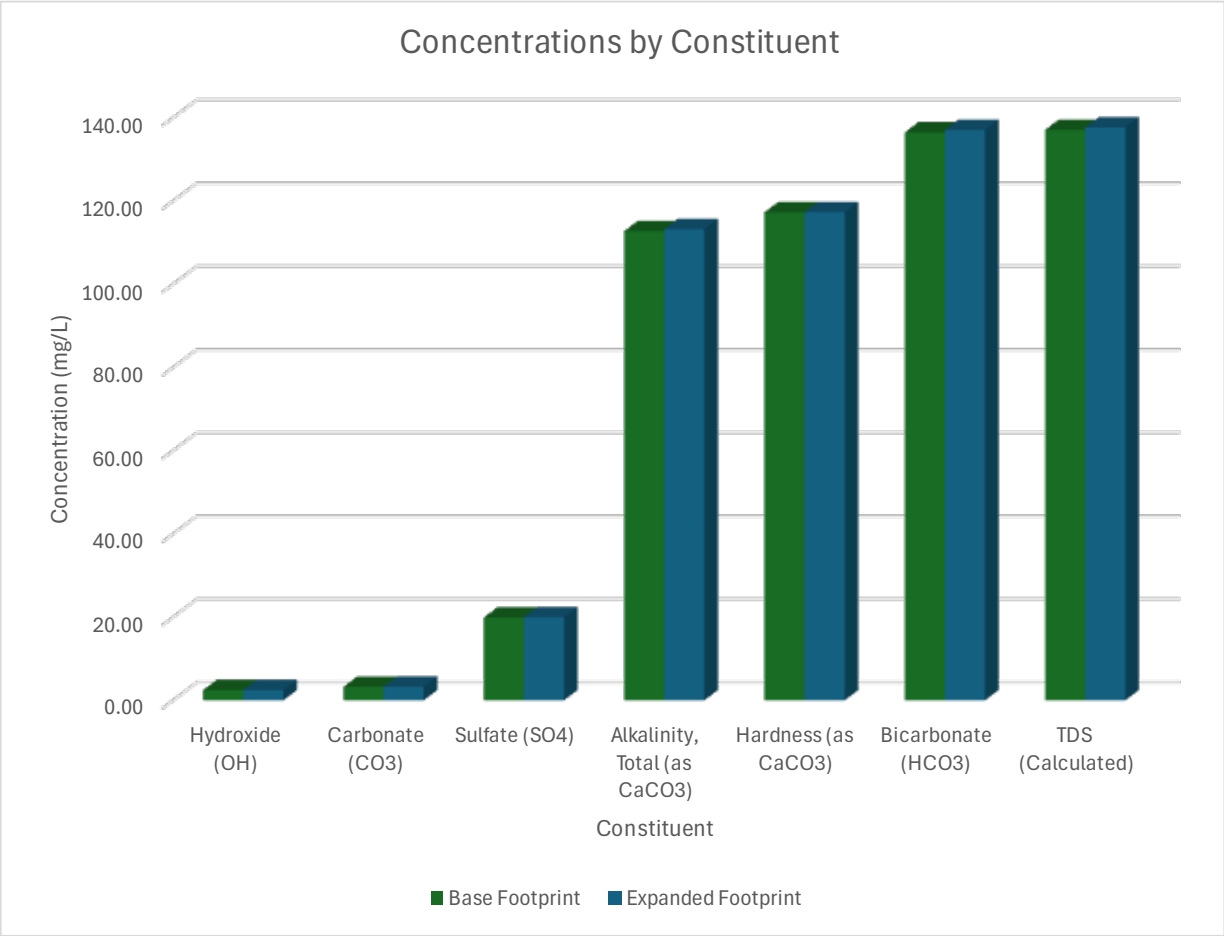


Figure 26. **Average modeled constituent concentrations, base and expanded footprint.**

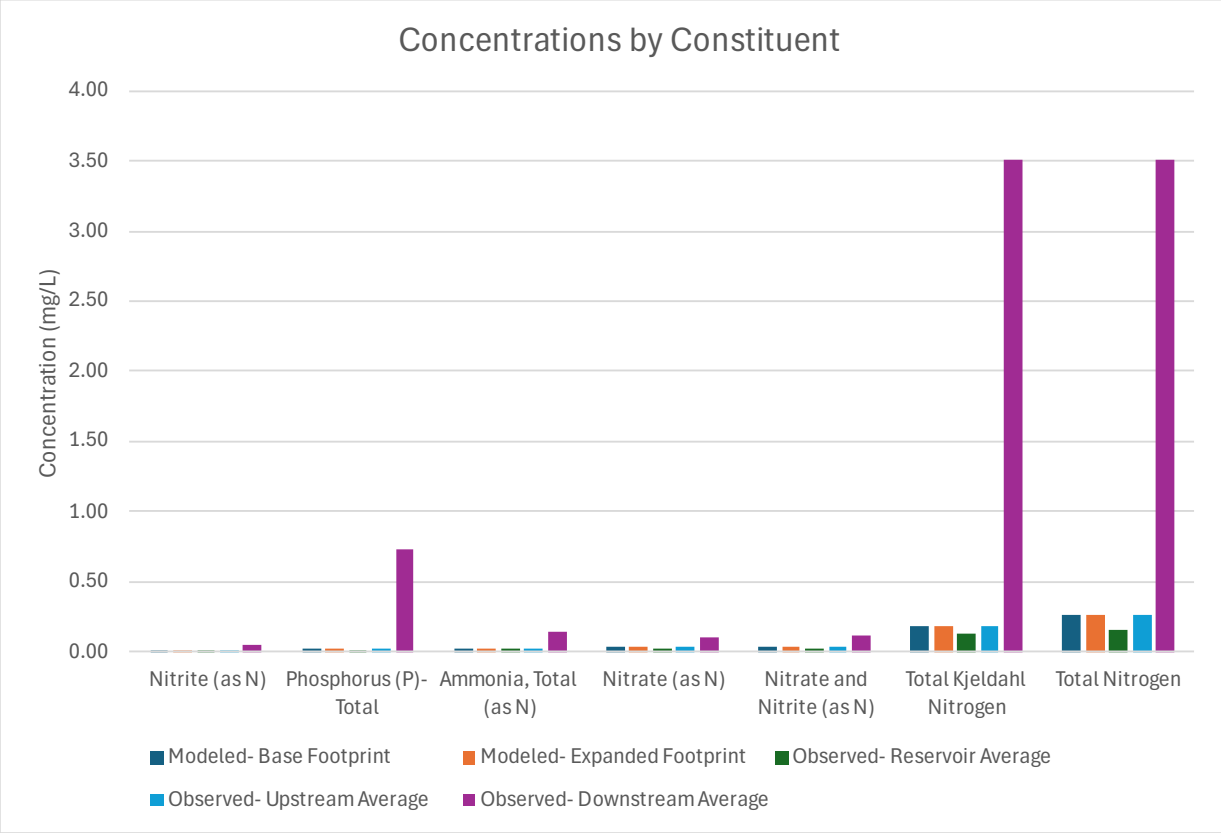


Figure 27. Modeled and observed concentrations (Base and Expanded footprints are simulated, Reservoir, Upstream, and Downstream averages are observed).

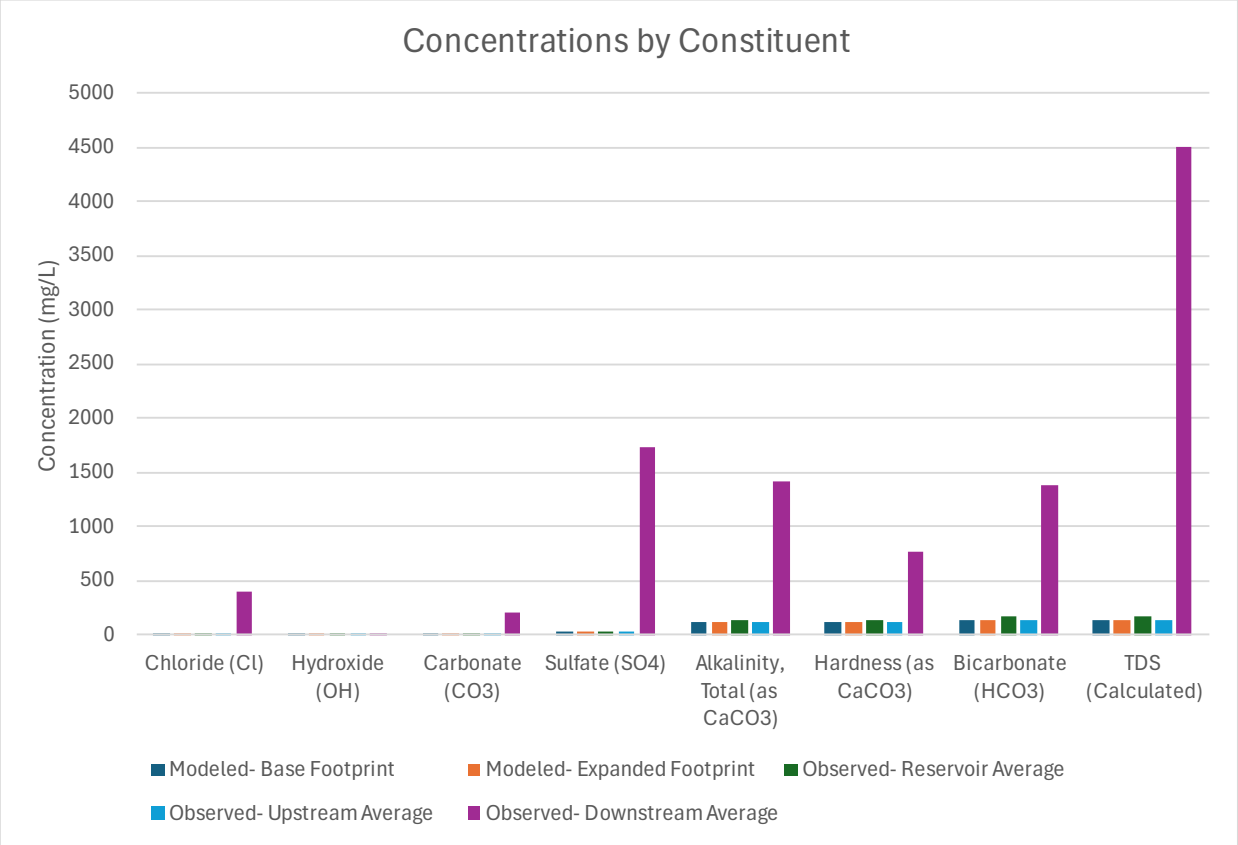


Figure 28. **Modeled and observed concentrations (Base and Expanded footprints are simulated, Reservoir, Upstream, and Downstream averages are observed).**

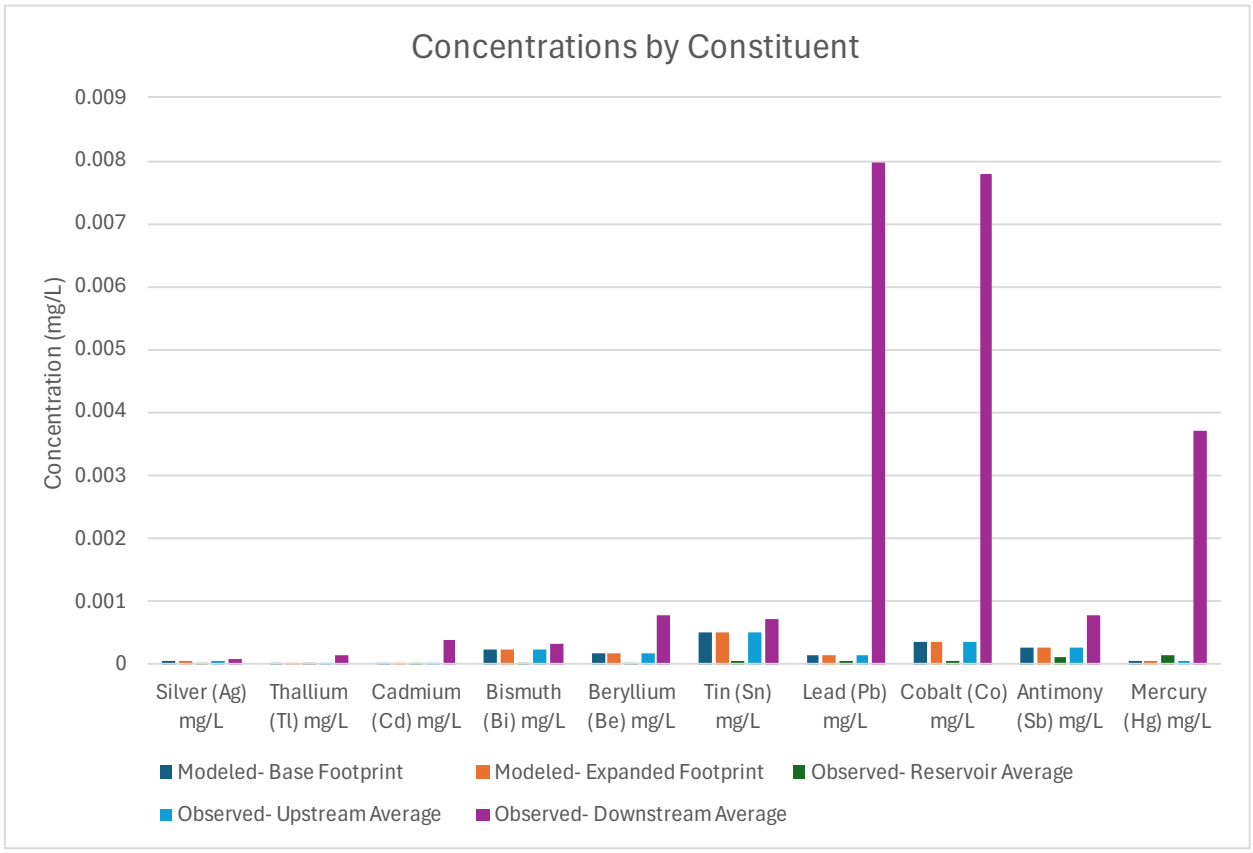


Figure 29. **Modeled and observed concentrations (Base and Expanded footprints are simulated, Reservoir, Upstream, and Downstream averages are observed).**

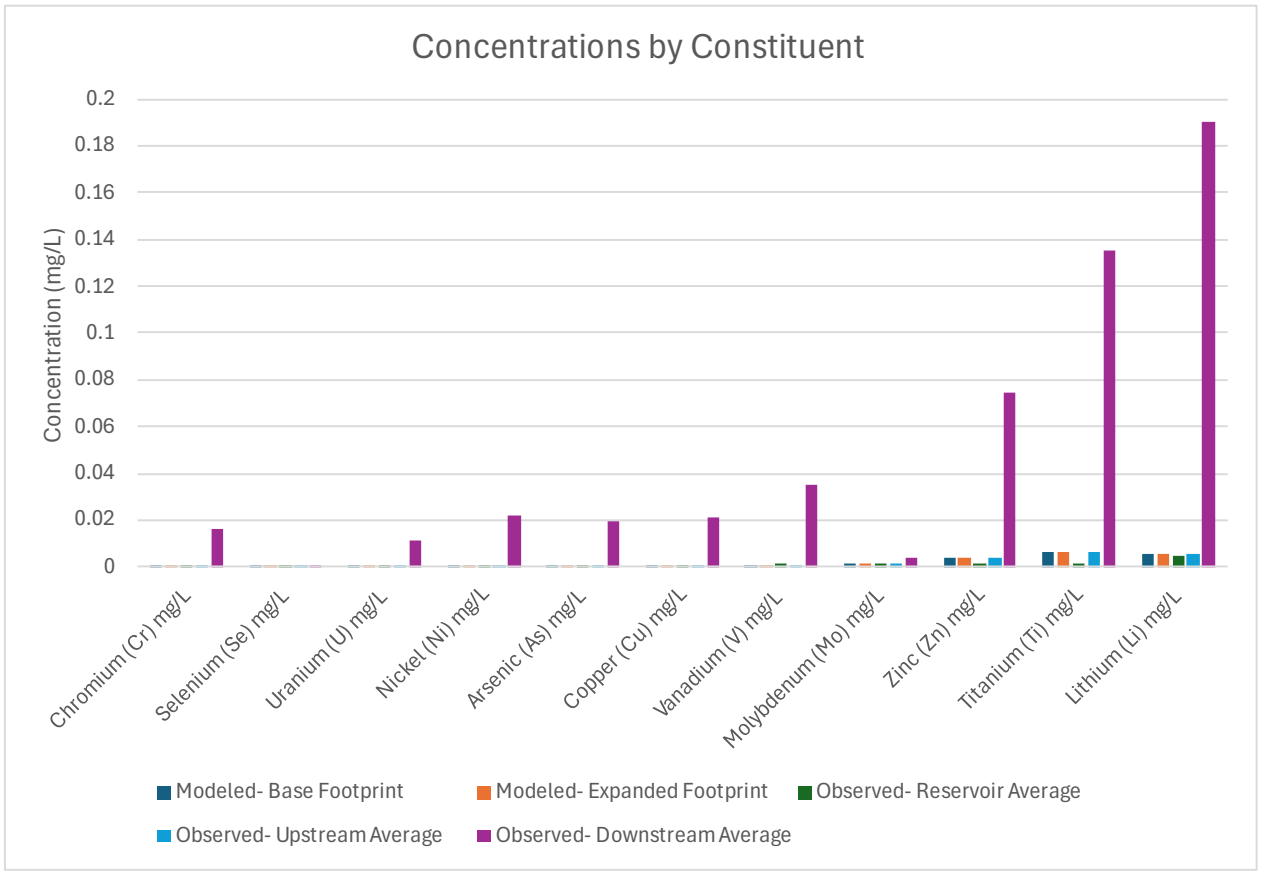


Figure 30. **Modeled and observed concentrations (Base and Expanded footprints are simulated, Reservoir, Upstream, and Downstream averages are observed).**

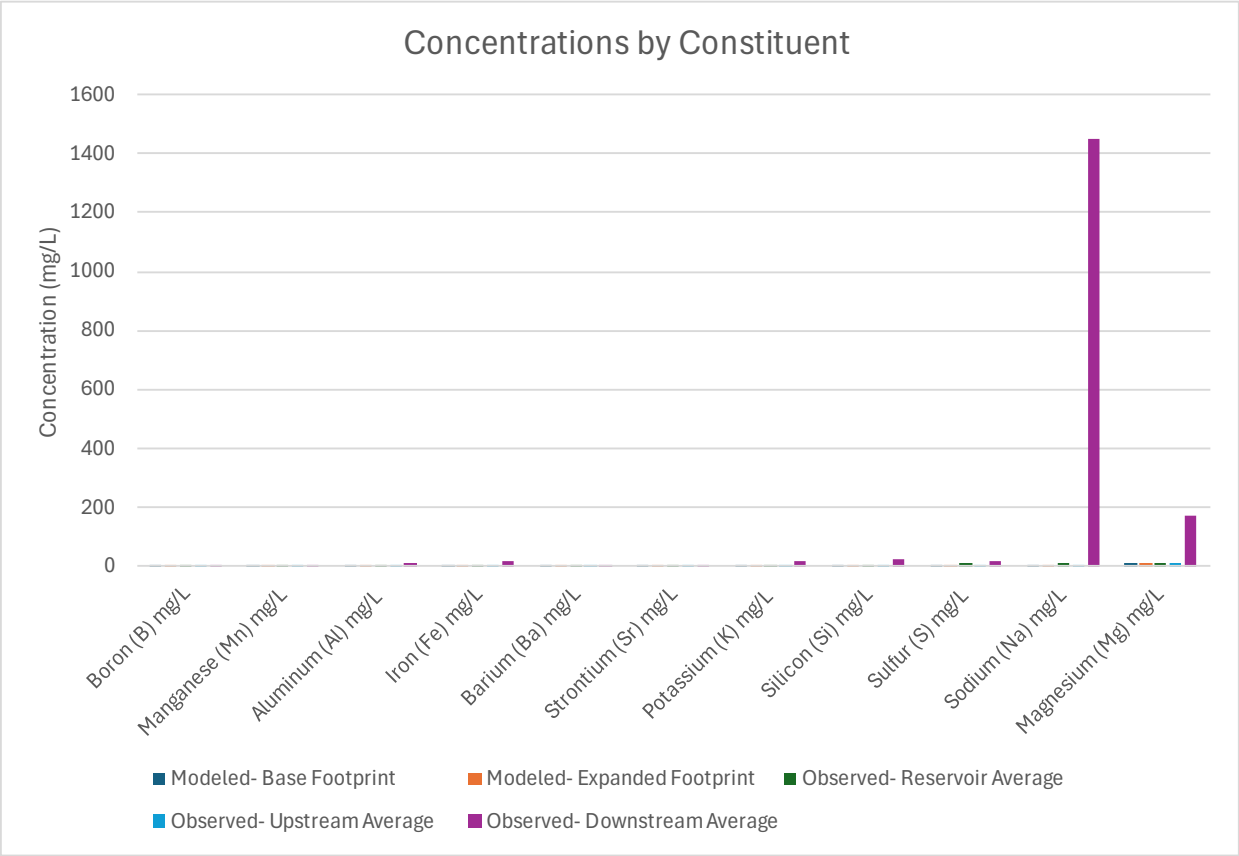


Figure 31. **Modeled and observed concentrations (Base and Expanded footprints are simulated, Reservoir, Upstream, and Downstream averages are observed).**

Using the pesticide data described in Section 2.3, the model was used to assess pesticide concentration in both the base and expanded reservoir footprints, and the model results are shown on **Figure 32** and **Figure 33**, respectively.

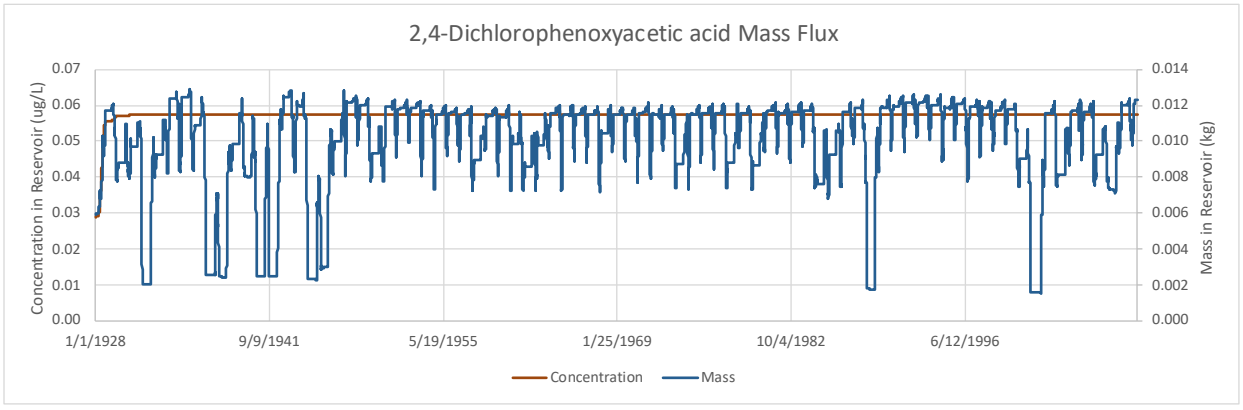


Figure 32. Mass and concentration flux for 2,4-Dichlorophenoxyacetic acid in reservoir base footprint.

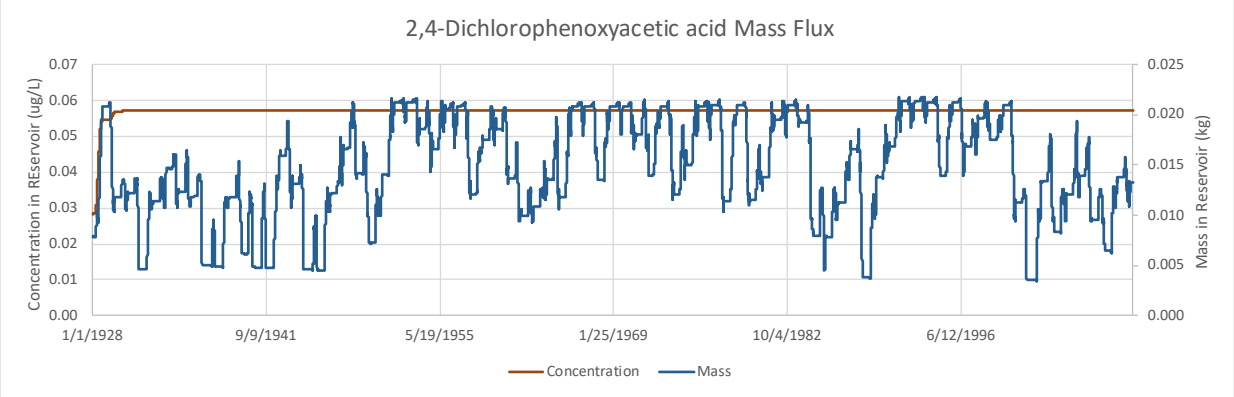


Figure 33. Mass and concentration flux for 2,4 Dichlorophenoxyacetic acid in reservoir expanded footprint.

4.0 Conclusions

The mass balance models developed for this task account for the total-in and total-out fluxes computed by the H&H Model for both the current and expanded reservoir footprints. The model results show that change in conditions of the reservoir system will result in minor change in load and concentration of assessed water quality parameters within the system. The modeling indicates that the Chin Reservoir system has sufficient inflow to dictate the concentration of the reservoir. Even though the initial concentrations (e.g., at commissioning of the Reservoir Expansion Area) might differ from the inflow concentrations, the reservoir would mix and equilibrate to mirror the inflow concentration in approximately one year. **Table 10** shows the model results compared to the published guidelines, which the model only exceeded was in Aluminum, Iron and in the Project Case in Manganese. Of these constituents, both the Iron and the Manganese exceedances were only for Aesthetic limit, while the Project Case Manganese exceeded the CCME Guidelines Freshwater Aquatics – Chronic. While the modeled Mercury values do exceed some of the regulatory limits, this is likely primarily due to the use of the one-half detection limit calculation method used when data was simply noted as being below the detection limit, rather than a constituent of concern. There are overall very few differences in regulatory exceedance between the base and project cases. This indicates that there will be no negative health-based water quality changes upon the expansion of the reservoir. Because the observed inflow and reservoir data did not temporally overlap, no adsorption rates were calculated for the constituents, as that would have simply increased uncertainty in the model; instead, a conservative modeling approach was used to estimate the worst-case scenario for the reservoir. Resultingly, the model results compare closer to those of the inflows than they do of the reservoir itself. Additionally, the concentrations of water quality constituents in the inflow canal show no significant increasing trends (see INTERA's Technical Memorandum entitled "Chin Reservoir Historical Canal Inflow and Modeled Arsenic Trend Analysis", which is provided with the submittal.).

Table 10. Comparison of model results to published guidelines.

		Guidelines										Base Case		Expanded Case	
		Alberta Surface Water Quality Guidelines					CCME Guidelines				Health Canada	Predicted Concentration		Predicted Concentration	
Parameter	Units	Freshwater Aquatics - Chronic [1a]	Freshwater Aquatics - Acute [1b]	Irrigation [1c]	Livestock [1d]	Recreation and Aesthetics [1e]	Freshwater Aquatics - Chronic [1f]	Freshwater Aquatics - Acute [1g]	Irrigation [1h]	Livestock [1d]	Drinking Water	Maximum	Average	Maximum	Average
Anions and Nutrients															
Alkalinity, Total (as CaCO3)	mg/L	<20	-	-	-	-	-	-	-	-		134.363	113.208	133.426	113.214
Ammonia, Total (as N)	mg/L	0.073	-	-	-	-	**0.089**	-	-	-	None required	0.02305	0.02303	0.02305	0.02303
Bicarbonate (HCO3)	mg/L	-	-	-	-	-	-	-	-	-		163.206	137.042	162.072	137.050
Carbonate (CO3)	mg/L	-	-	-	-	-	-	-	-	-		3.28723	3.27947	3.28723	3.27855
Chloride (Cl)	mg/L	120	640	100	-	-	**120**	640	100	-	AO: 250	0.84855	0.81088	0.84176	0.81086
Hardness (as CaCO3)	mg/L	-	-	-	-	-	-	-	-	-	None required	163.028	117.276	162.072	117.297
Hydroxide (OH)	mg/L	-	-	-	-	-	-	-	-	-		2.50000	2.49574	2.50000	2.49519
Nitrate and Nitrite (as N)	mg/L	-	-	-	100	-	-	-	100	100		0.03977	0.03969	0.03977	0.03968
Nitrate (as N)	mg/L	3	124	-	-	-	**13**	550	-	-	10	0.03894	0.03884	0.03894	0.03883
Nitrite (as N)	mg/L	0.02	0.06	-	10	-	**0.06**	-	-	10	1	0.00703	0.00702	0.00703	0.00702
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-		0.17500	0.17474	0.17500	0.17470
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	-		0.25897	0.25800	0.25897	0.25820
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-		0.01470	0.01464	0.01470	0.01463
TDS (Calculated)	mg/L	-	-	500	3000	-	-	-	-	3000	AO: 500	166.075	137.653	164.936	137.662
Sulfate (SO4)	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	AO: 500	26.6065	19.9887	26.4427	19.9916
Pesticides															
2,4-Dichlorophenoxyacetic acid	µg/L	0.4		-	-	-	-	-	-	-	100	0.05724	0.05705	0.05724	0.05703
Total Metals															
Aluminum (Al)-Total	mg/L	-	-	5	5	-	**0.1**	-	5	5	2.9, OG: 0.1	**0.22918**	**0.22822**	**0.22918**	**0.22811**
Antimony (Sb)-Total	mg/L	-	-	-	-	-	-	-	-	-	0.006	0.00026	0.00026	0.00026	0.00026
Arsenic (As)-Total	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.01 ALARA	0.00089	0.00083	0.00088	0.00083
Barium (Ba)-Total	mg/L	-	-	-	-	-	-	-	-	-	2	0.11529	0.11527	0.11529	0.11526
Beryllium (Be)-Total	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1		0.00018	0.00018	0.00018	0.00018
Bismuth (Bi)	mg/L											0.00025	0.00025	0.00025	0.00025
Boron (B)-Total	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	5	0.02011	0.02004	0.02011	0.02004
Cadmium (Cd)-Total	mg/L	0.00024	0.0035	0.0082	0.08	-	**0.00024**	0.0035	0.0051	0.08	0.007	0.000035	0.000034	0.000035	0.000034
Chromium (Cr)-Total	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.05	0.00095	0.00095	0.00095	0.00095
Cobalt (Co)-Total	mg/L	0.0013	-	0.05	1	-	-	-	0.05	1		0.00036	0.00036	0.00036	0.00036
Copper (Cu)-Total	mg/L	0.007	0.026	0.2	0.5	-	**0.00363**	-	0.2	0.5	2, AO 1	0.00093	0.00091	0.00092	0.00091
Iron (Fe)-Total	mg/L	-	-	5	-	-	**0.3**	-	5	-	AO 0.1	0.18739	0.18679	0.18739	0.18672
Lead (Pb)-Total	mg/L	0.006	-	0.2	0.1	-	**0.006**	-	0.2	0.1	0.005 ALARA	0.00013	0.00013	0.00013	0.00013
Lithium (Li)-Total	mg/L	-	-	2.5	-	-	-	-	2.5	-		0.00529	0.00528	0.00529	0.00528
Magnesium (Mg)-Total	mg/L	-	-	-	-	-	-	-	-	-	None required	13.0546	10.5041	12.9679	10.5050

Manganese (Mn)-Total	mg/L	-	-	0.2	-	-	**0.13**	10.332	0.2	-	0.12, AO: 0.02	0.04668	0.01414	0.04658	0.01416
Mercury (Hg)-Total	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	1	**0.14079**	**0.05275**	**0.14040**	**0.05280**
Molybdenum (Mo)-Total	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5		0.00119	0.00107	0.00118	0.00107
Nickel (Ni)-Total	mg/L	0.08	0.72	0.2	1	-	**0.14**	-	0.2	1		0.00088	0.00058	0.00088	0.00058
Potassium (K)-Total	mg/L	-	-	-	-	-	-	-	-	-		1.07085	0.93836	1.06305	0.93839
Selenium (Se)-Total	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.05	0.00028	0.00027	0.00028	0.00027
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-		1.50938	1.44094	1.49732	1.44090
Silver (Ag)-Total	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	None required	0.000062	0.000062	0.000062	0.000062
Sodium (Na)-Total	mg/L	-	-	-	-	-	-	-	-	-	AO: 200	8.89608	6.26706	8.84508	6.26829
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	7	0.13126	0.12295	0.13023	0.12295
Thallium (Tl)-Total	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-		0.000032	0.000032	0.000032	0.000032
Tin (Sn)-Total	mg/L	-	-	-	-	-	-	-	-	-		0.00050	0.00050	0.00050	0.00050
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-		0.00609	0.00606	0.00609	0.00606
Uranium (U)-Total	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.02	0.00074	0.00054	0.00073	0.00054
Vanadium (V)-Total	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1		0.00116	0.00087	0.00116	0.00087
Zinc (Zn)-Total	mg/L	0.03	-	1	50	-	**0.196**	0.34	5	50	AO: 5	0.00377	0.00375	0.00377	0.00375

Value	(a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
Value	(b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
Value	(c) AB Surface Water Quality Guidelines for Irrigation
Value	(d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
Value	(e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
Value	(f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
Value	(g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
Value	(h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
Value	(i) Guidelines for Canadian Drinking Water Quality
Value	(j) Concentration is less than guidelines

Aluminum guideline is pH dependent (assumed pH >6.5 based on baseline conditions).

Nitrite-N guidelines are chloride dependent (all predicted Cl concentrations are less than 0.2 mg/L).

Ammonia guideline is pH and temperature dependent (assumed pH 9 and temperature 15°C).

Sulphate guidelines are hardness dependent.

Cadmium, cobalt, copper, lead and nickel are hardness dependent (assumed maximum predicted hardness of 165 mg/L).

Manganese guideline is pH (assumed 9) and hardness (assumed maximum predicted hardness of 165 mg/L) dependent.

Zinc guideline is DO (assumed 8 mg/L based on baseline conditions), pH (assumed 9), and hardness (assumed maximum predicted hardness of 165 mg/L) dependent.

Drinking water guidelines are health based Maximum Acceptable Concentration (MAC), unless noted as low as reasonably achievable (ALARA), Aesthetic Objective (AO), or Operational Guidance (OG)

The high concentrations of metals and other constituents found in residual pools of water in the downstream Watercourse 126419, compared with both modeled concentrations and the observed reservoir and upstream values, indicate that the constituent concentrations become elevated through evapo-concentration and limited diluting inflows. The downstream water chemistry is not indicative of potential water quality in the Reservoir Expansion Area as canal inflow dominates the water quality of the reservoir. The limited variation between canal and reservoir water chemistry demonstrates this difference in processes.

Simulation of surface water and groundwater fluxes and associated loadings indicated that the relative contribution from groundwater inflows is a minor source for loadings. To meaningfully affect reservoir water quality, groundwater would need to have significantly higher constituent concentrations. Additionally, the increased pressure from the weight of the additional water will minimize inflow of pore water to the expanded portion of the reservoir, reducing the already small potential influence of groundwater inflow on reservoir water chemistry.

Ultimately, the Chin Reservoir Expansion project is expected to result in similar water quality to that of the existing reservoir. The filling process can be effectively managed in isolation from the existing reservoir, with monitoring and adaptive management undertaken to confirm that effects can be avoided. After the Reservoir Expansion Area has been filled with water and the expanded Chin Reservoir commissioned, inflow concentrations and associated loading will become the primary drivers for water quality. The reservoir will equilibrate to concentrations consistent with these dominant inputs.

5.0 References

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INTERA. 2025b. Adaptive Management Plan for Water Quality Technical Memo, June, 2025.

6.0 Appendices

6.1 Appendix A: Model Results

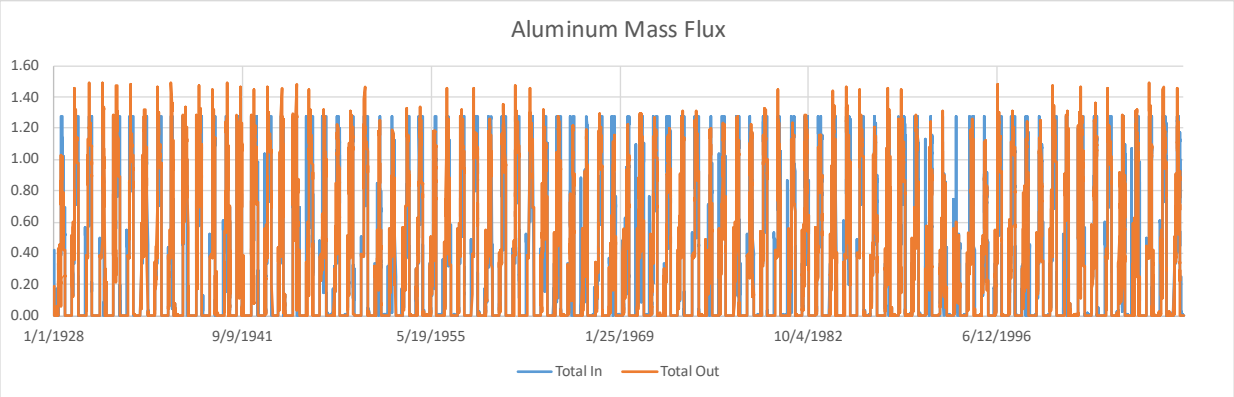


Figure 34. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

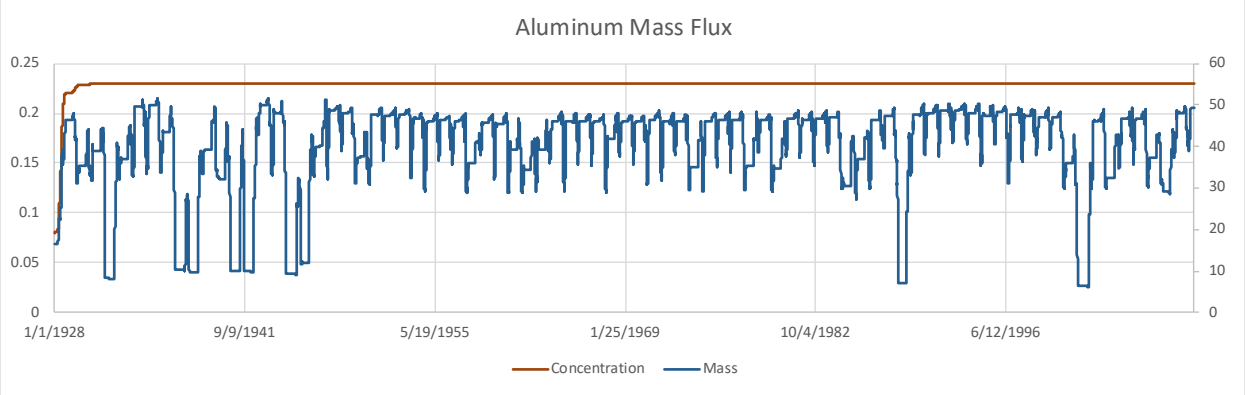


Figure 35. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

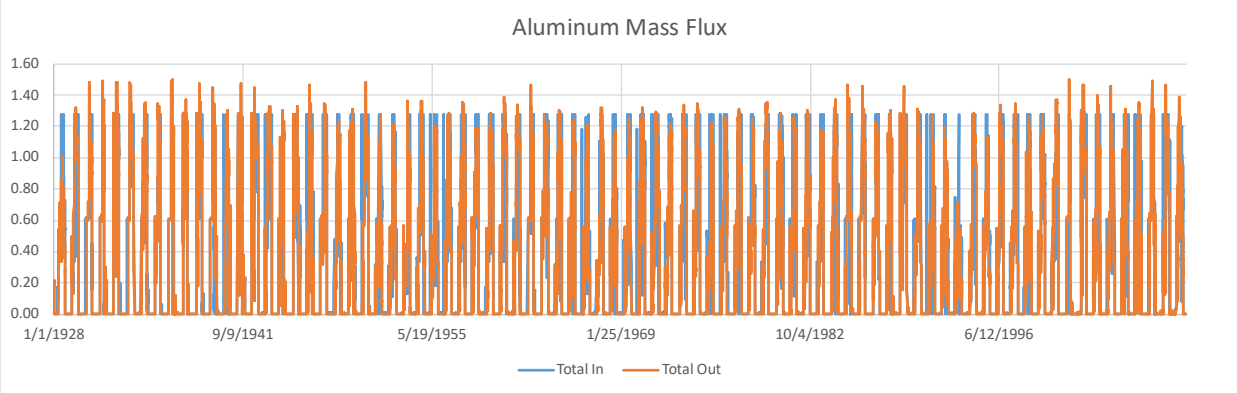


Figure 36. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

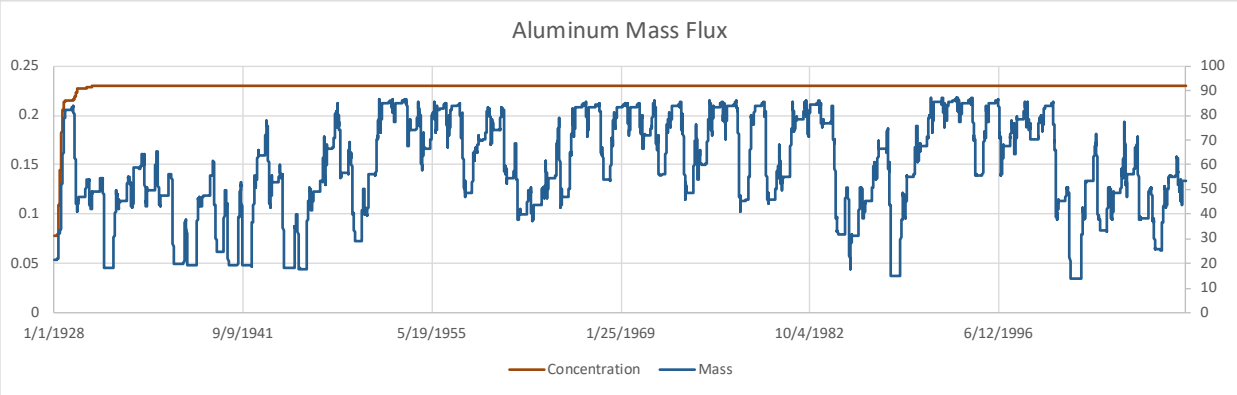


Figure 37. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

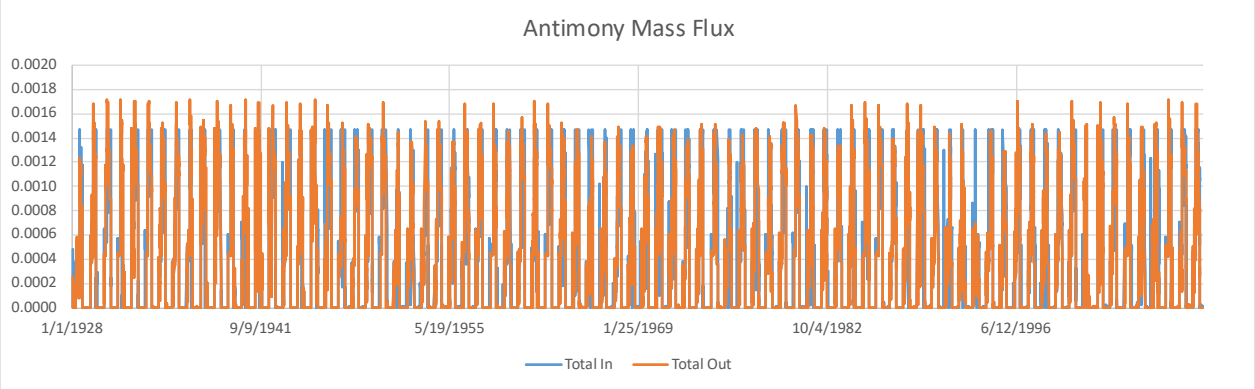


Figure 38. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

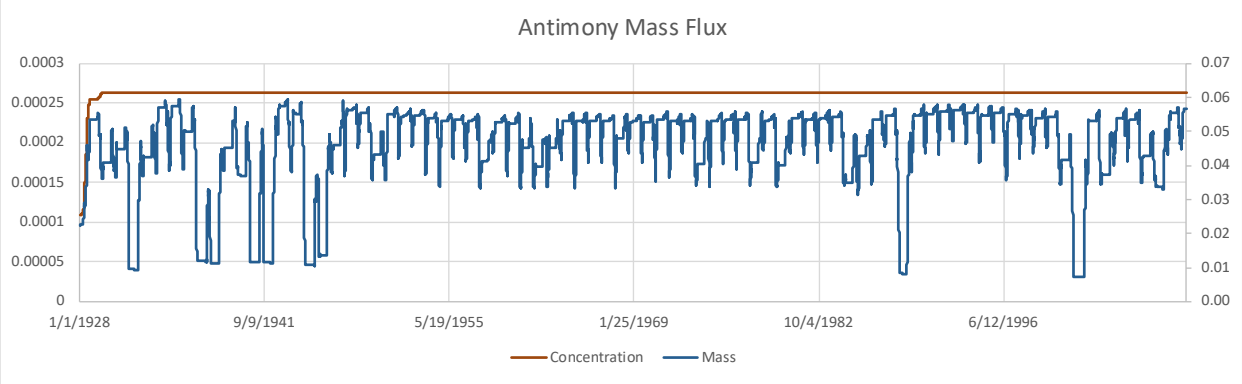


Figure 39. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

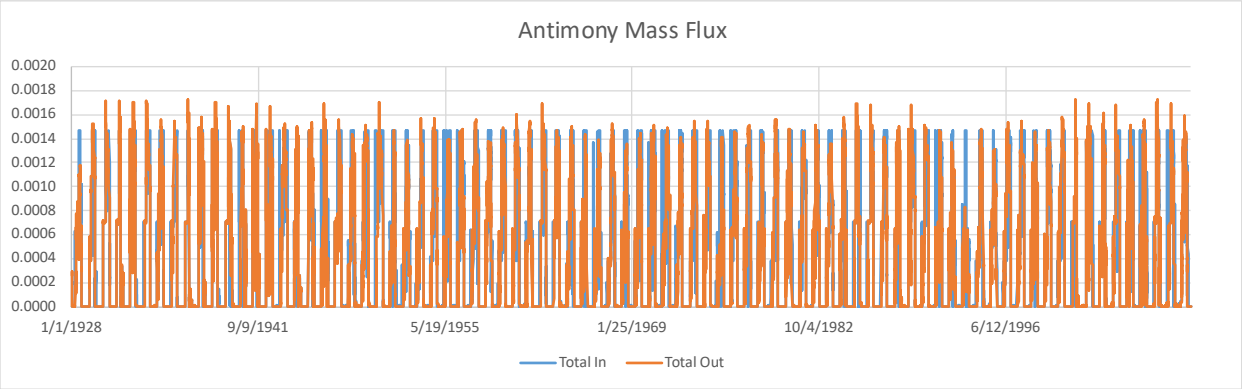


Figure 40. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

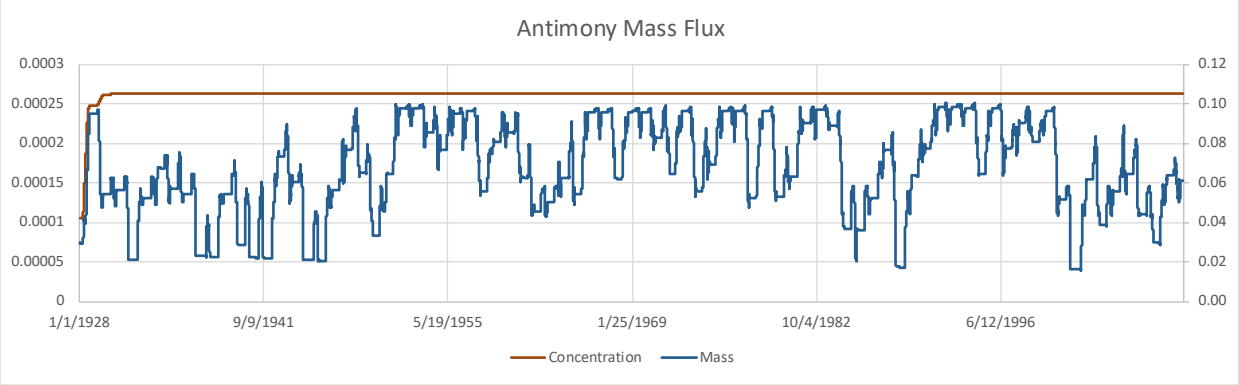


Figure 41. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

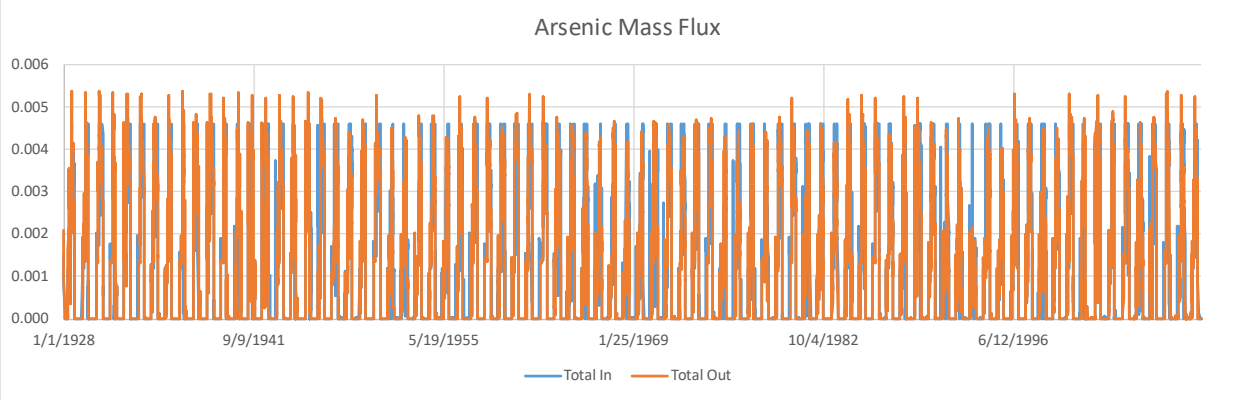


Figure 42. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

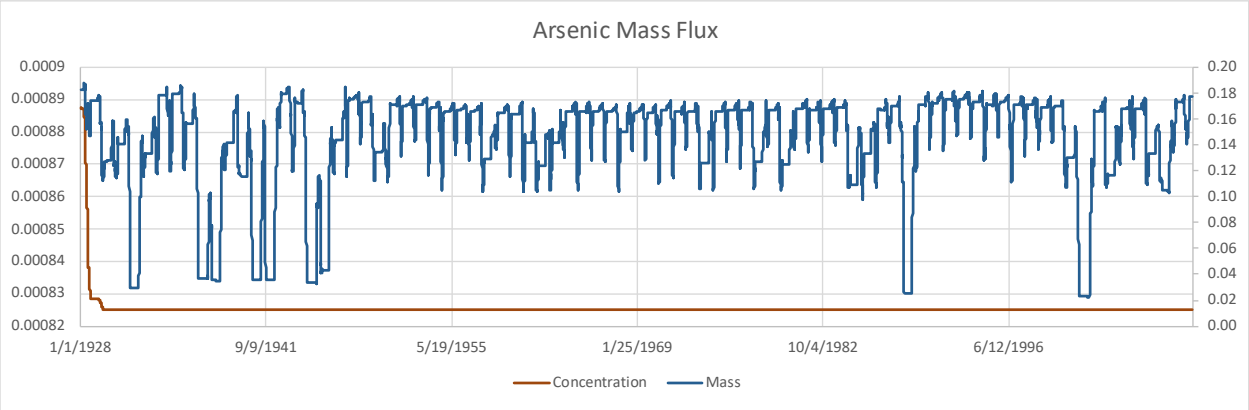


Figure 43. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

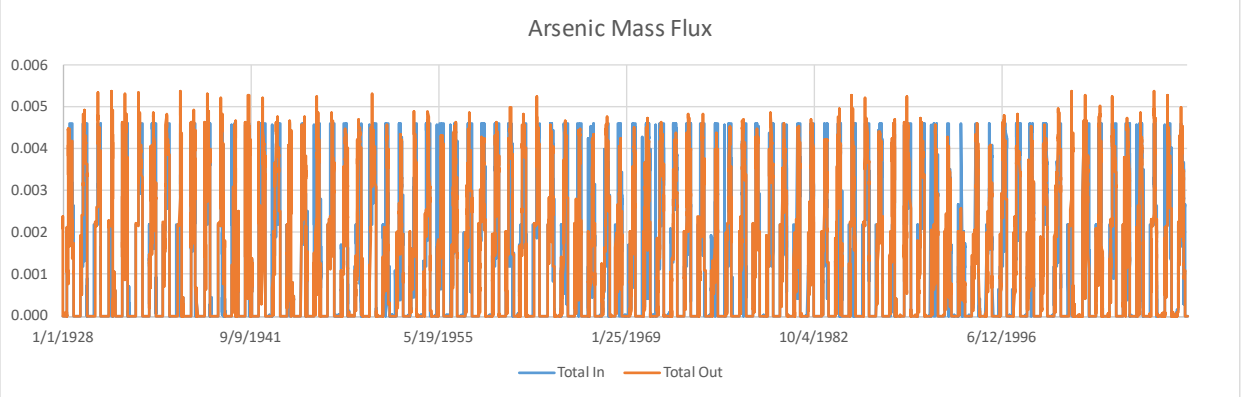


Figure 44. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

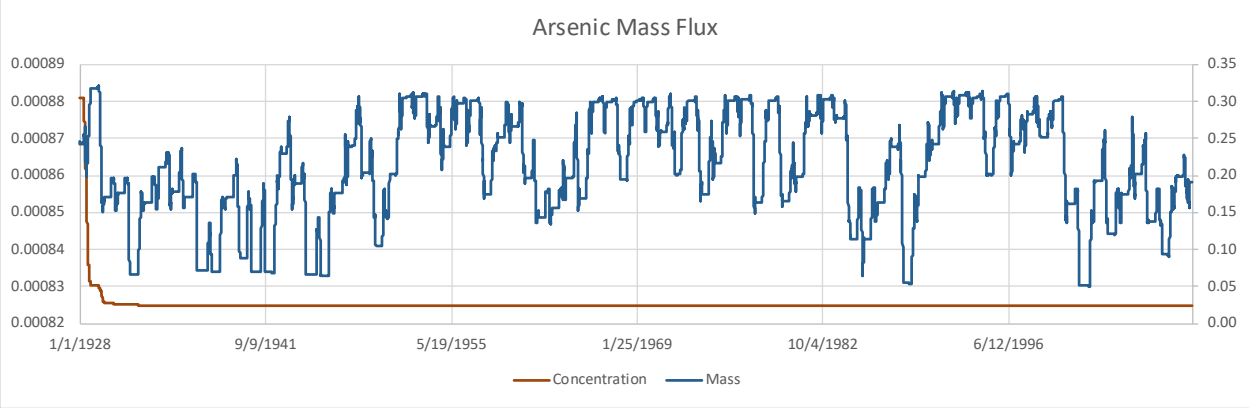


Figure 45. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

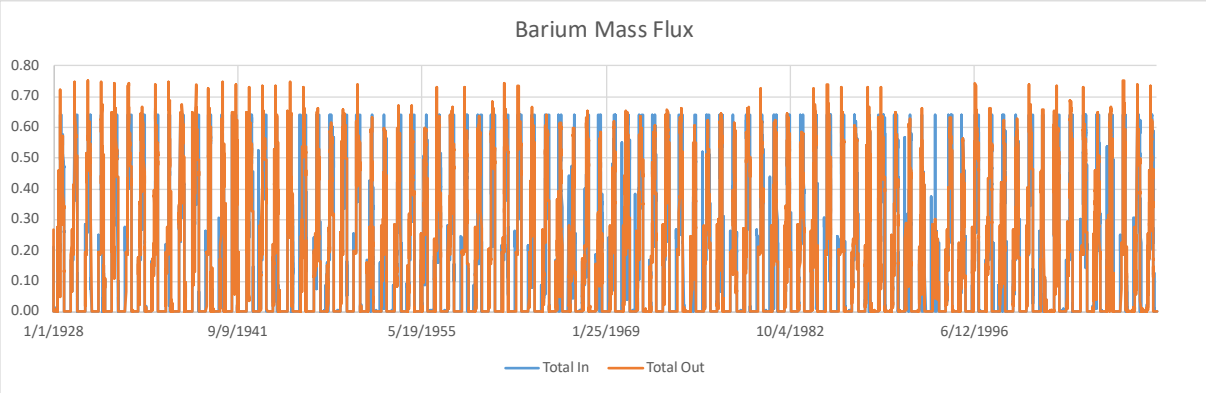


Figure 46. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

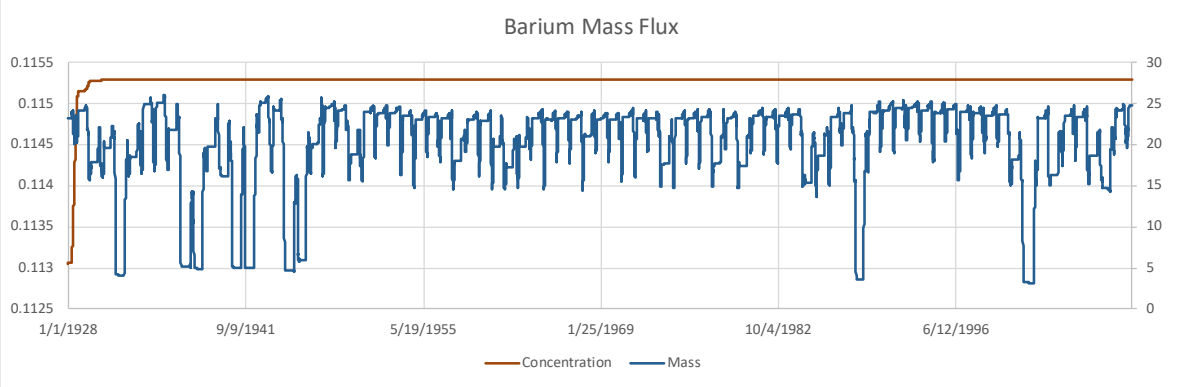


Figure 47. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

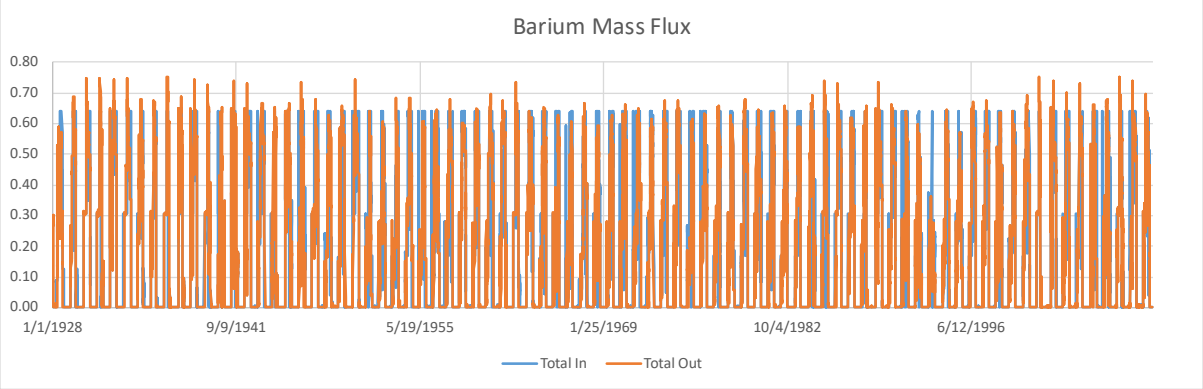


Figure 48. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

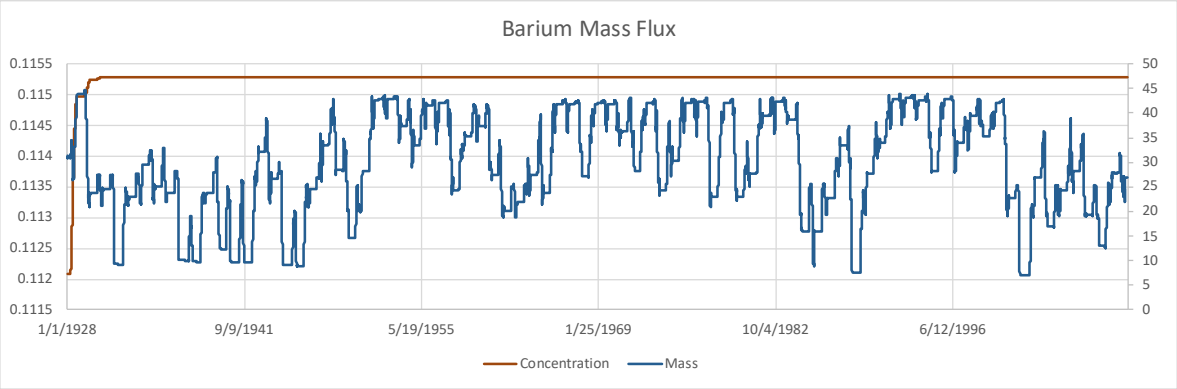


Figure 49. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

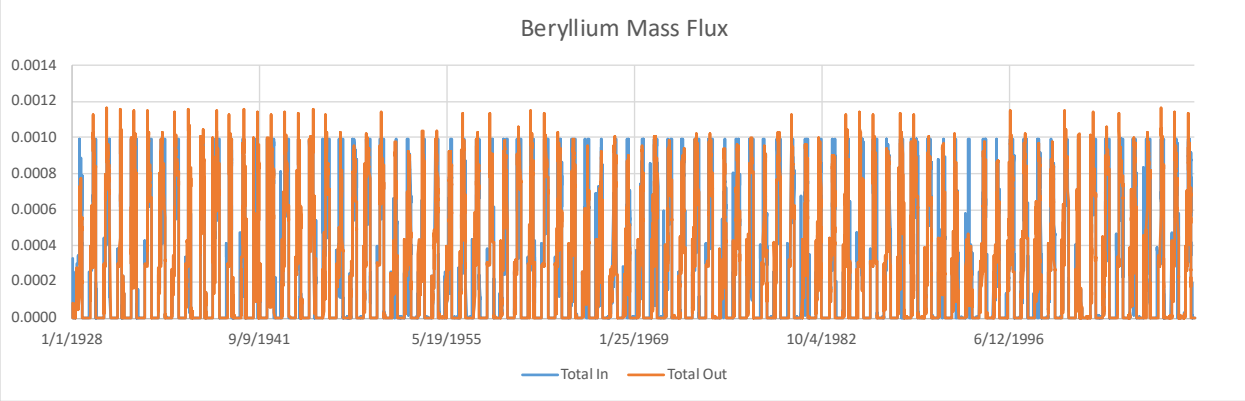


Figure 50. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

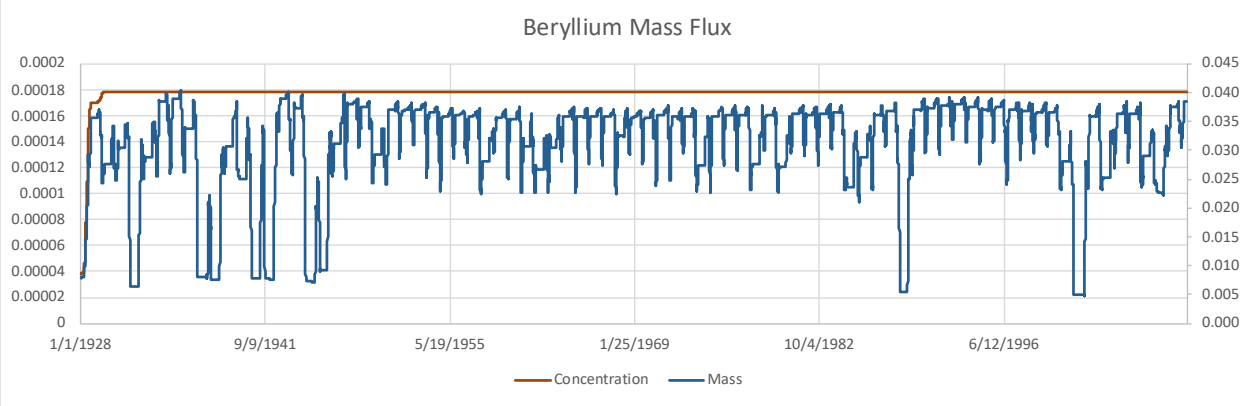


Figure 51. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

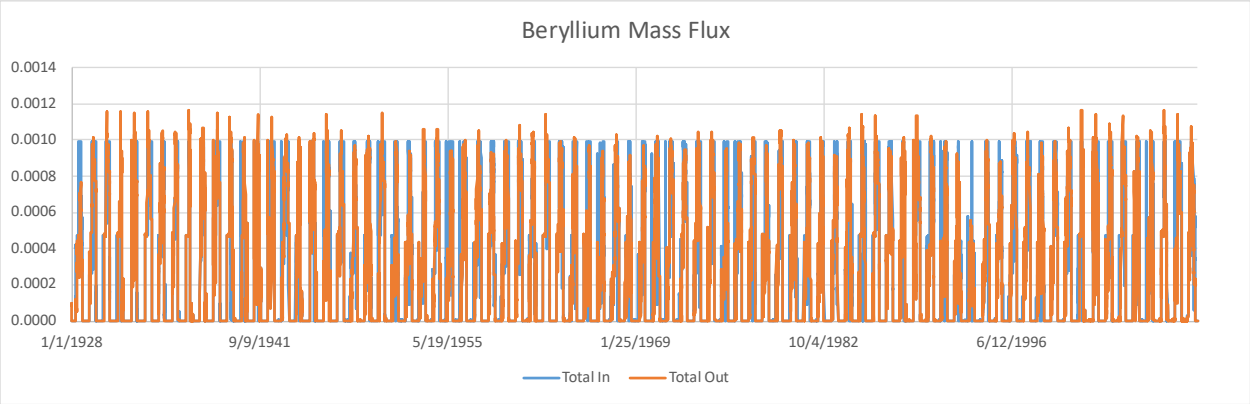


Figure 52. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

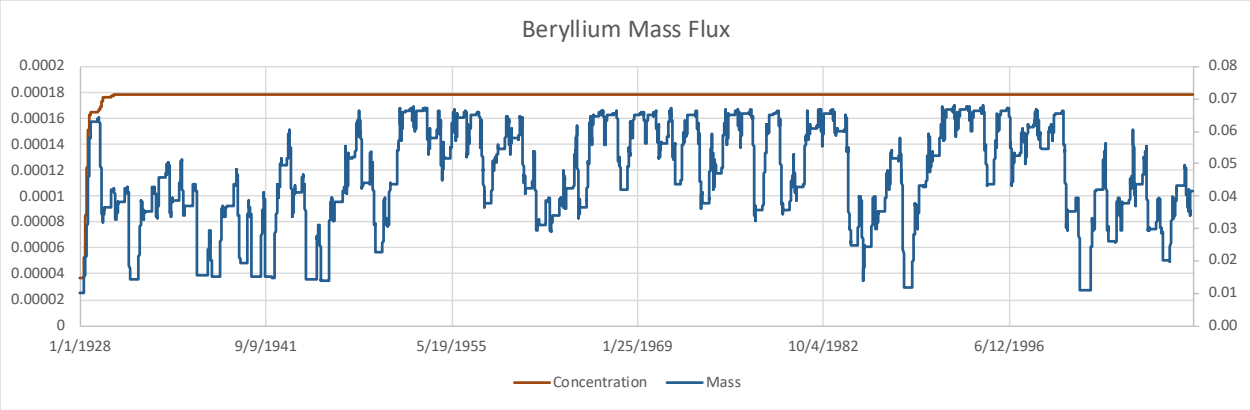


Figure 53. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

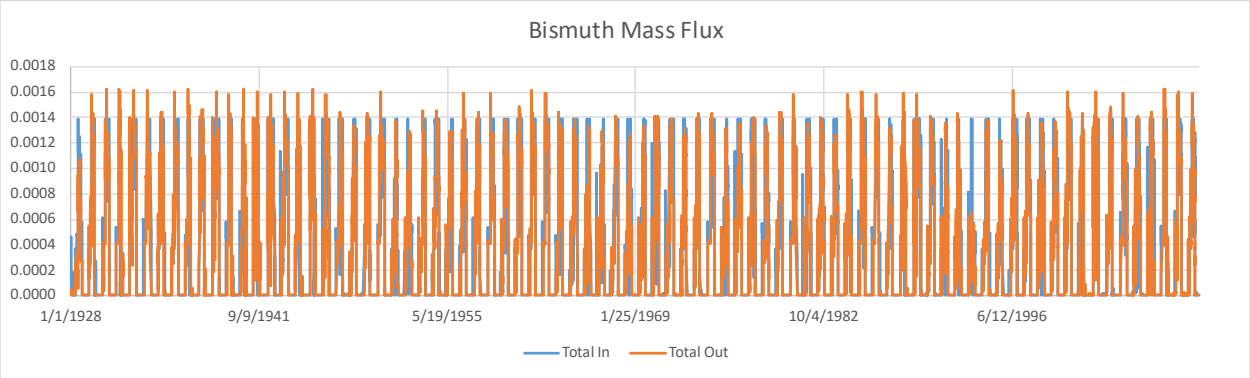


Figure 54. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

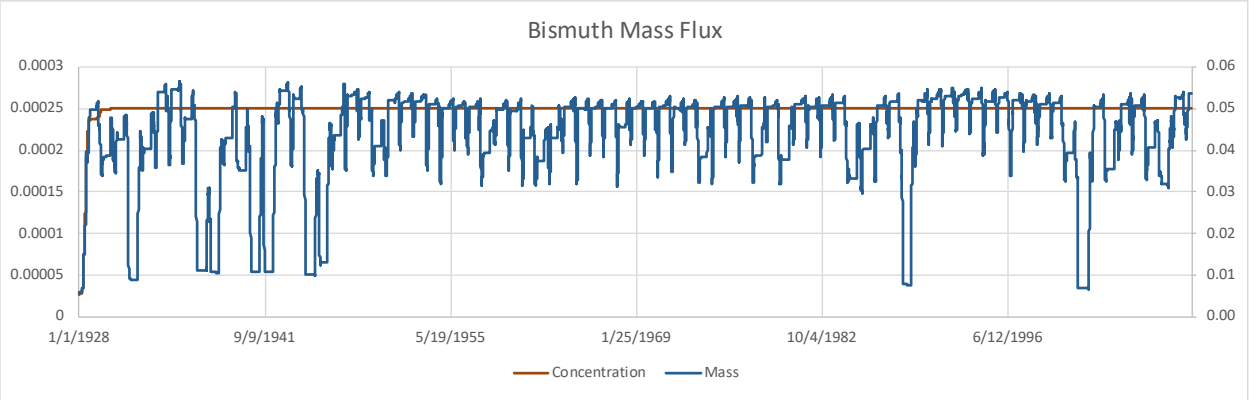


Figure 55. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

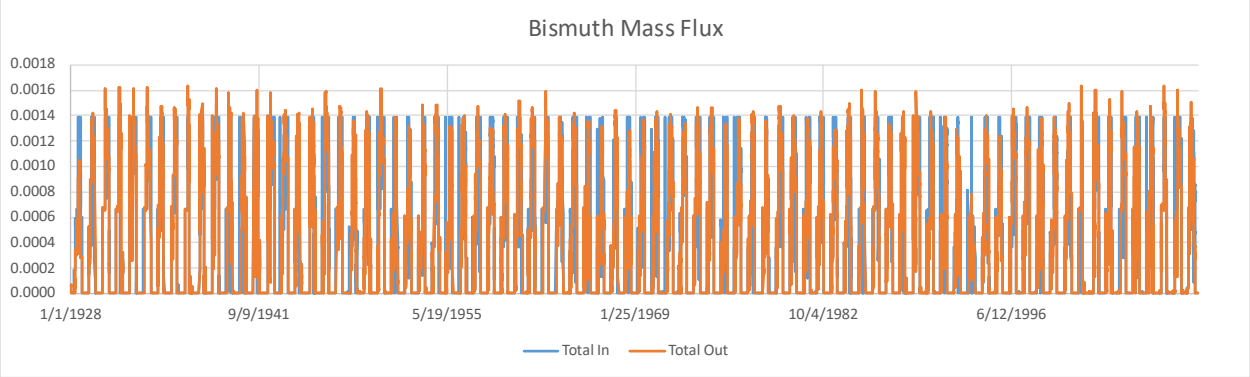


Figure 56. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

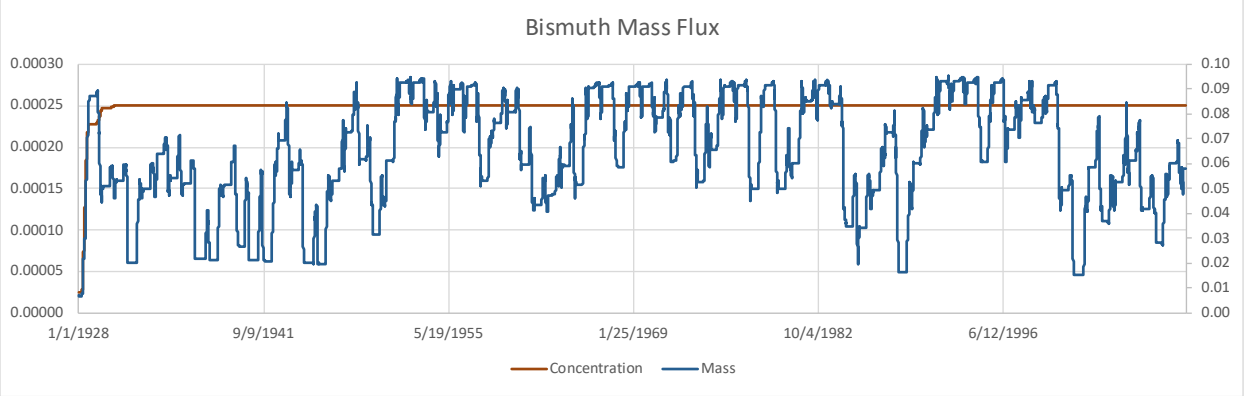


Figure 57. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

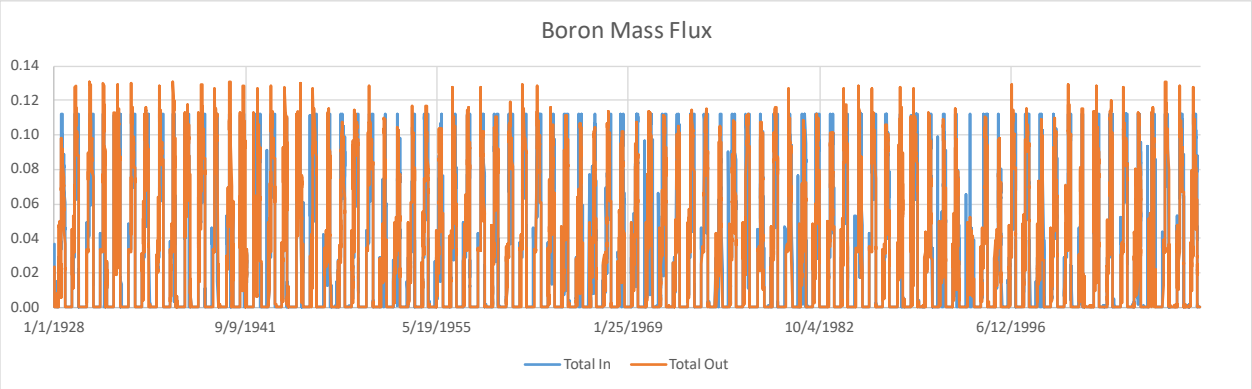


Figure 58. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

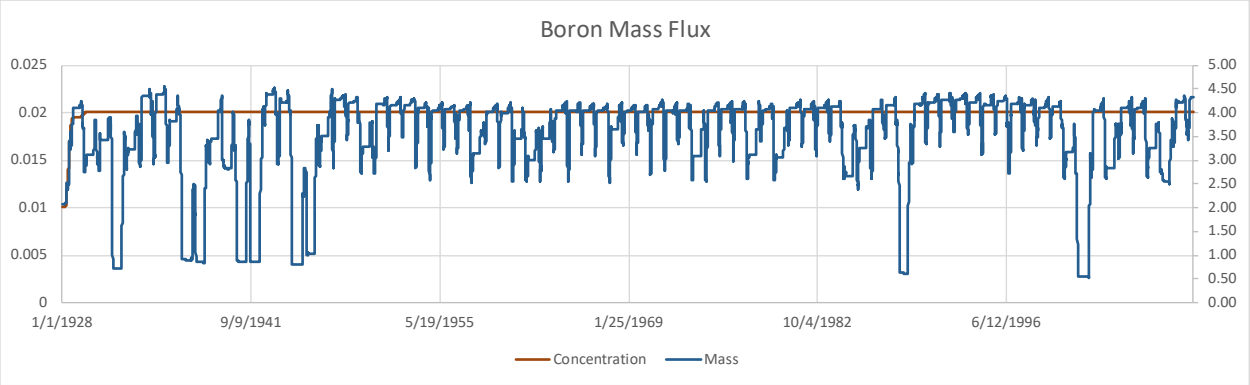


Figure 59. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

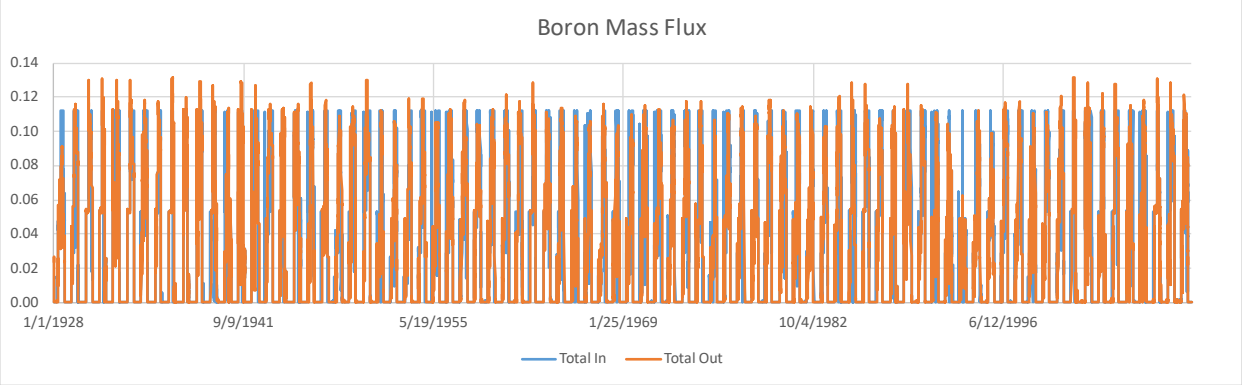


Figure 60. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

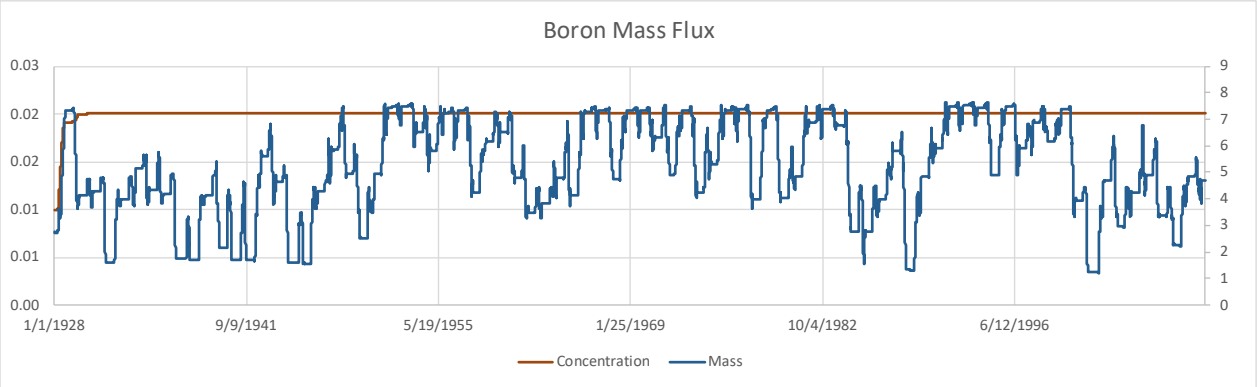


Figure 61. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

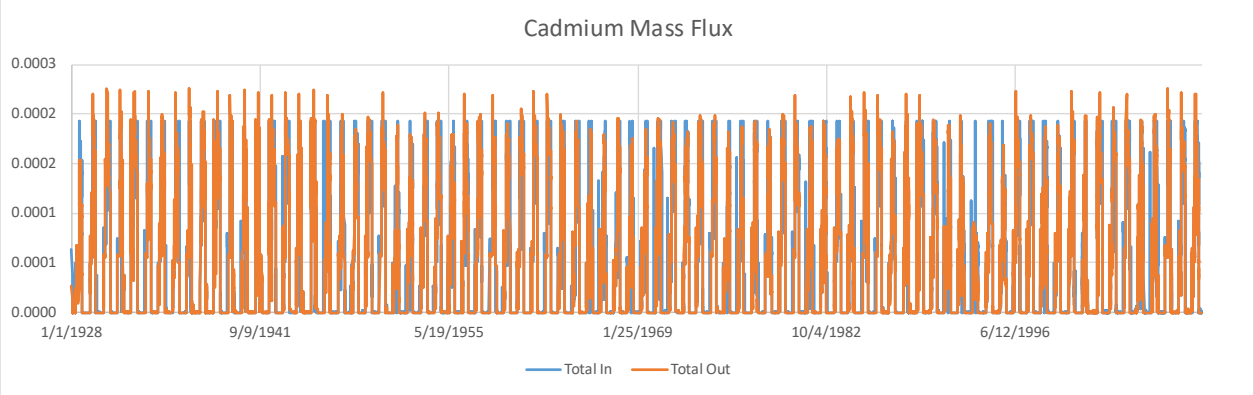


Figure 62. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

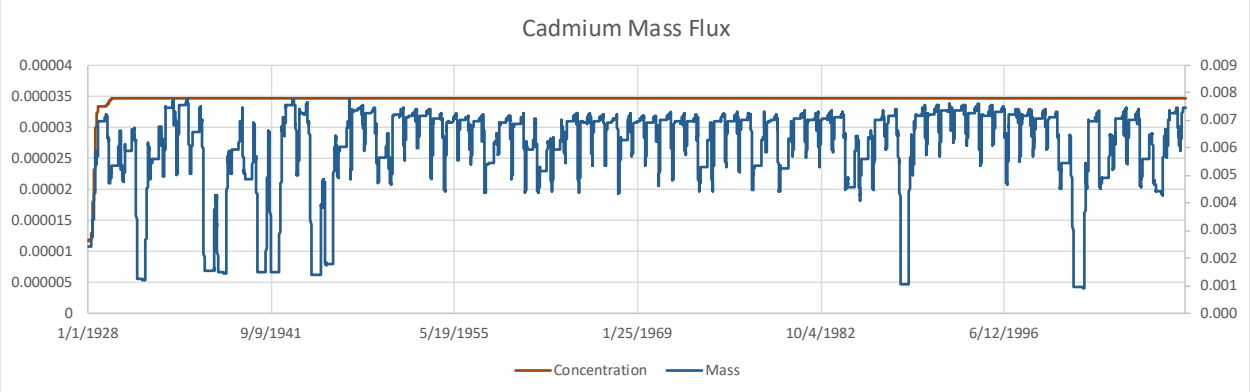


Figure 63. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

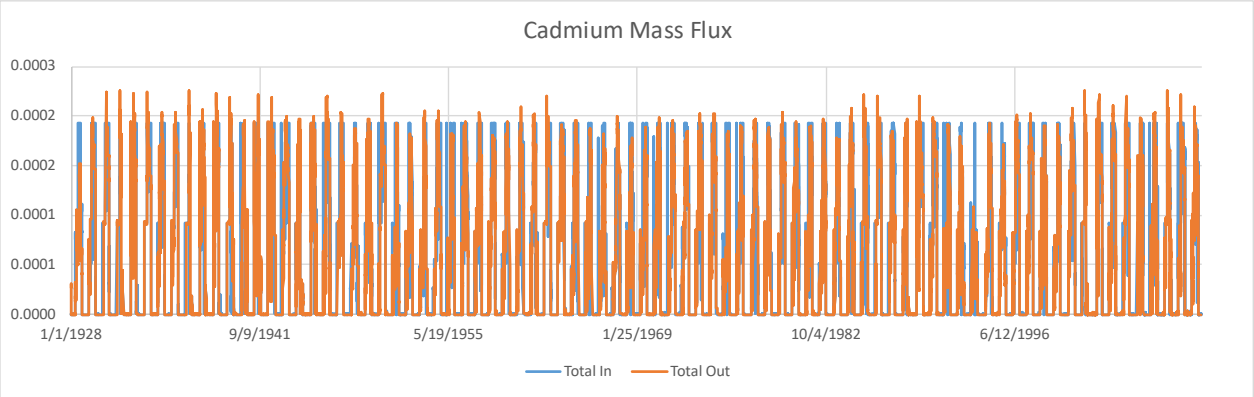


Figure 64. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

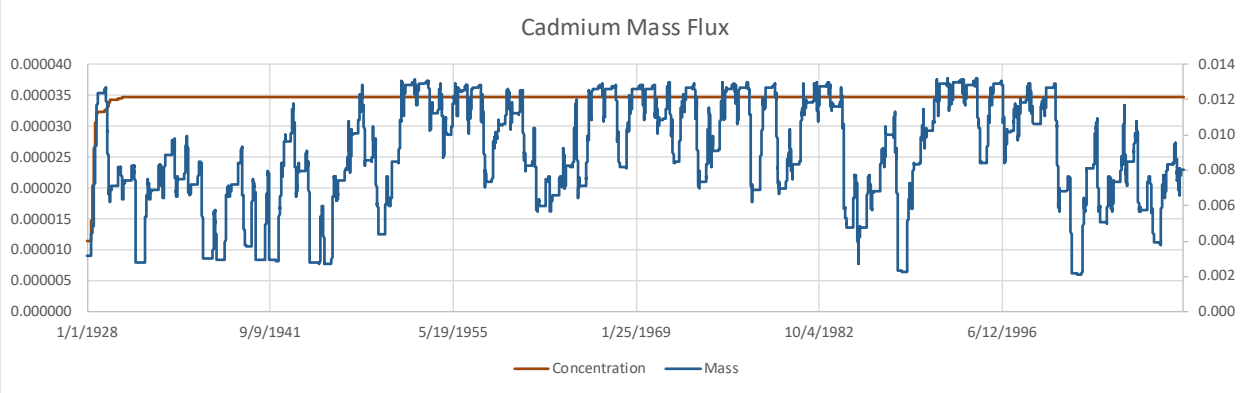


Figure 65. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

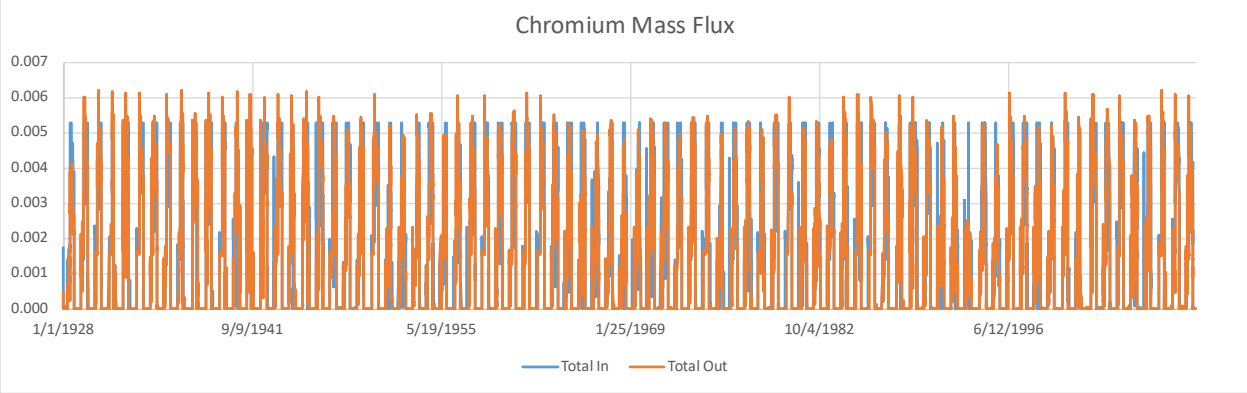


Figure 66. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

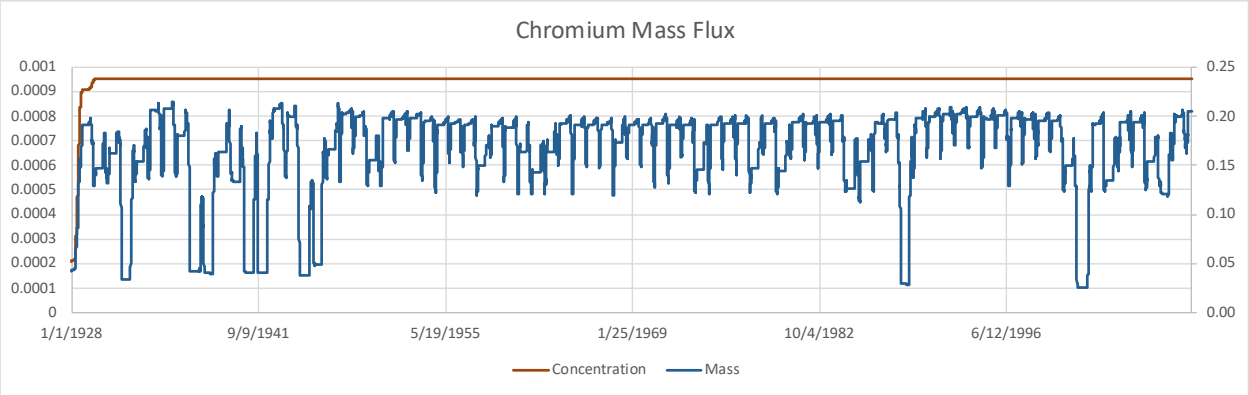


Figure 67. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

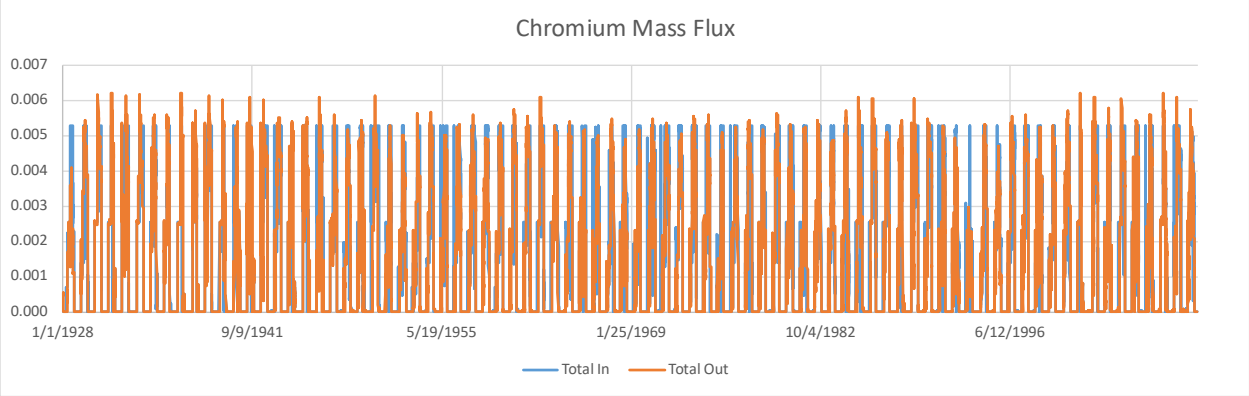


Figure 68. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

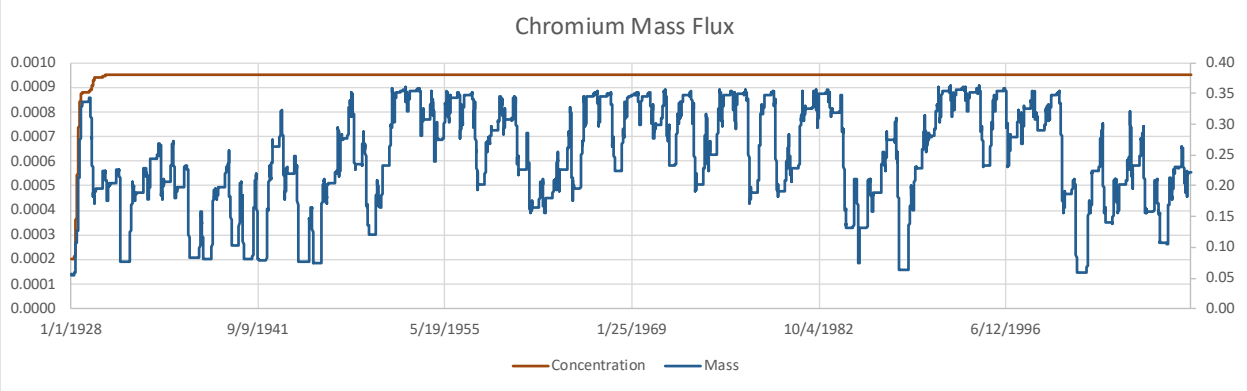


Figure 69. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

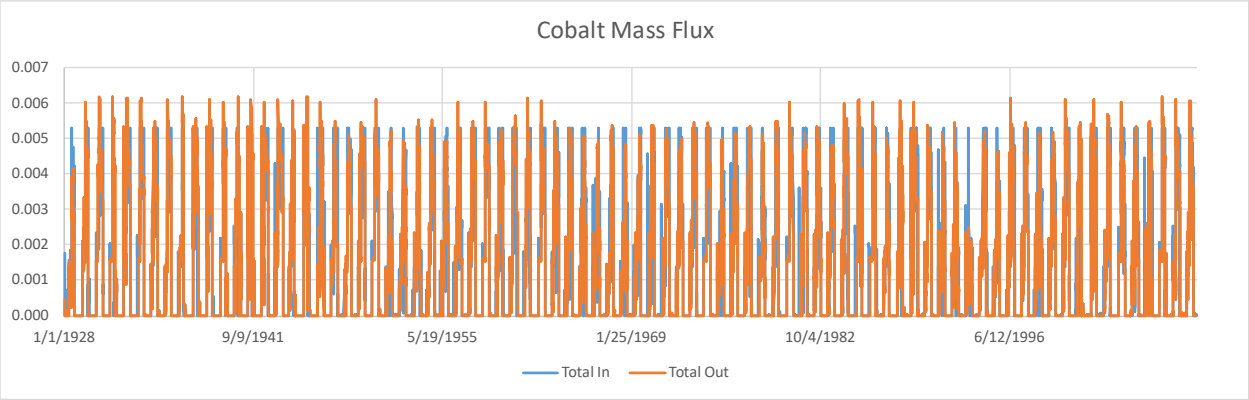


Figure 70. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

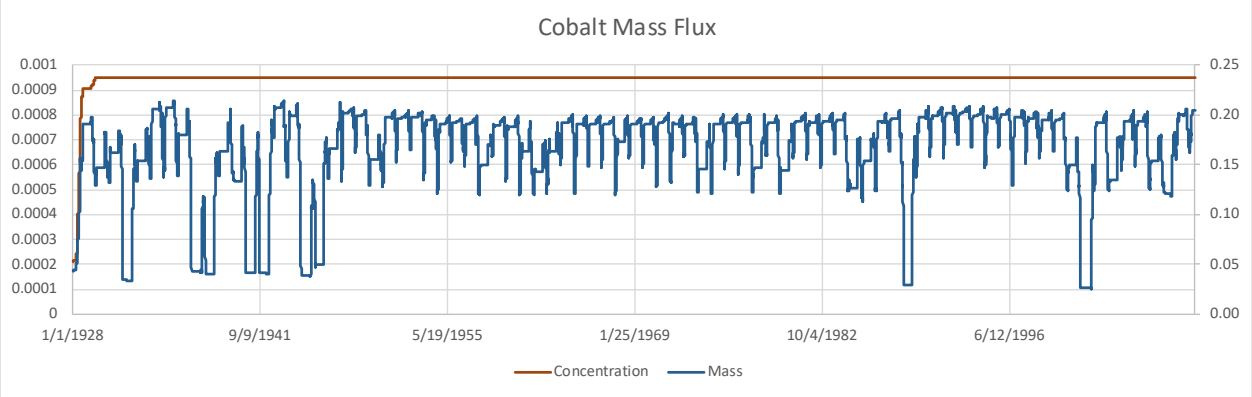


Figure 71. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

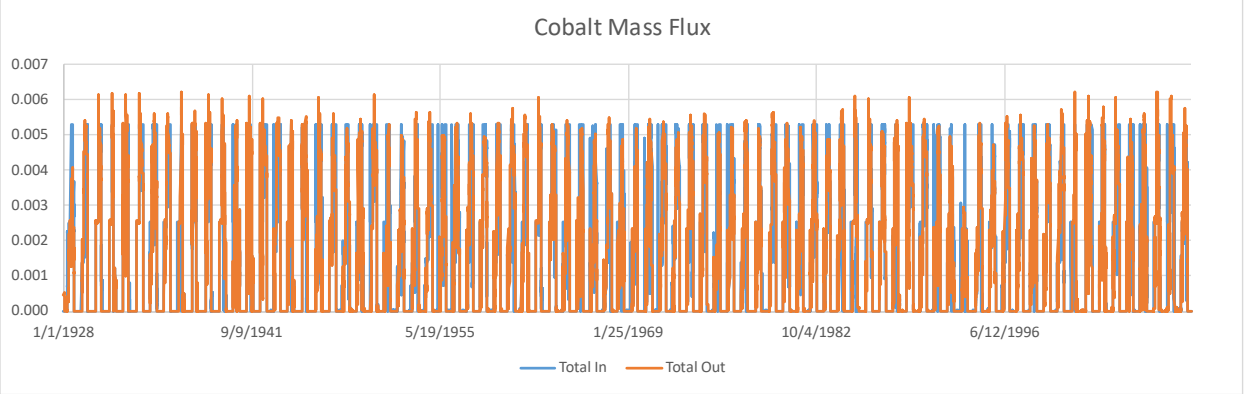


Figure 72. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

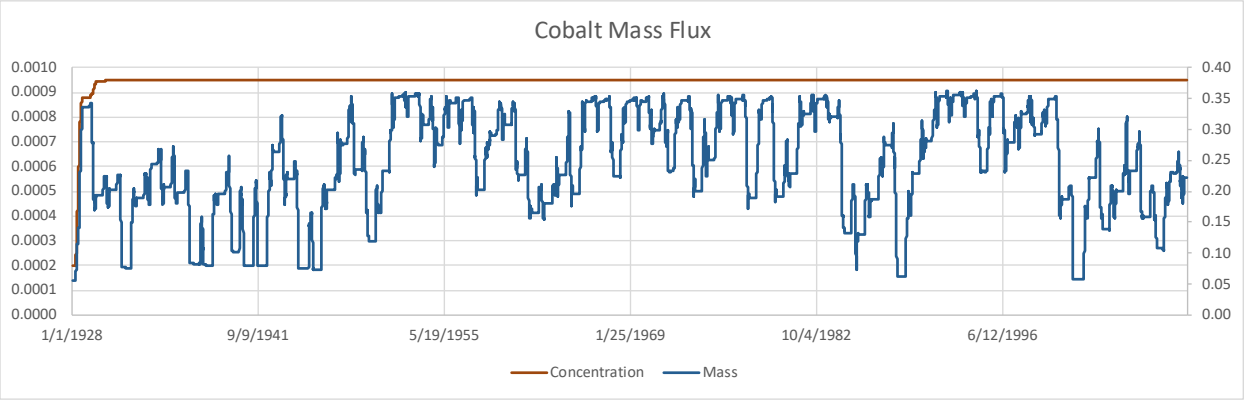


Figure 73. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

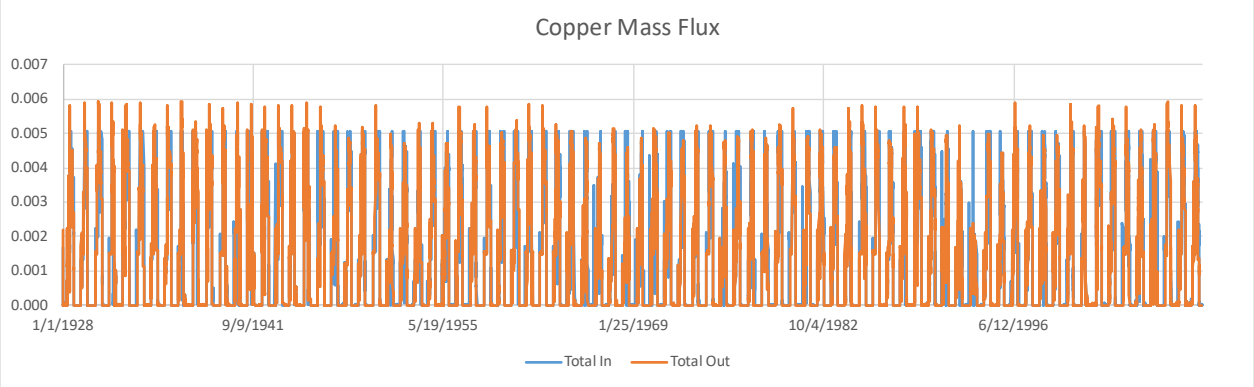


Figure 74. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

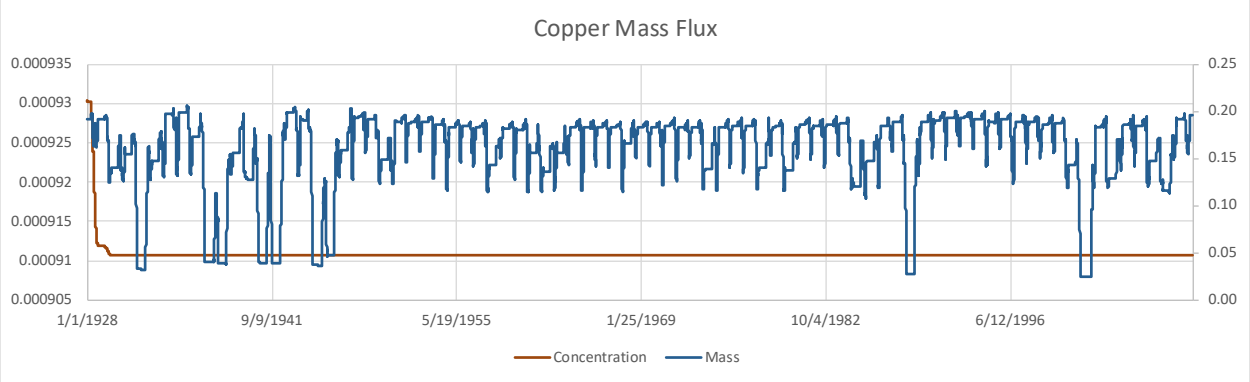


Figure 75. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

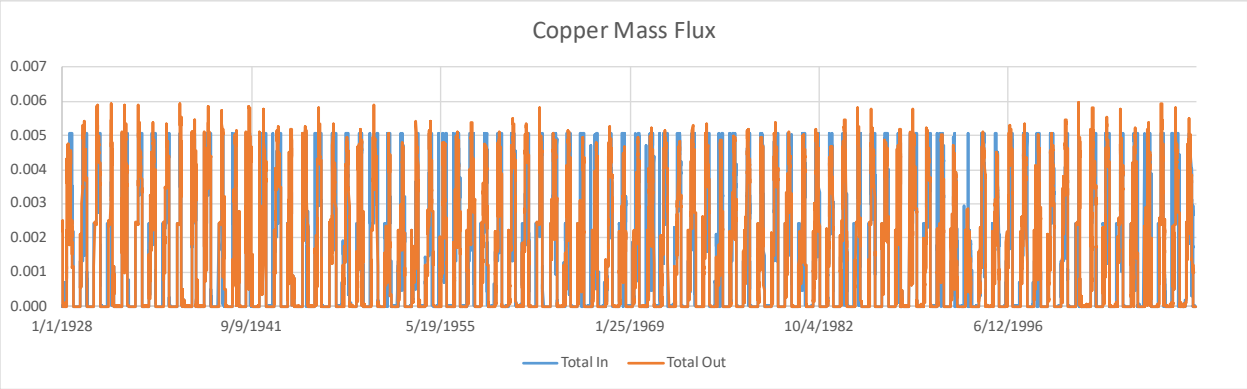


Figure 76. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

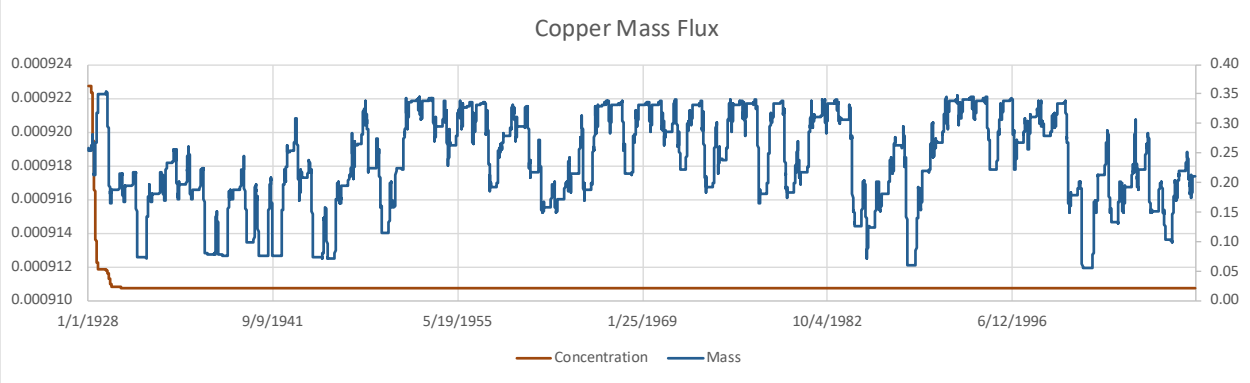


Figure 77. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

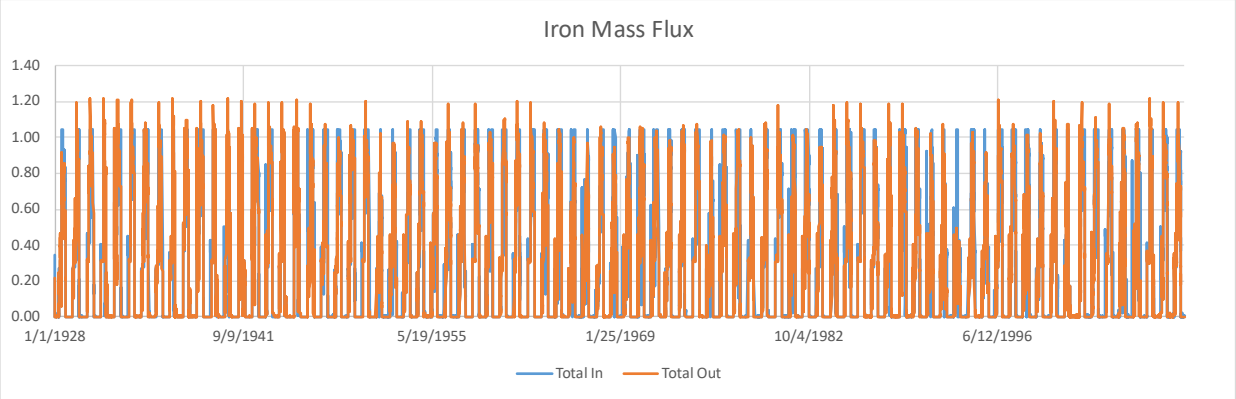


Figure 78. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

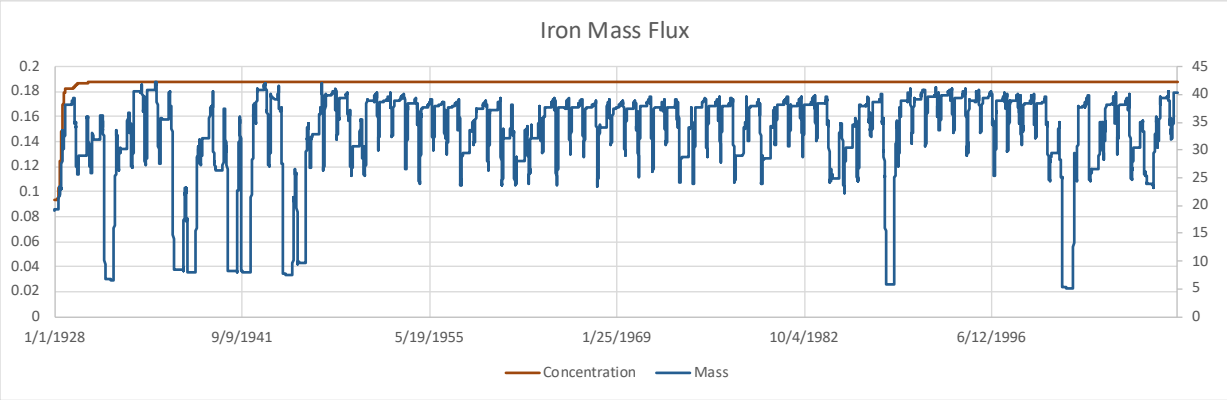


Figure 79. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

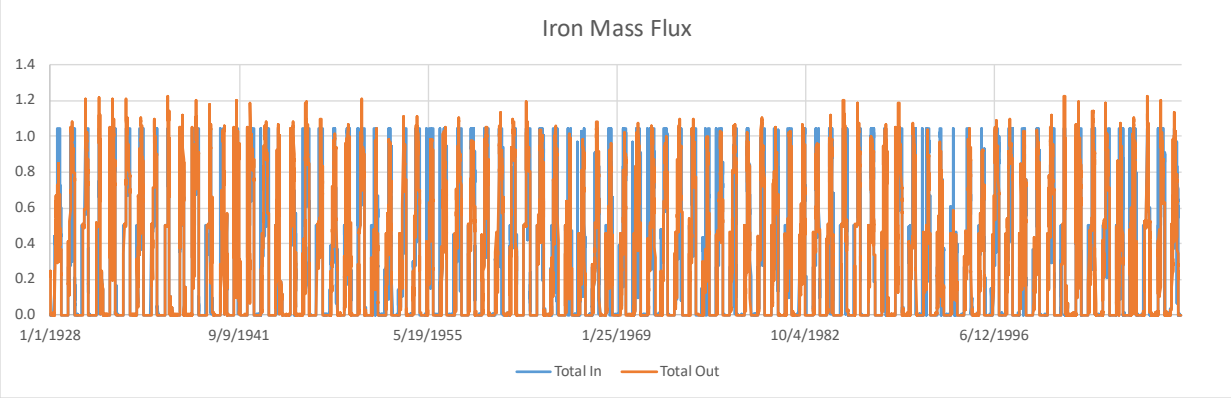


Figure 80. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

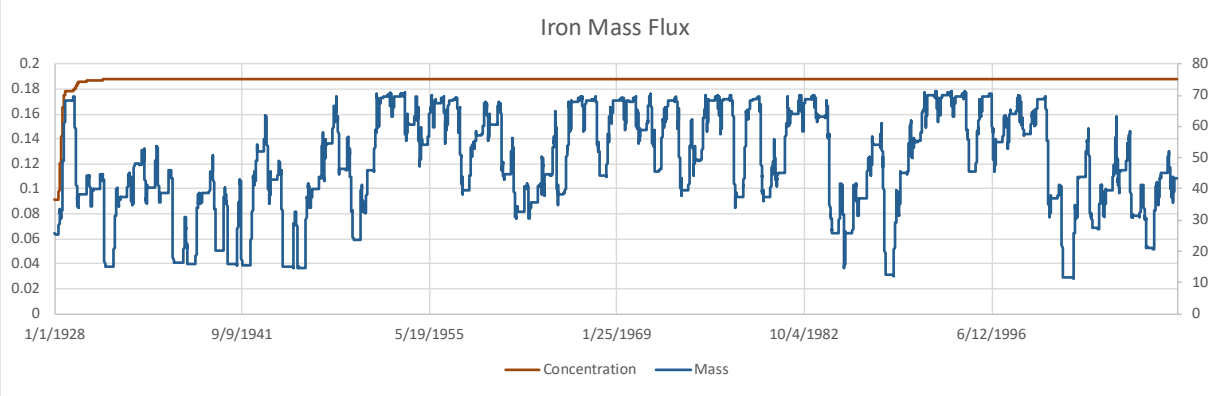


Figure 81. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

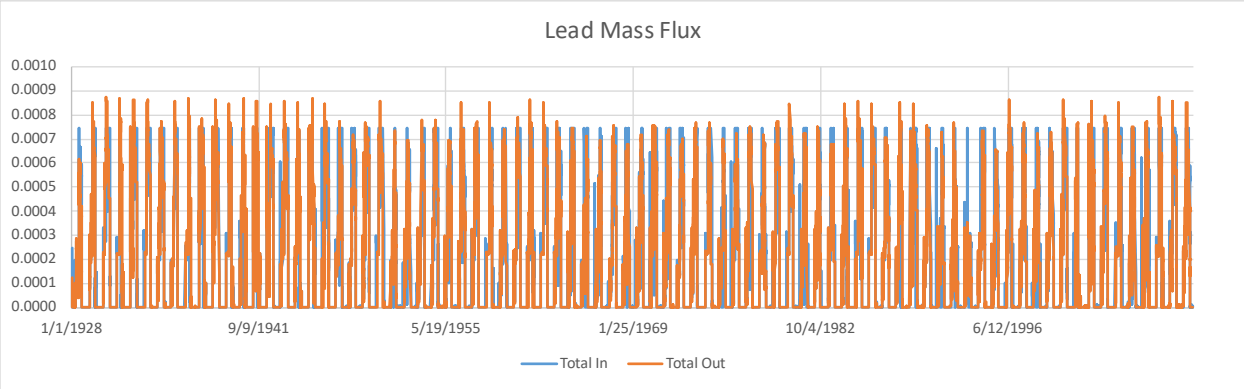


Figure 82. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

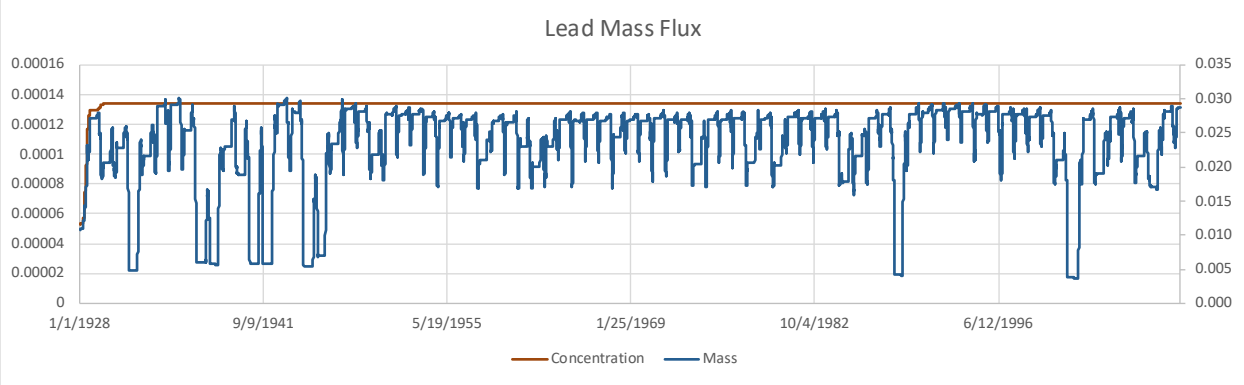


Figure 83. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

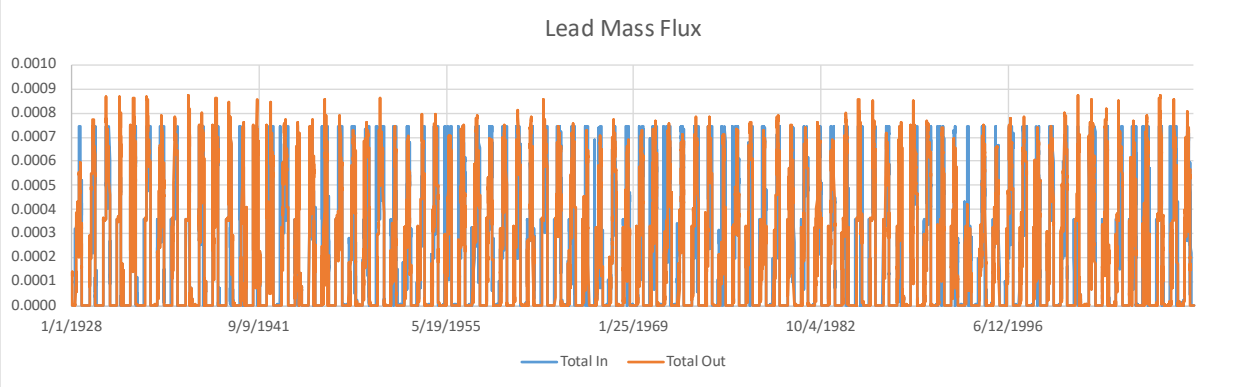


Figure 84. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

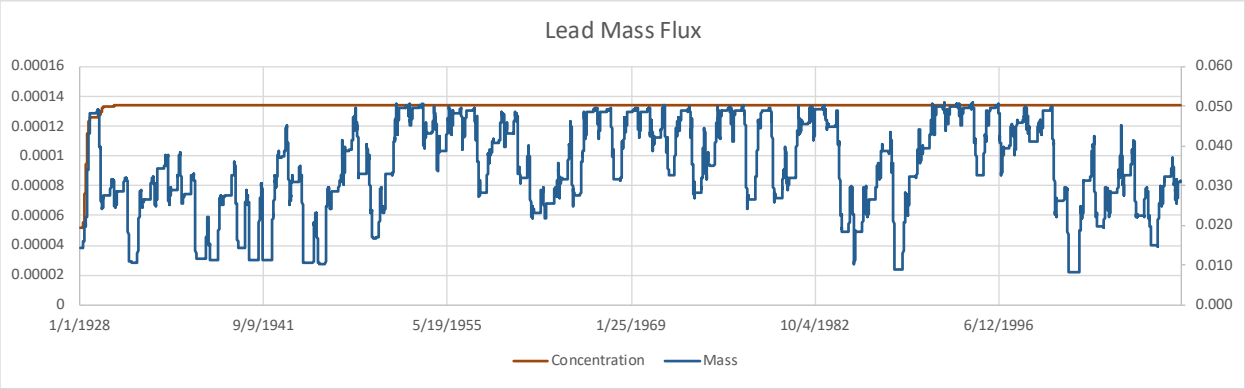


Figure 85. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

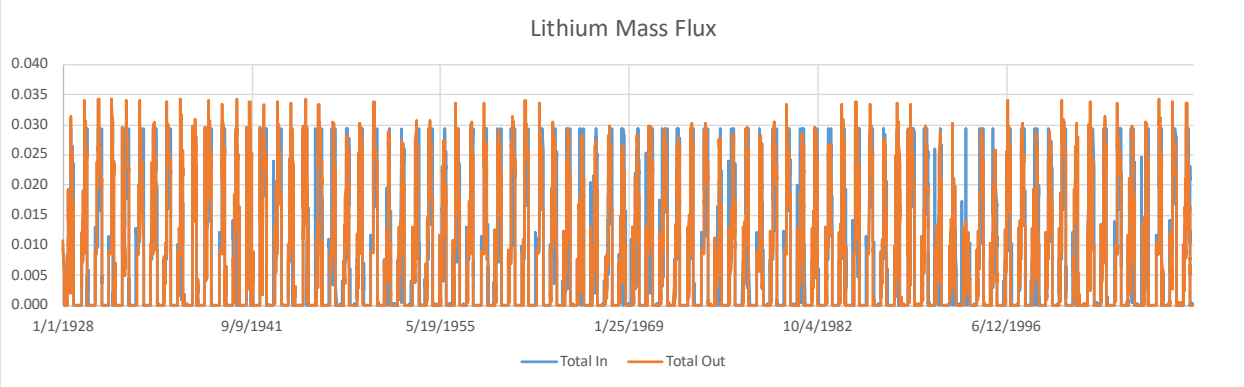


Figure 86. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

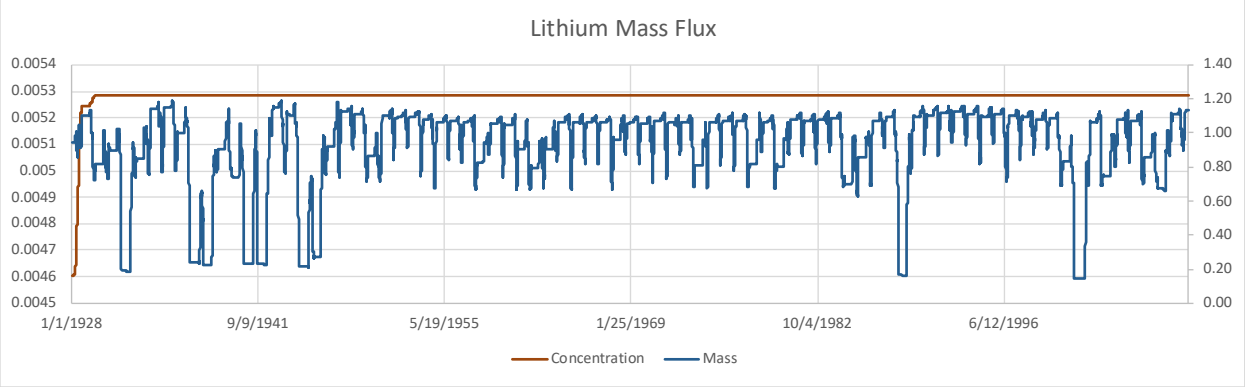


Figure 87. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

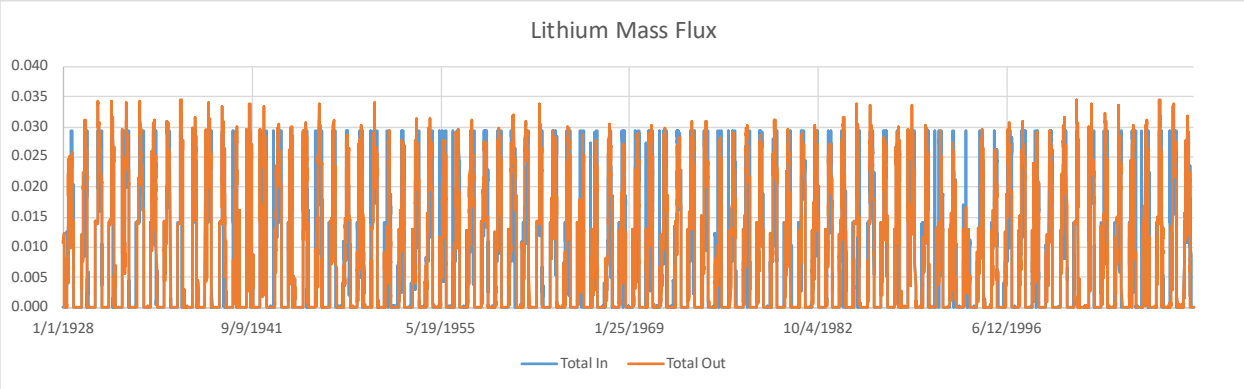


Figure 88. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

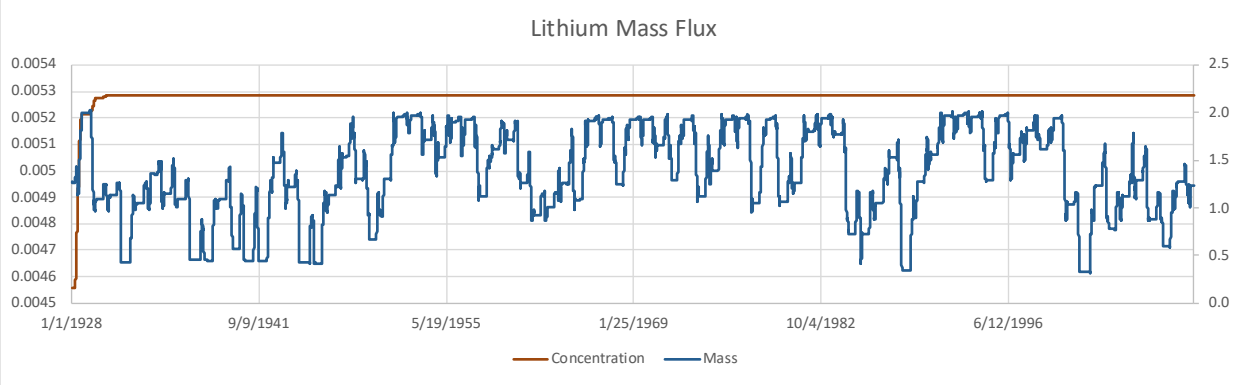


Figure 89. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

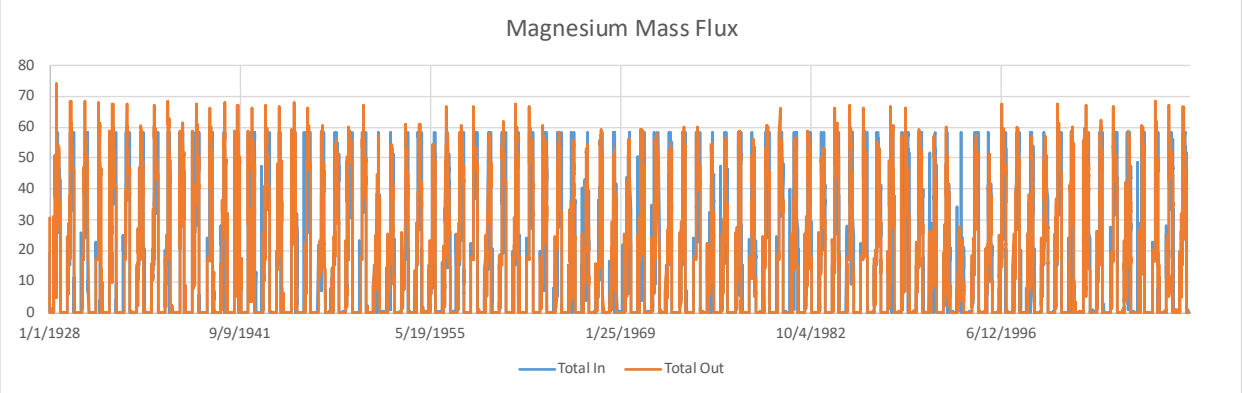


Figure 90. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

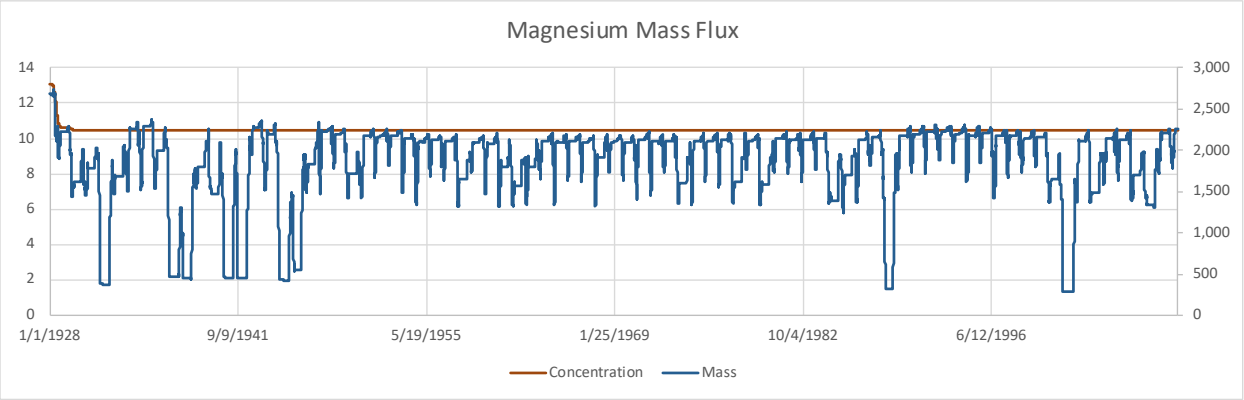


Figure 91. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

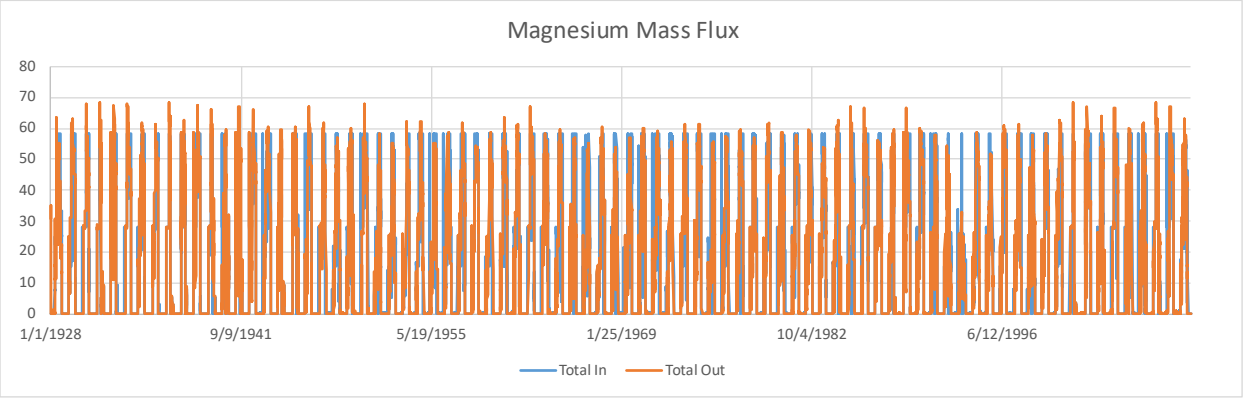


Figure 92. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

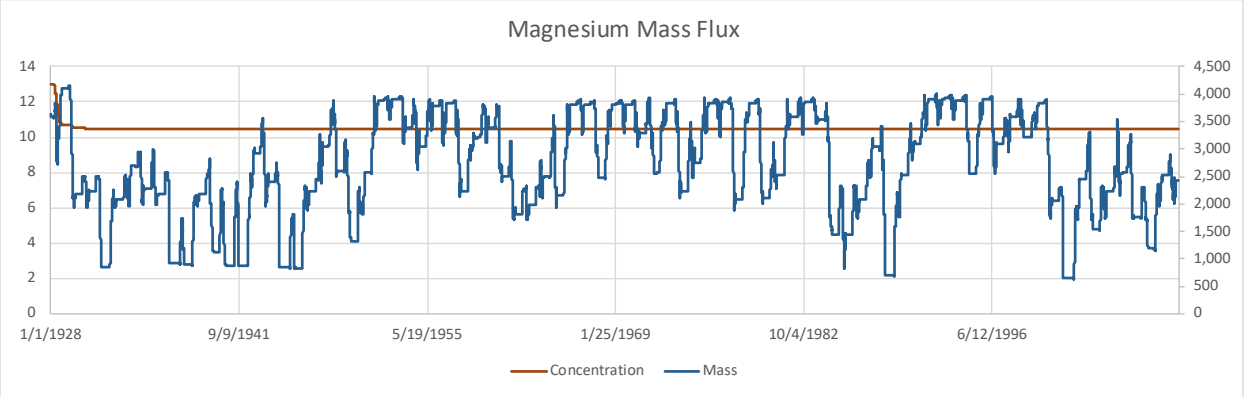


Figure 93. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

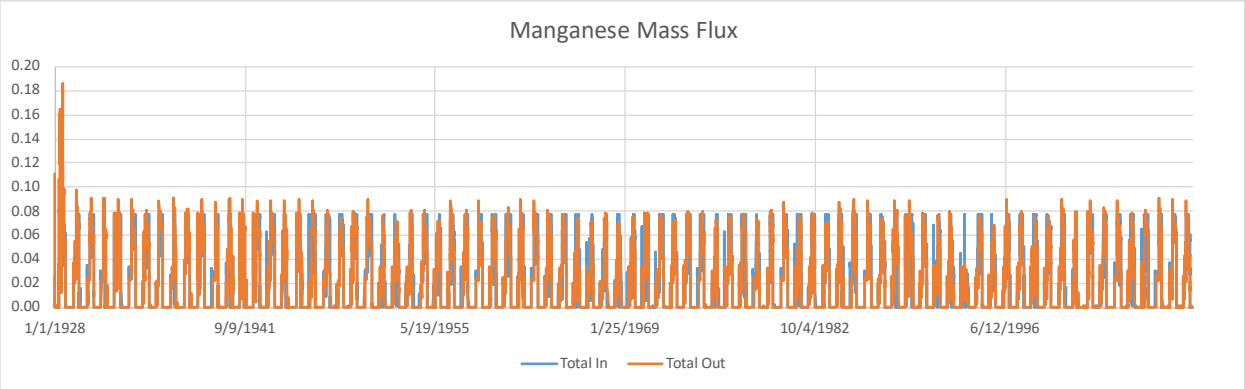


Figure 94. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

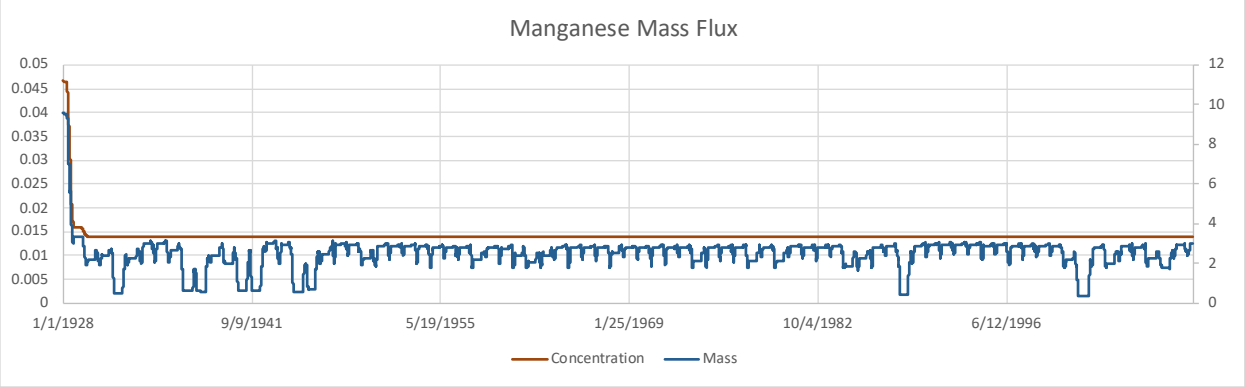


Figure 95. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

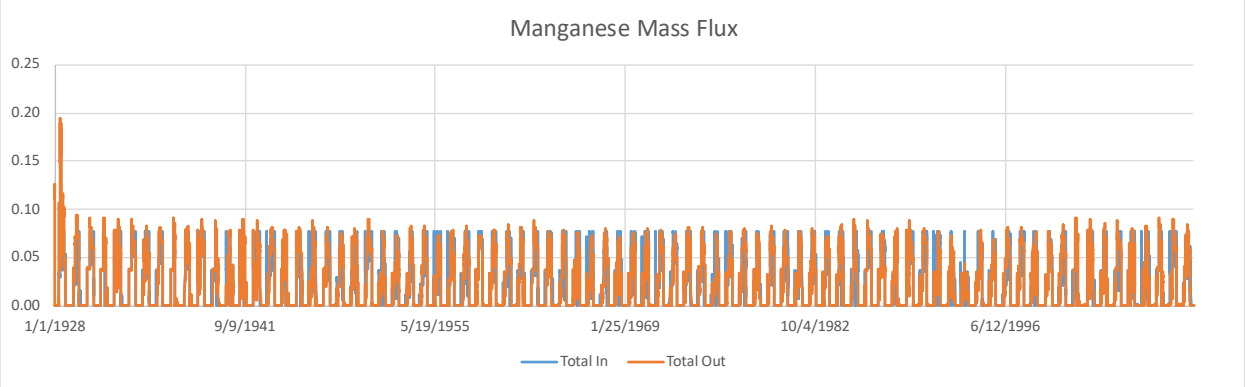


Figure 96. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

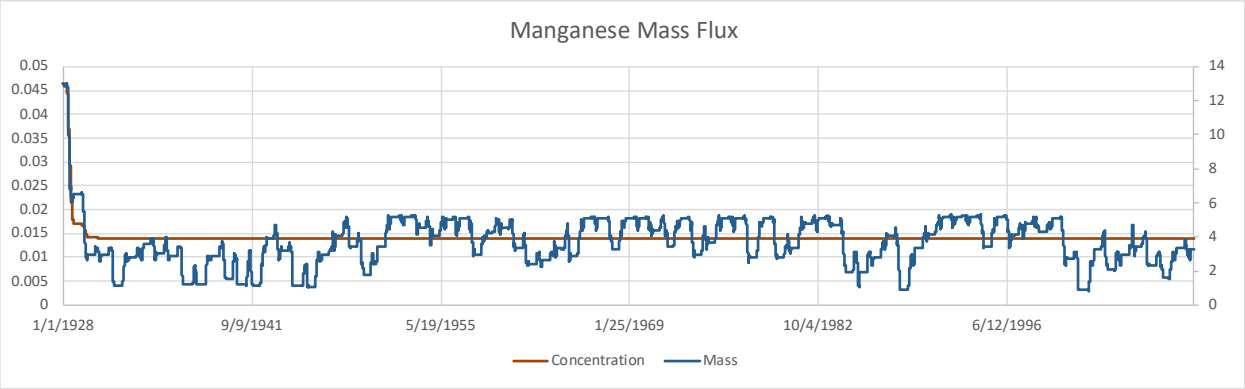


Figure 97. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

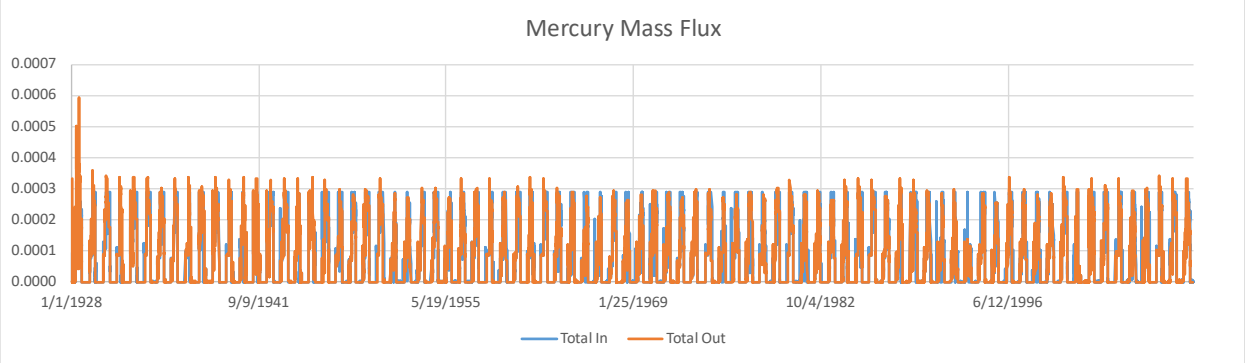


Figure 98. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

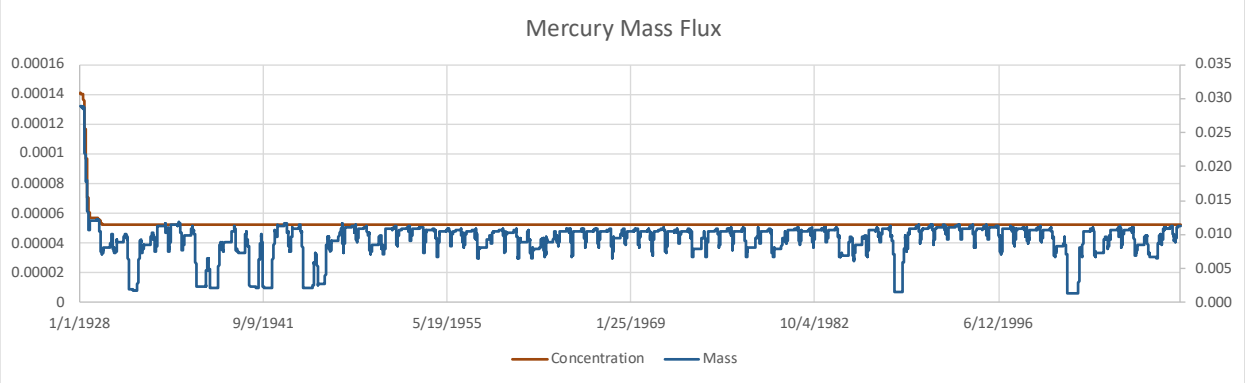


Figure 99. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

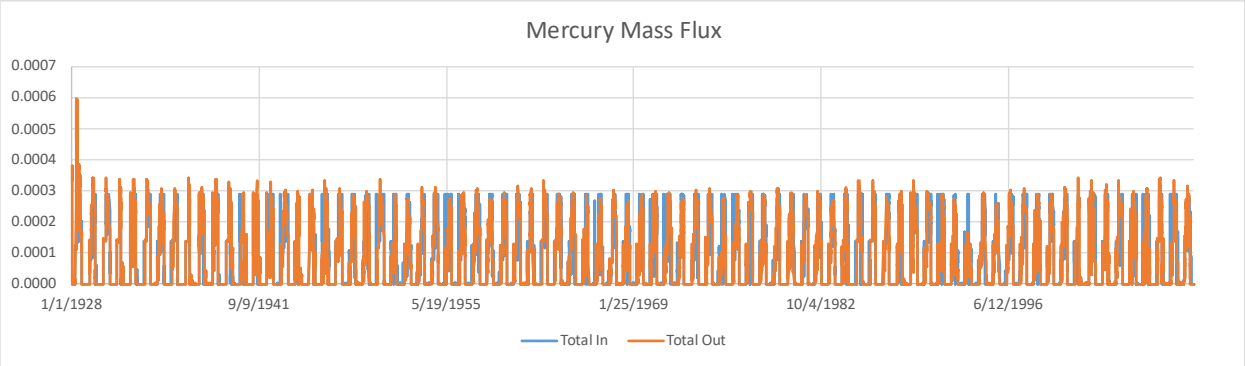


Figure 100. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

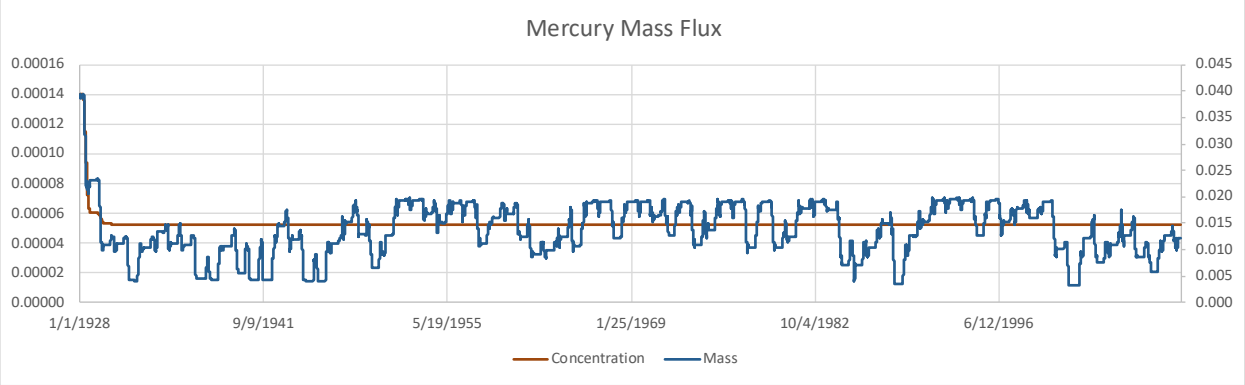


Figure 101. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

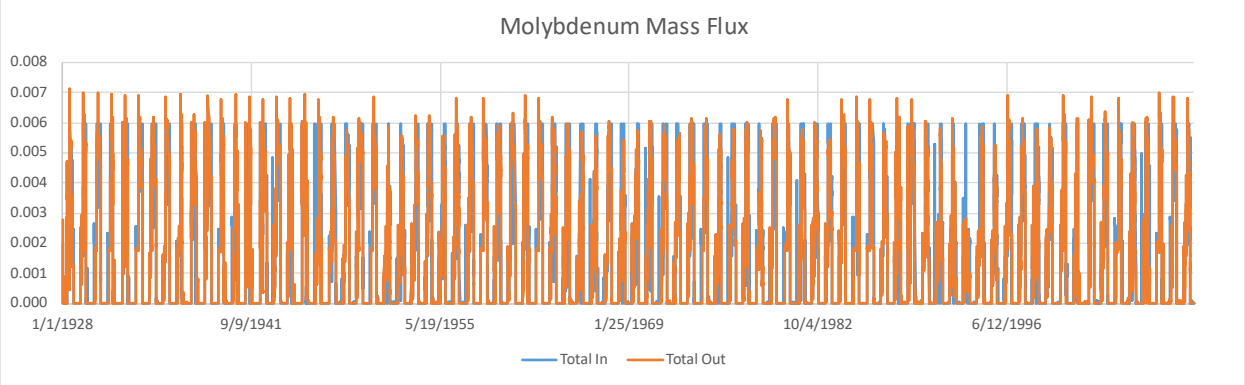


Figure 102. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

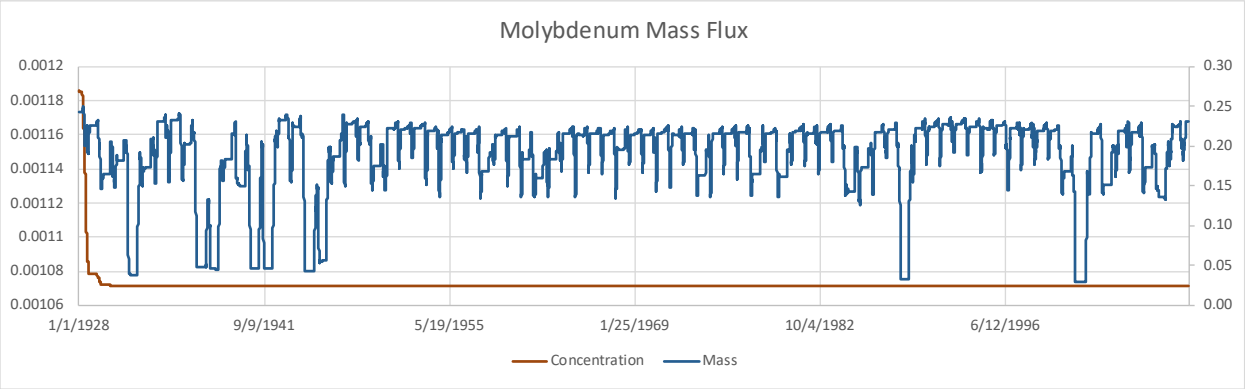


Figure 103. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

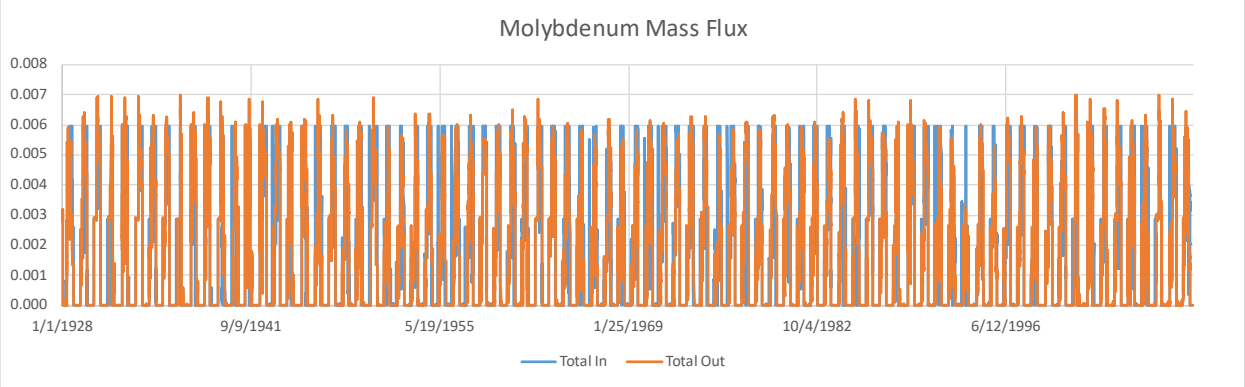


Figure 104. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

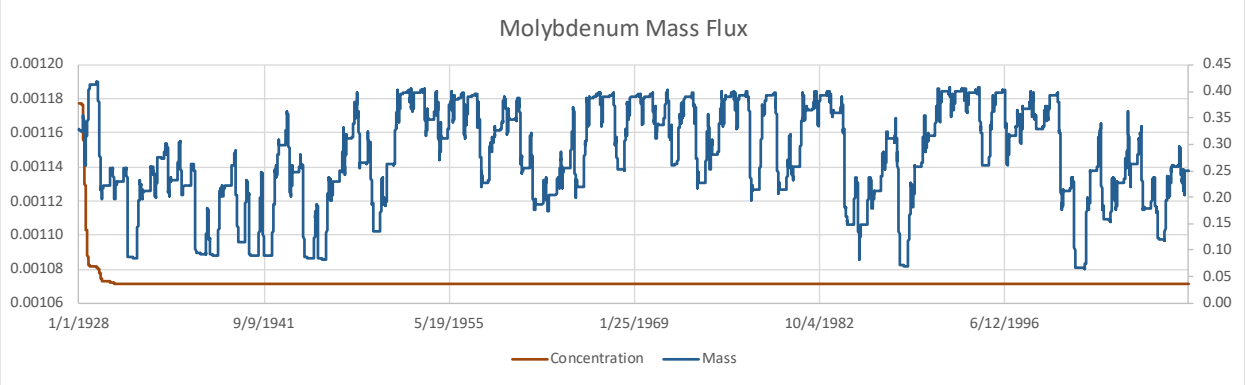


Figure 105. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

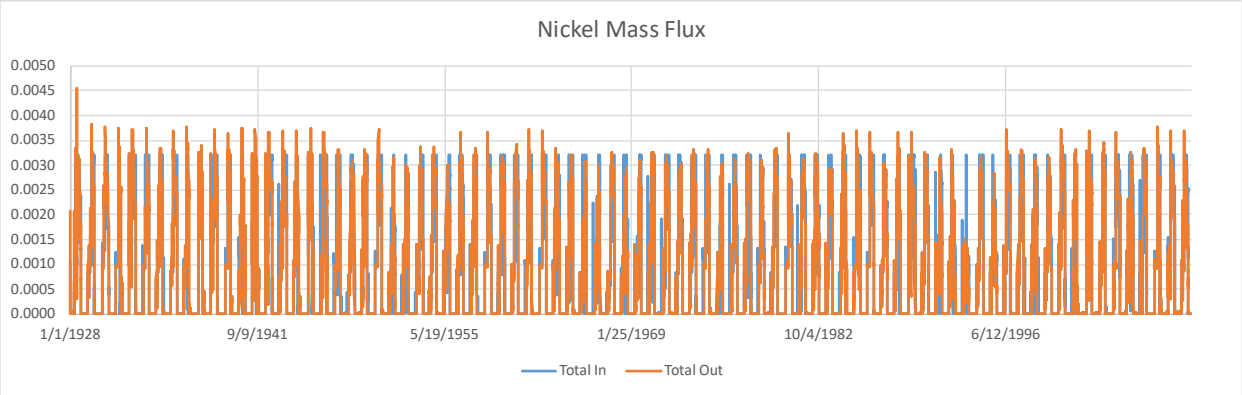


Figure 106. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

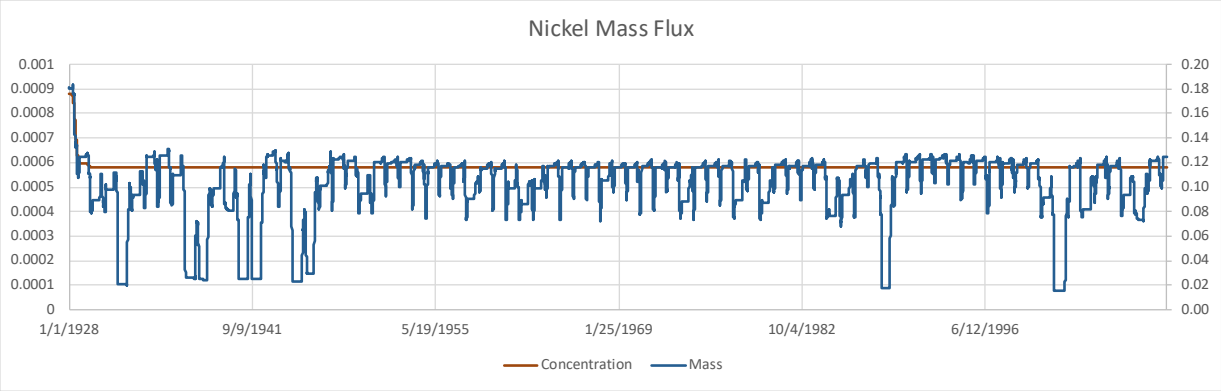


Figure 107. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

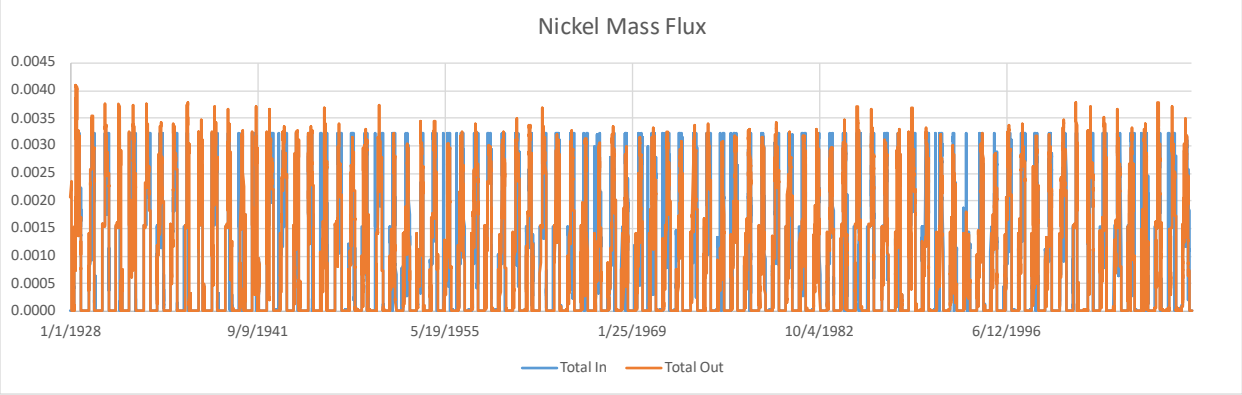


Figure 108. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

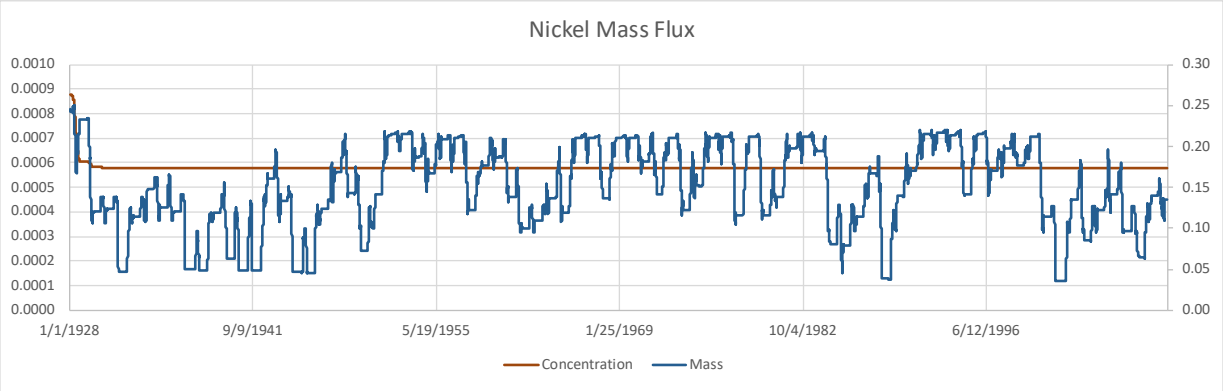


Figure 109. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

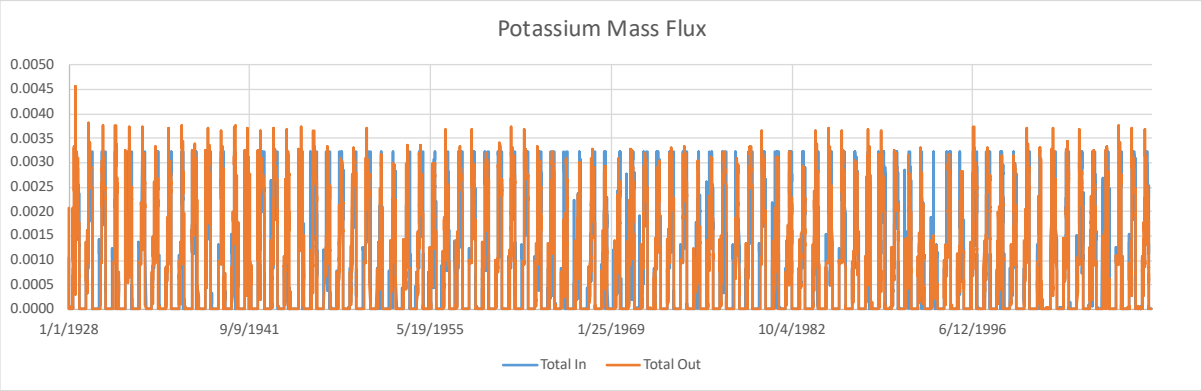


Figure 110. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

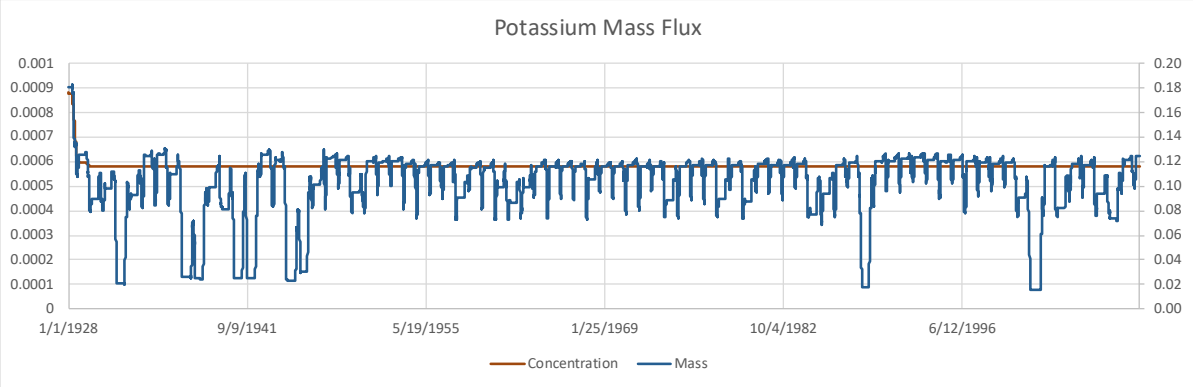


Figure 111. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

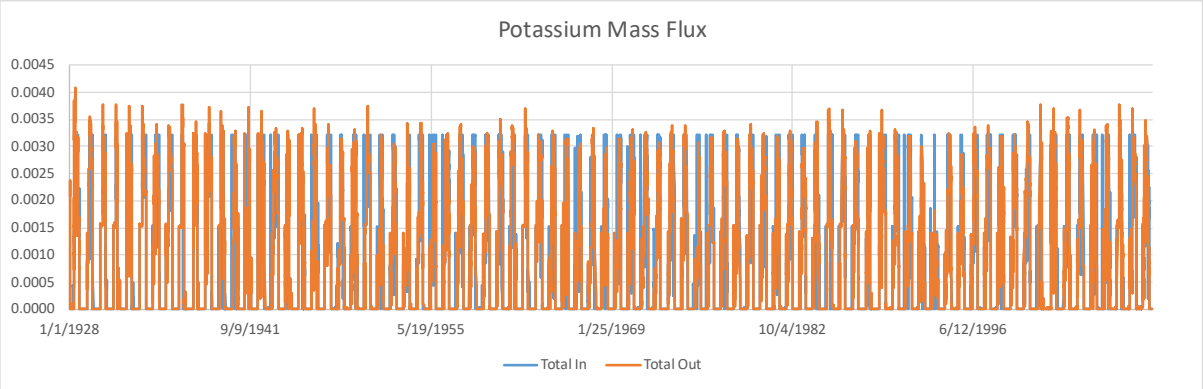


Figure 112. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

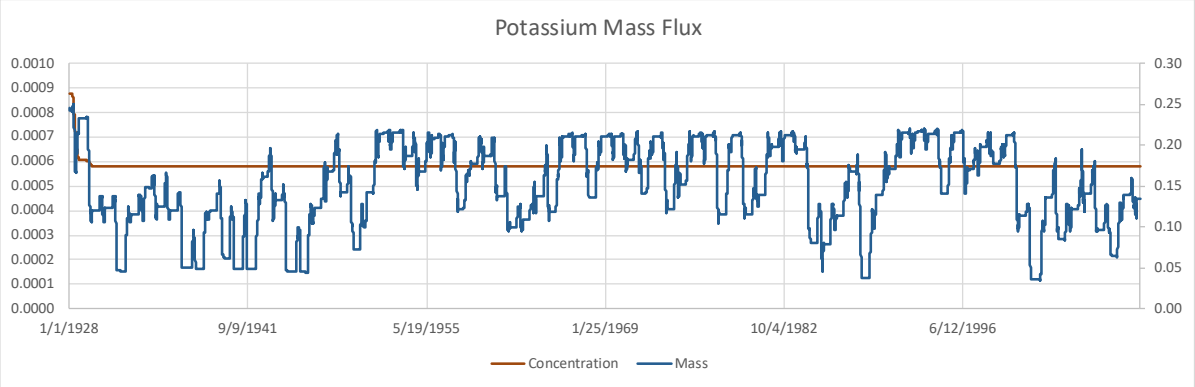


Figure 113. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

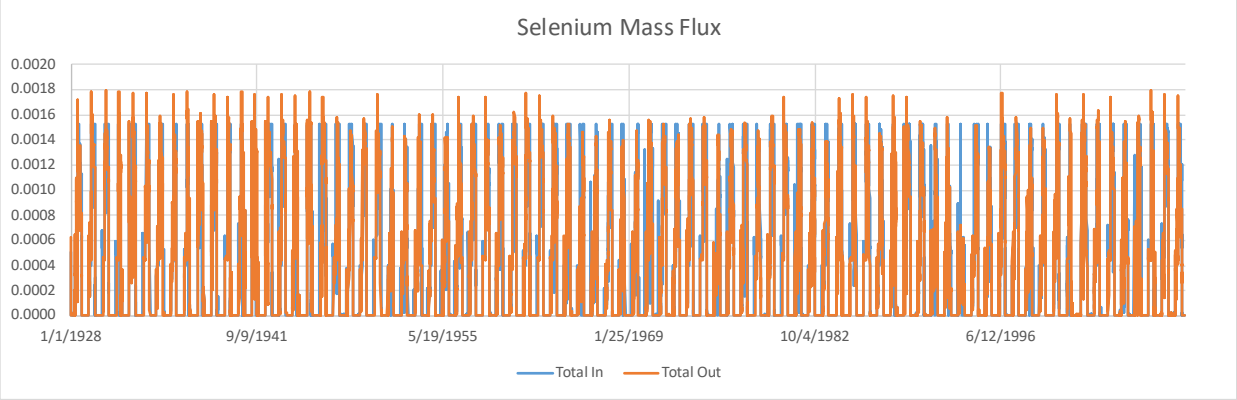


Figure 114. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

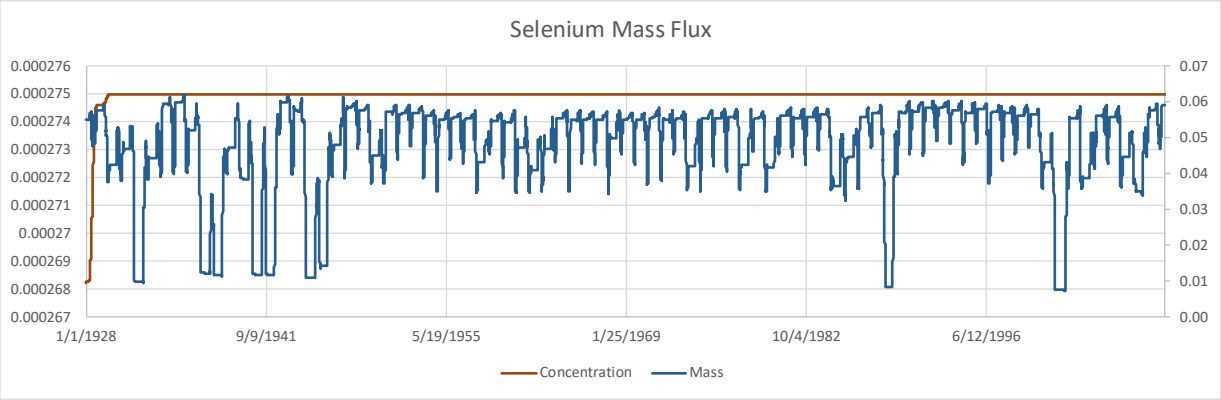


Figure 115. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

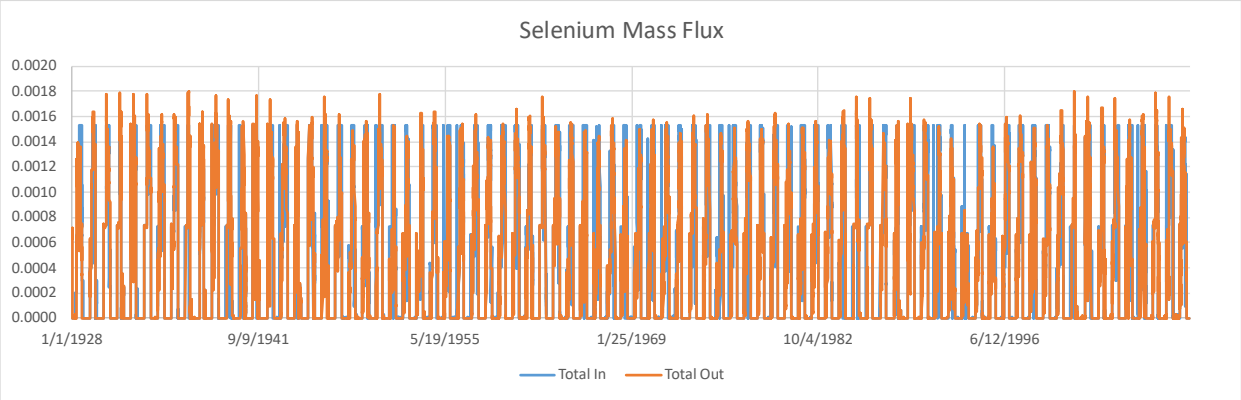


Figure 116. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

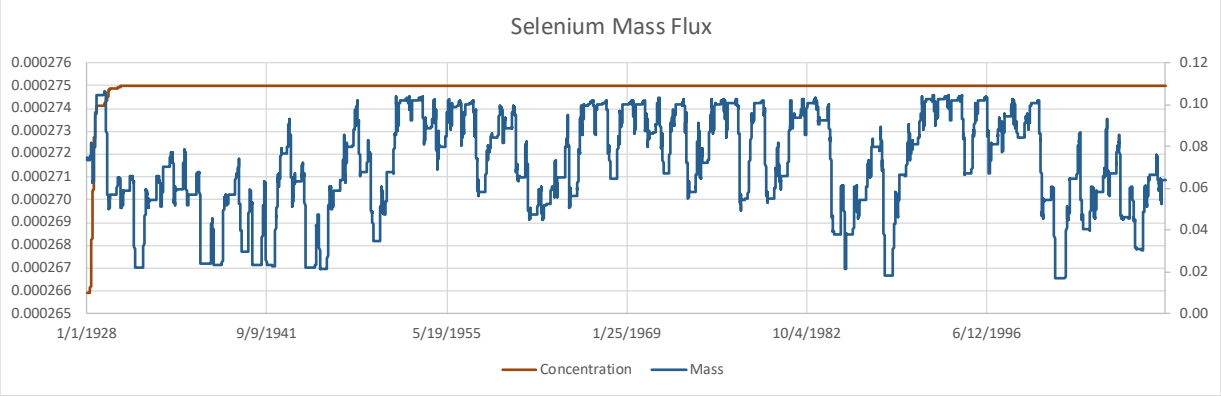


Figure 117. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

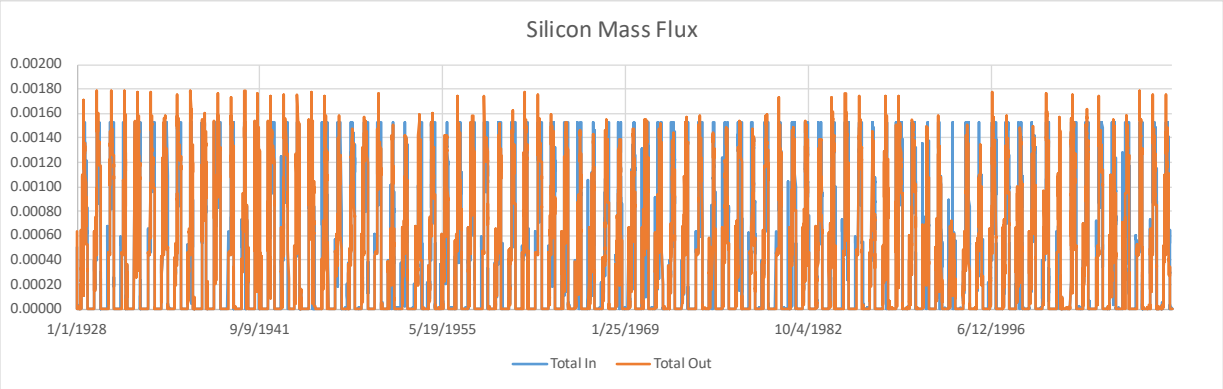


Figure 118. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

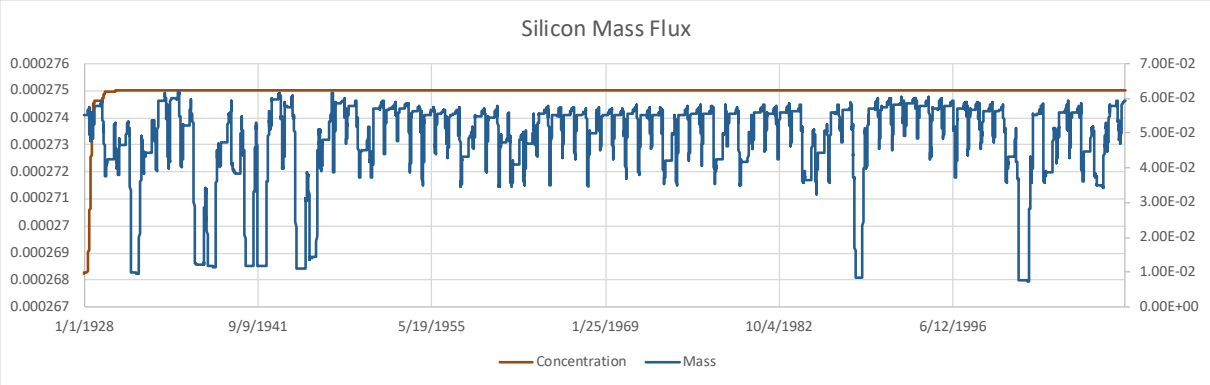


Figure 119. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

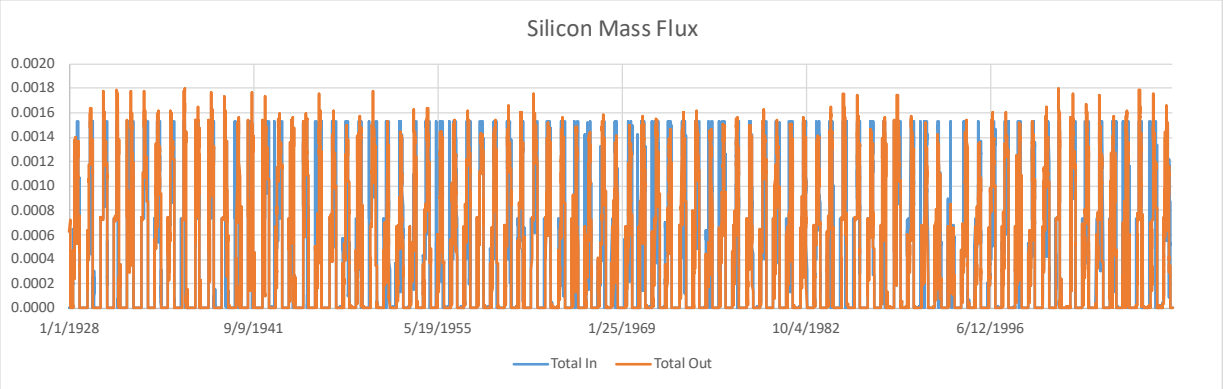


Figure 120. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

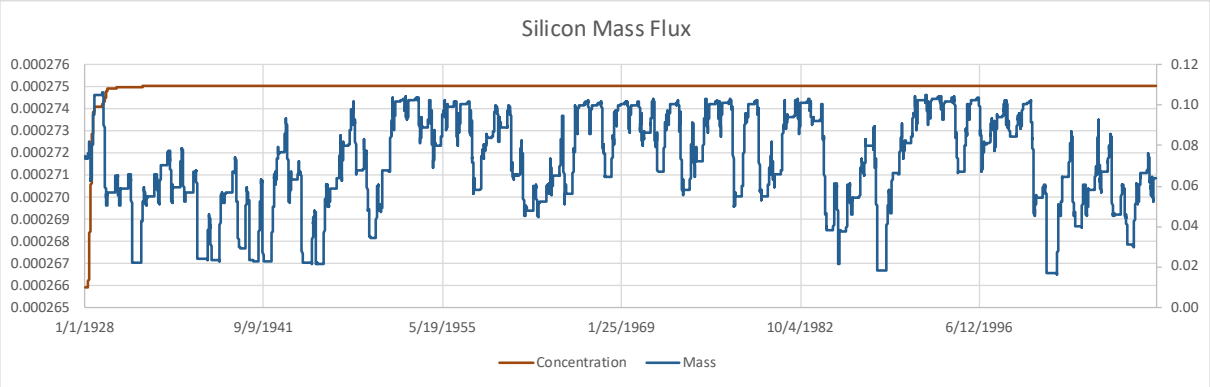


Figure 121. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

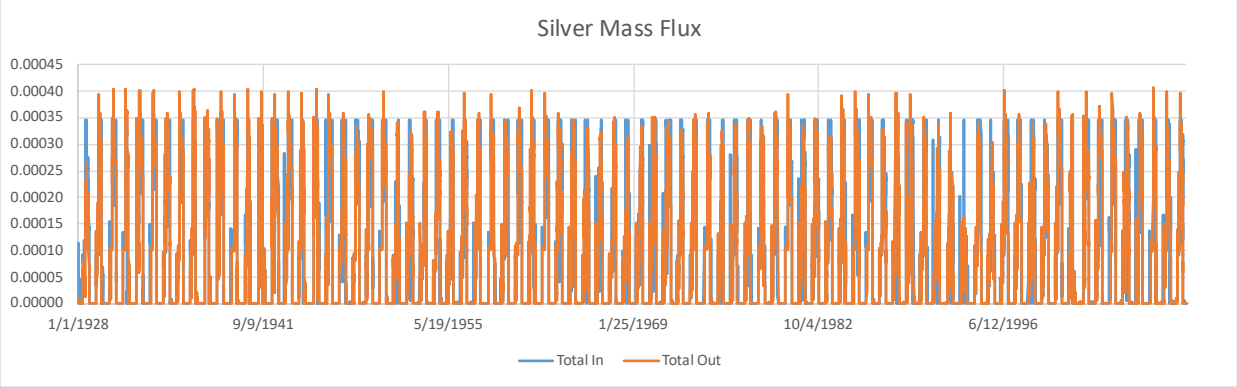


Figure 122. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

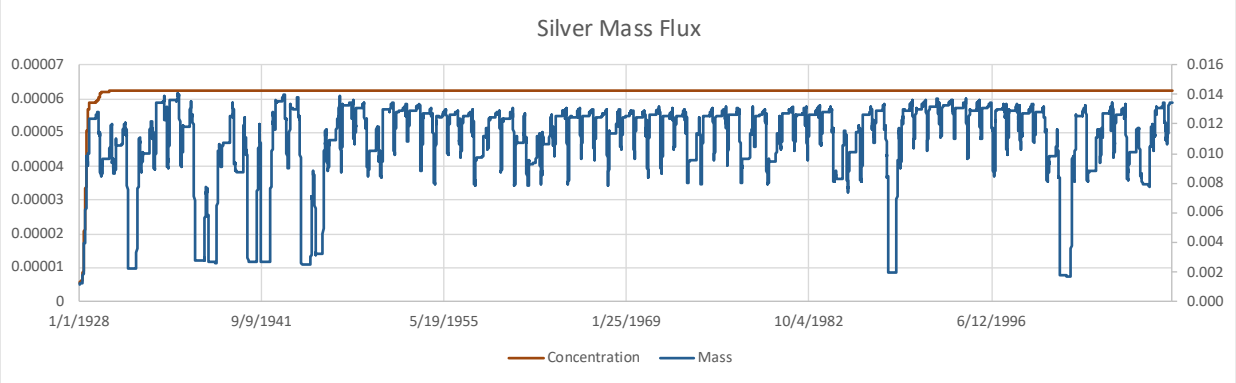


Figure 123. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

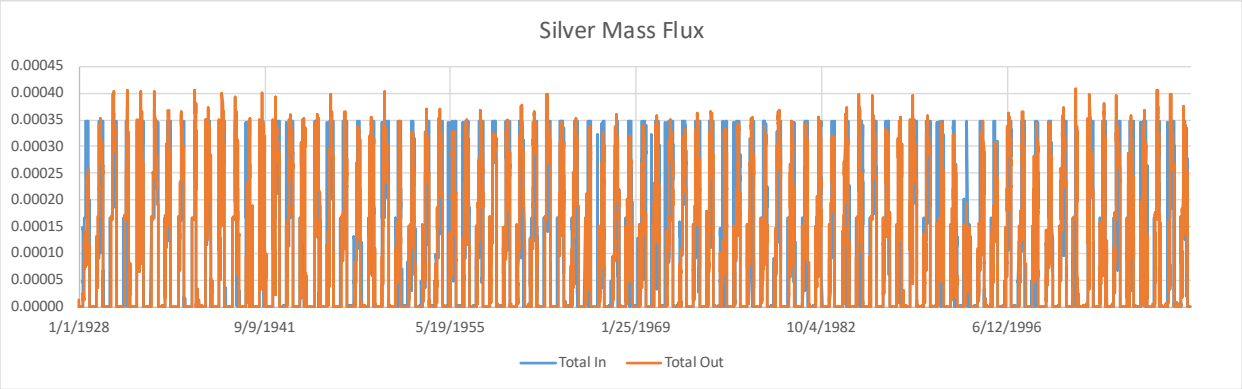


Figure 124. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

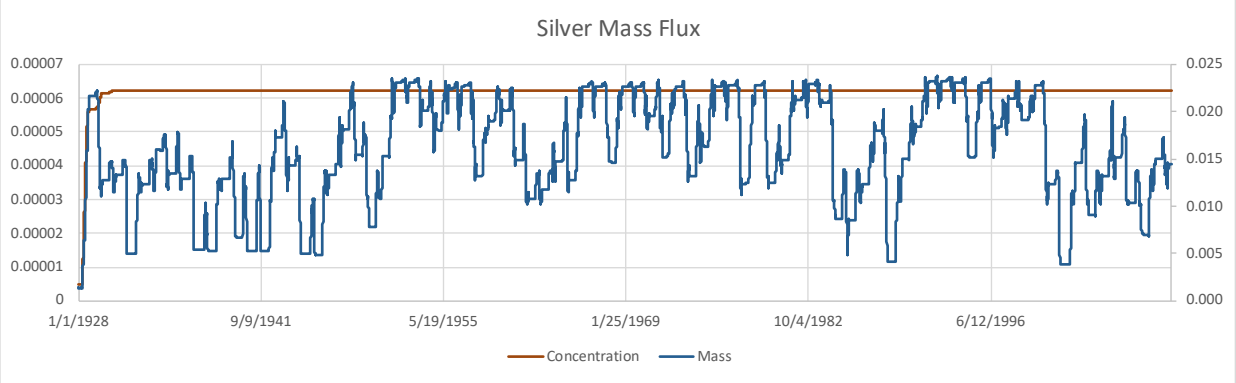


Figure 125. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

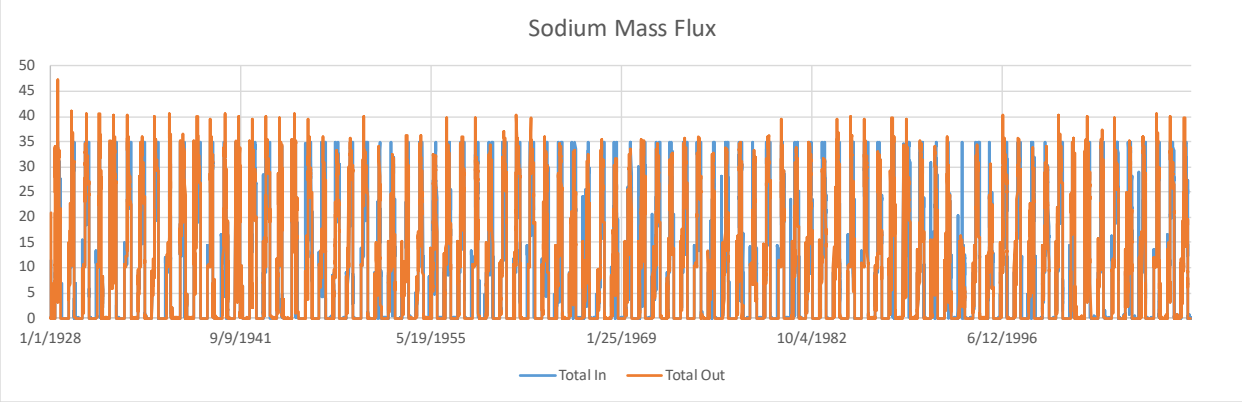


Figure 126. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

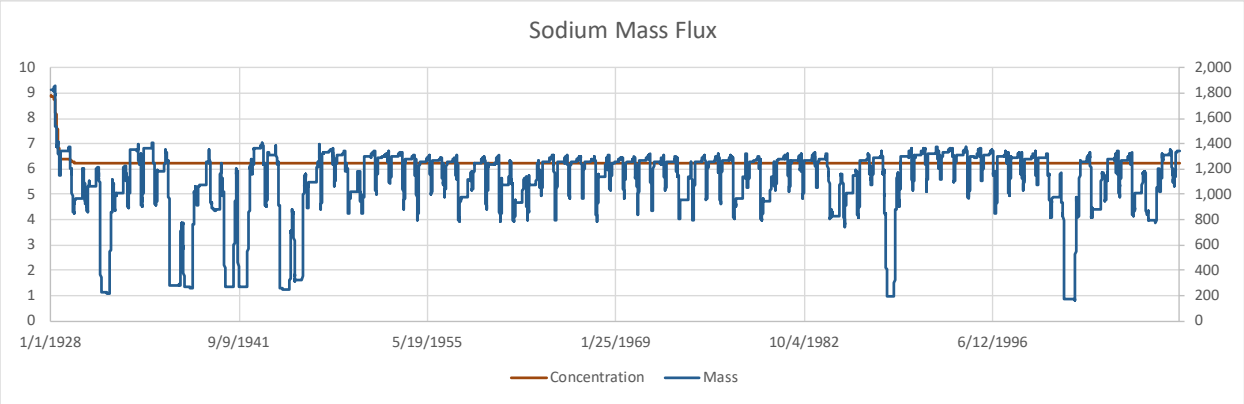


Figure 127. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

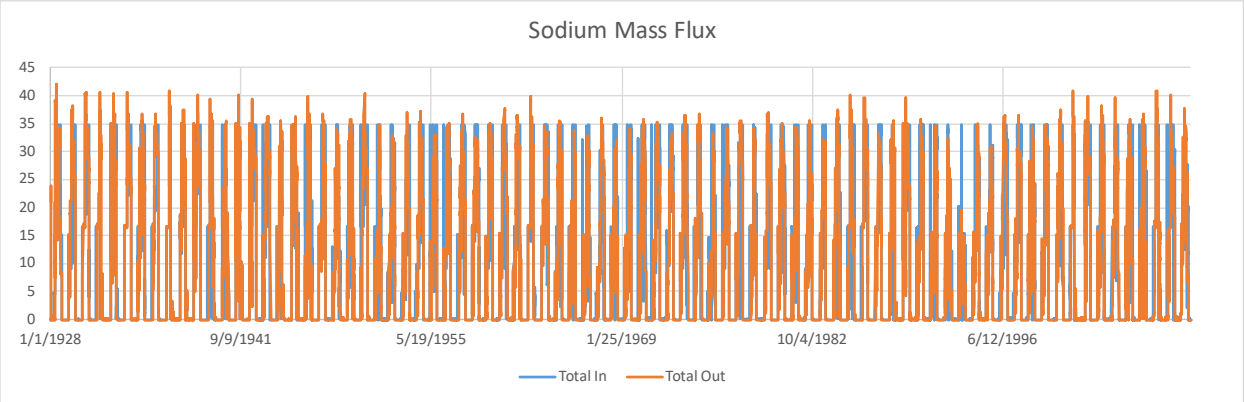


Figure 128. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

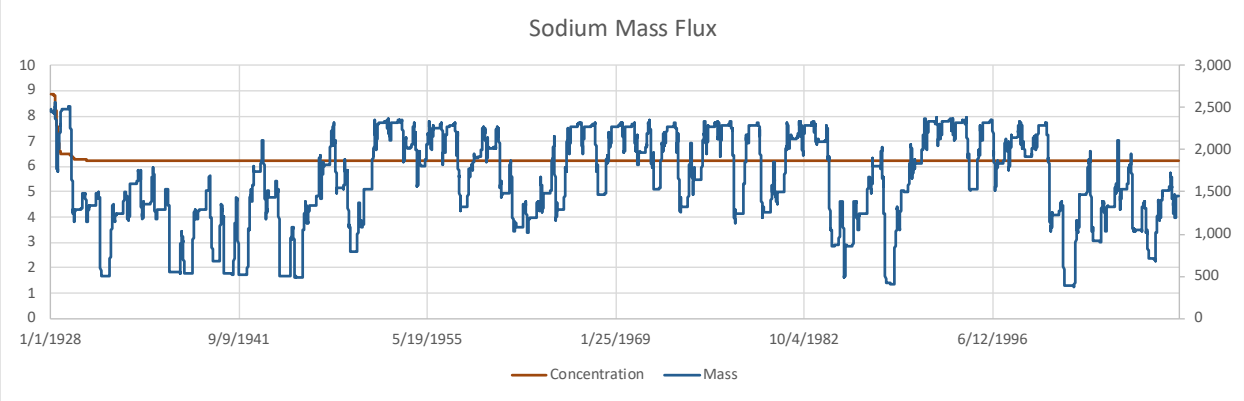


Figure 129. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

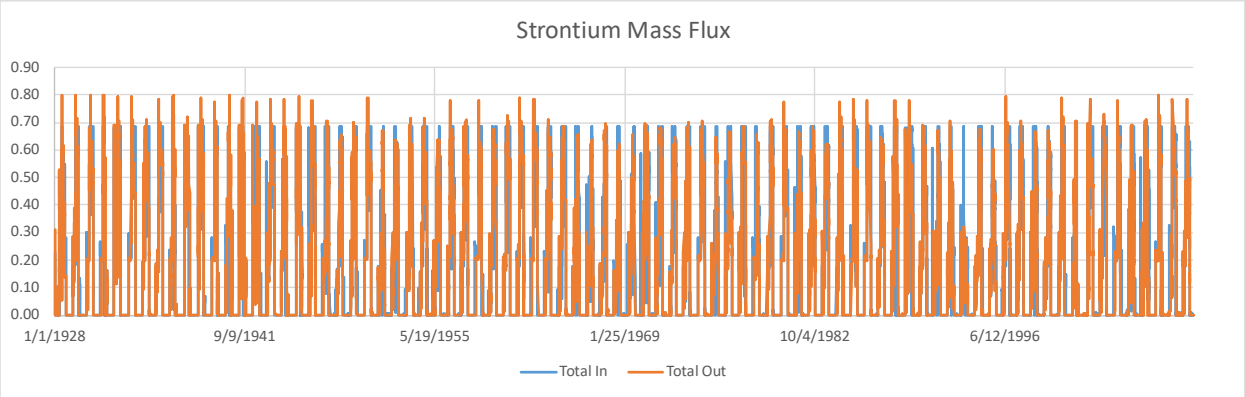


Figure 130. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

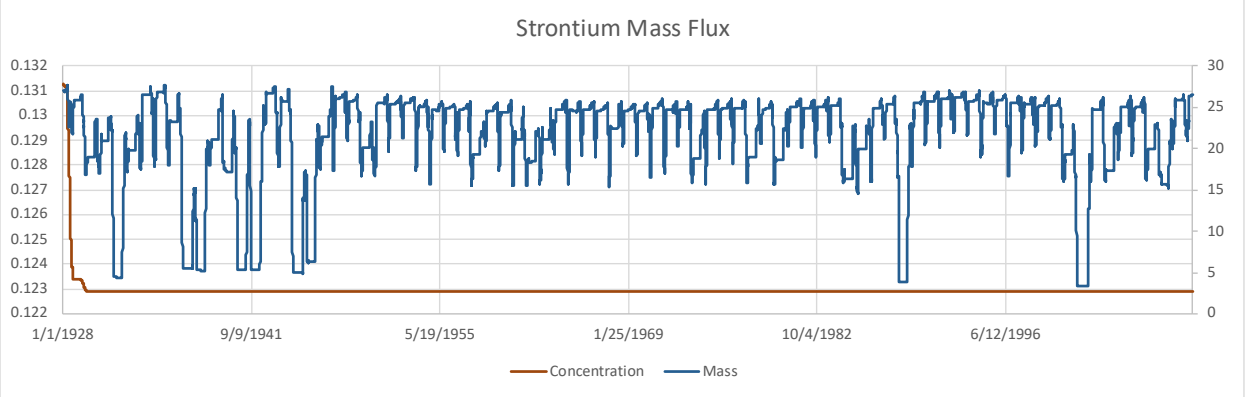


Figure 131. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

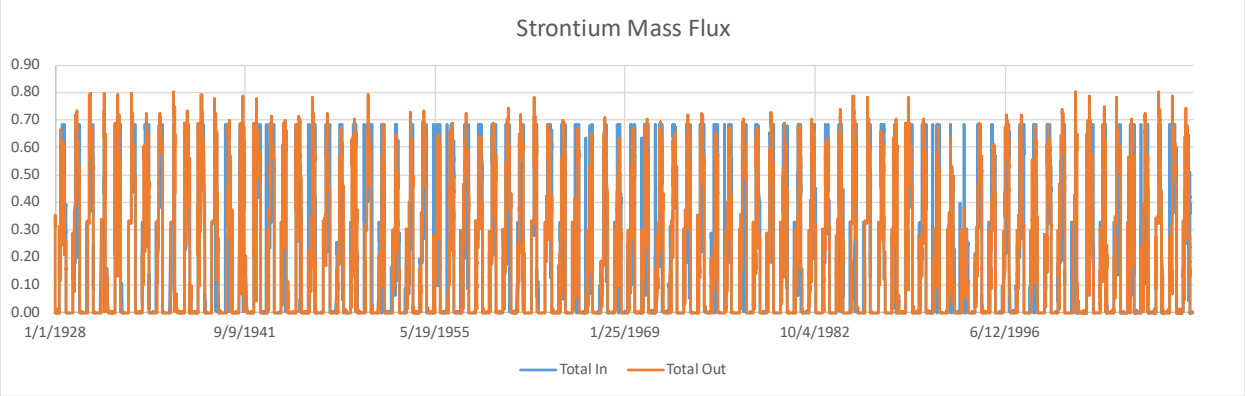


Figure 132. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

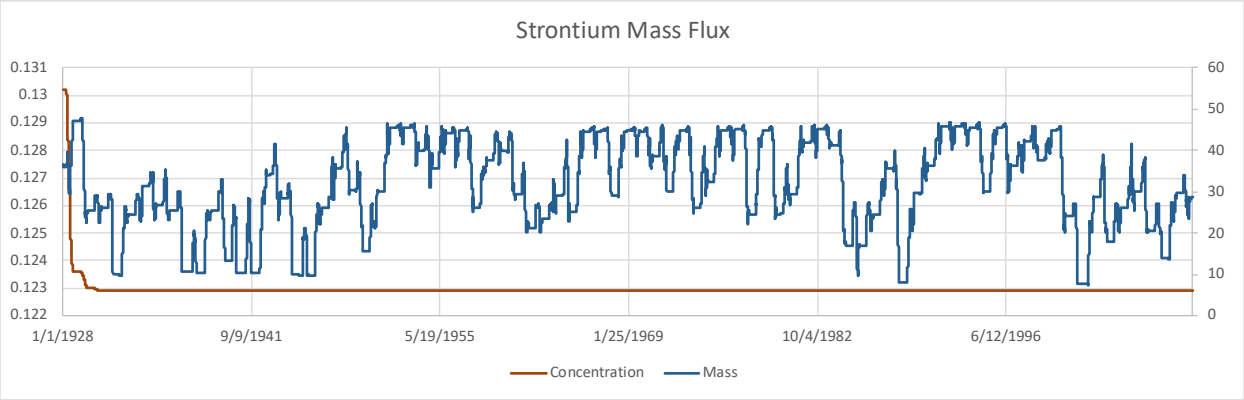


Figure 133. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

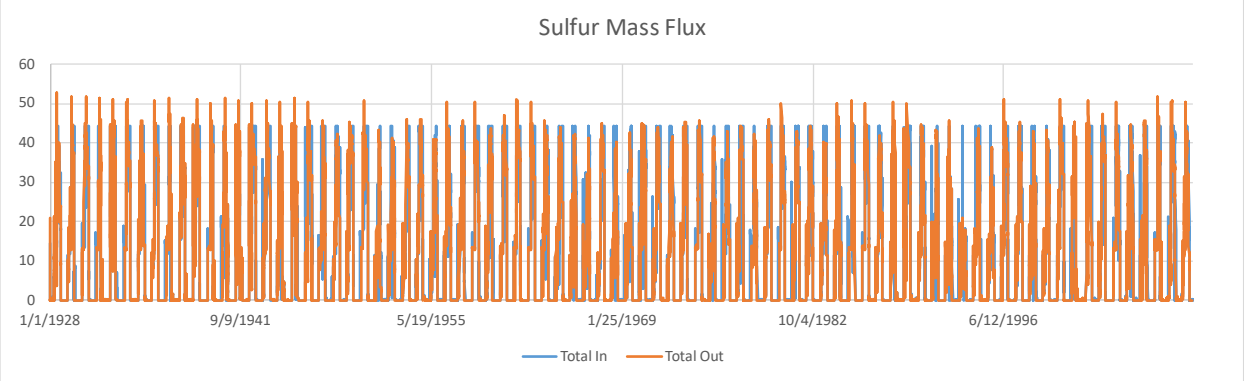


Figure 134. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

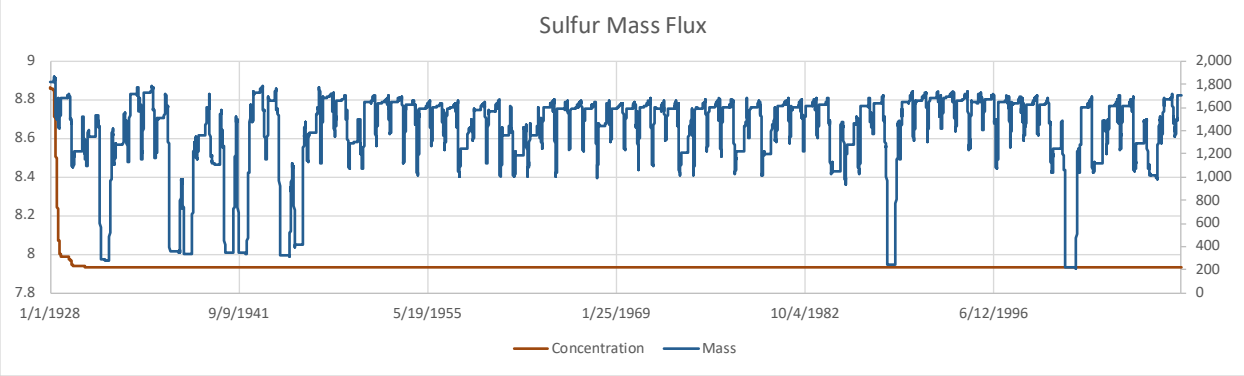


Figure 135. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

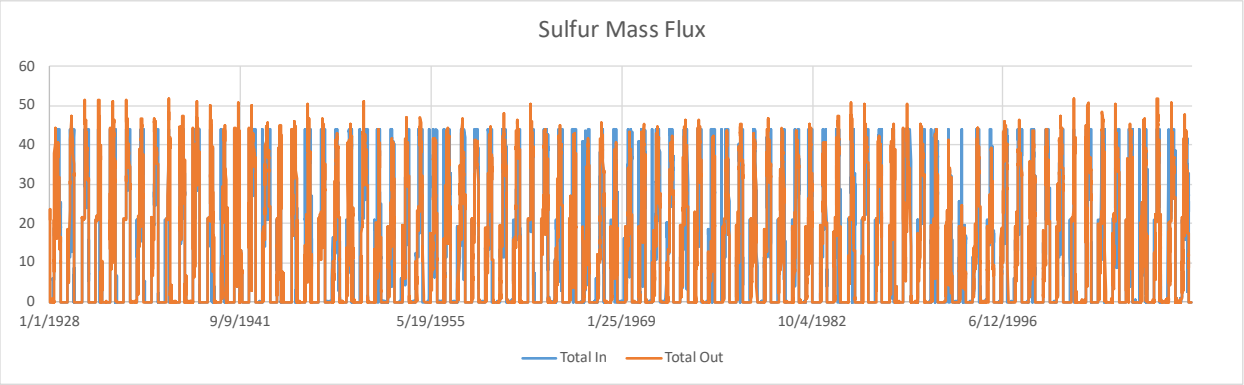


Figure 136. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

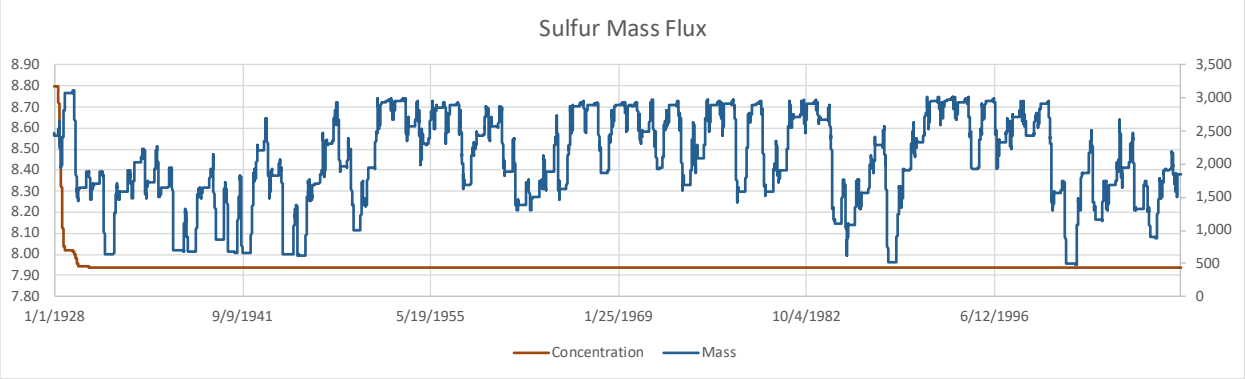


Figure 137. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

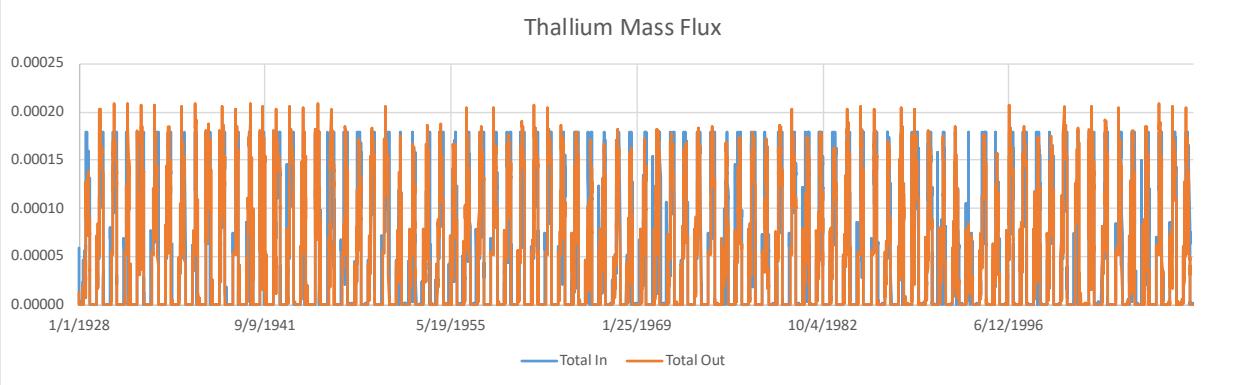


Figure 138. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

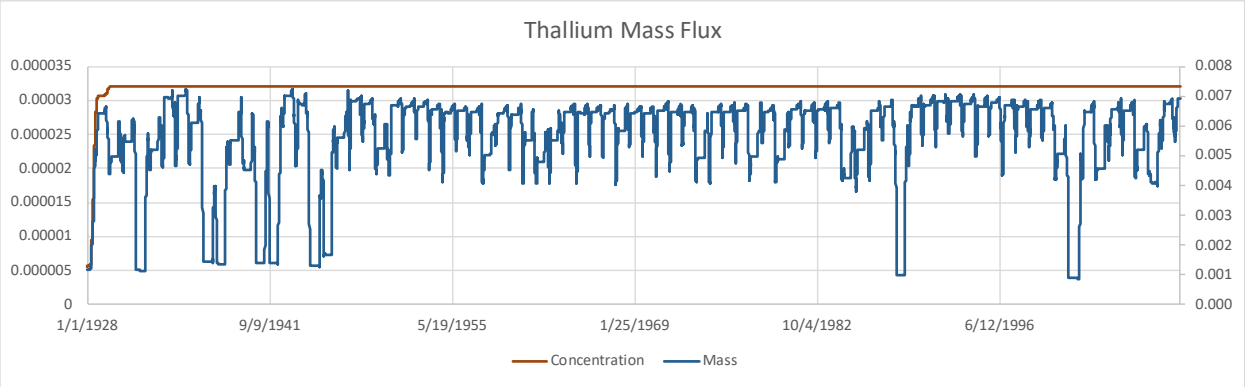


Figure 139. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

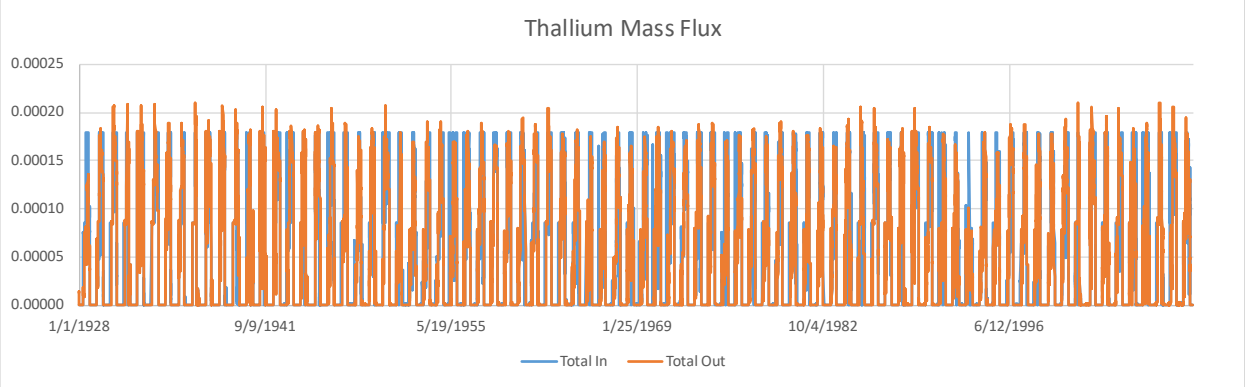


Figure 140. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

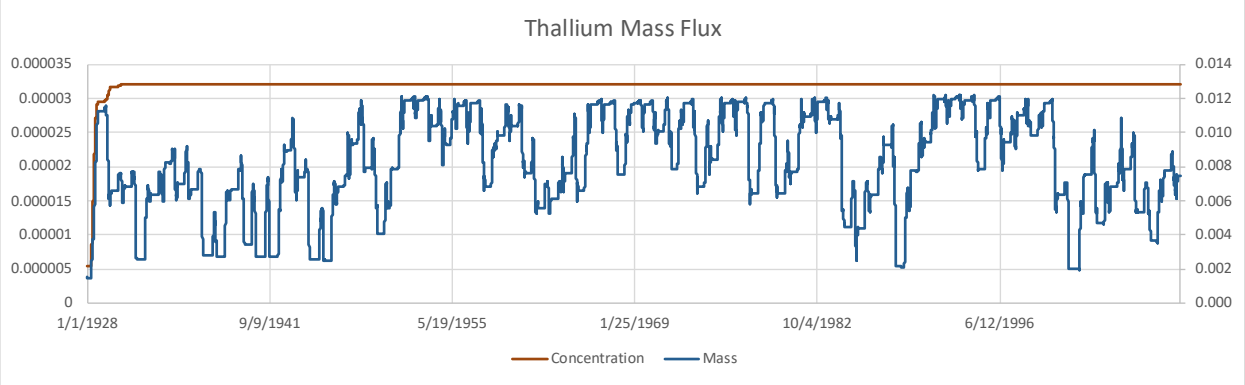


Figure 141. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

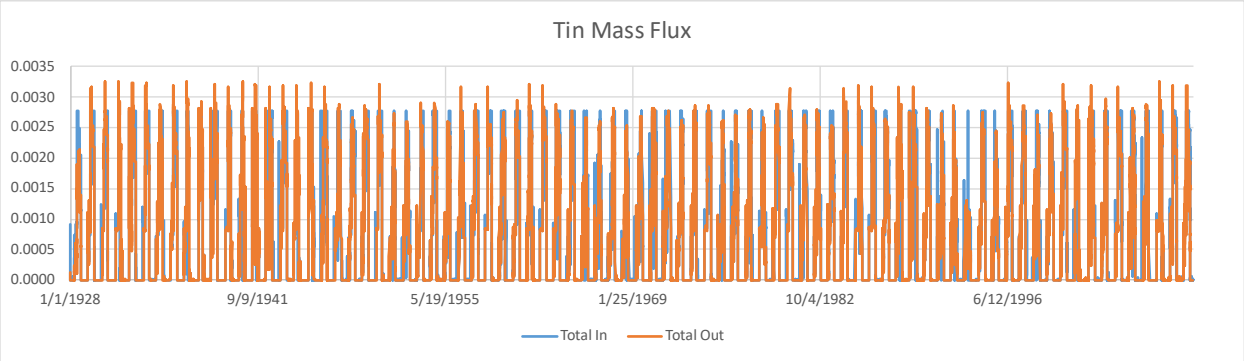


Figure 142. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

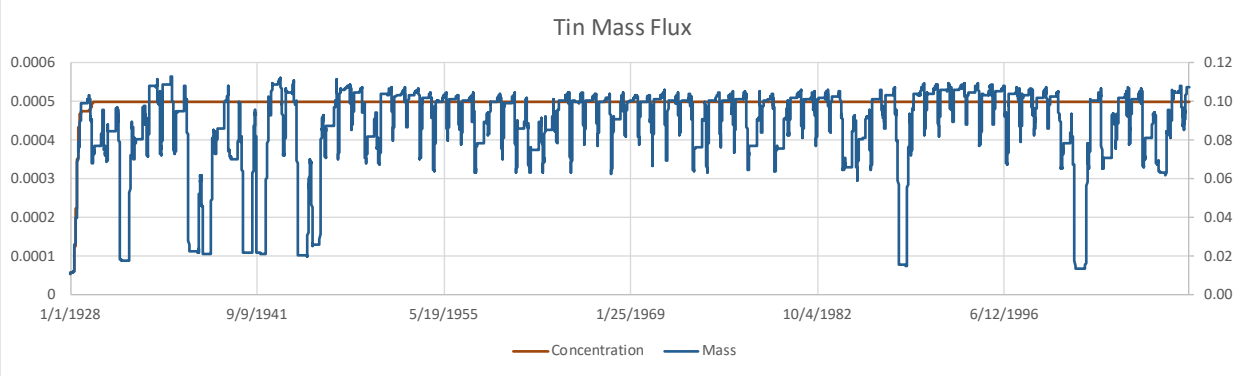


Figure 143. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

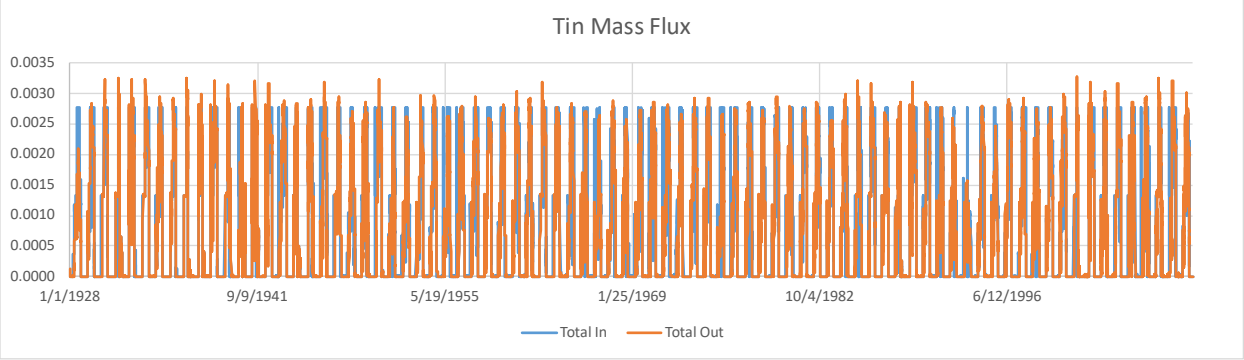


Figure 144. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

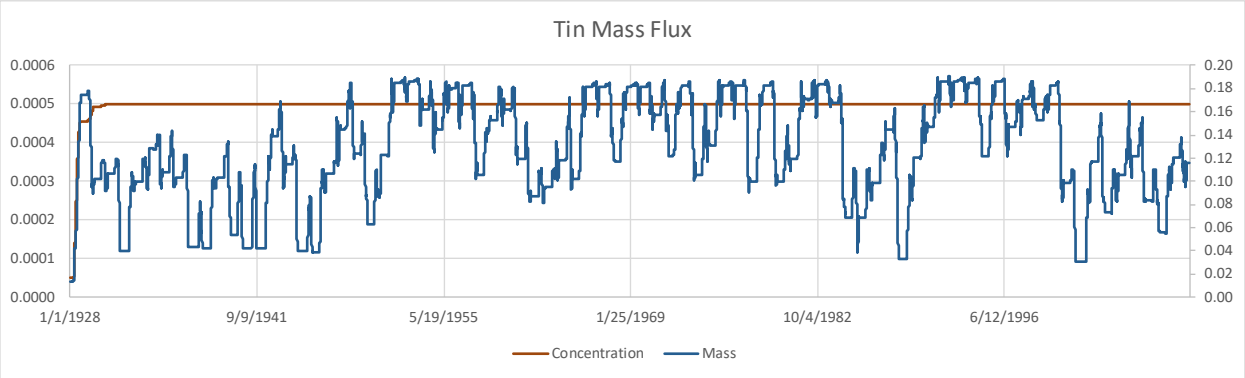


Figure 145. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

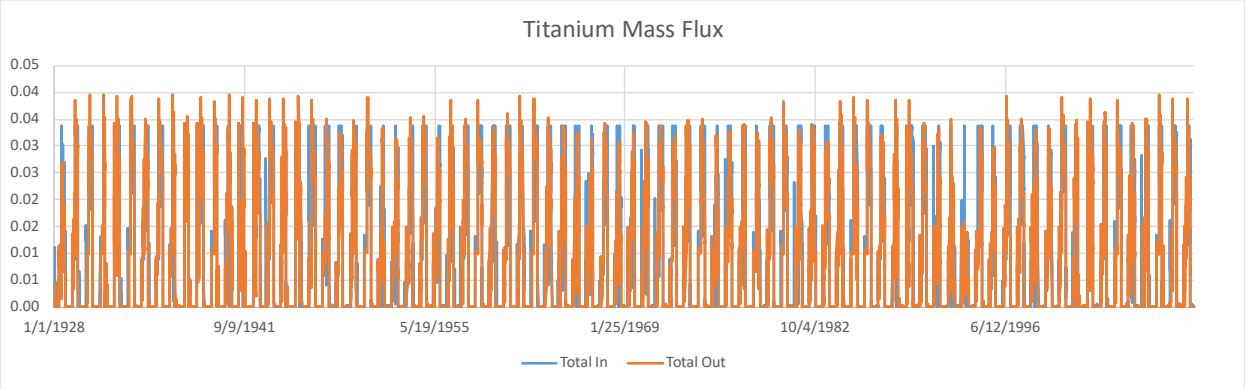


Figure 146. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

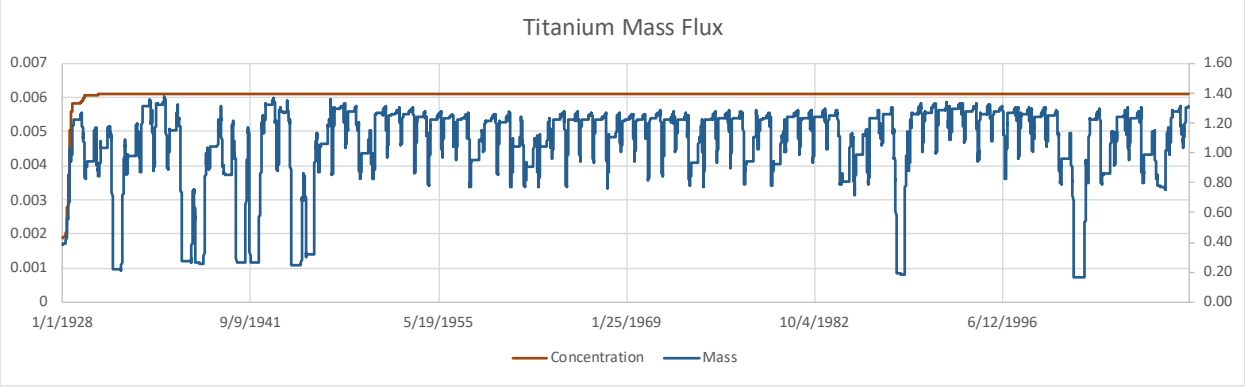


Figure 147. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

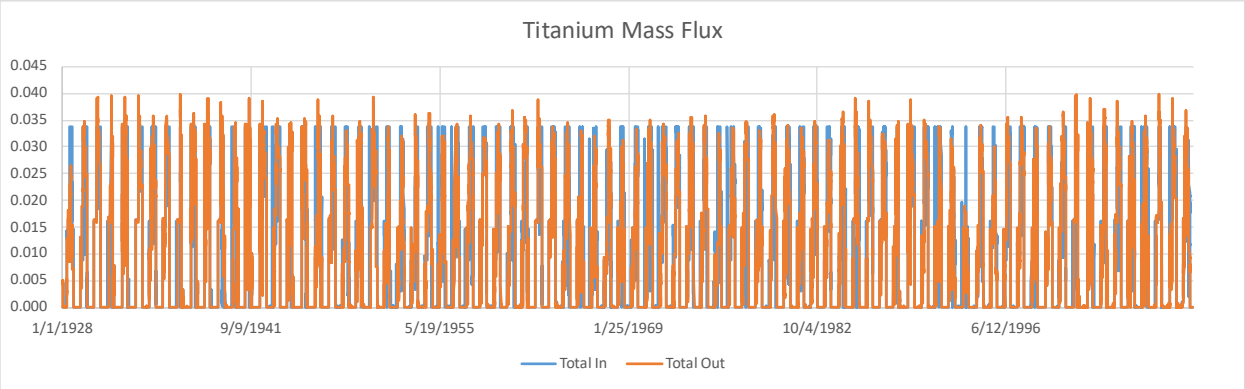


Figure 148. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

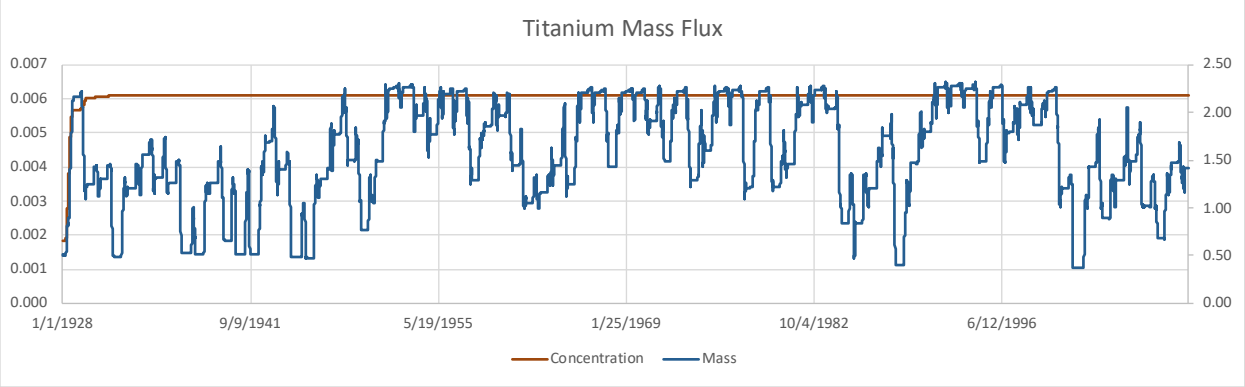


Figure 149. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

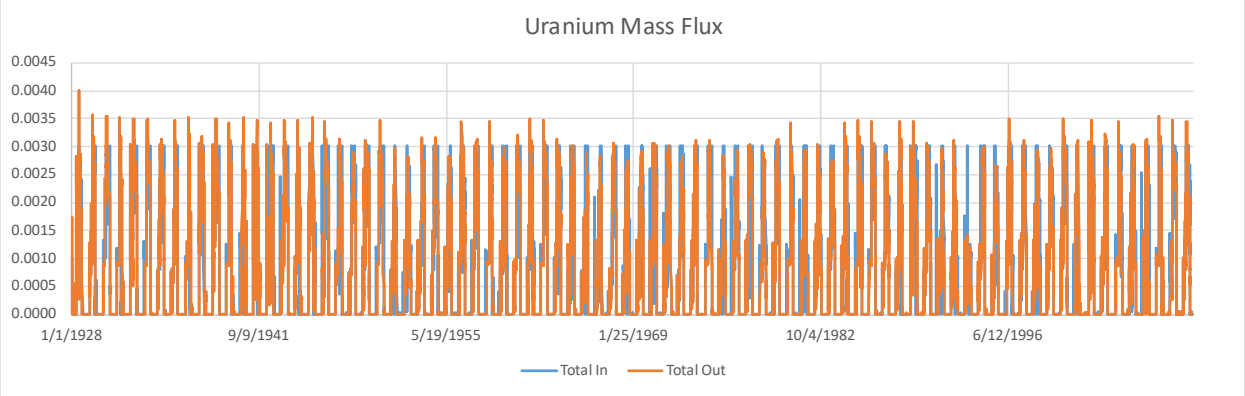


Figure 150. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

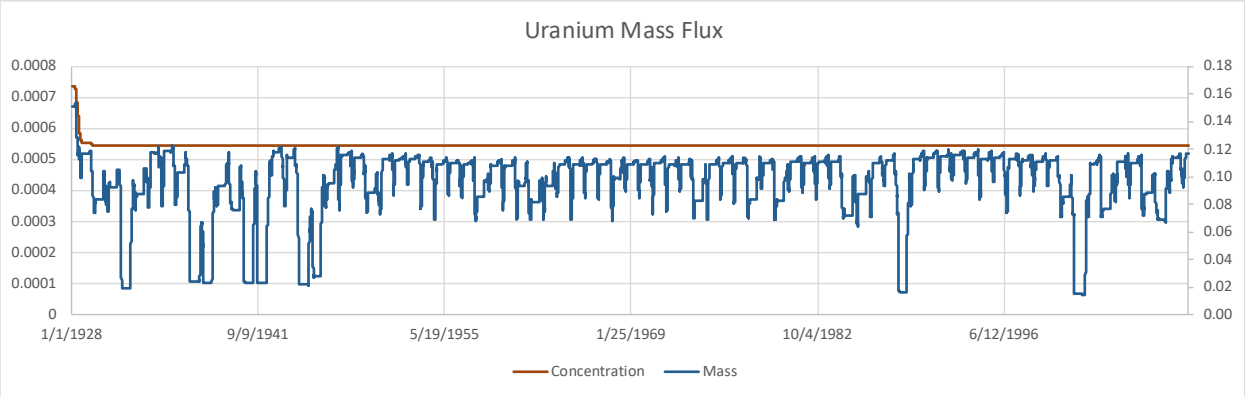


Figure 151. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

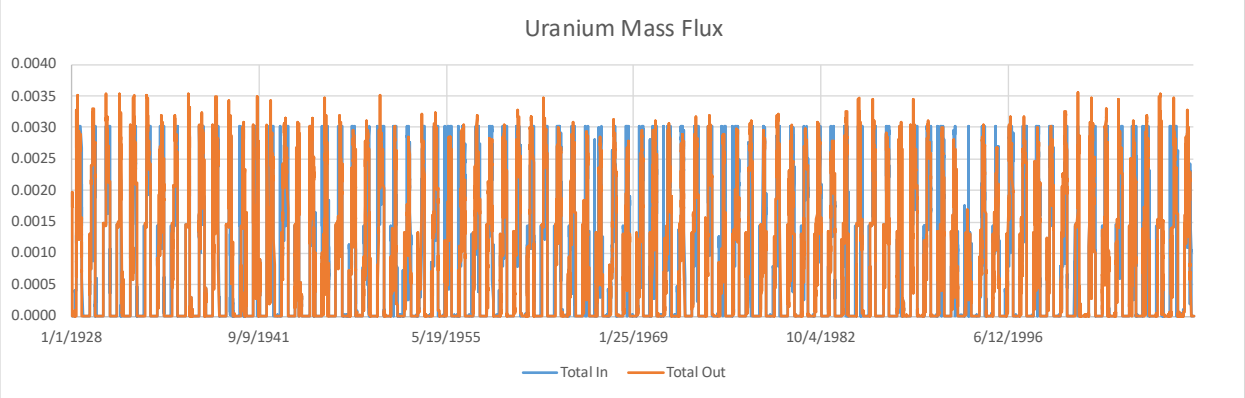


Figure 152. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

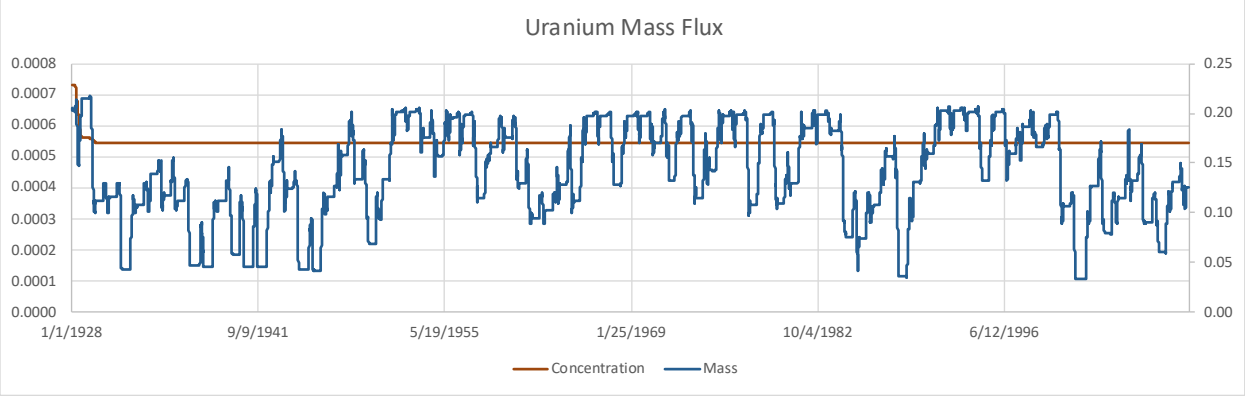


Figure 153. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

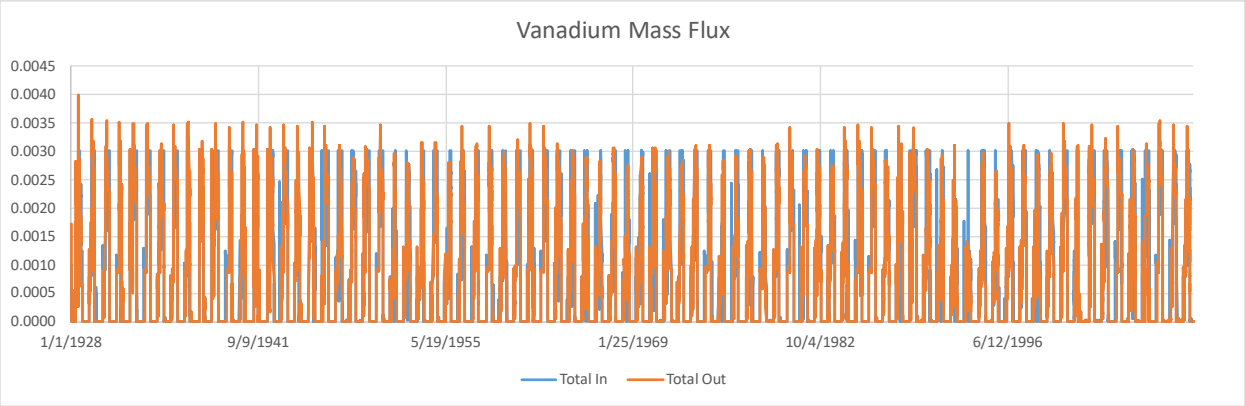


Figure 154. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

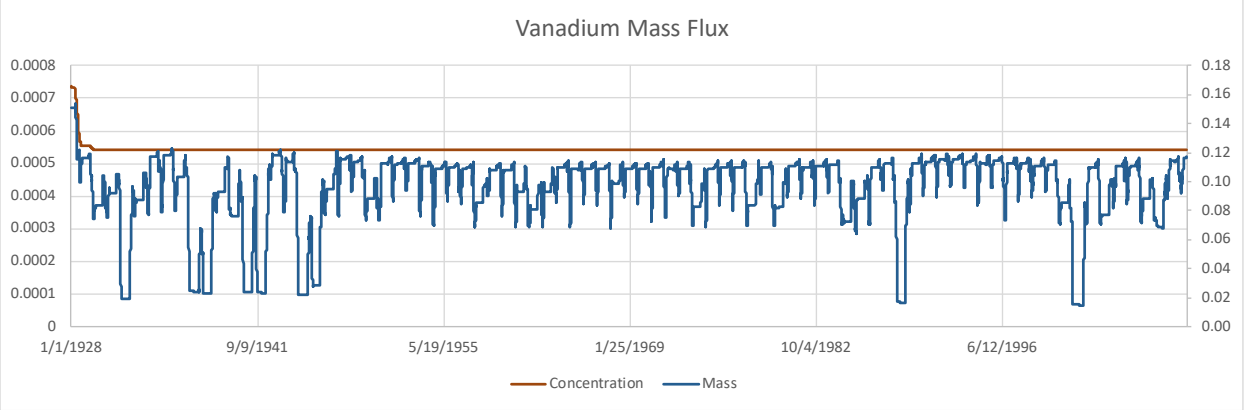


Figure 155. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

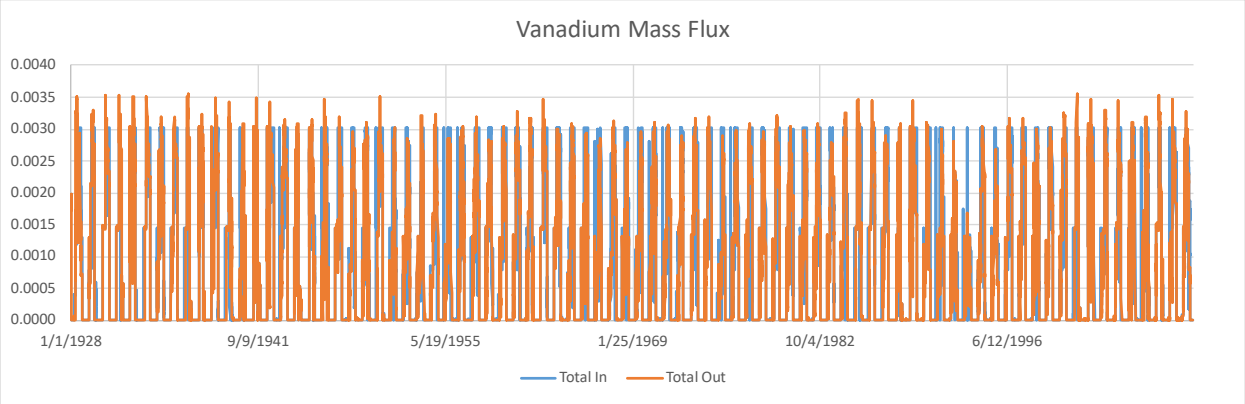


Figure 156. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

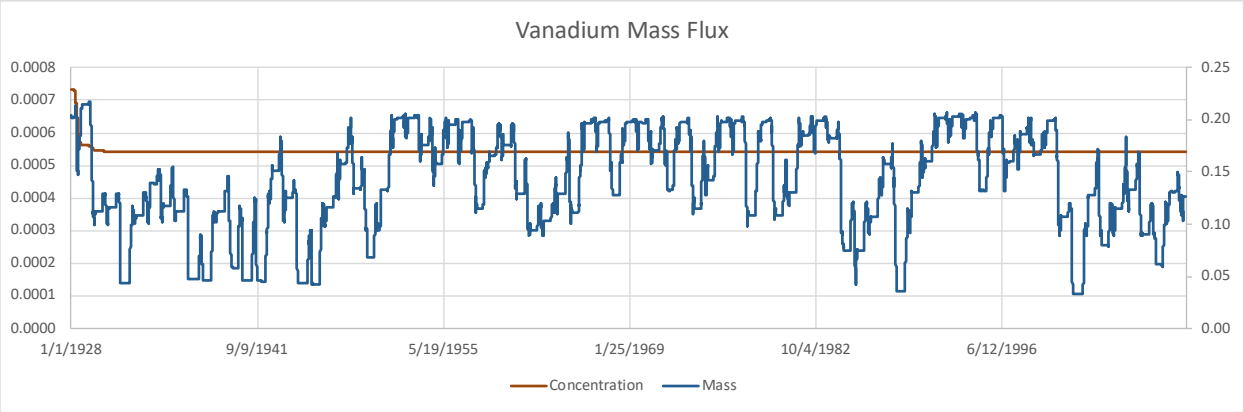


Figure 157. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

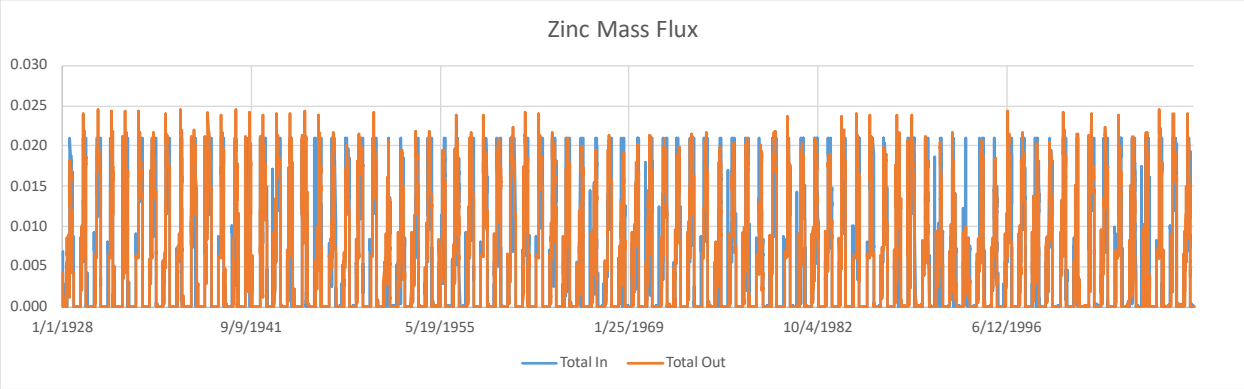


Figure 158. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

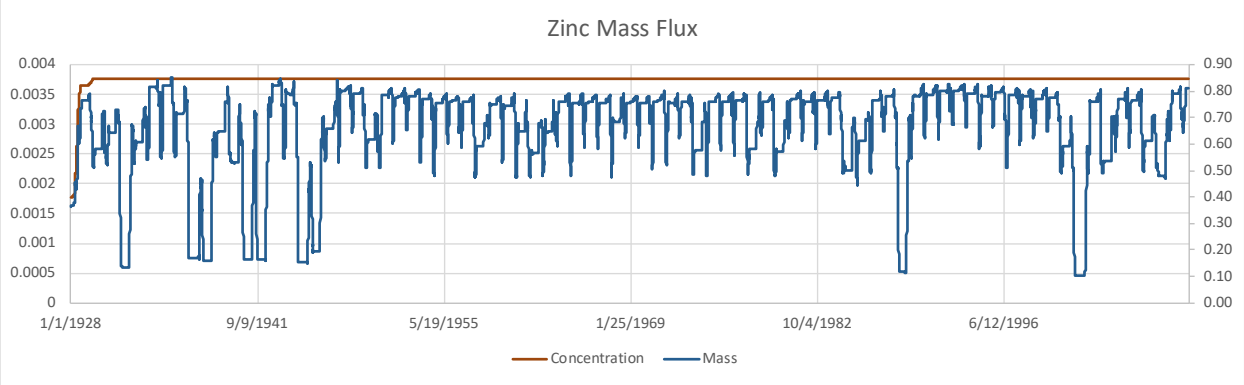


Figure 159. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

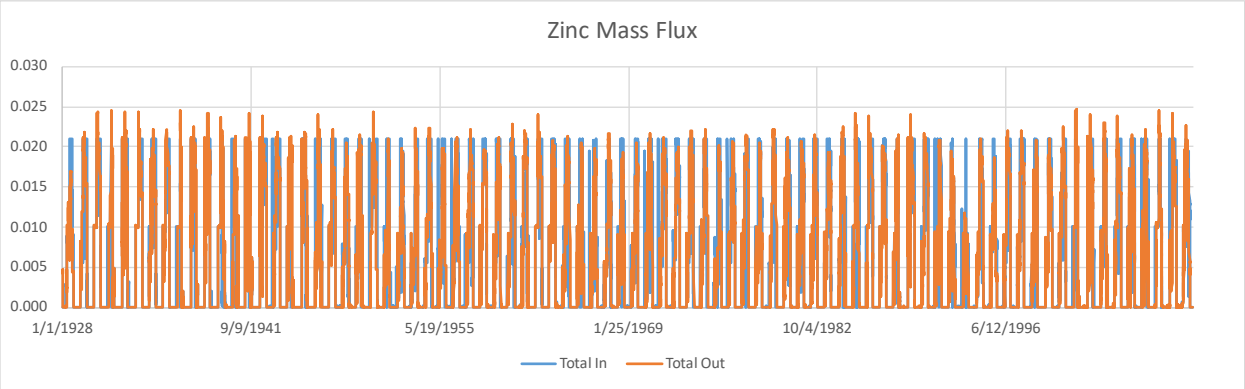


Figure 160. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

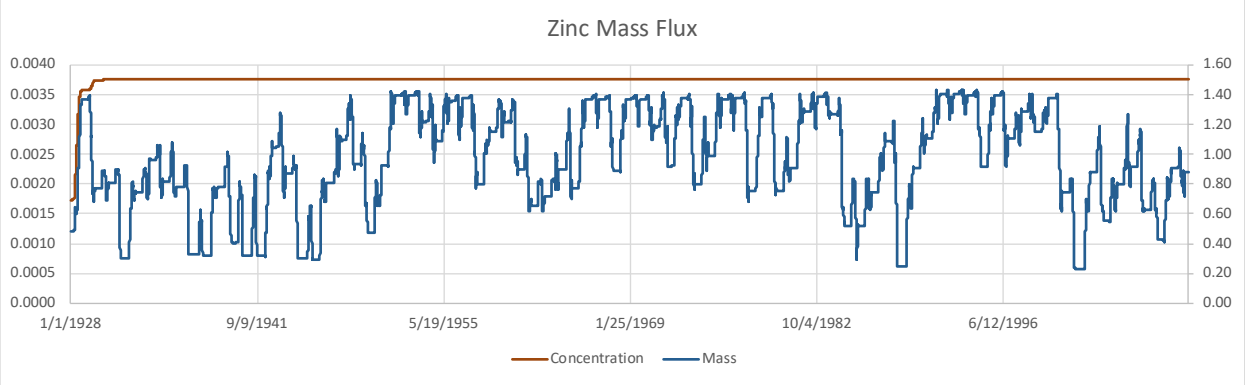


Figure 161. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

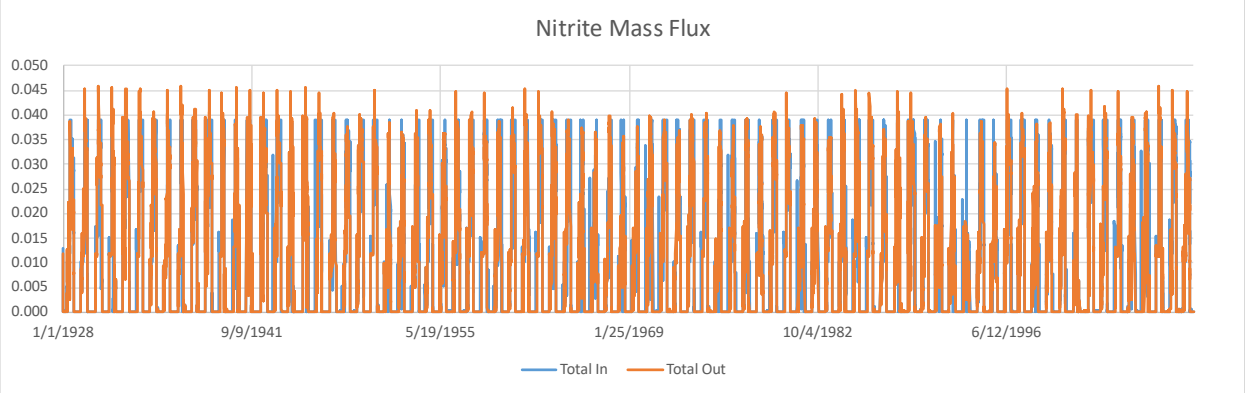


Figure 162. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

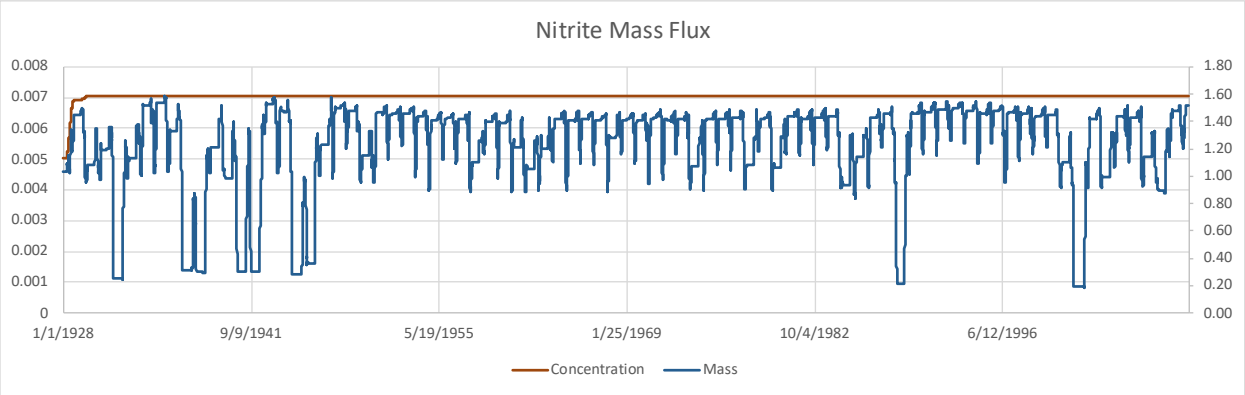


Figure 163. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

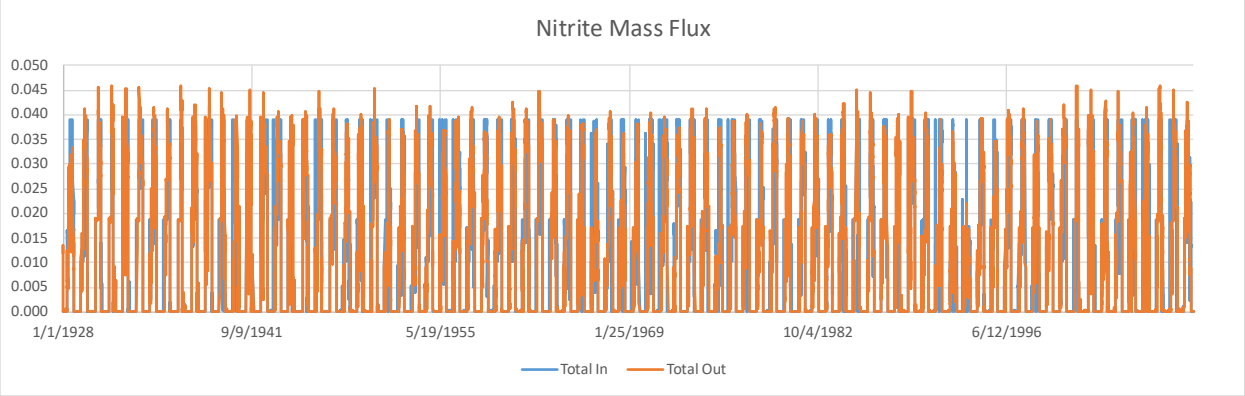


Figure 164. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

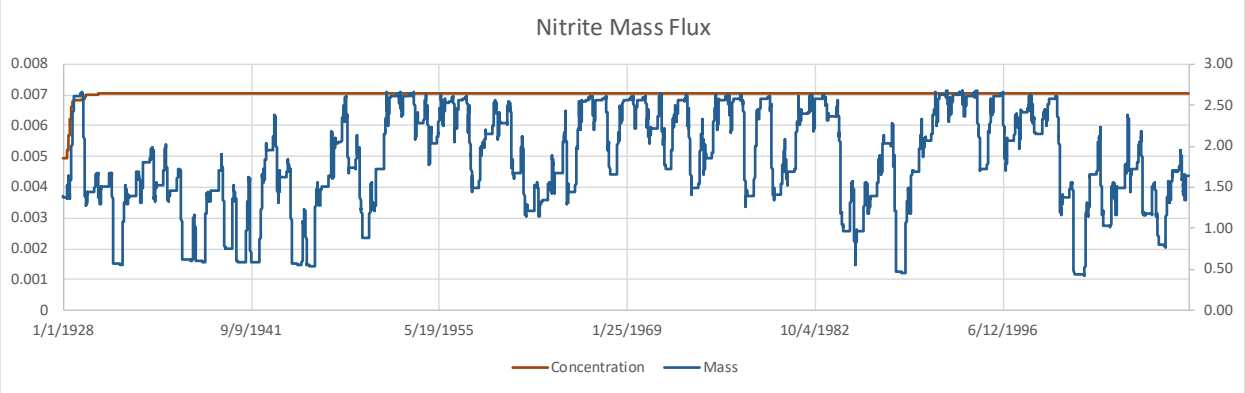


Figure 165. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

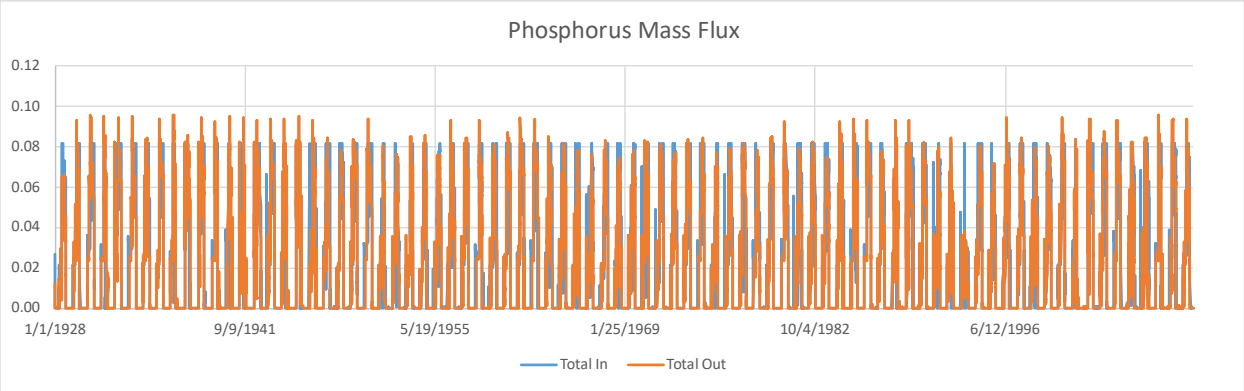


Figure 166. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

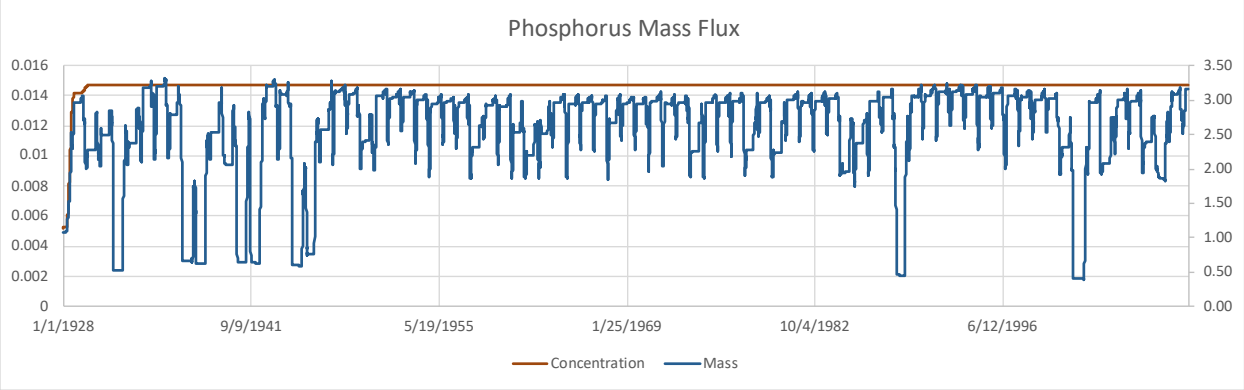


Figure 167. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

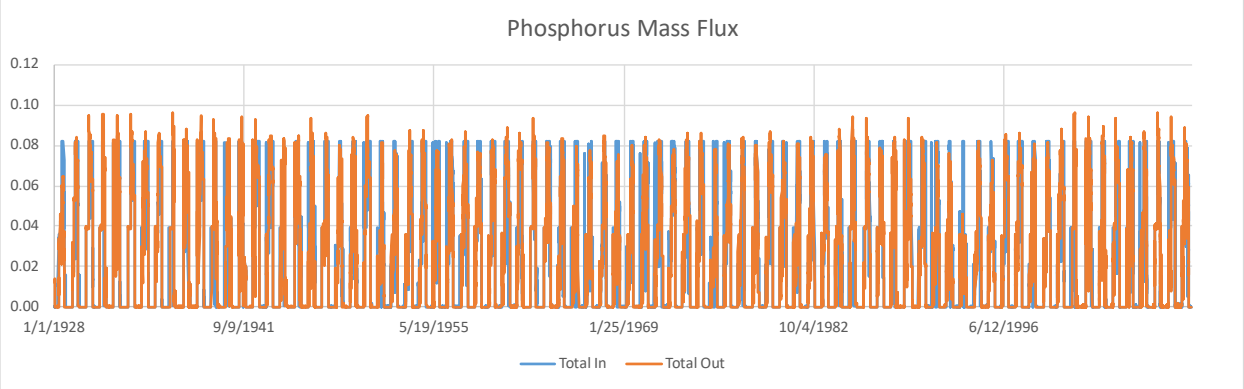


Figure 168. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

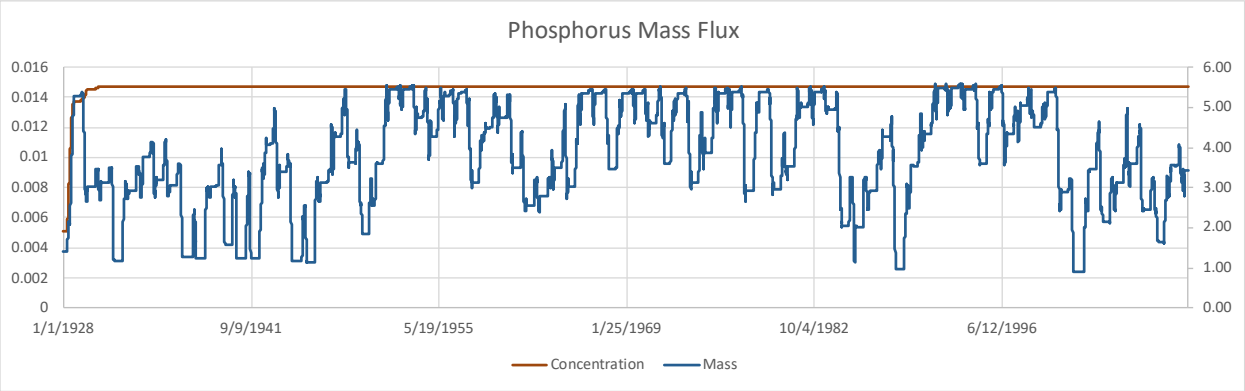


Figure 169. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

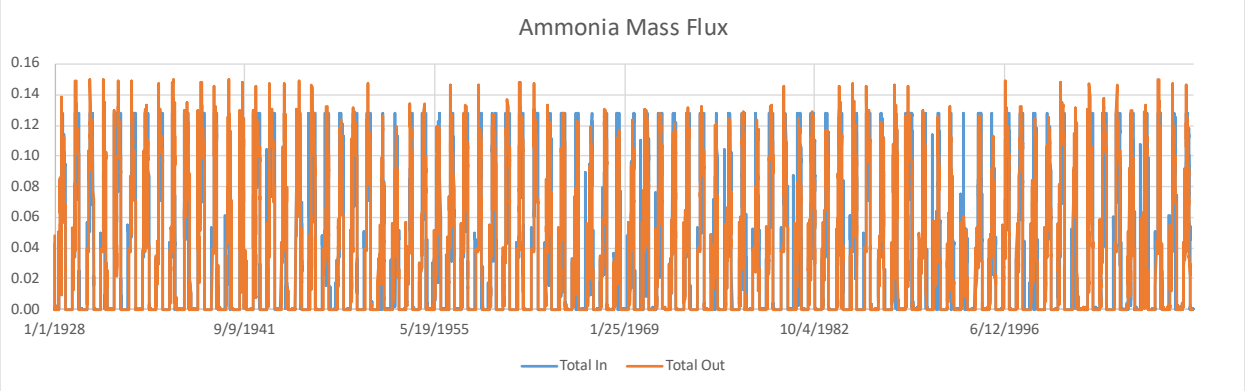


Figure 170. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

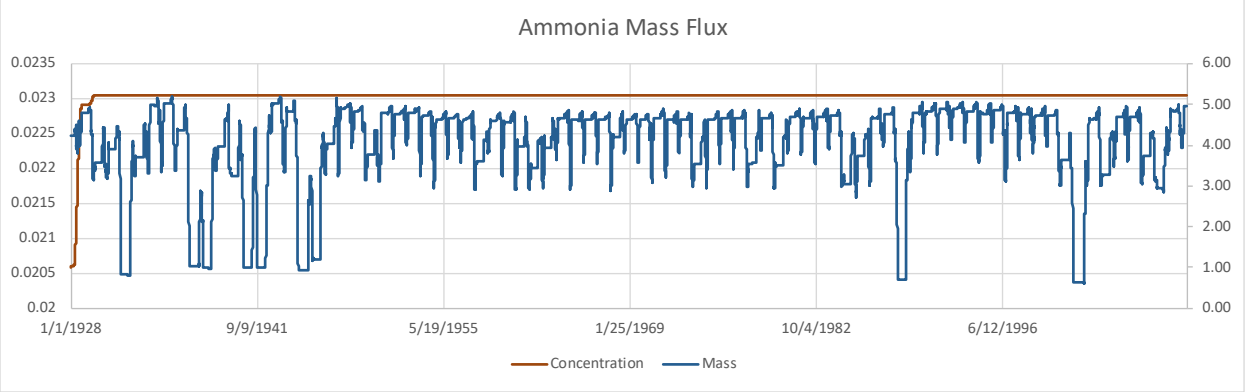


Figure 171. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

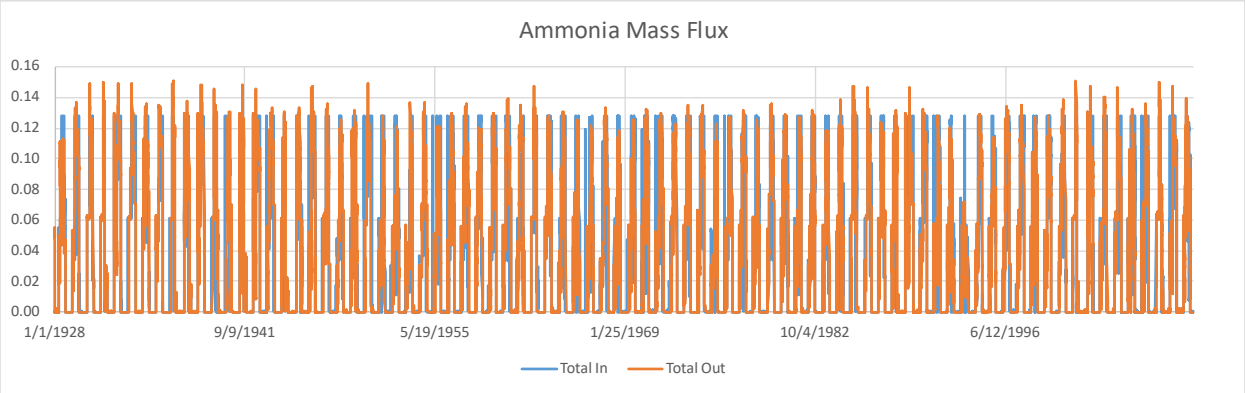


Figure 172. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

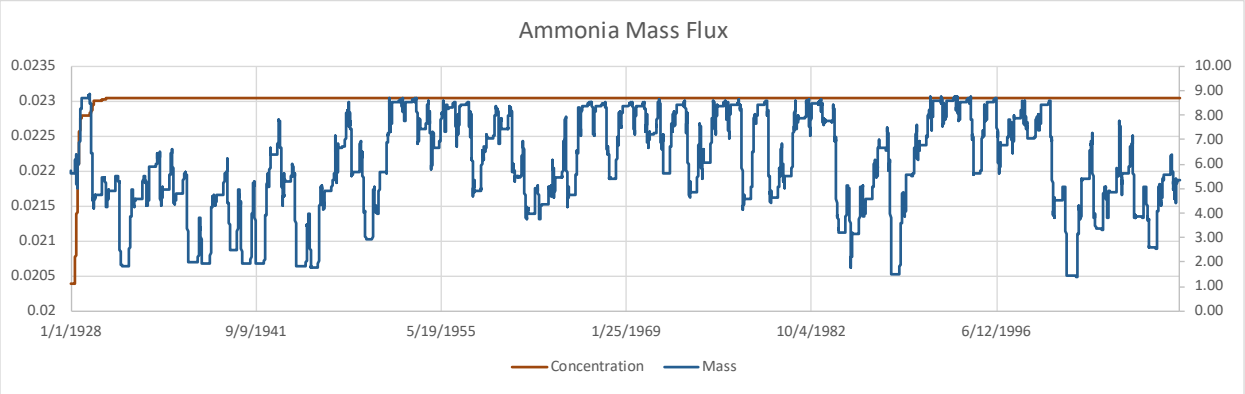


Figure 173. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

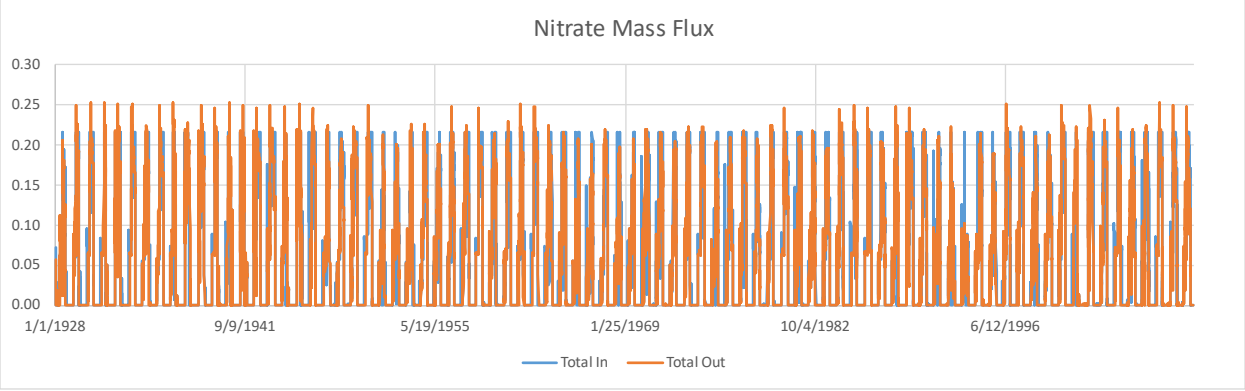


Figure 174. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

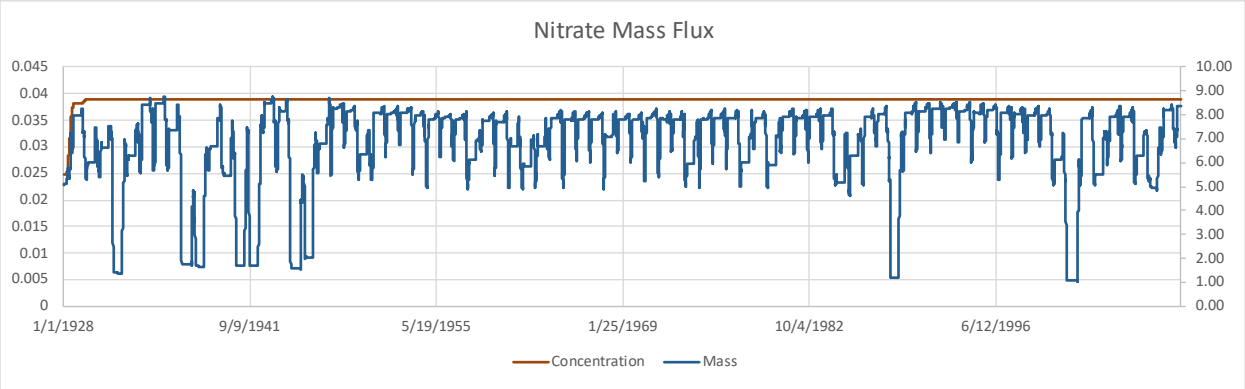


Figure 175. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

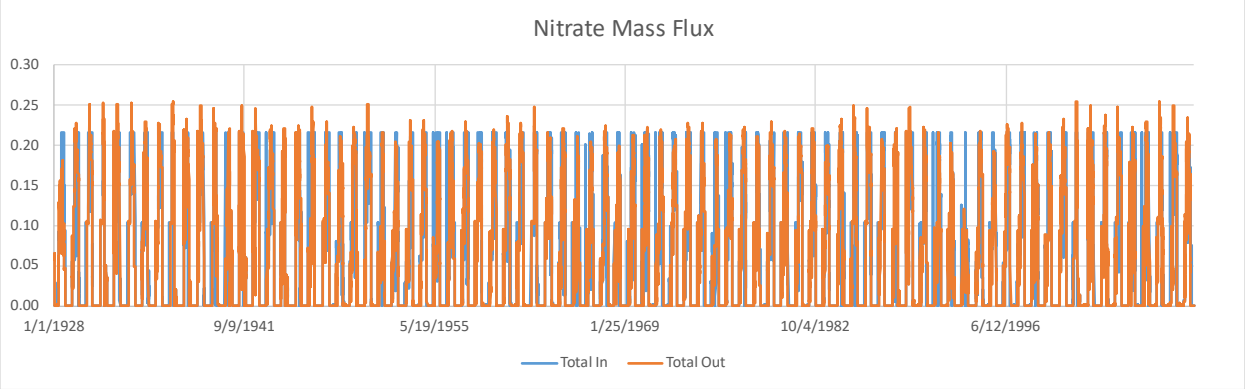


Figure 176. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

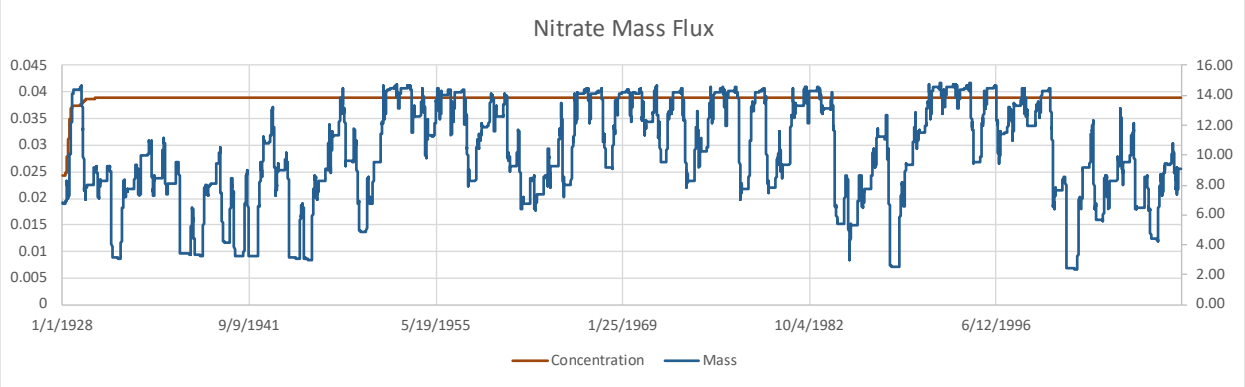


Figure 177. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

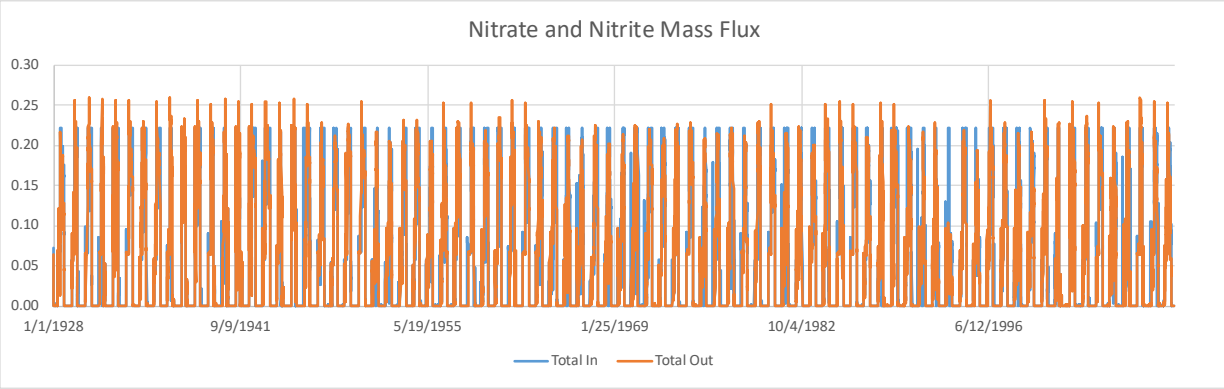


Figure 178. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

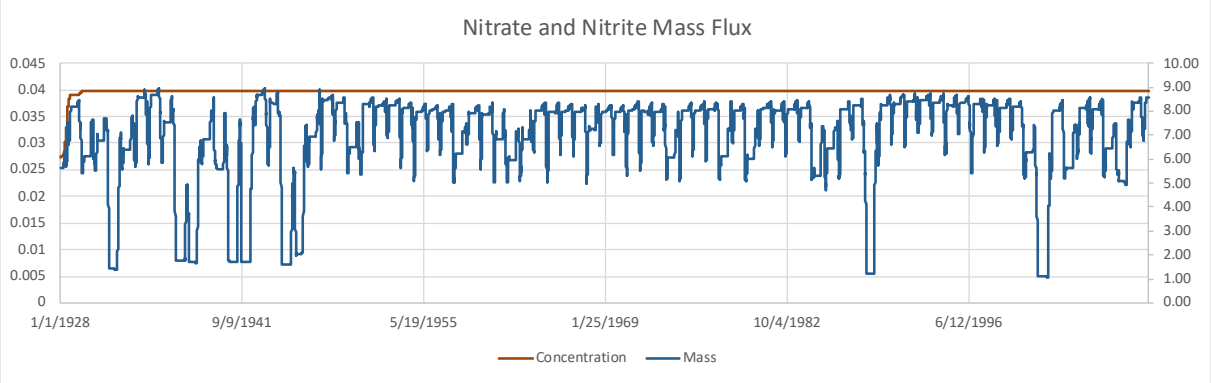


Figure 179. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

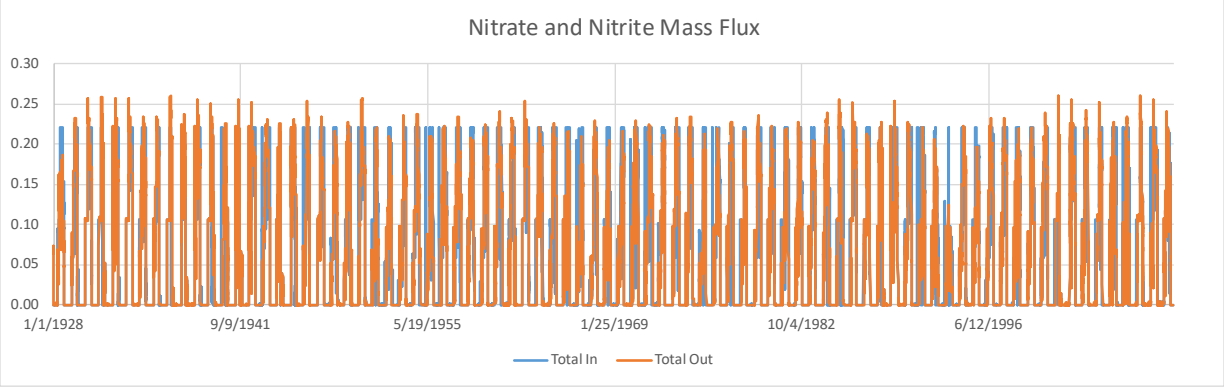


Figure 180. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

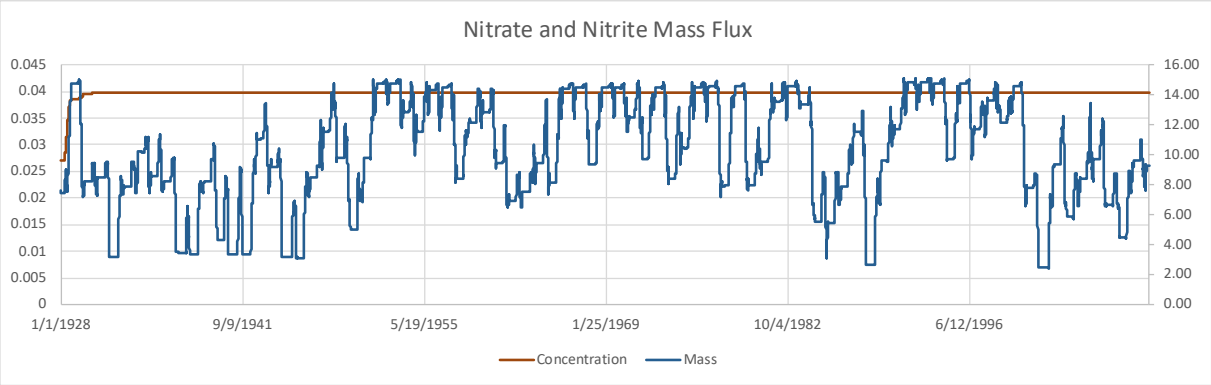


Figure 181. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

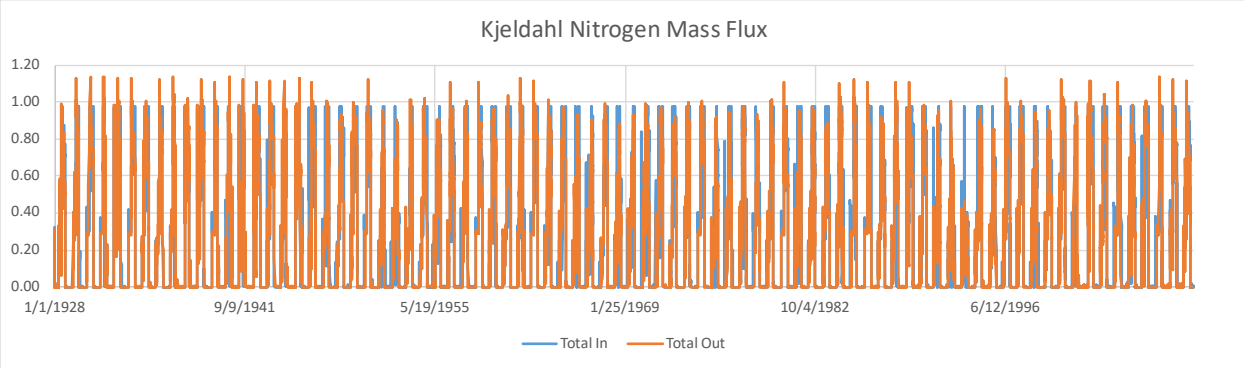


Figure 182. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

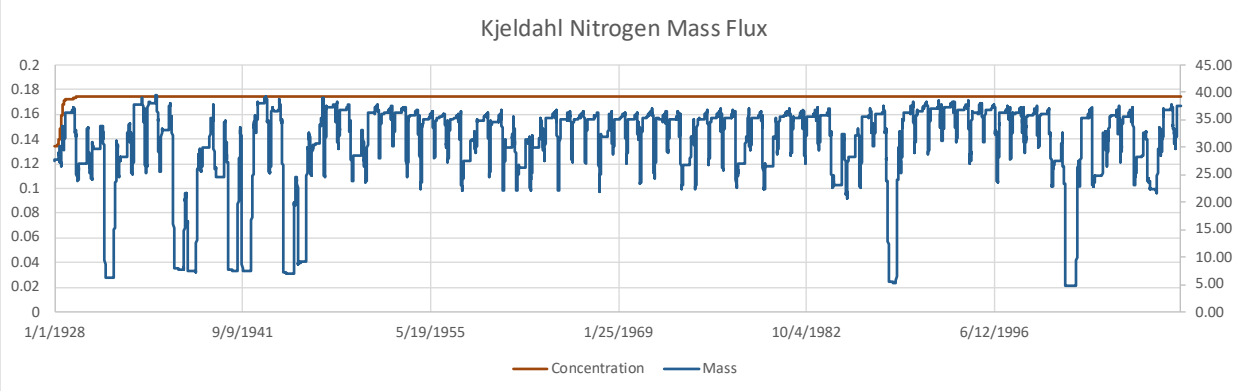


Figure 183. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

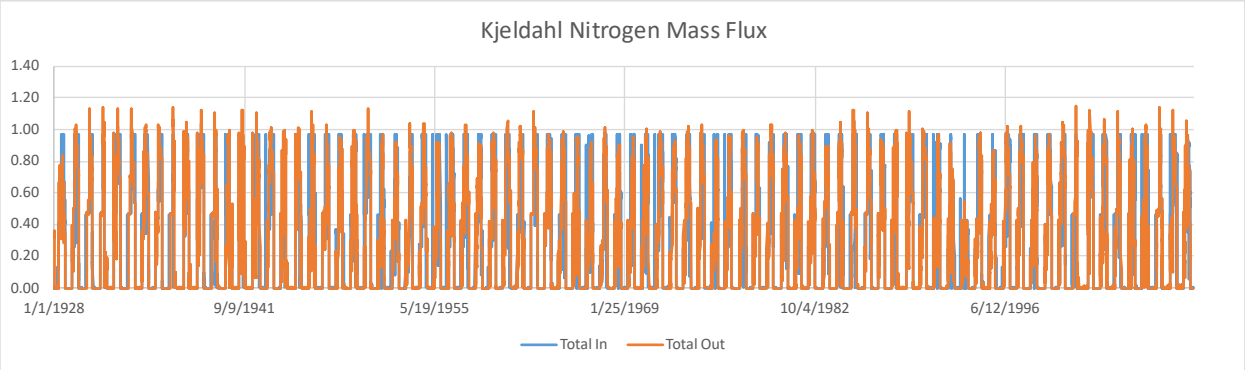


Figure 184. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

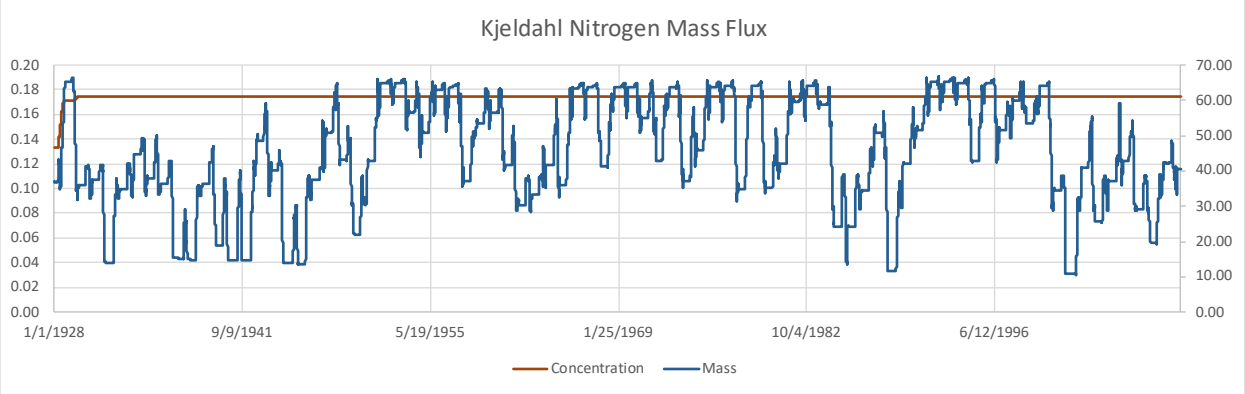


Figure 185. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

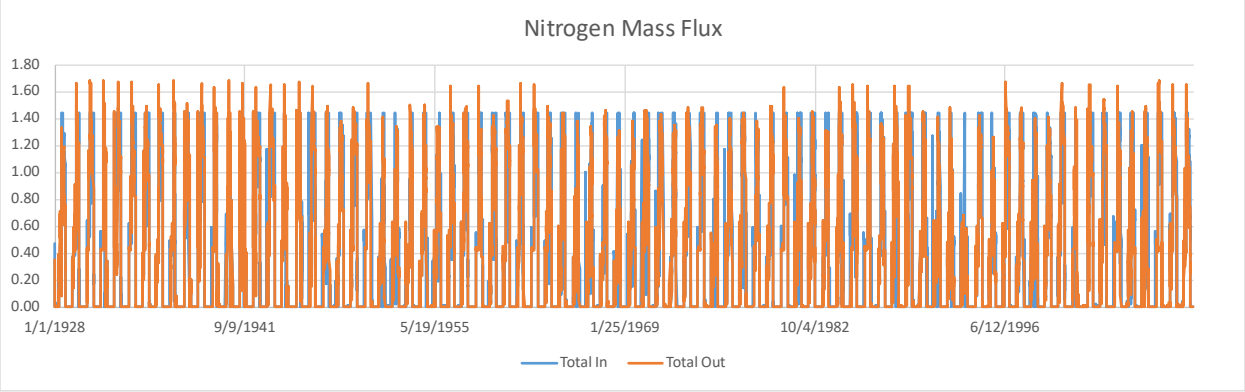


Figure 186. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

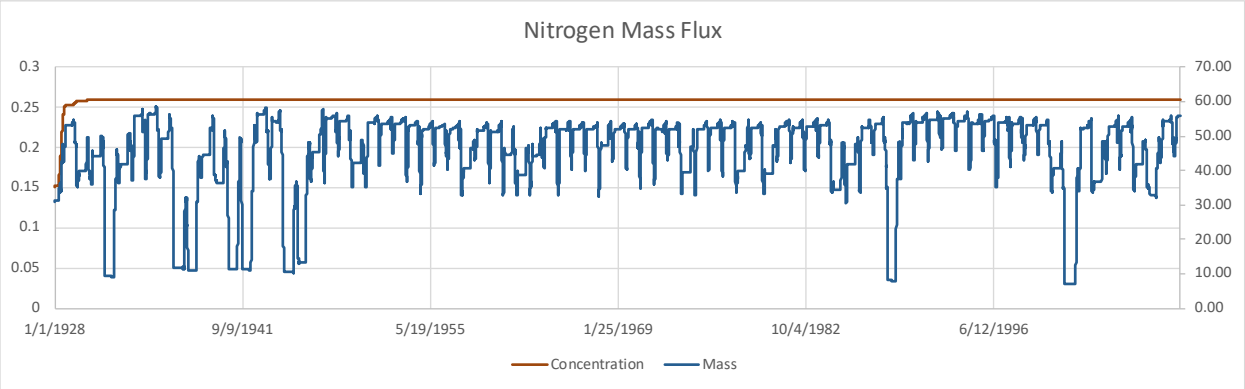


Figure 187. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

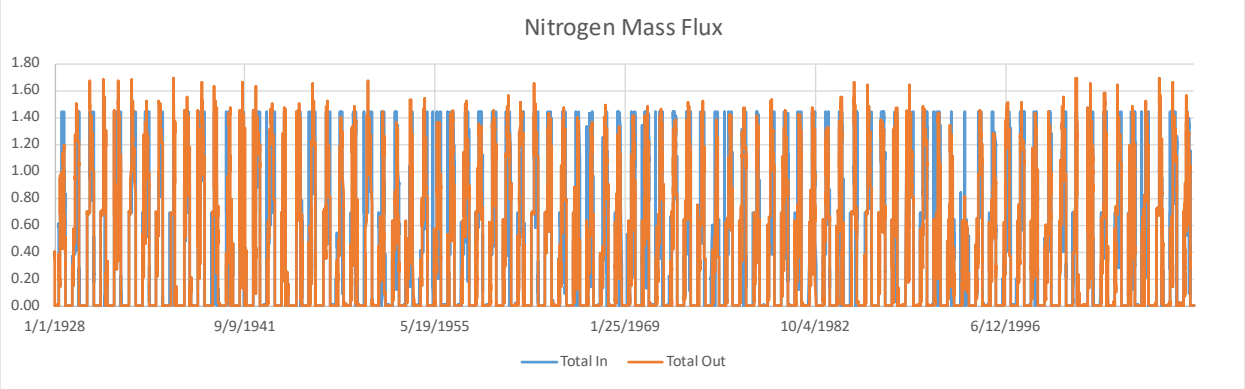


Figure 188. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

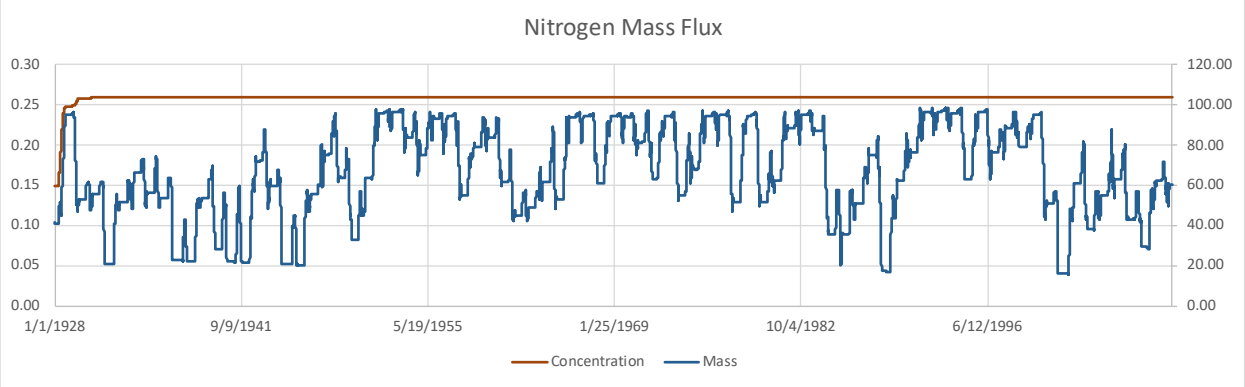


Figure 189. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

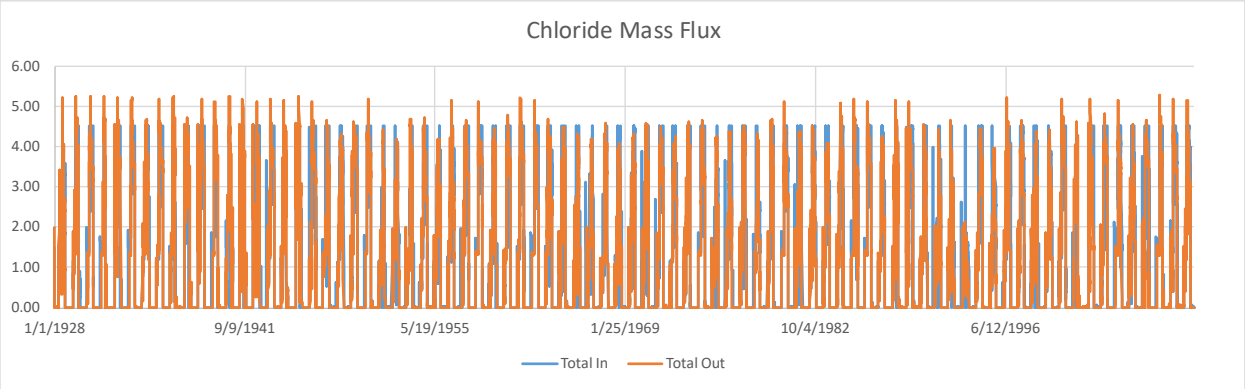


Figure 190. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

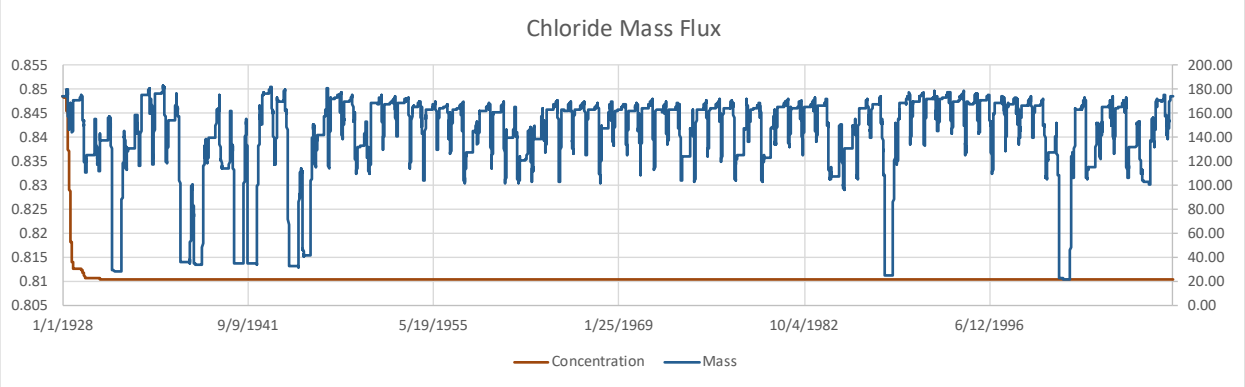


Figure 191. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

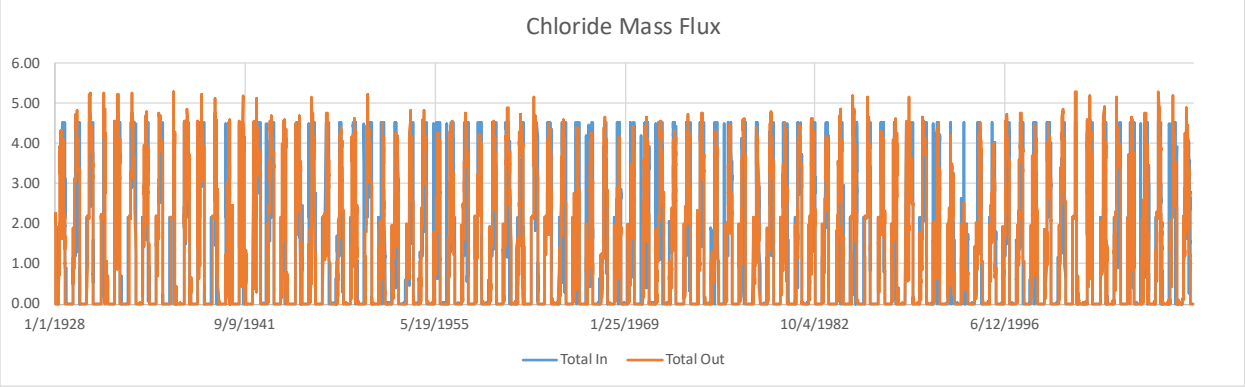


Figure 192. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

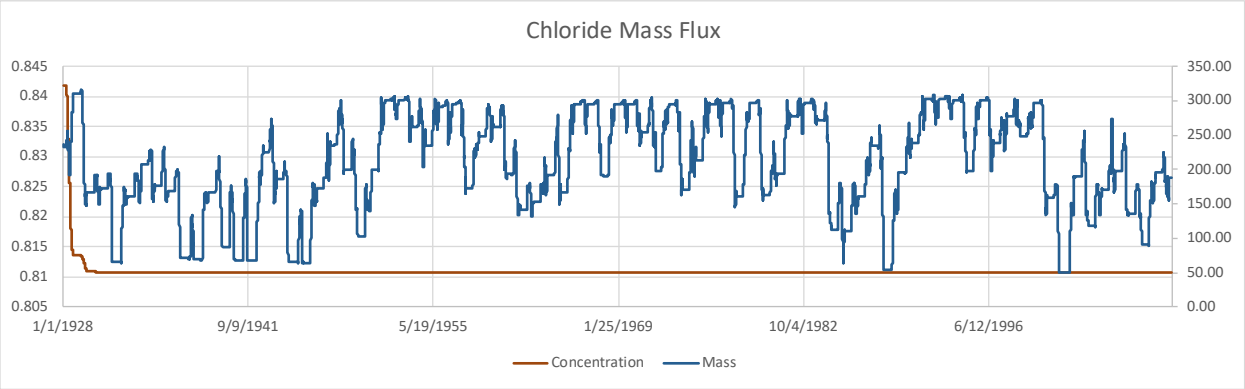


Figure 193. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

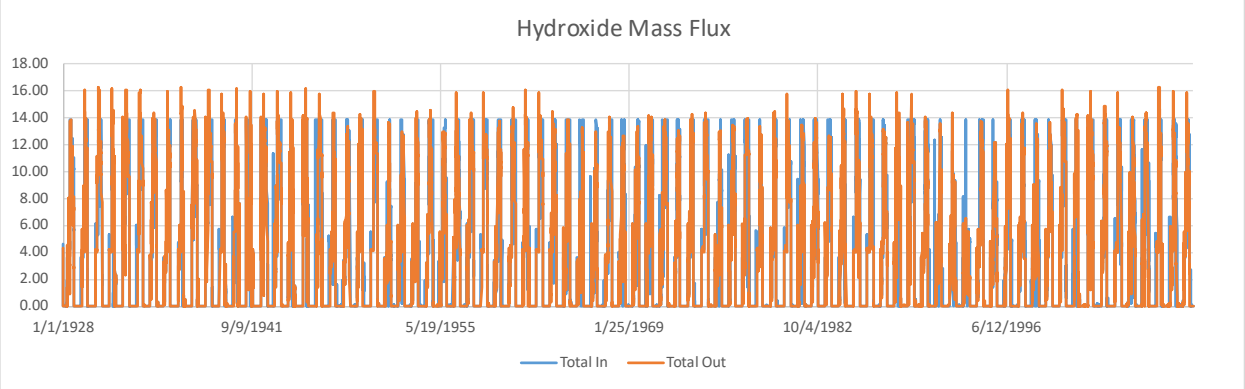


Figure 194. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

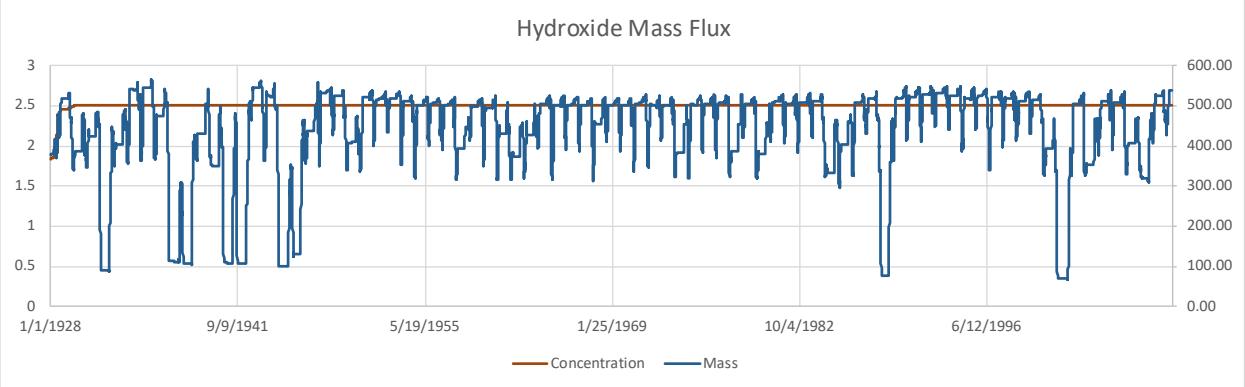


Figure 195. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

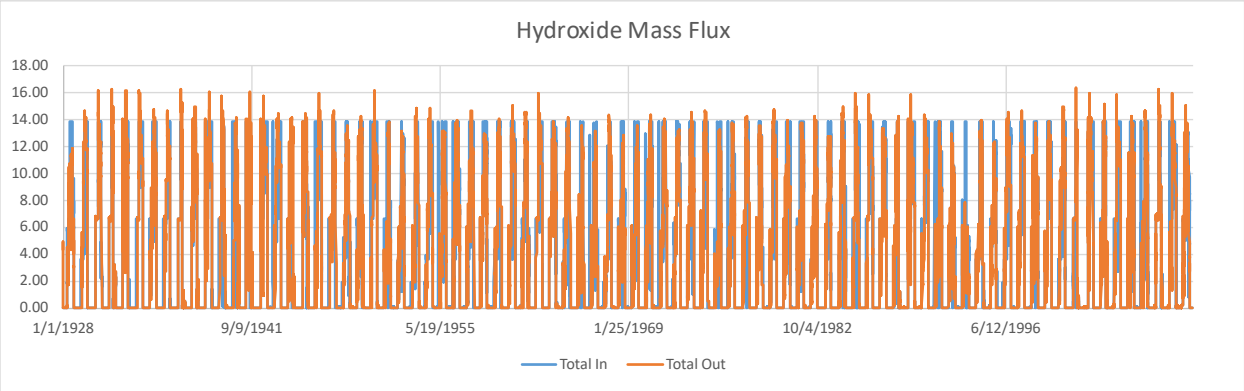


Figure 196. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

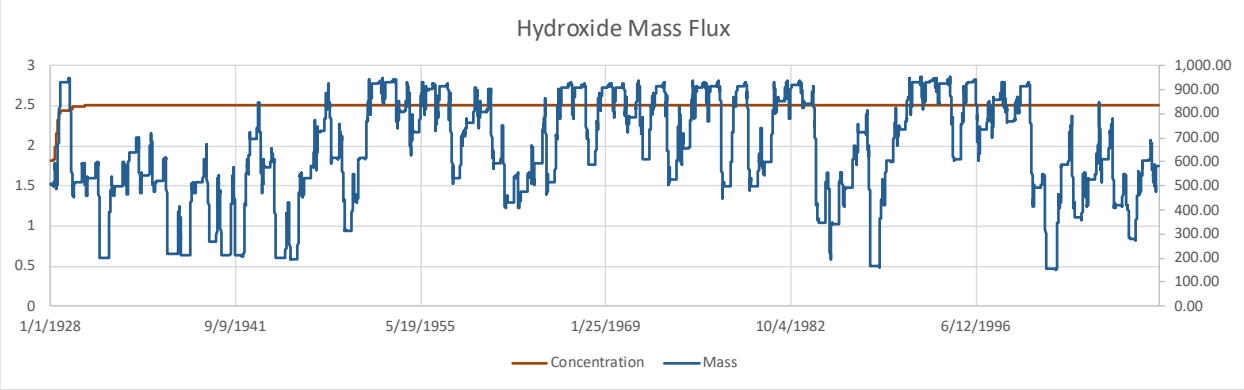


Figure 197. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

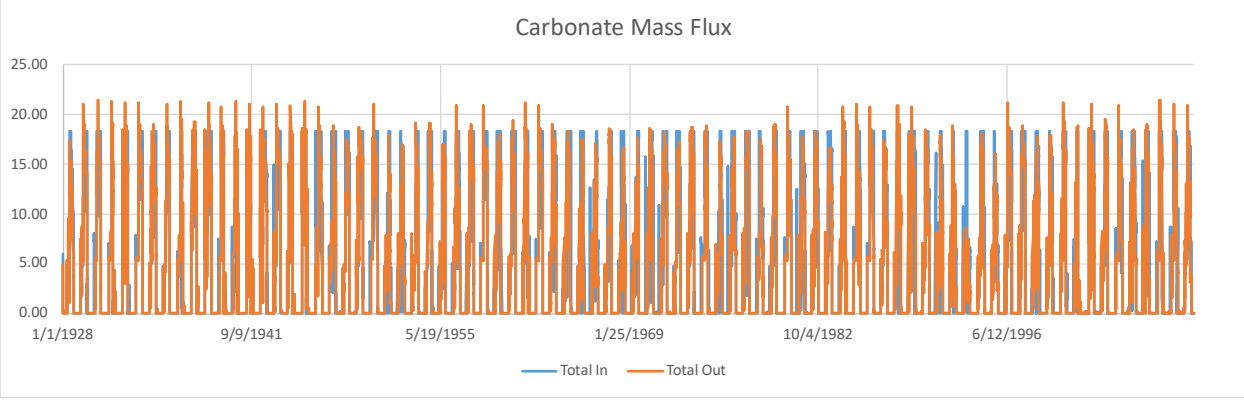


Figure 198. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

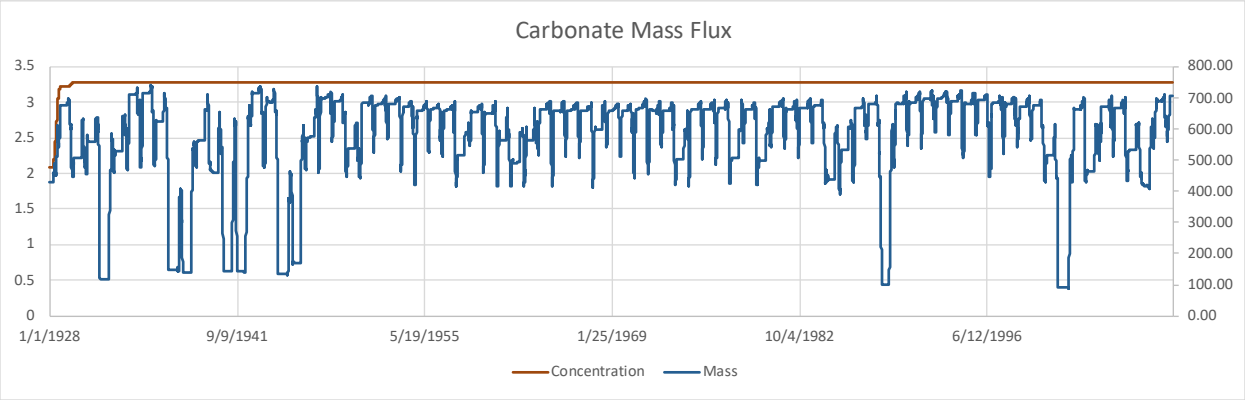


Figure 199. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

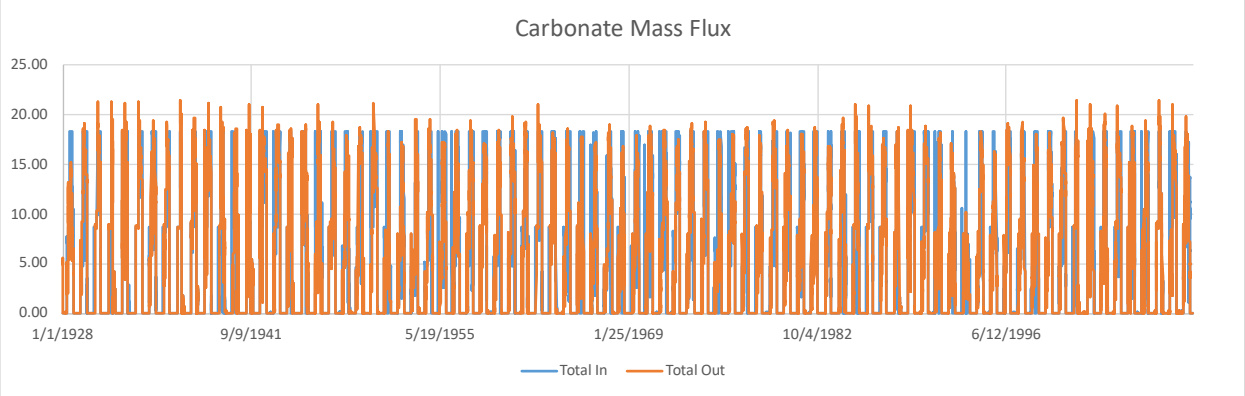


Figure 200. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

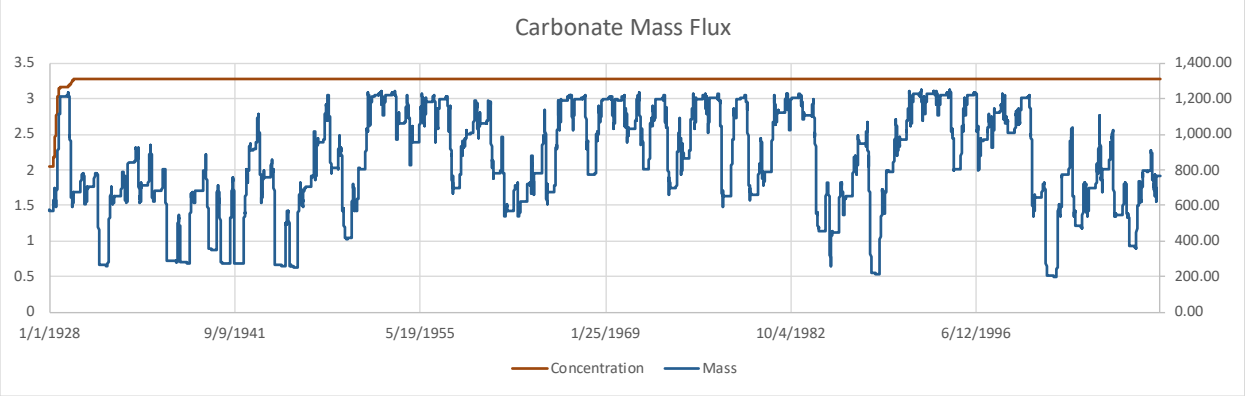


Figure 201. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

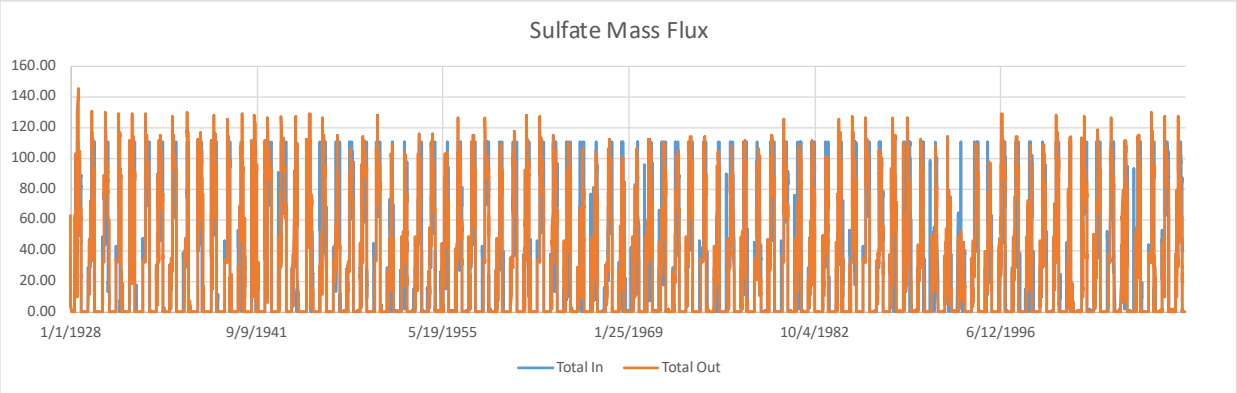


Figure 202. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

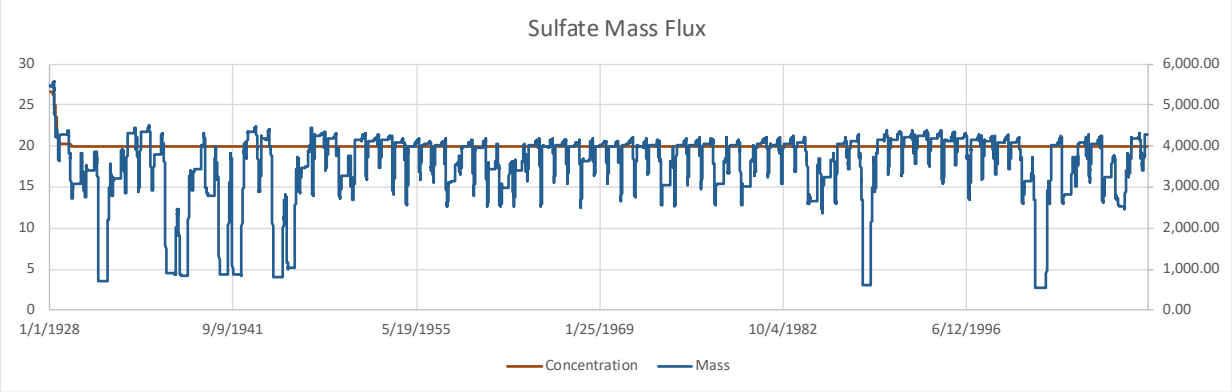


Figure 203. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

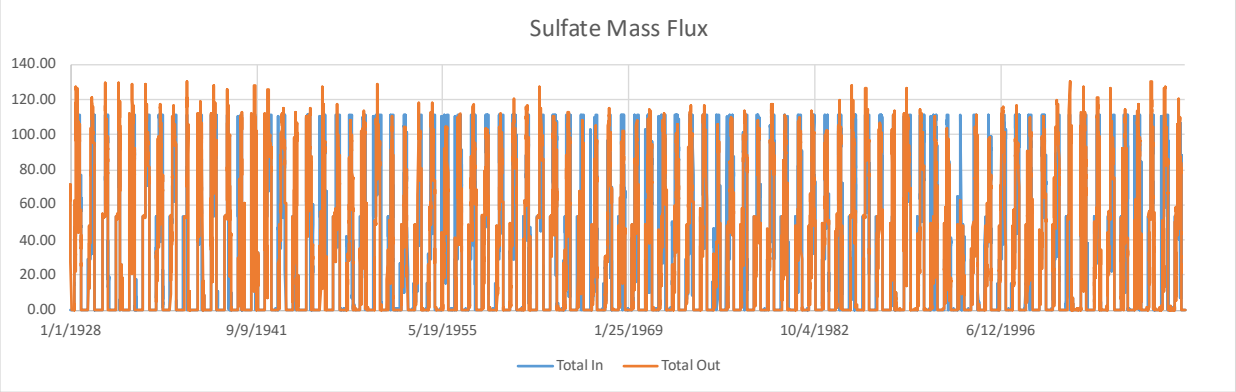


Figure 204. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

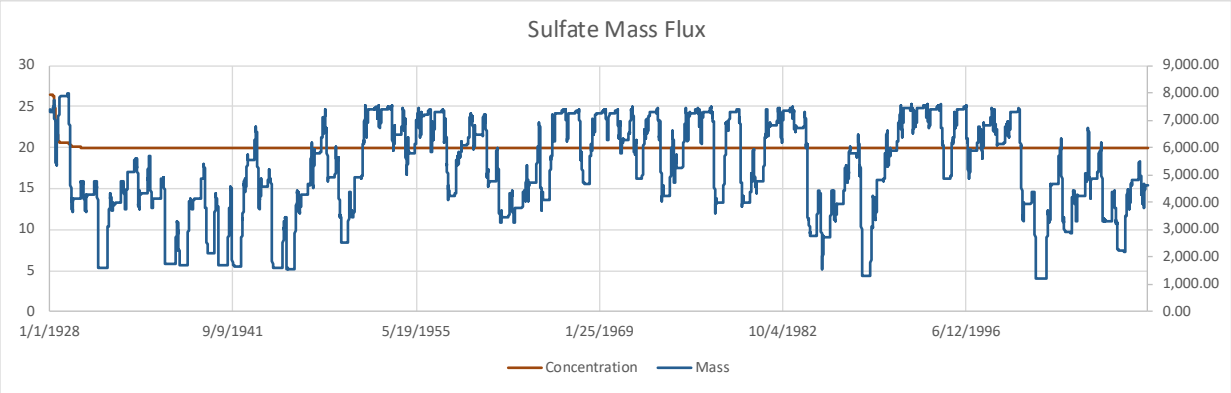


Figure 205. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

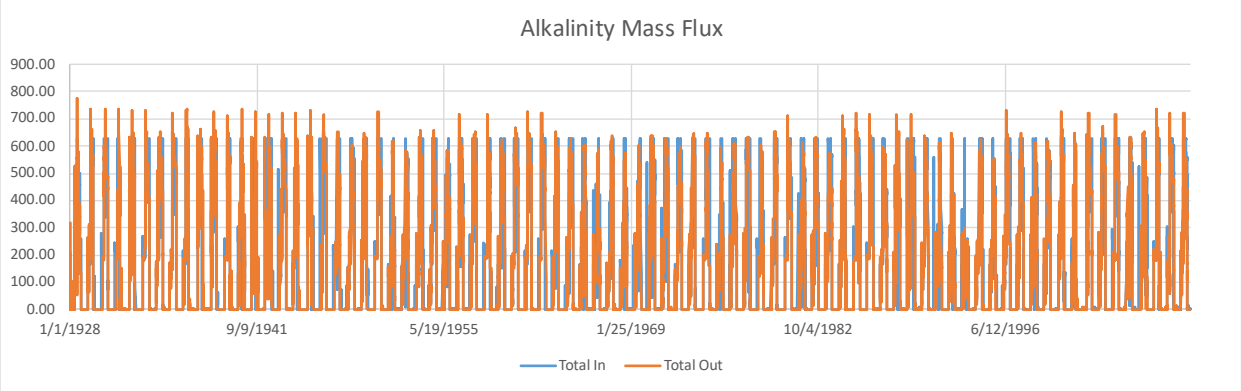


Figure 206. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

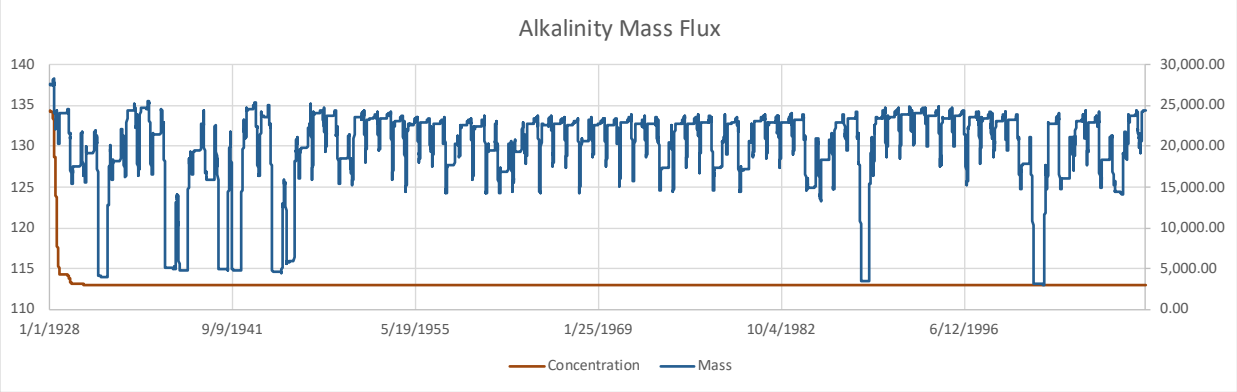


Figure 207. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

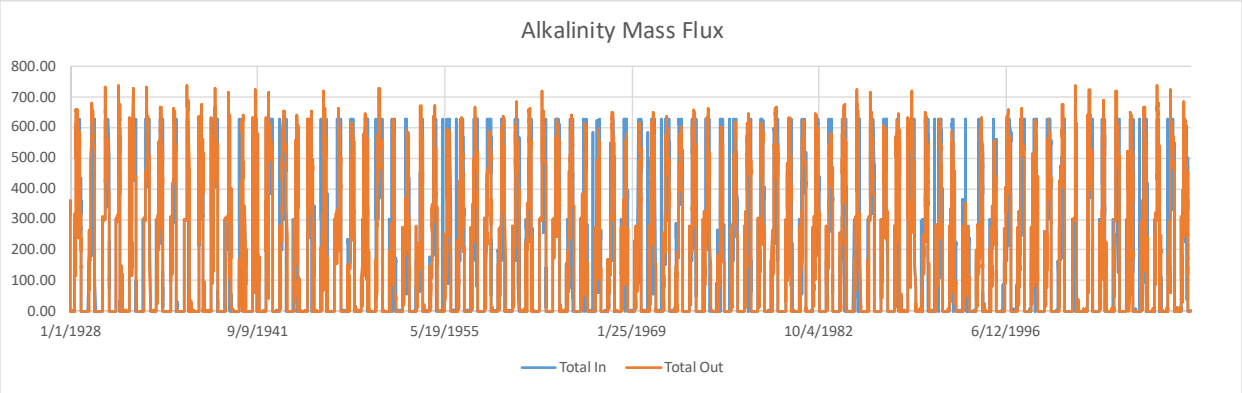


Figure 208. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

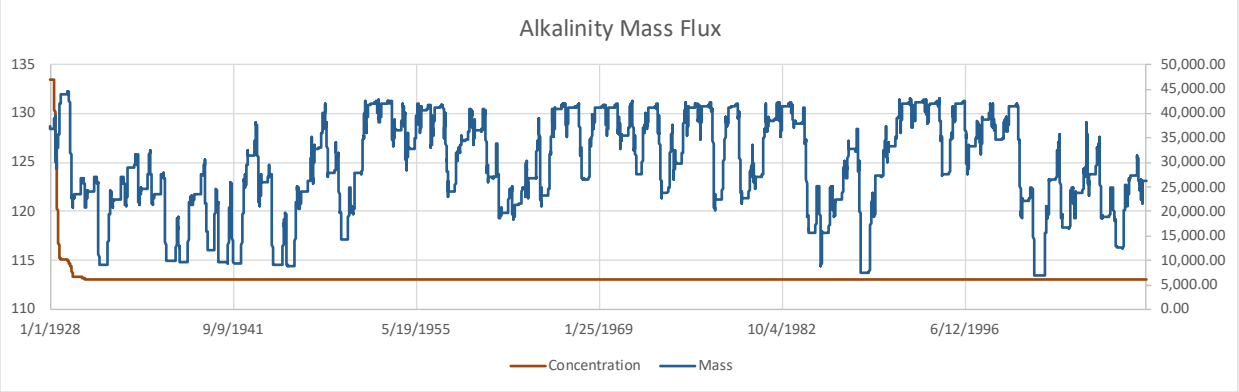


Figure 209. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

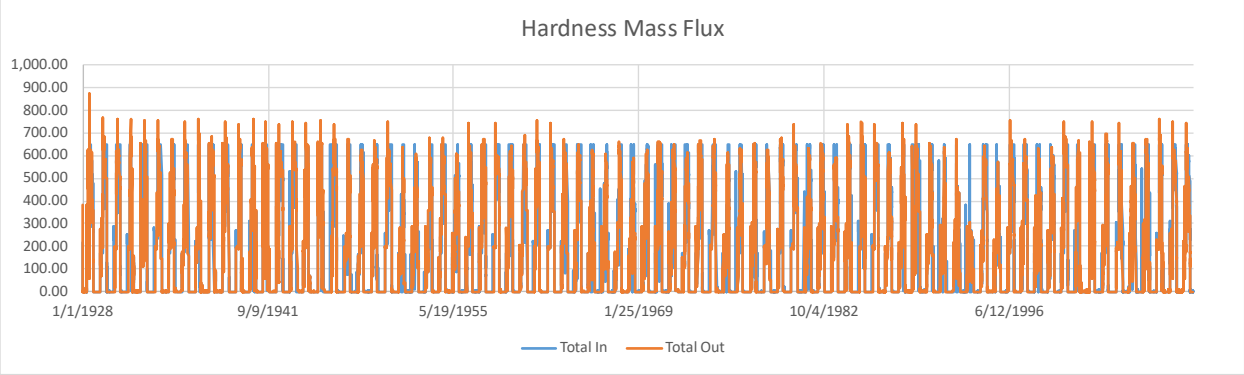


Figure 210. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

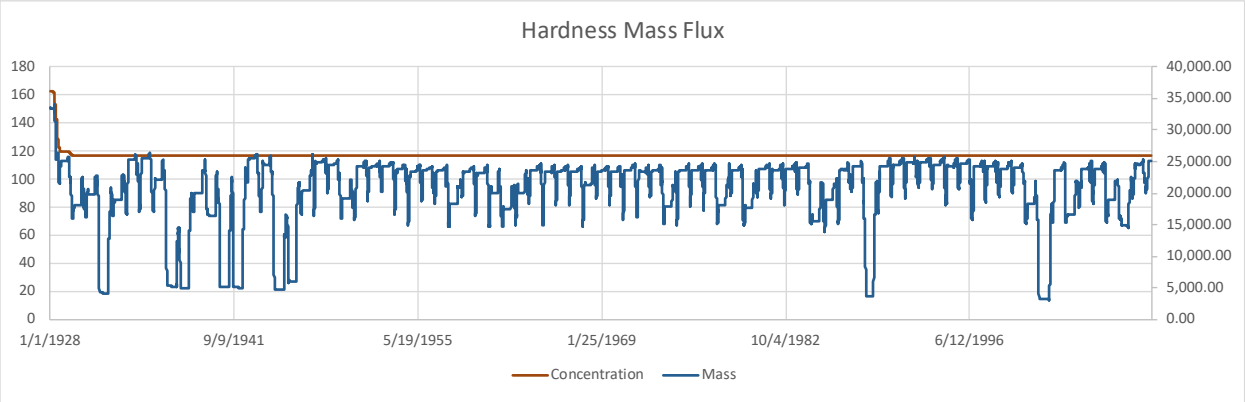


Figure 211. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

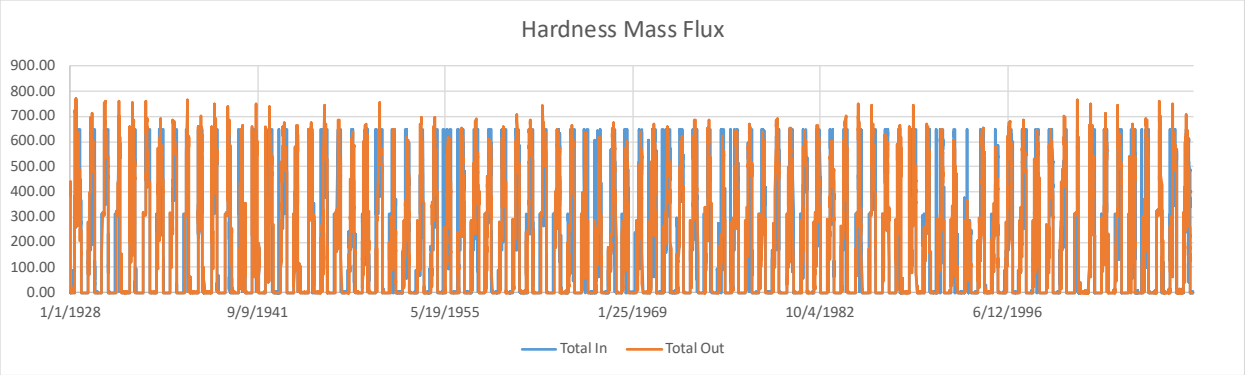


Figure 212. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

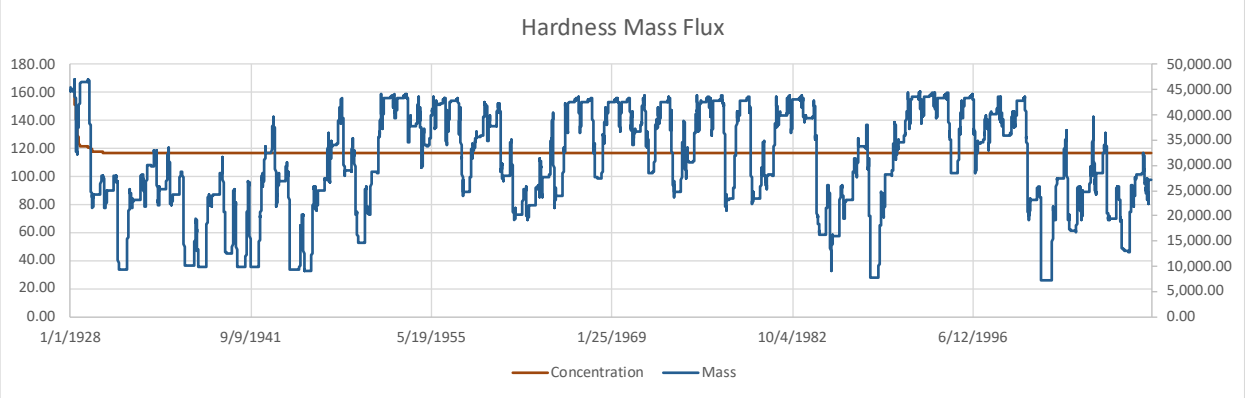


Figure 213. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

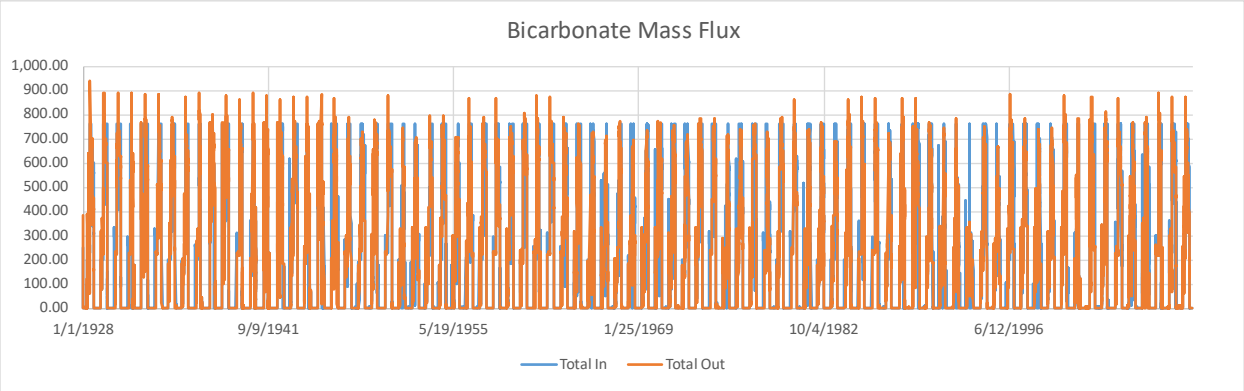


Figure 214. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

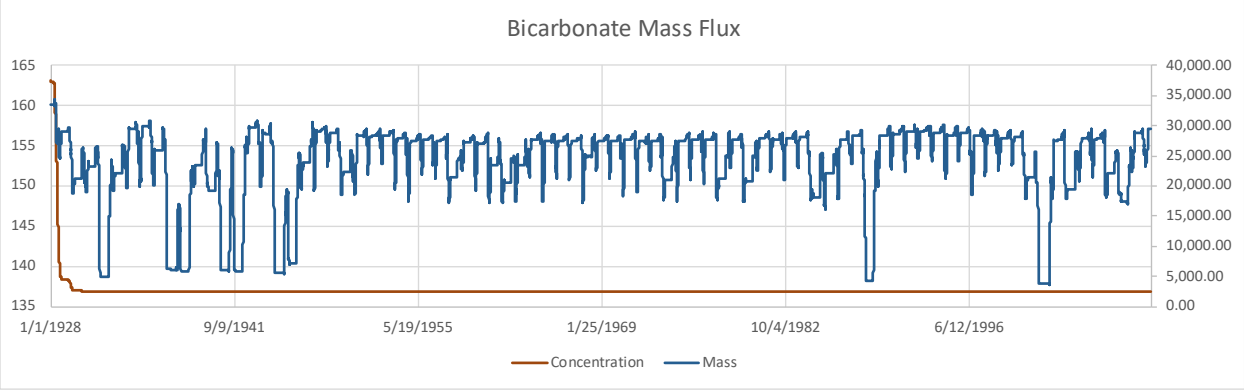


Figure 215. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

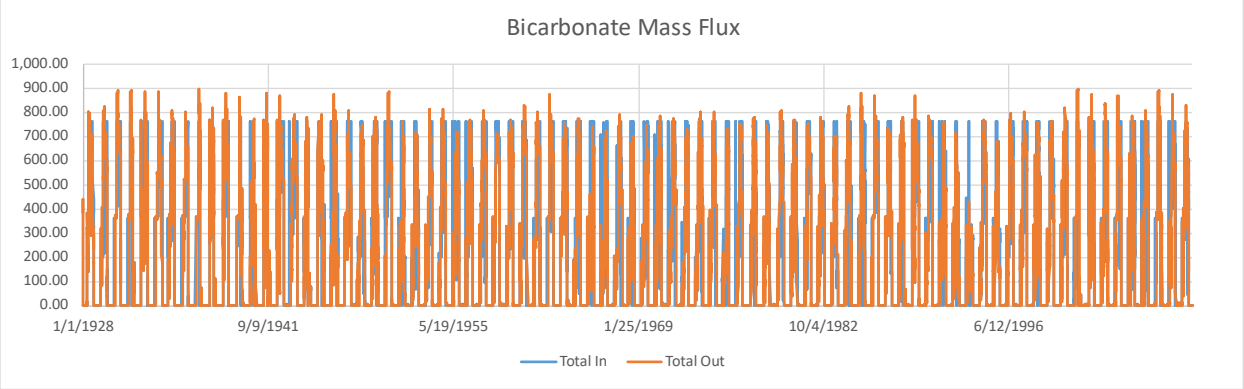


Figure 216. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

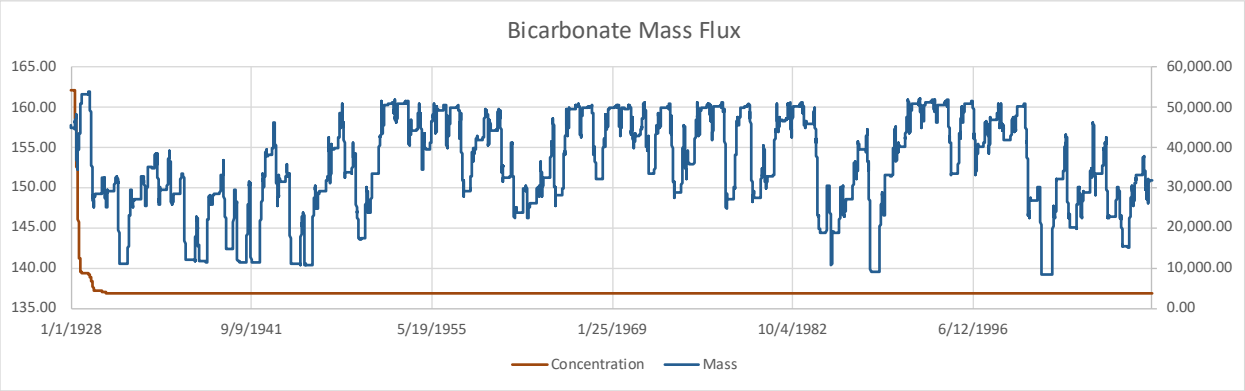


Figure 217. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

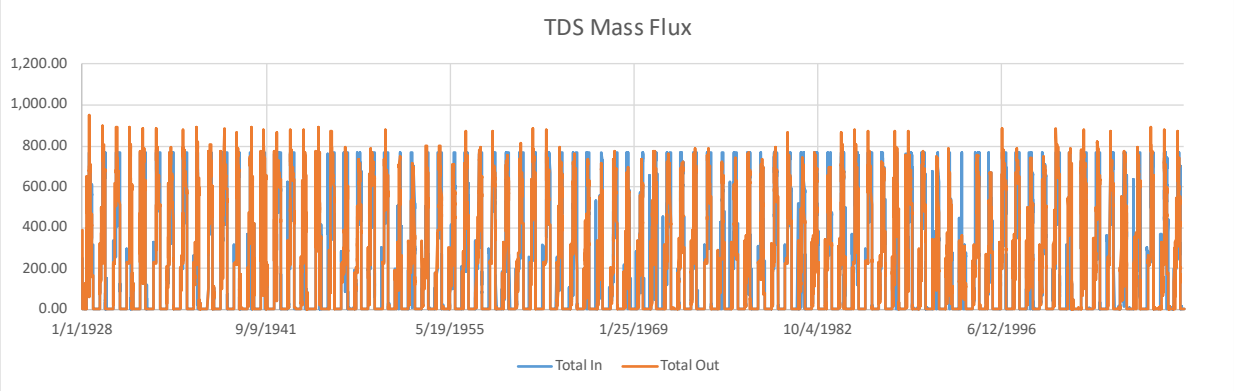


Figure 218. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

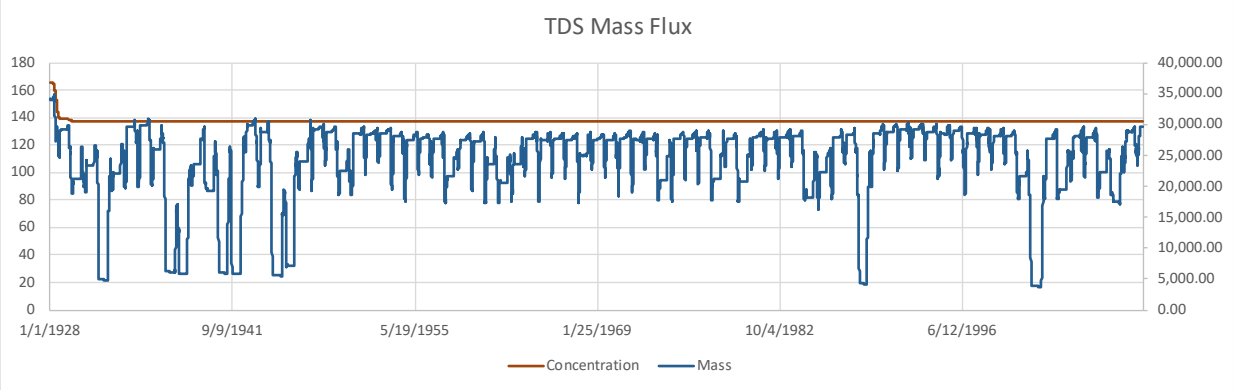


Figure 219. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

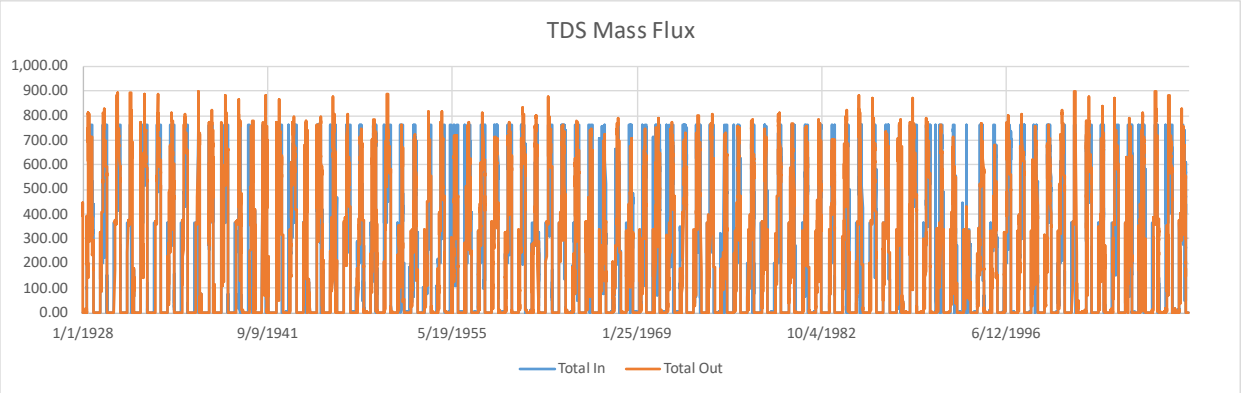


Figure 220. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

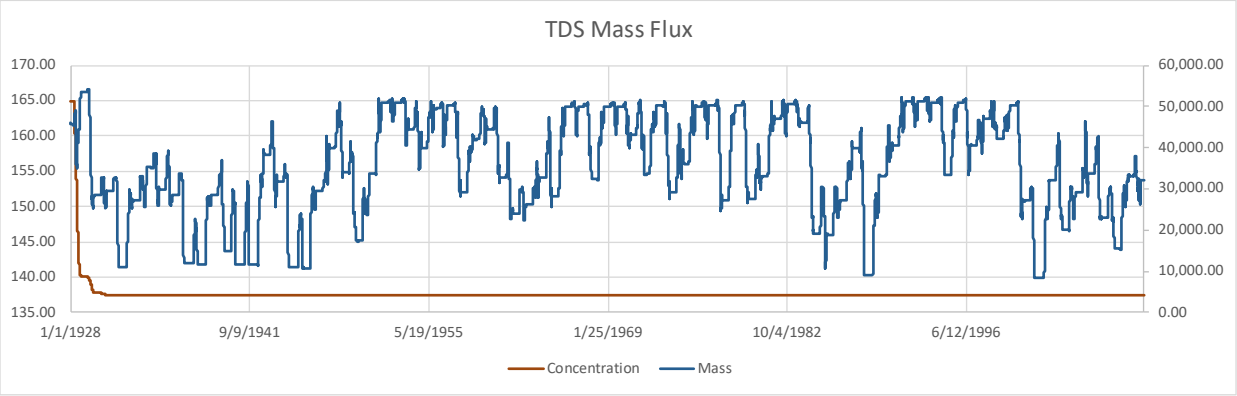


Figure 221. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

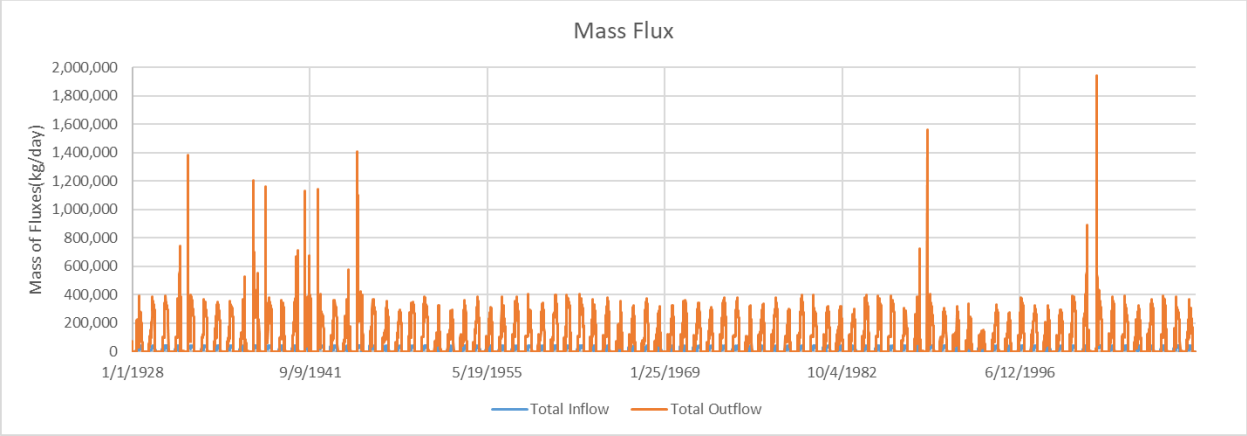


Figure 222. TSS mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses with erosion and settling included in model

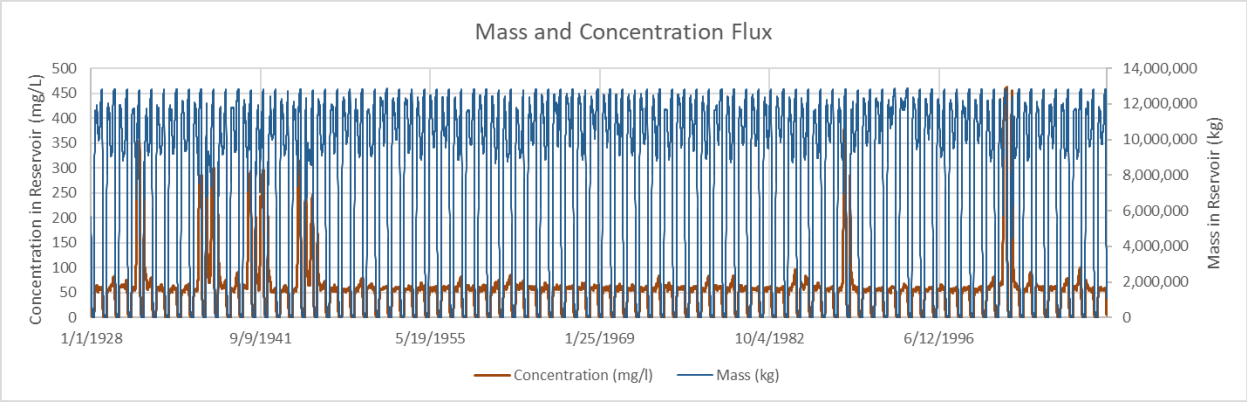


Figure 223. Modeled reservoir TSS mass in kilograms and concentration in mg/L for base case footprint with erosion and settling included in model

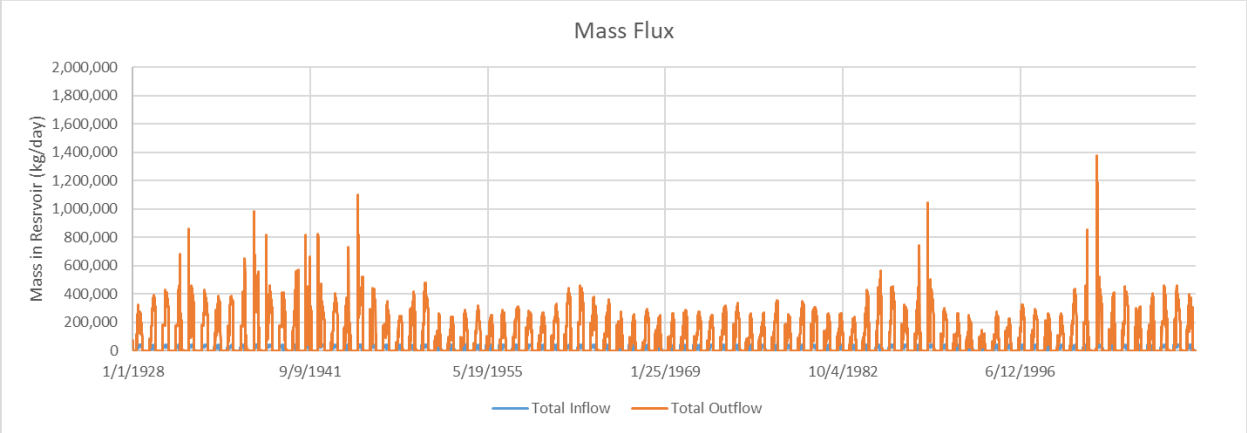


Figure 224. TSS mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses with erosion and settling included in model

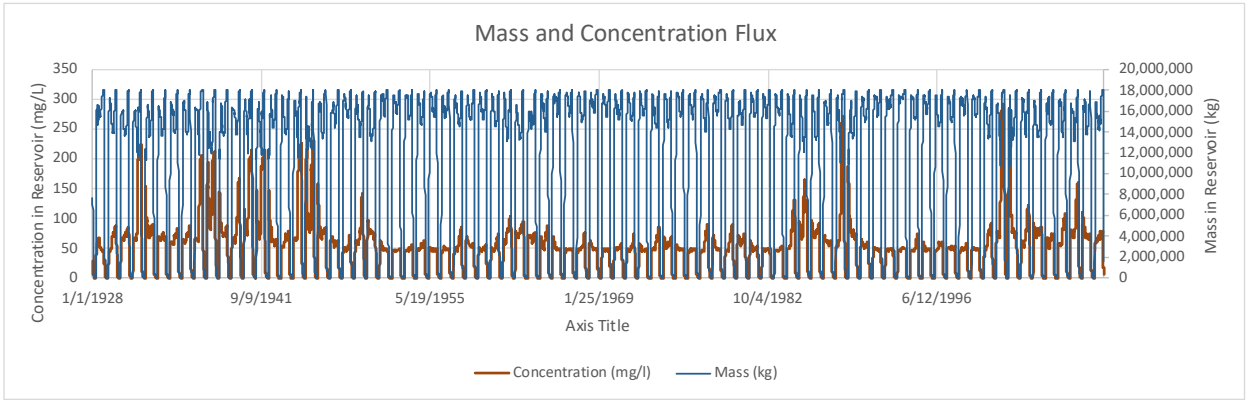


Figure 225. Modeled reservoir TSS mass in kilograms and concentration in mg/L for project case footprint with erosion and settling included in model

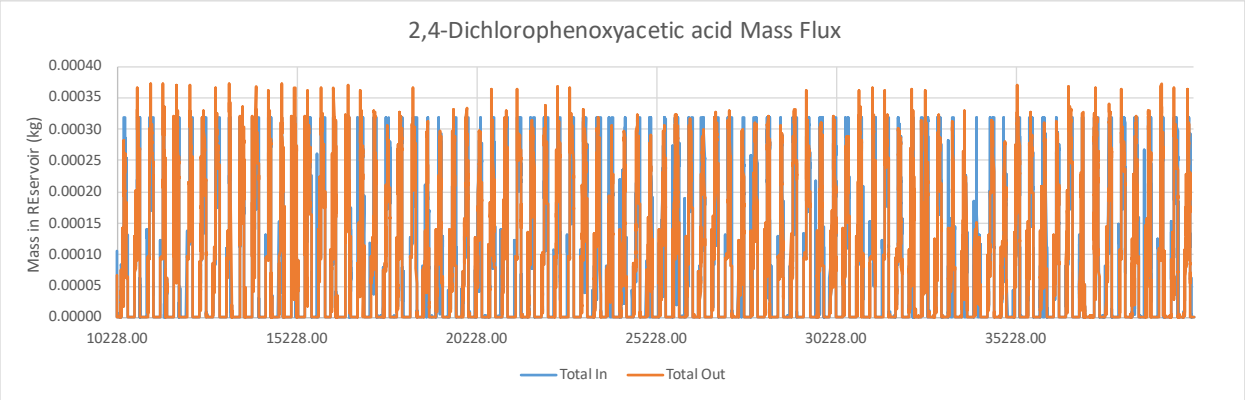


Figure 226. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

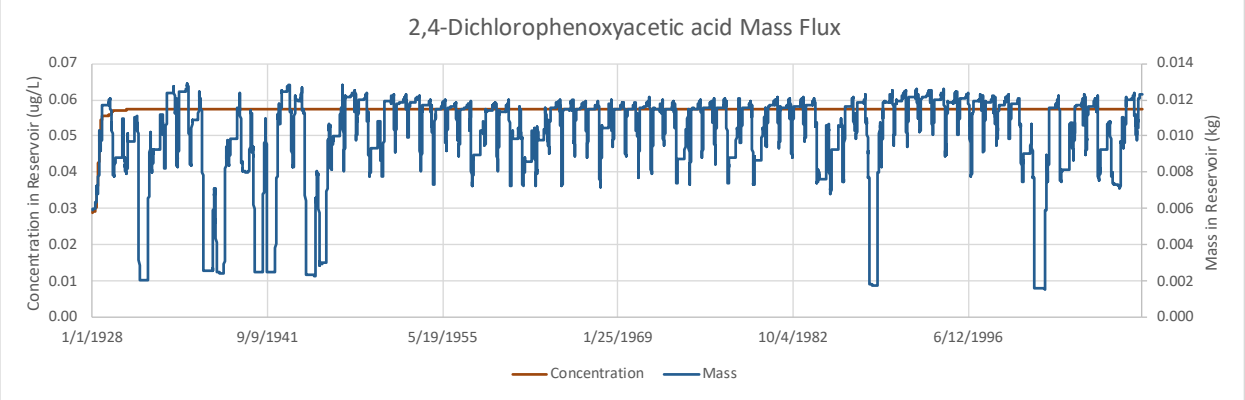


Figure 227. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint

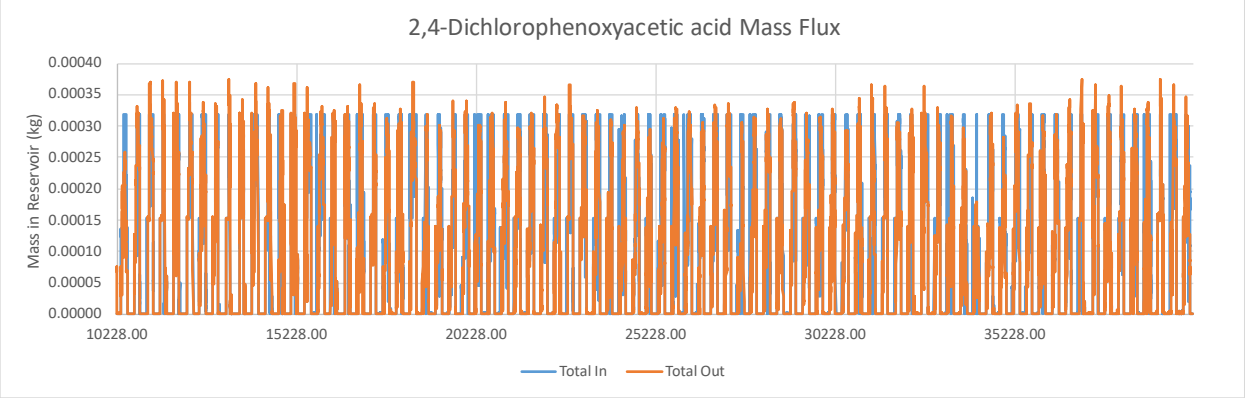


Figure 228. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses

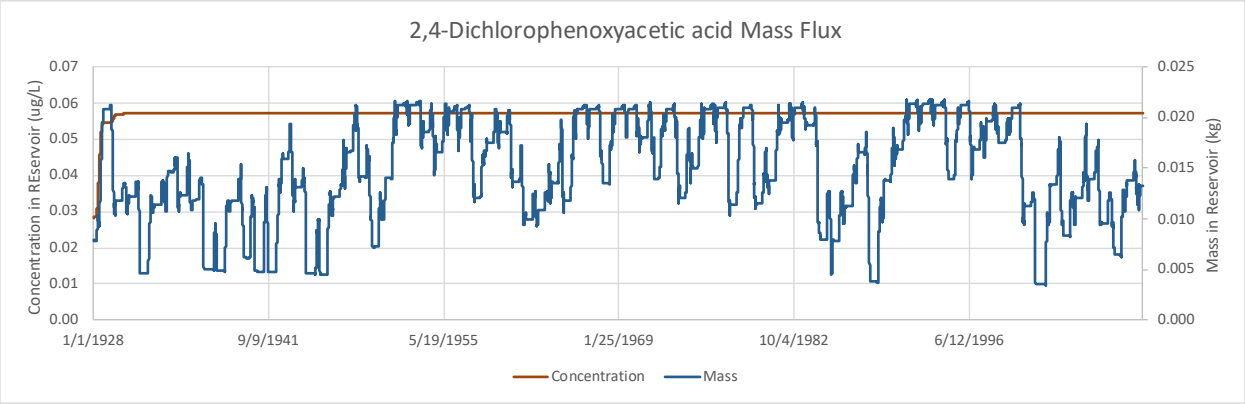


Figure 229. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint

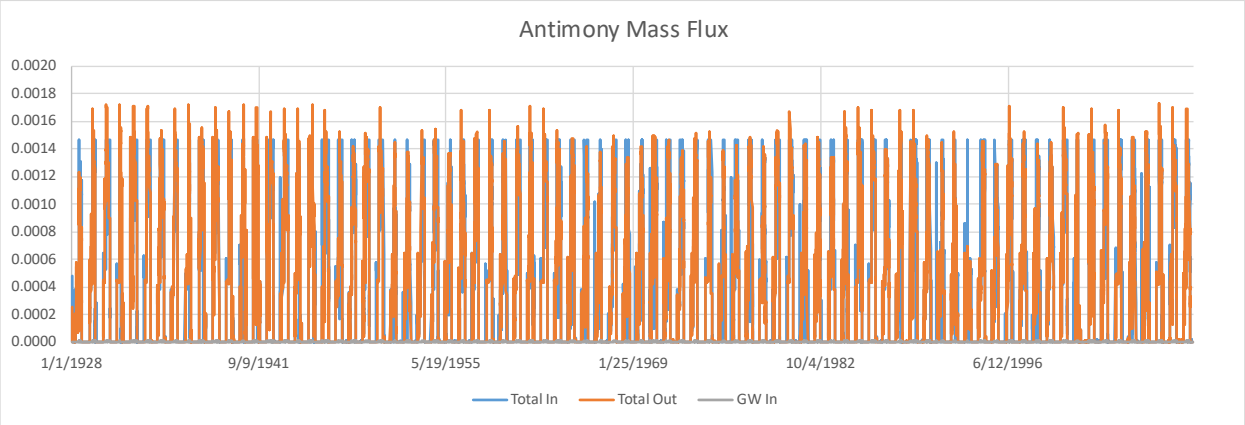


Figure 230. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses

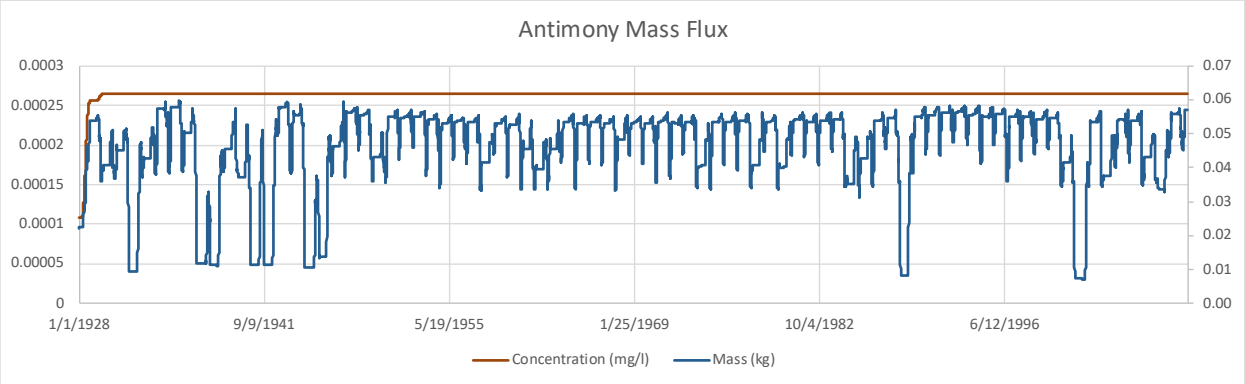


Figure 231. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint with groundwater constituent inflow included in model

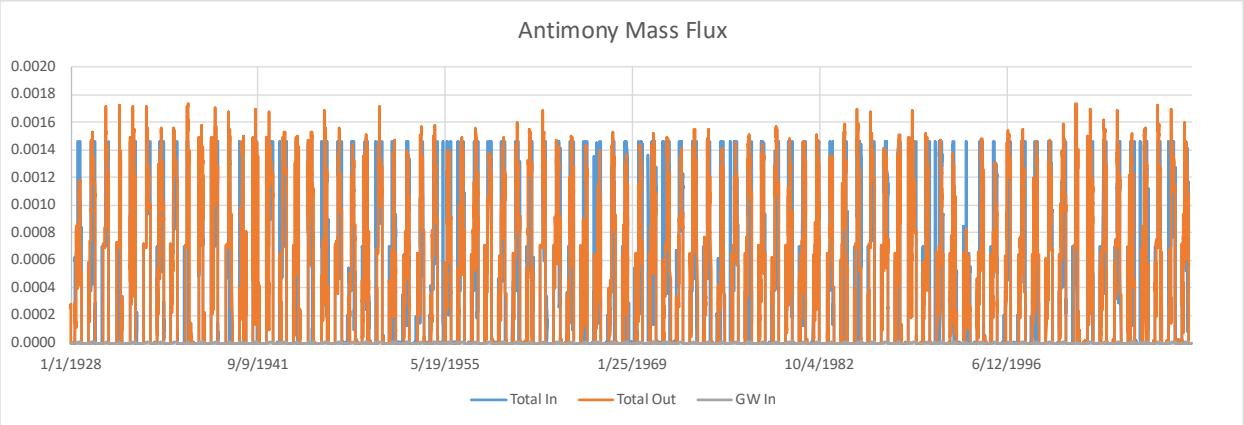


Figure 232. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses with groundwater constituent inflow included in model

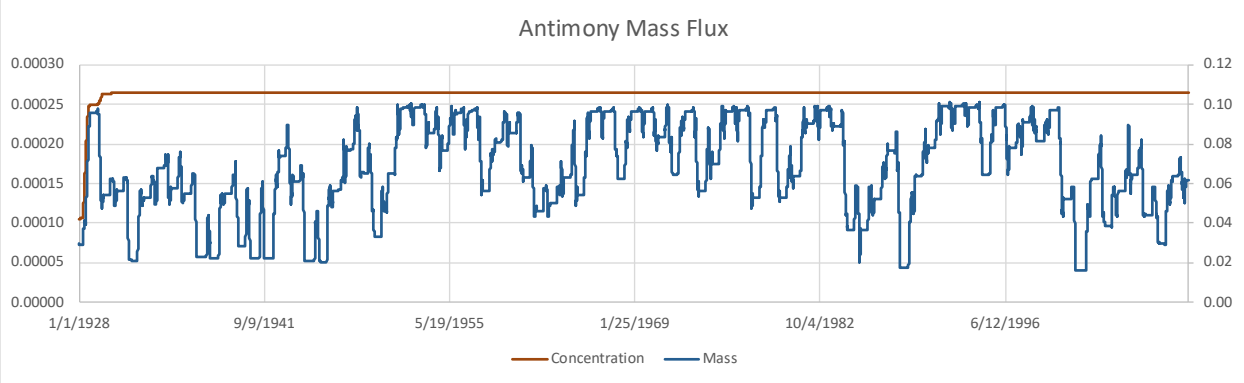


Figure 233. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint with groundwater constituent inflow included in model

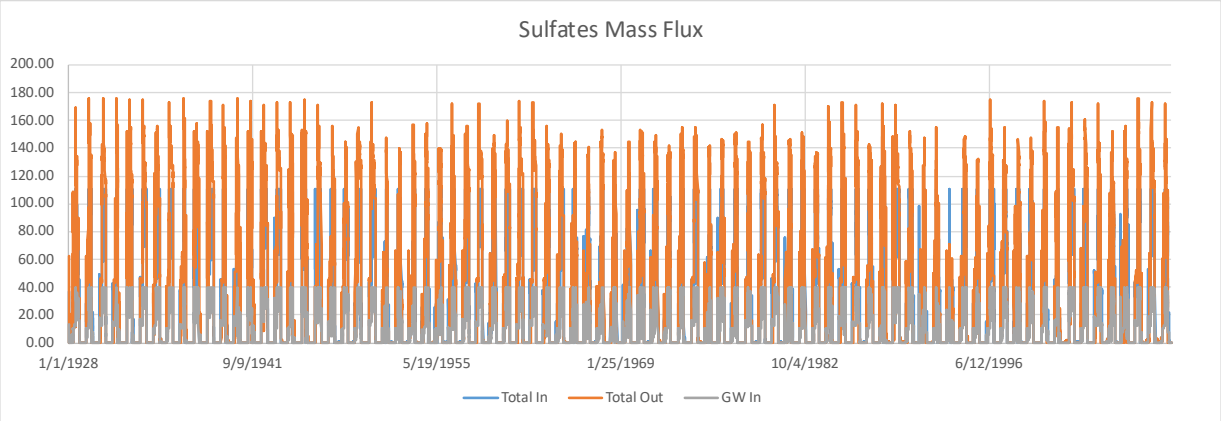


Figure 234. Constituent mass in kilograms for base case footprint reservoir based on Inflow and Outflow modeled constituent masses with groundwater constituent inflow included in model

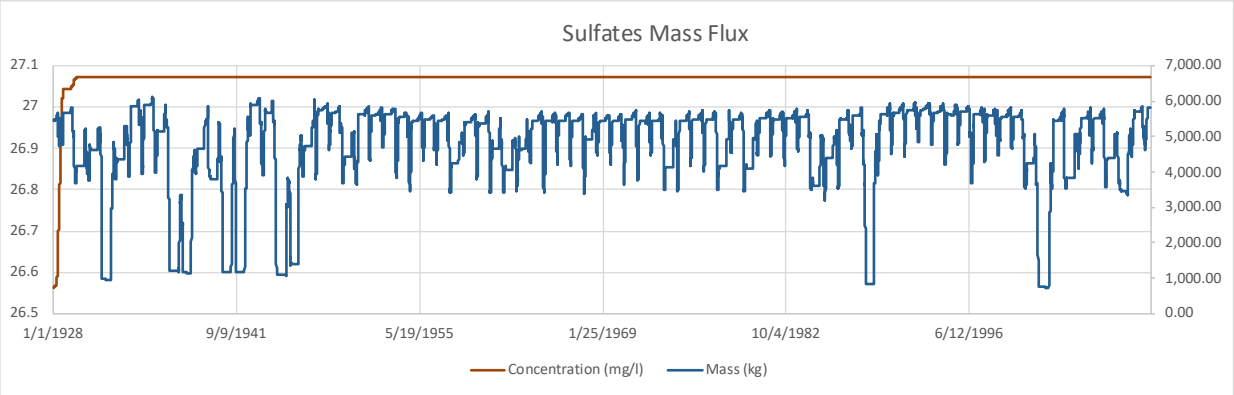


Figure 235. Modeled reservoir constituent mass in kilograms and concentration in mg/L for base case footprint with groundwater constituent inflow included in model

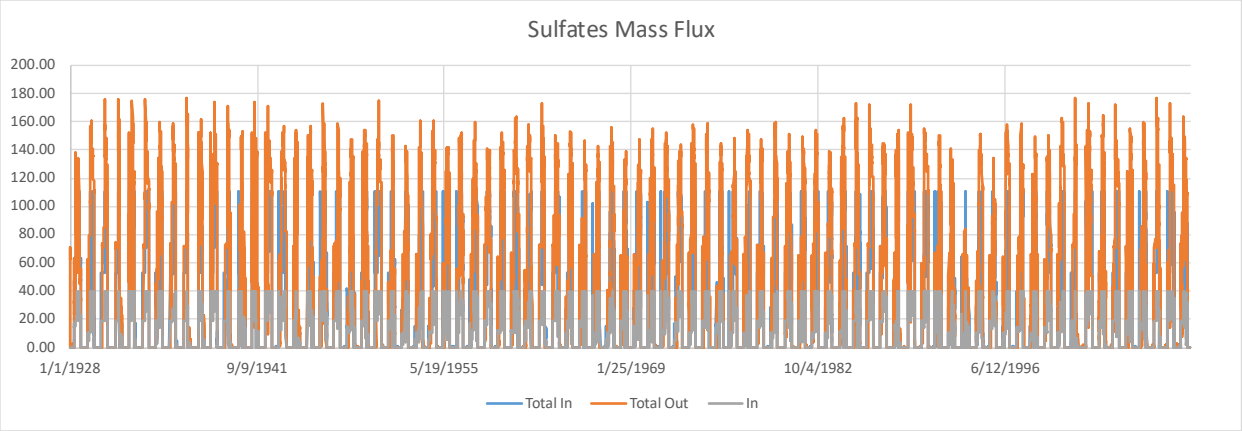


Figure 236. Constituent mass in kilograms for project case footprint reservoir based on Inflow and Outflow modeled constituent masses with groundwater constituent inflow included in model

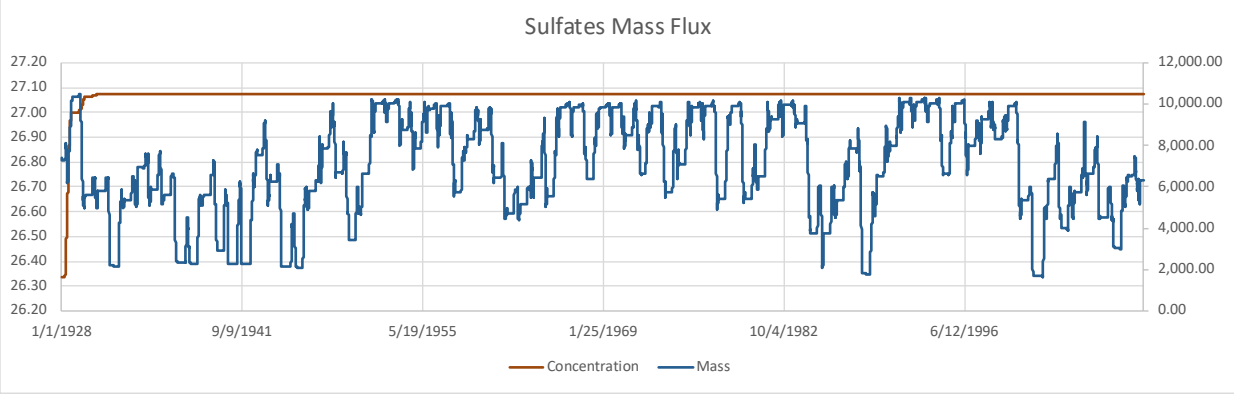


Figure 237. Modeled reservoir constituent mass in kilograms and concentration in mg/L for project case footprint with groundwater constituent inflow included in model

APPENDIX 15.1

Chin Reservoir Expansion – Phenols Modeling Technical Memorandum (INTERA 2025b)

INTERA Incorporated
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TECHNICAL MEMORANDUM

To: Jeffrey Olitch, P.Eng, PE

From: INTERA Incorporated

Date: June 30, 2025

Re: Chin Reservoir Expansion – Phenols Modeling

1.0 Introduction

INTERA, subcontracted by MPE (a division of Englobe) evaluated the benefits and risks of expanding the Chin Reservoir for the benefit of the St. Mary River Irrigation District (SMRID). The Chin Reservoir Expansion (**Figures 1** and **2**) would increase irrigation capacity and water supply reliability within the SMRID, Taber Irrigation District (TID), and Raymond Irrigation District (RID). INTERA's analysis provides additional information to support the response to Supplemental Information Request (SIR) #1 and the project Environmental Impact Assessment (EIA), particularly regarding phenols and livestock water within the system. This technical memorandum provides a brief summary of INTERA's analysis and findings related to phenols.

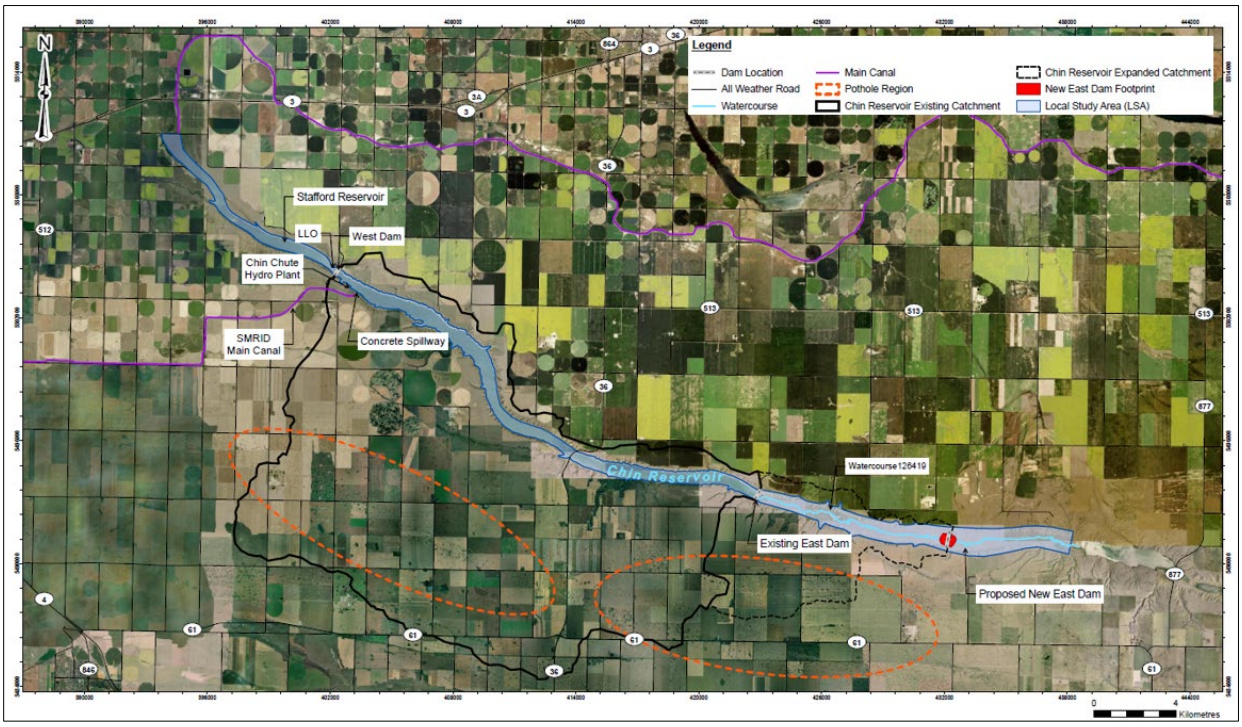
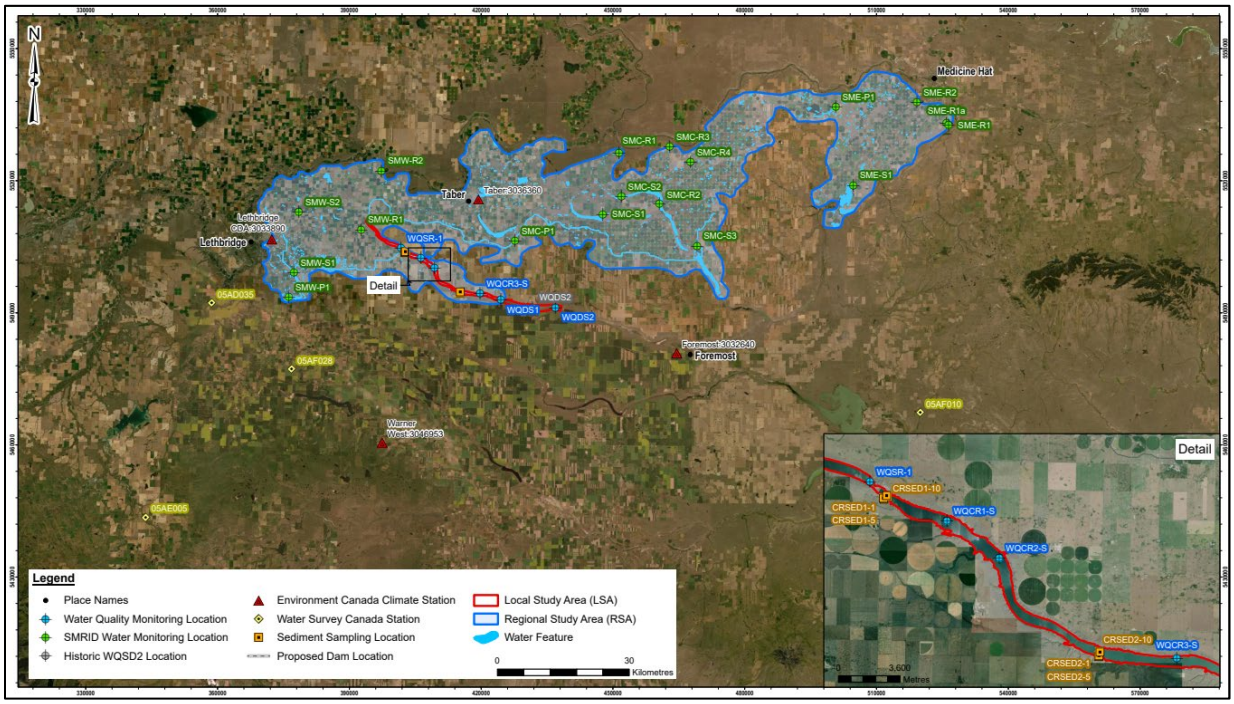


Figure 1. Chin Reservoir current and proposed expanded extent.



Note: WQCR = Water Quality Chin Reservoir; WQDS = Water Quality Downstream, WQSQ = Water Quality Stafford Reservoir

Figure 2. Surface water quality stations on the Chin Reservoir and surrounding areas (WQCR sites are in the Chin Reservoir, WQDS are in the expansion area, and WQSR site is in the Stafford Reservoir).

2.0 Livestock Water

To calculate the estimated total volume of livestock water use, INTERA assumed a stock rate of livestock intake based on maximum rates for each livestock type listed in Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (1999). The assumed rates utilized are listed in **Table 1**.

Table 1. Water intake of livestock

Animal	Stock Rate per km^2	Water Intake Rate (L/day)	Catchment Area (km^2)*	Estimated Volume (L/day)
Cattle	5	137	332	227,420
Pig	25	25		207,500
Sheep	20	15		99,600
Goat	20	7		46,480
Horse	5	42		69,720

#Catchment area is the maximum area reported in Table 2.1 of Volume 4-1 TBR.

3.0 Phenols

According to the *Canadian Water Quality Guidelines for the Protection of Agricultural Uses (Irrigation and Livestock Water)*, the threshold concentration for phenol to protect livestock is 2 µg/L (0.002 mg/L). Among the SMRID samples, INTERA observed exceedances of this threshold only in samples collected in March 2022, as detailed in **Table 2.** No exceedances were detected in samples collected during May, July, or September 2021.

Table 2. SMRID samples which exceed phenol threshold values.

Sample	Date	Reported Phenol Concentration (mg/L)
WQSR1-S	March 2022	0.0081
WQCR1-S	March 2022	0.0068
WQDS-1	March 2022	0.0097
WQDS-2	March 2022	0.0050
WQCR1-D	March 2022	0.0075
WQCR2-S	March 2022	0.0074
WQCR2-S (D)	March 2022	0.0081
WQCR2-D	March 2022	0.0056
WQCR3-D	March 2022	0.0113
WQCR3-S	March 2022	0.0107

*WQCR1-D samples from July 2021 were flagged as an estimate based on issues with phenol sample bottles.
Method Detection Limit is 0.001 mg/L

The livestock water quality value of 0.002 mg/L of phenol is near the reporting limit of the colorimetry method, which introduces uncertainty. Due to 4AAP being a colorimetry method, it is susceptible to interference from various chemical species, chemical conditions, or physical factors. Additionally, as a "total" method, it may include degradation products in the measurement, potentially inflating the reported phenol concentration. Due to these significant limitations, the 2016 Canadian Council of Ministers of the Environment (CCME) guidance documents have removed the 4AAP method from the list of acceptable analytical methods; therefore, results obtained using this method should be interpreted with caution.

In addition to analytical limitations of reported phenol, drinking water studies show relatively little toxicity from phenol, including studies of reproductive and developmental endpoints. This is attributed to phenol's rapid excretion and metabolites in urine. In Capel et al. 1972, upwards of 98% of phenol was excreted in urine within 14 hours. Hiser et al. (1994) reported results of the kinetics of oral doses of phenol in rats. Exposures included single and multiple bolus and drinking water doses at different concentrations. Peak blood concentrations of free phenol of 0.02 µg/g blood in rats that received a 1.5 mg/kg bolus dose were reached 1 to 3 minutes after receiving the dose. Hiser et al. calculated a terminal half-life of about 8 minutes for phenol following low doses. Indeed, if livestock did ingest phenol via drinking contaminated water, it should be quickly metabolized and excreted in the urine as free phenol or conjugates, resulting in minimal exposure.

4.0 Water Quality Guidelines

Upon comparing the sampled data to the Maximum Acceptable Concentrations (MACs) provided by the water quality parameters from the Canadian Drinking Water Quality Guidelines (2022), INTERA found exceedances for Total Dissolved Solids (TDS), detailed in **Table 3**. Additionally, the predicted maximum TDS concentration for the base (166 mg/L) and the expanded (165 mg/L) model cases were below the TDS water quality threshold. TDS measures the combined content of all organic and inorganic substances dissolved in water such as minerals, salts, and metals. High TDS values can cause bitter, salty, or metallic taste, but TDS itself is not harmful. The 500 mg/L threshold for TDS is based on drinking water taste and appearance rather than health. Standard treatment for potable water eliminates TDS and its impacts, therefore these exceedances are not concerning for potable supply.

Table 3. SMRID samples that exceed Canadian Water Quality Drinking Guidelines

Location	Sample Date	Attribute	Value (mg/L)	MAC (mg/L)	Exceedance?
SMC-R3	6/6/2012	Total Dissolved Solids	572	500	YES
SME-P1	8/28/2013	Total Dissolved Solids	663	500	YES
SME-R2	7/6/2011	Total Dissolved Solids	610	500	YES
SME-R2	7/20/2011	Total Dissolved Solids	509	500	YES

5.0 References

Canadian Council of Ministers of the Environment (CCME). 1999. *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*. In: *Canadian Environmental Quality Guidelines, 1999*. Canadian Council of Ministers of the Environment, Winnipeg.

Capel ID, French MR, Millburn P, et al 1972. Fate of [14C]-phenol in various species. Xenobiotica 2:25–34.

Health Canada. 2022. *Guidelines for Canadian Drinking Water Quality – Summary Table*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

Hiser MF, Kropscott BE, McGuirk RJ, et al 1994. Pharmacokinetics, metabolism and distribution of 14C-Phenol in Fischer 344 rats after oral gavage, drinking water and inhalation exposure. Dow Chemical Company. Submitted to U.S. Environmental Protection Agency under TSCA Section 8D. Study ID: K-002727–022. OTS0557473.

APPENDIX 17.1

Chin Reservoir Expansion – Phenols Modeling Technical Memorandum (INTERA 2025b)

INTERA Incorporated
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TECHNICAL MEMORANDUM

To: Jeffrey Olitch, P.Eng., PE

From: INTERA Incorporated

Date: June 30, 2025

Re: Chin Reservoir Historical Canal Inflow and Modeled Arsenic Trend Analysis

1.0 Introduction

INTERA, under subcontract to MPE (a division of Englobe), evaluated the benefits and risks of expanding the Chin Reservoir for the benefit of the St. Mary River Irrigation District (SMRID). The Chin Reservoir Expansion would increase irrigation capacity and water supply reliability within the SMRID, Taber Irrigation District, and Raymond Irrigation District. INTERA's environmental impact analysis performed provides additional information to support the response to Supplemental Information Request (SIR) #1 and the project Environmental Impact Assessment.

This technical memorandum describes the methodology and results of the Mann-Kendall trend test (Section 2.0), both with and without seasonality, for surface water quality stations within the SMRID system (**Figure 1**). The station locations (**Figure 1**) are color coded: blue sites are considered upstream of the Chin Reservoir and thus have a direct influence on the reservoir water quality; red sites are downstream of the reservoir and thus are impacted by additional sources. INTERA's trend analysis assesses monotonic trends in time series data for nutrients and anions, metals, and pesticides based on historical canal inflow records. The Mann-Kendall (Section 2.1) and Seasonal Kendall Test (Section 2.2) work best with large, continuous datasets; any large data gaps may introduce uncertainty.

This technical memorandum also includes an additional trend analysis of simulated base-case concentration of arsenic (Section 3.0) from the mass balance water quality model (described in detail in the Water Quality Analysis Technical Memorandum) as an additional measure for assessing potential seasonal or long-term trends. INTERA used simulated concentrations in lieu of observed data to provide a more robust data set for the trend analysis. While arsenic was specifically assessed as an indicator, we chose this approach to streamline the analysis and focus on a representative parameter for all of the simulated base-case concentrations.

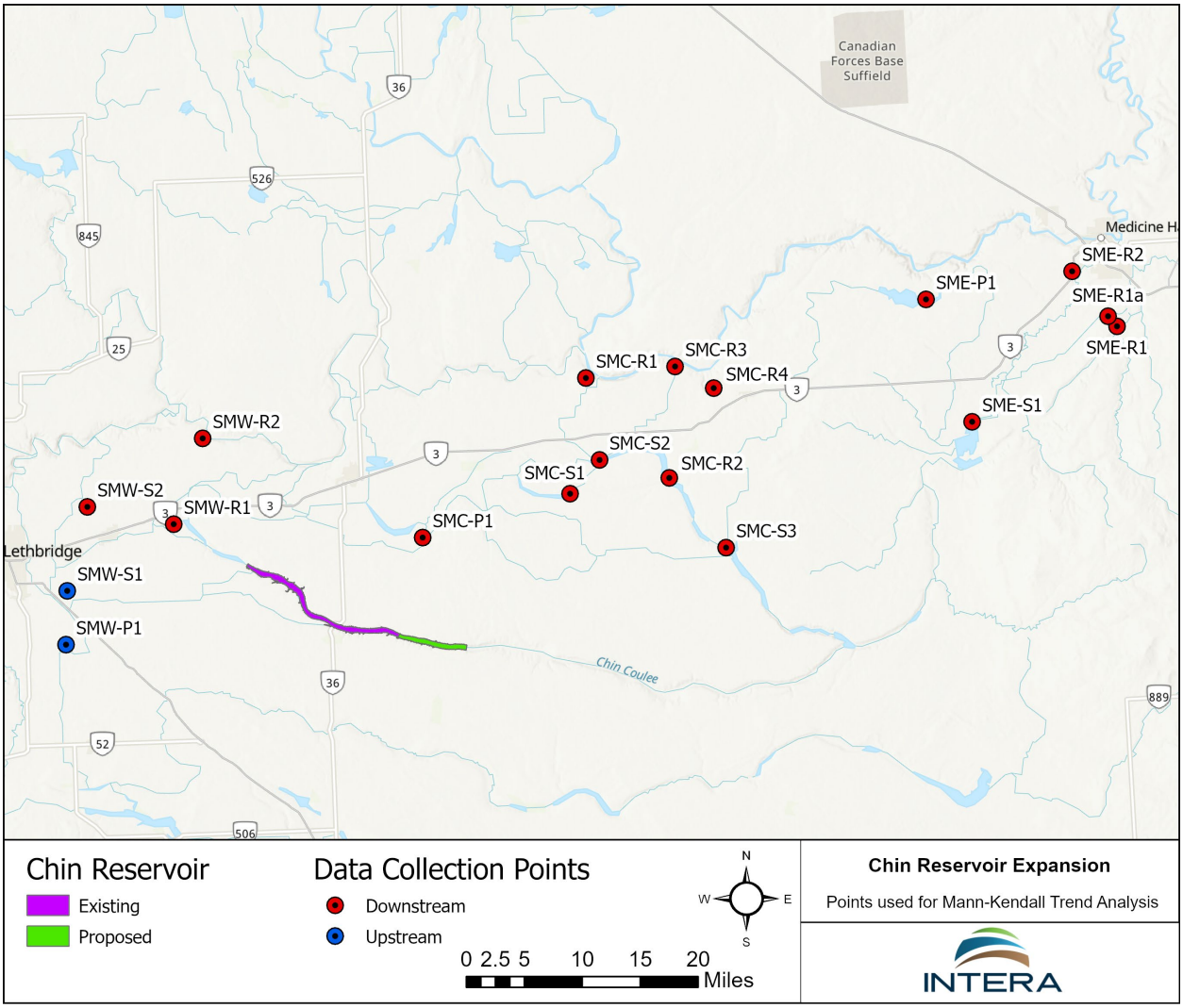


Figure 1. **Surface water quality stations on the Chin Reservoir and surrounding areas.**

2.0 Methodology

Before conducting the Mann-Kendall trend test, INTERA produced a correlation heatmap comparing each variable in the data set as well as a scatterplot matrix comparing the physical properties and each constituent; this step provided at-a-glance visualizations of potential relationships in the data (See Appendix A). We found no unexpected relationships in these results that warranted further investigation. Therefore, INTERA conducted only the Mann-Kendall and Seasonal Kendall Test.

2.1 Mann-Kendall Trend Test

A Mann-Kendall trend test is a nonparametric statistical tool used to assess whether there is a monotonic (consistently increasing or decreasing) trend in time series data. This test was implemented

in RStudio using the Kendall package for each constituent at each sample site. Due to limitations in the historical canal inflow data, INTERA calculated annual averages of the inflows prior to conducting the Mann-Kendall trend test.

Listed below are the null and alternative hypotheses for the Mann-Kendall regression test.

H_o: There is no monotonic trend associated with the constituent at that sample site.

H_a: A trend exists for the constituent at that sample site that is positive, negative, or non-null.

Below is a summary of the steps followed to perform the Mann-Kendall Trend Assessment:

1. Order the data: Sort the input data by the Sample Date in chronological order from earliest to latest date.
2. Group the data: Divide the input data into groups by category (anions and nutrients, metals, pesticides), then by sample site, then by constituent.
3. Apply the Mann-Kendall function: For constituents within each sample site subgroup with at least three data values, the Mann-Kendall function from the "Kendall" R Package calculates the test statistic, tau, and the corresponding p-value.
    a. The test statistic is calculated as the sum of the signs determined by the differences between each value and the value preceding it in the time series. A -1 sign is determined for negative differences between compared values, a +1 sign is determined for positive differences between compared values, and a 0 is determined for no differences between compared values.
    b. The tau statistic is calculated as the correlation between data values' ranks and their corresponding time orders. In the event of ties, the equation used for calculating variance is designed to incorporate the ties. If the p-value is less than or equal to alpha (0.05), the null hypothesis is rejected.

    For more specific information regarding this Mann-Kendall regression, refer to R package "Kendall," version 2.2.1, function "MannKendall(x)" (McLeod, 2022; "Package 'Kendall'").
4. Export the results: Write the results of each Mann-Kendall calculation to a table and export the table as a CSV.

2.2 Seasonal Kendall Test

A modified version of the Mann-Kendall Trend Test, known as the Seasonal Kendall Test, can be used to assess monotonic trends in time series that exhibit seasonality. The Seasonal Kendall Test calculates the Mann-Kendall test statistic separately for each month in the time series. In this case, all points in each month across the data set are grouped together, a Mann-Kendall Test is calculated on each group, and then all twelve of these statistics are summed for a final Seasonal Kendall Test statistic. Due to the data gaps and sparse historical canal inflow data, INTERA only performed the Seasonal Kendall Test for the modeled data. Due to the limitations of the historical canal inflow the data, we only conducted the Seasonal Kendall Test using the modeled arsenic data.

3.0 Results

3.1 Timeseries Plots

INTERA produced time series plots to visualize the input data. **Figure 2** and **Figure 3** show example time series for historical data and modeled data, respectively. Included in the figures are the constituent's name, sample site, category, and concentration over time. No additional figures have been included, as there were no significant increasing trends. Additional time series plots for upstream sample points SMW-S1 and SMW-P1 are provided in Appendix A.

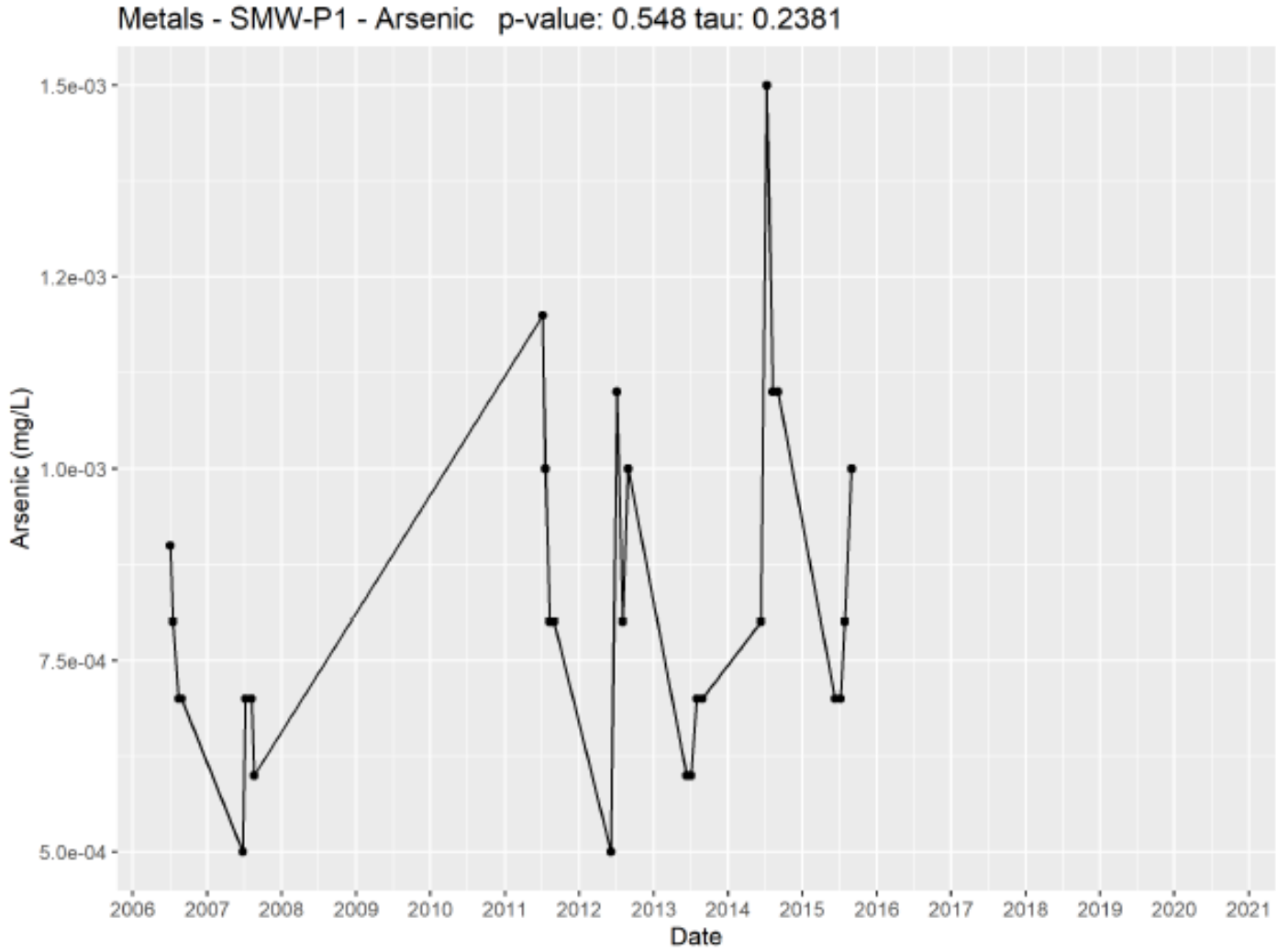


Figure 2. Time series plot for average annual nitrite historical data at sample site SMW-R1.

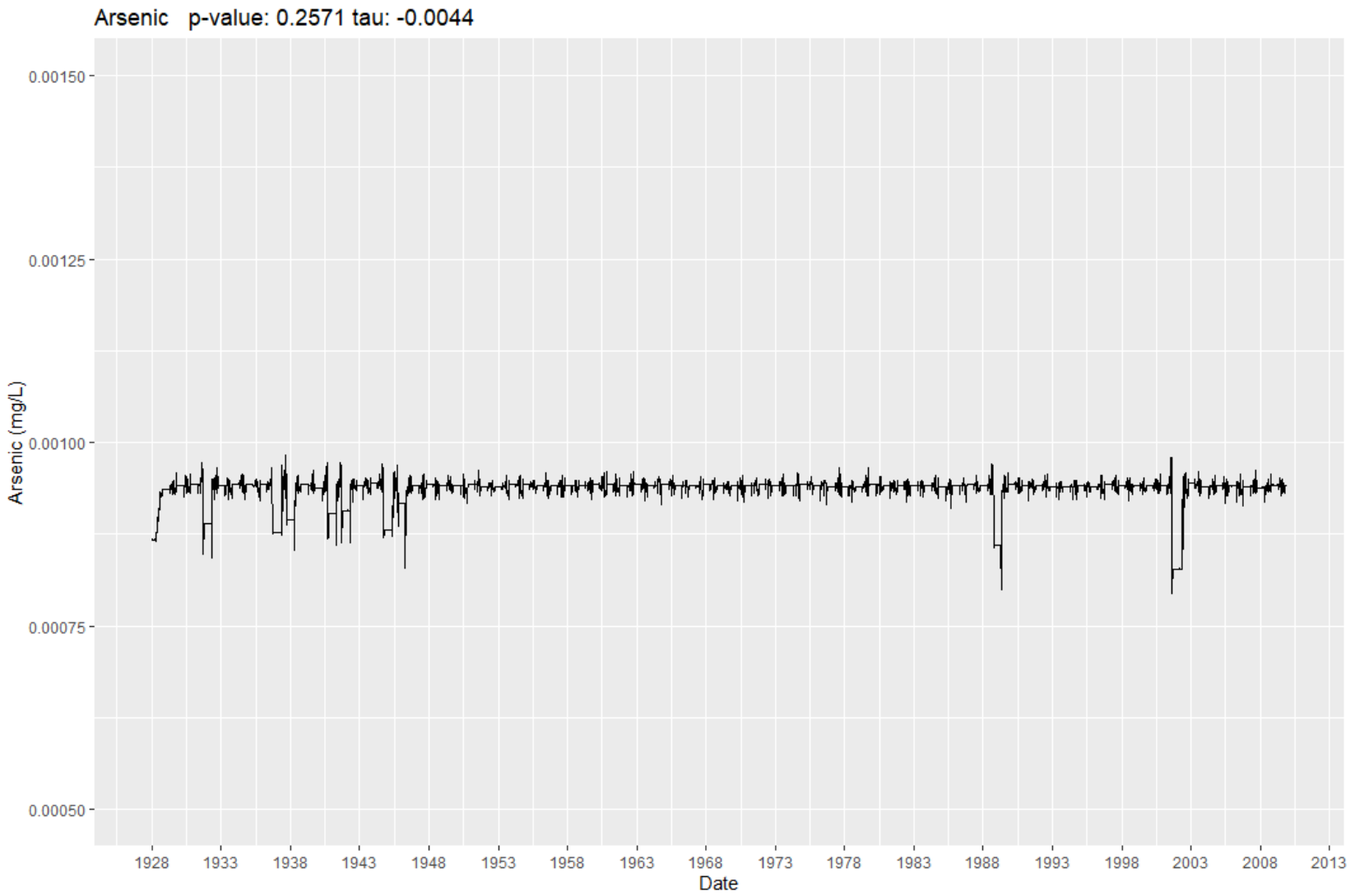


Figure 3. Time series plot for the base-case modeled arsenic concentrations.

3.2 Mann-Kendall Test Results

The results of the Mann-Kendall Trend Tests are presented in **Table 1**, **Table 2**, and **Table 3** for anions and nutrients, metals, and pesticides, respectively. The sample sites are labeled in red for downstream stations and blue for upstream stations (as seen in Figure 1). For the historical data, we observed significant p-values (<0.05) with decreasing trends and no significant p-values (<0.05) with an increasing trend for upstream stations SMW-P1 and SMW-S1. The modeled data for arsenic had no significant trend, with or without seasonality considered.

Stations SMW-P1 and SMW-S1 are upstream of the Chin Reservoir and have direct influence on its water quality. SMW-P1 showed significant decreasing trends for ammonia, antimony, boron, cadmium, carbonate, chromium (trivalent), cobalt, lithium, mercury, sulphate and zinc. SMW-S1 lacked sufficient data to calculate appropriate trends across the time series. Station SMC-R4 is downstream of the Chin Reservoir and was the only station with a significant increasing trend, noted for Manganese.

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
SMC-P1	Ammonia	31	0.05	Decreasing
	Bicarbonate - HCO3	47	0.63	Decreasing
	Calcium	47	0.54	Decreasing
	Carbonate - CO3	47	0.51	Increasing
	Chloride	47	1.00	No Trend
	Electrical Conductivity3	47	0.19	Decreasing
	Hardness	47	0.19	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.02	Decreasing
	Nitrite (as N)	47	0.04	Decreasing
	pH2	47	0.30	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.06	Decreasing
	Temperature	45	0.04	Decreasing
	Total Alkalinity	47	0.27	Decreasing
	Total Dissolved Solids	47	0.15	Decreasing
	Total Nitrogen	39	1.00	Increasing
	Total Phosphorus	47	0.04	Decreasing
SMC-R1	Ammonia	32	0.03	Decreasing
	Bicarbonate - HCO3	47	0.89	Decreasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Calcium	47	0.73	Decreasing
	Carbonate - CO3	47	0.70	Decreasing
	Chloride	47	0.24	Decreasing
	Electrical Conductivity3	50	0.45	Decreasing
	Hardness	47	0.05	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.53	Decreasing
	Nitrite (as N)	47	0.74	Decreasing
	pH2	47	0.02	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.01	Decreasing
	Temperature	61	<0.01	Decreasing
	Total Alkalinity	47	0.41	Decreasing
	Total Dissolved Solids	47	<0.01	Decreasing
	Total Nitrogen	39	0.28	Decreasing
	Total Phosphorus	47	0.45	Decreasing
SMC-R2	Ammonia	8	NA	No Trend
	Bicarbonate - HCO3	8	NA	No Trend
	Calcium	8	NA	No Trend
	Carbonate - CO3	8	NA	No Trend
	Chloride	8	NA	No Trend
	Electrical Conductivity3	8	NA	No Trend
	Hardness	8	NA	No Trend
	Magnesium	8	NA	No Trend
	Nitrate (as N)	8	NA	No Trend
	Nitrite (as N)	8	NA	No Trend
	pH2	8	NA	No Trend
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	8	NA	No Trend
	Temperature	8	NA	No Trend
	Total Alkalinity	8	NA	No Trend
	Total Dissolved Solids	8	NA	No Trend
	Total Phosphorus	8	NA	No Trend

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
SMC-R3	Ammonia	32	0.32	Decreasing
	Bicarbonate - HCO3	47	0.37	Increasing
	Calcium	47	1.00	No Trend
	Carbonate - CO3	47	0.02	Decreasing
	Chloride	47	0.02	Decreasing
	Electrical Conductivity3	47	<0.01	Decreasing
	Hardness	47	0.02	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.06	Decreasing
	Nitrite (as N)	47	0.01	Decreasing
	pH2	47	0.02	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.02	Decreasing
	Total Alkalinity	47	0.11	Decreasing
	Total Dissolved Solids	47	0.01	Decreasing
	Total Nitrogen	39	0.21	Decreasing
	Total Phosphorus	47	0.06	Decreasing
SMC-R4	Ammonia	32	0.05	Decreasing
	Bicarbonate - HCO3	47	0.78	Decreasing
	Calcium	47	0.84	Decreasing
	Carbonate - CO3	47	0.58	Increasing
	Chloride	47	0.63	Decreasing
	Electrical Conductivity3	47	0.19	Decreasing
	Hardness	47	0.30	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.04	Decreasing
	Nitrite (as N)	47	0.01	Decreasing
	pH2	47	0.05	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.02	Decreasing
	Total Alkalinity	47	0.37	Decreasing
	Total Dissolved Solids	47	0.06	Decreasing
	Total Nitrogen	39	0.86	Decreasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Total Phosphorus	47	0.13	Decreasing
SMC-S1	Ammonia	32	0.06	Decreasing
	Bicarbonate - HCO3	47	0.19	Decreasing
	Calcium	47	0.73	Decreasing
	Carbonate - CO3	47	0.09	Increasing
	Chloride	47	<0.01	Decreasing
	Electrical Conductivity3	47	<0.01	Decreasing
	Hardness	47	<0.01	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.05	Decreasing
	Nitrite (as N)	47	0.02	Decreasing
	pH2	47	0.95	Increasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.02	Decreasing
	Total Alkalinity	47	0.10	Decreasing
	Total Dissolved Solids	47	<0.01	Decreasing
	Total Nitrogen	39	0.07	Decreasing
	Total Phosphorus	47	0.30	Decreasing
SMC-S2	Ammonia	32	0.05	Decreasing
	Bicarbonate - HCO3	47	0.11	Decreasing
	Calcium	47	0.30	Decreasing
	Carbonate - CO3	47	0.72	Increasing
	Chloride	47	<0.01	Decreasing
	Electrical Conductivity3	47	<0.01	Decreasing
	Hardness	47	<0.01	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.20	Decreasing
	Nitrite (as N)	47	0.12	Decreasing
	pH2	47	0.37	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	<0.01	Decreasing
	Total Alkalinity	47	0.05	Decreasing
	Total Dissolved Solids	47	<0.01	Decreasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Total Nitrogen	39	0.15	Decreasing
	Total Phosphorus	47	0.03	Decreasing
SMC-S3	Ammonia	32	0.35	Decreasing
	Bicarbonate - HCO3	47	1.00	Decreasing
	Calcium	47	0.73	Decreasing
	Carbonate - CO3	47	1.00	No Trend
	Chloride	47	0.68	Decreasing
	Electrical Conductivity3	47	0.41	Decreasing
	Hardness	47	0.10	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.04	Decreasing
	Nitrite (as N)	47	0.03	Decreasing
	pH2	47	0.45	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.24	Decreasing
	Total Alkalinity	47	0.45	Decreasing
	Total Dissolved Solids	47	0.24	Decreasing
	Total Nitrogen	39	0.21	Decreasing
	Total Phosphorus	47	0.15	Decreasing
SME-P1	Ammonia	32	0.32	Decreasing
	Bicarbonate - HCO3	47	0.22	Increasing
	Calcium	47	0.73	Increasing
	Carbonate - CO3	47	<0.01	Decreasing
	Chloride	47	0.30	Decreasing
	Electrical Conductivity3	46	0.15	Decreasing
	Hardness	46	0.58	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.04	Decreasing
	Nitrite (as N)	47	0.04	Decreasing
	pH2	47	0.05	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.09	Decreasing
	Total Alkalinity	47	0.89	Increasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Total Dissolved Solids	46	0.15	Decreasing
	Total Nitrogen	39	0.28	Decreasing
	Total Phosphorus	47	0.24	Decreasing
SME-R1	Ammonia	8	NA	No Trend
	Bicarbonate - HCO3	8	NA	No Trend
	Calcium	8	NA	No Trend
	Carbonate - CO3	8	NA	No Trend
	Chloride	8	NA	No Trend
	Electrical Conductivity3	8	NA	No Trend
	Hardness	7	NA	No Trend
	Magnesium	8	NA	No Trend
	Nitrate (as N)	8	NA	No Trend
	Nitrite (as N)	8	NA	No Trend
	pH2	8	NA	No Trend
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	8	NA	No Trend
	Total Alkalinity	8	NA	No Trend
	Total Dissolved Solids	7	NA	No Trend
	Total Phosphorus	8	NA	No Trend
SME-R1A	Ammonia	24	0.07	Decreasing
	Bicarbonate - HCO3	39	0.11	Decreasing
	Calcium	39	0.05	Decreasing
	Carbonate - CO3	39	0.93	Increasing
	Chloride	39	0.11	Decreasing
	Electrical Conductivity3	39	<0.01	Decreasing
	Hardness	39	<0.01	Decreasing
	Nitrate (as N)	39	0.44	Decreasing
	Nitrite (as N)	39	0.79	Increasing
	pH2	39	0.28	Increasing
	Sulphate	39	<0.01	Decreasing
	Total Alkalinity	39	0.07	Decreasing
	Total Dissolved Solids	39	<0.01	Decreasing
	Total Nitrogen	39	0.72	Decreasing
	Total Phosphorus	39	0.28	Increasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
SME-R2	Ammonia	24	0.31	Decreasing
	Bicarbonate - HCO3	39	0.07	Decreasing
	Calcium	39	0.02	Decreasing
	Carbonate - CO3	39	1.00	Increasing
	Chloride	39	0.02	Decreasing
	Electrical Conductivity3	39	<0.01	Decreasing
	Hardness	39	0.02	Decreasing
	Nitrate (as N)	39	0.78	Increasing
	Nitrite (as N)	39	0.21	Increasing
	pH2	39	0.15	Decreasing
	Sulphate	39	<0.01	Decreasing
	Total Alkalinity	39	0.07	Decreasing
	Total Dissolved Solids	39	<0.01	Decreasing
	Total Nitrogen	39	0.37	Decreasing
	Total Phosphorus	39	0.37	Decreasing
SME-S1	Ammonia	32	0.35	Decreasing
	Bicarbonate - HCO3	47	0.63	Decreasing
	Calcium	47	0.73	Decreasing
	Carbonate - CO3	47	1.00	Decreasing
	Chloride	47	0.27	Decreasing
	Electrical Conductivity3	47	0.04	Decreasing
	Hardness	47	0.11	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.02	Decreasing
	Nitrite (as N)	47	<0.01	Decreasing
	pH2	47	0.54	Increasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.02	Decreasing
	Total Alkalinity	47	0.30	Decreasing
	Total Dissolved Solids	47	0.05	Decreasing
	Total Nitrogen	39	0.37	Decreasing
	Total Phosphorus	47	0.68	Increasing
SMW-P1	Ammonia	32	0.05	Decreasing
	Bicarbonate - HCO3	47	1.00	Increasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Calcium	47	0.84	Decreasing
	Carbonate - CO3	47	0.05	Increasing
	Chloride	47	1.00	No Trend
	Electrical Conductivity3	47	0.30	Decreasing
	Hardness	47	0.10	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.05	Decreasing
	Nitrite (as N)	47	0.45	Decreasing
	pH2	47	0.17	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.04	Decreasing
	Total Alkalinity	47	0.58	Decreasing
	Total Dissolved Solids	47	0.05	Decreasing
	Total Nitrogen	39	0.06	Decreasing
	Total Phosphorus	47	0.22	Decreasing
SMW-R1	Ammonia	32	0.05	Decreasing
	Bicarbonate - HCO3	47	0.73	Increasing
	Calcium	47	0.73	Increasing
	Carbonate - CO3	47	0.41	Increasing
	Chloride	47	0.54	Decreasing
	Electrical Conductivity3	47	0.15	Decreasing
	Hardness	47	0.24	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.05	Decreasing
	Nitrite (as N)	47	<0.01	Decreasing
	pH2	47	0.84	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.03	Decreasing
	Total Alkalinity	47	0.84	Decreasing
	Total Dissolved Solids	47	0.02	Decreasing
	Total Nitrogen	39	0.28	Decreasing
	Total Phosphorus	47	0.11	Decreasing
SMW-R2	Ammonia	32	0.20	Decreasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Bicarbonate - HCO3	47	0.84	Increasing
	Calcium	47	0.63	Decreasing
	Carbonate - CO3	47	0.41	Decreasing
	Chloride	47	1.00	Increasing
	Electrical Conductivity3	47	0.22	Decreasing
	Hardness	47	0.06	Decreasing
	Magnesium	8	NA	No Trend
	Nitrate (as N)	47	0.02	Decreasing
	Nitrite (as N)	47	0.17	Decreasing
	pH2	47	0.13	Decreasing
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	47	0.03	Decreasing
	Total Alkalinity	47	0.68	Decreasing
	Total Dissolved Solids	47	0.03	Decreasing
	Total Nitrogen	39	0.86	Decreasing
	Total Phosphorus	47	0.11	Decreasing
SMW-S1	Ammonia	8	NA	No Trend
	Bicarbonate - HCO3	8	NA	No Trend
	Calcium	8	NA	No Trend
	Carbonate - CO3	8	NA	No Trend
	Chloride	8	NA	No Trend
	Electrical Conductivity3	8	NA	No Trend
	Hardness	8	NA	No Trend
	Magnesium	8	NA	No Trend
	Nitrate (as N)	8	NA	No Trend
	Nitrite (as N)	8	NA	No Trend
	pH2	8	NA	No Trend
	Potassium	8	NA	No Trend
	Sodium	8	NA	No Trend
	Sulphate	8	NA	No Trend
	Total Alkalinity	8	NA	No Trend
	Total Dissolved Solids	8	NA	No Trend
	Total Phosphorus	8	NA	No Trend
SWM-S2	Ammonia	24	0.31	Decreasing

Table 1. Mann-Kendall trend test results for anions & nutrients of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Bicarbonate - HCO3	39	1.00	Increasing
	Calcium	39	0.86	Increasing
	Carbonate - CO3	39	0.80	Decreasing
	Chloride	39	0.86	Decreasing
	Electrical Conductivity3	39	0.28	Decreasing
	Hardness	39	0.65	Decreasing
	Nitrate (as N)	39	0.12	Decreasing
	Nitrite (as N)	39	0.58	Increasing
	pH2	39	0.07	Decreasing
	Sulphate	39	0.02	Decreasing
	Total Alkalinity	39	0.93	Decreasing
	Total Dissolved Solids	39	0.18	Decreasing
	Total Nitrogen	39	0.72	Decreasing
	Total Phosphorus	39	0.24	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
SMC-P1	Aluminum	26	0.07	Decreasing
	Antimony	26	0.02	Decreasing
	Arsenic	26	0.45	Increasing
	Barium	26	0.76	Increasing
	Beryllium	26	0.08	Decreasing
	Bismuth	18	1.00	Increasing
	Boron	26	<0.01	Decreasing
	Cadmium	26	0.06	Decreasing
	Chromium (Trivalent)	26	0.06	Decreasing
	Cobalt	26	0.03	Decreasing
	Copper	26	0.34	Increasing
	Iron	26	0.37	Decreasing
	Lead	26	0.64	Decreasing
	Lithium	26	0.07	Decreasing
	Manganese	26	0.76	Increasing
	Mercury	26	0.03	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Molybdenum	26	0.08	Decreasing
	Nickel	26	0.13	Decreasing
	Selenium	26	0.65	Decreasing
	Silver	26	0.08	Decreasing
	Strontium	18	0.46	Decreasing
	Thallium	26	0.08	Decreasing
	Tin	26	0.08	Decreasing
	Titanium	26	0.07	Decreasing
	Uranium	26	0.76	Decreasing
	Vanadium	26	0.45	Decreasing
	Zinc	26	0.13	Decreasing
SMC-R1	Aluminum	28	0.37	Decreasing
	Antimony	28	0.09	Decreasing
	Arsenic	28	0.37	Decreasing
	Barium	28	0.45	Decreasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	0.03	Decreasing
	Chromium (Trivalent)	28	0.03	Decreasing
	Cobalt	28	0.02	Decreasing
	Copper	28	1.00	No Trend
	Iron	28	1.00	Increasing
	Lead	28	0.75	Decreasing
	Lithium	28	0.02	Decreasing
	Manganese	28	1.00	Increasing
	Mercury	28	0.22	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.03	Decreasing
	Selenium	28	0.88	Decreasing
	Silver	28	0.23	Decreasing
	Strontium	20	0.46	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.13	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Uranium	28	0.65	Increasing
	Vanadium	28	0.45	Decreasing
	Zinc	28	0.07	Decreasing
SMC-R2	Aluminum	8	NA	No Trend
	Antimony	8	NA	No Trend
	Arsenic	8	NA	No Trend
	Barium	8	NA	No Trend
	Beryllium	8	NA	No Trend
	Boron	8	NA	No Trend
	Cadmium	8	NA	No Trend
	Chromium (Trivalent)	8	NA	No Trend
	Cobalt	8	NA	No Trend
	Copper	8	NA	No Trend
	Iron	8	NA	No Trend
	Lead	8	NA	No Trend
	Lithium	8	NA	No Trend
	Manganese	8	NA	No Trend
	Mercury	8	NA	No Trend
	Molybdenum	8	NA	No Trend
	Nickel	8	NA	No Trend
	Selenium	8	NA	No Trend
	Silver	8	NA	No Trend
	Thallium	8	NA	No Trend
	Tin	8	NA	No Trend
	Titanium	8	NA	No Trend
	Uranium	8	NA	No Trend
	Vanadium	8	NA	No Trend
	Zinc	8	NA	No Trend
SMC-R3	Aluminum	28	0.76	Decreasing
	Antimony	28	0.09	Decreasing
	Arsenic	28	0.23	Decreasing
	Barium	28	0.76	Increasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.04	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Cadmium	28	0.03	Decreasing
	Chromium (Trivalent)	28	0.03	Decreasing
	Cobalt	28	0.02	Decreasing
	Copper	28	0.53	Decreasing
	Iron	28	0.13	Increasing
	Lead	28	0.40	Increasing
	Lithium	28	0.23	Decreasing
	Manganese	28	0.55	Increasing
	Mercury	28	0.02	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.88	Decreasing
	Selenium	28	0.23	Decreasing
	Silver	28	0.11	Decreasing
	Strontium	20	0.46	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.13	Decreasing
	Uranium	28	0.43	Increasing
	Vanadium	28	0.13	Decreasing
	Zinc	28	0.04	Decreasing
SMC-R4	Aluminum	28	1.00	Increasing
	Antimony	28	0.02	Decreasing
	Arsenic	28	0.45	Increasing
	Barium	28	1.00	Decreasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	<0.01	Decreasing
	Cadmium	28	0.34	Decreasing
	Chromium (Trivalent)	28	0.34	Decreasing
	Cobalt	28	0.65	Decreasing
	Copper	28	0.87	Increasing
	Iron	28	0.37	Increasing
	Lead	28	0.75	Decreasing
	Lithium	28	0.05	Decreasing
	Manganese	28	0.04	Increasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Mercury	28	0.02	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.45	Decreasing
	Selenium	28	0.29	Decreasing
	Silver	28	0.08	Decreasing
	Strontium	20	0.22	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.37	Decreasing
	Uranium	28	0.88	Decreasing
	Vanadium	28	1.00	Decreasing
	Zinc	28	0.17	Decreasing
SMC-S1	Aluminum	28	0.12	Decreasing
	Antimony	28	0.09	Decreasing
	Arsenic	28	0.76	Decreasing
	Barium	28	0.23	Decreasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	0.08	Decreasing
	Chromium (Trivalent)	28	0.08	Decreasing
	Cobalt	28	0.13	Decreasing
	Copper	28	0.75	Increasing
	Iron	28	0.50	Increasing
	Lead	28	1.00	Increasing
	Lithium	28	0.17	Decreasing
	Manganese	28	1.00	Decreasing
	Mercury	28	0.02	Decreasing
	Molybdenum	28	0.13	Decreasing
	Nickel	28	0.28	Decreasing
	Selenium	28	0.64	Decreasing
	Silver	28	0.03	Decreasing
	Strontium	20	0.22	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Titanium	28	0.02	Decreasing
	Uranium	28	0.88	Increasing
	Vanadium	28	0.09	Decreasing
	Zinc	28	0.09	Decreasing
SMC-S2	Aluminum	28	1.00	Increasing
	Antimony	28	0.06	Decreasing
	Arsenic	28	0.37	Decreasing
	Barium	28	0.55	Decreasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.04	Decreasing
	Cadmium	28	0.04	Decreasing
	Chromium (Trivalent)	28	0.04	Decreasing
	Cobalt	28	0.04	Decreasing
	Copper	28	0.60	Decreasing
	Iron	28	0.13	Increasing
	Lead	28	0.80	Increasing
	Lithium	28	0.12	Decreasing
	Manganese	28	0.76	Decreasing
	Mercury	28	0.01	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.09	Decreasing
	Selenium	28	0.88	Decreasing
	Silver	28	0.06	Decreasing
	Strontium	20	0.22	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.23	Decreasing
	Uranium	28	0.76	Increasing
	Vanadium	28	0.04	Decreasing
	Zinc	28	0.09	Decreasing
SMC-S3	Aluminum	28	0.23	Decreasing
	Antimony	28	0.09	Decreasing
	Arsenic	28	0.88	Increasing
	Barium	28	0.76	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	0.06	Decreasing
	Chromium (Trivalent)	28	0.06	Decreasing
	Cobalt	28	0.09	Decreasing
	Copper	28	0.76	Decreasing
	Iron	28	0.37	Decreasing
	Lead	28	0.22	Decreasing
	Lithium	28	0.09	Decreasing
	Manganese	28	1.00	Increasing
	Mercury	28	0.07	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.17	Decreasing
	Selenium	28	0.23	Decreasing
	Silver	28	0.11	Decreasing
	Strontium	20	0.22	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.13	Decreasing
	Uranium	28	0.76	Decreasing
	Vanadium	28	0.29	Decreasing
	Zinc	28	0.13	Decreasing
SME-P1	Aluminum	28	0.04	Decreasing
	Antimony	28	0.04	Decreasing
	Arsenic	28	0.76	Decreasing
	Barium	28	0.55	Increasing
	Beryllium	28	0.08	Decreasing
	Bismuth	19	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	0.03	Decreasing
	Chromium (Trivalent)	28	0.03	Decreasing
	Cobalt	28	0.03	Decreasing
	Copper	28	0.80	Decreasing
	Iron	28	0.04	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Lead	28	0.45	Decreasing
	Lithium	28	0.76	Decreasing
	Manganese	28	0.76	Increasing
	Mercury	28	0.03	Decreasing
	Molybdenum	28	0.04	Decreasing
	Nickel	28	0.05	Decreasing
	Selenium	28	0.23	Decreasing
	Silver	28	0.03	Decreasing
	Strontium	19	0.22	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.07	Decreasing
	Uranium	28	1.00	Decreasing
	Vanadium	28	0.76	Decreasing
	Zinc	28	0.23	Decreasing
SME-R1	Aluminum	8	NA	No Trend
	Antimony	8	NA	No Trend
	Arsenic	8	NA	No Trend
	Barium	8	NA	No Trend
	Beryllium	8	NA	No Trend
	Boron	8	NA	No Trend
	Cadmium	8	NA	No Trend
	Chromium (Trivalent)	8	NA	No Trend
	Cobalt	8	NA	No Trend
	Copper	8	NA	No Trend
	Iron	8	NA	No Trend
	Lead	8	NA	No Trend
	Lithium	8	NA	No Trend
	Manganese	8	NA	No Trend
	Mercury	8	NA	No Trend
	Molybdenum	8	NA	No Trend
	Nickel	8	NA	No Trend
	Selenium	8	NA	No Trend
	Silver	8	NA	No Trend
	Thallium	8	NA	No Trend

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Tin	8	NA	No Trend
	Titanium	8	NA	No Trend
	Uranium	8	NA	No Trend
	Vanadium	8	NA	No Trend
	Zinc	8	NA	No Trend
SME-R1A	Aluminum	20	1.00	No Trend
	Antimony	20	0.29	Increasing
	Arsenic	20	0.22	Increasing
	Barium	20	0.61	Decreasing
	Beryllium	20	1.00	Increasing
	Bismuth	20	1.00	Increasing
	Boron	20	0.09	Decreasing
	Cadmium	20	0.29	Decreasing
	Chromium (Trivalent)	20	0.29	Decreasing
	Cobalt	20	1.00	Decreasing
	Copper	20	1.00	Decreasing
	Iron	20	0.81	Increasing
	Lead	20	1.00	Increasing
	Lithium	20	0.09	Decreasing
	Manganese	20	0.81	Increasing
	Mercury	20	0.10	Decreasing
	Molybdenum	20	0.29	Decreasing
	Nickel	20	0.46	Decreasing
	Selenium	20	0.58	Increasing
	Silver	20	0.29	Decreasing
	Strontium	20	0.09	Decreasing
	Thallium	20	1.00	Increasing
	Tin	20	1.00	Increasing
	Titanium	20	0.46	Decreasing
	Uranium	20	0.31	Decreasing
	Vanadium	20	0.81	Increasing
	Zinc	20	0.46	Increasing
SME-R2	Aluminum	20	0.22	Decreasing
	Antimony	20	0.29	Decreasing
	Arsenic	20	1.00	No Trend

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Barium	20	0.81	Decreasing
	Beryllium	20	1.00	Increasing
	Bismuth	19	1.00	Increasing
	Boron	20	0.09	Decreasing
	Cadmium	20	0.10	Decreasing
	Chromium (Trivalent)	20	0.10	Decreasing
	Cobalt	20	0.09	Decreasing
	Copper	20	0.10	Decreasing
	Iron	20	0.46	Decreasing
	Lead	20	0.13	Decreasing
	Lithium	20	0.03	Decreasing
	Manganese	20	0.09	Decreasing
	Mercury	20	0.10	Decreasing
	Molybdenum	20	0.04	Decreasing
	Nickel	20	0.09	Decreasing
	Selenium	20	0.13	Increasing
	Silver	20	0.29	Decreasing
	Strontium	19	0.09	Decreasing
	Thallium	20	1.00	Increasing
	Tin	20	1.00	Increasing
	Titanium	20	0.03	Decreasing
	Uranium	20	0.22	Decreasing
	Vanadium	20	0.09	Decreasing
	Zinc	20	0.22	Decreasing
SME-S1	Aluminum	28	0.13	Decreasing
	Antimony	28	0.06	Decreasing
	Arsenic	28	0.76	Increasing
	Barium	28	0.37	Decreasing
	Beryllium	28	0.08	Decreasing
	Bismuth	19	1.00	Increasing
	Boron	28	<0.01	Decreasing
	Cadmium	28	0.04	Decreasing
	Chromium (Trivalent)	28	0.04	Decreasing
	Cobalt	28	0.36	Decreasing
	Copper	28	0.15	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Iron	28	0.37	Decreasing
	Lead	28	0.88	Decreasing
	Lithium	28	0.88	Increasing
	Manganese	28	0.55	Decreasing
	Mercury	28	0.02	Decreasing
	Molybdenum	28	0.03	Decreasing
	Nickel	28	0.17	Decreasing
	Selenium	28	1.00	Decreasing
	Silver	28	0.06	Decreasing
	Strontium	19	0.09	Decreasing
	Thallium	28	0.13	Decreasing
	Tin	28	0.03	Decreasing
	Titanium	28	0.37	Decreasing
	Uranium	28	1.00	Increasing
	Vanadium	28	0.76	Decreasing
	Zinc	28	0.45	Decreasing
SMW-P1	Aluminum	28	0.13	Decreasing
	Antimony	28	0.04	Decreasing
	Arsenic	28	0.55	Increasing
	Barium	28	1.00	No Trend
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	0.03	Decreasing
	Chromium (Trivalent)	28	0.03	Decreasing
	Cobalt	28	0.04	Decreasing
	Copper	28	0.51	Increasing
	Iron	28	0.23	Decreasing
	Lead	28	0.43	Decreasing
	Lithium	28	0.02	Decreasing
	Manganese	28	1.00	Decreasing
	Mercury	28	0.01	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.12	Decreasing
	Selenium	28	0.09	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Silver	28	0.26	Decreasing
	Strontium	20	0.46	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.07	Decreasing
	Uranium	28	0.88	Decreasing
	Vanadium	28	0.12	Decreasing
	Zinc	28	0.04	Decreasing
SMW-R1	Aluminum	28	0.13	Decreasing
	Antimony	28	0.06	Decreasing
	Arsenic	28	0.45	Increasing
	Barium	28	0.23	Decreasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	<0.01	Decreasing
	Chromium (Trivalent)	28	<0.01	Decreasing
	Cobalt	28	0.09	Decreasing
	Copper	28	0.28	Increasing
	Iron	28	0.37	Decreasing
	Lead	28	0.55	Decreasing
	Lithium	28	0.04	Decreasing
	Manganese	28	0.37	Increasing
	Mercury	28	0.01	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.09	Decreasing
	Selenium	28	0.09	Decreasing
	Silver	28	0.13	Decreasing
	Strontium	20	0.46	Decreasing
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.37	Decreasing
	Uranium	28	1.00	Decreasing
	Vanadium	28	0.55	Decreasing
	Zinc	28	0.13	Decreasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
SMW-R2	Aluminum	28	0.09	Decreasing
	Antimony	28	0.06	Decreasing
	Arsenic	28	1.00	Decreasing
	Barium	28	1.00	Increasing
	Beryllium	28	0.08	Decreasing
	Bismuth	20	1.00	Increasing
	Boron	28	0.02	Decreasing
	Cadmium	28	<0.01	Decreasing
	Chromium (Trivalent)	28	<0.01	Decreasing
	Cobalt	28	0.02	Decreasing
	Copper	28	1.00	Increasing
	Iron	28	0.23	Decreasing
	Lead	28	0.29	Decreasing
	Lithium	28	0.17	Decreasing
	Manganese	28	1.00	Decreasing
	Mercury	28	0.01	Decreasing
	Molybdenum	28	0.08	Decreasing
	Nickel	28	0.17	Decreasing
	Selenium	28	0.17	Decreasing
	Silver	28	0.06	Decreasing
	Strontium	20	1.00	No Trend
	Thallium	28	0.08	Decreasing
	Tin	28	0.08	Decreasing
	Titanium	28	0.05	Decreasing
	Uranium	28	1.00	No Trend
	Vanadium	28	0.07	Decreasing
	Zinc	28	0.13	Decreasing
SMW-S1	Aluminum	8	NA	No Trend
	Antimony	8	NA	No Trend
	Arsenic	8	NA	No Trend
	Barium	8	NA	No Trend
	Beryllium	8	NA	No Trend
	Boron	8	NA	No Trend
	Cadmium	8	NA	No Trend
	Chromium (Trivalent)	8	NA	No Trend

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Cobalt	8	NA	No Trend
	Copper	8	NA	No Trend
	Iron	8	NA	No Trend
	Lead	8	NA	No Trend
	Lithium	8	NA	No Trend
	Manganese	8	NA	No Trend
	Mercury	8	NA	No Trend
	Molybdenum	8	NA	No Trend
	Nickel	8	NA	No Trend
	Selenium	8	NA	No Trend
	Silver	8	NA	No Trend
	Thallium	8	NA	No Trend
	Tin	8	NA	No Trend
	Titanium	8	NA	No Trend
	Uranium	8	NA	No Trend
	Vanadium	8	NA	No Trend
	Zinc	8	NA	No Trend
SMW-S2	Aluminum	20	0.22	Decreasing
	Antimony	20	1.00	Increasing
	Arsenic	20	1.00	Decreasing
	Barium	20	0.09	Increasing
	Beryllium	20	1.00	Increasing
	Bismuth	20	1.00	Increasing
	Boron	20	0.61	Decreasing
	Cadmium	20	0.29	Decreasing
	Chromium (Trivalent)	20	0.29	Decreasing
	Cobalt	20	1.00	Decreasing
	Copper	20	0.43	Increasing
	Iron	20	0.81	Decreasing
	Lead	20	0.79	Decreasing
	Lithium	20	0.81	Decreasing
	Manganese	20	0.46	Decreasing
	Mercury	20	0.10	Decreasing
	Molybdenum	20	1.00	Increasing
	Nickel	20	0.61	Increasing

Table 2. Mann-Kendall trend test results for metals of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Selenium	20	0.81	Decreasing
	Silver	20	0.77	Increasing
	Strontium	20	1.00	No Trend
	Thallium	20	1.00	Increasing
	Tin	20	1.00	Increasing
	Titanium	20	0.61	Decreasing
	Uranium	20	0.46	Decreasing
	Vanadium	20	0.46	Decreasing
	Zinc	20	0.46	Decreasing

Table 3. Mann-Kendall Trend test results for pesticides of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
SMC-P1	2,4-Dichlorophenoxyacetic acid	41	0.53	Decreasing
	Atrazine	1	NA	No Trend
	Bentazon	3	NA	No Trend
	Bromoxynil	1	NA	No Trend
	Clopyralid	3	NA	No Trend
	Dicamba	5	NA	No Trend
	Dichlorprop	2	NA	No Trend
	Fluroxypyr	7	0.31	Decreasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	17	0.75	Decreasing
	Metolachlor	1	NA	No Trend
SMC-R1	2,4-Dichlorophenoxyacetic acid	39	0.76	Decreasing
	Aminomethyl phosphonic acid	10	1.00	Decreasing
	Atrazine	3	NA	No Trend
	Bentazon	1	NA	No Trend
	Boscalid	2	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	2	NA	No Trend
	Dichlorprop	1	NA	No Trend
	Difenoconazole	1	NA	No Trend
	EPTC_(S-ethyl_dipropylthiocarbamate)	8	1.00	Decreasing
	Fluroxypyr	9	0.73	Increasing

Table 3. Mann-Kendall Trend test results for pesticides of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Glufosinate	10	0.19	Decreasing
	Glyphosate	10	0.58	Decreasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	12	0.81	Decreasing
	Mecoprop (methylchlorophenoxypropionic_acid)	1	NA	No Trend
	Tebuconazole	1	NA	No Trend
SMC-R2	2,4-Dichlorophenoxyacetic acid	8	NA	No Trend
	Dicamba	3	NA	No Trend
	Dichlorprop	2	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	7	NA	No Trend
SMC-R3	2,4-Dichlorophenoxyacetic acid	42	0.64	Decreasing
	Aminomethyl phosphonic acid	8	1.00	Decreasing
	Atrazine	2	NA	No Trend
	Boscalid	3	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	4	NA	No Trend
	Difenoconazole	1	NA	No Trend
	EPTC_(S-ethyl_dipropylthiocarbamate)	4	0.09	Decreasing
	Fluroxypyr	6	0.73	Decreasing
	Glufosinate	8	0.25	Decreasing
	Glyphosate	8	1.00	Decreasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	15	0.76	Increasing
	Mecoprop (methylchlorophenoxypropionic_acid)	2	NA	No Trend
	Picloram	1	NA	No Trend
	Prometryn	1	NA	No Trend
SMC-R4	2,4-Dichlorophenoxyacetic acid	41	0.64	Decreasing
	Aminomethyl phosphonic acid	8	0.73	Decreasing
	Atrazine	3	NA	No Trend
	Azinphos-methyl	2	NA	No Trend
	Bentazon	3	1.00	Decreasing
	Boscalid	1	NA	No Trend
	Bromoxynil	1	NA	No Trend
	Dicamba	4	NA	No Trend
	Dichlorprop	2	NA	No Trend
	Fluroxypyr	7	1.00	No Trend
	Glufosinate	8	0.15	Decreasing

Table 3. Mann-Kendall Trend test results for pesticides of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Glyphosate	8	0.37	Decreasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	18	0.08	Decreasing
	Mecoprop (methylchlorophenoxypropionic_acid)	1	NA	No Trend
	Metolachlor	1	NA	No Trend
	Prothioconazole-Desthio	1	NA	No Trend
SMC-S1	2,4-Dichlorophenoxyacetic acid	41	0.88	Decreasing
	Atrazine	2	NA	No Trend
	Bentazon	1	NA	No Trend
	Boscalid	2	NA	No Trend
	Bromoxynil	1	NA	No Trend
	Dicamba	5	NA	No Trend
	EPTC_(S-ethyl_dipropylthiocarbamate)	5	0.46	Decreasing
	Fluroxypyr	11	1.00	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	15	1.00	Increasing
	Mecoprop (methylchlorophenoxypropionic_acid)	3	1.00	Increasing
	Tebuconazole	1	NA	No Trend
SMC-S3	2,4-Dichlorophenoxyacetic acid	42	0.28	Decreasing
	Aminomethyl phosphonic acid	10	1.00	Decreasing
	Atrazine	1	NA	No Trend
	Bentazon	2	NA	No Trend
	Boscalid	1	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	6	NA	No Trend
	Dichlorprop	2	NA	No Trend
	EPTC_(S-ethyl_dipropylthiocarbamate)	3	1.00	Decreasing
	Fluroxypyr	7	0.73	Decreasing
	Glufosinate	10	0.15	Decreasing
	Glyphosate	10	1.00	Increasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	20	0.25	Decreasing
	Metolachlor	1	NA	No Trend
SME-P1	2,4-Dichlorophenoxyacetic acid	38	0.16	Decreasing
	Aminomethyl phosphonic acid	10	1.00	Decreasing
	Atrazine	3	NA	No Trend
	Bentazon	3	NA	No Trend
	Boscalid	3	NA	No Trend

Table 3. Mann-Kendall Trend test results for pesticides of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Clopyralid	1	NA	No Trend
	Dicamba	10	0.31	Increasing
	Dichlorprop	3	NA	No Trend
	Difenoconazole	1	NA	No Trend
	Fluroxypyr	7	1.00	Decreasing
	Glufosinate	10	0.19	Decreasing
	Glyphosate	10	1.00	Increasing
	Imazamethabenz	1	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	20	0.90	Decreasing
	Triallate	1	NA	No Trend
SME-R1A	2,4-Dichlorophenoxyacetic acid	34	0.75	Decreasing
	Aminomethyl phosphonic acid	10	0.81	Decreasing
	Azinphos-methyl	1	NA	No Trend
	Bentazon	1	NA	No Trend
	Boscalid	5	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	1	NA	No Trend
	Fluroxypyr	4	NA	No Trend
	Glufosinate	10	0.19	Decreasing
	Glyphosate	10	0.22	Increasing
	MCPA-EHE	1	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	6	0.81	Increasing
	Mecoprop (methylchlorophenoxypropionic_acid)	2	NA	No Trend
SME-R2	2,4-Dichlorophenoxyacetic acid	33	0.12	Decreasing
	Aminomethyl phosphonic acid	8	0.73	Decreasing
	Atrazine	1	NA	No Trend
	Bentazon	2	NA	No Trend
	Boscalid	3	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	1	NA	No Trend
	Fluroxypyr	6	1.00	Increasing
	Glufosinate	8	0.15	Decreasing
	Glyphosate	8	1.00	Decreasing
	Hexazinone	1	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	7	1.00	No Trend

Table 3. Mann-Kendall Trend test results for pesticides of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Metalaxyl	2	NA	No Trend
SME-S1	2,4-Dichlorophenoxyacetic acid	39	1.00	Decreasing
	Atrazine	1	NA	No Trend
	Boscalid	3	NA	No Trend
	Dicamba	1	NA	No Trend
	Dichlorprop	1	NA	No Trend
	Fluroxypyr	4	NA	No Trend
	Hexazinone	1	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	12	0.26	Decreasing
	Mecoprop (methylchlorophenoxypropionic_acid)	1	NA	No Trend
	Sulfentrazone	1	NA	No Trend
SMW-P1	2,4-Dichlorophenoxyacetic acid	34	0.12	Decreasing
	Bentazon	1	NA	No Trend
	Bromoxynil	1	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	2	NA	No Trend
	Dichlorprop	1	NA	No Trend
	Fluroxypyr	2	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	7	0.55	Decreasing
SMW-R2	2,4-Dichlorophenoxyacetic acid	40	0.44	Decreasing
	Aminomethyl phosphonic acid	10	1.00	Decreasing
	Atrazine	1	NA	No Trend
	Azinphos-methyl	1	NA	No Trend
	Bentazon	3	1.00	Increasing
	Bifenthrin	1	NA	No Trend
	Boscalid	1	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	13	0.45	Decreasing
	Dichlorprop	1	NA	No Trend
	EPTC_(S-ethyl_dipropylthiocarbamate)	4	1.00	Increasing
	Fluroxypyr	6	0.81	Decreasing
	Glufosinate	10	0.15	Decreasing
	Glyphosate	10	0.61	Decreasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	16	0.90	Increasing
SMW-S1	2,4-Dichlorophenoxyacetic acid	8	NA	No Trend

Table 3. Mann-Kendall Trend test results for pesticides of historical data.

Sample Site	Constituent	Number of Observations	p-value	Trend Direction
	Bromoxynil	1	NA	No Trend
	Dicamba	4	NA	No Trend
	Dichlorprop	1	NA	No Trend
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	1	NA	No Trend
SMW-S2	2,4-Dichlorophenoxyacetic acid	29	0.92	Increasing
	Aminomethyl phosphonic acid	10	1.00	Decreasing
	Bromoxynil	1	NA	No Trend
	Clopyralid	1	NA	No Trend
	Dicamba	1	NA	No Trend
	Flamprop-Methyl	1	NA	No Trend
	Fluroxypyr	2	NA	No Trend
	Glufosinate	10	0.15	Decreasing
	Glyphosate	10	0.58	Decreasing
	MCPA (2-methyl-4-chlorophenoxyacetic_acid)	7	0.81	Decreasing

3.3 Discussion

Due to the sparse data and large data gaps, seasonality cannot be properly tested using the historical sampling data. Based on the results of the Mann-Kendall trend test for historical data, there were patterns resembling seasonality noted that were not significant ($p<0.05$), which were considered likely to reflect initial flushing of the canal each year. However, the analysis revealed some significant decreasing trends at Station SMW-P1. These decreasing trends suggest that effective interventions or natural processes may have contributed to the reduction of constituent concentrations.

For the modeled arsenic data, we observed no discernible trends, regardless of whether seasonality was considered. The analysis revealed that the data remained stable over time, with no significant upward or downward movements. This indicates that the arsenic levels exhibit no consistent patterns or changes, maintaining a constant mean throughout the period studied.

4.0 References

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Hirsch, R.M., J.R. Slack, and R.A. Smith, 1982: Techniques for Trend Assessment for Monthly Water Quality Data, Water Resources Research, 18, 107-121.

Hipel, K.W., and A.I. McLeod, 2005: Time Series Modelling of Water Resources and Environmental Systems. Retrieved from http://www.stats.uwo.ca/faculty/aim/1994Book/

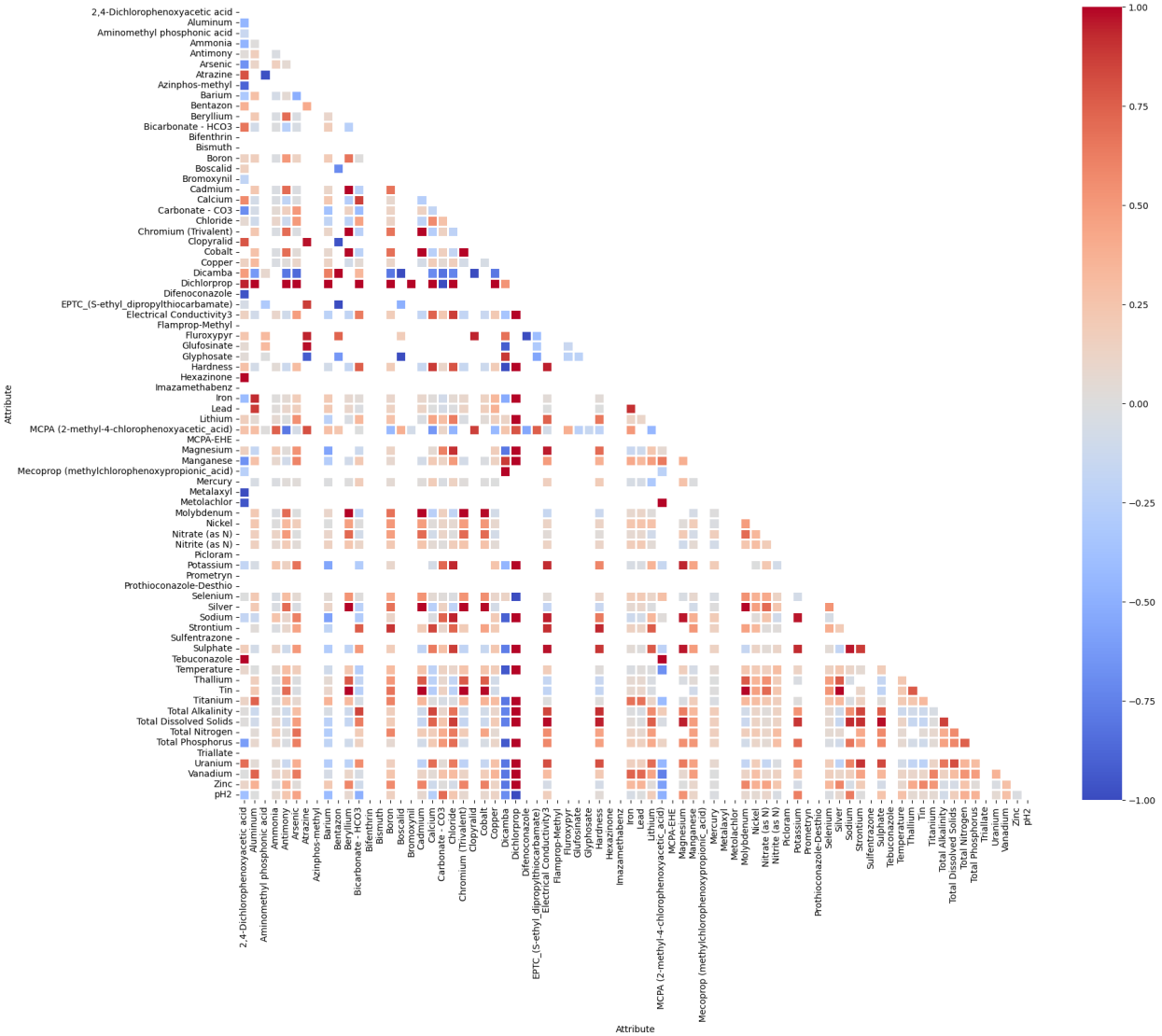
INTERA Inc., 2025: Technical Memorandum Entitled “Chin Reservoir Expansion – Water Quality Analysis”

Appendix A

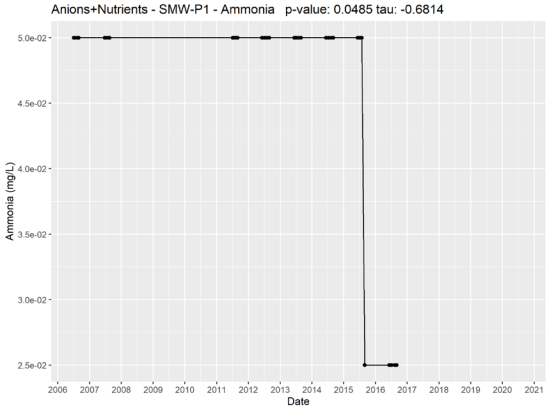
Additional Figures

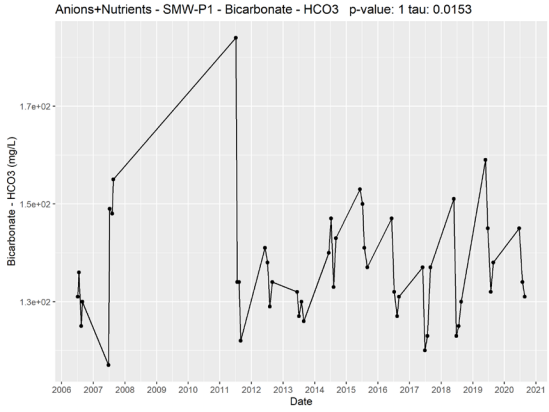
RE: Chin Reservoir Historical Canal Inflow Trend Analysis

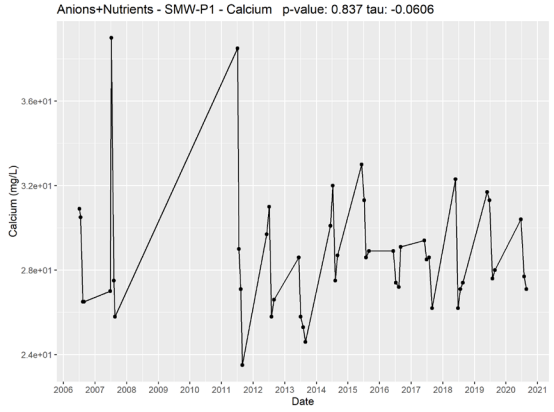
Heatmap

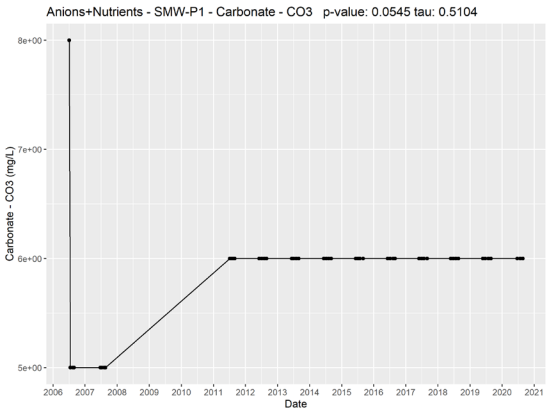

2,4-Dichlorophenoxyacetic acid
Aluminum
Aminomethyl phosphonic acid
Ammonia
Antimony
Arsenic
Atrazine
Azinphos-methyl
Barium
Bentazon
Beryllium
Bicarbonate - HCO3
Bifenthrin
Bismuth
Boron
Boscalid
Bromoxynil
Cadmium
Calcium
Carbonate - CO3
Chloride
Chromium (Trivalent)
Clopyralid
Cobalt
Copper
Dicamba
Dichlorprop
Difenoconazole
EPTC_(S-ethyl_dipropylthiocarbamate)
Electrical Conductivity3
Flamprop-Methyl
Fluroxypyr
Glufosinate
Glyphosate
Hardness
Hexazinone
Imazamethabenz
Iron
Lead
Lithium
MCPA (2-methyl-4-chlorophenoxyacetic_acid)
MCPA-EHE
Magnesium
Manganese
Mecoprop (methylchlorophenoxypropionic_acid)
Mercury
Metalaxyl
Metolachlor
Molybdenum
Nickel
Nitrate (as N)
Nitrite (as N)
Picloram
Potassium
Prometryn
Prothioconazole-Desthio
Selenium
Silver
Sodium
Strontium
Sulfentrazone
Sulphate
Tebuconazole
Temperature
Thallium
Tin
Titanium
Total Alkalinity
Total Dissolved Solids
Total Nitrogen
Total Phosphorus
Triallate
Uranium
Vanadium
Zinc
pH2
Attribute
Attribute
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

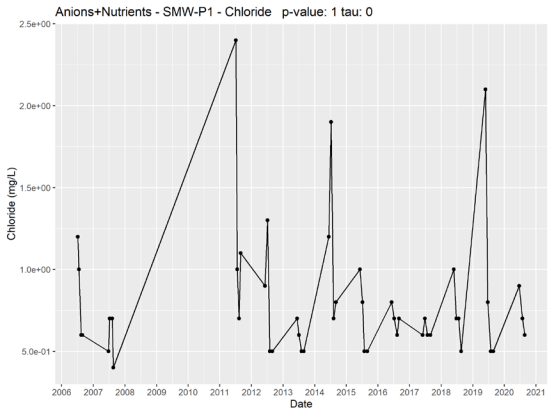
Time Series Plots SMW-S1 and SMW-P1

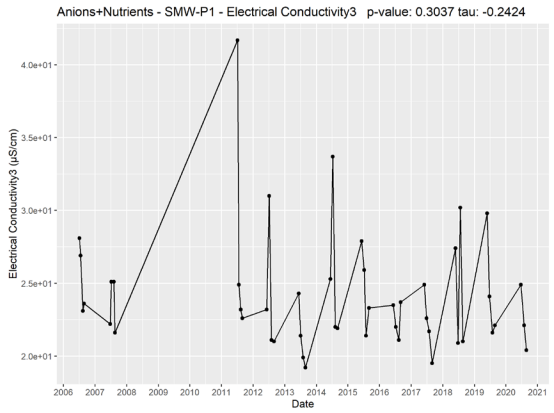


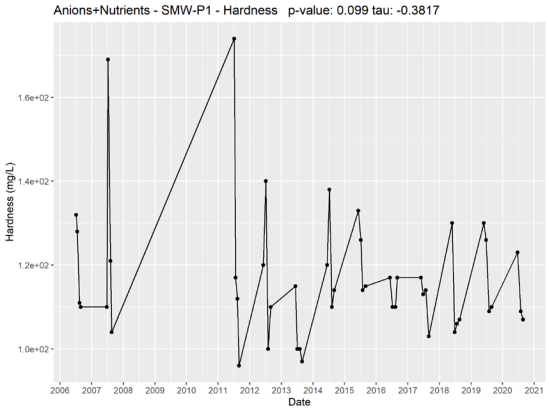


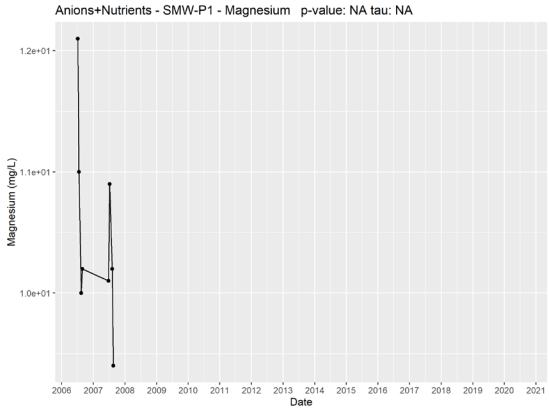


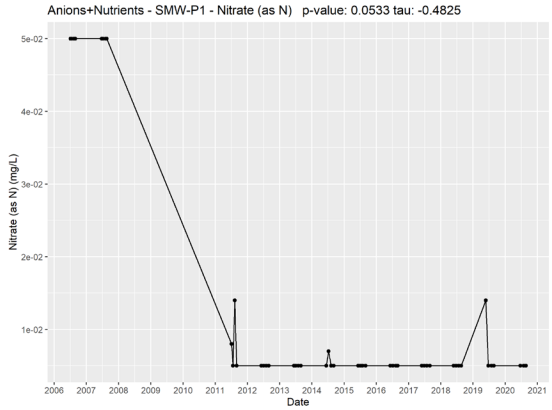


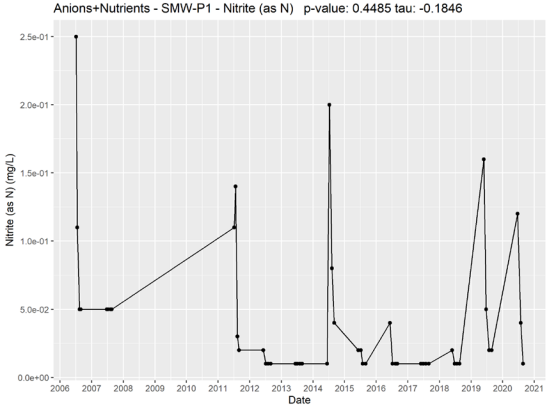


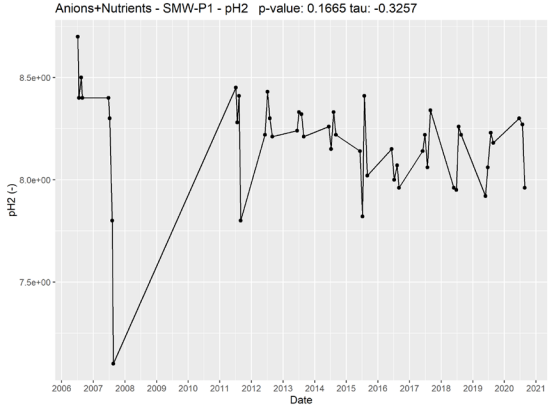


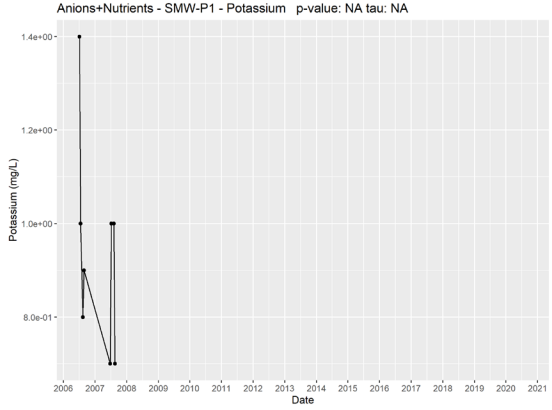

Anions+Nutrients - SMW-P1 - Hardness p-value: 0.099 tau: -0.3817
Hardness (mg/L)
1.6e+02
1.4e+02
1.2e+02
1.0e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

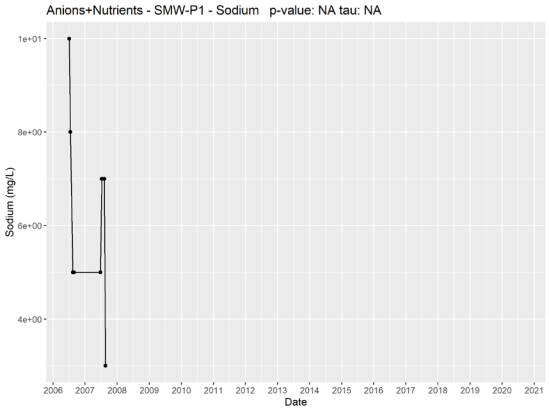

Anions+Nutrients - SMW-P1 - Magnesium p-value: NA tau: NA
Magnesium (mg/L)
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1.1e+01
1.0e+01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

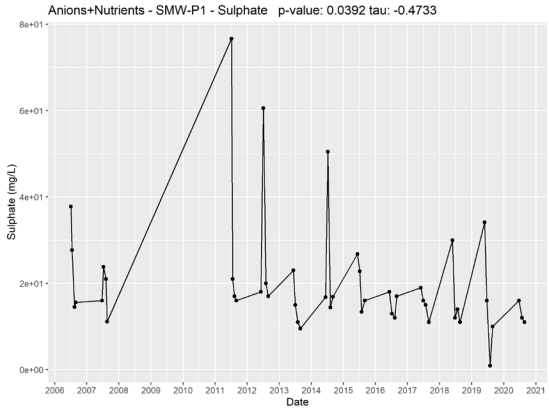

Anions+Nutrients - SMW-P1 - Nitrate (as N) p-value: 0.0533 tau: -0.4825
Nitrate (as N) (mg/L)
5e-02
4e-02
3e-02
2e-02
1e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

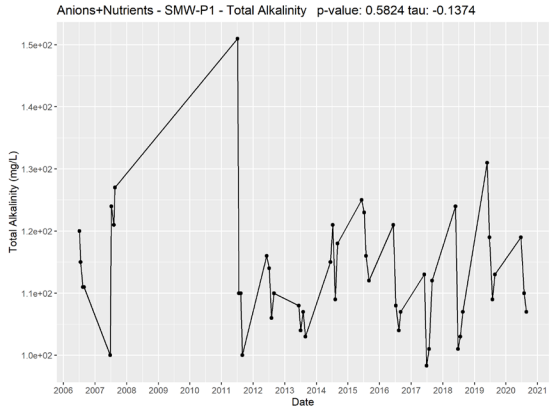

Anions+Nutrients - SMW-P1 - Nitrite (as N) p-value: 0.4485 tau: -0.1846
Nitrite (as N) (mg/L)
2.5e-01
2.0e-01
1.5e-01
1.0e-01
5.0e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

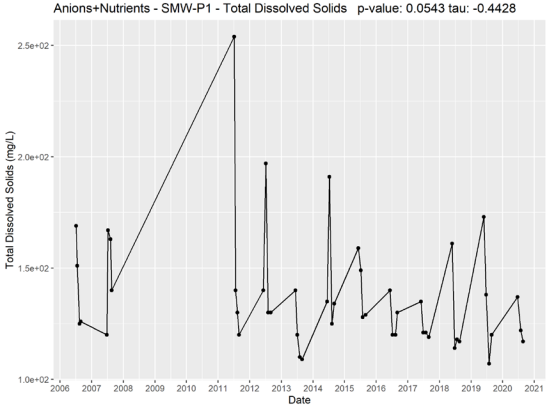

Anions+Nutrients - SMW-P1 - pH2 p-value: 0.1665 tau: -0.3257
pH2 (-)
8.5e+00
8.0e+00
7.5e+00
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Date

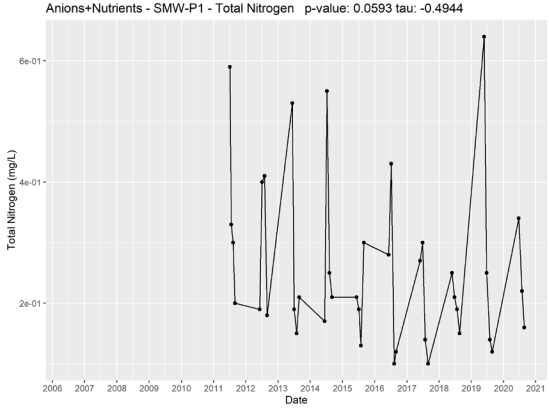

Anions+Nutrients - SMW-P1 - Potassium p-value: NA tau: NA
Potassium (mg/L)
1.4e+00
1.2e+00
1.0e+00
8.0e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

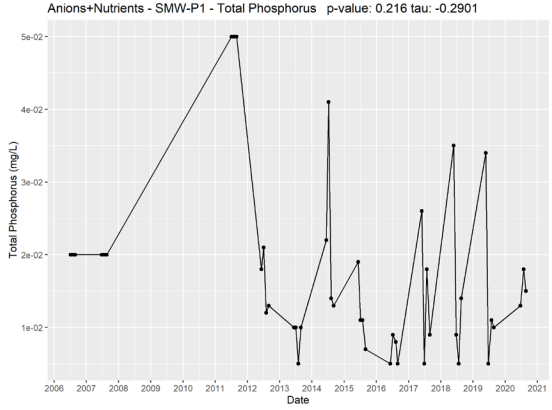

Anions+Nutrients - SMW-P1 - Sodium p-value: NA tau: NA
Sodium (mg/L)
1e+01
8e+00
6e+00
4e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

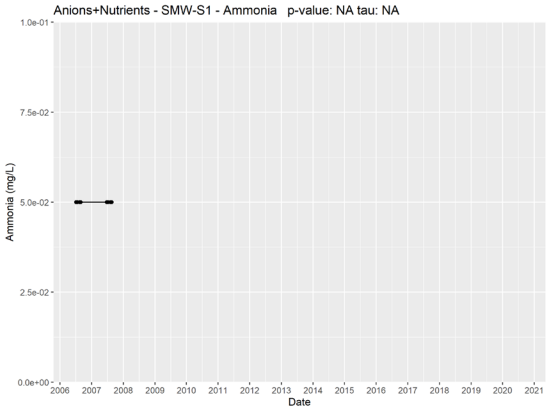

Anions+Nutrients - SMW-P1 - Sulphate p-value: 0.0392 tau: -0.4733
Sulphate (mg/L)
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6e+01
4e+01
2e+01
0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

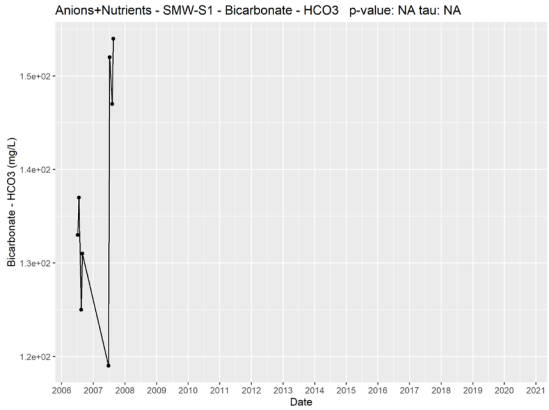

Anions+Nutrients - SMW-P1 - Total Alkalinity p-value: 0.5824 tau: -0.1374
Total Alkalinity (mg/L)
1.5e+02
1.4e+02
1.3e+02
1.2e+02
1.1e+02
1.0e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

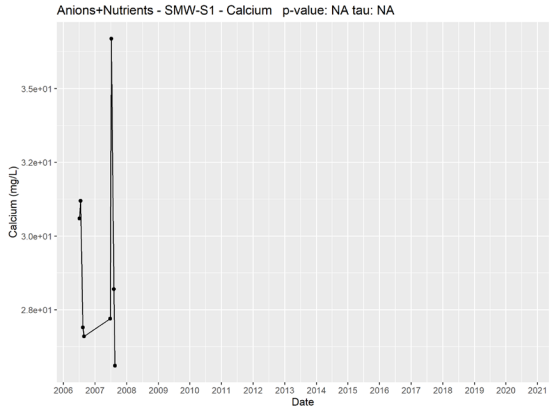

Anions+Nutrients - SMW-P1 - Total Dissolved Solids p-value: 0.0543 tau: -0.4428
Total Dissolved Solids (mg/L)
2.5e+02
2.0e+02
1.5e+02
1.0e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

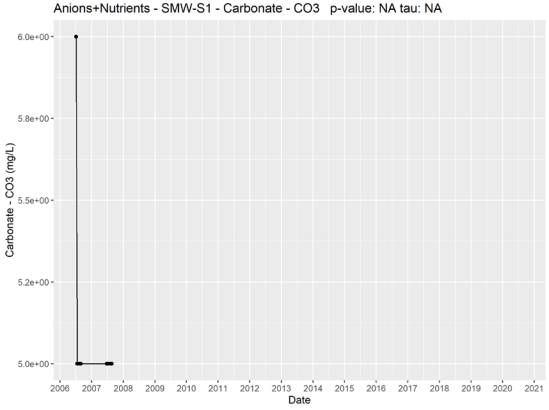

Anions+Nutrients - SMW-P1 - Total Nitrogen p-value: 0.0593 tau: -0.4944
Total Nitrogen (mg/L)
6e-01
4e-01
2e-01
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Date

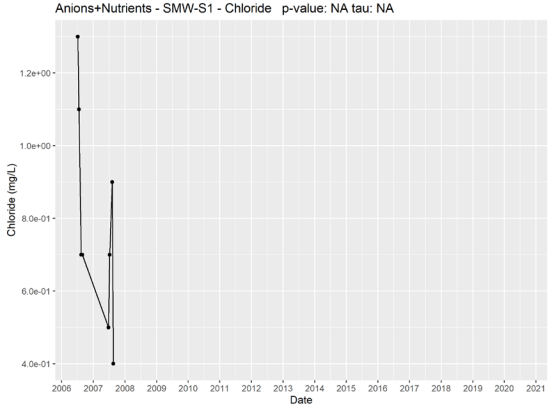

Anions+Nutrients - SMW-P1 - Total Phosphorus p-value: 0.216 tau: -0.2901
Total Phosphorus (mg/L)
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4e-02
3e-02
2e-02
1e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

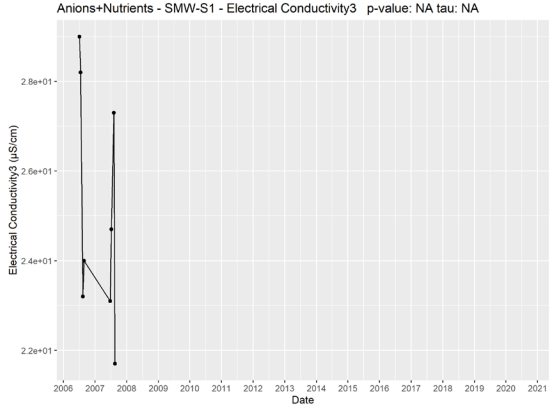

Anions+Nutrients - SMW-S1 - Ammonia p-value: NA tau: NA
Ammonia (mg/L)
1.0e-01
7.5e-02
5.0e-02
2.5e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

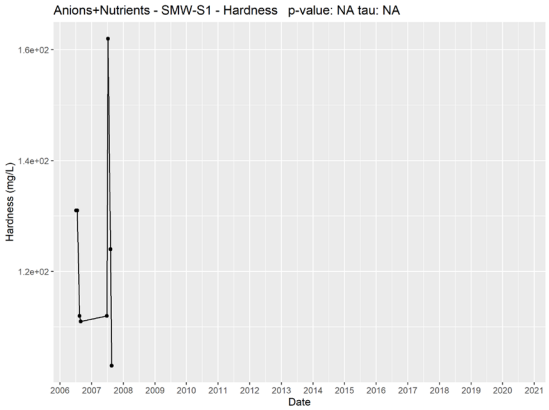

Anions+Nutrients - SMW-S1 - Bicarbonate - HCO3 p-value: NA tau: NA
Bicarbonate - HCO3 (mg/L)
1.5e+02
1.4e+02
1.3e+02
1.2e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

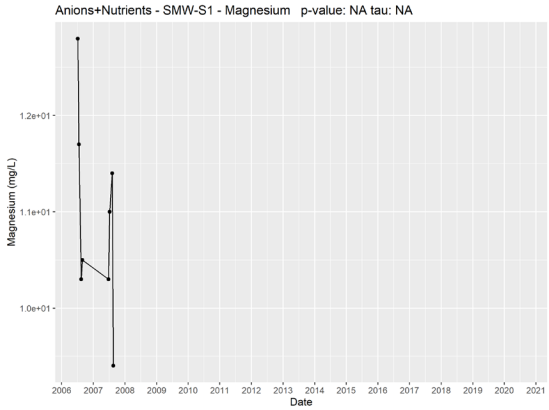

Anions+Nutrients - SMW-S1 - Calcium p-value: NA tau: NA
Calcium (mg/L)
3.5e+01
3.2e+01
3.0e+01
2.8e+01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

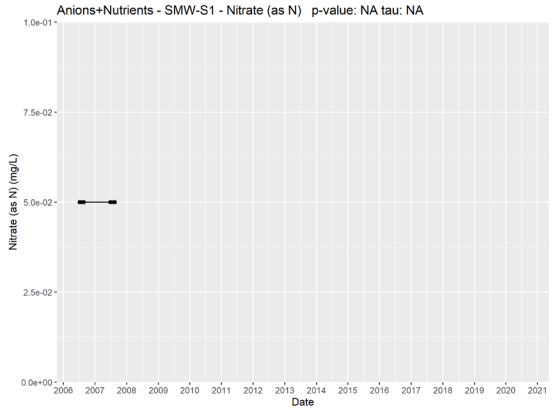

Anions+Nutrients - SMW-S1 - Carbonate - CO3 p-value: NA tau: NA
Carbonate - CO3 (mg/L)
6.0e+00
5.8e+00
5.5e+00
5.2e+00
5.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

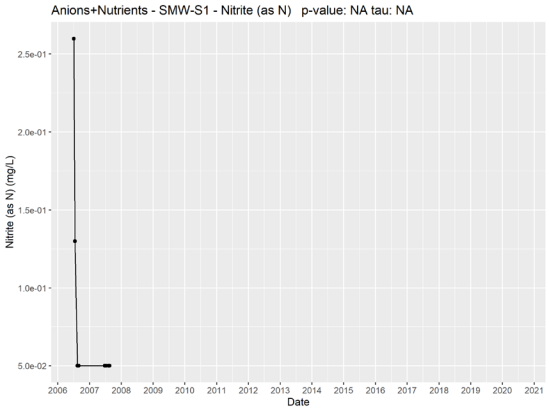

Anions+Nutrients - SMW-S1 - Chloride p-value: NA tau: NA
Chloride (mg/L)
1.2e+00
1.0e+00
8.0e-01
6.0e-01
4.0e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

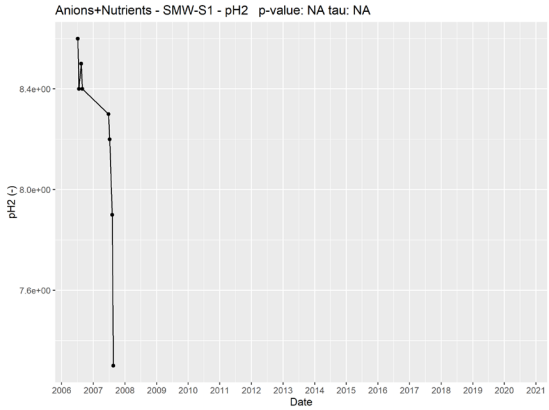

Anions+Nutrients - SMW-S1 - Electrical Conductivity3 p-value: NA tau: NA
Electrical Conductivity3 (µS/cm)
2.8e+01
2.6e+01
2.4e+01
2.2e+01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

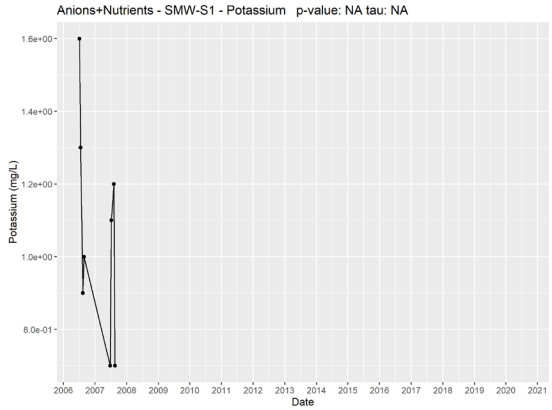

Anions+Nutrients - SMW-S1 - Hardness p-value: NA tau: NA
Hardness (mg/L)
1.6e+02
1.4e+02
1.2e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

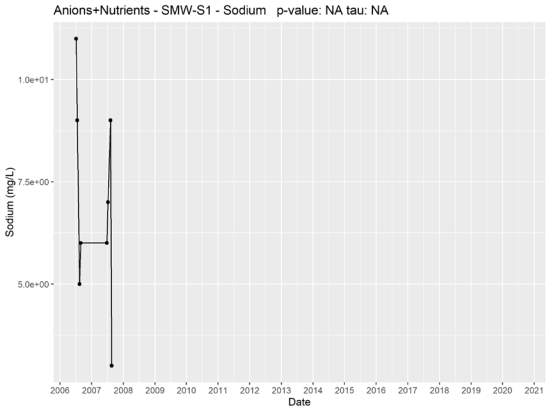

Anions+Nutrients - SMW-S1 - Magnesium p-value: NA tau: NA
Magnesium (mg/L)
1.2e+01
1.1e+01
1.0e+01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

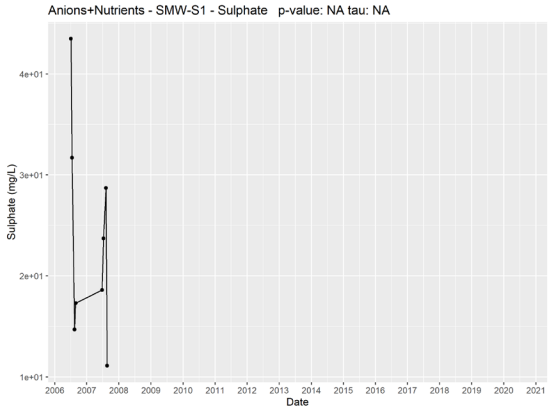

Anions+Nutrients - SMW-S1 - Nitrate (as N) p-value: NA tau: NA
Nitrate (as N) (mg/L)
1.0e-01
7.5e-02
5.0e-02
2.5e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

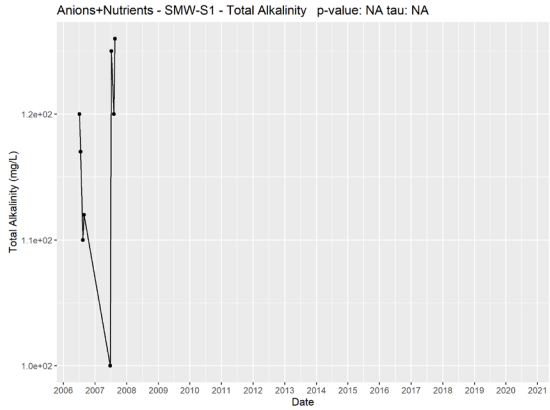

Anions+Nutrients - SMW-S1 - Nitrite (as N) p-value: NA tau: NA
Nitrite (as N) (mg/L)
2.5e-01
2.0e-01
1.5e-01
1.0e-01
5.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

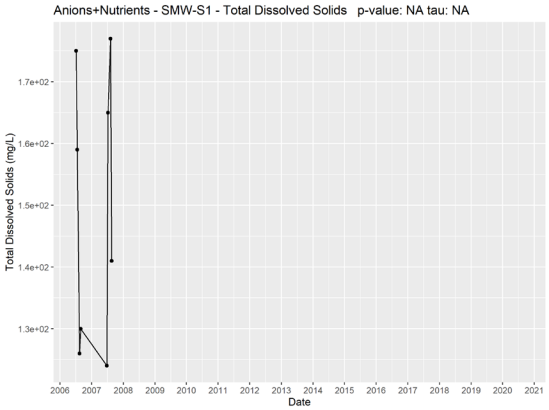

Anions+Nutrients - SMW-S1 - pH2 p-value: NA tau: NA
pH2 (-)
8.4e+00
8.0e+00
7.6e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

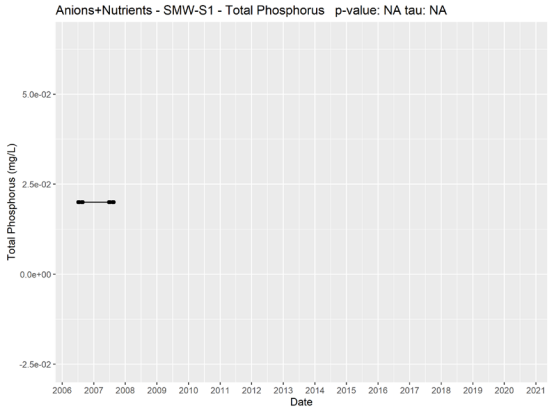

Anions+Nutrients - SMW-S1 - Potassium p-value: NA tau: NA
Potassium (mg/L)
1.6e+00
1.4e+00
1.2e+00
1.0e+00
8.0e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

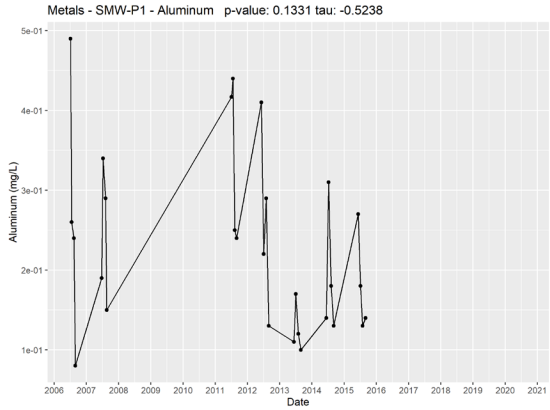

Anions+Nutrients - SMW-S1 - Sodium p-value: NA tau: NA
Sodium (mg/L)
1.0e+01
7.5e+00
5.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

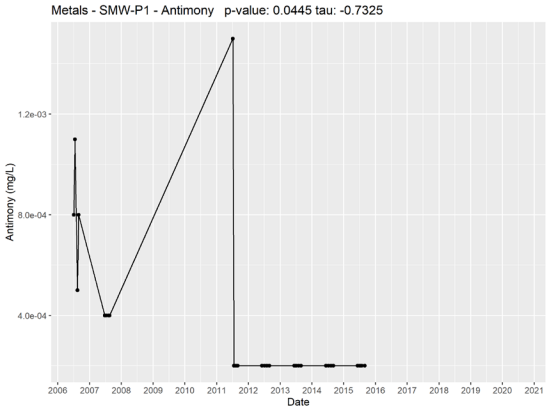

Anions+Nutrients - SMW-S1 - Sulphate p-value: NA tau: NA
Sulphate (mg/L)
4e+01
3e+01
2e+01
1e+01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

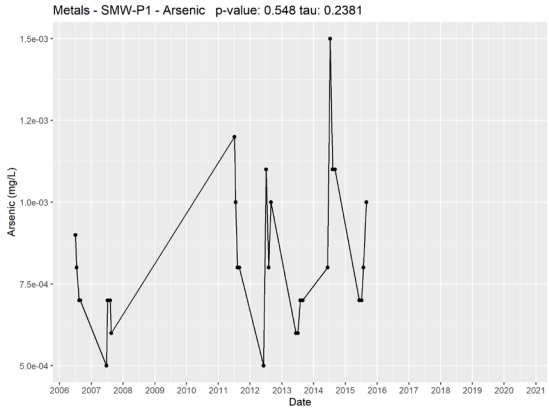

Anions+Nutrients - SMW-S1 - Total Alkalinity p-value: NA tau: NA
Total Alkalinity (mg/L)
1.2e+02
1.1e+02
1.0e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

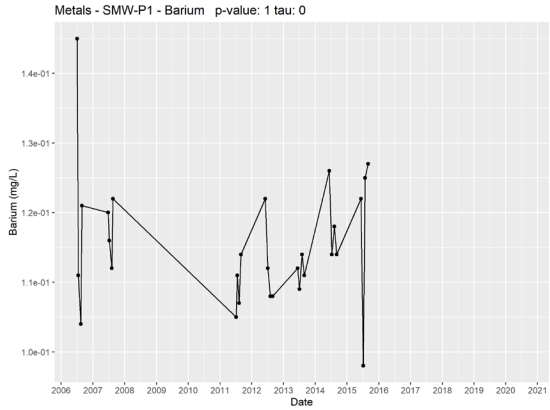

Anions+Nutrients - SMW-S1 - Total Dissolved Solids p-value: NA tau: NA
Total Dissolved Solids (mg/L)
1.7e+02
1.6e+02
1.5e+02
1.4e+02
1.3e+02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

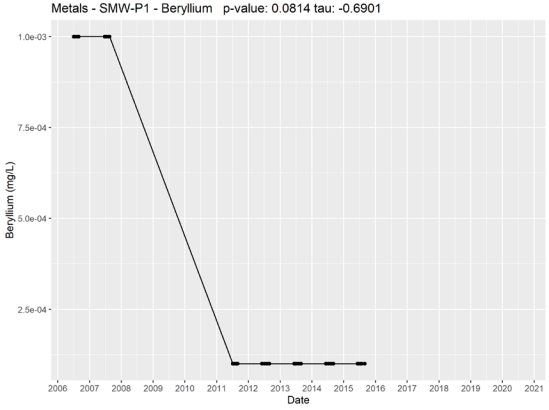

Anions+Nutrients - SMW-S1 - Total Phosphorus p-value: NA tau: NA
Total Phosphorus (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

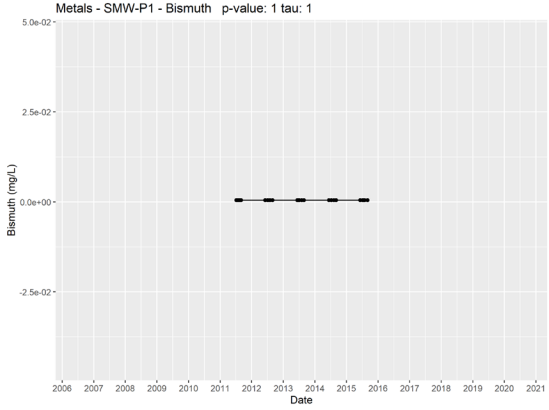

Metals - SMW-P1 - Aluminum p-value: 0.1331 tau: -0.5238
Aluminum (mg/L)
5e-01
4e-01
3e-01
2e-01
1e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

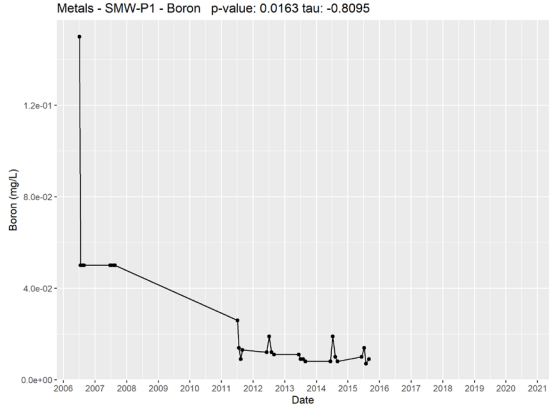

Metals - SMW-P1 - Antimony p-value: 0.0445 tau: -0.7325
Antimony (mg/L)
1.2e-03
8.0e-04
4.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

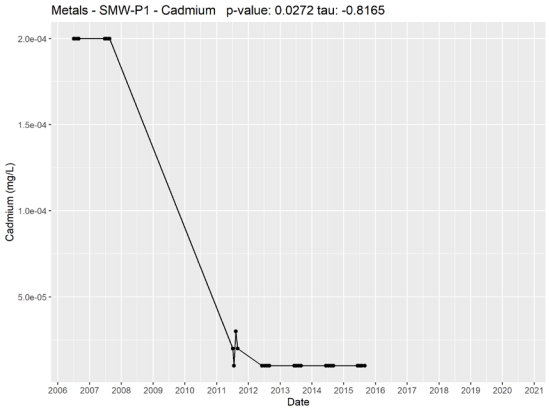

Metals - SMW-P1 - Arsenic p-value: 0.548 tau: 0.2381
Arsenic (mg/L)
1.5e-03
1.2e-03
1.0e-03
7.5e-04
5.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

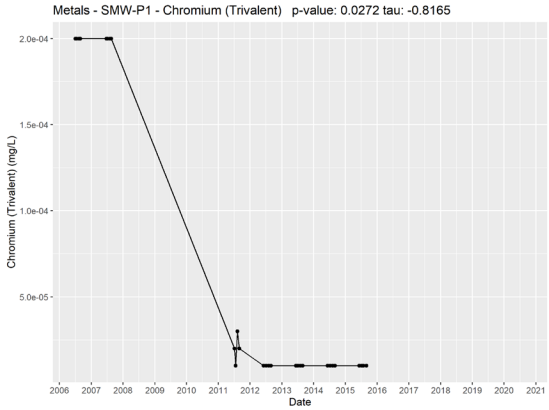

Metals - SMW-P1 - Barium p-value: 1 tau: 0
Barium (mg/L)
1.4e-01
1.3e-01
1.2e-01
1.1e-01
1.0e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

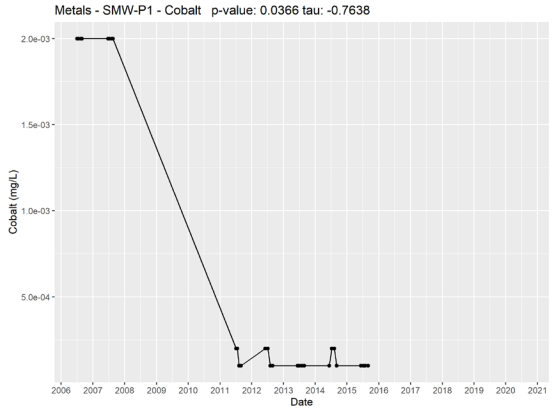

Metals - SMW-P1 - Beryllium p-value: 0.0814 tau: -0.6901
Beryllium (mg/L)
1.0e-03
7.5e-04
5.0e-04
2.5e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

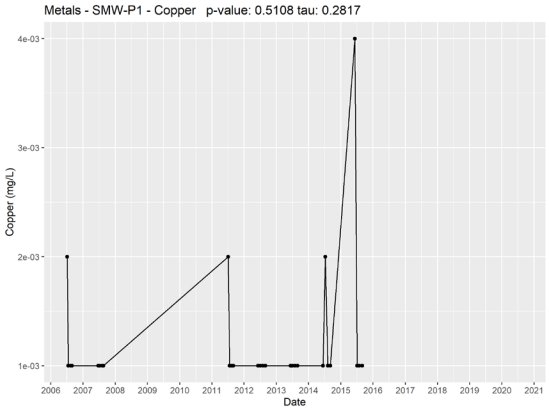

Metals - SMW-P1 - Bismuth p-value: 1 tau: 1
Bismuth (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

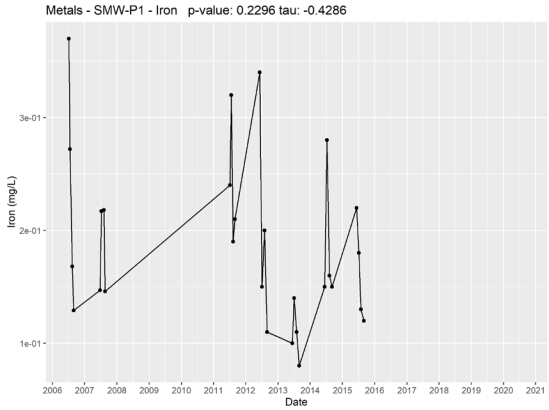

Metals - SMW-P1 - Boron p-value: 0.0163 tau: -0.8095
Boron (mg/L)
1.2e-01
8.0e-02
4.0e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

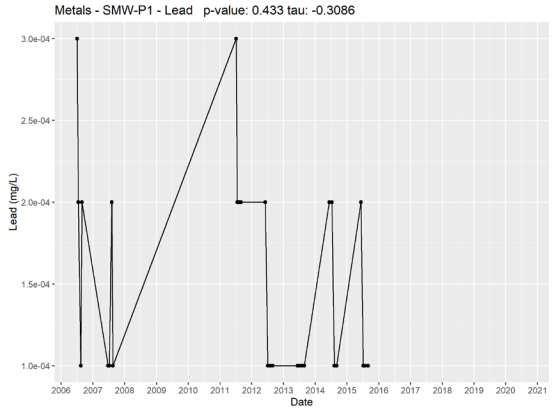

Metals - SMW-P1 - Cadmium p-value: 0.0272 tau: -0.8165
Cadmium (mg/L)
2.0e-04
1.5e-04
1.0e-04
5.0e-05
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

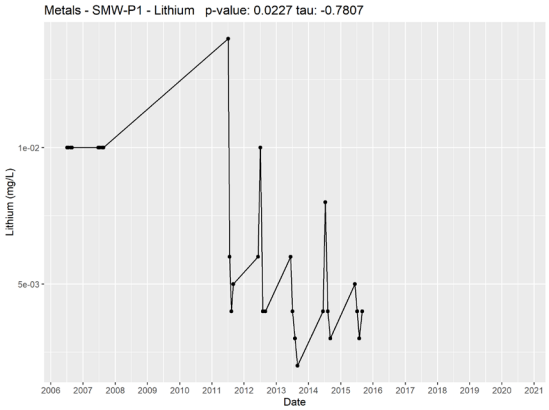

Metals - SMW-P1 - Chromium (Trivalent) p-value: 0.0272 tau: -0.8165
Chromium (Trivalent) (mg/L)
2.0e-04
1.5e-04
1.0e-04
5.0e-05
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

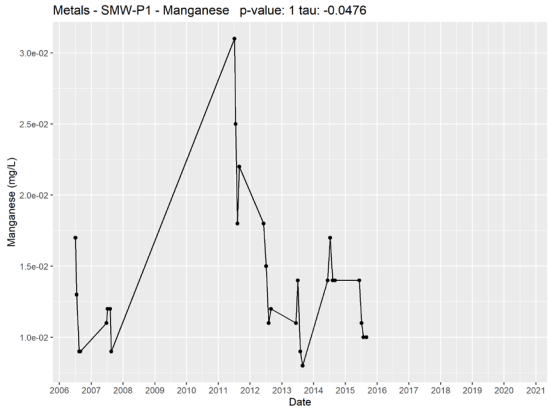

Metals - SMW-P1 - Cobalt p-value: 0.0366 tau: -0.7638
Cobalt (mg/L)
2.0e-03
1.5e-03
1.0e-03
5.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

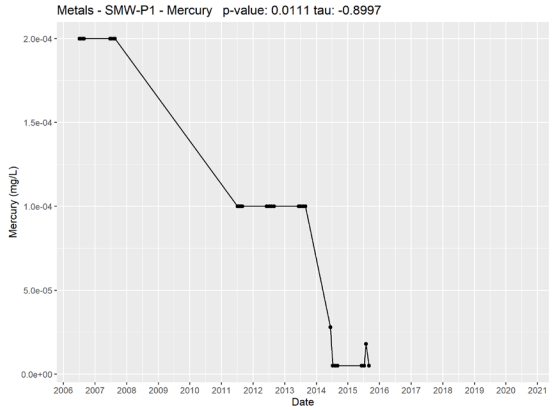

Metals - SMW-P1 - Copper p-value: 0.5108 tau: 0.2817
Copper (mg/L)
4e-03
3e-03
2e-03
1e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

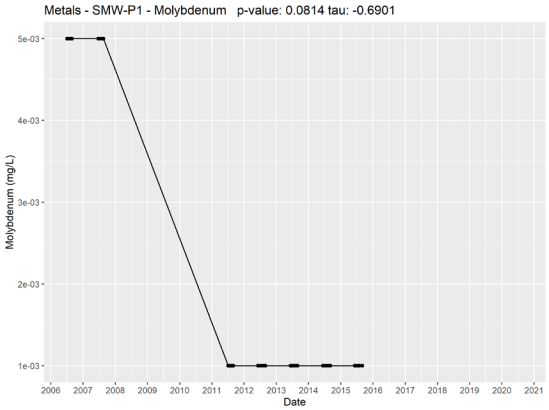

Metals - SMW-P1 - Iron p-value: 0.2296 tau: -0.4286
Iron (mg/L)
3e-01
2e-01
1e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

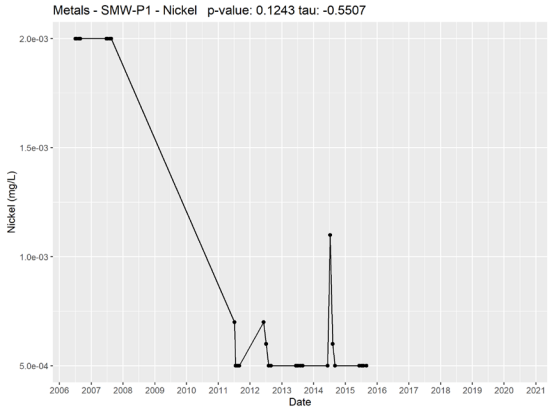

Metals - SMW-P1 - Lead p-value: 0.433 tau: -0.3086
Lead (mg/L)
3.0e-04
2.5e-04
2.0e-04
1.5e-04
1.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

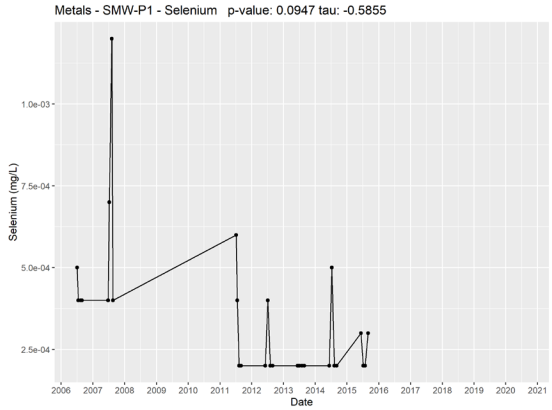

Metals - SMW-P1 - Lithium p-value: 0.0227 tau: -0.7807
Lithium (mg/L)
1e-02
5e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

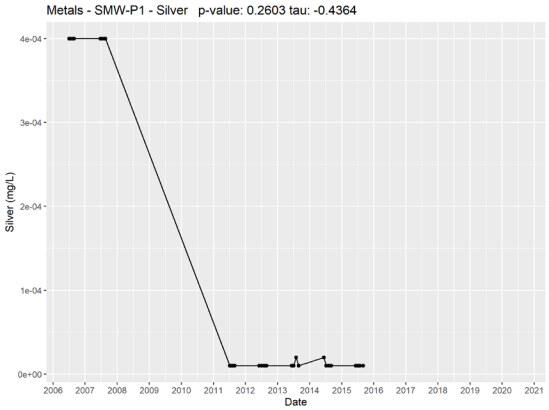

Metals - SMW-P1 - Manganese p-value: 1 tau: -0.0476
Manganese (mg/L)
3.0e-02
2.5e-02
2.0e-02
1.5e-02
1.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

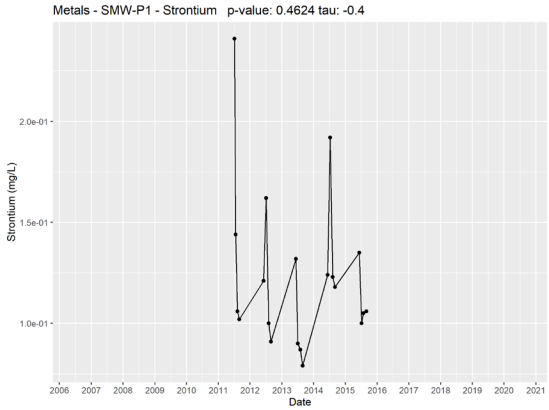

Metals - SMW-P1 - Mercury p-value: 0.0111 tau: -0.8997
Mercury (mg/L)
2.0e-04
1.5e-04
1.0e-04
5.0e-05
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

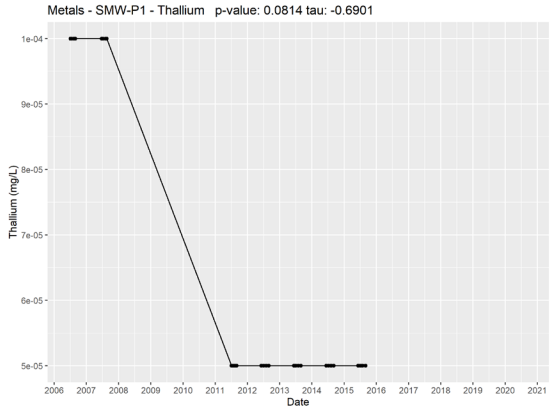

Metals - SMW-P1 - Molybdenum p-value: 0.0814 tau: -0.6901
Molybdenum (mg/L)
5e-03
4e-03
3e-03
2e-03
1e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Metals - SMW-P1 - Nickel p-value: 0.1243 tau: -0.5507
Nickel (mg/L)
2.0e-03
1.5e-03
1.0e-03
5.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

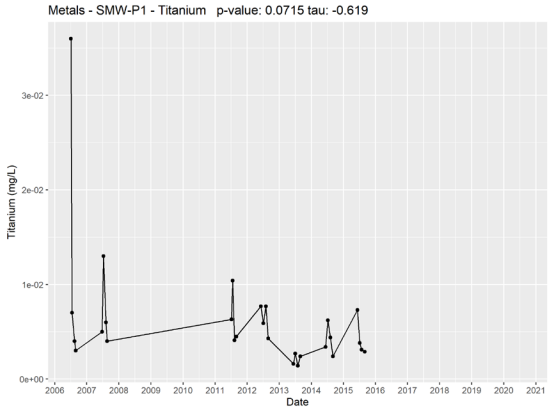

Metals - SMW-P1 - Selenium p-value: 0.0947 tau: -0.5855
Selenium (mg/L)
1.0e-03
7.5e-04
5.0e-04
2.5e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

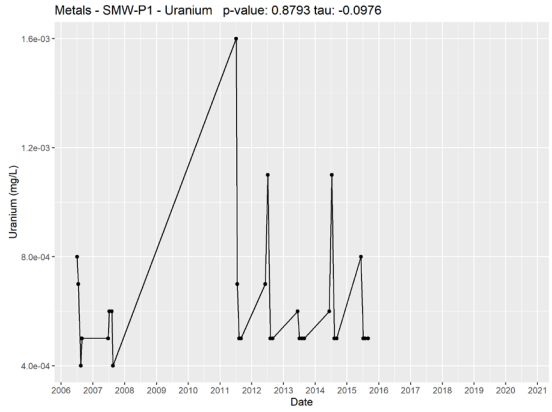

Metals - SMW-P1 - Silver p-value: 0.2603 tau: -0.4364
Silver (mg/L)
4e-04
3e-04
2e-04
1e-04
0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

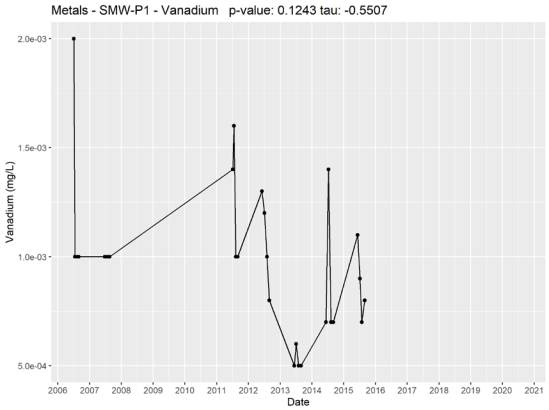

Metals - SMW-P1 - Strontium p-value: 0.4624 tau: -0.4
Strontium (mg/L)
2.0e-01
1.5e-01
1.0e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

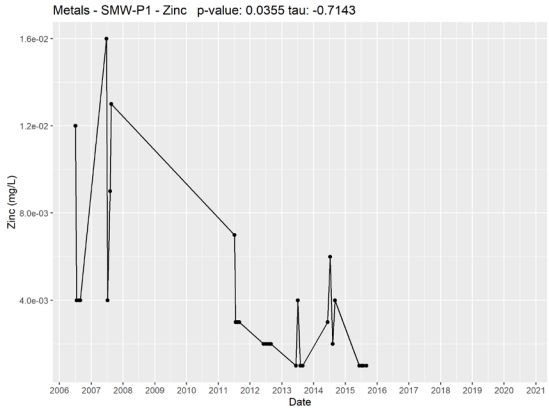

Metals - SMW-P1 - Thallium p-value: 0.0814 tau: -0.6901
Thallium (mg/L)
1e-04
9e-05
8e-05
7e-05
6e-05
5e-05
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

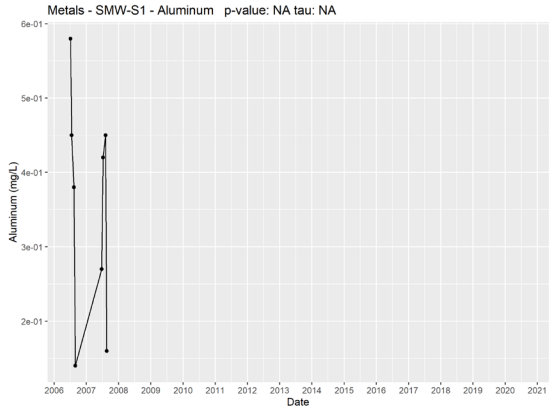

Metals - SMW-P1 - Tin p-value: 0.0814 tau: -0.6901
Tin (mg/L)
5e-02
4e-02
3e-02
2e-02
1e-02
0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

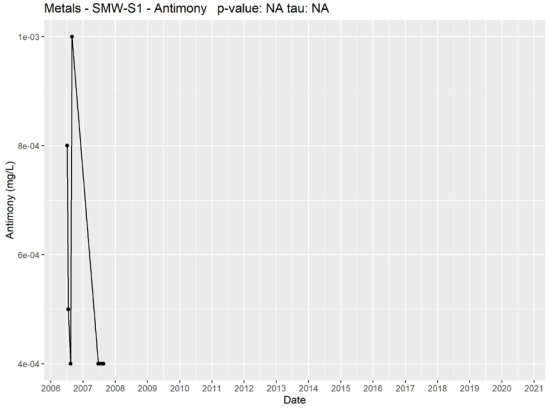

Metals - SMW-P1 - Titanium p-value: 0.0715 tau: -0.619
Titanium (mg/L)
3e-02
2e-02
1e-02
0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Metals - SMW-P1 - Uranium p-value: 0.8793 tau: -0.0976
Uranium (mg/L)
1.6e-03
1.2e-03
8.0e-04
4.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

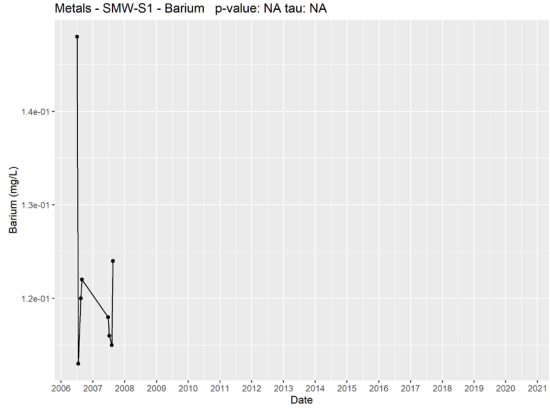

Metals - SMW-P1 - Vanadium p-value: 0.1243 tau: -0.5507
Vanadium (mg/L)
2.0e-03
1.5e-03
1.0e-03
5.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

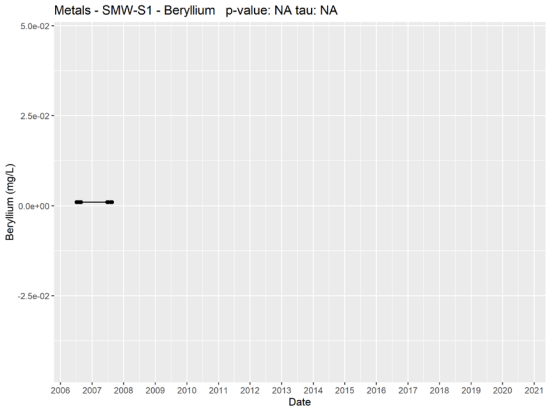

Metals - SMW-P1 - Zinc p-value: 0.0355 tau: -0.7143
Zinc (mg/L)
1.6e-02
1.2e-02
8.0e-03
4.0e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

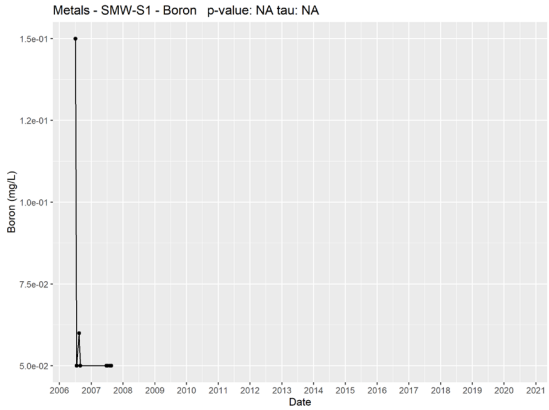

Metals - SMW-S1 - Aluminum p-value: NA tau: NA
Aluminum (mg/L)
6e-01
5e-01
4e-01
3e-01
2e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

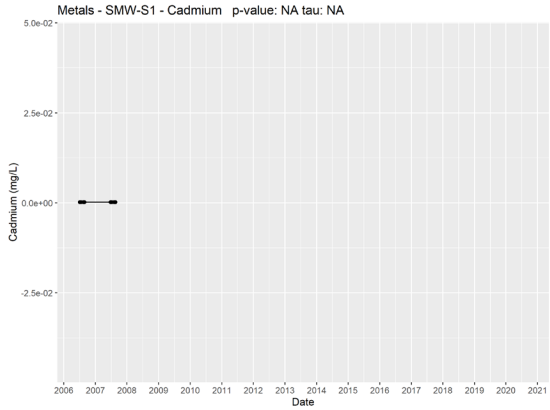

Metals - SMW-S1 - Antimony p-value: NA tau: NA
Antimony (mg/L)
1e-03
8e-04
6e-04
4e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

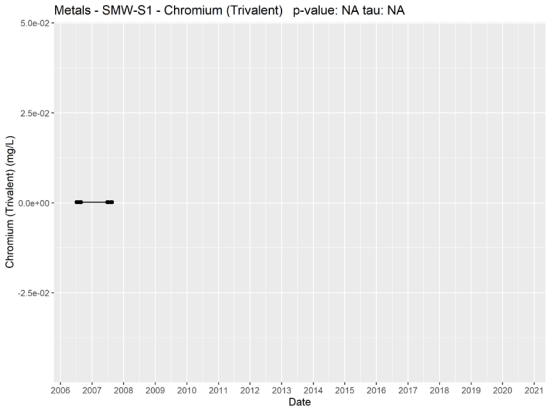

Metals - SMW-S1 - Arsenic p-value: NA tau: NA
Arsenic (mg/L)
9e-04
8e-04
7e-04
6e-04
5e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

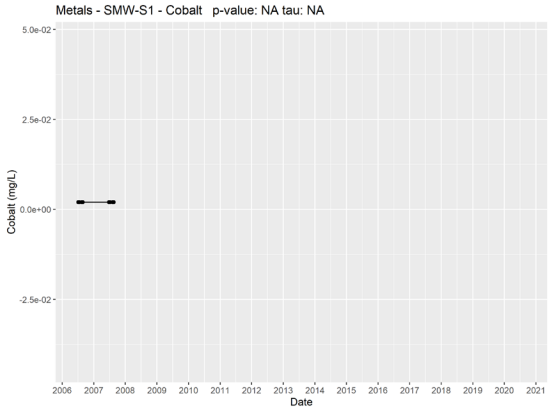

Metals - SMW-S1 - Barium p-value: NA tau: NA
Barium (mg/L)
1.4e-01
1.3e-01
1.2e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

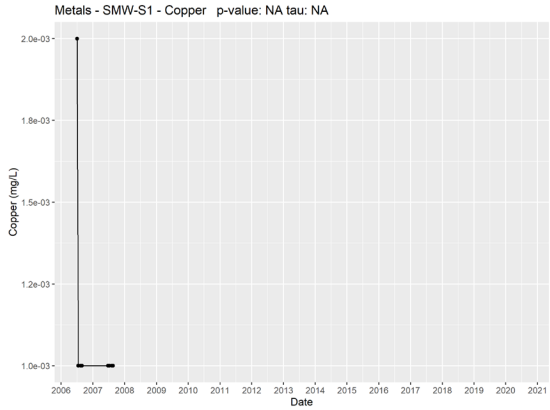

Metals - SMW-S1 - Beryllium p-value: NA tau: NA
Beryllium (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

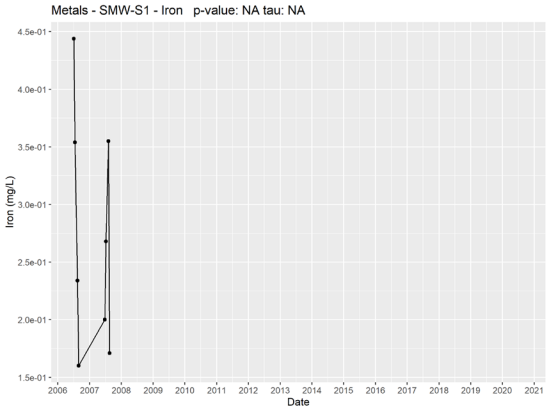

Metals - SMW-S1 - Boron p-value: NA tau: NA
Boron (mg/L)
1.5e-01
1.2e-01
1.0e-01
7.5e-02
5.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

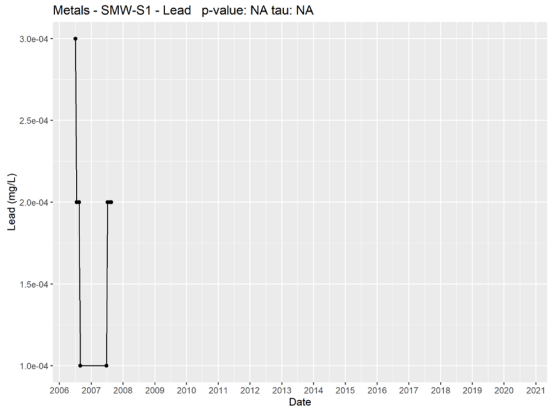

Metals - SMW-S1 - Cadmium p-value: NA tau: NA
Cadmium (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

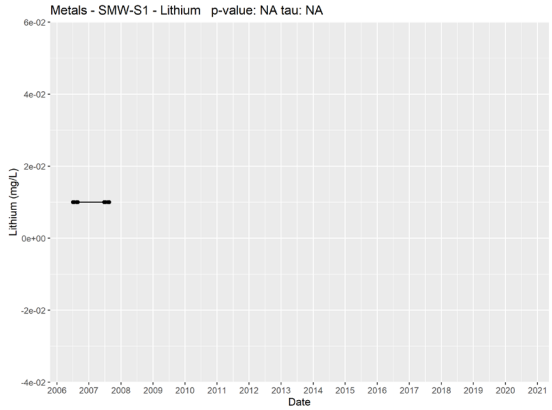

Metals - SMW-S1 - Chromium (Trivalent) p-value: NA tau: NA
Chromium (Trivalent) (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

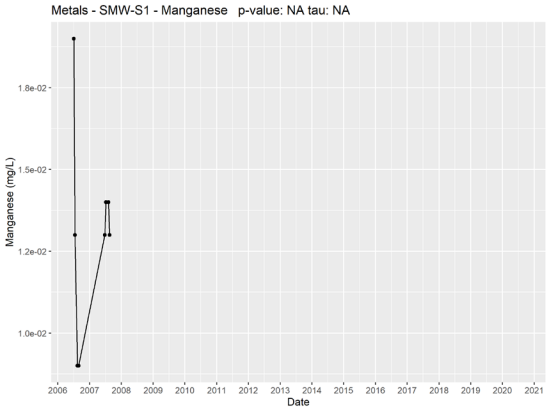

Metals - SMW-S1 - Cobalt p-value: NA tau: NA
Cobalt (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

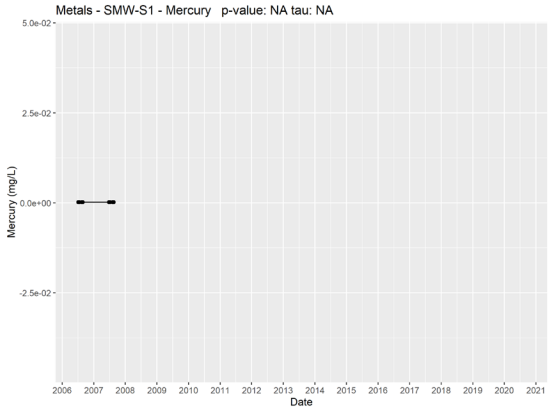

Metals - SMW-S1 - Copper p-value: NA tau: NA
Copper (mg/L)
2.0e-03
1.8e-03
1.5e-03
1.2e-03
1.0e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

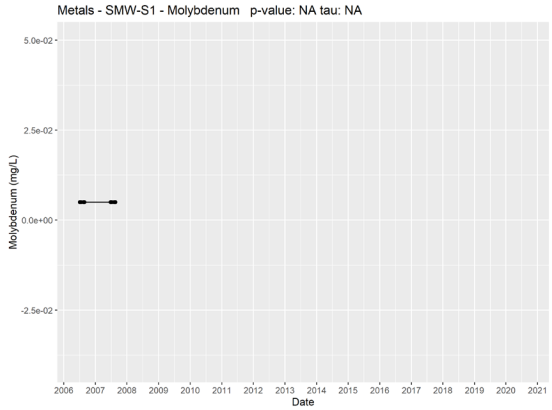

Metals - SMW-S1 - Iron p-value: NA tau: NA
Iron (mg/L)
4.5e-01
4.0e-01
3.5e-01
3.0e-01
2.5e-01
2.0e-01
1.5e-01
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

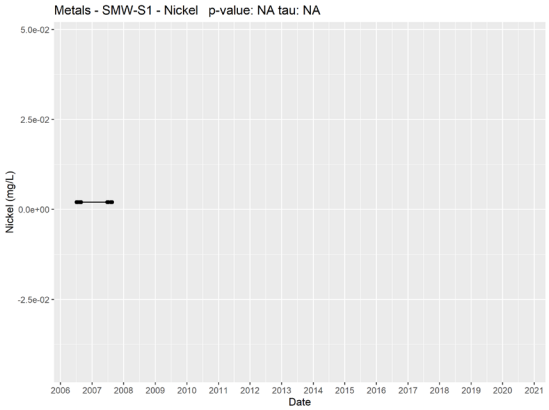

Metals - SMW-S1 - Lead p-value: NA tau: NA
Lead (mg/L)
3.0e-04
2.5e-04
2.0e-04
1.5e-04
1.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

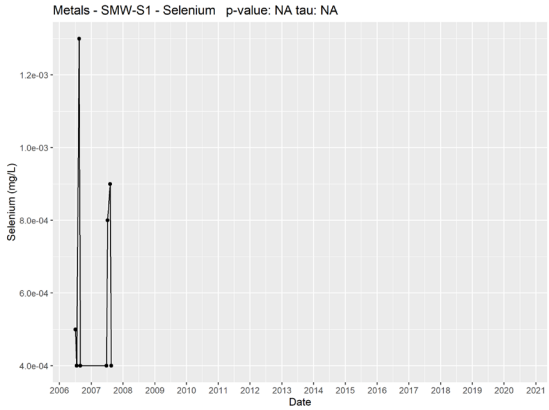

Metals - SMW-S1 - Lithium p-value: NA tau: NA
Lithium (mg/L)
6e-02
4e-02
2e-02
0e+00
-2e-02
-4e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

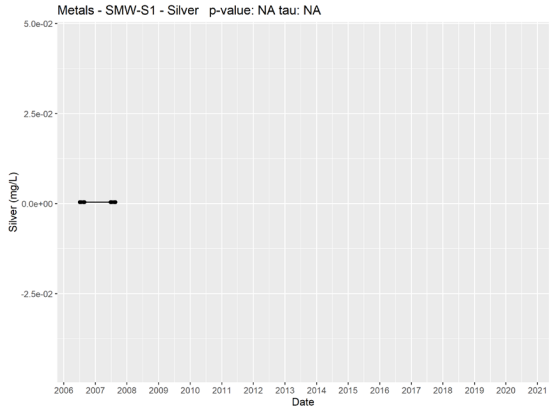

Metals - SMW-S1 - Manganese p-value: NA tau: NA
Manganese (mg/L)
1.8e-02
1.5e-02
1.2e-02
1.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

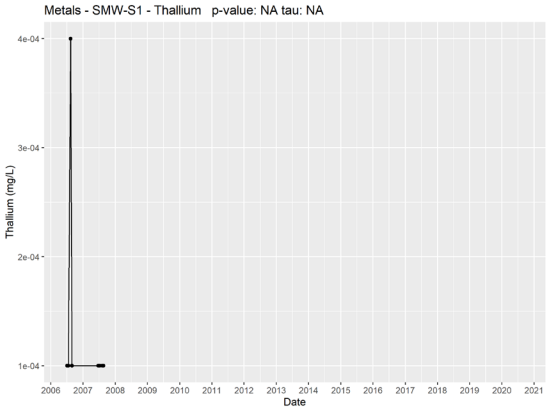

Metals - SMW-S1 - Mercury p-value: NA tau: NA
Mercury (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

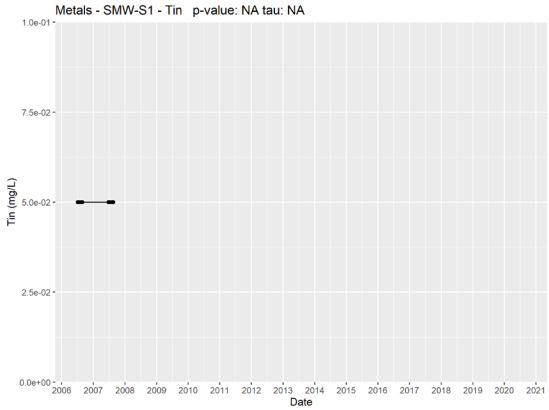

Metals - SMW-S1 - Molybdenum p-value: NA tau: NA
Molybdenum (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

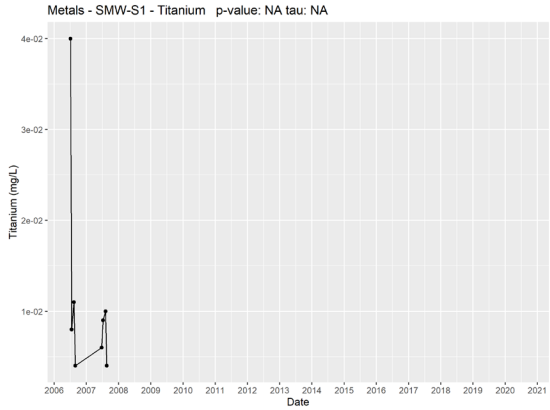

Metals - SMW-S1 - Nickel p-value: NA tau: NA
Nickel (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

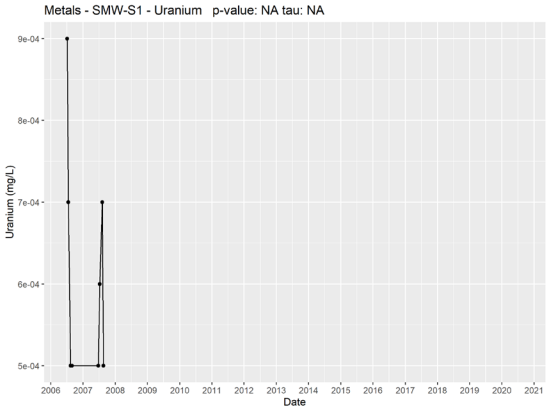

Metals - SMW-S1 - Selenium p-value: NA tau: NA
Selenium (mg/L)
1.2e-03
1.0e-03
8.0e-04
6.0e-04
4.0e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

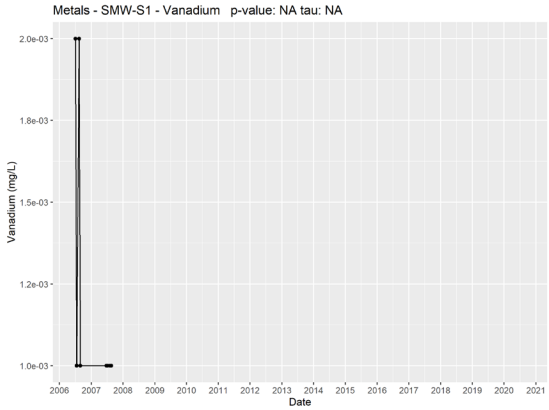

Metals - SMW-S1 - Silver p-value: NA tau: NA
Silver (mg/L)
5.0e-02
2.5e-02
0.0e+00
-2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

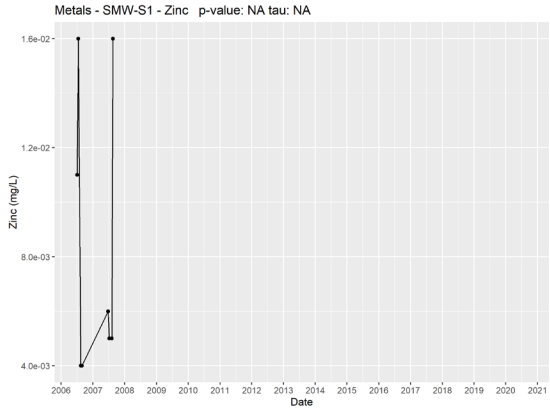

Metals - SMW-S1 - Thallium p-value: NA tau: NA
Thallium (mg/L)
4e-04
3e-04
2e-04
1e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

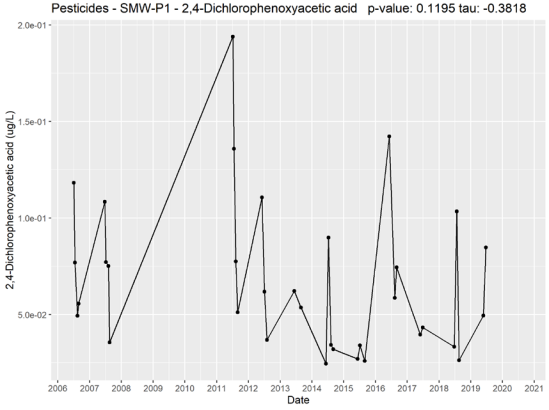

Metals - SMW-S1 - Tin p-value: NA tau: NA
Tin (mg/L)
1.0e-01
7.5e-02
5.0e-02
2.5e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

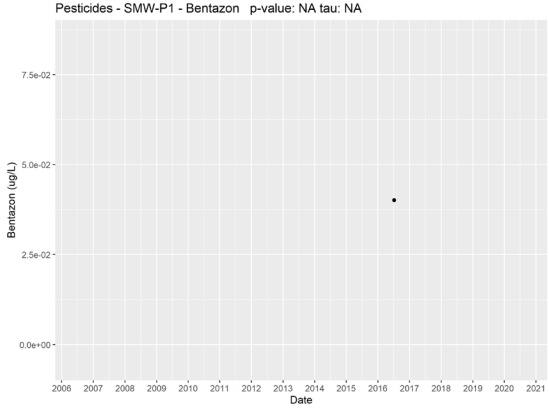

Metals - SMW-S1 - Titanium p-value: NA tau: NA
Titanium (mg/L)
4e-02
3e-02
2e-02
1e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

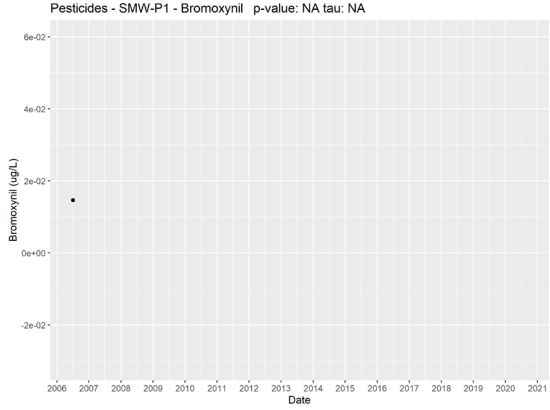

Metals - SMW-S1 - Uranium p-value: NA tau: NA
Uranium (mg/L)
9e-04
8e-04
7e-04
6e-04
5e-04
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

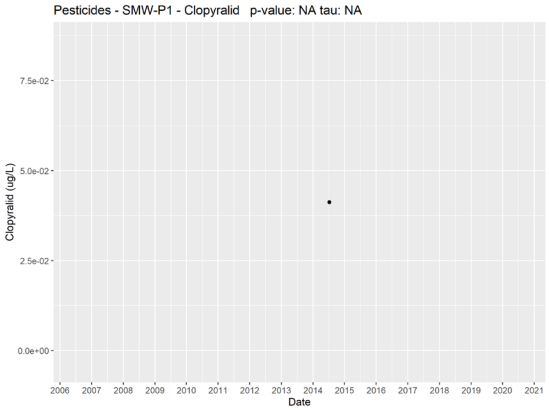

Metals - SMW-S1 - Vanadium p-value: NA tau: NA
Vanadium (mg/L)
2.0e-03
1.8e-03
1.5e-03
1.2e-03
1.0e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

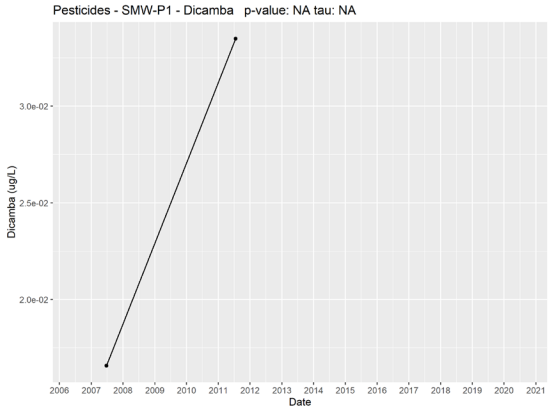

Metals - SMW-S1 - Zinc p-value: NA tau: NA
Zinc (mg/L)
1.6e-02
1.2e-02
8.0e-03
4.0e-03
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

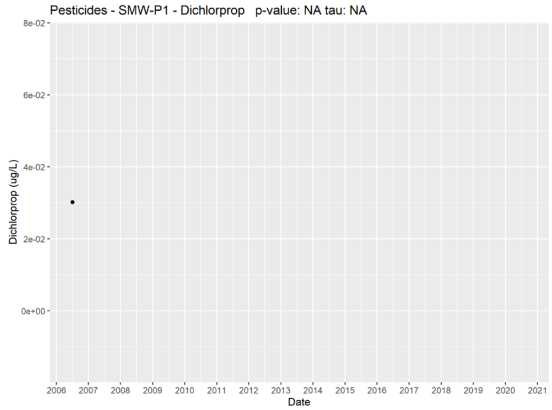

Pesticides - SMW-P1 - 2,4-Dichlorophenoxyacetic acid p-value: 0.1195 tau: -0.3818
2,4-Dichlorophenoxyacetic acid (ug/L)
2.0e-01
1.5e-01
1.0e-01
5.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

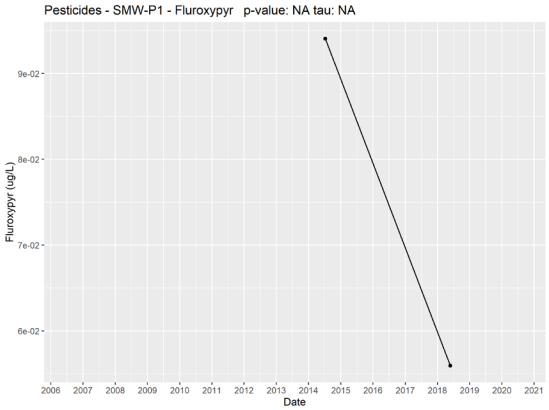

Pesticides - SMW-P1 - Bentazon p-value: NA tau: NA
Bentazon (ug/L)
7.5e-02
5.0e-02
2.5e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

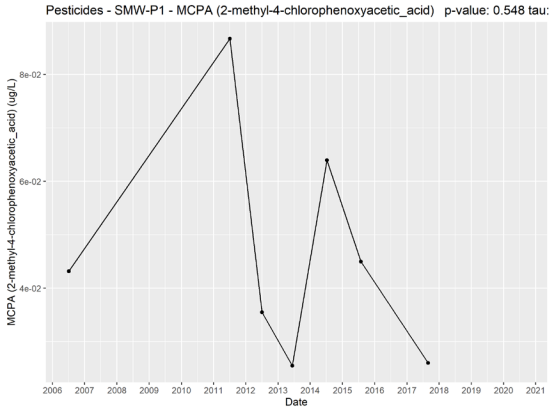

Pesticides - SMW-P1 - Bromoxynil p-value: NA tau: NA
Bromoxynil (ug/L)
6e-02
4e-02
2e-02
0e+00
-2e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

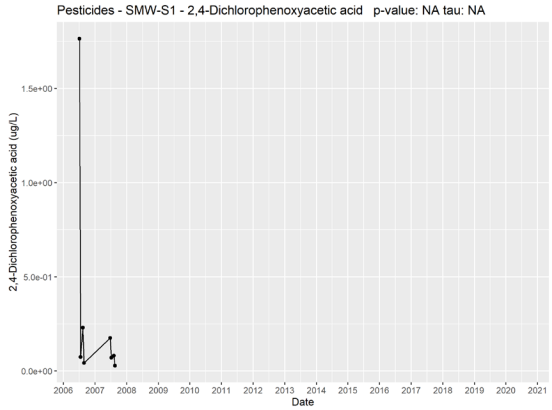

Pesticides - SMW-P1 - Clopyralid p-value: NA tau: NA
Clopyralid (ug/L)
7.5e-02
5.0e-02
2.5e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

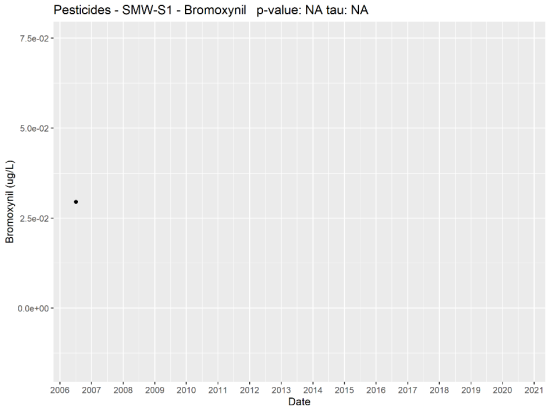

Pesticides - SMW-P1 - Dicamba p-value: NA tau: NA
Dicamba (ug/L)
3.0e-02
2.5e-02
2.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

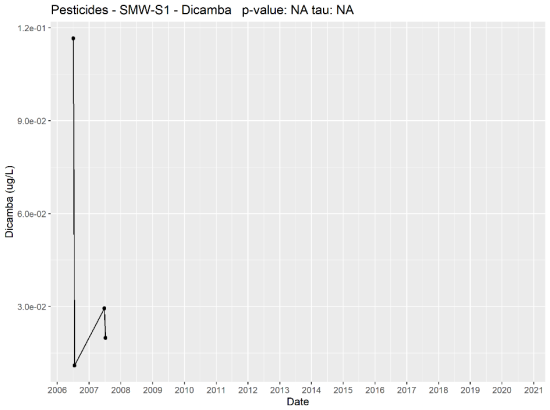

Pesticides - SMW-P1 - Dichlorprop p-value: NA tau: NA
Dichlorprop (ug/L)
8e-02
6e-02
4e-02
2e-02
0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

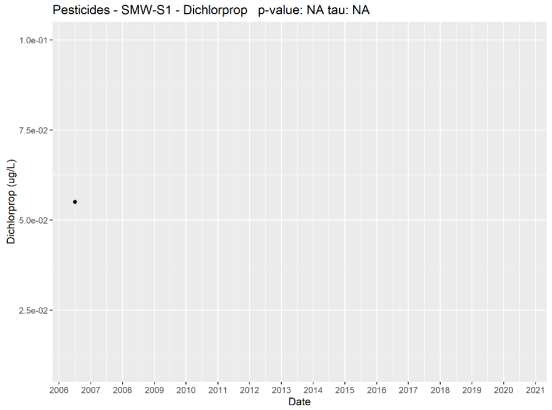

Pesticides - SMW-P1 - Fluroxypyr p-value: NA tau: NA
Fluroxypyr (ug/L)
9e-02
8e-02
7e-02
6e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

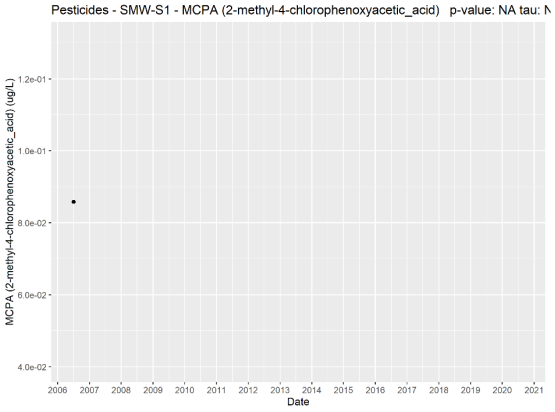

Pesticides - SMW-P1 - MCPA (2-methyl-4-chlorophenoxyacetic_acid) p-value: 0.548 tau:
MCPA (2-methyl-4-chlorophenoxyacetic_acid) (ug/L)
8e-02
6e-02
4e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Pesticides - SMW-S1 - 2,4-Dichlorophenoxyacetic acid p-value: NA tau: NA
2,4-Dichlorophenoxyacetic acid (ug/L)
1.5e+00
1.0e+00
5.0e-01
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Pesticides - SMW-S1 - Bromoxynil p-value: NA tau: NA
Bromoxynil (ug/L)
7.5e-02
5.0e-02
2.5e-02
0.0e+00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Pesticides - SMW-S1 - Dicamba p-value: NA tau: NA
Dicamba (ug/L)
1.2e-01
9.0e-02
6.0e-02
3.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Pesticides - SMW-S1 - Dichlorprop p-value: NA tau: NA
Dichlorprop (ug/L)
1.0e-01
7.5e-02
5.0e-02
2.5e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date


Pesticides - SMW-S1 - MCPA (2-methyl-4-chlorophenoxyacetic_acid) p-value: NA tau: N
MCPA (2-methyl-4-chlorophenoxyacetic_acid) (ug/L)
1.2e-01
1.0e-01
8.0e-02
6.0e-02
4.0e-02
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Date

APPENDIX 24.1

Alberta Transportation and Economic Corridors Highway 36 Bridge (BF 7150) Replacement Letter

Alberta Transportation and Economic Corridors

Construction and Maintenance
Southern Region
Box 314, 909 3 Avenue North
Lethbridge, Alberta T1H 0H5
www.alberta.ca

May 6, 2025

Mr. Travis Geremia
Infrastructure Manager
St. Mary River Irrigation District
525 40th Street South
Lethbridge, Alberta T1J 4M1

Dear Mr. Geremia:

Subject: Highway 36 Bridge (BF 7150) replacement

Transportation and Economic Corridors (TEC) is currently in the preliminary design phase of the replacement of BF 7150 located on Highway 36 over the Chin Coulee Reservoir.

TEC confirms that the replacement bridge structure is being designed with pier pile caps at an elevation of 864.5m, which is 0.5m above the new Full Supply Level (FSL). This design ensures a clearance of over 8 meters from the new FSL to the underside of the girders at their lowest point.

Sincerely,

James Herian, P.Eng.
Bridge Manager
Construction & Maintenance Division - Southern Region
Alberta Transportation and Economic Corridors
Government of Alberta

Classification: Public

APPENDIX 42.1

Hydrogeology Laboratory Analytical Report

AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
7315 - 8 STREET NE
CALGARY, AB T2E 8A2
(403) 274-3424
ATTENTION TO: Nancy Graingen
PROJECT: A03701E05 Chincoulee, Taber, AB
AGAT WORK ORDER: 25C265107
TRACE ORGANICS REVIEWED BY: Elena Gorobets, Report Writer
WATER ANALYSIS REVIEWED BY: Parampreet Kaur, Report Writer
DATE REPORTED: Apr 05, 2025
PAGES (INCLUDING COVER): 14
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*Notes

Disclaimer:

- *All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.*
- *All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
- *This Certificate shall not be reproduced except in full, without the written approval of the laboratory.*
- *The test results reported herewith relate only to the samples as received by the laboratory.*
- *Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.*
- *All reportable information is available on request from AGAT Laboratories, in accordance with ISO/IEC 17025:2017, ISO/IEC 17025:2005 (Quebec), DR-12-PALA and/or NELAP Standards.*
- *This document is signed by an authorized signatory who meets the requirements of the MELCCFP, CALA, CCN and NELAP.*
- *For environmental samples in the Province of Quebec: The analysis is performed on and results apply to samples as received. A temperature above 6°C upon receipt, as indicated in the Sample Reception Notification (SRN), could indicate the integrity of the samples has been compromised if the delay between sampling and submission to the laboratory could not be minimized.*

Member of: Association of Professional Engineers and Geoscientists of Alberta (APEGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation. Measurement Uncertainty is not taken into consideration when stating conformity with a specified requirement.

AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Petroleum Hydrocarbons (BTEX/F1-F2) in Water

DATE RECEIVED: 2025-03-27

DATE REPORTED: 2025-04-02

		SAMPLE DESCRIPTION:		**MW22-04**	**MW22-02**	**MW22-03**	**MW22-01**	**151387**	**BH24-S-14B**	**BH24-D-16**	**BH21-03**
		SAMPLE TYPE:		**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**
		DATE SAMPLED:		**2025-03-24 15:15**	**2025-03-24 18:07**	**2025-03-25 11:24**	**2025-03-25 14:27**	**2025-03-25 16:01**	**2025-03-26 11:52**	**2025-03-26 15:07**	**2025-03-26 17:06**
Parameter	**Unit**	**G / S**	**RDL**	**6618143**	**6618305**	**6618306**	**6618307**	**6618308**	**6618309**	**6618310**	**6618311**
Benzene	mg/L		0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	mg/L		0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Ethylbenzene	mg/L		0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Xylenes	mg/L		0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
C6 - C10 (F1)	mg/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C6 - C10 (F1 minus BTEX)	mg/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C10 - C16 (F2)	mg/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sediment				Trace	Not Present	Not Present	Not Present	Not Present	Trace	Not Present	Not Present
Surrogate	**Unit**	**Acceptable Limits**									
Toluene-d8 (BTEX)	%	60-140		95	93	122	117	125	113	106	113
o-Terphenyl (F2)	%	60-140		101	100	101	101	101	102	102	100

		SAMPLE DESCRIPTION:		**2096581**	**DUP-01**
		SAMPLE TYPE:		**Water**	**Water**
		DATE SAMPLED:		**2025-03-26 17:50**	**2025-03-26 12:00**
Parameter	**Unit**	**G / S**	**RDL**	**6618312**	**6618313**
Benzene	mg/L		0.0005	<0.0005	<0.0005
Toluene	mg/L		0.0003	<0.0003	<0.0003
Ethylbenzene	mg/L		0.0005	<0.0005	<0.0005
Xylenes	mg/L		0.0005	<0.0005	<0.0005
C6 - C10 (F1)	mg/L		0.1	<0.1	<0.1
C6 - C10 (F1 minus BTEX)	mg/L		0.1	<0.1	<0.1
C10 - C16 (F2)	mg/L		0.1	<0.1	<0.1
Sediment				Not Present	Not Present
Surrogate	**Unit**	**Acceptable Limits**			
Toluene-d8 (BTEX)	%	60-140		114	109
o-Terphenyl (F2)	%	60-140		101	102

Certified By: Elena Gorobets

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Petroleum Hydrocarbons (BTEX/F1-F2) in Water

DATE RECEIVED: 2025-03-27 **DATE REPORTED: 2025-04-02**

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

6618143
The F1 (C6 - C10) fraction is determined by integrating the FID chromatogram from the beginning of the nC6 peak to the apex of the last nC10 peak.
The C6 - C10 fraction is calculated from the FID toluene response factor.
The F2 (C10 - C16) fraction is determined by integrating the FID chromatogram from the apex of the nC10 peak to the apex of the nC16 peak.
The F2 (C10 - C16) fraction is calculated using the average response factor for nC10, nC16, and nC34.
Quality control for the calibration follows the guidelines set out in the CCME Contaminated Sites Method for Soils.
C6 –C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
C>10 – C16 (F2- Napthalene) is a calculated parameter. The calculated value is F2 - Napthalene (if PAH analysis has already been requested and reported). The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylenes + o-Xylene. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Sediment parameter is comment only based on visual inspection of the sample prior to extraction and is not an accredited test.
Extraction and holding times were met for this sample.

Sediment present in sample.
Whole bottle extraction performed.

6618305-6618308
The F1 (C6 - C10) fraction is determined by integrating the FID chromatogram from the beginning of the nC6 peak to the apex of the last nC10 peak.
The C6 - C10 fraction is calculated from the FID toluene response factor.
The F2 (C10 - C16) fraction is determined by integrating the FID chromatogram from the apex of the nC10 peak to the apex of the nC16 peak.
The F2 (C10 - C16) fraction is calculated using the average response factor for nC10, nC16, and nC34.
Quality control for the calibration follows the guidelines set out in the CCME Contaminated Sites Method for Soils.
C6 –C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
C>10 – C16 (F2- Napthalene) is a calculated parameter. The calculated value is F2 - Napthalene (if PAH analysis has already been requested and reported). The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylenes + o-Xylene. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Sediment parameter is comment only based on visual inspection of the sample prior to extraction and is not an accredited test.
Extraction and holding times were met for this sample.

6618309
The F1 (C6 - C10) fraction is determined by integrating the FID chromatogram from the beginning of the nC6 peak to the apex of the last nC10 peak.
The C6 - C10 fraction is calculated from the FID toluene response factor.
The F2 (C10 - C16) fraction is determined by integrating the FID chromatogram from the apex of the nC10 peak to the apex of the nC16 peak.
The F2 (C10 - C16) fraction is calculated using the average response factor for nC10, nC16, and nC34.
Quality control for the calibration follows the guidelines set out in the CCME Contaminated Sites Method for Soils.
C6 –C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
C>10 – C16 (F2- Napthalene) is a calculated parameter. The calculated value is F2 - Napthalene (if PAH analysis has already been requested and reported). The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylenes + o-Xylene. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Sediment parameter is comment only based on visual inspection of the sample prior to extraction and is not an accredited test.
Extraction and holding times were met for this sample.

Certified By: Elena Gorobets

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Certificate of Analysis

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Petroleum Hydrocarbons (BTEX/F1-F2) in Water

DATE RECEIVED: 2025-03-27

DATE REPORTED: 2025-04-02

Sediment present in sample.
Whole bottle extraction performed.

6618310-6618313 The F1 (C6 - C10) fraction is determined by integrating the FID chromatogram from the beginning of the nC6 peak to the apex of the last nC10 peak.
The C6 - C10 fraction is calculated from the FID toluene response factor.
The F2 (C10 - C16) fraction is determined by integrating the FID chromatogram from the apex of the nC10 peak to the apex of the nC16 peak.
The F2 (C10 - C16) fraction is calculated using the average response factor for nC10, nC16, and nC34.
Quality control for the calibration follows the guidelines set out in the CCME Contaminated Sites Method for Soils.
C6 –C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
C>10 – C16 (F2- Napthalene) is a calculated parameter. The calculated value is F2 - Napthalene (if PAH analysis has already been requested and reported). The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylenes + o-Xylene. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Sediment parameter is comment only based on visual inspection of the sample prior to extraction and is not an accredited test.
Extraction and holding times were met for this sample.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By: Elena Gorobets

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AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Water Package - Routine Chemistry Water Analysis - Lab Filtered Cations

DATE RECEIVED: 2025-03-27

DATE REPORTED: 2025-04-02

		SAMPLE DESCRIPTION:		MW22-04		MW22-02		MW22-03		MW22-01
		SAMPLE TYPE:		Water		Water		Water		Water
		DATE SAMPLED:		2025-03-24 15:15		2025-03-24 18:07		2025-03-25 11:24		2025-03-25 14:27
Parameter	Unit	G / S	RDL	6618143	RDL	6618305	RDL	6618306	RDL	6618307
pH	pH Units	7.0-10.5	N/A	7.47	N/A	7.97	N/A	8.10	N/A	7.91
p - Alkalinity (as CaCO3)	mg/L		5	<5	5	<5	5	<5	5	<5
T - Alkalinity (as CaCO3)	mg/L		5	946	5	886	5	801	5	1280
Bicarbonate	mg/L		5	1150	5	1080	5	977	5	1560
Carbonate	mg/L		5	<5	5	<5	5	<5	5	<5
Hydroxide	mg/L		5	<5	5	<5	5	<5	5	<5
Electrical Conductivity	uS/cm		5	4920	5	3810	5	3650	5	8920
Chloride	mg/L	(250)	1.0	24.0	1.0	15.4	1.0	14.2	3.0	776
Fluoride	mg/L	1.5	0.03	0.28	0.03	0.24	0.03	0.12	0.06	0.43
Nitrate	mg/L	45	0.5	**158**	0.5	0.6	0.5	1.5	0.5	<0.5
Nitrate-N	mg/L	10	0.02	**35.7**	0.02	0.14	0.02	0.34	0.02	<0.02
Nitrite	mg/L	3	0.10	1.58	0.10	0.19	0.10	0.15	0.20	<0.20
Nitrite-N	mg/L	1	0.01	0.48	0.01	0.06	0.01	0.05	0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	36.2	0.02	0.19	0.02	0.38	0.02	<0.02
Sulfate	mg/L	(500)	1.5	2470	1.5	1410	1.5	1220	3.0	2480
Dissolved Calcium	mg/L		0.28	482	0.14	137	0.07	58.7	0.7	88.3
Dissolved Magnesium	mg/L		0.05	235	0.05	85.4	0.05	22.2	0.05	47.6
Dissolved Sodium	mg/L	(200)	0.05	466	0.05	668	0.05	756	0.12	2310
Dissolved Potassium	mg/L		0.05	22.5	0.05	8.03	0.05	6.17	0.05	7.79
Dissolved Iron	mg/L	(0.3)	0.001	<0.001	0.001	0.035	0.001	0.002	0.001	0.003
Dissolved Manganese	mg/L		0.00005	3.40	0.00005	0.417	0.00005	0.0411	0.00005	0.0281
Sodium Adsorption Ratio				4.35		11.0		21.3		49.3
Calculated TDS	mg/L	(500)	0.6	4420	0.6	2860	0.6	2560	0.6	6480
Hardness	mg CaCO3/L		0.5	2170	0.5	694	0.5	238	0.5	417
Ion Balance	%		1	88	1	91	1	90	1	110
Lab Filtration on Routine for IC				Complete		Complete		Complete		Complete
Lab Filtration on Routine for Metals				Complete		Complete		Complete		Complete

Certified By: PKaur

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Certificate of Analysis

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Water Package - Routine Chemistry Water Analysis - Lab Filtered Cations

DATE RECEIVED: 2025-03-27

DATE REPORTED: 2025-04-02

		SAMPLE DESCRIPTION:		151387		BH24-S-14B		BH24-D-16		BH21-03
		SAMPLE TYPE:		Water		Water		Water		Water
		DATE SAMPLED:		2025-03-25 16:01		2025-03-26 11:52		2025-03-26 15:07		2025-03-26 17:06
Parameter	Unit	G / S	RDL	6618308	RDL	6618309	RDL	6618310	RDL	6618311
pH	pH Units	7.0-10.5	N/A	8.49	N/A	7.89	N/A	7.81	N/A	7.79
p - Alkalinity (as CaCO3)	mg/L		5	39	5	<5	5	<5	5	<5
T - Alkalinity (as CaCO3)	mg/L		5	1400	5	1020	5	2080	5	914
Bicarbonate	mg/L		5	1610	5	1250	5	2540	5	1110
Carbonate	mg/L		5	46	5	<5	5	<5	5	<5
Hydroxide	mg/L		5	<5	5	<5	5	<5	5	<5
Electrical Conductivity	uS/cm		5	3320	5	12200	5	14100	5	12900
Chloride	mg/L	(250)	1.5	338	3.0	1130	1.0	916	1.0	1150
Fluoride	mg/L	1.5	0.03	**3.76**	0.06	0.47	0.1	0.1	0.1	0.4
Nitrate	mg/L	45	0.5	<0.5	0.5	<0.5	1.0	<1.0	1.0	<1.0
Nitrate-N	mg/L	10	0.02	<0.02	0.02	<0.02	0.02	<0.02	0.02	<0.02
Nitrite	mg/L	3	0.10	<0.10	0.20	<0.20	0.40	<0.40	0.40	<0.40
Nitrite-N	mg/L	1	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	<0.02	0.02	<0.02	0.02	<0.02	0.02	<0.02
Sulfate	mg/L	(500)	1.0	2.4	3.0	4170	6.0	4670	6.0	5080
Dissolved Calcium	mg/L		0.07	1.80	0.7	157	0.7	101	0.14	481
Dissolved Magnesium	mg/L		0.05	0.88	0.05	87.3	0.05	55.5	0.05	208
Dissolved Sodium	mg/L	(200)	0.05	814	0.12	2800	0.12	3730	0.12	2590
Dissolved Potassium	mg/L		0.05	2.19	0.05	8.84	0.05	12.2	0.05	11.1
Dissolved Iron	mg/L	(0.3)	0.001	0.014	0.001	0.004	0.001	0.003	0.001	0.014
Dissolved Manganese	mg/L		0.00005	0.00041	0.00005	0.485	0.00005	0.0517	0.00005	1.10
Sodium Adsorption Ratio				124		44.4		74.0		24.8
Calculated TDS	mg/L	(500)	0.6	2000	0.6	8970	0.6	10700	0.6	10100
Hardness	mg CaCO3/L		0.5	8.1	0.5	752	0.5	481	0.5	2060
Ion Balance	%		1	94	1	98	1	105	1	99
Lab Filtration on Routine for IC				Complete		Complete		Complete		Complete
Lab Filtration on Routine for Metals				Complete		Complete		Complete		Complete

Certified By: PKaur

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Certificate of Analysis

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Water Package - Routine Chemistry Water Analysis - Lab Filtered Cations

DATE RECEIVED: 2025-03-27

DATE REPORTED: 2025-04-02

		SAMPLE DESCRIPTION:		2096581	DUP-01
		SAMPLE TYPE:		Water	Water
		DATE SAMPLED:		2025-03-26 17:50	2025-03-26 12:00
Parameter	**Unit**	**G / S**	**RDL**	**6618312**	**6618313**
pH	pH Units	7.0-10.5	N/A	8.54	8.52
p - Alkalinity (as CaCO3)	mg/L		5	49	44
T - Alkalinity (as CaCO3)	mg/L		5	1450	1450
Bicarbonate	mg/L		5	1640	1660
Carbonate	mg/L		5	59	53
Hydroxide	mg/L		5	<5	<5
Electrical Conductivity	uS/cm		5	3160	3170
Chloride	mg/L	(250)	1.0	318	334
Fluoride	mg/L	1.5	0.03	**4.62**	**4.70**
Nitrate	mg/L	45	0.5	<0.5	<0.5
Nitrate-N	mg/L	10	0.02	<0.02	<0.02
Nitrite	mg/L	3	0.10	<0.10	<0.10
Nitrite-N	mg/L	1	0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	<0.02	<0.02
Sulfate	mg/L	(500)	1.0	<1.0	1.1
Dissolved Calcium	mg/L		0.07	1.65	1.59
Dissolved Magnesium	mg/L		0.05	0.80	0.82
Dissolved Sodium	mg/L	(200)	0.05	905	845
Dissolved Potassium	mg/L		0.05	2.16	2.19
Dissolved Iron	mg/L	(0.3)	0.001	0.016	0.016
Dissolved Manganese	mg/L		0.00005	0.00028	0.00029
Sodium Adsorption Ratio				145	136
Calculated TDS	mg/L	(500)	0.6	2090	2050
Hardness	mg CaCO3/L		0.5	7.4	7.3
Ion Balance	%		1	104	96
Lab Filtration on Routine for IC				Complete	Complete
Lab Filtration on Routine for Metals				Complete	Complete

Certified By: PKaur

Results relate only to the items tested. Results apply to samples as received.

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Certificate of Analysis

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Water Package - Routine Chemistry Water Analysis - Lab Filtered Cations

DATE RECEIVED: 2025-03-27 **DATE REPORTED: 2025-04-02**

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to 2024 Canadian Drinking Water Quality MAC (AO)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

6618143-6618313 < - Values refer to Report Detection Limits.
SAR is a calculated parameter. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
Ion Balance is a calculated parameter. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Hardness is a calculated parameter. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
Calculated TDS is a calculated parameter. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By: PKaur

Results relate only to the items tested. Results apply to samples as received.

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Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Trace Organics Analysis

RPT Date:			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Petroleum Hydrocarbons (BTEX/F1-F2) in Water															
Benzene	5685	6615428	<0.0005	<0.0005	NA	< 0.0005	97%	60%	140%	98%	60%	140%	80%	60%	140%
Toluene	5685	6615428	<0.0003	<0.0003	NA	< 0.0003	107%	60%	140%	99%	60%	140%	86%	60%	140%
Ethylbenzene	5685	6615428	<0.0005	<0.0005	NA	< 0.0005	109%	60%	140%	94%	60%	140%	85%	60%	140%
Xylenes	5685	6615428	<0.0005	<0.0005	NA	< 0.0005	117%	60%	140%	102%	60%	140%	91%	60%	140%
C6 - C10 (F1)	5685	6615428	<0.1	<0.1	NA	< 0.1	112%	60%	140%	115%	60%	140%	91%	60%	140%
C10 - C16 (F2)	931	6618313	<0.1	<0.1	NA	< 0.1	108%	60%	140%	96%	60%	140%	96%	60%	140%

Comments: Duplicate NA: results are less than 5X the RDL and RDP will not be calculated.
The sample spikes and dups are not from the same sample ID.

Certified By: Elena Gorobets

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation. RPDs calculated using raw data. The RPD may not be reflective of duplicate values shown, due to rounding of final results.

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

Water Analysis

RPT Date:			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Water Package - Routine Chemistry Water Analysis - Lab Filtered Cations															
pH	6628494	6628494	7.09	7.10	0.1%	N/A	100%	90%	110%						
p - Alkalinity (as CaCO3)	6628494	6628494	<5	<5	NA	< 5	NA	80%	120%						
T - Alkalinity (as CaCO3)	6628494	6628494	374	371	0.8%	< 5	110%	80%	120%						
Bicarbonate	6628494	6628494	456	452	0.9%	< 5									
Carbonate	6628494	6628494	<5	<5	NA	< 5									
Hydroxide	6628494	6628494	<5	<5	NA	< 5									
Electrical Conductivity	6628494	6628494	2090	2090	0.0%	< 5	101%	90%	110%						
Chloride	6618312	6618312	265	276	4.1%	< 1.0	89%	70%	130%	85%	80%	120%	NA	70%	130%
Fluoride	6618312	6618312	4.5	4.9	8.5%	< 0.01	97%	70%	130%	94%	80%	120%	98%	70%	130%
Nitrate	6618312	6618312	<2.5	<2.5	NA	< 0.5	86%	70%	130%	83%	80%	120%	82%	70%	130%
Nitrite	6618312	6618312	<1.0	<1.0	NA	< 0.05	94%	70%	130%	93%	80%	120%	97%	70%	130%
Sulfate	6618312	6618312	7.6	6.4	17.1%	< 1.0	93%	70%	130%	93%	80%	120%	92%	70%	130%
Dissolved Calcium	6618333	6618333	148	143	3.4%	< 0.07	100%	70%	130%	NA	80%	120%	NA	70%	130%
Dissolved Magnesium	6618333	6618333	101	103	2.0%	< 0.05	105%	70%	130%	NA	80%	120%	NA	70%	130%
Dissolved Sodium	6618333	6618333	90.2	92.9	2.9%	< 0.05	110%	70%	130%	NA	80%	120%	NA	70%	130%
Dissolved Potassium	6618333	6618333	4.56	4.77	4.5%	< 0.05	102%	70%	130%	NA	80%	120%	109%	70%	130%
Dissolved Iron	6618333	6618333	<0.001	<0.001	NA	< 0.001	105%	70%	130%	NA	80%	120%	112%	70%	130%
Dissolved Manganese	6618333	6618333	0.00174	0.00181	3.9%	< 0.00005	96%	70%	130%	NA	80%	120%	103%	70%	130%

Comments: Matrix spike NA: Spike level < native concentration. Matrix spike acceptance limits do not apply and are not calculated.
Duplicate NA: results are less than 5X the RDL and RDP will not be calculated.

pH has been analyzed past the recommended holding time of 15 minutes from sampling (field measurement ideal if more accurate data required)

Nitrate and Nitrite: The regulatory hold time for the analysis of nitrate and/or nitrite in water is 72 hours.

Certified By: PKaur

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FAX (403)735-2771
http://www.agatlabs.com

Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 25C265107

PROJECT: A03701E05 Chincoulee, Taber, AB

ATTENTION TO: Nancy Graingen

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Trace Organics Analysis			
Benzene	TO 0332	EPA SW-846 5021 & 8260	GC/MS
Toluene	TO 0332	EPA SW-846 5021 & 8260	GC/MS
Ethylbenzene	TO 0332	EPA SW-846 5021 & 8260	GC/MS
Xylenes	TO 0332	EPA SW-846 5021 & 8260	GC/MS
C6 - C10 (F1)	TO 0542	CCME Tier 1 Method	GC/FID
C6 - C10 (F1 minus BTEX)	TO 0542	CCME Tier 1 Method	GC/FID
C10 - C16 (F2)	TO 0511	CCME Tier 1 Method	GC/FID
Toluene-d8 (BTEX)	TO-0543	EPA SW-846 5021 & 8260	GC/MS
o-Terphenyl (F2)	TO 0511	CCME Tier 1 Method	GC/FID
Sediment	TO-0511	CCME Tier 1 Method	GC/FID
Water Analysis			
pH	INST 0101, INST 0104	SM 4500 H+	PH METER
p - Alkalinity (as CaCO3)	INST-0100, INST-0101	SM 2320 B	TITRATION
T - Alkalinity (as CaCO3)	INST-0100, INST-0101	SM 2320 B	TITRATION
Bicarbonate	INST 0101	SM 2320 B	PC TITRATE
Carbonate	INST 0101	SM 2320 B	PC TITRATE
Hydroxide	INST 0101	SM 2320 B	PC TITRATE
Electrical Conductivity	INST 0101, INST 0120	SM 2510 B	CONDUCTIVITY METER
Chloride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Fluoride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate-N	INST 0150	SM 4110 B	CALCULATION
Nitrite	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrite-N	INST 0150	SM 4110 B	CALCULATION
Nitrate+Nitrite - Nitrogen	INST 0150	SM 4110 B	CALCULATION
Sulfate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Dissolved Calcium	INST 0141	SM 3125 B	ICP-MS
Dissolved Magnesium	INST 0141	SM 3125 B	ICP-MS
Dissolved Sodium	INST 0141	SM 3125 B	ICP-MS
Dissolved Potassium	INST 0141	SM 3125 B	ICP-MS
Dissolved Iron	INST 0141	SM 3125 B	ICP-MS
Dissolved Manganese	INST 0141	SM 3125 B	ICP-MS
Sodium Adsorption Ratio		CARTER & GREGORICH 2007	CALCULATION
Calculated TDS		SM 1030E	CALCULATION
Hardness		SM 2340 B	CALCULATION
Ion Balance		SM 1030E	CALCULATION
Lab Filtration on Routine for IC			N/A
Lab Filtration on Routine for Metals			N/A

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories
2910 12 Street NE
Calgary, Alberta T2E 7P7
P: 403-735-2005 • F: 403-735-2771
webearth.agatlabs.com

27-MAR-25 PM 5:33

Laboratory Use Only 20°C
Arrival Temperature:
Cooler Quantity:
Custody Seal Intact: ☐ Yes ☐ No ☐ N/A
AGAT Job Number: 25C265107

Chain of Custody Record

Emergency Support Services Hotline 1-855-AGAT 245 (1-855-242-8245)

Report Information

Company: Klohn Crippen Berger
Contact: Nancy Grainger
Address: 7315 8 St NE Calgary.
Phone: 403 274 3424

Project Information

Client Project #: A037011E05
Site Location: Chin Coulee, Taber, AB
Sample By: Shafik Vadsariya
AGAT Quote #:
If a quotation number is not provided, client will be billed at standard rates. See terms and conditions of quote for full details.

Invoice To

Same as Report to ☑
Company:
Contact:
Email:
Address
Phone:
PO/CC #:

Report Information

1. Name: Nancy Grainger
   Email: NGrainger@Klohn.com
2. Name: Dustin Bailey
   Email: DBailey@klohn.com
3. Name: Shafik Vadsariya
   Email: svadsariya@klohn.com

Requirements (Selection may impact detection limits)

CCME	AB Tier 1	Alberta Surface Water
☐ Agricultural	☐ Agricultural	☐ Chronic
☐ Industrial	☐ Industrial	☐ Acute
☐ Residential/Park	☐ Residential/Park	☐ SK Notice of Site Cond.
☐ Commercial	☐ Commercial	☐ Drinking Water
☐ FWAL	☐ Natural Area	☐ Other:

Is this part of the Alberta SRP program? ☐ YES ☑ NO (If yes, please fill below)
Application Number:
Grant Amount:
Well/Facility/Location ID:
UWI:

Turnaround Time Required (TAT)

Regular TAT ☑ 5 to 7 Business Days
Rush TAT
☐ <24 Hours (200%)
☐ Next Business Day (100%)
☐ 2 Business Days (50%)
☐ 3 Business Days(25%)
Date Required:

LABORATORY USE (LAB ID #)	SAMPLE IDENTIFICATION	DEPTH	DATE/TIME SAMPLED	SAMPLE MATRIX	COMMENTS	# OF CONTAINERS: VIALS / JARS	# OF CONTAINERS: BAGS	# OF CONTAINERS: BOTTLES
1	MW22-04	–	24Mar25, 15:15			2	1	3
2	MW22-02	–	24Mar25, 18:17			2	1	3
3	MW22-03	–	25Mar25, 11:24			2	1	3
4	MW22-01	–	25Mar25, 14:27			2	1	3
5	151387	–	25Mar25, 16:01			2	1	3
6	BH23-S-14B	–	26Mar25, 11:52			2	1	3
7	BH24-D-16	–	26Mar25, 15:07			2	1	3
8	BH21-03	–	26Mar25, 17:06			2	1	3
9	2096581	–	26Mar25, 17:50			2	1	3
10	DUP-01	–	26Mar25, 12:00			2	1	3

Field Filtered (Y/N)	Preserved (Y/N)	Detailed Salinity: ☐ AB ☐ SK ☐ BC ☐ D50	☐ CCME/AB : BTEX/F1-F4 ☐ CCME/AB : BTEX/F1-F2	☐ BC: BTEXS/VPH/EPH ☐ BC: LEPH/HEPH	SK: BTEX/TVH/C11-C22, C23-C60	Soil Metals: ☐ HWS-B ☐ SP-B ☐ Hg ☐ Cr^{6+}	Water Metals: ☐ Dissolved ☐ Total ☐ Hg ☐ Cr^{6+}	Routine Water Chemistry	Landfill: ☐ AB Class 2 ☐ BC ☐ SK	Coliforms: ☐ Total ☐ Fecal ☐ E.coli	Particle Size: ☐ Sieve (75µm) ☐ Texture				Hold For 30 Days No Analysis (Additional Fee)	Long Term Storage - 6 Months	Long Term Storage - 1 Year	Hazardous (Y/N)
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										
			✓					✓										

Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time
SHAFIK VADSARIYA	Mar27, 25, 17:30		
Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time
Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time

Pink Copy - Client
Yellow Copy - AGAT
White Copy- AGAT

N°: AB 195646

Document ID: DIV-50-1507.007
Date Revised: Oct 14, 2021

AGAT Laboratories

SAMPLE INTEGRITY RECEIPT FORM

RECEIVING BASICS - Shipping

Company/Consultant: Kiln Gripper

Courier: D/O Prepaid Collect

Waybill#

Branch: EDM GP FN FM RD VAN LYD FSJ EST SASK Other: C

If multiple sites were submitted at once: Yes (No)

Custody Seal Intact: Yes No NA

TAT: <24hr 24-48hr 48-72hr (Reg) Other

Cooler Quantity: 1-L

TIME SENSITIVE ISSUES - Shipping

ALREADY EXCEEDED HOLD TIME? Yes (No)

Inorganic Tests (Please Circle): Mibi , BOD , Nitrate/Nitrite , Turbidity , Color , Microtox , Ortho PO4 , Tedlar Bag , Residual Chlorine , Chlorophyll* , Chloroamines*

Earliest Expiry:

Hydrocarbons: Earliest Expiry

SAMPLE INTEGRITY - Shipping

Hazardous Samples: YES (NO) Precaution Taken:

Legal Samples: Yes (No)

International Samples: Yes (No)

Tape Sealed: Yes No

Coolant Used: Icepack Bagged Ice Free Ice Free Water (None)

Temperature (Bottles/Jars only) N/A if only Soil Bags Received

FROZEN (Please Circle if samples received Frozen)

1 (Bottle/Jar) 19.9 + 19.9 + 20.1 = °C 2(Bottle/Jar)___+___+___=___°C

3 (Bottle/Jar)___+___+___=___°C 4 (Bottle/Jar)___+___+___=___°C

5 (Bottle/Jar)___+___+___=___°C 6 (Bottle/Jar)___+___+___=___°C

7 (Bottle/Jar)___+___+___=___°C 8 (Bottle/Jar)___+___+___=___°C

9 (Bottle/Jar)___+___+___=___°C 10 (Bottle/Jar)___+___+___=___°C

(If more than 10 coolers are received use another sheet of paper and attach)

LOGISTICS USE ONLY

Workorder No:

Samples Damaged: Yes No If YES why?

No Bubble Wrap Frozen Courier

Other:

Account Project Manager: have they been notified of the above issues: Yes No

Whom spoken to: Date/Time:

CPM Initial

General Comments:

* Subcontracted Analysis (See CPM)

Date issued: March 11, 2020
Document ID: SR-9505.004

AGAT Laboratories

LC Use Only

Bottle Order # 577970

Completed By JN

Date Complete 17 MAR 24 28

Checked

Date Required By: 2025 Mar 19

For any questions or concerns regarding this bottle order please contact your AGAT Client Project Manager at 403-735-2005. Please notify of incoming RUSH or TIME SENSITIVE samples

Client Information

KLOHN CRIPPEN BERGER LTD.
Nancy Grainger
7315 8th St NE CALGARY Alberta Canada T2E 8A2
403.648.4272
ngrainger@klohn.com
Project Number:
PO Number:
Quote Number:

Delivery Method

Ship to Location
7315 8 Street NE CALGARY Alberta Canada T2E 8A2

Supplies

Small Cooler ☑ As Required | Medium Cooler ☑ As Required | Large Cooler ☑ As Required
COC 1

Matrix	Analysis	Bottle	Quantity	Preservative	Instructions	Hold Time	Total Bottles
Water	Routine Potable Water Chemistry	250 mL Plastic	1	No Preservative	Fill Bottle	0 Multiple	15
Water	Dissolved CCME/Alberta Tier 1 Metals in Water (Al, Sb, As, Ba, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Se, Ag, Na, Tl, U, Zn)	60 mL Plastic	1	Nitric acid (HNO3)	Field Filter then Fill Bottle	6 Months	15
Water	BTEX, F1 -F2 (C6-C10, C10-16)	100 mL Amber Glass	2	Sodium Bisulfate (NaHSO4)	Fill Bottles	14 Days	30
Water	BTEX, F1 -F2 (C6-C10, C10-16)	40 mL Glass Vial	2	Sodium Bisulfate (NaHSO4)	Fill Vials; No Headspace	14 Days	30
	Total						**90**

Preservatives

No Preservative	15
Nitric acid (HNO3)	15
Sodium Bisulfate (NaHSO4)	60

Special Instructions

Delivery / 403.648.4272

APPENDIX 44.1

Water Coop Meeting Record (June 20, 2022)

Quarterly Review Minutes of Meeting #1

Client: St. Mary River Irrigation District **File:** N:\15\20\167\WCM1.DOC
Project: Chin Reservoir Expansion
Date: June 20, 2022
Time: 10:00 am

Attendance:	Travis Geremia	St. Mary River Irrigation District (SMRID)
	Jeff Olitch	MPE Engineering Ltd. (MPE)
	Jason Saunders	Twelve Mile Road Coop (Twelve Mile)
	Lawrence Barany	Twelve Mile
	Gord Gejdos	Skiff Coop (Skiff)
	Dale Collins	Skiff
	Jake Waldner	Skiff
	John Waldner	Skiff
Location:	TID Board Room	
Purpose:	Water Coop Meeting #1	
Distribution:	All Present	
	David Westwood	SMRID
	Trevor Helwig	SMRID

1.0 Water Coop Meeting

SMRID and MPE provided an update on the status on the Chin Expansion Project. Key comments from the discussion on the future work are as follows:

- SMRID identified the current FSL is 861.40 and the new FSL will be 864.00.
- MPE identified construction of the new east dam will begin around 2025 and be completed by 2028. The expanded area will be flooded starting in 2028 and will take a minimum of 2 years to fill.
- SMRID and MPE will need to coordinate filling schedule with new infrastructure to ensure water coops are to continue being operational as the current pump structure is in the bottom of the coulee within the expanded area.
- The water coops receive water year-round. SMRID did identify they will provide water to the coops through construction.
- Skiff would like SMRID to investigate the opportunity to relocate the intake near the new east dam.
- Skiff identified possibly having a combined intake off the revoir for the coop and irrigation deliveries.
- Both 12 Mile and Skiff are interested in expansion of their water coop distribution areas and will need to be considered during the design phase.
- Skiff identified they have capacity issues.
- 12 Mile suggested that Lawrence Barany's irrigation inlet could be used a temporary intake during the reservoir filling.

- Current water licenses are close to their 25-year renewal period which is usually a good time to expand. MPE to provide some background in who to approach for an expansion. MPE will also provide details on any grants available to potentially fund an expansion.
- SMRID notified that if there is any interest in irrigated acres then they are to contact Linda Park with SMRID.
- SMRID identified the expansion areas are not determined yet.
- With respect to the water coops, T. Geremia that it is the goal of SMRID to not leave the water coops "worse off than they were before" upon completion of the project.

Action: Info/MPE/SMRID

The meeting ended at approximately 11:00 am.

Minutes recorded by Jeff Olitch

If there are any errors, omissions or discrepancies please contact Jeff Olitch at 317-3629 within five working days, or minutes will be considered accurate.

APPENDIX 44.2

SMRID Proposed Irrigation Expansion Information Package (2022)



SMRID

ST. MARY RIVER IRRIGATION DISTRICT

Proposed Irrigation Expansion Information Package

PUBLIC INFORMATION MEETINGS:

November 22, 2022
Taber Heritage Inn
Time: 1:30 pm

November 23, 2022
Bow Island Legion Hall
Time: 1:30 pm

November 24, 2022
Seven Persons Community Hall
Time: 1:30 pm

November 25, 2022
Readymade Community Hall
Time: 1:30 pm

To Our Fellow Water Users,

How thankful we are for irrigation! Imagine what Southern Alberta would look like today without irrigation. We owe a great deal to our forefathers who had the foresight and courage to bring water to our communities. At a time when so many irrigation projects in the world are threatened, we are fortunate that, here in Southern Alberta, we are presented with an opportunity to expand and enhance our irrigation district, allowing our communities to grow and prosper.

Your SMRID Board of Directors has authorized the holding of a plebiscite to ask the water users to approve a phased expansion of the District by about 15% or 80,000 acres. This expansion is to be phased in over a number of years with a stringent set of rules that ensure that our current irrigators water security is as good or better than it is today.

In the spring of 2020 Irrigation Districts in Southern Alberta were invited by the Provincial Government to take part in a program to enhance and increase irrigation. Their reasoning was that dollars spent in irrigation agriculture would be a very effective way to stimulate the Alberta economy. SMRID responded aggressively with a list of eligible projects to replace open canals with pipelines as well as a proposal for the expansion of the Chin Reservoir. Our Board sees this as a once in a lifetime opportunity that cannot be passed up. The modelling shows that the combined gains in water savings and increased storage capacity exceed the additional water required to support the 15% expansion we are proposing and therefore reduces the risk of water shortage in times of severe drought. In addition to the Alberta Irrigation Modernization projects, over the past 12 years since the last expansion in 2011, both District water conveyance and on-farm application efficiencies have improved significantly. We expect these gains to continue.

In the planning process, we have taken the time to talk to many of our irrigators throughout the District for their views on expansion. We found that there was general support for the concept with one provision: water security must not be harmed. We have taken this message to our engineers and asked for an expansion limit that would retain or improve water security for our current water users. We have also designed a plan to regulate the allotment of acres in a prudent and cautious manner assuring those new acres are added only when it is wise to do so. This information package and the Public Information meetings will explain how we can enjoy the many benefits of expanding the SMRID without putting existing water users at risk.

We encourage you to attend the information meetings that will be held throughout the District, where you will be given the opportunity to learn about the proposed expansion and ask pertinent questions. We will be presenting relevant expansion-related information. After the information session there will be an opportunity to mingle with your neighbours, board members, and staff.

Your SMRID Board of Directors

INFORMATION PACKAGE

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Page 3	**Rationale for Irrigation Expansion**
Page 6	**General Information**
Page 7	**Efficiency Gains**
Page 8	**Chin Reservoir Expansion**
Page 10	**Who and How to Acquire Acres**
Page 12	**Plebiscite Vote**
Page 13	**Proposed Irrigation Expansion Summary Information**

LIST OF FIGURES

Page 17	**Figure 1: 2021 Crop Mix**
Page 17	**Figure 2: 2021 Irrigation Systems Summary**

RATIONALE FOR IRRIGATION EXPANSION

The Board of Directors have decided to take a proposal to the irrigators of the St. Mary River Irrigation District for an 80,000-acre expansion in the form of a plebiscite vote planned for November 28, 2022 based on the following rationale:

1. Chin Reservoir Expansion
2. Efficiency Gains
3. Revenue Generated from Capital Asset Charges will fund AIM Projects
4. Rate Stabilization
5. Increase Irrican Power Generation
6. Retention of Licensed Allocations
7. Attraction of Value-Added Industry
8. Provide Opportunity for Additional Recreation Sites
9. Provide Job Opportunities

1. **Expansion of the Chin Reservoir will supply water for new acres and provide water security for existing acres.**

   - Allows for new irrigation development within the district, which can enable individual producers to improve their farm profitability and provide greater financial stability.
   - Additional water storage will provide a buffer to help mitigate restrictions in a dry year.
   - An expanded reservoir will allow for extra storage capacity to capture water from high volume storm events and provide flood mitigation.

2. **Efficiency gains provided by replacing open canals with closed pipelines will allow our existing water flows to irrigate more acres.**

   - Our engineers have determined that water savings from our pipeline modernization projects that result from the elimination of seepage, evaporation, and spill losses, will allow us to irrigate more acres with the same amount of water.

RATIONALE FOR IRRIGATION EXPANSION

3. **Revenue generated from Capital Asset Charges will:**

    - Pay for the Alberta Irrigation Modernization projects, removing the burden of this payment from our current irrigators who are not able to expand.
    - Provide revenue for continued accelerated rehabilitation beyond the scope of the AIM program. Allow for the creation of a financial reserve to provide for disaster repairs.
    - Allow for enhancements to existing infrastructure. Many of our early pipelines did not include settling ponds or screeners. Our plan would direct a portion of Expansion Revenue to bring older infrastructure to present day standards.

4. **Expanded acre base will spread fixed costs over more acres to allow for water rate stabilization.**

    - The cost of expansion, including the cost of infrastructure to deliver water to a project, is born by those who contribute Capital Asset Charges. The District will therefore spread its current overhead costs over more acres resulting in greater efficiency and rate stabilization.

5. **Increased water flow through Irrican Power plants would maximize generation revenue and further stabilize water rates.**

    - New acres derived from the expansion of Chin Reservoir will require increased flows. The more water that flows through Irrican, the more revenue it generates for our irrigators.
    - 2021 saw record net income before tax generation of $7.8 million.
    - The future role that Irrican would play in water rate stabilization is substantial when you consider the bullish outlook for green power pricing coupled with the increased flows of the proposed expansion.

6. **Retention of Licensed Allocations.**

    - Expansion will demonstrate more efficient use of our licensed water allocations to reduce the potential for regulatory reductions to our licensed authorizations through a possible “Use It or Lose It” initiative.

RATIONALE FOR IRRIGATION EXPANSION

7. **Attract value adding industry and support production of specialty crops.**

    - An increase in available irrigation land will enhance and solidify Southern Alberta's reputation as one of the most attractive locations in North America for quality food production. Food processors demand stability. Irrigation provides consistent yield and quality for the many specialty crops grown in our district. Increased value-added processing will provide new opportunities for our existing irrigators as well as new irrigators.

8. **Provide opportunities for an additional recreation site.**

    - The expansion of Chin Reservoir will allow for a new recreation site opportunity. Our community would appreciate an additional recreation and boating site. Our co-operation with the development of such a facility would go a long way to maintain our good relationship with the public, while maintaining the primary use of the reservoir for irrigation.

9. **Irrigation expansion within our communities will provide jobs and opportunities to support continued growth and prosperity.**

    - Irrigation Agriculture provides employment opportunities for our families and allows our communities to grow and thrive.
    - Please use this link to be able to download the Economic Value of Alberta's Irrigation report: https://www.albertairrigation.ca/?page_id=148



GENERAL INFORMATION

Background

In October 2020 and November 2021, the Government of Alberta announced the $933M Alberta Irrigation Modernization (AIM) program to invest in irrigation infrastructure. The investment is shared between the Alberta Government, and Irrigation Districts, with long term financing from the Canada Infrastructure Bank.

The purpose of the AIM program is to stimulate the Alberta economy and increase irrigation in Alberta. The program includes two areas of focus: projects that modernize irrigation infrastructure and the expansion of off-stream water storage.

Modernization Projects

The amalgamated SMRID received approval for 30 modernization projects; primarily converting open channel water delivery systems with enclosed underground pipelines. The District has been completing similar projects for the past 40 years. These modernization projects increase water use efficiency within the District. The total budget for the 30 Modernization projects is $206 Million.

Off-Stream Water Storage

The SMRID, along with its main canal partner, the Raymond Irrigation District (RID), was also approved for funding to expand Chin Reservoir. The project will result in significant additional water storage (increasing the Chin Reservoir storage by roughly 50%) which will provide additional water security for our water users and the ability to expand our irrigation acres. The project is estimated at $133 Million, of which the RID is contributing $13.3 Million.



EFFICIENCY GAINS

Efficiency Gains

Since our last expansion in 2011, approximately 226 km of canals have been replaced through the District's Irrigation Rehabilitation Program (IRP). In addition, we have committed to replacing another 198 km of open canals through the Alberta Irrigation Modernization Program (AIM), so in total 424 km of canals will be replaced with buried PVC pipelines since the last expansion.

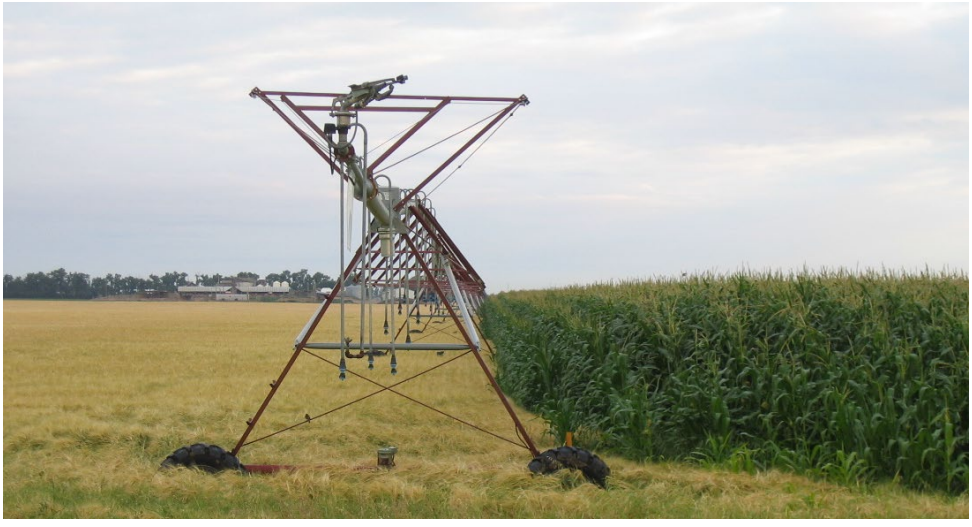
In addition, there have also been significant improvements in on-farm irrigation application efficiencies over the past 11 years since the last expansion.

Accounting for both on-farm and infrastructure improvements, it is estimated that the amalgamated SMRID will be saving 54,550 ac-ft of water per year, which is enough to serve an expansion of **40,912** acres. Water will continue to be saved through ongoing on-farm improvements and continuing rehabilitation efforts.

Water savings from on-farm and infrastructure improvements (SMRID)

Category	Estimated water savings
Infrastructure Improvements (2011-present)	9,201 ac-ft
On-farm improvements (2011-present)	16,292 ac-ft
Alberta Irrigation Modernization Program projects (2020+)	29,057 ac-ft
TOTAL	54,550 ac-ft

We are proposing that 40,000 acres derived from efficiency gains be put towards expanding additional acres.



CHIN RESERVOIR EXPANSION

Chin Reservoir Expansion

In addition to the expansion based on water savings from efficiency gains, SMRID engaged WaterSmart Solutions Ltd. (WaterSmart), to review expansion of the Chin Reservoir. SMRID is proposing to enlarge Chin Reservoir by relocating the East Dam 10 kilometers to the East, and raising the water level by 2.6 metres which will result in an additional 103,500 ac-ft of water storage.

Computer Modelling and Risk of a Water Shortage

Based on WaterSmart's modelling, it is estimated that the enlarged reservoir could support an additional 46,500 acres of expansion. WaterSmart's analysis involved computer modelling using 82 years of climate and river flow records, which have been accumulated for the period of 1928 – 2009. The model used irrigation demand based on 2020 acres and the 2016 crop mixes, irrigation management techniques and practices and District infrastructure against recorded river flows and weather data from 1928 to 2009 (inclusive). Modelling showed that 75,000 ac-ft was adequate to support the proposed expansion with minimal additional risk.

Modelled Water Requirements



Modelled scenarios used a variety of expansion acreages, which indicated what level of water deficits would have happened over the 82-year period. The base (current water demand) and anticipated (after expansion water demand) was compared to the water supply over those 82 years. In years where demand is higher than supply, a deficit was calculated.

CHIN RESERVOIR EXPANSION

Modelled Deficit Frequency 82 years (1928–2009 inclusive) – Amalgamated SMRID

Model Deficit Range (inches)	Base Case	75,000 ac-ft Storage Increase 46,500 acre Expansion
0 to 2	73	71
2 to 4	8	8
4 to 6	0	2
6 to 8	1	1
TOTAL	82	82

Based on an expansion of an additional 46,500 acres, there were two fewer deficits of 0 to 2 inches and two additional deficit water shortages of 4 to 6 inches based on a modelled 82-year period. SMRID and RID would share the 46,500 additional acres, **41,850 (90%)** and 4,650 (10%), respectively. The modelled deficits show there is minimal change in the risk of insufficient water to irrigators. **We are proposing that 40,000 acres derived from the expanded Chin Reservoir be put towards expanding additional acres.**

In total, the 40,000 acres of water savings from efficiency gains plus the 40,000 acres of additional storage from an expanded Chin Reservoir will allow for 80,000 additional irrigation acres within the District.

Amalgamated modelling results are of former SMRID and TID expansion modelling performed by WaterSmart prior to amalgamation.

Gross Diversion of Water

The St. Mary River Irrigation District has eight water licenses which authorize the diversion of up to 880,000 acre-feet annually. Over the 35-year period of 1987 to 2021 inclusive, the gross diversion of water for the District, which includes water conveyed for other than irrigation purposes, seepage and evaporation losses and return flows, has **averaged 497,475 ac-ft in the amalgamated SMRID.** Over this period the greatest gross diversion was 685,289 ac-ft in 1988 and a low of 254,835 ac-ft in 2010. Over the 20-year period 2001-2021, **the average irrigation diversion for the amalgamated SMRID has been 13.0 inches.**

WHO AND HOW TO ACQUIRE ACRES

In the proposed Expansion the District would be divided into four development blocks allowing for distribution of expansion acres across the entire District to fully utilize the capacity of each block.

- The distribution of expansion acres would be accomplished in Phases by a lottery system.
- Each Phase could include more than one lottery round, depending on demand, so that expansion is done in a controlled and prudent manner.
- If you are considering expansion, please note that the only time to enter your application for Phase 1 is in the designated application window. There will not be another opportunity to apply for acres until Phase 2.
- All applications received any time within the 30-day application window would be entered into the draw.
- Once each lottery round is complete, successful applicants would have 30 days to place a 10 percent down payment of the Capital Asset Charge. Successful applicants would then be required to provide proof of any necessary easements for their project, an acceptable irrigable land classification for irrigation, and full payment of the Capital Asset Charge before irrigation of the parcel could commence. Successful applicants have one year from the date of the lottery to complete the above requirements, otherwise these acres will be returned to the pool of available acres.

Expansion must go to areas that have sufficient capacity. There will be canals, laterals and pipelines that may have capacity constraints that could limit their ability to effectively supply irrigation water to new expansion acres.

- The District would consider all applications received to determine if the applied-for acres could be properly serviced.
- A special exemption from this capacity requirement would be made for successful applicants that are on the list for AIM modernization projects. These applicants may apply in the first round, make a 10 percent down payment, then make full payment when their rehab is complete and capacity is available.
- Successful lottery acres that apply for the same limited capacity within a specified system, would be accepted in the order that they are picked.

WHO AND HOW TO ACQUIRE ACRES

The proposed Expansion would begin with Phase 1 planned for the spring of 2023. The primary goal of Phase 1 is to allow our existing irrigators to maximize the irrigation acres of their farms.

- This goal would be achieved by limiting applications to 150 acres per **registered landowner.**
- Irrigators would be allowed to hold new acres on their existing dryland corners for future corner system development.
- The first lottery round would be limited to **15,000 acres** and awarded based on the capacity within each block.
- The acreage limit and timing of future rounds to complete Phase 1 would be based on the District's ability to provide adequate capacity.
- **All current and future irrigators** could apply in Phase 1 and lottery rounds would be run until all eligible requests are satisfied.

Once the eligible applications in Phase 1 are allocated the expansion process would move to Phase 2.

- The goal of Phase 2 would be to direct expansion to where demand and capacity is available
- Acreage limits will be increased to accommodate larger projects.
- Capital cost of expansion would be determined at that time, based on market conditions.

During the expansion process, it is imperative to protect the water security of our current irrigators.

- Expansion progress would be tied to demonstrated and verified capacity gains from completed modernization projects.
- The Board of Directors would review the expansion progress at the end of each irrigation season. If the rate of expansion is found to be detrimental to the interests of the irrigators the Board of Directors has the option of adjusting or delaying any further expansion within each block.

PLEBISCITE VOTE

Voting regulations for a plebiscite are identical to the election process for Directors.

The plebiscite is approved if more than 50% of the irrigators voting, vote in favour on a ballot which will have wording similar to:

> **The St. Mary River Irrigation District presently has an expansion limit of 504,200 acres. The Board of Directors has determined that 584,200 acres could be served with its existing water license(s). The Board of Directors is seeking the approval of the irrigators to change the expansion limit to 584,200 acres.**

The **plebiscite vote** will be held at poll stations on:

Date: November 28, 2022
Time: 10:00 a.m. to 8:00 p.m.
Locations: Lethbridge, Taber and Bow Island District Offices

Public Information Meetings:

The Board of Directors will hold public information meetings for all irrigators prior to the plebiscite vote. These meetings will be held on:

Date: November 22, 2022
Location: Taber Heritage Hall
Time: 1:30 p.m.

Date: November 23, 2022
Location: Bow Island Legion Hall
Time: 1:30 p.m.

Date: November 24, 2022
Location: Seven Persons Community Hall
Time: 1:30 pm

Date: November 25, 2022
Location: Readymade Community Hall
Time: 1:30 p.m.

All irrigators are strongly urged to attend one of these meeting to hear the presentations on the expansion proposal.

PROPOSED IRRIGATION AREA EXPANSION SUMMARY INFORMATION

Background:

The Board of Directors of the St. Mary River Irrigation District (SMRID) is proposing to acquire authorization to increase the expansion limit of the SMRID by an additional **80,000 acres**. The current expansion limit for the amalgamated SMRID is 504,200 acres, which will increase the expansion limit to **584,200 acres**.

Required Information:

Within the governing requirements, as specified in the Irrigation Districts Act and its Regulations, the Board of Directors must:

- Provide notice of their intention to increase the District's irrigation expansion limit by approval of the irrigators;
- Provide specific water use and associated information to the public;
- Hold at least one public meeting to explain the details of the proposed increase in the irrigation expansion limit, and
- Hold a plebiscite vote of the irrigators on the proposed expansion.

The following information is provided in accordance with the stipulation of the Irrigation Plebiscite Regulation and is to be referenced as supporting rationale for expansion and the basis on which a plebiscite vote is implemented. Much of the detailed water requirement data has been derived through irrigation demand modelling work carried out on behalf of the SMRID by WaterSmart. The modelling analysis considers climate and water supply conditions representing 82 years of historical records. Expansion assessments are compared with water requirements as if the District were developed fully to a 584,200 acre Expansion Limit, as defined in the Irrigation Districts Act. All quantities derived and presented below are based on average annual conditions. 2021 crop mix (Figure 1) and on-farm system information (Figure 2) are included for recent information purposes.

A. Allocated License Volume of Water

The SMRID retains the equivalent of eight (8) irrigation diversion licenses totalling 880,000 acre feet of water. The date of these priority licences range in date of issue from 1899 – 1991.

PROPOSED IRRIGATION AREA EXPANSION SUMMARY INFORMATION

B. Volume of Water Lost from Canals and Reservoirs

Water related to the SMRID licenses is lost through either seepage or evaporation from the district conveyance canal systems, as end of canal flows that do not return to the system and flow to the river, and notably through evaporation off system reservoirs. Seepage has been significantly reduced over the last number of years through the rehabilitation of these works and the installation of more and more pipelines. As of 2021, it was estimated that approximately 10,902 acre-feet of water is being lost due to seepage and 38,507 acre-feet is lost from District canals and reservoir evaporation for a total of 49,409 acre-feet of water per operating season.

C. Volume of Return Flow

Water related to the amalgamated SMRID diversion licenses that is returned to the natural river systems, (return flow), is estimated as 47,467 ac-ft per operating season. This is based on the average of years 2016 to 2021. It is also recognized that in recent years the District is making notable reductions in the quantity of return flow as a result of continued upgrading of infrastructure with pipelines and landowner efficiency gains.

D. Volume of SMRID Licence Water Used for Other Purposes

The amalgamated **District** supplies **20,000 acre-feet** of its licensed diversion water to uses other than irrigation. In 2021, approximately 33% of this volume was remaining to be allocated for agricultural and industrial water conveyance agreements.

E. Volume of Remaining License Water Available for Crop Use

The remaining licensed water available for use at the farm delivery is the net amount after the above "losses". This is equivalent to:

Total Licensed Volume	880,000 ac-ft
Less:	
Losses from Seepage and Evaporation	(49,409) ac-ft
Return Flow Volume	(47,467) ac-ft
Other Use Commitment	(20,000) ac-ft
Remaining for Irrigation	763,124 ac-ft

PROPOSED IRRIGATION AREA EXPANSION SUMMARY INFORMATION

F. Water Requirements

SMRID has collected flow data over the past 35 years (1987-2021) and can demonstrate that the average volume of water diverted to meet farm delivery requirements is 497,475 acre-feet annually. The diversion has ranged as high as 685,289 acre-feet (1988) and as low as 254,835 ac-ft (2010). This includes both the volume required for consumption by crops as well as the losses incurred through the application and water delivery process, as well as other uses;

1) **Average Gross Water diverted, including losses (2001-2021): 13.0 inches**
Average On Farm Water applied, (2001-2021): 9.6 inches
(***based on acres actually irrigated)***

2) **2021 SMRID Crop Mix (Figure 1)**

Crop	Percentage %
Cereals	33%
Forages	25%
Oil Seeds	12%
Specialty Crops	29%
Other	1%

3) **Level of Risk of Water Shortage –** For the 40,000 acres of the proposed irrigation expansion from efficiency gains, there is no change in deficit and frequency of water shortage. For the additional 40,000 acres of proposed irrigation expansion based on the Chin Reservoir expansion, please see the **Modelled Deficit Frequency Table** on Page 9 which summarizes the number of deficits and frequency for the planned Chin expansion.

Based on calculated Efficiency gains and the modelled expansion of additional storage in Chin Reservoir the level of risk of water shortage of the proposed 80,000 acre expansion is minimal to our water users.

PROPOSED IRRIGATION AREA EXPANSION SUMMARY INFORMATION

G. Total Acres that could Be Irrigated

Based on the modelled irrigation demand the District's current licensing has enough capacity to support irrigation of at least 584,200 acres.

H. Current Expansion Limit

The present Expansion Limit is 504,200 acres.

I. Current Irrigation Area on the Assessment Roll

As of the 2021 assessment roll for the amalgamated SMRID, 502,794 acres were identified as irrigated, including 3,537 annual acre agreements and 623 terminable acres.

J. Proposed Expansion Limit

The SMRID Board of Directors is proposing a revised Expansion Limit of **584,200 acres.**

K. Location of Expansion Areas

Throughout the District, particularly where in-fill is beneficial and along main canal.



FIGURE 1

2021 SMRID CROP MIX

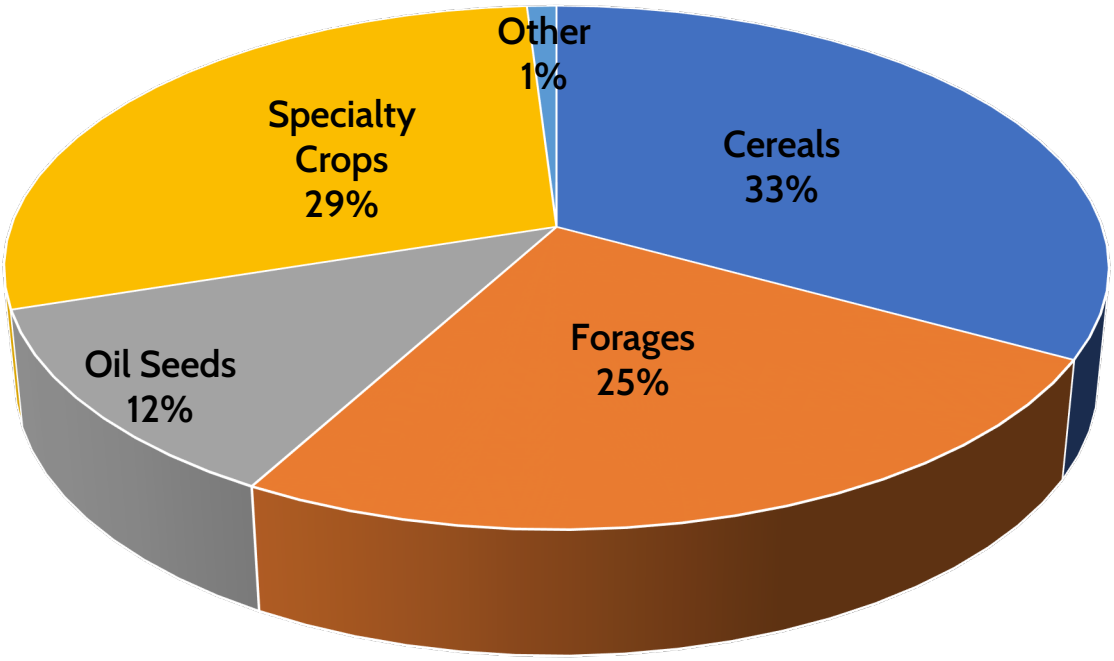
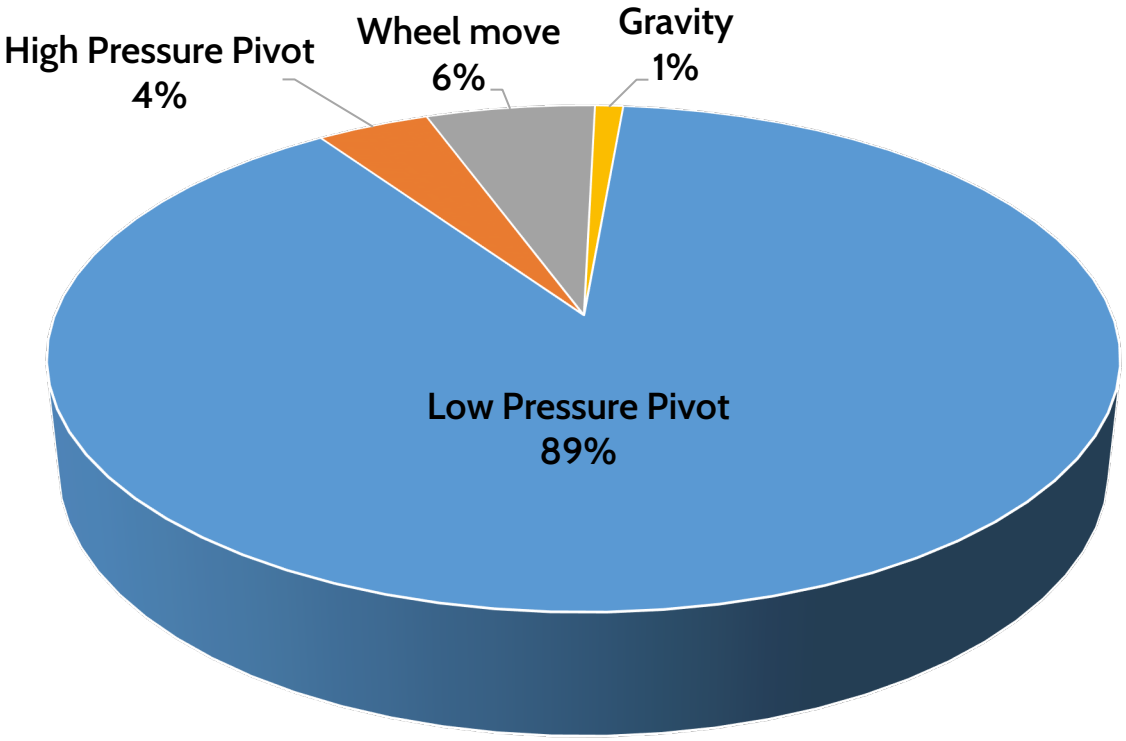


FIGURE 2

2021 SMRID IRRIGATION SYSTEMS



APPENDIX 45.1

November 10, 2022 SAGE Letter

A leading voice for a healthy and environmentally sustainable community

http://www.sage-environment.org/

10 November, 2022

To: The Honourable Stephen Guilbeault, Minister of Environment and Climate Change Canada, ministre-minister@ec.gc.ca

To: Hon. Sonja Savage, Minister of Environment and Protected Areas, Alberta, AEP.minister@gov.ab.ca

To: Hon. Nate Horner, Minister of Agriculture and Irrigation, AFRED.Minister@gov.ab.ca

To: Ehren Cory, Chief Executive Officer, Canada Infrastructure Bank, contact@cib.bic.ca

To: Sean Carriere, IAAC Director, Edmonton sean.carriere@iaac-aeic.gc.ca

To: Steven Mathyk, AEP, Regional Regulatory Assurance Manager, Lethbridge stephen.mathyk@gov.ab.ca

To: Lori Havanka, AEP, Approvals Program Manager, Edmonton lori.havanka@gov.ab.ca

Dear Sir/Madam,

Re: Environmental Impact Assessment of the "historic expansion of Alberta irrigation" including Chin Reservoir, Deadhorse Coulee Reservoir and Snake Lake Reservoir

I am writing on behalf of parties interested in environmental impact assessment of the activities associated with the "historic expansion for Alberta irrigation". Interested parties include Alberta Chapter of the Wildlife Society, Alberta Wilderness Association, Bow Valley Naturalists, Canadian Parks and Wilderness Society – Southern Alberta Chapter, Society of Grasslands Naturalists, Nature Alberta, Sierra Club Canada Foundation – Prairie Chapter, Southern Alberta Group for Environment, Arlene Kwasniak and David Swann.

"Historic expansion" was first announced in media releases (09 October and 21 December 2020) and described in information posted on the Alberta Water Portal (Why Alberta Irrigation Matters 05 August 2021). We are responding to Minister Guilbeault's recent decisions that three proposed irrigation reservoir projects that are part of the larger project do not warrant designation under the *Impact Assessment Act* because existing legislation and processes provide a framework to address potential adverse effects within federal jurisdiction (Minister's responses - Chin Reservoir 29 June 2022, Deadhorse Coulee Reservoir 05 August 2022 and Snake Lake Reservoir 21 September 2022). We have reviewed IAAC analysis reports for the three projects and have identified gaps and uncertainties to be addressed if the Minister's rationale for decision is to be realized.

1) **Requirement for environmental impact assessment (EIA) of all project activities is uncertain** – Activities associated with the proposed historic expansion of Alberta irrigation include modernization of 85 infrastructure components, construction or expansion of four reservoirs and over 95,000 hectares of newly irrigated lands. Only two activities have so far been determined to require EIA under the *Alberta Environmental Protection and Enhancement Act* (*AEPEA*) - expansion of Chin Reservoir and of Snake Lake Reservoir.

A provincial EIA must be required for construction of Deadhorse Coulee Reservoir and the fourth reservoir, (for which the proposed location is as yet undisclosed), if potential adverse effects within federal jurisdiction are to be fully addressed. We would appreciate confirmation of this.

Expansion of irrigation (95,000 ha) is proposed using water saved through infrastructure modernization and secured through reservoir expansion. Decisions regarding expansion of irrigation are largely the purview of Irrigation Districts under the provincial *Irrigation Districts Act*. The *South Saskatchewan Regional Plan* direction to protect native grasslands may be implemented in decisions regarding sale of public lands for irrigation expansion, however application on private lands (approximately half of the native prairie remaining) is not defined. We request clarification on the process by which potential adverse effects would be assessed in decisions regarding expansion of irrigated lands, including fish and fish habitat, migratory birds, species at risk and public concerns (e.g. loss of native grasslands, degraded aquatic ecosystems, water scarcity).

2) **Requirement for and scope of cumulative effects assessment (CEA), including transboundary effects, is uncertain** - According to the *Guide to Preparing Environmental Impact Assessment Reports in Alberta* (March 2013) proponents are required to define a Regional Study Area and describe the environmental conditions that would exist as a result of the interaction of the proposed project, other existing projects and other planned projects that can be reasonably expected to occur (Sec 2.1 and 2.2). Terms of reference for environmental assessment of the three reservoir projects have not yet been made publicly available. However, proponents in their submissions to the Impact Assessment Agency assert there are no irrigation expansion components of the project, contributions to cumulative effects will be minimal and any adverse residual effects will be mitigated.

   The Bow, Oldman and South Saskatchewan river basins in southern Alberta, Saskatchewan and Manitoba are experiencing degraded aquatic ecosystems, significant loss of native grasslands and high levels of greenhouse gas emissions from the cumulative effects of numerous projects including irrigation agriculture as a major contributor. At a minimum, cumulative effects assessment must consider all the activities associated with the "historic expansion for Alberta irrigation" and include the river basins in which these activities are proposed. There may be opportunity to consider innovative approaches to reduce adverse changes. Currently there is lack of assurance that this will occur.

   There is an assertion in IAAC analysis reports for the three proposed reservoirs that the Prairie Provinces Water Board (PPWB) will manage potential effects on water moving from Alberta to Saskatchewan according to the *Master Agreement on Apportionment* (MAA). Our understanding is that the PPWB monitors and reports on achieving apportionment and water quality requirements stipulated in the MAA. We are seeking confirmation that PPWB will take a proactive and precautionary approach to assessing potential transboundary effects of the proposed irrigation expansion on water quantity and quality.

3) **Public access to the impact assessment process is severely curtailed** – The preamble to the *Impact Assessment Act* "recognizes the importance of public participation in the impact assessment process, including the planning phase, and is committed to providing Canadians with the opportunity to participate in that process and with the information they need in order to be able to participate in a meaningful way". Public involvement in Alberta's environmental assessment process is limited to "people whom may be affected by a proposed project".

   Review by the Natural Resources Conservation Board only specifically permits input from persons who are *directly affected* by a project. Government officials and courts have interpreted "directly affected" narrowly to require an individual's or group's interests to be personally, directly, and adversely

affected by a project to participate, for example a person with property rights that the project directly will harm. Unlike federal review processes that invite public input and provide standing to parties concerned about environmental impacts (e.g. joint review panel hearings for proposed Grassy Mountain coal mine), we are effectively shut out of contributing information to NRCB's determination of whether or not the project is in the public interest.

We are also constrained from contributing information to a Director's decisions on specific approvals related to the project.

Public comment is allowed on the draft Terms of Reference for an EIA requiring that interested parties be notified by the proponent or are aware of posting on government's EIA webpage. Can we be assured of receiving notification when EIA Terms of Reference are available?

4) **Meaningful consultation with Indigenous peoples is not guaranteed** – There is an assumption in IAA analysis reports for the three reservoirs that the provincial EIA process will address potential effects on Indigenous peoples. Federal consultation with Indigenous groups would occur only if a *Fisheries Act* authorization is required. Proponents have submitted applications to the Alberta Aboriginal Consultation Office (ACO) regarding requirements for consultation with Indigenous peoples under the *Water Act* and the *Environmental Protection and Enhancement Act*. A decision was issued that consultation is not required under the *Water Act* for the proposed Chin Reservoir expansion. All other ACO decisions regarding Indigenous consultation requirements are pending and meaningful consultation is unlikely to occur within proposed timelines for the reservoir projects.

5) **Canada Infrastructure Bank (CIB) monitoring and public reporting on its obligations is not defined** – The Ministers' decisions state the CIB, who is providing financial assistance for the irrigation expansion project, is "responsible for meeting all of its legal obligations, including responding to the Duty to Consult to Indigenous groups and ensuring that the Project has met environmental assessment and other regulatory requirements". What is CIB's process to ensure these obligations are met and to publicly report on them?

We would appreciate any insights you may have on these gaps and uncertainties and how they will be addressed in assessment of the "historic expansion of Alberta irrigation".

Yours sincerely



Cheryl Bradley
Email: cebradley@shaw.ca
Phone: (403)328-1245

cc:
Jamie Wuite, AFRED, ED, Irrigation & Farm Water Branch, Edmonton Jamie.Wuite@gov.ab.ca
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APPENDIX 46.1

JFK Law LLP Letter to ECCC and IAAC on behalf of the Blood Tribe/Kainai (May 12, 2022)

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May 12, 2022

File No. 1187-038

Delivered by Email:
ministre-minister@ec.gc.ca;
information@iaac-aeic.gc.ca

Environment and Climate Change Canada
Fontaine Building
12th Floor, 200 Sacré-Coeur Blvd
Gatineau, QC K1A 0H3
Honourable Minister Steven Guilbeault

Impact Assessment Agency of Canada
757 W Hastings St.
Site 210A
Vancouver, BC V6W 3M2

Dear Honourable Minister Guilbeault and the Impact Assessment Agency of Canada:

Re: Chin Reservoir Expansion Project

We are legal counsel to Blood Tribe/Kainai ("**Kainai**") with regard to the Chin Reservoir Expansion and Modernization project (the "**Project**").

On April 22, 2022 the Impact Assessment Agency of Canada ("**IAAC**") sent a letter to Chief Roy Fox informing Kainai that the IAAC had received a request to designate the proposed Project from Ecojustice on behalf of several interested parties (including multiple environmental groups and two individuals) (the "**Ecojustice Request**").

We write on behalf of our client to request that the Minister of Environment and Climate Change Canada (the "**Minister**") designate the Project for federal review under section 9(1) of the *Impact Assessment Act*, SC 2019, c 28, s 1 (the "**Act**").

1. EXECUTIVE SUMMARY

Kainai is a party to the Blackfoot Treaty (Treaty 7) and are members of the Blackfoot Confederacy. Kainai are Aboriginal peoples and possess Aboriginal and Treaty rights protected and defined under section 35 of the *Constitution Act*, 1982.

This Project requires a federal review by the IAAC. As proposed, the Project:

- is located in the environmentally sensitive watershed of the Oldman River Basin;
- has potential adverse effects on areas of federal jurisdiction (incl. species at risk, migratory birds, federal lands, Indigenous peoples) and may have transboundary impacts in Saskatchewan and the United States;
- has the potential to cause adverse effects directly related to federal authority as it is partially funded by a federal institution – the Canada Infrastructure Bank; and
- has the potential to cause adverse impacts on the section 35 rights of the Blackfoot to take and use water and to practice traditional activities protected under the Blackfoot Treaty.

Further, this Project is part of a much larger program proposed by irrigation districts in Alberta to dramatically expand and modernize the irrigation system throughout southern Alberta. It is crucial that there is federal oversight of this program, and the projects contained within.

Kainai requests that the Minister designate the Chin Reservoir Expansion and Modernization Project using their discretion under section 9(1) of the *Impact Assessment Act.*

2. BLOOD TRIBE/KAINAI

Kainai is a party to the Blackfoot Treaty (Treaty 7) and are members of the Blackfoot Confederacy. Blackfoot traditional territory extends from the Rocky Mountains in the west to the Sand Hills in the east, and from the North Saskatchewan River in the north to the Yellowstone River in the south (present day Montana). The western boundary of Blackfoot traditional territory – the Rockies – was an overlapping area of trade, war, and peace-making between the Blackfoot tribes and their neighbours.

Kainai are Aboriginal peoples and possess Aboriginal and Treaty rights protected and defined under section 35 of the *Constitution Act*, 1982. Kainai is also an Indian band within the meaning of section 2 of the *Indian Act,* RSC 1985, c-I-15. They hold reserve lands covering approximately 136,265 hectares bordering the Old Man River, the St. Mary River, and the Belly River in southern Alberta.

Kainai have used and continue to use the lands, waters, and resources within Blackfoot traditional territory for a variety of purposes including: hunting, fishing, trapping, gathering, travelling, and cultural practices. The ability to use their traditional lands for a range of practices is critical to Kainai as the lands and resources underpin their governance, culture, tradition, identity, well-being, and spirituality. The traditional practices conducted on the land and waters are integral to Kainai's physical and cultural survival.

The rights contained under section 35 include rights to take and use water to support all other Treaty and Aboriginal rights but in particular includes rights to water to ensure that Kainai is able to fully use and benefit from reserve lands set aside pursuant to the Blackfoot Treaty. Providing for the safe and abundant water for their members is a key component of Kainai governance and their responsibilities as Blackfoot.

3. CHIN RESERVOIR EXPANSION AND MODERNIZATION PROJECT

1.1 PROJECT DETAIL

Project Name:	Chin Reservoir Expansion and Modernization Project
Project Proponent:	St. Mary River Irrigation District
Proponent Contact Information:	525 40th St. South Lethbridge, Alberta T1J 4M1 403 328 4401

1.2 PROJECT DESCRIPTION

The expansion and modernization of the existing Chin Reservoir is a major project that forms part of Alberta's nearly one billion dollar plan to revamp Alberta's irrigation infrastructure. The entire program includes constructing hundreds of kilometres of pipelines to replace canal systems and four new or expanded off-stream storage reservoirs. If approved, these changes will have major impacts throughout southern Alberta and Blackfoot traditional territory.

This Project will expand and modernize the existing Chin Reservoir (an off-stream reservoir on the St. Mary main canal located in TWP 8, RGE 17 and RGE 18 and TWP 7, RGE 16 and RGE 17 – W4M). Proposed Project activities include:

- relocating the east dam to Section 23 TWP 7-RG 15 – W4M (approx. 30 km southeast of Taber, Alberta);
- constructing a new east dam;
- raising the west dam;
- replacing the road over the crest of the west dam;
- replacing the existing cast-in-place outlet at the west dam; and
- replacing the Chin chute inlet spillway.

By raising and relocating the existing dams, it is expected that reservoir capacity will increase by 75,000 to 100,000 acre-feet of storage. Further, the expansion will flood approximately 650 hectares of previously unflooded area. The increased storage at the Chin Reservoir is intended to provide the Taber, Raymond, and St. Mary River Irrigation District with increased water security. The current land use within the reservoir footprint is agriculture, with all land privately owned. Construction is expected to begin in 2023.

It is important to place this Project in the context of the proposed expansion and modernization of irrigation in Alberta. The Project is part of a much larger program proposed by Irrigating Alberta Inc. (a corporate entity wholly-owned by ten of Alberta's irrigation districts), which consists of: the modernization of 85 components of irrigation infrastructure; and construction of four off-stream reservoirs (incl. this Project).

As identified in Ecojustice Request, this would be the "largest expansion of irrigation infrastructure and irrigated lands in Alberta's history" and would include "over 200 kilometers of new or converted pipelines and canals, over 1,850 hectares of new reservoir footprint, and over 95,000 hectares of newly irrigated land".[1]

4. DESIGNATION REQUEST

Please see the responses to the questions posed by the *Operational Guide: Designating a Project under the Impact Assessment Act* below.

4.1 The Project is part of a broader expansion of Alberta's irrigation system

While the Project, taken as an individual activity, does not near the threshold for federal review under ss. 58-61 of the *Physical Activities Regulation,* the Project is part of a broader program of expansion and modernization of Alberta's irrigation system that will certainly exceed these thresholds. The impacts of the project will be felt in conjunction with each individual project proposed under the larger program and will not be isolated or split like the projects.

4.2 The Project is in an environmentally sensitive location

The sensitive nature of this ecosystem is sufficient to warrant a federal review. The Minister should exercise their discretion to designate to Project under the *Impact Assessment Act*.

The Project is located within the Oldman River Basin, a watershed suffering from increasingly high water demand. Kainai's reserve lands are in the Oldman River Basin and Kainai relies on the basin for drinking water, community and commercial water needs,

[1] Ecojustice Request at p 2.

and agricultural water supply. The quality of this basin is of critical importance to Kainai members and government.

The South Saskatchewan Regional Plan ("**SSRP**"), which governs the Oldman River Basin, notes that the headwaters of the Bow and Oldman rivers are critical to water supply and water quality throughout the region. Generally, there is "significant" pressure on water resources in the region. The SSRP notes that "demands and the resulting pressure on water resources are compounded by periods of natural low flow and drought experienced periodically by the region".[2]

The SSRP states that degradation of riparian lands and reduction in viable wetlands throughout the prairies has contributed "to altered flow regimes and degraded water quality".[3] As noted in the Ecojustice Request, the project footprint consists primarily of wetlands and native grasslands, which includes permanent and temporary wetland habitats and habitats for many waterfowl and migratory bird species.

The wetlands and the sensitive ecosystem components are integral to the continued practice of the Blackfoot way of life. By preserving and protecting critical species and ecosystems we are also preserving and protecting the conditions necessary for the practice of Blackfoot rights by Kainai members.

4.3 The Project has the potential to cause adverse effects that fall within federal jurisdiction

The Project has the potential to cause adverse effects on multiple areas of federal jurisdiction that are of importance to Kainai. The designation request prepared by ecojustice contained detailed account and description of the specific effects on:

- *fish and fish habitat, and aquatic species, as defined in subsection 2(1) of the Species at Risk Act;*
- *species at risk; and*
- *effects on migratory birds.*

We do not need to reiterate these concerns as Ecojustice has adequately summarize those issue. However, we stress that the impacts on these three areas is felt directly and acutely by Kainai and its members that engage in traditional activities on the rivers and lands within Blackfoot territory.

- *Changes to the environment on federal lands*

The Project would impact the aquatic ecosystems of the Oldman River Basin that run through Blood Reserve No. 148 as well as federal lands including (Piikani Reserve No. 147 and Siksika's traditional lands). The withdrawal of large quantities of water and

[2] SSRP at 25.

[3] SSRP at 27.

altered flow through the Oldman River Basin will likely impact quality and quantity of water available to support Treaty and Aboriginal rights. As this watershed provides drinking water to Kainai's members living on-reserve, it is crucial that these impacts are properly accounted for and mitigated.

These impacts should be assessed on a regional and cumulative basis by the IAAC.

- *Changes to the environment that occur outside of Canada*

The Oldman River system flows into Saskatchewan and the United States. As the Project will impact this river system, it will have transboundary and international effects.

- *Changes to the environment that could affect the Indigenous peoples of Canada*

The Project will have direct and adverse effects on land within Blackfoot territory.

The Project will impact Blackfoot historical resources. By flooding an additional 650 hectares of land, there is a high likelihood that historical resources and artefacts belonging to the Blackfoot will be lost. It is not Kainai's preference to identify, dig up, and move important items. These items are tied to place and linked to stories. Their movement and relocation will diminish the value they hold and potentially destroy them. Despite best efforts, many would likely be lost. The areas around streams and rivers in southern Alberta are of significant historical and cultural importance to Kainai.

The Project will impact the ecosystem necessary for the continued practice of Blackfoot ways of life. As described above, the Project will have impacts on wildlife, birds, fish and aquatic species, and wetlands. These are all critical components for the continued practice of Blackfoot ways of life, which include: hunting, ceremonial uses, fishing, gathering plants and medicines, ceremonial uses, and camping.

4.4 The Project has the potential to cause adverse effects that are directly related or incidental to a federal authority

The larger irrigation expansion and modernization program is funding by the Canada Infrastructure Bank. This Project may not have been proposed nor could it have been carried out (in whole or in part) without this funding. Its impacts can be tied directly or incidentally to a federal authority – the Canada Infrastructure Bank.

4.5 The Project has the potential to cause adverse impacts on Kainai's section 35 rights

Canada and Alberta must ensure that the changes proposed to irrigation in Alberta will not adversely impact Treaty and Aboriginal rights, particularly those in relation to the rights promised by Canada under the terms of the Blackfoot Treaty. Water resources are an acute issue in the Blackfoot Treaty region. Any significant misstep by Canada and Alberta in the management of water resources in the Blackfoot Treaty region could risk a serious breach of the Treaty.

The Project will significantly alter the Oldman River Basin, in which Kainai's reserve lands are located. This will have a substantial impact on Kainai's section 35 right to water. To date, Canada has failed to recognize and accommodate Kainai's water rights in relation to its reserve lands and Alberta has adhered to an aggressive denial of Kainai's water rights. Expanding irrigation use and water storage in the same watershed as Kainai's reserve lands without addressing the very serious matter of Kainai's water rights could result in a fundamental breach of the Blackfoot Treaty by Canada and Alberta.

Kainai has section 35 rights to take and use water for their reserve lands. This includes maintaining a quality water supply in sufficient quantity to meet their needs. This right has been asserted since the settlement of Blackfoot territory by Canada and neither Alberta nor Canada has taken steps to resolve the impairment of this right.

This right to water is enshrined in the United Nations Declaration on the Rights of Indigenous Peoples ("**UNDRIP**") in several places. Article 25 states that:

> Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.

Further, the obligation for Canada to obtain free, prior, and informed consent on projects of this nature is included in Article 32, which states:

> States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources. [emphasis mine]

In addition to direct impacts to the section 35 right to take and use water, the Project will also have impacts on the conditions necessary for the practice of traditional activities protected under section 35. As noted above, the Project will have significant impacts to fish and aquatic species, wildlife, and migratory birds – all components of the ecosystem in Blackfoot traditional territory that support the practice of their section 35 rights. Further, the large footprint of the Project will reduce the overall landscape available for the practice of traditional activities. Although the lands are private, flooding will render them permanently and irreversibly unusable for traditional use.

The substantial impacts to Kainai's section 35 rights, both on reserve and throughout their traditional territory, warrant a federal review of this Project.

5. CONCLUDING REMARKS

This Project requires a federal review. As proposed, the Project:

- is located in an environmentally sensitive watershed;
- has potential adverse effects on areas of federal jurisdiction (incl. species at risk, migratory birds, federal lands, Indigenous peoples) and may have transboundary impacts in Saskatchewan and the United States;
- has the potential to cause adverse effects directly related to federal authority as it is partially funded by a federal institution – the Canada Infrastructure Bank; and
- has the potential to cause adverse impacts on the section 35 rights of the Blackfoot to take and use water and to practice traditional activities protected under the Blackfoot Treaty.

Further, we think it is incumbent on the IAAC to play a role in the review of a Project that forms part of a concentrated effort to expand and modernize the irrigation system throughout southern Alberta. Although this Project (taken alone) does not meet the thresholds established by the *Physical Activities Regulation*, the program certainly does. As such, we support the submission made in the Ecojustice Request to consider all the broader Alberta program's physical activities and their cumulative effects together. This would both be efficient from a regulatory perspective and also account for the scale of the efforts.

Kainai requests that the Minister designate the Chin Reservoir Expansion and Modernization Project using their discretion under section 9(1) of the *Impact Assessment Act.*

Yours truly,

JFK Law LLP

<Original signed by>

Blair Feltmate

Associate

BLF/jlw

cc: Mike Oka, Blood Tribe /Kainai (<email address removed>)
Annabel Crop Eared Wolf, Blood Tribe/Kainai (<email address removed>)
Clayton Leonard, JFK Law LLP (<email address removed>)

APPENDIX 46.2

Blood Tribe Meeting Record (December 15, 2022)

Minutes of Meeting #1

Client: St. Mary River Irrigation District **File:** N:\15\20\167\01.DOC
Project: Chin Reservoir Expansion
Date: December 15, 2022
Time: 1:00 pm

Attendance:	David Westwood	St. Mary River Irrigation District (SMRID)
	Travis Geremia	SMRID
	Jeff Olitch	MPE Engineering Ltd. (MPE)
	JJ Shade	Blood Tribe Tribal Government (BT)
	Dennis First Rider Jr.	BT
	Mike Tail Feathers	BT
Location:	West Dam of Chin Reservoir	
Purpose:	Chin Expansion Project Discussion Meeting	
Distribution:	All Present	
	Tanner Philipps	MPE
	Mike Oka	BT

1.0 General Items

- All attendees completed introductions
- SMRID provided background into the purpose of the project and purpose of the meeting.
- MPE/SMRID provided BT with project information sheets (see attached).
- MPE provided the Chin Expansion project description.
- MPE provided the current schedule for project and identified where the design is at.
- BT requested to have access to walk the expansion area before being flooded. SMRID confirm to provide this access. SMRID notified that the area is still privately owned, and access may not be available until the land is purchased. SMRID/MPE to update BT on access.
- BT asked if there were provisions to protect the fish. MPE provided the construction methodologies to protect the fish.
- BT asked who was conducting the HRIA. MPE stated Bison Historical Services is working on the HRIA.

Action: Info/MPE/SMRID

The meeting ended at approximately 2:00 pm.

Minutes recorded by Jeff Olitch

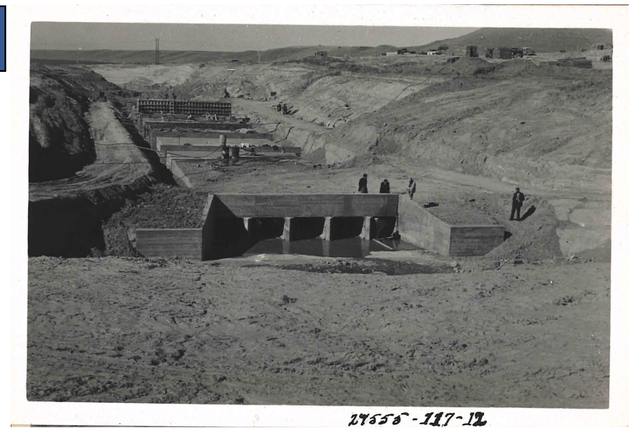
If there are any errors, omissions or discrepancies please contact Jeff Olitch at 317-3629 within five working days, or minutes will be considered accurate.

Chin Reservoir Expansion

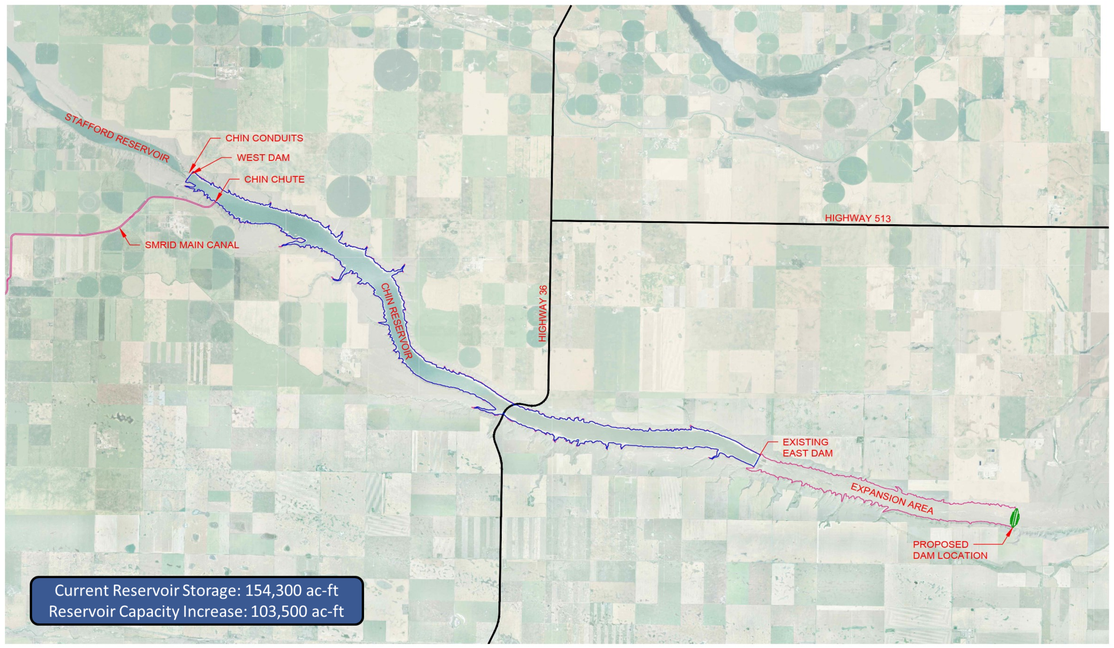
Background Information

- Chin Reservoir is impounded by two dams: West Dam and East Dam and is the largest storage reservoir within SMRID
- SMRID has received funding from the Alberta Government and the Canada Infrastructure Bank to expand the existing Chin Reservoir by raising the Full Supply Level (FSL) and relocating the East Dam 10 km to the east
- The Chin Reservoir Expansion Project was one of the options recommended by St. Mary River Main Canal Committee (SMCC) largely in response to the 2000/01 drought event that taxed the irrigation network in Southern Alberta
- To improve the resiliency of the irrigation infrastructure network, the project has a dual purpose in that it can mitigate the severe impacts of droughts and floods in the region

Original Construction Date: 1949 - 1954



Chin Reservoir Overhead



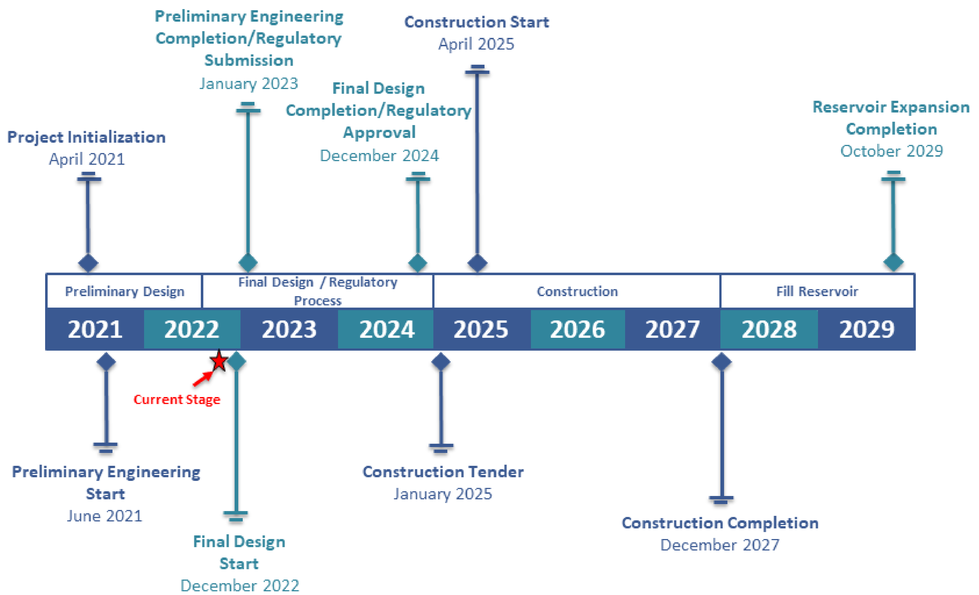
West Dam

- Raise West Dam
- Upgrade seepage collection and monitoring system on West Dam
- Replace existing Chin Outlet Conduits; capacity will remain the same
- Replace existing Chin Chute; increase capacity to handle maximum possible flow of the SMRID Main Canal



Overall Scope

- Raise reservoir capacity by performing upgrades at East and West Dam
- Raise Reservoir FSL from 861.36 to 864.00

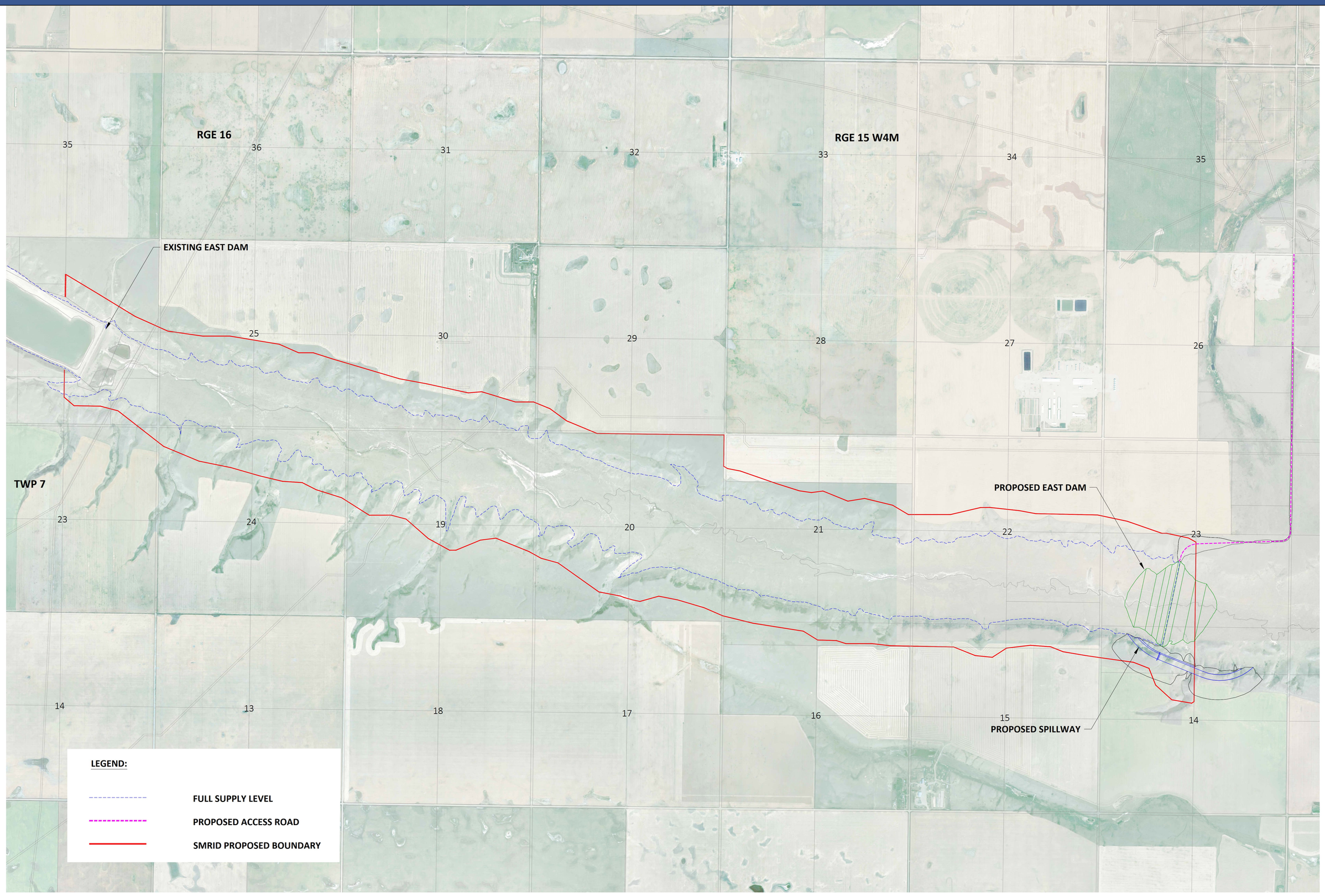


East Dam

- The new East Dam is located approximately 10 km southeast of the existing East Dam
- The maximum height of the new East Dam will be approximately 40 m
- Field work completed to date includes geophysics to assess depth to bedrock and drilling investigations to assess foundation materials



Chin Reservoir Expansion



APPENDIX 49.1

Example of Municipality Notification Package
Chin Reservoir Expansion Project Summary (March 2022)

SMRID
St. Mary River Irrigation District
403.328.4401 (Phone)
403.328.4460 (Fax)
525 40 Street South
Lethbridge, AB T1J 4M1

2022 03 25

Files: 700-140
via: email

Lethbridge County
#100, 905 – 4th Ave South
Lethbridge, Alberta
T1J 4E4

Attn: Ann Mitchell

Re: Chin Reservoir Expansion, Project Summary

Background

Chin Reservoir is an off-stream storage reservoir that is located roughly in the middle of the St. Mary River Irrigation District (SMRID) system approximately 10 km southeast of the Town of Coaldale. Chin Reservoir is the largest off-stream reservoir within the SMRID and has a current storage volume of 154,320 ac-ft (190,350 dam^3) at the operating Full Supply Level (FSL) of 861.40 m. Chin Reservoir is currently impounded by two dams: Chin 1 (West Dam) and Chin 2 (East Dam). The dams were completed in 1955. No significant alterations have occurred since construction. Water enters Chin Reservoir from the SMRID main canal through a combination of the Chin Hydro Plant or Chin Chute, both located in SEC-26-8-18-W4. The only outlet on the reservoir is the irrigation outlet structure on Chin 1 Dam that discharges into Stafford Reservoir.

Project Description

SMRID is proposing to expand the reservoir by constructing a new East Dam approximately 10 km downstream (east) of the existing East Dam and raising the design FSL to 864.00. The surface area of the reservoir will increase from 1670 ha to 2370 ha, an increase of 42%. The reservoir level will be raised after rehabilitation of the HWY 36 bridge, which is the responsibility of Alberta Transportation. The expansion will result in two areas of focus; namely, the East Dam and West Dam.

The East Dam work will include the following scope:

- The new East Dam will be located 10 km east of the existing East Dam, within SW 23-7-15 W4 and NW-14-7-15-W4.
- With the dam relocation and the rise in FSL, the total estimated storage will increase to 257,820 ac-ft and add 1750 acres (708 ha) to the reservoir's footprint, an increase of 42%
- The existing East Dam located in SE-26-7-16-W4 will either be removed or breached.
- The new East Dam will include a structure for flood management (i.e. overflow spillway).

The West Dam work will include the following scope:

- The West Dam, located in NE-27-8-18-W4, will be raised to account for the change in FSL to 864.00.
- The Low-Level Outlet is to be replaced. Capacity of the structure is currently not to be changed but will be reviewed as part of the project.

- The Chin Chute is to be replaced. The capacity of the structure will be reviewed and likely increased.
- Minor upgrades to the Chin Hydro Plant to account for the change in FSL.

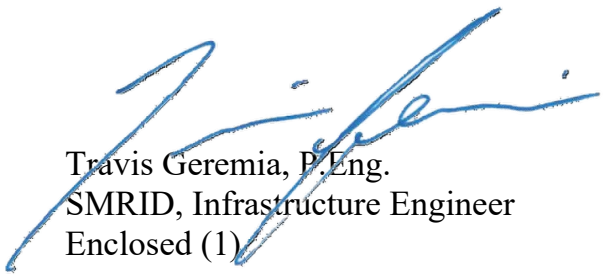
The work is currently at the preliminary design stage. A brief schedule for the project is as follows:

- Preliminary Engineering/ EIA/Submission of Regulatory – Now to Aug. 2022
- Final Design /Regulatory Approvals – Aug. 2022 to end of 2024
- Tender/ Construction – start of 2025 to start of 2028
- Fill Expansion Area to Low Water Level – start of 2028 to end of 2029 (variable to weather)

The Chin Reservoir Expansion Project is a significant project for the SMRID. You are invited to review the information provided and to provide comment on items affecting your organization. Depending on interest, a formal meeting may take place between the SMRID and representatives from the several municipalities directly affected by this project.

You can direct any comments or questions to myself at (403) 328-4401 ext. 115 or via email: tgeremia@smrid.ab.ca.

Sincerely,



Travis Geremia, P.Eng.
SMRID, Infrastructure Engineer
Enclosed (1)

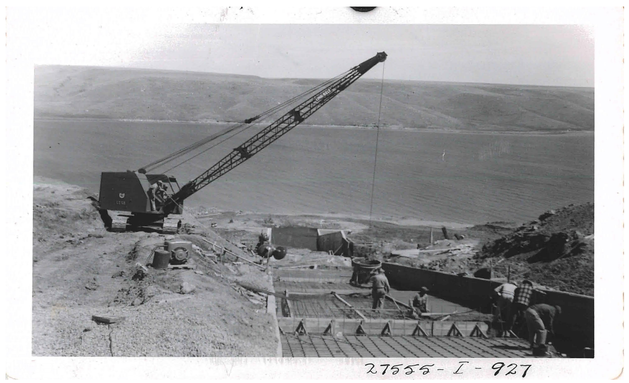
Chin Reservoir Expansion

Background Information

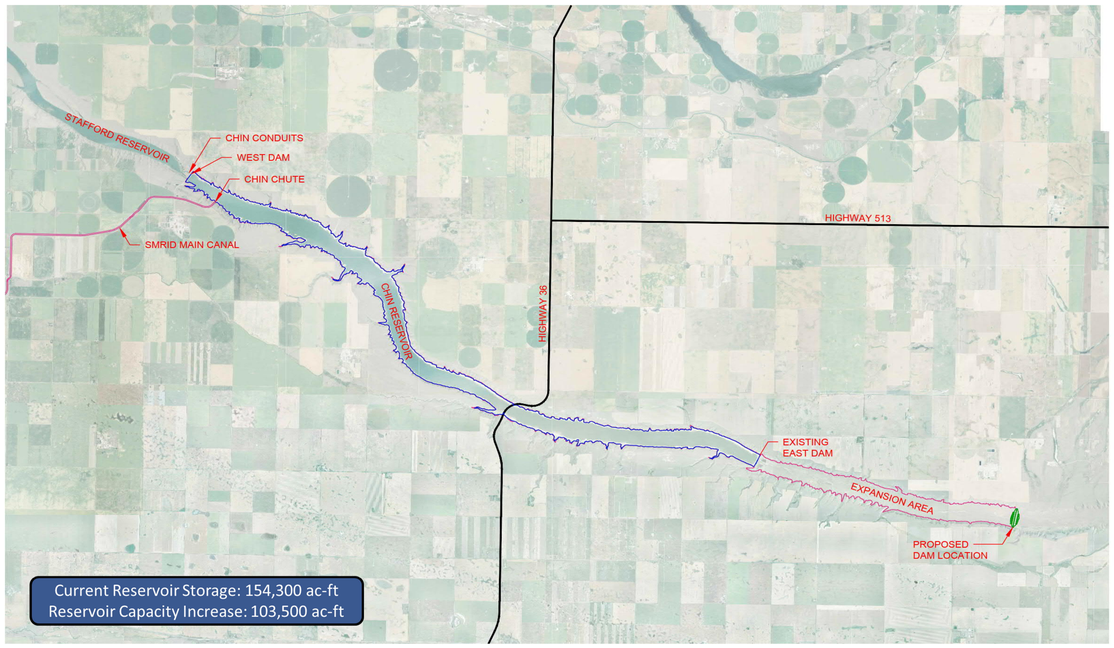
- Chin Reservoir is an off-stream storage reservoir that is located roughly in the middle of the St. Mary River Irrigation District
- Chin Reservoir is impounded by two dams: West Dam and East Dam and is the largest storage reservoir within SMRID
- SMRID has received funding from the Alberta Government and the Canada Infrastructure Bank to expand the existing Chin Reservoir by raising the Full Supply Level (FSL) and Relocang the East Dam 10 km to the` east.
- The Chin Reservoir Expansion Project was one of the options recommended by St. Mary River Main Canal Commiee (SMCC) largely in` response to the 2000/01 drought event that taxed the irrigaon network in` Southern Alberta.

Original Construction Date: 1949 - 1954





Chin Reservoir Overhead



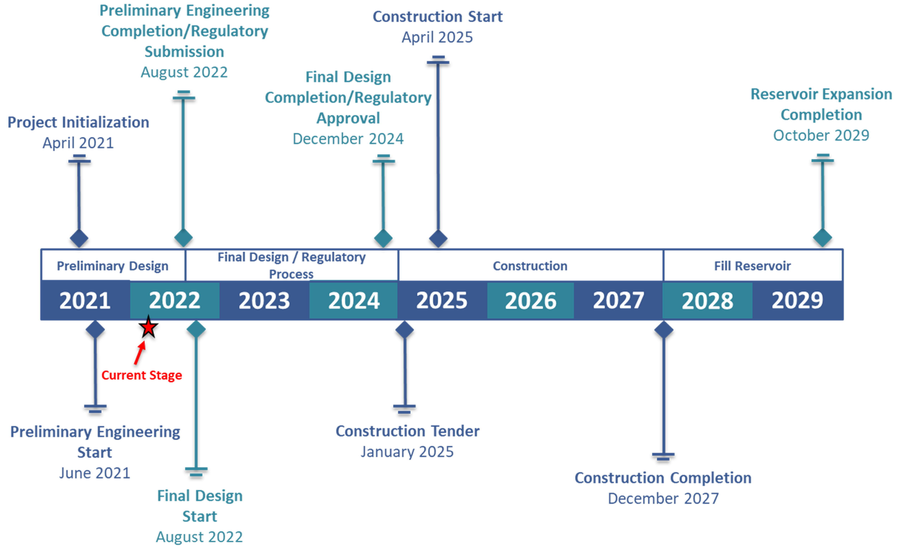
West Dam

- Raise West Dam
- Upgrade seepage collecon and` monitoring system on West Dam
- Replace existing Chin Outlet Conduits ; Capacity will remain the same
- Replace existing Chin Chute; Increase Capacity to handle maximum possible flow of the SMRID Main Canal



Overall Scope

- Raise reservoir capacity by performing upgrades at East and West Dam
- Raise Reservoir FSL from 861.4 to 864.00



East Dam

- The new East Dam is located approximately 10 km southeast of the existing Dam
- The maximum height of the new East Dam will be approximately 40 m
- Field work completed to date includes geophysics to assess depth to bedrock and a drilling investigation to assess foundation materials



APPENDIX 49.2

Chin Reservoir Expansion Slide Deck for Council Presentations

SMRID
ST. MARY RIVER IRRIGATION DISTRICT

MPE
Engineering Ltd.

Klohn Crippen Berger

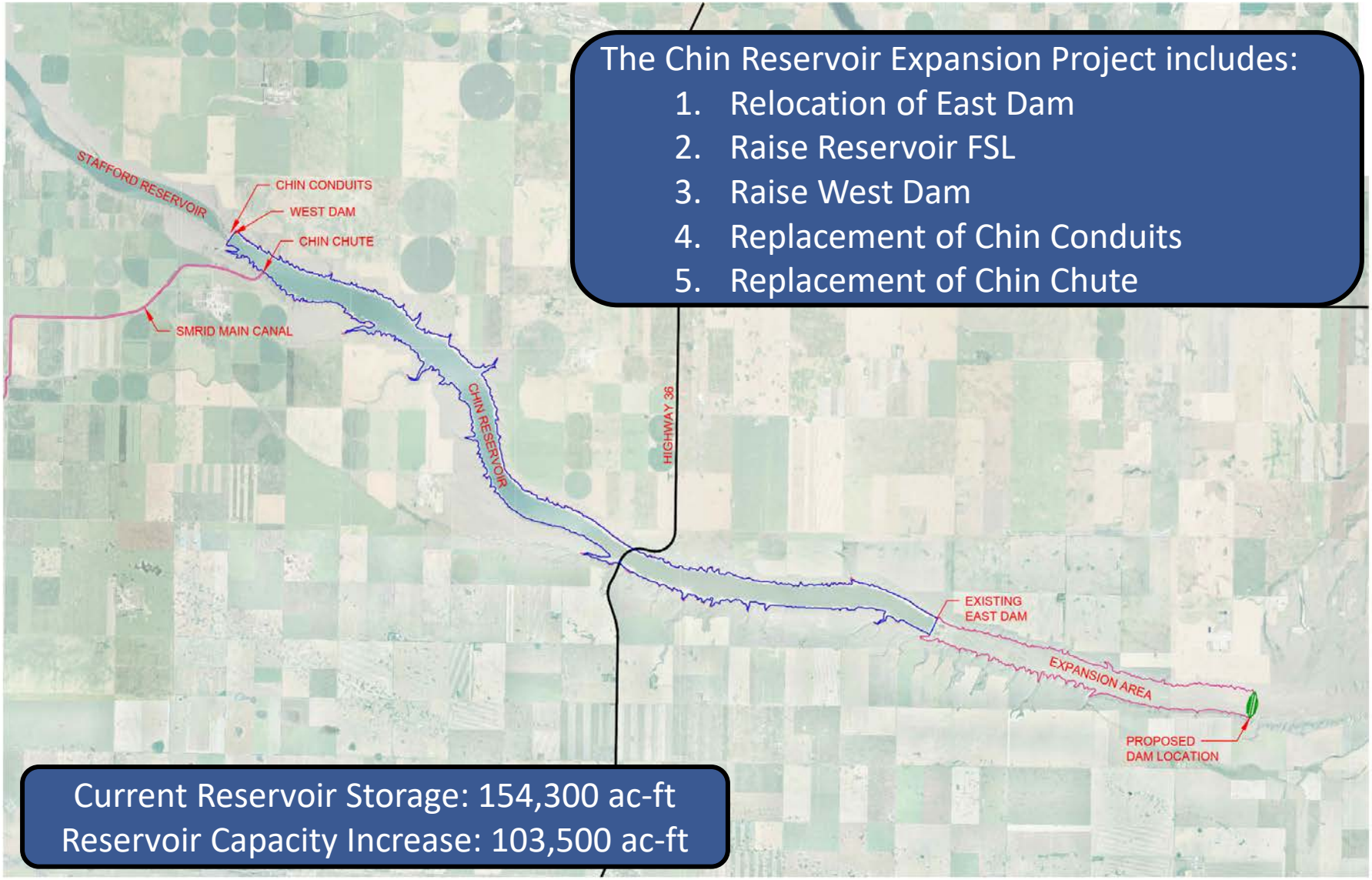
CHIN RESERVOIR EXPANSION

Agenda

- Introductions
- Project Overview
- Proposed Chin East Dam
- Chin West Dam
- Environmental and Regulatory
- Project Schedule
- Upcoming Work Planned

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Project Overview



The Chin Reservoir Expansion Project includes:

1. Relocation of East Dam
2. Raise Reservoir FSL
3. Raise West Dam
4. Replacement of Chin Conduits
5. Replacement of Chin Chute

Current Reservoir Storage: 154,300 ac-ft
Reservoir Capacity Increase: 103,500 ac-ft

New East Dam

- The New East Dam is located approximately 10 km (6.2 miles) southeast of the existing East Dam.
- Enlarged Reservoir with New East Dam and increased reservoir level (approximately 2.6 m higher than current) results in a 80% increase in total water storage volume.
- The maximum height of the New East Dam will be approximately 40 m (131 ft, 13 stories).
- The top of the dam is approximately 36 m (118 ft) below the top of Chin Coulee.
- Field work completed to date included geophysics to assess depth to bedrock and a drilling investigation to assess foundation materials. Finalizing preliminary design (est. Oct 2022).



SMRID ST. MARY RIVER IRRIGATION DISTRICT
MPE Engineering Ltd.
Klohn Crippen Berger

West Dam

West Dam

- Raise West Dam
- Upgrade seepage collection and monitoring system

Chin Conduits

- Replacement of the existing Chin Outlet Conduits which was constructed in 1951
- Capacity will remain the same as the existing structure

Chin Chute

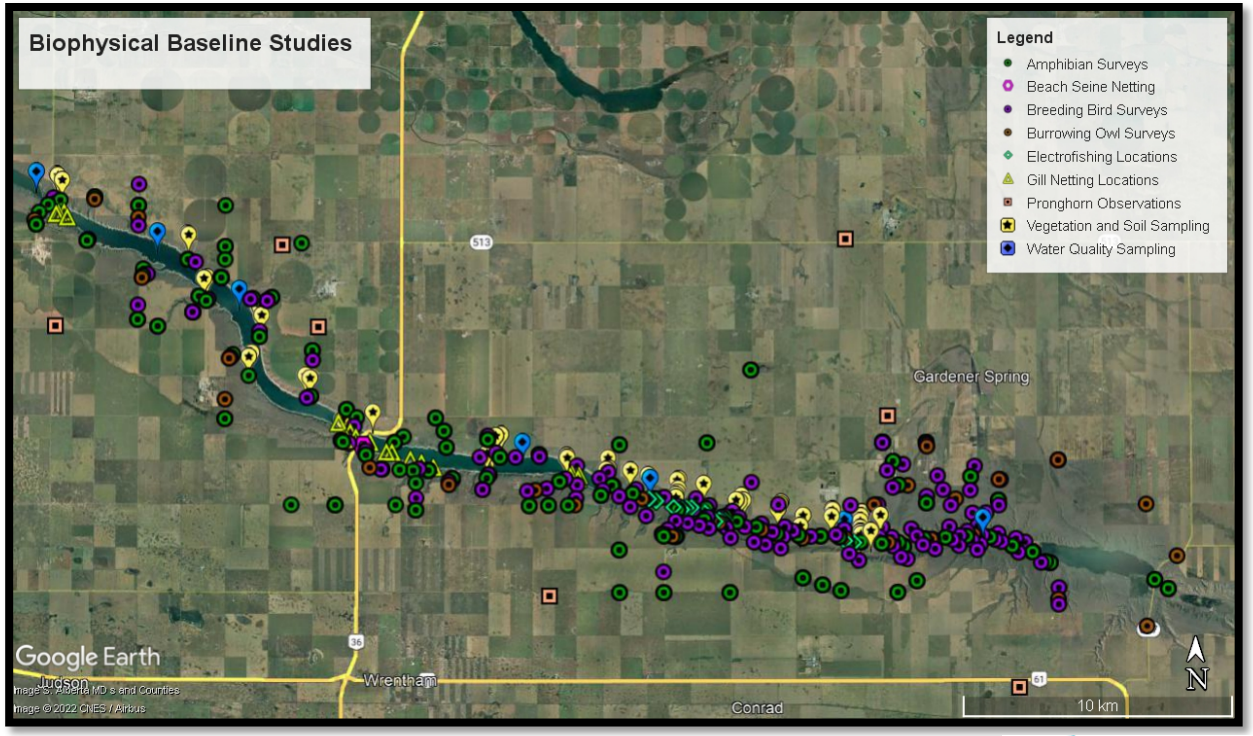
- Replacement of the existing Chin Chute was were constructed in 1954
- Increase capacity to handle maximum possible flow of the SMRID Main Canal



SMRID ST. MARY RIVER IRRIGATION DISTRICT
MPE Engineering Ltd.
Klohn Crippen Berger

Regulatory and Permitting

In preparation of obtaining government approvals for the expansion project, the collection of environmental and historical resource data began in 2021. The expected environmental sensitivities include soil conservation, rare plants, wetlands, wildlife species at risk, fish and fish habitat, surface water, groundwater, and historical resources.



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Regulatory and Permitting

- In February 2022, the SMRID was notified by Alberta Environment that the Project will require an Environmental Impact Assessment (EIA).
- The Terms of Reference (TOR) for the EIA is to be submitted by the end of the month. The EIA is to be completed by the end of January 2023.
- The EIA is to evaluate the potential effects of the Project on identified sensitive environmental elements.
- The goal of the assessment is to recognize the potential effects and develop mitigation strategies to reduce or remove those potential environmental effects.



- The demonstration of an understanding of the potential effects and then mitigating them through design, operation, and or conservation is the ideal pathway towards obtaining government approvals and public support / acceptance.

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Regulatory and Permitting



Terms of Reference Drafted

Terms of Reference Reviewed

Terms of Reference Finalized

EIA Required

EIA Initiated

EIA Submitted for Review

Supplemental Information Requests and Completion of EIA

Obtain Approval with Conditions

Preliminary Design Ongoing

Preliminary Design Completed

Final Design Initiated

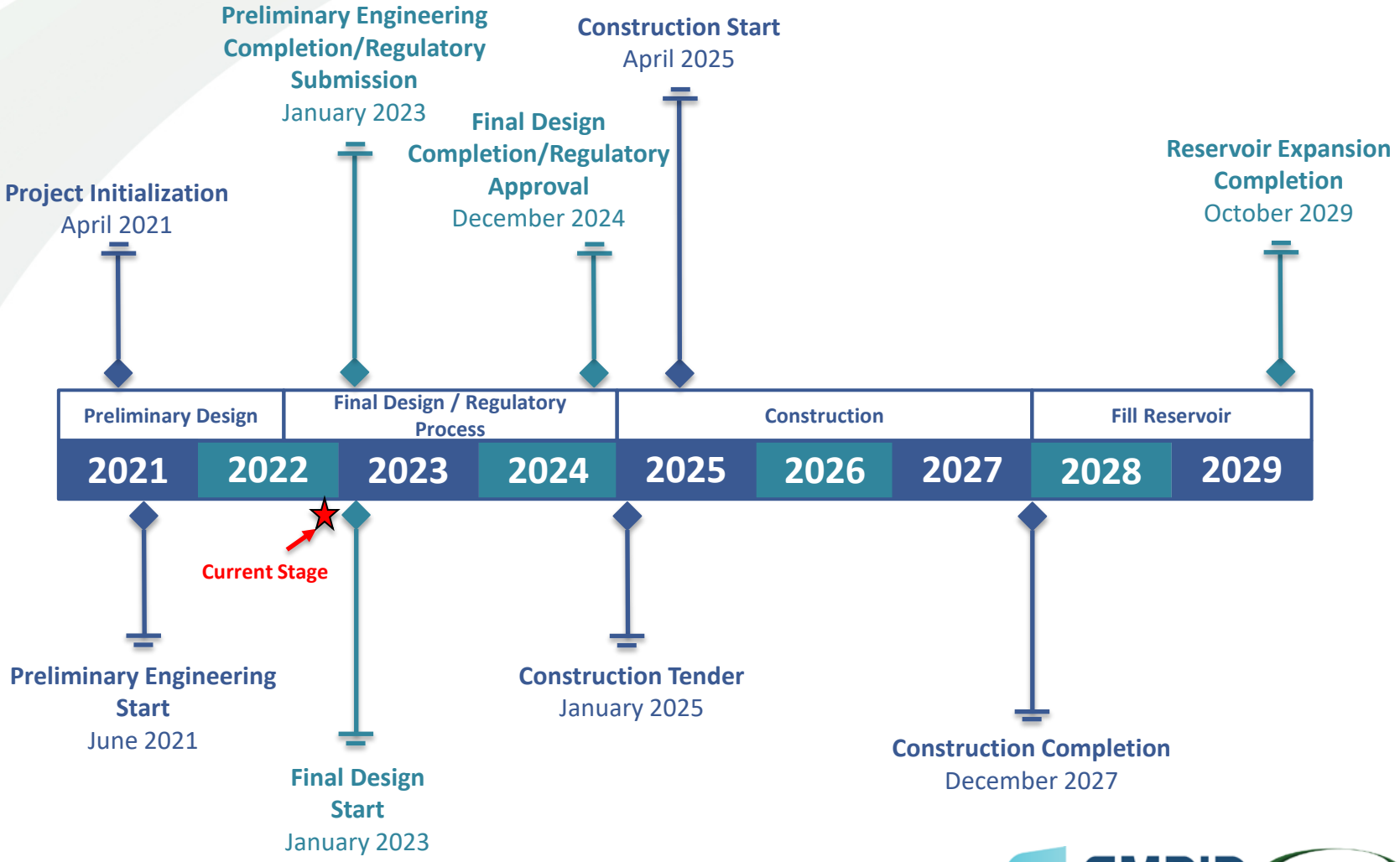
Final Design Completed

SMRID ST. MARY RIVER IRRIGATION DISTRICT

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Project Schedule



SMRID ST. MARY RIVER IRRIGATION DISTRICT
MPE Engineering Ltd.
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Upcoming Work Planned

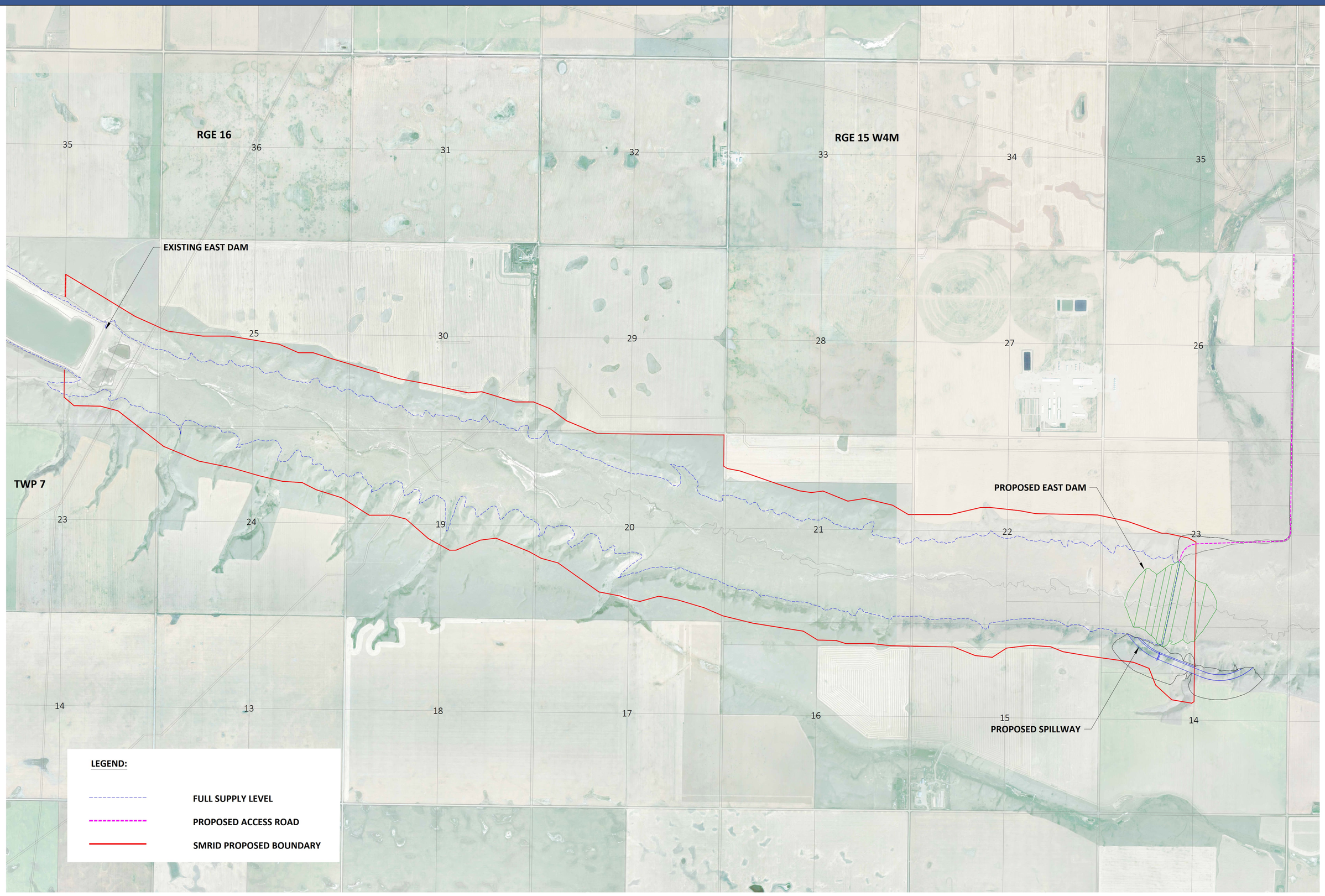
- EIA TOR to be submitted in January
- East Dam Preliminary Design to be complete by December
- West Dam Preliminary Design to be complete by December
- Chin Outlet Preliminary Design to be complete by December
- Chin Chute Preliminary Design to be complete by December

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Engineering Ltd.
Klohn Crippen Berger

APPENDIX 49.3

Supplemental Chin Reservoir Expansion Area Poster (2022)

Chin Reservoir Expansion



APPENDIX 49.4

SMRID AIM Program (Modernization Projects and Proposed Chin Expansion) Slide Deck Presented at the November 2022 Open Houses



SMRID PROPOSED EXPANSION

SMRID

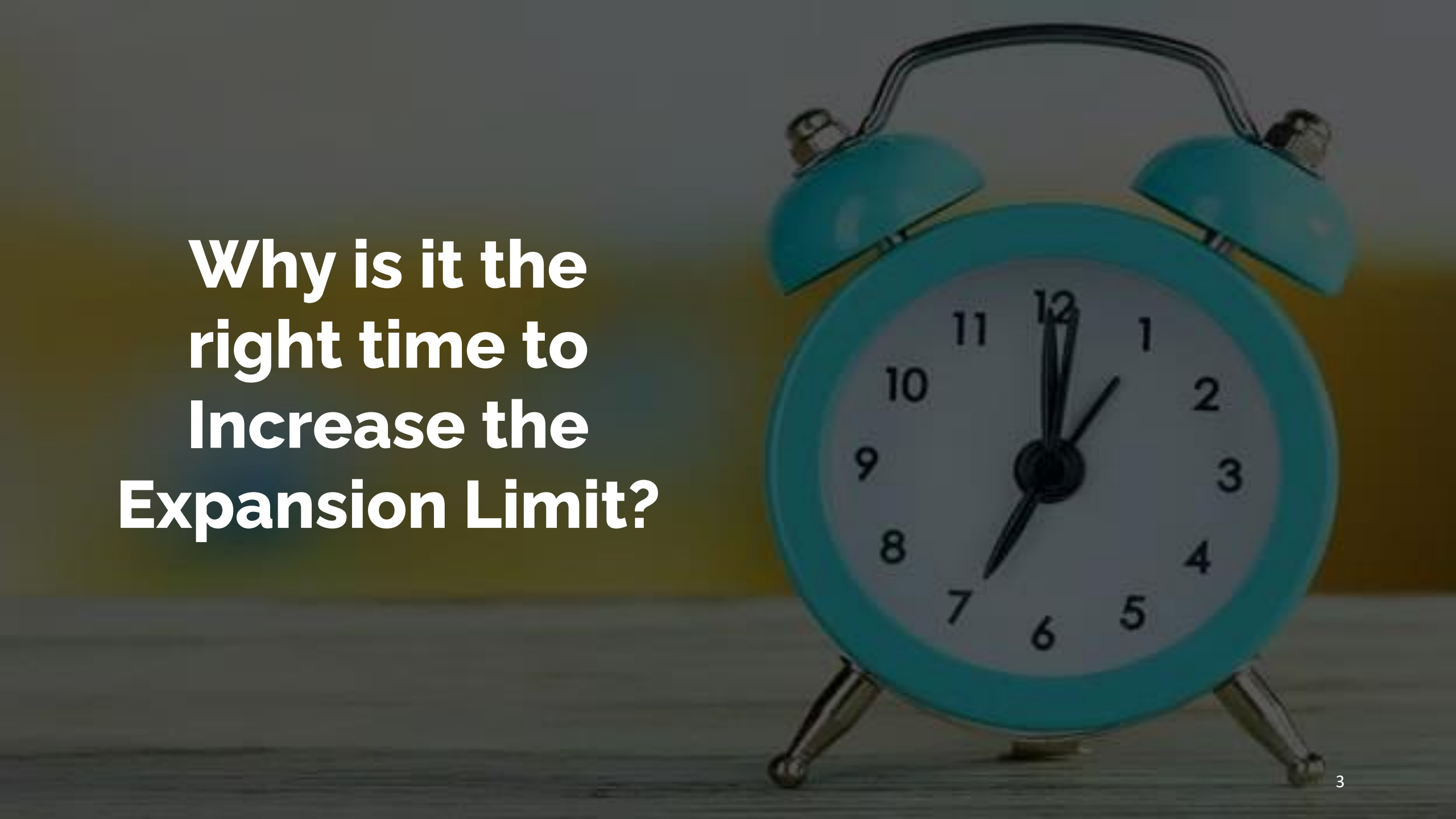
ST. MARY RIVER IRRIGATION DISTRICT

The Proposal



To Increase the Expansion Limit from ***504,200*** acres to ***584,200 acres***

Why is it the right time to Increase the Expansion Limit?



Rationale for Expansion

1. **Chin Reservoir Expansion**
   - ✓ Increase district storage capacity to help capture storm events and provide flood mitigation
   - ✓ Irrigation of new acres around Chin Reservoir
   - ✓ Provide water security for existing Acres

2. **Efficiency Gains**
   - ✓ Pipeline rehabilitation has created water saving efficiencies resulting from the elimination of seepage and evaporation losses from open canals and reduction in the volume of return flows that leave the SMRID system

Rationale for Expansion

3. **Revenue Generated from Capital Asset Charges (CAC)**
   - ✓ Capital Asset Charge revenue will pay for SMRID cost share of the AIM Program and provide funds for future rehabilitation projects

4. **Rate Stabilization**
   - ✓ Expanded acre base will spread fix costs over more acres to allow for water rate stabilization

5. **Increase Hydro Power Generation for Irrican**
   - ✓ Increased water flow rates through the Irrican plants will lead to more power production

Rationale for Expansion

6. **Retention of Licenses Allocations**
   - ✓ Efficient use of our licensed allocations

7. **Attract Value - Added Industry**
   - ✓ Economic Development will continue if we can attract additional food processing facilities to Canada's Premiere Agri-Food Corridor.

8. **Additional Recreation**
   - ✓ Chin Reservoir expansion will provide for additional recreation opportunities

Rationale for Expansion

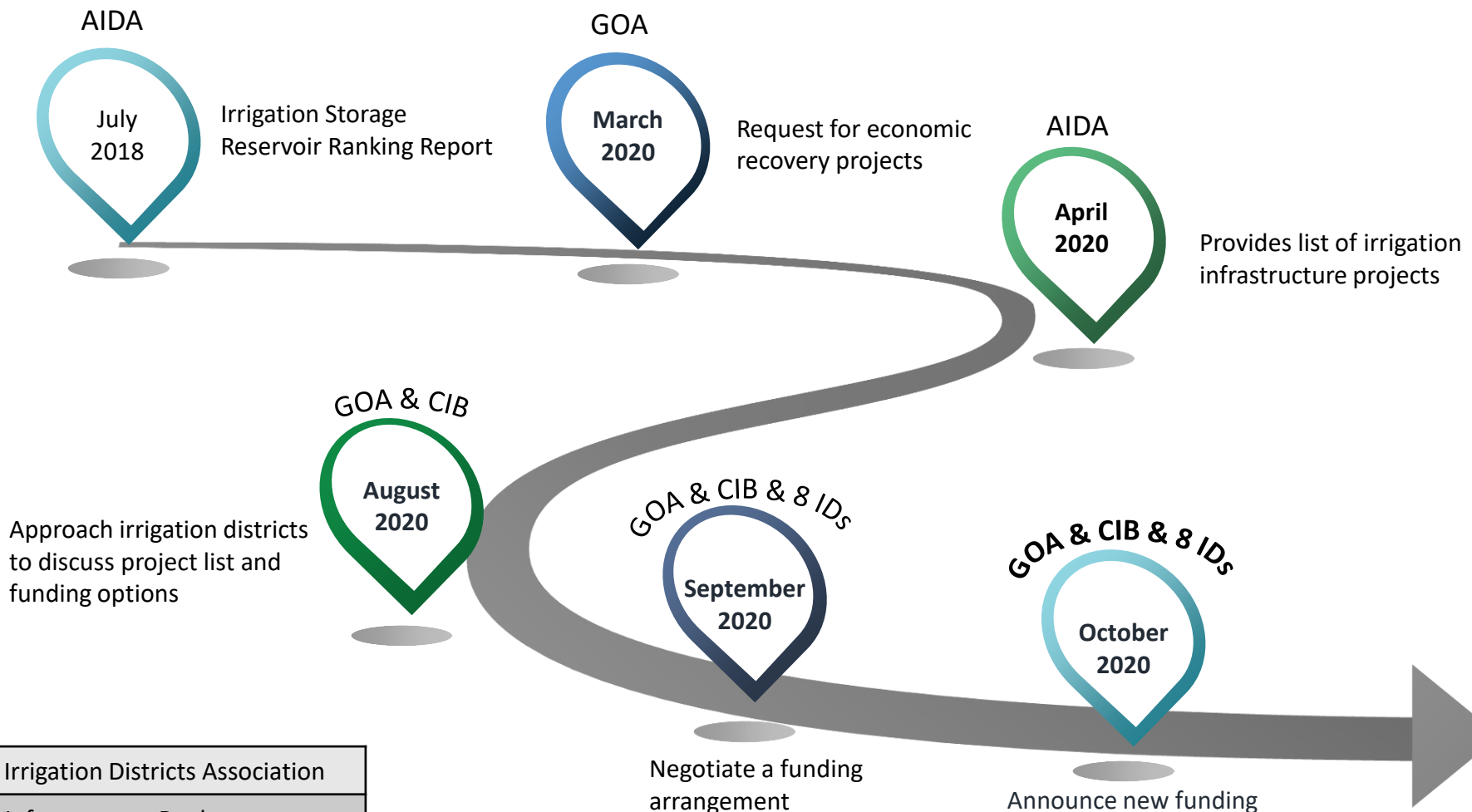
9. Job Opportunities

- ✓ Irrigation agriculture provides employment opportunities
- ✓ Every $1.00 invested by the Government of Alberta to irrigation districts returns $3.56 in revenue to the province (Economic Value of Alberta's Irrigation Districts –ACERA Consulting, June 2021)

AIM Program Background



Program Timeline



AIDA	Alberta Irrigation Districts Association
CIB	Canada Infrastructure Bank
GOA	Government of Alberta
IDs	Irrigation Districts

AIM Program

- In October 2020 and November 2021, the Government of Alberta announced the $933 Million Alberta Irrigation Modernization (AIM) program to invest in irrigation infrastructure.

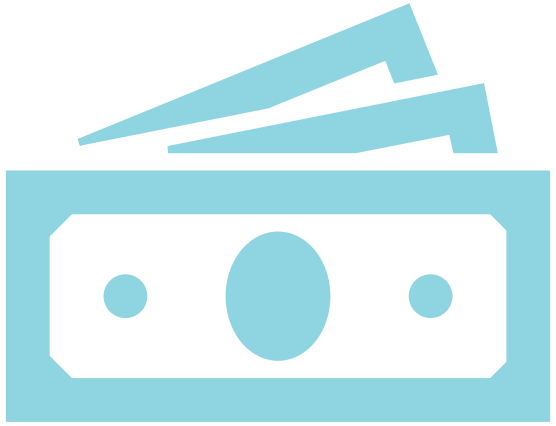
- The desired outcome of the AIM program is to stimulate the Alberta economy and increase irrigation in Alberta.

Program Funding Details

Participant / Role	Portion	Type
Irrigation Districts (developers/owners/funders)	20% + 50%	Initial payment + loan repayment
Government of Alberta (funder)	30%	Grant
Canada Infrastructure Bank (lender)	50%	Interest bearing loan to districts

$933 million investment for 10 participating Irrigation Districts

- 70% of costs covered by irrigation districts
- Districts pay 20% up front, with 50% as an interest-bearing loan from the CIB
- 30% of costs are a grant from GoA
- Any cost overruns are covered 100% by irrigation districts



SMRID Portion of the AIM Program

SMRID has 30 Modernization projects

$206 Million

Chin Reservoir Expansion

$120 Million

AIM Program Commitment

$326 Million

SMRID Modernization Projects

30 Modernization Projects

- Replacement of canals with buried water pipelines (29 projects)
- Modernization/ replacement of major water control structure (Sauder Chute)

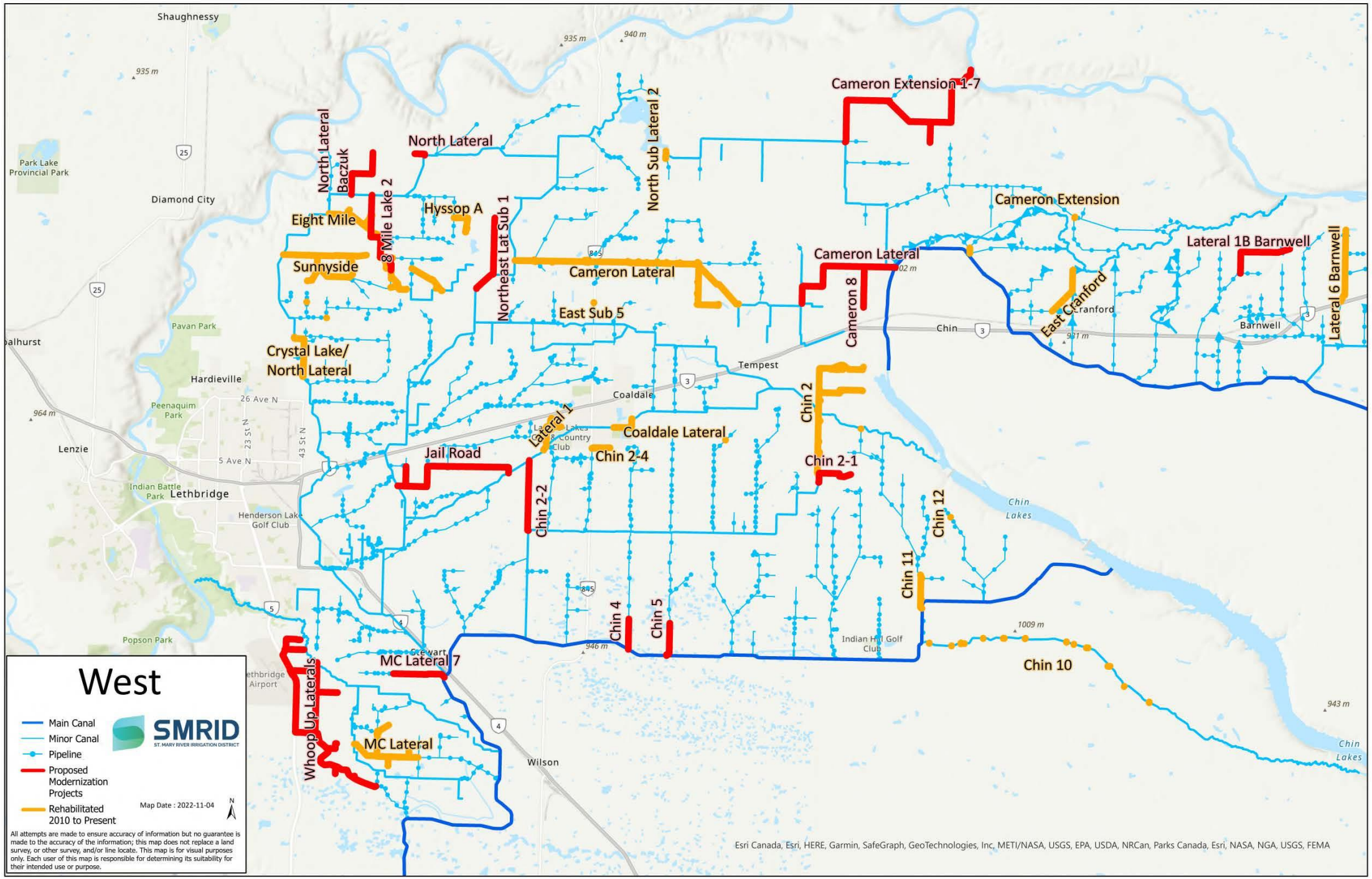


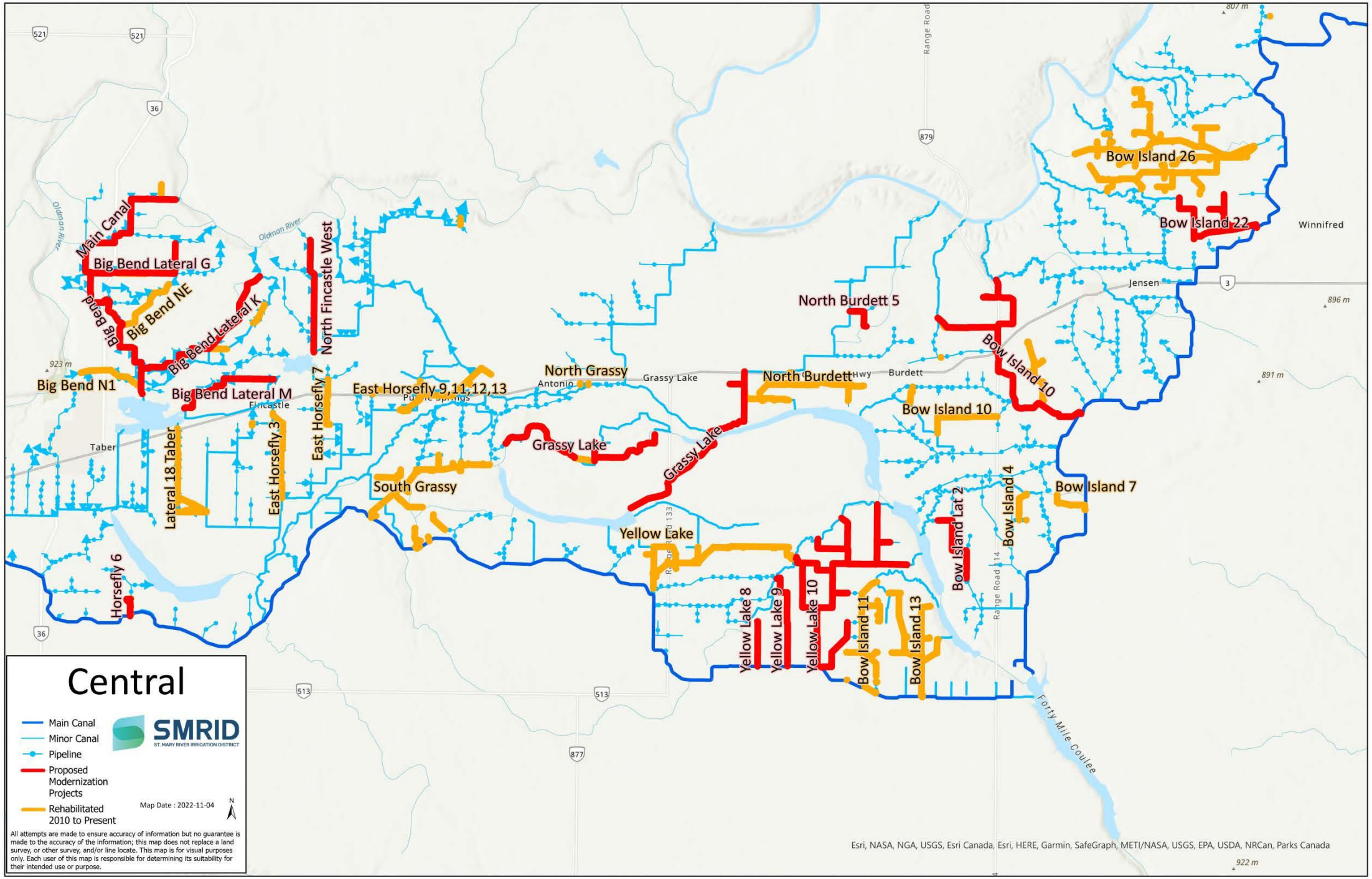


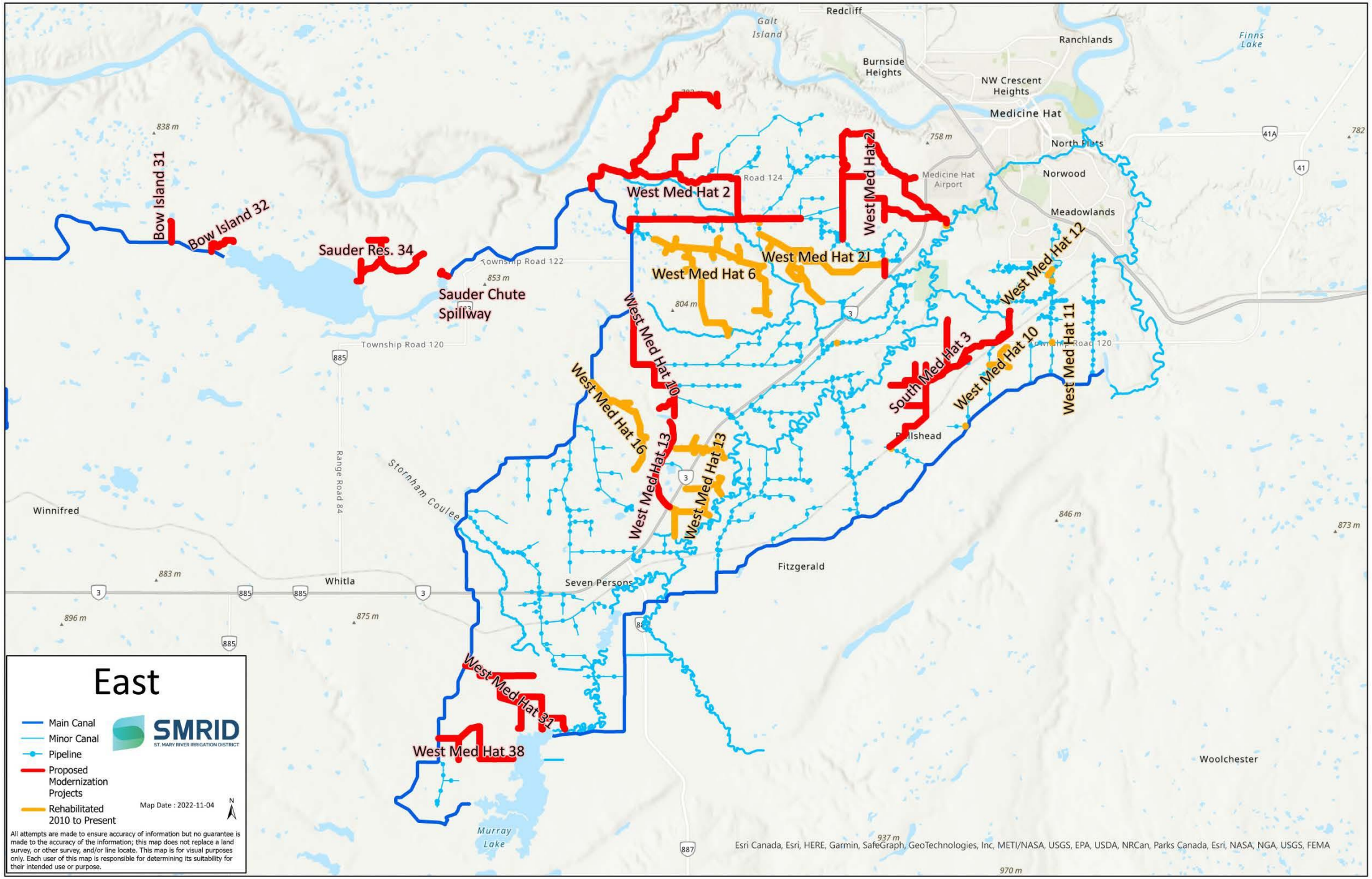
Benefits

- Water savings
  - Reduction of evaporation and seepage
  - Reduction of spill
  - On-farm application improvements
  - Climate change adaptation

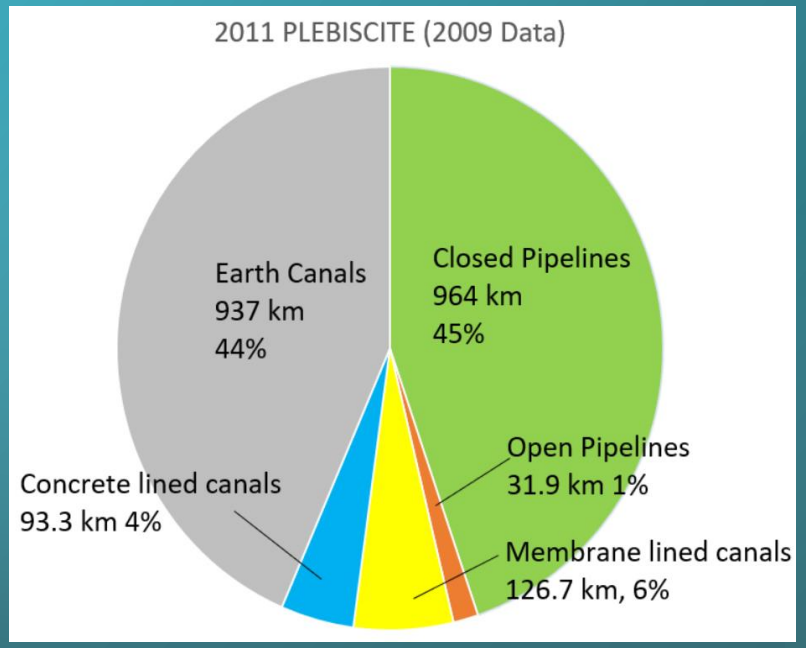


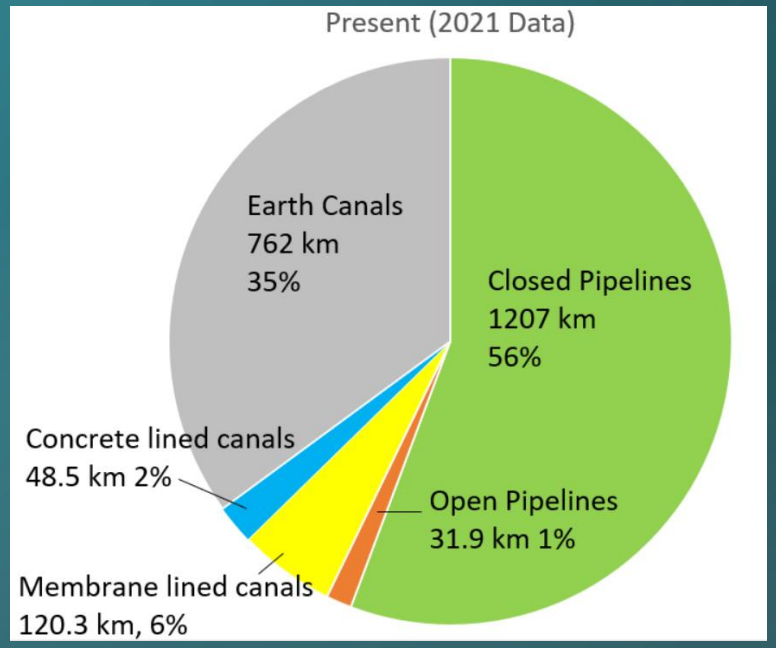

Shaughnessy
Park Lake Provincial Park
Diamond City
Pavan Park
Hardieville
Peenaquim Park
Lenzie
Indian Battle Park
Lethbridge
Henderson Lake Golf Club
Popson Park
Stewart
Wilson
Tempest
Coaldale
Chin
Chin Lakes
Cranford
Barnwell
Indian Hill Golf Club
North Lateral
North Lateral Baczuk
8 Mile Lake 2
Eight Mile
Sunnyside
Hyssop A
Northeast Lat Sub 1
North Sub Lateral 2
Cameron Extension 1-7
Cameron Extension
Cameron Lateral
Cameron 8
East Cranford
Lateral 1B Barnwell
Lateral 6 Barnwell
East Sub 5
Crystal Lake/ North Lateral
Lateral 1
Coaldale Lateral
Jail Road
Chin 2-4
Chin 2
Chin 2-1
Chin 2-2
Chin 12
Chin 11
Chin 4
Chin 5
Chin 10
MC Lateral 7
MC Lateral
Whoop Up Laterals
26 Ave N
5 Ave N
23 St N
43 St N
Lethbridge Airport
Lakes & Country Club
935 m
940 m
964 m
845
946 m
1009 m
943 m
931 m
West
Main Canal
Minor Canal
Pipeline
Proposed Modernization Projects
Rehabilitated 2010 to Present
SMRID
ST. MARY RIVER IRRIGATION DISTRICT
Map Date : 2022-11-04
N
All attempts are made to ensure accuracy of information but no guarantee is made to the accuracy of the information; this map does not replace a land survey, or other survey, and/or line locate. This map is for visual purposes only. Each user of this map is responsible for determining its suitability for their intended use or purpose.
Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, Esri, NASA, NGA, USGS, FEMA

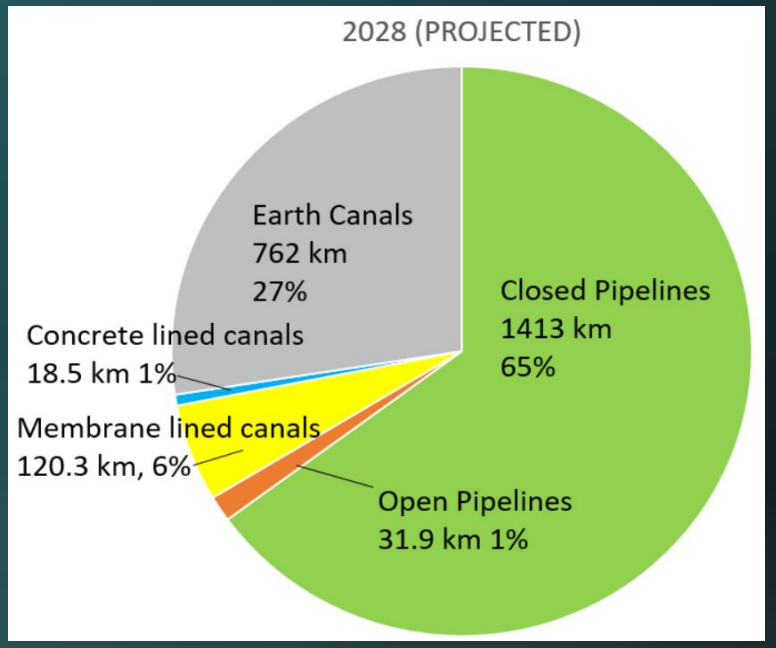

Central
Main Canal
Minor Canal
Pipeline
Proposed Modernization Projects
Rehabilitated 2010 to Present
SMRID
ST. MARY RIVER IRRIGATION DISTRICT
Map Date : 2022-11-04
N
All attempts are made to ensure accuracy of information but no guarantee is made to the accuracy of the information; this map does not replace a land survey, or other survey, and/or line locate. This map is for visual purposes only. Each user of this map is responsible for determining its suitability for their intended use or purpose.
Esri, NASA, NGA, USGS, Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
Main Canal
Big Bend Lateral G
Big Bend NE
Big Bend K
Big Bend Lateral K
Big Bend N1
Big Bend Lateral M
North Fincastle West
East Horsefly 7
East Horsefly 3
East Horsefly 9,11,12,13
Lateral 18 Taber
Horsefly 6
South Grassy
North Grassy
Grassy Lake
Grassy Lake
Yellow Lake
Yellow Lake 8
Yellow Lake 9
Yellow Lake 10
Bow Island 11
Bow Island 13
North Burdett 5
North Burdett
Bow Island 10
Bow Island 10
Bow Island 26
Bow Island 22
Bow Island Lat 2
Bow Island 4
Bow Island 7
Taber
Fincastle
Antonio
Grassy Lake
Burdett
Jensen
Winnifred
Oldman River
Forty Mile Coulee
Range Road
Range Road 133
Range Road 114
807 m
923 m
896 m
891 m
922 m
521
36
879
3
513
877


East
Main Canal
Minor Canal
Pipeline
Proposed Modernization Projects
Rehabilitated 2010 to Present
SMRID
ST. MARY RIVER IRRIGATION DISTRICT
Map Date : 2022-11-04
N
All attempts are made to ensure accuracy of information but no guarantee is made to the accuracy of the information; this map does not replace a land survey, or other survey, and/or line locate. This map is for visual purposes only. Each user of this map is responsible for determining its suitability for their intended use or purpose.
Bow Island 31
Bow Island 32
Sauder Res. 34
Sauder Chute Spillway
West Med Hat 2
West Med Hat 2
West Med Hat 2J
West Med Hat 6
West Med Hat 10
West Med Hat 10
West Med Hat 16
West Med Hat 13
West Med Hat 13
West Med Hat 3
West Med Hat 10
West Med Hat 12
West Med Hat 11
West Med Hat 31
West Med Hat 38
Redcliff
Galt Island
Ranchlands
Burnside Heights
NW Crescent Heights
Medicine Hat
Medicine Hat Airport
North Flats
Norwood
Meadowlands
Finns Lake
Township Road 122
Township Road 120
Township Road 120
Road 124
Range Road 84
Stornham Coulee
Winnifred
Whitla
Seven Persons
Fitzgerald
Bullshead
Woolchester
Murray Lake
838 m
758 m
853 m
804 m
846 m
873 m
883 m
896 m
875 m
937 m
970 m
782
41A
41
3
885
887
Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, Esri, NASA, NGA, USGS, FEMA

Efficiency Gains from Infrastructure Rehabilitation







- Eliminating > 425 km of canals through investment in buried PVC pipelines over 2011 – 2028
- Capital Expenditures of $305 M (inclusive of AIM and IRP)



Efficiency Gains

Efficiency Gains (2011-2021)

- On-farm Efficiencies: 16,292 ac-ft
- Infrastructure Improvements (IRP - 2011 to present): 9,201 ac-ft
- TOTAL = 25,493 ac-ft

Modernization Projects

- Estimated savings from AIM Program (2021 -2028): 29,057 ac-ft

  (This is inclusive of tailout, evaporation and seepage)

Total Savings From Efficiency Gains

ON-FARM EFFICIENCIES
16,292 ac-ft

2011-PRESENT INFRASTRUCTURE IMPROVEMENTS
9,201 ac-ft

2021-2028 AIM MODERNIZATION PROGRAM
29,057 ac-ft

TOTAL WATER SAVINGS
54,550 ac-ft

54,550 ac-ft of water savings equates to 40,912 acres.

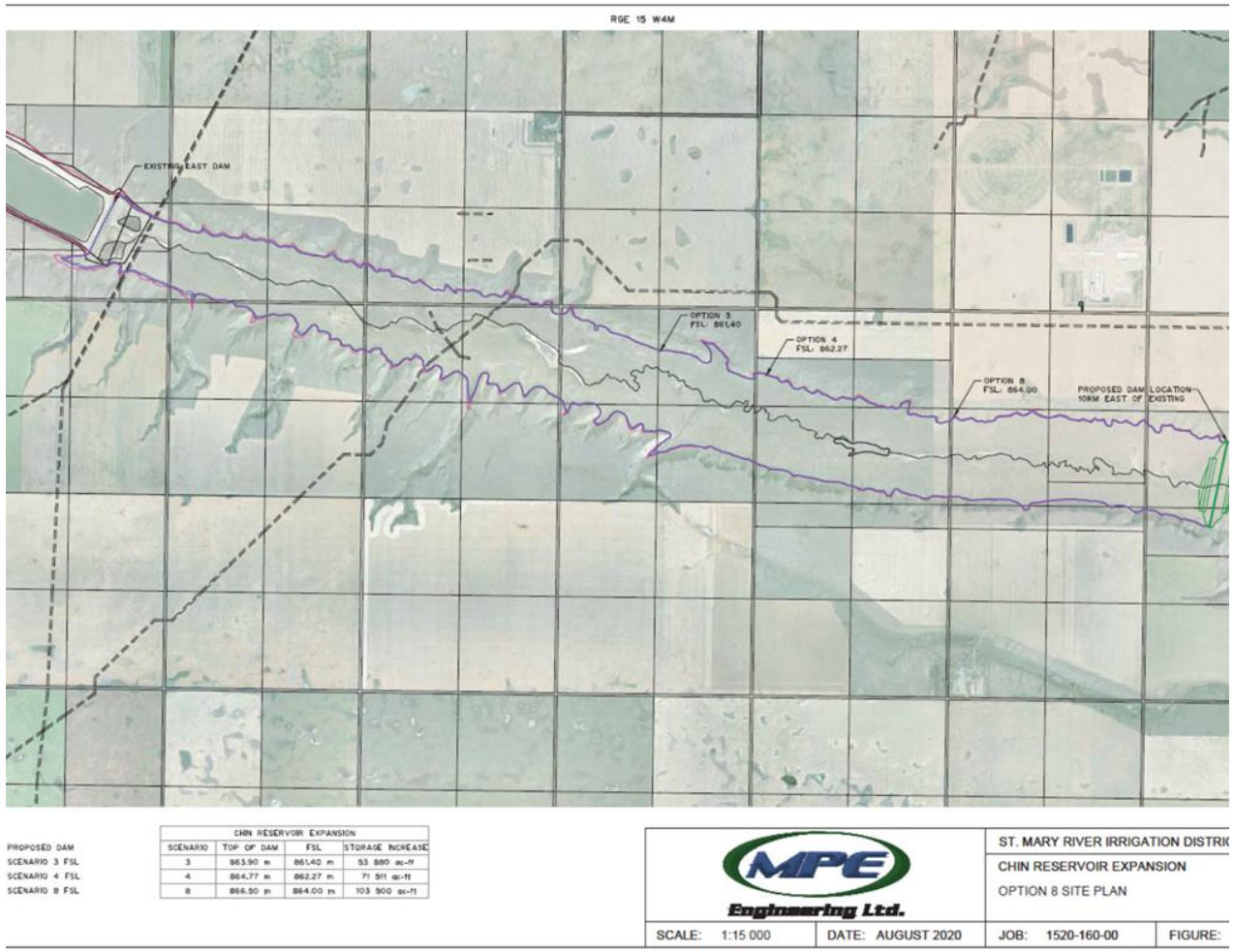
The Proposed expansion from Efficiency Gains is only 40,000 acres. The additional savings can be allocated to increase 'other use' volume

Chin Reservoir Expansion

Chin Reservoir Expansion

- Off stream
- Current land use is agricultural
- Footprint on privately owned lands

Increasing storage helps mitigate increasing variability in the water supply



2022+

Public and indigenous consultations, environmental and historical assessment. Obtain Right of Ways, Water license amendment. Geotechnical data collection

2024+

Finalize regulatory approvals Acquire Right of Way Refurbish West Dam (including conduits and Chin Chute) Start construction of East Dam 2025

2026+

Construction of East Dam To be phased over 3 years to accommodate settlement

2028

Commissioning of East Dam Filling 2028 onwards Filling to FSL when Highway 36 Bridge is re-done

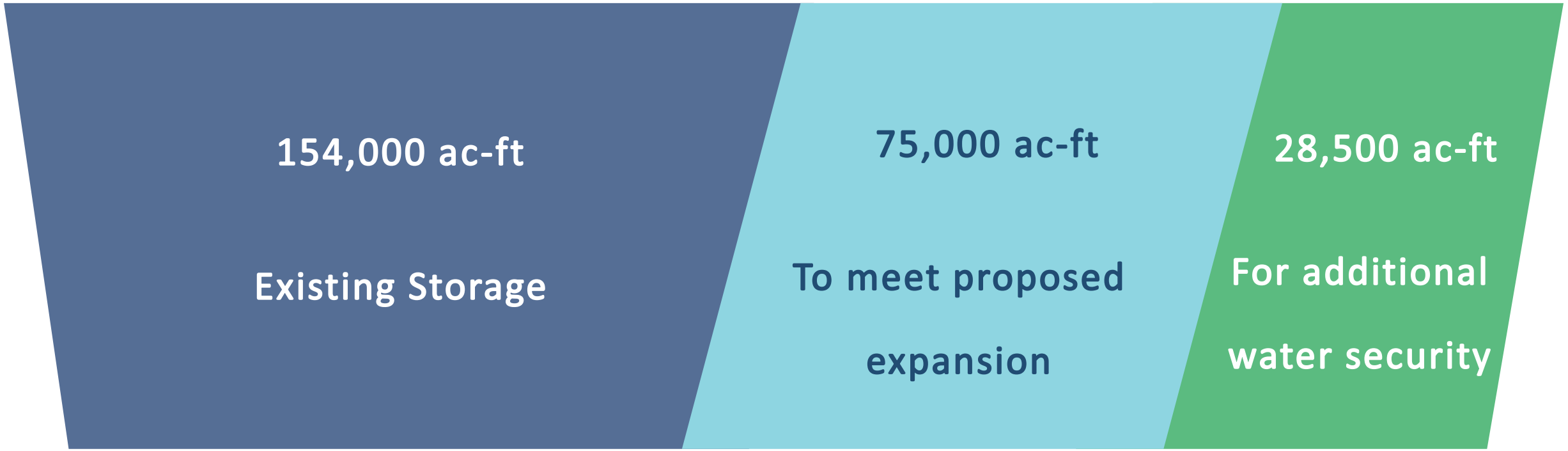
Chin Reservoir Expansion

Chin Reservoir Expansion

CHIN RESERVOIR

DAM TO BE MOVED 10KM EAST

ADDITIONAL STORAGE 103,500 AC-FT



WaterSmart Modelling

- Multiple simulations were modelled, incorporating scenarios for: Entitlement Flows Historical Flows Naturalized Flows

- 82 years of weather data from 1928 to 2009 modelled against 2016 crop demand and crop mix and on 2020 acreage



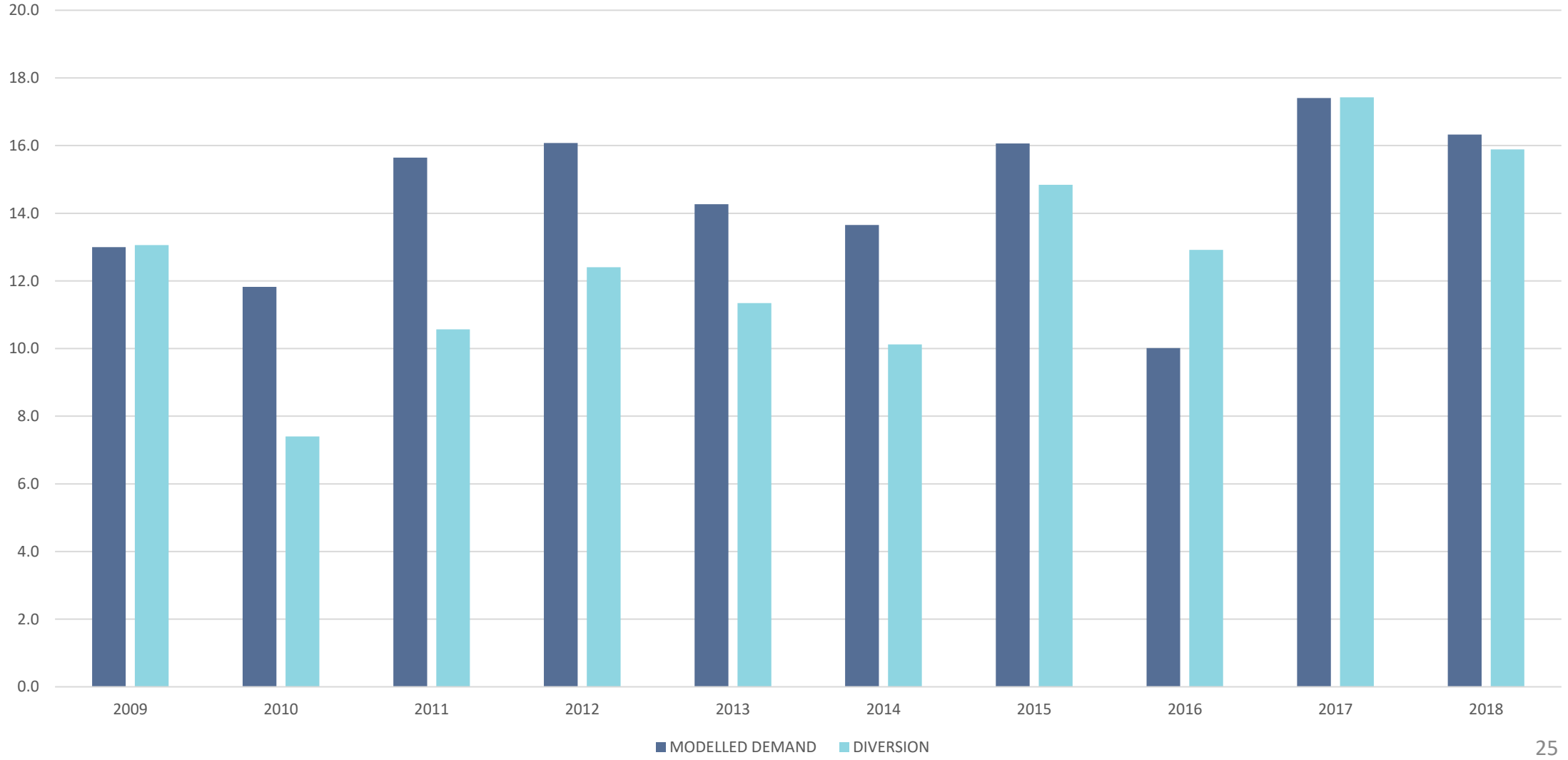
Modelled Deficit Frequency

Modelled Deficit (")	Base Case	75,000 ac-ft Storage Increase 46,500 acre expansion
0 to 2	73	71
2 to 4	8	8
4 to 6	0	2
6 to 8	1	1
TOTAL	82	82

WaterSmart's Modelling concluded 75,000 ac-ft could support an additional 46,500 acres of expansion based on the 82 year modelling period. This would translate into 41,850 acres for SMRID and 4,650 for RID.

Modelled Demand vs Actual Demand (inches)

diverted volume/acres actually irrigated



Expansion Summary

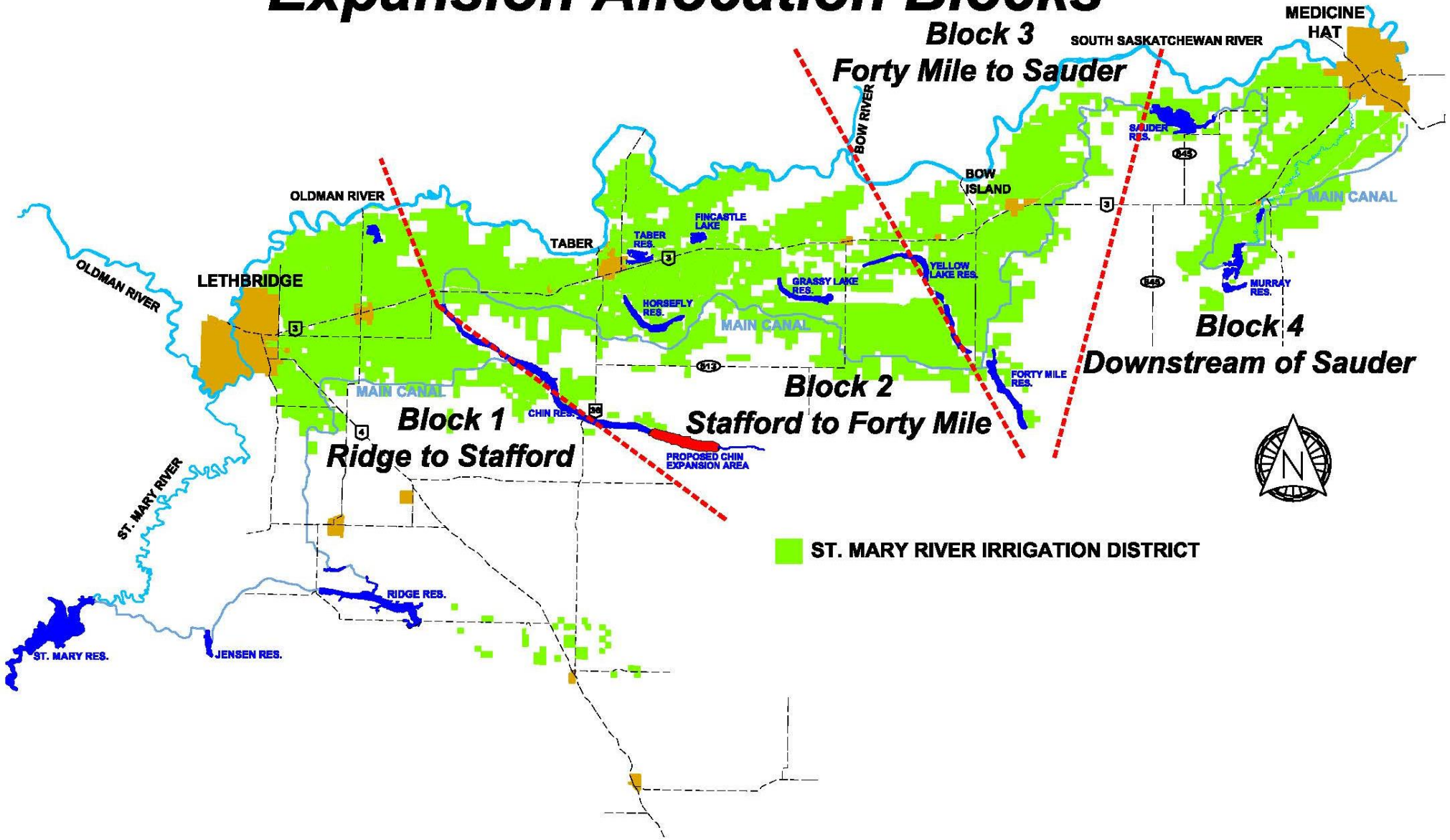
- Total water savings from Modernization = enough to expand by approximately 40,912 acres
- Expansion based on additional storage at Chin: 41,850 acres
- We are being conservative and planning on expanding by only 80,000 acres
- Plebiscite is to expand 80,000 acres. This is inclusive of water savings from modernization projects and the additional storage that will be made available at Chin Reservoir.
- Some water is being reserved for additional 'Other Water Use' (2,762 acres or 3,625 ac-ft) and for increased water security.

How to Acquire Acres

In the Proposed Expansion the District would be divided into four development areas or blocks. These are similar to our last expansion as they incorporate how we operate the District



Expansion Allocation Blocks



How to Acquire Acres

The distribution of expansion acres will be accomplished in Phases by a lottery system

Each Phase could have more than one lottery round, depending on demand

If you are interested in trying to acquire acres in Phase 1, there will be only one 30 day application window.

There will not be another opportunity to apply for acres until Phase 2 is announced sometime in the future

Phase 1

The primary goal of Phase 1 is to allow our existing irrigators (and potential future irrigators) to maximize the irrigation of their farms

The first lottery round in Phase 1 would be limited to **15,000 acres**

The applications for the first lottery round in Phase 1 will be limited to up to 150 acres **per registered landowner**

All **current and future irrigators** could apply in Phase 1 and lottery rounds would be run until all eligible requests are satisfied subject to District's ability to provide adequate capacity

How to Acquire Acres

Once the lottery application window is closed, successful applicants will have 30 days to place a 10 % down payment of the Capital Asset Charge

Successful applicants will the have one year from the date of the lottery to:

- provide an acceptable irrigable land classification for irrigation
- provide proof of any easements required for their project and
- pay the remaining balance of the Capital Asset Charge

If all of these requirements are not met, these acres will be returned to the pool of available acres

Plebiscite Vote

Date: November 28, 2022

Time: 10:00 am – 8:00 pm

Locations: Lethbridge, Taber and Bow Island District Offices

APPENDIX 49.5

SMRID Proposed Irrigation Expansion Information Sheet and Invitation to November 2022 Open Houses and Plebiscite Vote

RATIONALE FOR EXPANSION

1. **CHIN RESERVOIR EXPANSION**
   Expansion of the Chin Reservoir will supply water for new acres and provide water security for existing acres.

2. **EFFICIENCY GAINS**
   Efficiency gains provided by replacing open canals with closed pipelines will allow our existing water flows to irrigate more acres.

3. **REVENUE GENERATED**
   Revenue generated from Capital Asset Charges will pay for SMRID cost share of the AIM projects as well as provide revenue for future rehabilitation and enhancements to infrastructure.

4. **RATE STABILIZATION**
   Expanded acre base will spread fixed costs over more acres to allow for water rate stabilization.

5. **INCREASE HYDRO POWER GENERATION**
   Increased water flow through Irrican Power plants would maximize generation revenue and further stabilize water rates.

6. **RETENTION OF LICENSED ALLOCATIONS**
   Expansion will maintain the efficient use of our licensed water allocations to mitigate the risk of potential regulatory reductions through a possible “Use it or lose it” initiative.

7. **ATTRACT VALUE-ADDED INDUSTRY**
   Attraction of new value-added processing will help support production of specialty crops.

8. **ADDITIONAL RECREATION SITES**
   The Chin expansion will provide opportunities for additional recreation sites

9. **JOB OPPORTUNITIES**
   Irrigation expansion within our communities will provide jobs and opportunities to support continued growth and prosperity.

PUBLIC INFORMATION MEETINGS

The Board of Directors is holding public information meetings for all irrigators prior to the plebiscite vote.

NOVEMBER 22, 2022
TABER HERITAGE HALL
1:30 P.M.

NOVEMBER 23, 2022
BOW ISLAND LEGION HALL
1:30 P.M.

NOVEMBER 24, 2022
SEVEN PERSONS COMMUNITY HALL
1:30 P.M.

NOVEMBER 25, 2022
READYMADE COMMUNITY HALL
1:30 P.M.

THE PLEBISCITE VOTE WILL BE HELD AT POLL STATIONS ON:
NOVEMBER 28, 2022
BETWEEN
10:00 A.M. TO 8:00 P.M.
AT
LETHBRIDGE
TABER
BOW ISLAND
DISTRICT OFFICES

Phone
403-328-4401 - West
403-223-2148 - Central
403-545-6866 - East

Office
525 40 St. S, Lethbridge
4420 44th St., Taber
702 Centre St., Bow Island



SMRID

PROPOSED IRRIGATION EXPANSION

smrid.com

GENERAL INFORMATION

In 2020/2021, the Government of Alberta announced the $933M Alberta Irrigation Modernization (AIM) program to invest in irrigation infrastructure with the purpose to increase irrigation and stimulate the economy in Alberta.

The two areas of focus for the program are to modernize infrastructure and expand off-stream water storage.

MODERNIZATION

The amalgamated SMRID was approved for 30 modernization projects, primarily converting open canals with underground pipelines. The projects increase water use efficiency.

STORAGE

The amalgamated SMRID along with our main canal partner, Raymond Irrigation District (RID), were also approved to expand the Chin Reservoir. This expansion will increase Chin Reservoir by roughly 50%. This helps provide water security and the abiliy to expand irrigation acres in the distirct.

MODERNIZATION GAINS & STORAGE EXPANSION

EFFICIENCY GAINS

Since 2011 approximately 226 km of canals have been replaced through the Irrigation Rehabilitation Program (IRP) and an additional 198 km of canals have been committed to be replaced through the AIM program for a total of 424 km of open canals replaced with buried PVC pipelines.

In addition to the modernization of canals, there has been significant advancements in on-farm irrigation efficiencies since the last expansion 11 years ago.

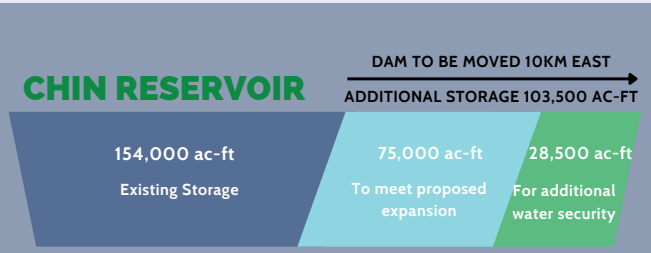
With these improvements, it is estimated that the amalgamated SMRID will be saving 54,500 ac-ft of water per year, enough to serve an expansion of 40,912 acres. Continued rehabilitation and on-farm efficiencies will further improve water security.

Category	Estimated Water Savings
Infrastructure Improvements (2011-present)	9,201 ac-ft
On-Farm Improvements (2011-present)	16,292 ac-ft
Alberta Irrigation Modernization Program Projects (2020+)	29,057 ac-ft
TOTAL	54,500 ac-ft

40,000 acres derived from efficiency gains will be put towards expanding additional acres.

CHIN RESERVOIR EXPANSION

With the help from WaterSmart Solutions Ltd. (WaterSmart), SMRID is proposing to enlarge Chin Reservoir which will result in an additional 103,500 ac-ft of water storage.



Based on WaterSmart's modelling, 75,000 ac-ft could support an additional 46,500 acres of expansion based on a 82 year modelling period. SMRID and RID would share the additional acres 41,850 (90%) and 4,650 (10%), respectively

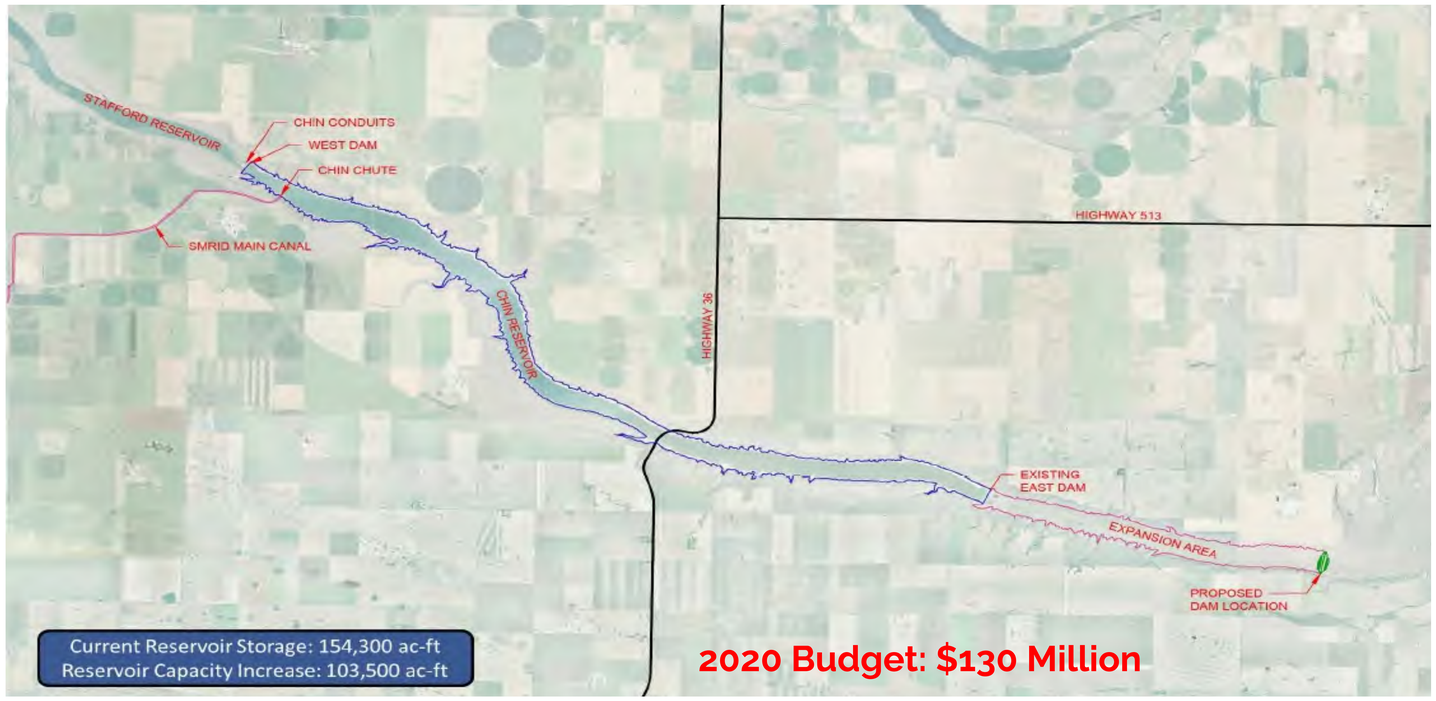
40,000 acres derived from expanding Chin Reservoir will be put towards expanding additional acres.

In total Efficiency gains from modernization projects plus additional storage from an expanded Chin reservoir will allow for 80,000 additional acres within the SMRID.

APPENDIX 49.6

Chin Expansion Projects Information Poster (2024)

Chin Expansion Projects:



Chin West Dam Project:





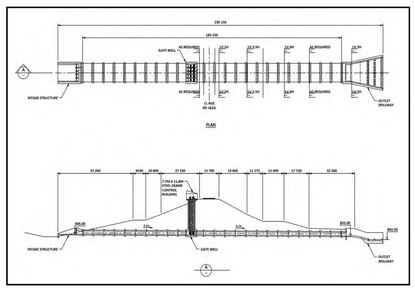


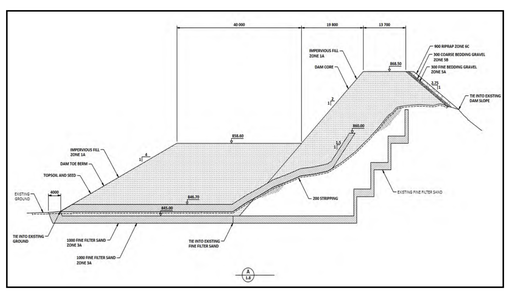




Conduits constructed in 1953 are in "Poor" Condition







Project Description:

- Raise existing West Dam by 5 m, & improve seepage collection system to accommodate new reservoir elevation.
- Replace Irrigation Outlet Structure to modern design. Flow capacity will stay the same
- Abandon in place existing conduits
- Up to 3 year construction period

Status:

- Water Act (Dam Safety) regulatory review underway
- Additional Geotechnical Investigation underway to confirm design parameters
- In detailed design

Schedule:

- Q2 2025: Contractor Request for Qualifications
- Q4 2025: Begin Construction
- Q4 2027: Construction Completion

Chin Chute Replacement Project



September 2023



July 2024



September 2024

Description of Project:

- Replacement of 1951 PFRA Chute Spillway with modern Chute Spillway
- Flood Capacity increased from 65 m^3/s to 115 m^3/s

Status:

- Under construction

Schedule:

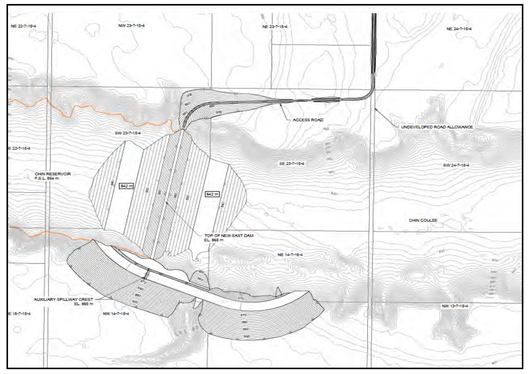
- Scheduled to be completed March 2025

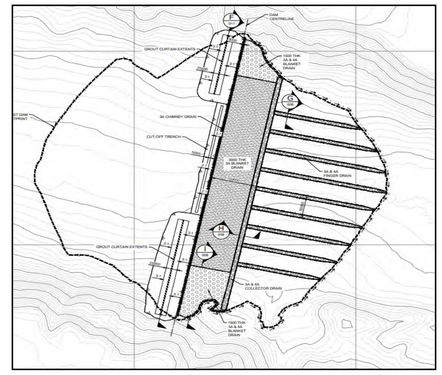
Funded by IRP funding streams pooled between SMRID and RID.

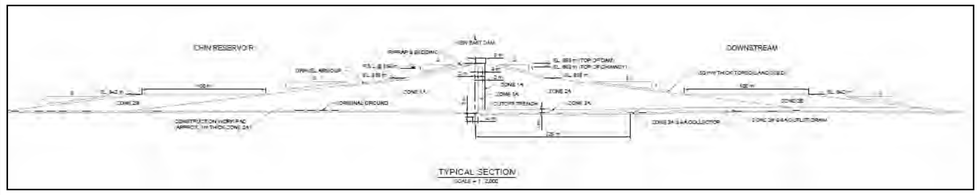
Valuation: $24 Million

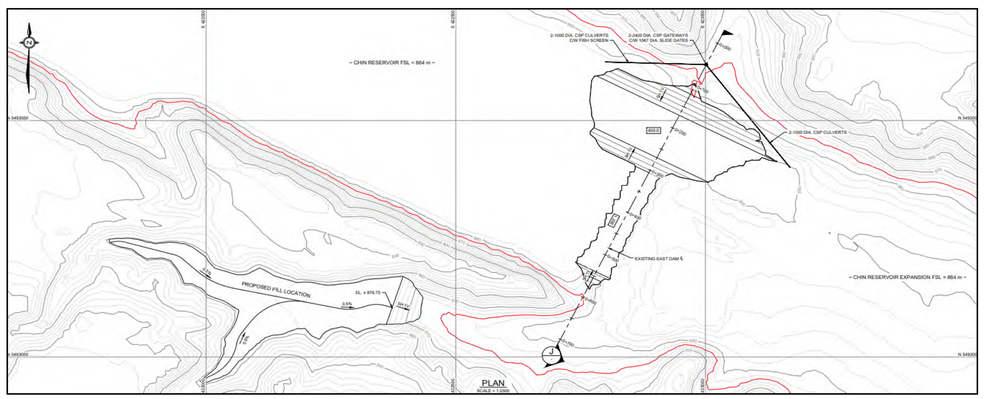
Chin East Expansion:











Decommissioning Plan for Existing Chin East Dam:

Description of Project:

- New dam to be constructed 10 km east of the existing Chin East Dam
- New dam 41 m tall by 750 m wide
- Auxiliary Spillway 50 m wide by 1,120 m long with a max capacity of 139 m^3/s. Operating during events above the 1:1000 year event
- Embankment will consist of ~5.6 Million m^3 of fill, and ~400,000 m^3 of various aggregate
- The flooded area (1,850 ac.) and 2.6 m FSL raise will add 103,000 ac-ft of live storage to Chin Reservoir

Status:

- Environmental Impact Assessment Report submitted in July 2024
- Concurrent filing with AEPA and NRCB
- Review Period ~2 years
- Investigative drilling completed in 2024 and detailed design underway

Schedule:

- Regulatory Approval: July 2026
- Request for Contractor Qualifications: Q3 2026
- Construction start: 2027 over a 3 year construction period
- Reservoir filling, minimum 2 years, difficult to predict.

SMRID ST. MARY RIVER IRRIGATION DISTRICT

MPE Engineering Ltd.

Klohn Crippen Berger

APPENDIX 49.7

October 2022 Invitation and Supporting Figures sent to Mike Oka (Blood Tribe)

Suite 300, 714 5 Avenue South
Lethbridge, AB T1J 0V1
Phone: 403-329-3442
1-866-329-3442
Fax: 403-329-9354

Engineering Ltd.

Mike Oka, Consultation Coordinator
Kainai Nation
PO Box 60
Standoff, Alberta
T0l 1Y0

October 12th, 2022

Dear Mike Oka:

Re: MPE Engineering Ltd. – St. Mary River Irrigation District – Proposed Chin Reservoir Expansion

MPE Engineering Ltd. was informed by the Aboriginal Consultation Office (ACO) that the Chin Reservoir Expansion Project has been assessed as Level 0-No Consultation Recommended by the ACO. The SMRID Board of Directors has instead favoured consulting with the Kainai Nation given our past history on being able to collaborate on the construction of the St. Mary River Dam while at the same time recognizing that the Blood Tribe Agricultural Project shares its headworks with the St. Mary Project. Please take this letter as notification of the proposed project.

SMRID is proposing to expand the reservoir by constructing a new East Dam approximately 10 km downstream (east) of the existing East Dam and raise the design Full Supply Level (FSL) to 864.00. The surface area of the reservoir is expected to increase from 1670 ha to 2370 ha, an increase of 42%. The expansion will result in two areas of focus; namely, the East Dam and West Dam. The expansion of the reservoir will be completely encompassed of private land.

The East Dam work will include the following scope:

- The new East Dam will be located 10 km east of the existing East Dam within SW 23-7-15 W4 and NW-14-7-15-W4.
- With the dam relocation and the rise in FSL, the total estimated storage will increase to 257,820 ac-ft and add 1750 acres (708 ha) to the reservoir's footprint, an increase of 42%
- The existing East Dam located in SE-26-7-16-W4 will be removed.
- The East Dam project will include a structure for flood management.

The West Dam work will include the following scope:

- The West Dam, located in NE-27-8-18-W4, will be raised to account for the change in FSL to 864.00.
- The Low Level Outlet is to be replaced. Capacity of the structure is currently not to be changed but will be reviewed as part of the project.
- The Chin Chute is to be replaced. The capacity of the structure will be reviewed and likely increased.
- Minor upgrades to the Chin Hydro Plant to account for the change in FSL.

There are no known potential short term or long term adverse impacts to First Nations Rights and Traditional uses.

Suite 300, 714 5 Avenue South
Lethbridge, AB T1J 0V1
Phone: 403-329-3442
1-866-329-3442
Fax: 403-329-9354

MPE Engineering Ltd.

This project has a proposed construction start date of Spring of 2025 and will take approximately three years to complete.

Please review all relevant information included and provide a written submission identifying any potential adverse impacts the project may have on your Treaty rights and traditional uses. The concerns identified should be spatially located, tied to a Treaty right or traditional use and identify how the proposed project will adversely impact that Treaty right or traditional use. SMRID and MPE would like to afford the Kainai Nation with an opportunity to provide a presentation on the project and address any questions or concerns that the Kainai Nation may have.

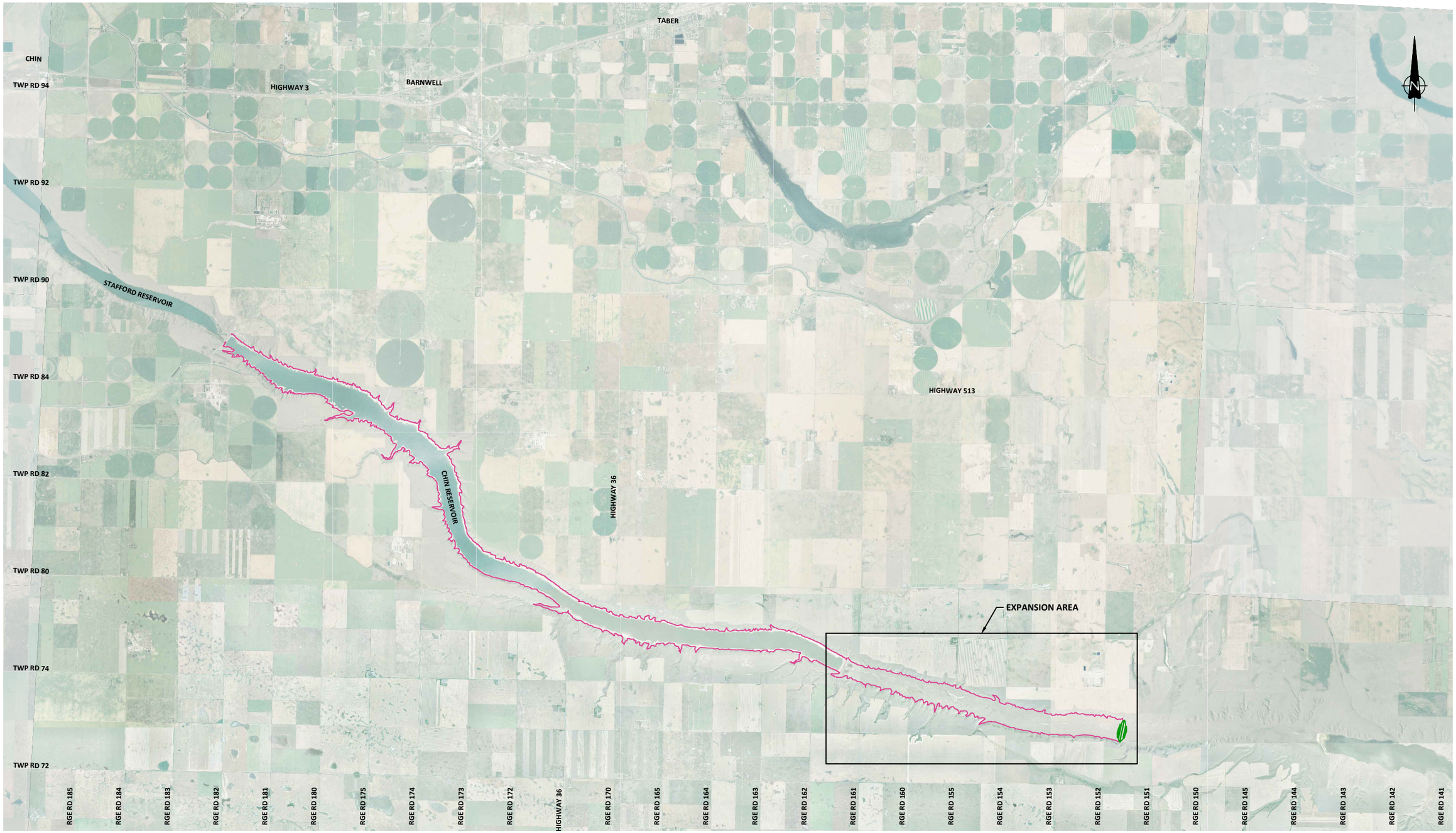
If you have any questions or wish to discuss this project further, please contact me by email at jolitch@mpe.ca or at (403) 317-3629 at your earliest convenience.

Sincerely,

MPE ENGINEERING LTD.

Jeff Olitch, P. Eng.
Project Manager

TP: mw
Enclosure



PROPOSED DAM
FSL: 864.00

CHIN RESERVOIR EXPANSION			
SCENARIO	TOP OF DAM	FSL	STORAGE INCREASE
8	866.50 m	864.00 m	103 500 ac-ft

MPE Engineering Ltd.

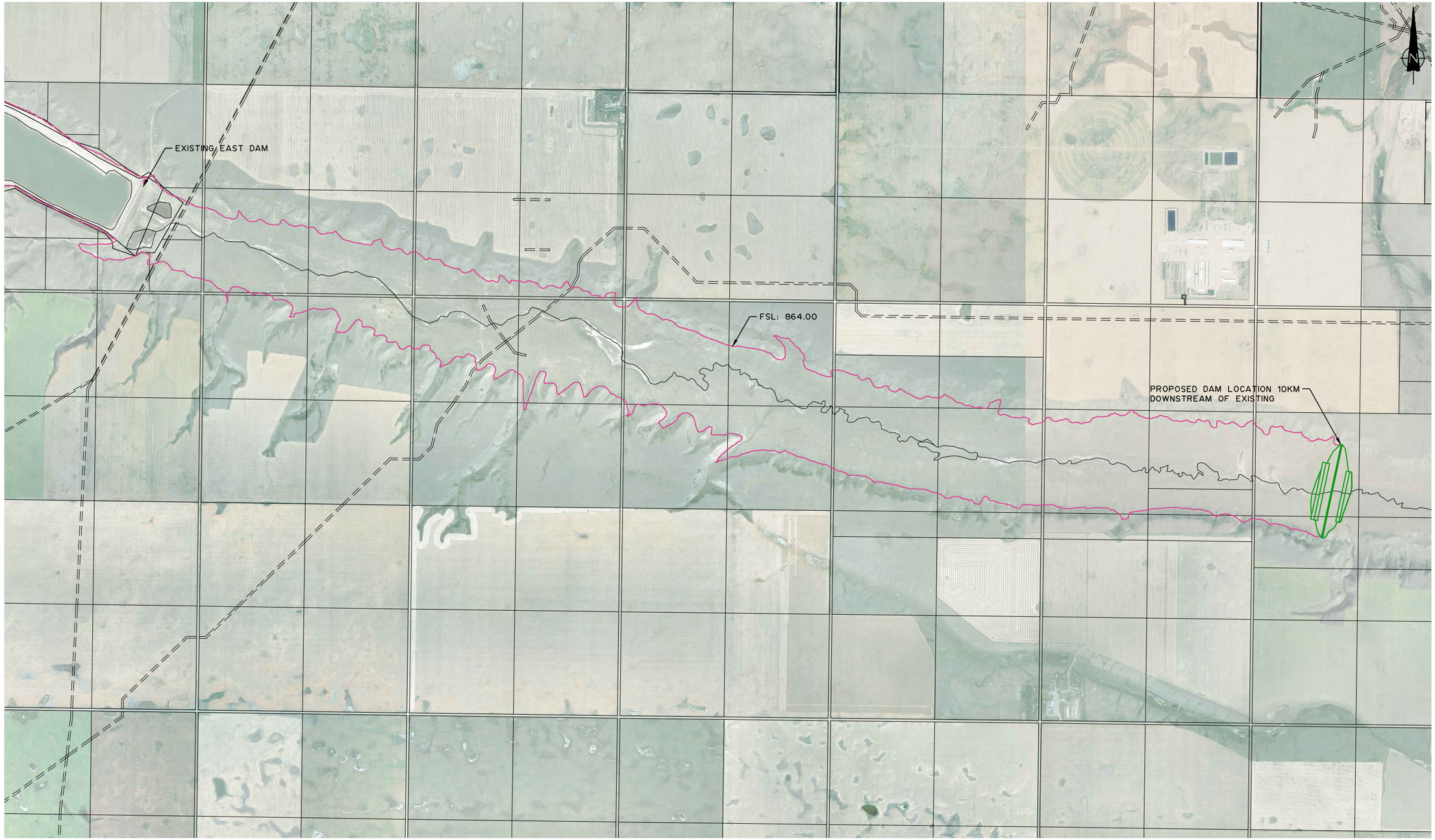
ST. MARY IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION
KAINAI NATION CONSULTATION
SITE PLAN

SCALE: 1:125 000	DATE: OCTOBER 2022	JOB: 1520-167-00	FIGURE: 1

RGE 15 W4M

TWP 7



LEGEND	
	PROPOSED DAM
	FSL: 864.00

CHIN RESERVOIR EXPANSION			
SCENARIO	TOP OF DAM	FSL	STORAGE INCREASE
8	866.50 m	864.00 m	103 500 ac-ft

MPE Engineering Ltd.

ST. MARY RIVER IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION
SITE PLAN

SCALE: 1:15 000	DATE: AUGUST 2021	JOB: 1520-167-00	FIGURE: 5.2

APPENDIX 52.1

Chin Reservoir Expansion Project – Noise Impact Assessment (RWDI 2025)

REPORT

CHIN RESERVOIR EXPANSION PROJECT

LETHBRIDGE COUNTY, COUNTY OF WARNER NO. 5, AND MUNICPAL DISTRICT OF TABER, ALBERTA

NOISE IMPACT ASSESSMENT

RWDI #2403751

April 24, 2025

SUBMITTED TO

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APPENDICES

Appendix A: Practitioner Biographies
Appendix B: Environmental Descriptors
Appendix C: Sound Power Levels

VERSION HISTORY

Index	Date	Pages	Author
1	April 24, 2025	All	Teresa Drew, B.Sc., INCE Michel Parent, C.E.T. Mingsan Boulter

Executive Summary

RWDI AIR Inc. (RWDI) was retained by Klohn Crippen Berger (KCB) in support of the St. Mary River Irrigation District (SMRID) to perform an environmental noise impact assessment (NIA) on the dam construction phases of the proposed Chin Reservoir Expansion Project (the Project) located near Lethbridge, Alberta.

This NIA was prepared to support responses to the first set of supplementary information requests (SIRs) regarding the Environmental Impact Assessment (EIA) for the Project and follows the requirements of the Alberta Energy Regulator (AER) Directive 038: Noise Control (D-038; AER 2023). The assessment considered three construction phases and predicts the cumulative noise impact of Project related sound sources.

RWDI has incorporated a conservative modelling approach for the NIA by assuming full daytime period (07:00 to 22:00) operations, and reasonable estimates of construction equipment size and utilization of equipment based on information provided by KCB. The model considered Project design data, including but not limited to, equipment list and proposed construction phases as provided by the client.

This NIA has found that the predicted Project cumulative sound levels will comply with the AER D-038 daytime Permissible Sound Levels during construction. In the event nighttime activities are required, noise management plans should be developed as the specific equipment and location of the activity is refined.

The NIA has found the potential for low-frequency noise (LFN) to be generated by the Project is considered low due to the predicted dBC minus dBA level being below the 20 dB threshold for all phases (i.e., temporary works, proposed East Dam construction and existing reservoir east dam decommissioning) at all receptors.

1 INTRODUCTION

RWDI AIR Inc. (RWDI) was retained by Klohn Crippen Berger (KCB) in support of the St. Mary River Irrigation District (SMRID) to perform an environmental noise impact assessment (NIA) on the dam construction phases of the proposed Chin Reservoir Expansion Project (the Project) located near Lethbridge, Alberta.

This NIA was prepared to support responses to the first set of supplementary information requests (SIRs) regarding the Environmental Impact Assessment (EIA) for the Project and follows the requirements of the Alberta Energy Regulator (AER) Directive 038: Noise Control (D-038; AER 2023). The assessment considers three construction phases and predicts the cumulative noise impact of Project related sound sources. Predicted noise levels were evaluated against permissible sound levels (PSLs) established within D-038 for the nearest receptors.

All work was completed by technical staff experienced in acoustic assessment, as detailed in Appendix A. A detailed glossary of terms is provided in Appendix B to aid the non-technical reader.

2 ASSESSMENT APPROACH

Noise from the proposed Project has been estimated using predictive modelling to determine the impact at the nearest receptors. The assessment was completed by:

- Identifying receptors and respective PSLs per D-038;
- Determining existing ambient conditions per D-038;
- Estimating sound emissions from the proposed Project;
- Modelling the sound emissions to predict noise levels at receptors; and
- Comparing the predictions to the D-038 PSLs.

This report describes methods and results of the NIA to demonstrate compliance with AER D-038 PSLs. This NIA evaluates the following three phases of Project related construction activity:

- Access road construction to the proposed East Dam,
- Construction of proposed East Dam,
- Decommissioning of existing reservoir east dam.

This NIA does not quantify the noise impacts of the post-construction operation phase. Long-term operation of the dam is not anticipated to significantly contribute to the overall environmental sound levels in the study area.

2.1 Environmental Noise Descriptors

As environmental noise varies over time, a single number descriptor known as the Energy Equivalent Sound Level or L_{EQ} is used to quantify noise. It is defined as the steady continuous sound level, over a specified time period, that has the same acoustic energy as the actual varying sound levels occurring over the same time period. The L_{EQ} values are reported as A-weighted sound levels expressed in units of dBA (A-weighted decibels). The A-weightings are assigned to account for the frequency response of the human ear, which is most sensitive to mid-frequency sounds. The L_{EQ} in dBA is the primary sound level criteria addressed by AER criteria.

D-038 has different allowable sound levels for daytime, which it defines as 07:00 to 22:00 hours, and nighttime, which it defines as 22:00 to 07:00 hours. The L_{EQ} during daytime periods is the 15-hour A-weighted energy equivalent sound level and is denoted as the L_{EQ} Day. Similarly, the L_{EQ} during nighttime periods is a 9-hour A-weighted energy equivalent sound level and is denoted as the L_{EQ} Night.

In addition to assessing A-weighted L_{EQ} sound levels, D-038 recommends that low frequency noise (LFN) be assessed at the NIA stage where data is available. LFN is measured using C-weighted L_{EQ} sound levels, expressed in dBC, which represent a nearly flat frequency response. The C-weighted levels are considered because A-weighted levels may not indicate the potential for disturbance caused by high levels of LFN. D-038 assesses the potential for LFN complaints based on the difference between the dBC and dBA levels, and whether there is tonality of the sound within the LFN frequencies.

A detailed glossary of terms is provided in Appendix A to aid the non-technical reader.

2.2 Computer Modelling

Modelling for this assessment was conducted using Cadna/A (Version 2025 – 209.5501) sound level prediction software set that use the environmental sound propagation calculation methods prescribed by the ISO Standard 9613 (ISO 1993, 2024). The ISO 9613 sound propagation method predicts sound levels under moderately developed temperature inversion and downwind conditions, which enhance sound propagation to the receptor. The evaluation is based on typical summertime weather conditions, as outlined in D-038. Table 1 describes the configuration of the calculation parameters used to complete the noise modelling.

The sound emissions for all sources considered in the Cadna/A modelling were established by reviewing proposed equipment lists, site layouts and activity descriptions. Sound emissions were identified for each type of equipment using, in order of preference: manufacturer data, measured data from similar equipment, public literature or theoretical calculation.

Table 1: Model Configuration Parameters

Parameter	Model Settings	Description/Notes
Calculation Standard	ISO 9613 (2024)	All sources and attenuators are treated as required by the cited standard.
Ground Absorption	0.8 (index value 0 to 1)	Values used for soft ground located beyond the Project boundaries
	0.2 (index value 0 to 1)	Values used for disturbed ground within the Project
	0.0 (index value 0 to 1)	Values used for water
Temperature and Humidity	10°C/70% Relative Humidity	Average summer conditions for area.
Wind Conditions	Default ISO 9613	The propagation conditions in the ISO (2024) standard are valid for wind speeds between 4 and 18 km/h; all points are considered downwind.
	moderate inversion condition	
Terrain	Terrain applied	Terrain in the area is modelled at 1 m height points in the vertical direction to account for terrain within the study area
Reflections	3	Three reflections are taken into account for reflections from on-site structures.

2.3 Noise Model Conservative Assumptions and Uncertainty

Several conservative assumptions have been used in the assessment. The primary conservative assumption is in using D-038 to assess noise impacts. D-038 noise limits do not typically apply to construction noise, however, the methods and PSLs used in D-038 are well established in Alberta for assessing the environmental noise impacts of large projects both regulated and not regulated by the AER. The nature and duration of the construction activities associated with the Project in this case indicate that D-038 is an appropriate method to use. D-038 allows for elevated PSLs for temporary activities, however, since the Project construction activities are planned over several years duration, the temporary adjustments to the PSLs are not applicable.

The main sources of conservative assumptions in the technical analysis include source modelling, acoustic shielding, weather conditions, wind directions, and ground attenuation.

The following information and assumptions that were used for modelling are:

- *"Chin Reservoir Expansion -EIA – Volume 2" (dated July 2024)* was referenced to model the proposed Project construction areas. Construction is assumed to occur over the entire Project footprint identified therein.
- A list of construction equipment type and quantities was provided from KCB on February 10th, 2025.
    - Equipment time usage factors were not provided. RWDI referred to previous experience assessing construction activities to estimate percent usage time as a percentage of the total daytime period.
    - Size of equipment was not provided for most cases. RWDI referred to previous experience assessing construction activities to determine appropriate equipment size.
- A 10-hour workday (07:00 to 17:00) has been assumed with no works occurring during the nighttime period (22:00 to 07:00). Predicted sound levels assume the equipment is in operation over the entire 15-hour daytime period (07:00 to 22:00). Limited activities are anticipated to occur from 17:00 to 22:00.
- Weather conditions, specifically temperature and humidity factors, were selected for conditions that allow the maximum propagation of sound. A temperature of 10°C and relative humidity of 70 % was used in the noise model configuration. These are not dominant conditions in summer but can occur and these conditions favor sound propagation to the receptors. Other combinations of temperature and humidity in summer are expected to result in more attenuation and less propagation. The meteorological parameters are within the range of parameters outlined in D-038.
- The assessment uses the ISO 9613 (2024) propagation standard which considers all receptors as always being downwind from all sources. The standard considers conservative wind conditions, as the maximum downwind contribution of each noise source is calculated, when in reality, receptors are exactly downwind of a source for only specific wind directions of origin.
- All receptors are categorized according to D-038 Table 1 as Proximity to Transportation Category 1, and 1 to 8 dwelling density per quarter section of land. Adjustments available to increase thresholds for increased dwelling density at the Evergreen Colony receptor were not used due to the anticipated work/sleep schedule of the colony residents reflecting rural communities, not the sub-urban levels of nighttime activity that the higher density thresholds represent.

- D-038 adjustments for temporary activities like construction are not applicable in this NIA as the duration of activities exceeds one-year.

The uncertainty inherent in noise modelling is addressed with these conservative assumptions. The overall uncertainty or conservatism of sound level predictions cannot be quantified in terms of +/- dBA per parameter. Values will vary for each reception points based on distance from sound sources and terrain/ground conditions. The intent of modelling is to estimate the potential for sound to exceed the permissible sound level (PSL) at reception points, under a reasonably conservative or "realistic worst-case" condition. The methods used, and standards developed for modeling and prediction of sound, along with ground-truthing through measurement, result in estimates with sufficient confidence to manage the potential risk of exceeding regulatory limits.

3 STUDY AREA AND RECEPTORS

3.1.1 Study Area

The study area extends 1.5 km from the project disturbance footprint as shown in the Noise and Air Quality disturbance zone figure of the Chin Reservoir Expansion EIA (KCB 2025). For the purpose of this NIA, the study area has been separated into specific assessment areas based on the phases of activity.

Figure 1 shows the location of the Project access road construction phase, noise sensitive receptors R1 and R3, and the 1.5 km Criteria Boundary.

Figure 2 shows the location of the Project proposed East Dam construction phase, noise sensitive receptors R1 and R3, and the 1.5 km Criteria Boundary.

Figure 3 shows the location of the Project existing reservoir east dam decommissioning phase, noise sensitive receptor R2, and the 1.5 km Criteria Boundary.

3.1.2 Receptors

This assessment is focused on impacts on human receptors in accordance with Alberta criteria.

D-038 defines a noise-sensitive receptor as any permanent or seasonally occupied dwelling within 1.5 km of a facility. In areas where there are no nearby residents, D-038 sets a limit on the sound levels at a distance of 1.5 km from the Project fenceline, referred to here as the 1.5 km Criteria Boundary. To be consistent with other applications to the AER, the construction limits, as supplied in site drawings, has been defined as the Project fenceline.

R1 is the nearest receptor to the proposed East Dam construction area. The road construction phase and proposed East Dam construction phase occur within 1.5 kilometers of the Evergreen Colony situated west of Range Road 152 and north of Township Road 74. The number of dwelling units at the colony is unknown. However, it is understood the colony has a resident population of 100 people. Due to the nature of colony activities, this site is treated as a single receptor with existing ambient sound levels consistent with a proximity to transportation Category 1 and 1 to 8 dwelling density.

R2 is the 1500 meter boundary receptor to the existing east dam site. No dwellings are within 1.5 kilometers of the existing reservoir east dam decommissioning area, therefore a receptor north of the dam decommissioning activity footprint was chosen at the representative 1.5 km Criteria Boundary receptor, designated R2. The nearest dwelling identified is approximately 2.4 kilometers north of the existing reservoir east dam decommissioning site.

R3 is a residence of interest within 1500m of the Project Boundary, located southeast of the proposed East Dam construction area.

Table 2 shows the geographic coordinates, distance, and direction of noise sensitive receptors per phase of the project. All receptors were modelled at 1.5 m, which is the standard height for a receptor at ground level. The residential dwelling receptors were also evaluated at 4.5 m to represent a second story bedroom window receptor location.

Table 2: Location of Receptors and Spatial Locations from Project

Receptor ID	UTM Coordinates (NAD 83, Zone 12)		Modelled Height (m)	Distance from Project (m)	Direction from Project
	Easting (m)	Northing (m)			
Access Road Construction					
R1 - Dwelling	431163	5492726	1.5	420 [1]	NW
R1 - Dwelling	431163	5492726	4.5	420 [1]	NW
R3 - Dwelling	433455	5489423	1.5	2100 [2]	SE
R3 - Dwelling	433455	5489423	4.5	2100 [2]	SE
Proposed East Dam Construction					
R1 - Dwelling	431163	5492726	1.5	990 [3]	N
R1 - Dwelling	431163	5492726	4.5	990 [3]	N
R3 - Dwelling	433455	5489423	1.5	1150 [4]	SE
R3 - Dwelling	433455	5489423	4.5	1150 [4]	SE
Existing Reservoir East Dam Decommissioning					
R2 – Boundary Receptor	422662	5495081	1.5	1500 [5]	N

Notes: [1] – Approximate distance from the Evergreen Colony dwelling to the road construction area northwest extent.
[2] – Approximate distance from the dwelling to the road construction area southeast extent.
[3] – Approximate distance from the Evergreen Colony dwelling to the proposed East Dam construction area north extent.
[4] – Approximate distance from the dwelling to the proposed East Dam construction area southeast extent.
[5] – Distance from the existing reservoir east dam decommissioning area extent north edge to the 1.5 km boundary receptor point.

4 AER DIRECTIVE 038 CRITERIA

4.1 Existing Conditions

4.1.1 Assumed Ambient Sound Level

AER D-038 requires the consideration of ambient levels in the determination of PSLs and compliance of proposed projects. In areas where the assumed ambient sound level described in Table 1 of D-038 is not representative of an area, measured values may be used in establishing the PSLs such as areas meeting the definition of 'pristine' in the rule or may be influenced by non-noise regulated development.

The project area does not meet the definition of pristine according to D-038, which states:

> A natural area that might have a dwelling but no industrial presence, including energy, agricultural, forestry, manufacturing, recreational or other industries that affect the noise environment.

The project area is typical of rural Alberta, primarily agricultural land use.

The use of the assumed ambient sound level as being 5 dB less than the Basic Sound Level (BSL) is well founded and may be considered a reasonable approach to establishing the PSL for all dwellings in this assessment.

4.1.2 Existing Regulated Facilities

D-038 requires existing sound levels be established for use in a cumulative assessment. The cumulative existing sound level includes the noise contributions from existing adjacent regulated facilities, and the ambient sound level considered typical of remote rural areas. Facilities regulated by the AER under D-038 and the Alberta Utilities Commission (power generation facilities) are considered in this NIA, as required by AER.

The Project is in a rural area in Alberta. Satellite imagery does not indicate the presence of active well pads or other oil/gas related facilities within 3 kms of the Project footprint areas. Review of the AER ST37 (AER 2023a) well database and the AER ST102 (AER 2023b) facility list did not show nearby active oil and gas facilities that could potentially contribute to the cumulative sound level. A review of area mapping also did not indicate the presence of thermal, wind or solar power related facilities. Therefore, no third-party facility sound level contributions were considered in this NIA.

Unregulated operations from agricultural activities or existing area aggregate extraction sites are not included in the modeled sound sources and are considered part of the ambient conditions.

4.2 PSL Determination

The requirements of D-038 limit the amount of sound contribution at a receptor location that may be generated by facilities. The sound level limits for a receptor are set by calculating permissible sound levels (PSLs) according to the procedures in D-038. If a PSL has been previously approved for a receptor, the approved PSL must be used.

A PSL is determined using a BSL modified by any allowed adjustments. Where no special conditions exist, the PSL is determined as follows:

Permissible Sound Level	=	Basic Sound Level (Table 1 in D-038)	+	Daytime Adjustment (If applicable)

As no special ambient conditions were identified, the BSL is determined based on dwelling density and proximity to heavily travelled roadways per D-038 Table 1. For all receptors identified in Table 2, the unadjusted PSL is 40 dBA night and 50 dBA day. All receptors are rural residences with a dwelling density of less than 8 dwellings per quarter section, and the resulting PSL is 40 dBA for nighttime and 50 dBA for daytime. A summary of the PSLs is provided in Table 3.

Table 3: Daytime and Nighttime Permissible Sound Levels

Receptor ID[1]	BSL[2] (dBA)	Assumed Nighttime Ambient Level[3] (dBA)	Nighttime PSL[4] (22:00 - 07:00) (dBA)	Assumed Daytime Ambient Level[5] (dBA)	Daytime PSL[6] (07:00 - 22:00) (dBA)
R1- Dwelling	40	35	40	45	50
R2 - Boundary	40	35	40	45	50
R3- Dwelling	40	35	40	45	50

Notes: 1 – Dwelling receptors as identified by client, county maps, and satellite imagery. Boundary receptor is 1500-meters north of existing east dam site.
2 - Basic sound level as identified per Table 1 of AER D-083.
3 - Assumed ambient sound level is five dBA less than BSL.
4 - Nighttime PSL is equal to the BSL as there are no Class A,B, or C adjustments.
5 - Assumed daytime ambient sound level is the assumed nighttime ambient plus the 10 dBA daytime adjustment.
6 - Daytime PSL is equal to the BSL plus the 10 dBA daytime adjustment, as there are no Class A,B, or C adjustments.

4.3 Low Frequency Noise

Regarding low frequency noise (LFN), D-038 states that a LFN condition may exist where the difference between Project contributed time weighted average dBA and dBC levels is equal to or greater than 20 dB, and where a clear tonal component exists at a frequency below 250 Hz. This evaluation is performed herein.

5 RESULTS

5.1 Project Noise Sources

This NIA evaluates the following three phases of Project related construction activity:

- Access road construction to the proposed East Dam,
- Construction of proposed East Dam,
- Decommissioning of the existing reservoir east dam.

A list of proposed equipment type and number of each item was provided to RWDI. Sound power levels, size rating of most equipment and operational times were not provided. RWDI used a mixture of publicly available sound level data and manufacturers' data on file to determine sound power level inputs for modelling. Sound level correction has been applied to equipment based on estimated percent usage time as a percentage of the total daytime period with the sound source in a continuous steady state. Sound sources have been modelled as area sources at 1.5 meters in height operating over the entire construction/decommissioning area footprint, or as stationary point sources for select sources, or as moving point/line sources for light vehicles and haul trucks. Ground elevation contours with 1-meter intervals are included in the model space to account for the elevation difference between the lower dam construction working area and receptors on the upper plain.

For the purposes of this NIA it is assumed that construction activities will occur continuously during the daytime hours (07:00 to 22:00). The construction core-hour working shift is 10-hours in duration from 07:00 to 17:00, and this NIA does not include a lower ambient sound level for the remainder of the daytime period, instead it assumes that construction activities occur continuously during the entire daytime period (15-hours).

5.1.1 Construction Phase Equipment

Appendix C presents the Project sound sources for each phase evaluated.

Road construction temporary works consist of access road construction, work laydown area, construction site office locations and waste and stockpile areas. Major sound sources for these activities include:

- Earthworks haul fleet including dump trucks, scrapers, bulldozers and excavators operating over an area, as shown in Figure 4.

Proposed East Dam construction sound sources include:

- Earthworks haul fleet including dump trucks, scrapers, bulldozers and excavators operating over an area,
- Granular fill / Riprap fleet including wheeled loaders and dump trucks operating over an area,
- Packing equipment including vibratory rollers, graders and skid steers operating over an area,

- Diesel engine powered water pumps and portable generators modelled as a stationary point source, and,
- Dump trucks hauling, water trucks and light vehicles modelled as moving point/line sources, as shown in Figure 5.

Existing reservoir east dam decommissioning sound sources include:

- Earthworks haul fleet including dump trucks, scrapers, bulldozers and excavators operating over an area,
- Diesel engine powered water pumps and portable generators modelled as a stationary point source, and,
- Dump trucks hauling, water trucks and light vehicles modelled as moving point/line sources, as shown in Figure 6.

A listing of the Project sound sources, with quantity of each type of equipment listed, source type and operational usage times that were modelled are presented in Appendix C Table C1: Access Road Construction, Table C2: Proposed East Dam Construction and Table C3: Existing Reservoir East Dam Decommissioning.

5.1.2 Temporal Boundaries

Road construction temporary works will be completed prior to the start of the proposed East Dam construction in 2026. Project scheduling and construction sequencing anticipates the new East Dam will be completed in 2029. Filling of the reservoir will take several years to complete and subsequent decommissioning of the existing reservoir east dam is scheduled to begin in 2030 and be completed in 2032.

5.2 Operation Results

5.2.1 Daytime Operational Results

The predicted results indicate the Project phases assessed will comply with D-038 PSLs at all receptors evaluated. The ASL, predicted Project sound level contributions, and the calculated cumulative operational activity sound levels at the receptors are presented in Table 4 for the daytime period only. Predicted sound levels assume the equipment is in operation over the entire 15-hour daytime period from 07:00 to 22:00, however, limited activities are anticipated to occur from 17:00 to 22:00 due to the anticipated 10-hour work-shift.

Table 4: Predicted Sound Levels and Assessment of Compliance with Daytime PSLs

Receptor	Ambient Sound Level[1] (Daytime, dBA)	Proposed Project Phase Contributions (Daytime, dBA)	Cumulative Sound Level[2] (Daytime, dBA)		PSL[3] (Daytime, dBA)	Meet Daytime PSL? (Y/N)
			Sum	Rounded		
Access Road Construction						
R1 – 1.5 m	45.0	44.6	47.8	48	50	Yes
R1 – 4.5 m	45.0	45.4	48.2	48	50	Yes
R3 – 1.5 m	45.0	34.9	45.4	45	50	Yes
R3 – 4.5 m	45.0	36.1	45.5	46	50	Yes
Proposed East Dam Construction						
R1 – 1.5 m	45.0	45.0	48.0	48	50	Yes
R1 – 4.5 m	45.0	46.5	48.8	49	50	Yes
R3 – 1.5 m	45.0	41.4	46.6	47	50	Yes
R3 – 4.5 m	45.0	42.8	47.0	47	50	Yes
Existing Reservoir East Dam Decommissioning						
R2	45.0	43.2	47.2	47	50	Yes

Notes: 1 – As per Table 3.
2 – Logarithmic addition of AER D-038 assumed ambient and predicted Project contributions.
3 – As per Table 3.

Figure 7, Figure 8 and Figure 9 show the predicted sound levels contour due to each proposed Project activity evaluated at a 1.5 m grid receiver height. Figure 7 shows the Access Road Construction phase; Figure 8 shows the Proposed East Dam Construction phase and Figure 9 shows the Existing Reservoir East Dam Decommissioning phase daytime operations predicted sound level contours.

5.2.2 Nighttime Operational Results

The Project is expected to work a typical 10-hour workday (07:00 to 17:00). It is assumed no works will occur during the nighttime period (22:00 to 07:00), therefore nighttime operational results are not presented for Project related construction activities. D-038 assumed ambient sound levels are expected for R1 and R2.

Certain activities (i.e., grouting operations) may require continuous 24-hour operations to complete. It is recommended that those activities are assessed for compliance and management plans be developed once equipment utilization, location and duration of shift activities are known. Developing mitigation requirements at this stage of design is considered premature since the extent and duration of activities are unknown. Generally, selecting quieter equipment, sourcing better mufflers or using reduced amounts of equipment, or designing local berms or barriers can reduce the overall nighttime sound levels at the receivers.

5.3 Low Frequency Noise

The C-Weighted sound level (dBC) results have been reviewed to determine if there is potential for LFN from the Project at the receptors. Table 5 shows that the potential for an LFN condition is considered low as the results are below the 20 dB threshold for each receptor evaluated.

Table 5: Low Frequency Noise Assessment

Receptor	Proposed Project Phase Contributions		dBC-dBA	Potential LFN Condition? (Yes / No)
	(dBC)	(dBA)		
Access Road construction				
R1 – 1.5 m	58.2	44.6	13.6	No
R1 – 4.5 m	58.3	45.4	12.9	No
R3 – 1.5 m	53.5	34.9	18.6	No
R3 – 4.5 m	53.7	36.1	17.6	No
Proposed East Dam Construction				
R1 – 1.5 m	61.7	45.0	16.7	No
R1 – 4.5 m	61.7	46.5	15.2	No
R3 – 1.5 m	58.2	41.4	16.8	No
R3 – 4.5 m	58.3	42.8	15.5	No
Existing Reservoir East Dam Decommissioning				
R2	59.4	43.2	16.2	No

6 SUMMARY

RWDI has incorporated a conservative modelling approach for the NIA by assuming full daytime period (07:00 to 22:00) operations, and reasonable estimates of construction equipment size and utilization of equipment. The model considered Project design data, including but not limited to, equipment list and proposed construction phases as provided by the client.

This NIA has found that the predicted Project cumulative sound levels will comply with the AER D-038 daytime PSLs for construction activities. In the event nighttime activities are required, noise management plans should be developed as the specific equipment and location of the activity is refined.

The NIA has also found the potential for LFN to be generated by the Project is considered low due to the predicted dBC minus dBA level being below the 20 dB threshold for all phases at all receptors.

7 STATEMENT OF LIMITATIONS

This report entitled Chin Reservoir Expansion Noise Impact Assessment, dated April 24, 2025, was prepared by RWDI Air Inc. ("RWDI") for Klohn Crippen Berger ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared. Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client during the final stages of the project to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

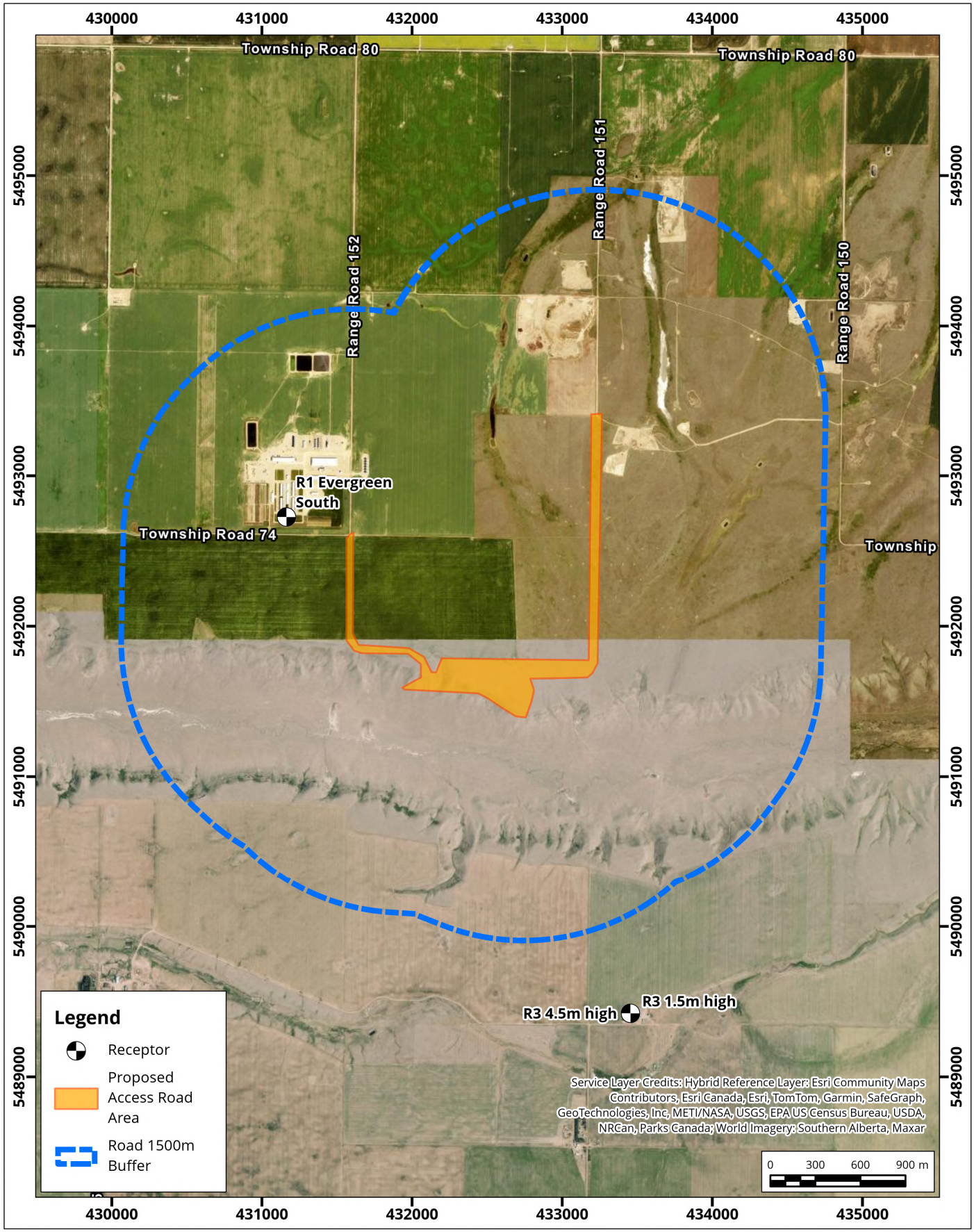
The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.

8 REFERENCES

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9. International Organization for Standardization (ISO). (1993), *International Standard ISO 9613-1, Acoustics – Attenuation of Sound During Propagation Outdoors – Part 1: Calculation of Absorption of Sound by the Atmosphere*. Geneva, Switzerland.
10. Klohn Clippen Berger (KCB). 2025. Chin Reservoir Expansion Project Environmental Impact Assessment – Noise and Air Quality, FIG No 57.1., Project No. A03701E01

FIGURES



Study Area: Project, Receptors, and 1.5 km Boundary

Access Road Construction

Map Projection: NAD 1983 UTM Zone 12N

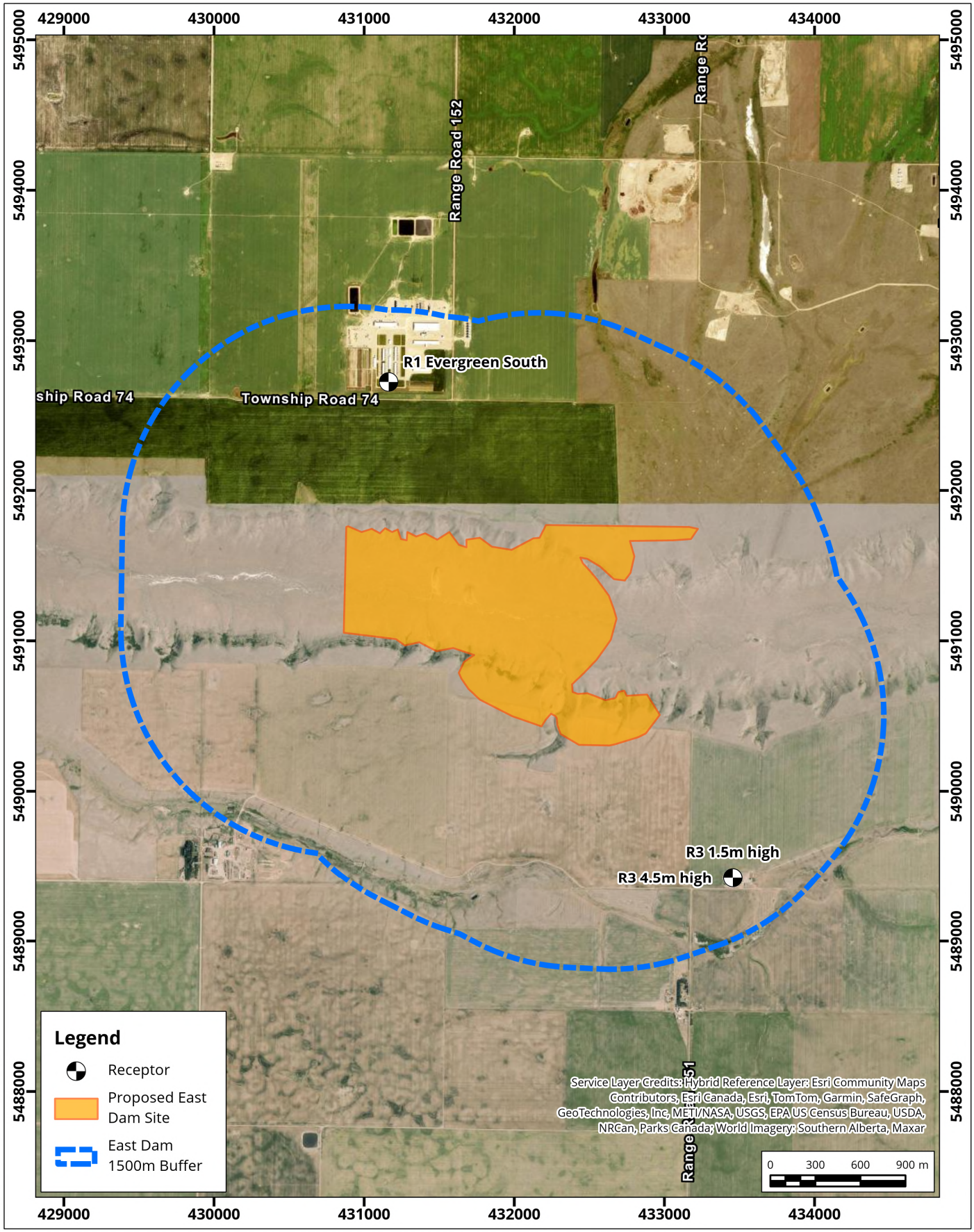
Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

Drawn by:	PIP	Figure:	1
Approx. Scale:		1:35,000	
Date Revised:		Apr 22, 2025	

Map Document: C:\WorkingFolder\Jobs_America\P2403751\P2403751.aprx



Study Area: Project, Receptors, and 1.5 km Boundary

Proposed East Dam Construction

True North

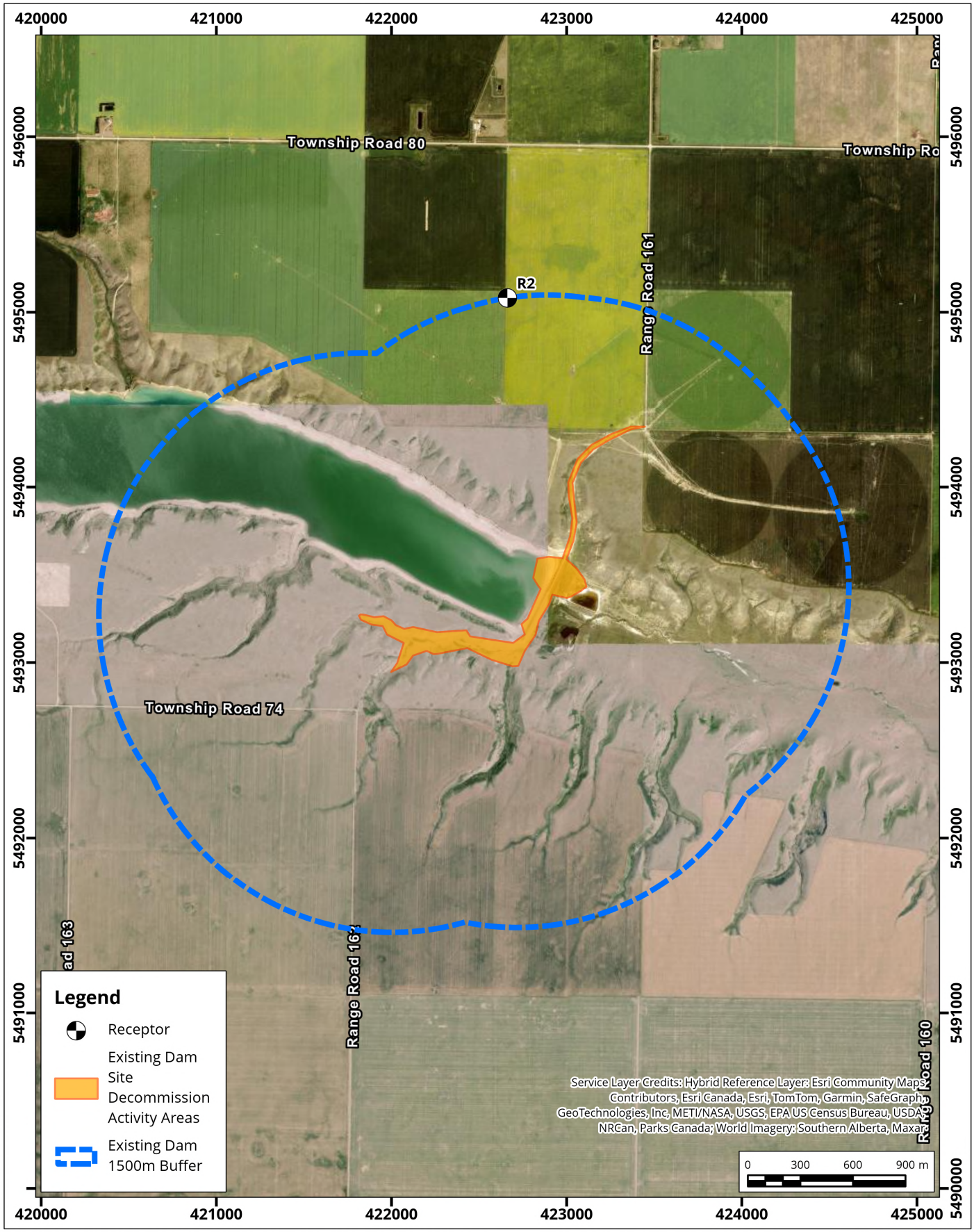
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Map Projection: NAD 1983 UTM Zone 12N

Chin Reservoir - Lethbridge, Alberta

Project #: 2403751

Map Document: C:\WorkingFolder\Jobs_America\P2403751\P2403751.aprx



Study Area: Project, Receptors, and 1.5 km Boundary

Existing Reservoir East Dam Decommissioning

True North

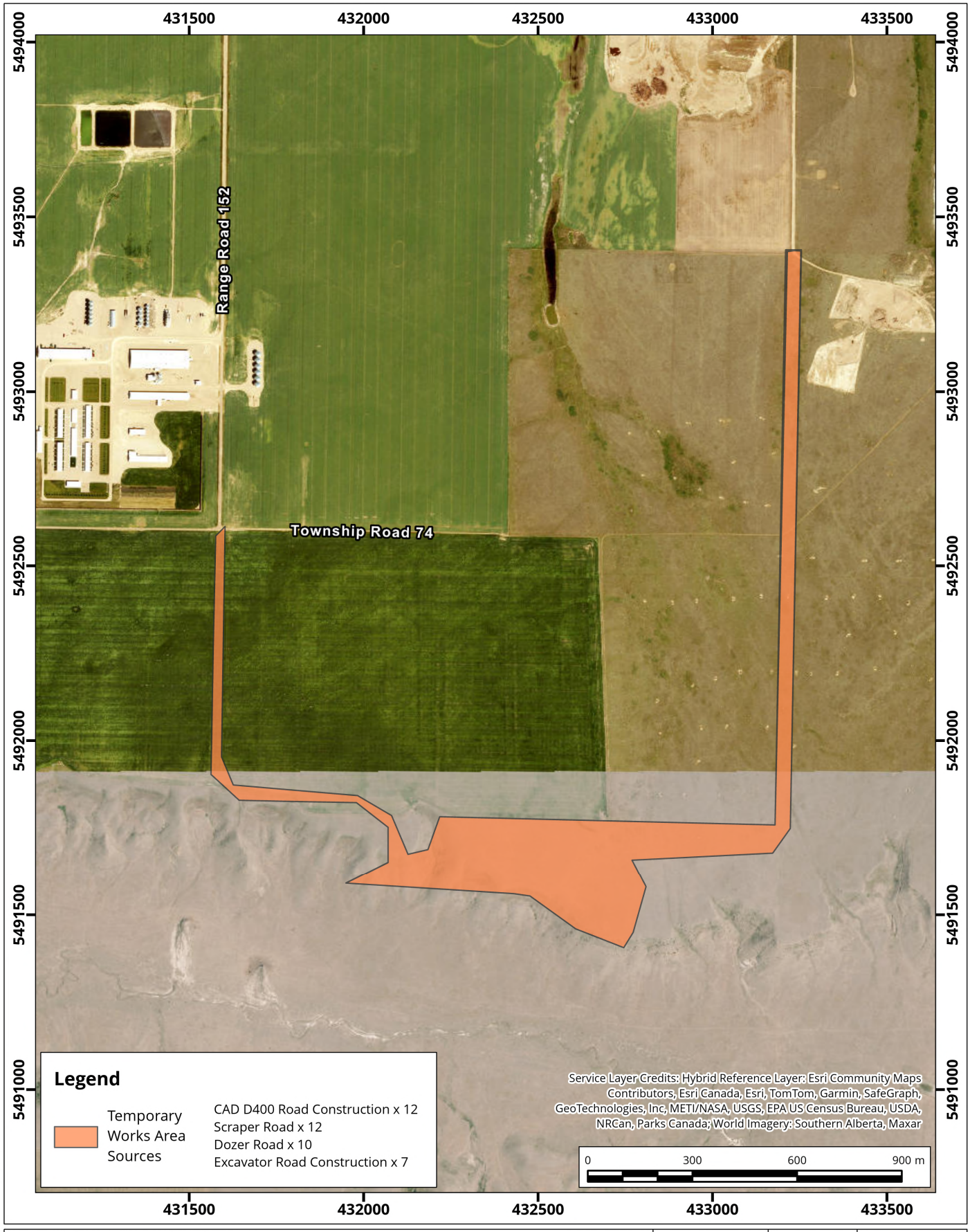
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Date Revised:		Mar 5, 2025	

Map Projection: NAD 1983 UTM Zone 12N

Chin Reservoir - Lethbridge, Alberta

Project #: 2403751

Map Document: C:\Working\Folder\Jobs_America\P2403751\P2403751.aprx



Location of Sound Sources

Access Road Construction

Map Projection: NAD 1983 UTM Zone 12N

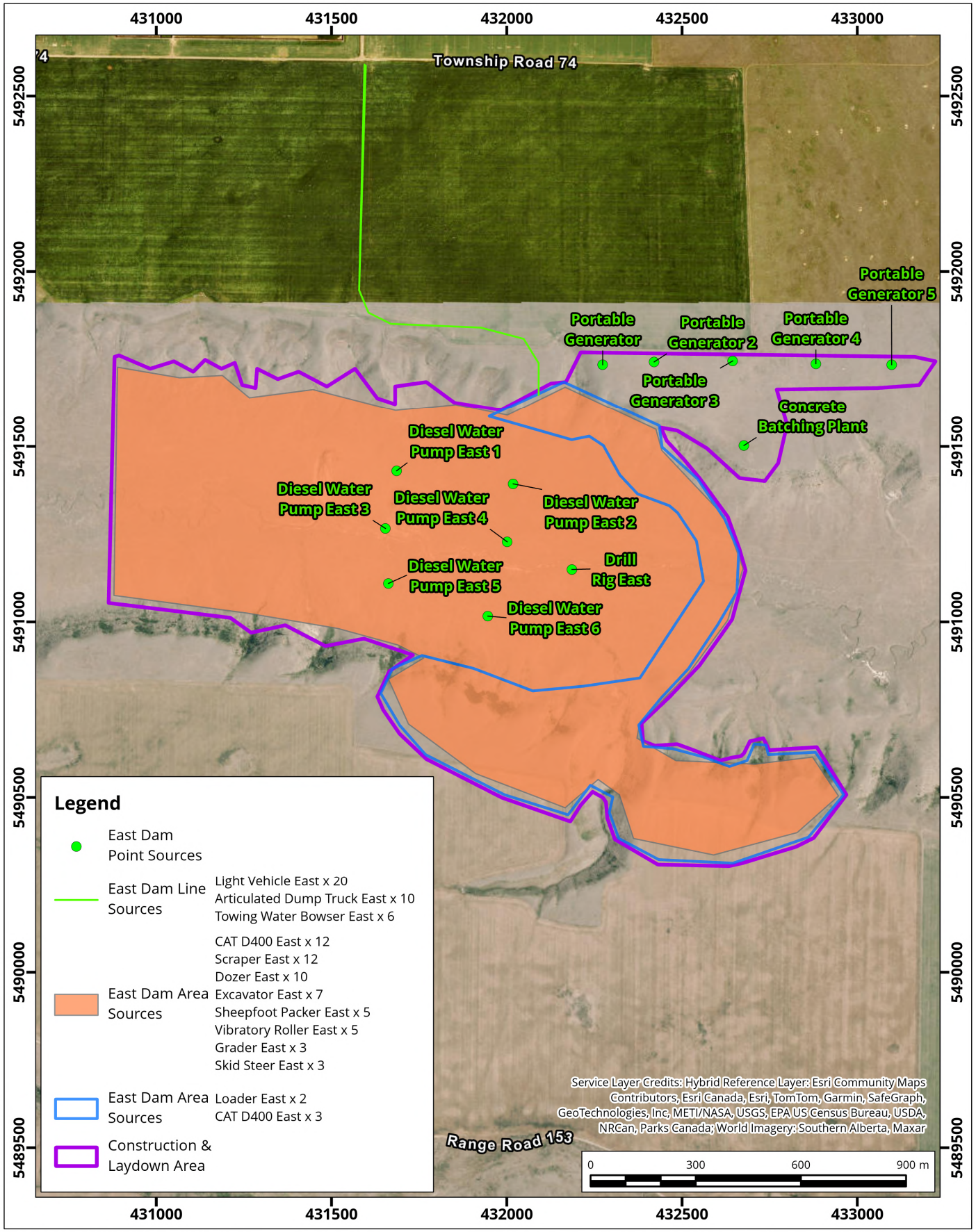
Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

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Approx. Scale:			1:15,000
Date Revised:			Mar 5, 2025

Map Document: C:\WorkingFolder\Jobs_America\P2403751\P2403751.aprx



Location of Sound Sources

Proposed East Dam Construction

Map Projection: NAD 1983 UTM Zone 12N

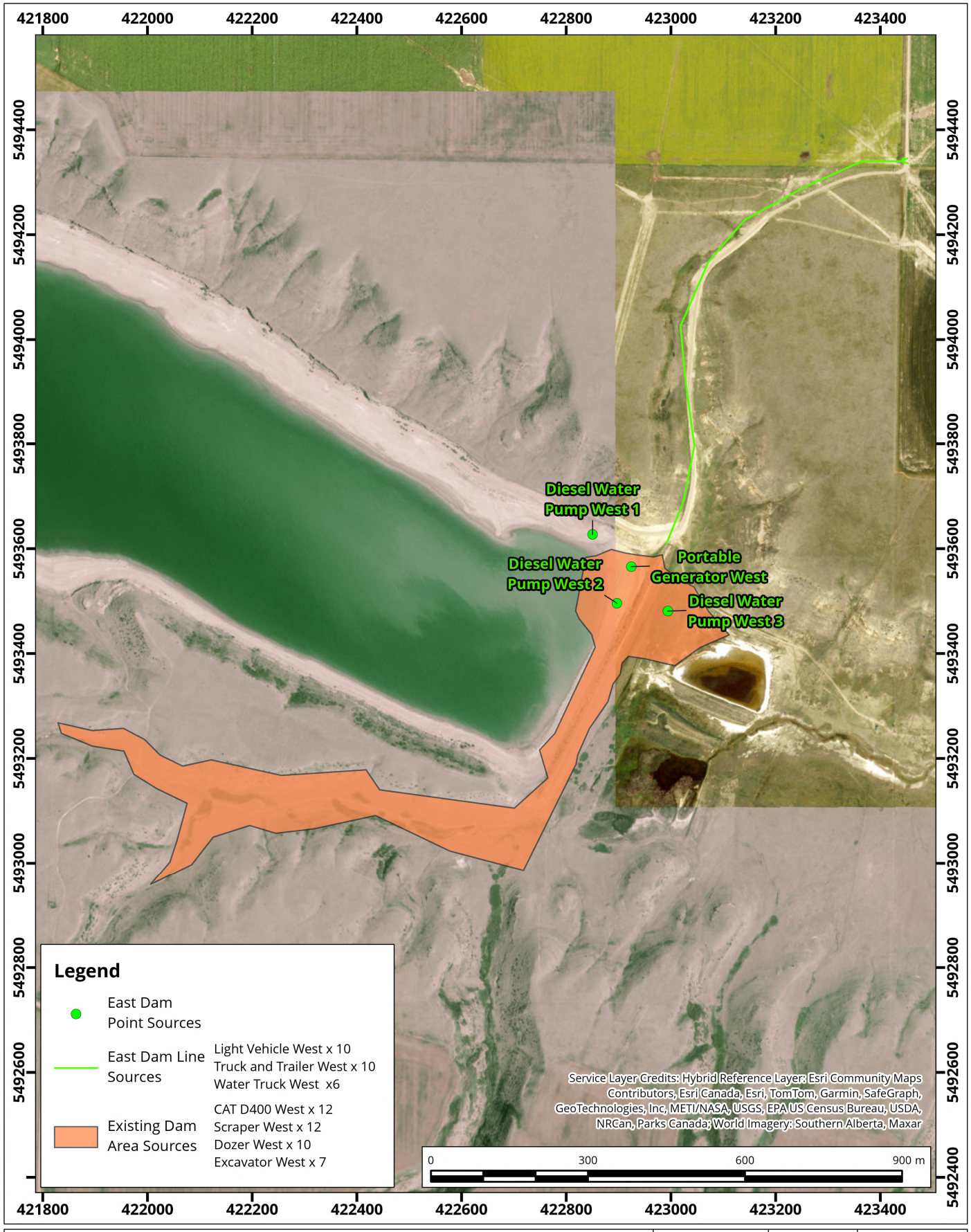
Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

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Date Revised:		Mar 5, 2025	

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Location of Sound Sources

Existing Reservoir East Dam Decommissioning

Map Projection: NAD 1983 UTM Zone 12N

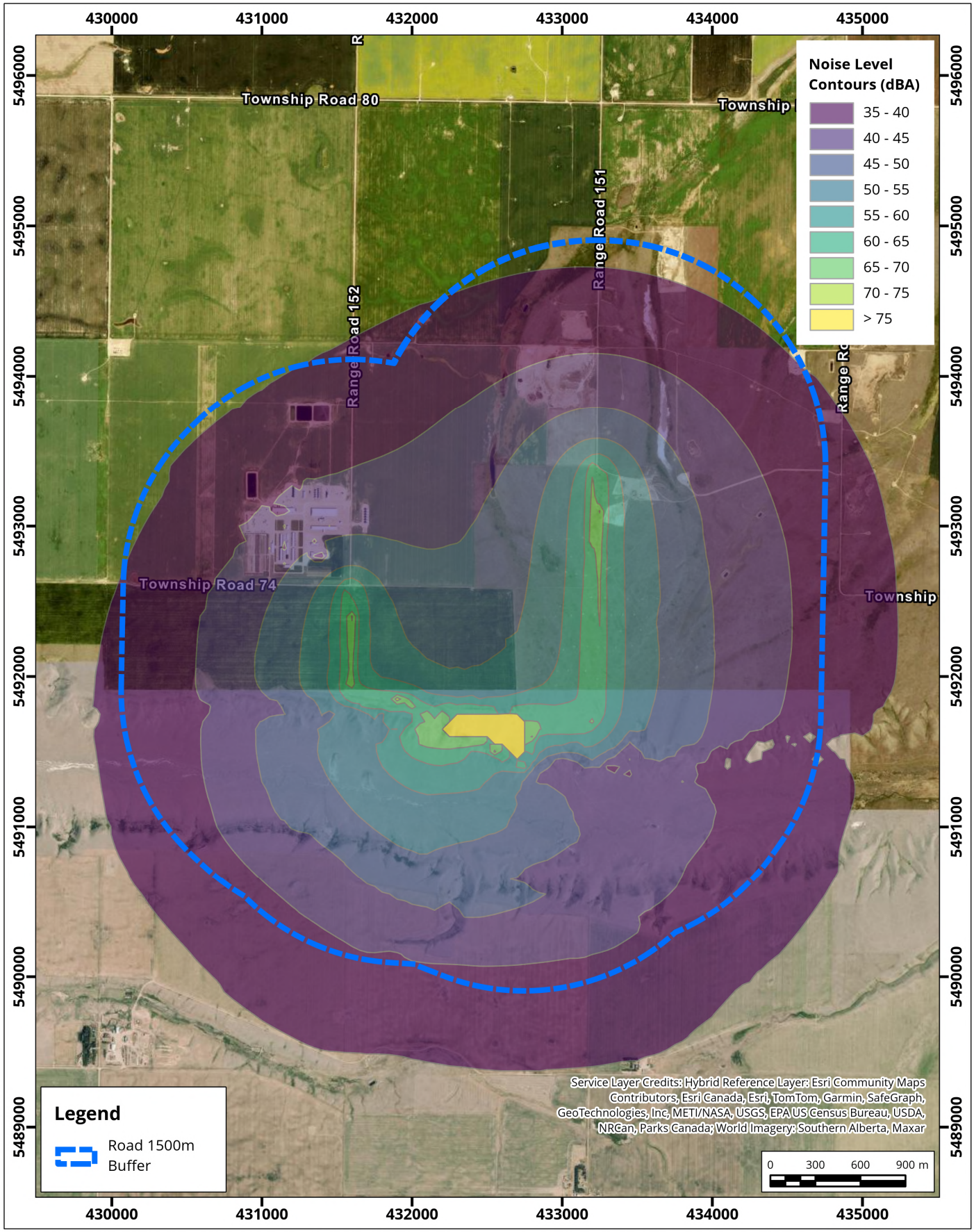
Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

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Date Revised:		Mar 5, 2025	

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Predicted Sound Level Contours at 1.5 m Height

Access Road Construction

Map Projection: NAD 1983 UTM Zone 12N

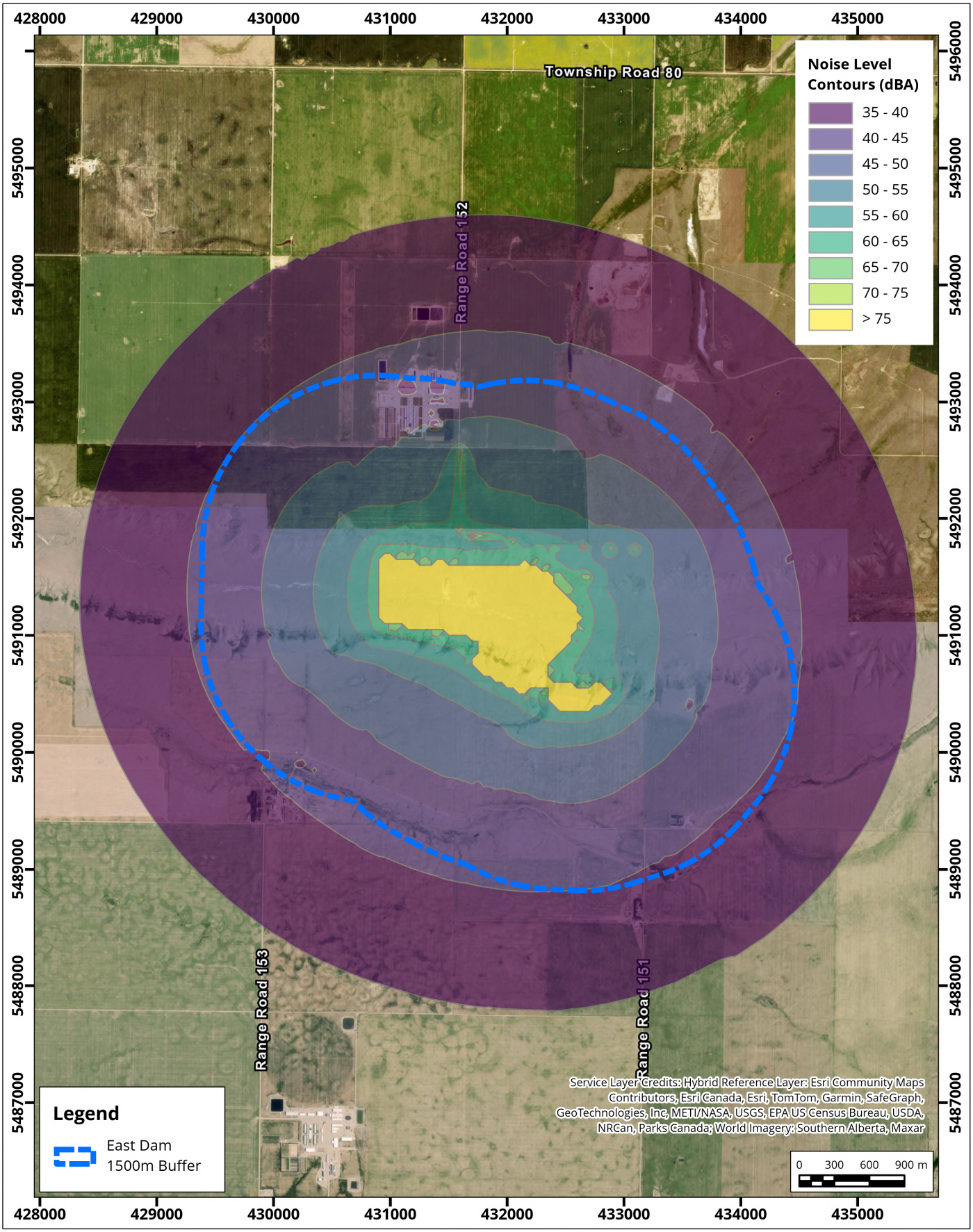
Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

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Date Revised:		Mar 6, 2025	

Map Document: C:\WorkingFolder\Jobs_America\P2403751\P2403751.aprx



Predicted Sound Level Contours at 1.5 m Height

Proposed East Dam Construction

Map Projection: NAD 1983 UTM Zone 12N

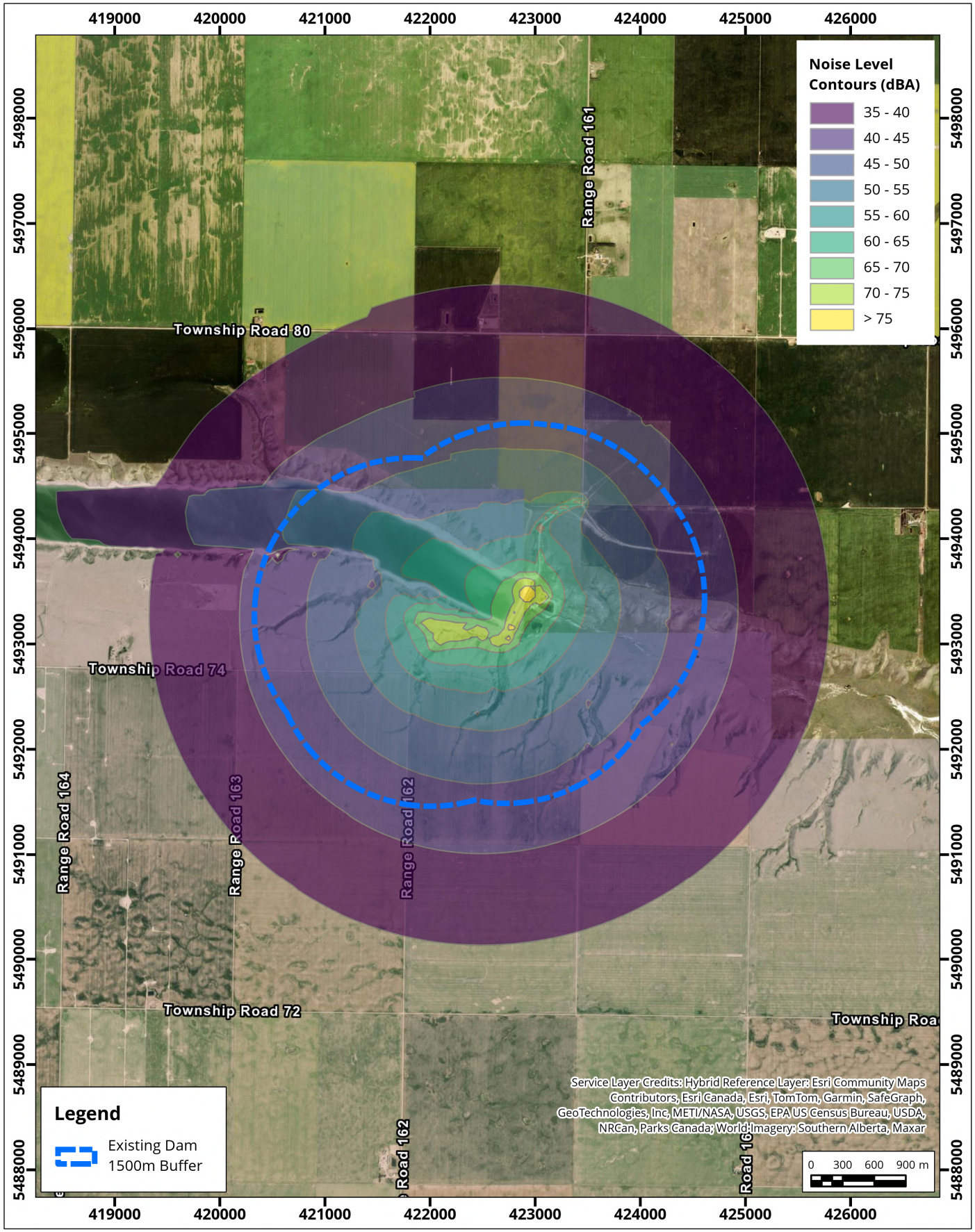
Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

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Date Revised:		Mar 6, 2025	

Map Document: C:\WorkingFolder\Jobs_America\P2403751\P2403751.aprx



Predicted Sound Level Contours at 1.5 m Height

Existing Reservoir East Dam Decommission

Map Projection: NAD 1983 UTM Zone 12N

Chin Reservoir - Lethbridge, Alberta

True North

Project #: 2403751

Drawn by:	PIP	Figure:	9
Approx. Scale:		1:50,000	
Date Revised:		Mar 6, 2025	

Map Document: C:\Work\ingFolder\Jobs_America\P2403751\P2403751.aprx

APPENDIX A

APPENDIX A: PRACTITIONER BIOGRAPHIES

Teresa Drew, B.Sc., INCE

Teresa joined the Calgary RWDI team in 2011, and is a Noise, Acoustics and Vibration Team Technical Director and Senior Consultant on environmental noise assessments. She also supports RWDI's global consulting operations as holder of the Technical Operations Office.

Teresa is an accomplished professional with over 35 years of consulting experience. Her expertise is in the areas of regulatory permitting, noise assessments, renewable energy, health impact assessments and mitigation. Teresa has also been called for expert testimony on several occasions.

Michel Parent, C.E.T. Senior Acoustical Consultant

Michel joined RWDI in 2019 and began his career in environmental noise and acoustical consulting in 2005. Michel has evaluated sound for regulatory assessment for a wide variety of facilities including gas plants, compressor stations, field gas compressor units, open pit mine operations and large turbine driven pipeline compressor stations, commuter train rail corridors and building land-use planning studies.

Over the course of his career, Michel has been involved in the on-site sound pressure level measurements of equipment at hundreds of energy industry facilities in western Canada and prepared over 2000 noise models and Noise Impact Assessment reports for client facility license application and regulatory audit needs and conducted over a hundred ambient and comprehensive sound surveys investigating environmental sound at sensitive receptor locations.

Mingsan Boulter, MIOA, Acoustical Consultant

Mingsan joined RWDI in 2024 as a member of RWDI's Acoustics team, bringing with him a wide range of acoustical consulting experience dating back to 2016. Mingsan has carried out acoustic consulting for a range of environmental projects back in Australia. These projects consisted of environmental noise modeling and noise compliance monitoring for large infrastructure projects including wind farms and light rail lines.

APPENDIX B

APPENDIX B: ENVIRONMENTAL NOISE DESCRIPTORS AND TERMINOLOGY

Abnormal noise events

Noises that are sufficiently infrequent as to be uncharacteristic of an area or that occur so close to the microphone as to dominate the measurements in an unrealistic manner. Consideration must be given to deleting occurrences of abnormal noise from the measurements to obtain a reasonably accurate representation of the sound environment. Examples of abnormal noises include a dog barking close to the microphone, a vehicle passing nearby, people talking in the vicinity of the microphone in a quiet environment, or a passing road grader.

Airborne Sound

Sound that reaches the point of interest by propagation through air.

Ambient noise or sound

All noises that exist in an area and are not related to a facility under study. Ambient noise may include sound from other existing industrial facilities, transportation sources, animals, and nature. Context for ambient noise should be defined for each project.

Attenuation

The reduction of sound intensity by various means (e.g., air, humidity, porous materials, etc.)

A-weighted sound level

The sound level as measured on a sound level meter using a setting that emphasizes the middle frequency components similar to the frequency response of the human ear.

A-weighting shows that the measured sound pressure levels have been filtered using a frequency weighting network that mimics the response of the human ear.

The resultant sound pressure level with the associated unit “dBA” is therefore a representative of the subjective response of the human ear. The weightings are assigned in a way to reflect the higher sensitivity of human ear to sound in the mid and high frequency band as shown in the curve labelled A-weighting in Figure B-1.

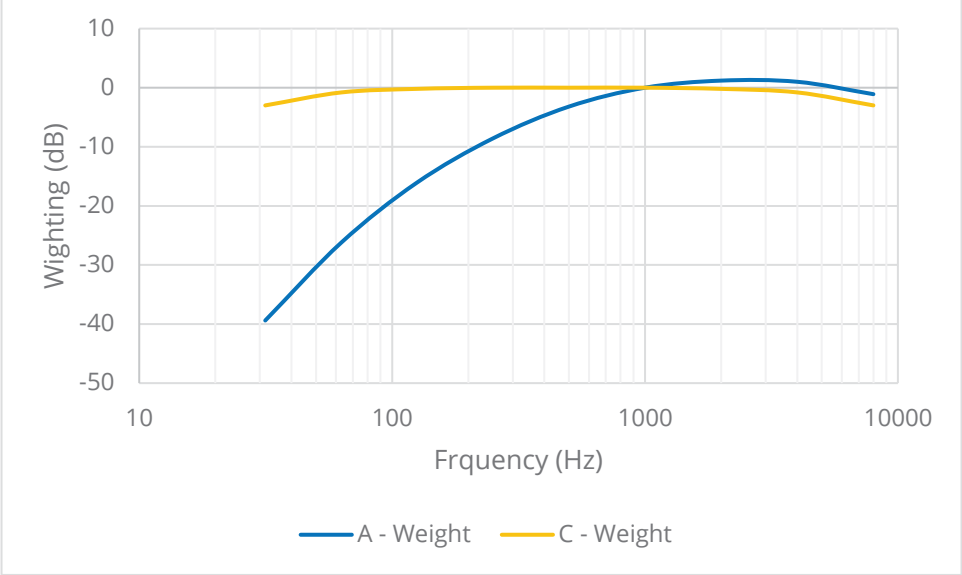


Figure B-1 Sound Weighting Network

Calibration

The procedure used for the adjustment of a sound level meter using a reference source of a known sound pressure level and frequency. Calibration must take place before and after the sound level measurements.

C-Weighted Sound Level

The sound level as measured on a sound level meter using a setting that emphasizes the low and middle frequency components. The weightings are assigned as shown in the curve labelled C-weighting in Figure B-1. The resultant sound pressure level is reported with the associated unit “dBC”

Daytime

Defined as the hours from 07:00 to 22:00.

dB (decibel)

A unit of measure of sound pressure that compresses a large range of numbers into a more meaningful scale. Hearing tests indicate that the lowest audible pressure is approximately 2 x 10-5 Pa (0 dB), while the sensation of pain is approximately 2 x 102 Pa (120 dB). Generally, an increase of 10 dB is perceived as twice as loud.

dBA

The decibel (dB) sound pressure level filtered through the A filtering network to approximate human hearing response at low frequencies.

dBC

The decibel (dB) sound pressure level filtered through the C filtering network to highlight low and middle frequencies.

Dwelling

Any permanently or seasonally occupied residence with the exception of an employee or worker residence, dormitory, or construction camp located within an industrial plant boundary. Trailer parks and campgrounds may qualify as a dwelling unit if it can be demonstrated that they are in regular and consistent use during the applicable season.

Energy equivalent sound level (Leq)

The Leq is the average A-weighted sound level over a specified period of time. It is a single-number representation of the cumulative acoustical energy measured over a time interval. If a sound level is constant over the measurement period, the Leq will equal the constant sound level where f is the fraction of time the constant level L is present.

Standardized Wind Speed at 10 m

The standardized wind speed at a height of 10 m is calculated in accordance with IEC 614000-11 (2012) and is given below. In the case of calculating the standardized wind speed for turbines in Alberta, a roughness length of 0.05 m is used, which is representative of farmland with vegetation.

$$V_H = V_{10}\left[\frac{\ln\left(\frac{H}{z_{0ref}}\right)}{\ln\left(\frac{10}{z_{0ref}}\right)}\right]$$

Where:

V_H is the wind speed at hub height z (m), determined from the power curve;

V_{10} is the standardized wind speed at 10m;

z_{0ref} is the reference roughness length of 0.05 m; and

H is the rotor centre height (m).

Far Field

Describes a region in free space where the sound pressure level from a source obeys the inverse-square law (the sound pressure level decreases 6 dB with each doubling of distance from the source). Also, in this region the sound particle velocity is in phase with the sound pressure. Closer to the source where these two conditions do not hold constitutes the “near field” region.

Frequency

The number of times per second that the sine wave of sound or of a vibrating object repeats itself. The unit is expressed in hertz (Hz), formerly in cycles per second (cps).

Human Perception of Sound

The human perception of noise impact is an important consideration in qualifying the noise effects caused by projects. The following table presents a general guideline.

Table B-1 Human Perception of Sound

Increase in Noise Level (dBA)	Perception
1 to 3	Imperceptible to possibly perceptible
4 to 5	just-noticeable difference
6 to 9	marginally significant
10 or more	significant, perceived as a doubling of sound level

Impulsive Noise

Single or multiple sound pressure peak(s) (with either a rise time less than 200 milliseconds or total duration less than 200 milliseconds) spaced at least by 500 millisecond pauses. A sharp sound pressure peak occurring in a short interval of time.

L_{EQ}

See Energy equivalent sound level.

Nighttime

Defined as the hours from 22:00 to 07:00.

Noise

Generally defined as the unwanted portion of sound.

Noise Level

This is the same as sound level except that it is applied to unwanted sounds, general the sound level at a point of reception.

Sound

A dynamic (fluctuating) pressure.

Sound level meter (SLM)

An instrument designed and calibrated to respond to sound and to give objective, reproducible measurements of sound pressure level. It normally has several features that would enable its frequency response and averaging times to be changed to make it suitable to simulate the response of the human ear.

Sound Pressure Level (SPL)

The logarithmic ratio of the RMS sound pressure to the sound pressure at the threshold of hearing. The sound pressure level is defined by equation (1) where P is the RMS pressure due to a sound and P0 is the reference pressure. P0 is usually taken as 2.0 × 10-5 Pascals.

(1) SPL (dB) = 20 log(PRMS/P0)

Sound Power Level (PWL)

The logarithmic ratio of the instantaneous sound power (energy) of a noise source to that of an international standard reference power. The sound power level is defined by equation (2) where W is the sound power of the source in watts, and W0 is the reference power of 10-12 watts.

(2) PWL (dB) = 10 log(W/W0)

Interrelationships between sound pressure level (SPL) and sound power level (PWL) depend on the location and type of source.

Spectrum

The description of a sound wave's resolution into its components of frequency and amplitude.

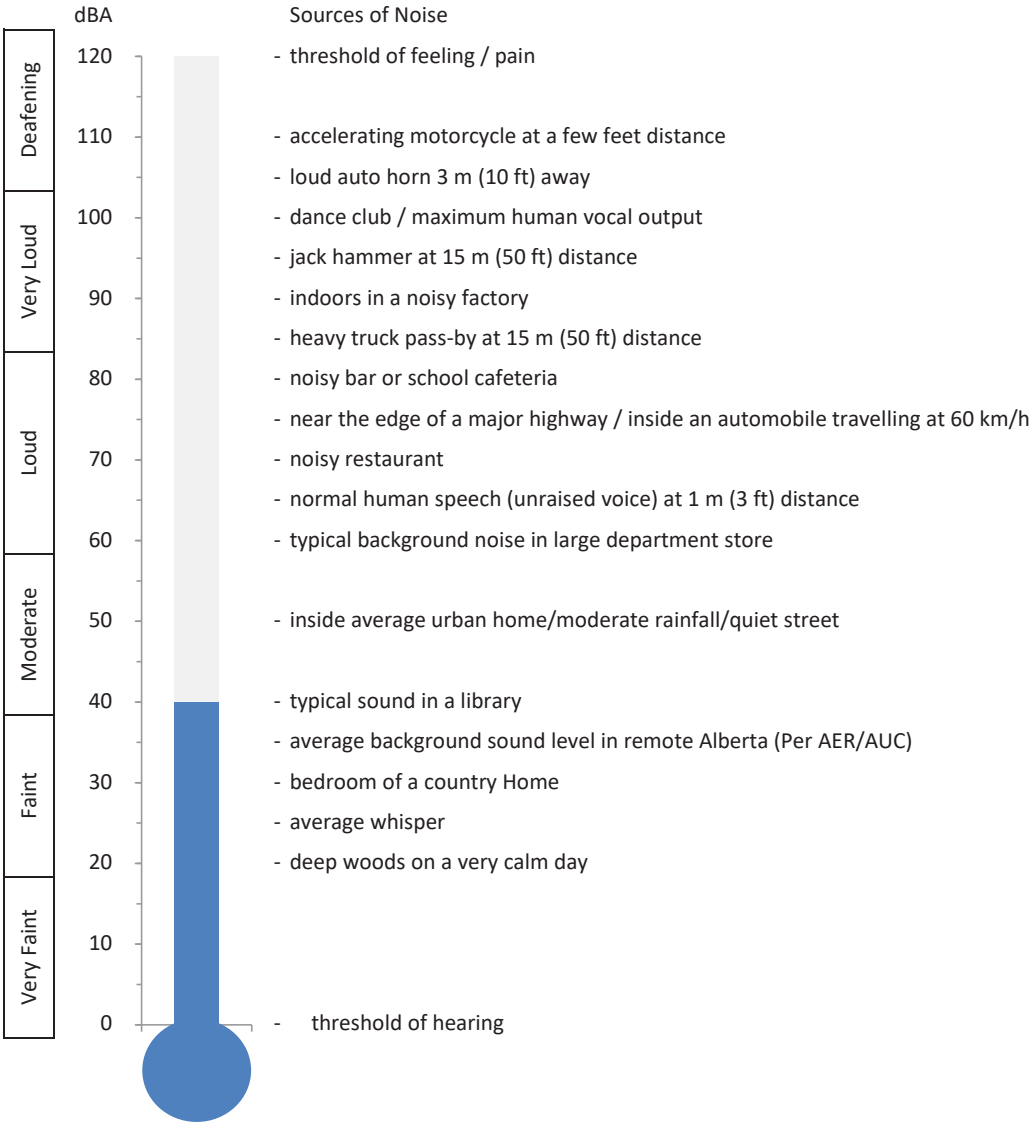
Speed of Sound in Air

344 m/s at 70°F (21°C) in air at sea level.

Tonal Components

Some industrial facilities typically exhibit a tonal component. Examples of tonal components are transformer hum, sirens, and piping noise. The test for the presence of tonal components consists of two parts. The first part must demonstrate that the sound pressure level of any one of the slow-response, A-weighted, 1/3-octave bands between 20 and 16000Hz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3-octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within 2 bandwidths on the opposite side. The second part is that the tonal component must be a pronounced peak clearly obvious within the spectrum.

RELATIONSHIPS BETWEEN EVERYDAY SOUNDS



APPENDIX C

Table C1: Access Road and Laydown Area Construction Equipment Sound Power Levels

Quantity	Source Type	Acoustic Usage Factor (%) [1]	Construction Equipment	Sound Power Level (dBA, re: 10^{-12} W) Octave Band Frequency (Hertz)											Data Source
				63	125	250	500	1000	2000	4000	8000	dB	dBA	dBC	
Earthworks Haul Fleet (Earth Fill)															
12	Area	50%	D400 Articulated dump truck - 287kw - 40t	116	112	103	101	103	100	96	88	118	107	117	British Standard BS-5228
			D400 Articulated Dump Truck Area Source TOTAL	**124**	**120**	**111**	**109**	**111**	**108**	**104**	**96**	**126**	**115**	**125**	**Calculated based on Quantity and Usage Factor**
12	Area	50%	Scraper	118	117	113	109	114	108	104	95	122	117	122	Department of Transport Brisbane
			Scraper Area Source TOTAL	**126**	**125**	**121**	**117**	**122**	**116**	**112**	**103**	**130**	**124**	**130**	**Calculated based on Quantity and Usage Factor**
Bulldozers															
10	Area	80%	Dozer - 142kw - 20t	113	102	104	101	100	106	90	84	115	109	114	British Standard BS-5228
			Dozer Area Source TOTAL	**122**	**111**	**113**	**110**	**109**	**115**	**99**	**93**	**124**	**118**	**123**	**Calculated based on Quantity and Usage Factor**
Excavators															
7	Area	80%	Tracked excavator - 226kw - 40t	113	106	105	105	101	99	96	91	115	107	115	British Standard BS-5228
			Tracked Excavator rea Source TOTAL	**120**	**113**	**112**	**112**	**108**	**106**	**103**	**98**	**123**	**114**	**122**	**Calculated based on Quantity and Usage Factor**

[1] Acoustic Usage Factor is a percentage of the entire daytime period (07:00 to 22:00).

Table C2: Proposed East Dam Construction Equipment Sound Power Levels

Quantity	Source Type	Acoustic Usage Factor (%) [1]	Construction Equipment	Model Equipment	Sound Power Level (dBA, re: 10^{-12} W) Octave Band Frequency (Hertz)											Data Source
					63	125	250	500	1000	2000	4000	8000	dB	dBA	dBC	
Earthworks Haul Fleet (Earth Fill)																
12	Area	50%	D400 Articulated dump truck - 287kw - 40t	cat_D400	116	112	103	101	103	100	96	88	118	107	117	British Standard BS-5228
			D400 Articulated Dump Truck Area Source TOTAL	**Standard Ops**	**124**	**120**	**111**	**109**	**111**	**108**	**104**	**96**	**126**	**115**	**125**	**Calculated based on Quantity and Usage Factor**
12	Area	50%	Scraper	scraper	118	117	113	109	114	108	104	95	122	117	122	Department of Transport Brisbane
			Scraper Area Source TOTAL	**Standard Ops**	**126**	**125**	**121**	**117**	**122**	**116**	**112**	**103**	**130**	**124**	**130**	**Calculated based on Quantity and Usage Factor**
Granular Fill / Riprap Fllet																
2	Area	40%	Wheeled loader - 364 - 56t	loaders	119	122	118	114	114	111	105	97	126	118	125	British Standard BS-5228
			Wheeled Loader Area Source TOTAL	**Standard Ops**	**118**	**121**	**117**	**113**	**113**	**110**	**104**	**96**	**125**	**118**	**124**	**Calculated based on Quantity and Usage Factor**
3	Area	40%	D400 Articulated dump truck - 287kw - 40t	cat_d400	116	112	103	101	103	100	96	88	118	107	117	British Standard BS-5228
			D400 Dump Truck Area Source TOTAL	**Standard Ops**	**117**	**113**	**104**	**102**	**104**	**101**	**97**	**89**	**119**	**108**	**118**	**Calculated based on Quantity and Usage Factor**
Bulldozers																
10	Area	80%	Dozer - 142kw - 20t	dozer	113	102	104	101	100	106	90	84	115	109	114	British Standard BS-5228
			Dozer Area Source TOTAL	**Standard Ops**	**122**	**111**	**113**	**110**	**109**	**115**	**99**	**93**	**124**	**118**	**123**	**Calculated based on Quantity and Usage Factor**
Excavators																
7	Area	80%	Tracked excavator - 226kw - 40t	excavator	113	106	105	105	101	99	96	91	115	107	115	British Standard BS-5228
			Tracked Excavator rea Source TOTAL	**Standard Ops**	**120**	**113**	**112**	**112**	**108**	**106**	**103**	**98**	**123**	**114**	**122**	**Calculated based on Quantity and Usage Factor**
Packing Equipment																
5	Area	40%	Vibratory roller - 32kw - 4.5t	sheepfoot_packer_push_blade	117	110	104	105	100	102	109	89	119	112	118	British Standard BS-5228
			Sheepfoot Packer Area Source TOTAL	**Standard Ops**	**120**	**113**	**107**	**108**	**103**	**105**	**112**	**92**	**122**	**115**	**121**	**Calculated based on Quantity and Usage Factor**
5	Area	40%	Vibratory roller - 29kw - 4t	vibratory_roller	116	111	97	96	95	93	90	87	117	101	117	British Standard BS-5228
			Roller / Vibratory Area Source TOTAL	**Standard Ops**	**119**	**114**	**100**	**99**	**98**	**96**	**93**	**90**	**120**	**104**	**120**	**Calculated based on Quantity and Usage Factor**
3	Area	40%	Grader - 205kW - 25t	grader	116	115	111	107	112	106	102	93	120	114	120	British Standard BS-5228
			Grader Area Source TOTAL	**Standard Ops**	**117**	**116**	**112**	**108**	**113**	**107**	**103**	**94**	**121**	**115**	**121**	**Calculated based on Quantity and Usage Factor**
3	Area	30%	Skid Steer	skid_steer	108	107	104	105	101	98	94	87	113	106	112	British Standard BS-5228
			Skid Steer Area Source TOTAL	**Standard Ops**	**108**	**107**	**104**	**105**	**101**	**98**	**94**	**87**	**112**	**106**	**112**	**Calculated based on Quantity and Usage Factor**
Stationary Equipment																
5	Point	100%	Portable Generator [2]	genset	103	100	104	98	97	93	84	75	108	102	108	British Standard BS-5228
6	Point	30%	Diesel Water pump @ 136Kw	water_truck_pump	109	111	105	103	104	103	97	91	115	109	115	British Standard BS-5228
2	Point	80%	Drill rig	drill_rig_drilling	113	121	106	107	108	107	104	102	122	114	122	RWDI Library Data
1	point	100%	Concrete Batching Plant	Grout_Plant	111	106	109	105	103	98	93	83	115	108	115	British Standard BS-5228 and site measurements
Mobile Equipment																
10	Line	10/hr	Articulated dump truck - 309kw - 40t	truck_and_trailer	126	122	117	113	107	107	98	93	128	115	127	British Standard BS-5228
6	Line	1/hr	Tractor (towing water bowser)	water_truck	106	114	112	106	106	105	98	97	118	111	117	British Standard BS-5228
Light Duty Vehicles																
20	Line	5/hr	Light Vehicle (Bus) F450	light_vehicle_1	95	94	87	82	84	83	81	72	98	90	98	RWDI Library Data

[1] Acoustic Usage Factor is a percentage of the entire daytime period (07:00 to 22:00).

Table C3: Existing Reservoir East Dam Decommissioning Equipment Sound Power Levels

Quantity	Source Type	Acoustic Usage Factor (%) [1]	Construction Equipment	Sound Power Level (dBA, re: 10^{-12} W) Octave Band Frequency (Hertz)											Data Source
				63	125	250	500	1000	2000	4000	8000	dB	dBA	dBC	
Earthworks Haul Fleet (Earth Fill)															
12	Area	50%	D400 Articulated dump truck - 287kw - 40t	116	112	103	101	103	100	96	88	118	107	117	British Standard BS-5228
			D400 Articulated Dump Truck Area Source TOTAL	**124**	**120**	**111**	**109**	**111**	**108**	**104**	**96**	**126**	**115**	**125**	**Calculated based on Quantity and Usage Factor**
12	Area	50%	Scraper	118	117	113	109	114	108	104	95	122	117	122	Department of Transport Brisbane
			Scraper Area Source TOTAL	**126**	**125**	**121**	**117**	**122**	**116**	**112**	**103**	**130**	**124**	**130**	**Calculated based on Quantity and Usage Factor**
Bulldozers															
10	Area	80%	Dozer - 142kw - 20t	113	102	104	101	100	106	90	84	115	109	114	British Standard BS-5228
			Dozer Area Source TOTAL	**122**	**111**	**113**	**110**	**109**	**115**	**99**	**93**	**124**	**118**	**123**	**Calculated based on Quantity and Usage Factor**
Excavators															
7	Area	80%	Tracked excavator - 226kw - 40t	113	106	105	105	101	99	96	91	115	107	115	British Standard BS-5228
			Tracked Excavator rea Source TOTAL	**120**	**113**	**112**	**112**	**108**	**106**	**103**	**98**	**123**	**114**	**122**	**Calculated based on Quantity and Usage Factor**
Stationary Equipment															
1	Point	100%	Portable Generator [2]	103	100	104	98	97	93	84	75	108	102	108	British Standard BS-5228
3	Point	30%	Diesel Water pump @ 136Kw	109	111	105	103	104	103	97	91	115	109	115	British Standard BS-5228
Mobile Equipment															
10	Line	10/hr	Articulated dump truck - 309kw - 40t	126	122	117	113	107	107	98	93	128	115	127	British Standard BS-5228
6	Line	1/hr	Tractor (towing water bowser)	106	114	112	106	106	105	98	97	118	111	117	British Standard BS-5228
Light Duty Vehicles															
10	Line	5/hr	Light Vehicle (Bus) F450	95	94	87	82	84	83	81	72	98	90	98	RWDI Library Data

[1] Acoustic Usage Factor is a percentage of the entire daytime period (07:00 to 22:00).

APPENDIX 71.1

Chin Reservoir Expansion – East Dam Traffic Impact Assessment (MPE 2025)

a division of Englobe

Final Report (Revision 1) for:

ST. MARY RIVER IRRIGATION DISTRICT

Chin Reservoir Expansion – East Dam Traffic Impact Assessment

Date: August 6, 2025
Project Number: 1520-167-00

Suite 101, 10630-172 Street
Edmonton, AB T5S 1H8
Phone: 780-486-2000

a division of Englobe

St. Mary River Irrigation District
525 40th Street South
Lethbridge, AB T1J 4M1

August 6, 2025
File: N:\1520-167-00\L01

Attention: Travis Geremia, P.Eng.
Infrastructure Engineer

Dear Mr. Geremia:

Re: Chin Reservoir Expansion - East Dam
Traffic Impact Assessment

MPE a Division of Englobe (MPE) is pleased to submit our Traffic Impact Assessment Final Report (Revision 1) in support of the proposed Chin Reservoir Expansion East Dam within SW 23-7-15-W4M and SE 23-7-15-W4M, approximately 26 kilometers (km) southeast of the Town of Taber, Alberta, and 10 km east of the existing east dam.

All traffic projections, analysis, and recommendations included herein were prepared by MPE in accordance with Alberta Transportation and Economic Corridors (TEC) and the Municipal District of Taber (MD) guidelines.

We appreciate the opportunity to provide our services for this project. Should you have any questions or require additional information, please contact the undersigned at (780) 486-2000 or jarango@mpe.ca.

Yours truly,

MPE a division of Englobe

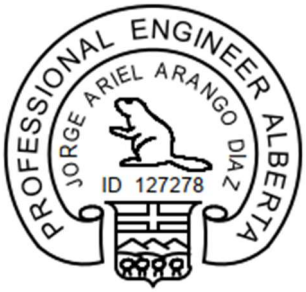
Jorge Arango, P.Eng.
Transportation Engineer

CORPORATE AUTHORIZATION

This report has been prepared by MPE a division of Englobe (MPE) under authorization of the St. Mary River Irrigation District (SMRID). The material in this report represents the best judgment of MPE given the available information. Any use that a third party makes of this report, or reliance on or decisions made based upon it is the responsibility of the third party. MPE accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken based upon this report.

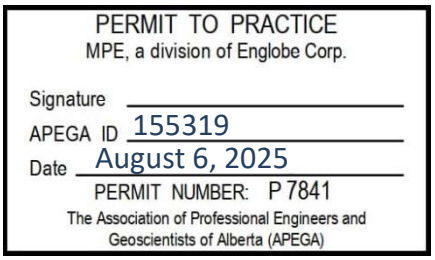
Should any questions arise regarding content of this report, please contact the undersigned.

MPE a division of Englobe (MPE).



August 6, 2025

Jorge Arango, P.Eng.



Professional Seal

Corporate Permit

EXECUTIVE SUMMARY

MPE a division of Englobe (MPE) was retained by the St. Mary River Irrigation District (SMRID) to prepare a Traffic Impact Assessment (TIA) to support the proposed Chin Reservoir Expansion East Dam. The Chin Reservoir Expansion includes the following key tasks:

- Construction of a new earth filled East Dam, 10 km east of the existing East Dam;
- Equalizing the hydraulic pressure differential across the existing East Dam and removing the existing East Dam; and
- Raising the reservoir Full Supply Level (FSL) from 861.36 m to 864.00 m, which will occur following TEC's replacement of the Hwy 36 causeway which currently transverses the existing reservoir.

The proposed development consists of four construction phases:

- Phase 1 (Dam Foundation Preparation/Initial Embankment Fill): This phase includes mobilization, temporary works, erosion control, access road construction, and foundation preparation. This phase is anticipated to begin in July 2026, with completion in November 2026.
- Phase 2 (Complete Stage 1 Embankment Fill): This phase includes auxiliary spillway excavation and embankment placement. This phase is anticipated to begin in May 2027, with completion in November 2027.
- Phase 3 (Complete Stage 2 Embankment Fill): This phase includes continuation of earthworks and gravel placement. This phase is anticipated to begin in May 2028, with completion in November 2028.
- Phase 4 (Construction Completion): This phase includes auxiliary spillway crest, gravel armour placement, and site reclamation and demobilization. This phase is anticipated to begin in May 2029, with completion in November 2029.

Reservoir filling is scheduled to begin in 2030, followed by the Old East Dam decommissioning and associated works, which are planned to occur between 2032 and 2033.

The 2029 horizon year has been identified as the peak construction period and is therefore selected as the horizon for traffic analysis. Phase 4, anticipated to be underway by 2029, is expected to generate the highest combined volumes of background traffic, construction-related truck traffic, and commuter traffic. As such, this horizon represents the worst-case scenario for traffic operations. After completion of the Chin Reservoir Expansion East Dam, no significant changes in the number of staff working at the site are anticipated; therefore, changes in current traffic patterns and volumes are not anticipated for the long-term horizon.

By Phase 4 (2029), the proposed development is anticipated to generate:

- 12 new truck trips (6 in and 6 out) during the AM and PM peak hours, and 110 new truck daily trips (55 in and 55 out), during Phase 4 by 2029. These truck trips are anticipated between the pit locations and the construction site.

- 20 new trips (10 in and 10 out) during the AM and PM peak hours, and 140 new daily trips (70 in and 70 out), during Phase 4 by 2029. These trips are anticipated between the construction site and two key urban centres (City of Lethbridge and Town of Taber).

Based on these findings, the following recommendations are made:

- It is recommended to maintain the Hwy 36 and Twp Rd 80 intersection layout to accommodate the post-development traffic conditions (temporary construction traffic).
- It is recommended to implement the following temporary mitigation measures to improve the safety and efficiency of truck operations at the intersection of Hwy 36 and Twp Rd 80:
    - Implement a temporary speed reduction of the posted speed limit to 90 kph along Hwy 36 in the vicinity of the intersection with Twp Rd 80.
    - Install temporary advance warning signage, such as a *Truck Entrance Sign (WC-8)*, to alert drivers of increased truck activity where unusual manoeuvres or geometric constraints may pose an uncommon degree of hazard.
    - Deploy temporary traffic control (TTC) measures, including flagging personnel or portable traffic signals, to facilitate one-direction-at-a-time truck movements during peak hauling operations.
    - As part of the Traffic Accommodation Strategy (TAS), provide targeted instruction to construction personnel and truck drivers regarding the geometric limitations at the intersection, and emphasize the need for staggered turning movements, ensuring that only one truck navigates the intersection at a time to avoid conflicts.
- It is recommended to contact the approving authorities to identify any further requirements as part of the development permit approval, to identify further requirements as a condition of approval. These requirements may include:
    - A Traffic Accommodation Strategy (TAS) including provisions for traffic detours and public access during the temporary construction traffic conditions (if any).
    - Mitigation measures for dust and noise control along Twp Rd 80 to minimize potential impact to the locals.
    - A pavement condition assessment on the project roadways within the Municipal District of Taber's limits.
- It is recommended that the project owner discuss road bans with the approving authorities.

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1.0 INTRODUCTION

As part of the Chin Reservoir Expansion East Dam, the St. Mary River Irrigation District (SMRID) is required to complete a provincial Environmental Impact Assessment (EIA) submission, which includes a transportation infrastructure analysis, as detailed below. The EIA transportation requirements include the following:

- Prepare a Traffic Impact Assessment as per the latest Transportation and Economic Corridors' *Traffic Impact Assessment Guidelines* (https://open.alberta.ca/publications/traffic-impact-assessment-guidelines), including the following:
    - Describe and map the project boundary, internal road network, and any existing or proposed access location to/from the provincial highway system.
    - Discuss the options considered for the proposed highway access locations and provide rationale for selecting the preferred option.
    - Discuss compatibility of the preferred option with Transportation and Economic Corridors' future highway plans.
    - Describe existing and future background traffic and development traffic, and consider the cumulative effects from other existing and planned developments that are or will be using the same highways and highway accesses.
    - Consider potential traffic impacts for all stages of the project (e.g., construction, operations, expansion, shutdown, etc.), and determine any necessary improvements to maintain the safe operation of the highway intersection and access road infrastructure.
    - Provide a schedule for undertaking the necessary improvements prior to commencing the Project.

MPE a division of Englobe (MPE) was retained by the St. Mary River Irrigation District (SMRID) to prepare a Traffic Impact Assessment (TIA) to support the proposed infrastructure development. This memo addresses the requirements for a Traffic Impact Assessment as per Alberta Transportation and Economic Corridors (TEC) and the Municipal District of Taber (MD of Taber) guidelines.

1.1 Project Details Overview

The proposed Chin Reservoir Expansion East Dam is located within SW and SE 23-7-15-W4M, approximately 26 kilometers (km) southeast of the Town of Taber, Alberta, and 10 km east of the existing East Dam. A location plan for the proposed development is provided in **Appendix A – Location and Site Plan (Figure A1)**.

The Chin Reservoir Expansion East Dam includes the following key tasks:

- Construction of a new earth filled East Dam, 10 km east of the existing East Dam;
- Equalizing the hydraulic pressure differential across the existing East Dam and removing the existing East Dam; and
- Raising the reservoir Full Supply Level (FSL) from 861.36 m to 864.00 m, which will occur following TEC's replacement of the Hwy 36 causeway which currently transverses the existing reservoir.

The proposed development consists of four construction phases:

- Phase 1 (Dam Foundation Preparation/Initial Embankment Fill): This phase includes mobilization, temporary works, erosion control, access road construction, and foundation preparation. This phase is anticipated to begin in July 2026, with completion in November 2026.
- Phase 2 (Complete Stage 1 Embankment Fill): This phase includes auxiliary spillway excavation and embankment placement. This phase is anticipated to begin in May 2027, with completion in November 2027.
- Phase 3 (Complete Stage 2 Embankment Fill): This phase includes continuation of earthworks and gravel placement. This phase is anticipated to begin in May 2028, with completion in November 2028.
- Phase 4 (Construction Completion): This phase includes auxiliary spillway crest, gravel armour placement, and site reclamation and demobilization. This phase is anticipated to begin in May 2029, with completion in November 2029.

Reservoir filling is scheduled to begin in 2030, followed by the Old East Dam decommissioning and associated works, which are planned to occur between 2032 and 2033.

After completion of the Chin Reservoir Expansion East Dam, no significant changes in the number of staff working at the site are anticipated; therefore, changes in current traffic patterns and volumes are not anticipated for the long-term horizon.

1.2 Project Boundary and Traffic Routes

The project is located within SW and SE 23-7-15-W4M, approximately 26 kilometers (km) southeast of the Town of Taber, Alberta, and 10 km east of the existing east dam. The access point to the construction site will be via an extension of Range Road 152, extending 750 m south to the rim of Chin Coulee.

At this time, the specific locations of the material source pits to be utilized during the various phases of construction have not been confirmed. However, it is anticipated that the most viable options will be pits situated to the north and south of the construction site, both with access to Highway 36 (Hwy 36). For the purposes of this analysis, it is assumed that two material pits (designated as the North Pit and the South Pit) will be employed, each connecting to Hwy 36. Additionally, It is also assumed that construction personnel will primarily originate from, or be destined for, the Town of Taber and the City of Lethbridge.

The construction truck traffic routes and commuting route have been selected based on the most direct travel corridors, considering factors such as travel time, the existing road network, and the potential capacity of the infrastructure to accommodate the construction-related and commuting traffic volumes. A review of collision history and Intersection Sight Distances (ISD) along these routes is provided in subsequent sections. Moreover, the selected routes offer direct connectivity within the MD of Taber road network, thereby minimizing reliance on and potential impacts to lower-classified secondary roadways.

Based on the project assumptions, the following road segments are anticipated to be part of the truck traffic routes to provide materials from the North and South Pits to the Chin Reservoir construction site, and to the commuting traffic route for the construction personnel, as illustrated in **Appendix A – Site Location and Transportation Network (Figure A2)**.

- Truck Traffic Route from the North Pit to the construction site:
  - Highway 36 (southbound) to Township Road 80.
  - Township Road 80 (eastbound) from Highway 36 to Range Road 152 (approx. 16.3 km).
  - Range Road 152 (southbound) to the construction site (approx. 3.2 km).

- Truck Traffic Route from the South pit to the construction site:
  - Highway 36 (northbound) to Township Road 80.
  - Township Road 80 (eastbound) from Highway 36 to Range Road 152 (approx. 16.3 km).
  - Range Road 152 (southbound) to the construction site (approx. 3.2 km).

- Commuting Route for site personnel to the construction site from or through the Town of Taber or the City of Lethbridge:
  - Highway 36 (southbound) to Township Road 80.
  - Township Road 80 (eastbound) from Highway 36 to Range Road 152 (approx. 16.3 km).
  - Range Road 152 (southbound) to the construction site (approx. 3.2 km).

Based on the above information, the roadways that are expected to accommodate project-related truck traffic and commute traffic are Highway 36, Township Road 80, and Range Road 152. In addition, the intersection of Highway 36 and Township Road 80 (Hwy 36 and Twp Rd 80) is anticipated as the study intersection for traffic analysis during the weekday AM and PM peak hours.

Weekday morning (AM) and afternoon (PM) peak hours were identified as the hours of interest for traffic operation analysis and are assessed accordingly in this study. Estimates of daily traffic volumes are also provided.

Considering the proposed construction phasing outlined in Section 1.1 and based on input from the project manager, the 2029 horizon year has been identified as the peak construction period and is therefore selected as the horizon for traffic analysis. Phase 4, anticipated to be underway by 2029, is expected to generate the highest combined volumes of background traffic, construction-related truck traffic, and commuter traffic. As such, this horizon represents the worst-case scenario for traffic operations.

After completion of the Chin Reservoir Expansion East Dam, no significant changes in the number of staff working at the site are anticipated; therefore, changes in current traffic patterns and volumes are not anticipated for the long-term horizon.

2.0 EXISTING CONDITIONS

2.1 Existing Transportation Network

Characteristics of the existing transportation network were observed with data collected from Google Earth, as well as gathered from TEC's Transportation Infrastructure Management System (TIMS) and the MD of Taber Regional GIS and Wall Map. The existing transportation network consists of Provincial and Municipal highways and roads. The following roads are considered part of the study area and are described briefly.

- **Highway 36:2 (Hwy 36)** is a two-lane undivided highway connecting the Town of Taber to Highway 4 near the Village of Warner, Alberta. This highway is classified as a Major Rural Arterial Undivided (RAU) roadway, with a Level 2 service classification. The posted speed limit is 100 kph. The typical two-lane cross-section of Hwy 36:2 has a measured width of 10.0 m.
    - ***Highway 36 and Township Road 80 (Hwy 36 and Twp Rd 80):*** is a four-leg unsignalized intersection with stop signs on both the east and west legs of Twp Rd 80. The intersection layout includes one shared left-turn/through/right-turn lane on all approaches. The geometry of this intersection most resembles TEC's S*tandard Type I-b* intersection treatment.
- **Township Road 80 (Twp Rd 80)** is an undivided gravel rural roadway under the jurisdiction of the MD of Taber. The posted speed limit is 80 kph. The typical two-lane cross-section of Twp Rd 80 has a road width of approximately 8.5 m.
- **Range Road 152 (RR 152)** is an undivided gravel rural road under the jurisdiction of the MD of Taber. The posted speed limit is 80 kph. The typical two-lane cross-section of RR 152 has a road width of approximately 9.0 m.

The existing lane configuration and traffic controls for the study intersection are illustrated in **Appendix B – Traffic Diagrams**.

2.2 Existing Traffic Characteristics

Traffic data is available for the intersection of Hwy 36 and Twp Rd 80 based on 12-hour Turning Movement Counts (TMC) from 7:00 AM to 7:00 PM conducted by TEC. The turning movement summary diagrams provide estimates of Annual Average Daily Traffic (AADT), Design Hour Volumes (DHV) for the AM and PM peak hour, and vehicle classification data.

Historical traffic growth rates on Hwy 36 around the study area were obtained from TEC's Transportation Infrastructure Management System (TIMS) and are listed in **Table 2.1**. Based on this, a non-compound annual growth rate of 2.00% was selected for the study intersection to forecast background traffic growth. TIMS's Traffic growth reports are provided in **Appendix C – Traffic Data**.

Table 2.1: Growth Rate

Roadway	Growth Rate			
	Historical 20-Year Linear Regression	Historical 10-Year Linear Regression	Historical 5-Year Linear Regression	*Selected for Traffic Projections 20-Year*
Hwy 36:02 (ATR 60360450)	0.02%	0.34%	2.10%	***2.00%***
Hwy 36:02 (ATR 60360260)	0.27%	-2.11%	3.33%	***2.00%***

2.3 Historical Collision Data Review

Collision data was obtained for the study area intersection from the TIMS Network Expansion Support System (NESS) for the years 2016 to 2020, which is the most recent period that collision data was released by TEC. Collision rates for the intersection were compared to provincial benchmark values that were established by TEC using statistical analyses of collision rates at similar intersections around the province. When the actual collision rate exceeds the benchmark value, the risk of collision at an intersection is recognized as being significant, and it is advisable to perform a more detailed safety assessment. Historical collision rates for each study area intersection are summarized in **Table 2.2 – Historical Collision Rates, 2016 to 2020**. Detailed collision summaries are provided in **Appendix C – Traffic Data.**

Table 2.2: Historical Collision Rates, 2016 to 2020

Intersection	Collision Statistic	Actual	Benchmark	Deltas	Safety Issue
Hwy 36 and Twp Rd 80 (Unsignalized)	Total Rate	71.224	233.7	162.5	***No***
	Non-animal Rate	71.224	227.9	156.7	
	Collision Cost ($ x M)	0.006	0.246	0.24	

1. Results are shown in **bold and red** where the 'actual' value exceeds the provincial benchmark value.

At the study intersection, one collision was reported for the years 2016-2020, and collision rates were found to be below the provincial benchmark, with frequency and collision costs below the provincial benchmark.

2.4 Sight Distance Review

Adequate sight distances are critical for safe traffic operations. A site review of the Intersection Sight Distance (ISD) requirements for the study intersection was conducted in accordance with methods outlined in the TEC Highway Geometric Design Guide[1]. ISD is the minimum sight distance required along the main road to permit a vehicle stopped on the minor road approach to safely make a left turn onto the major road. ISD measurements should be made based on the vehicle with the greatest ISD requirement that is expected to use the intersection daily. A semitrailer combination (WB-23) was selected as the design vehicle for the study intersection.

[1] Alberta Transportation and Economic Corridors, (1999). Highway Geometric Design Guide. Edmonton, AB.

Figure 2.1 shows a WB-23 and WB-21 design vehicle, complete with key design dimensions. ISD was also checked for the single unit truck (SU) and passenger car (P) design vehicles. The design speed for the highway was assumed to be 10 km/h higher than the posted speed.

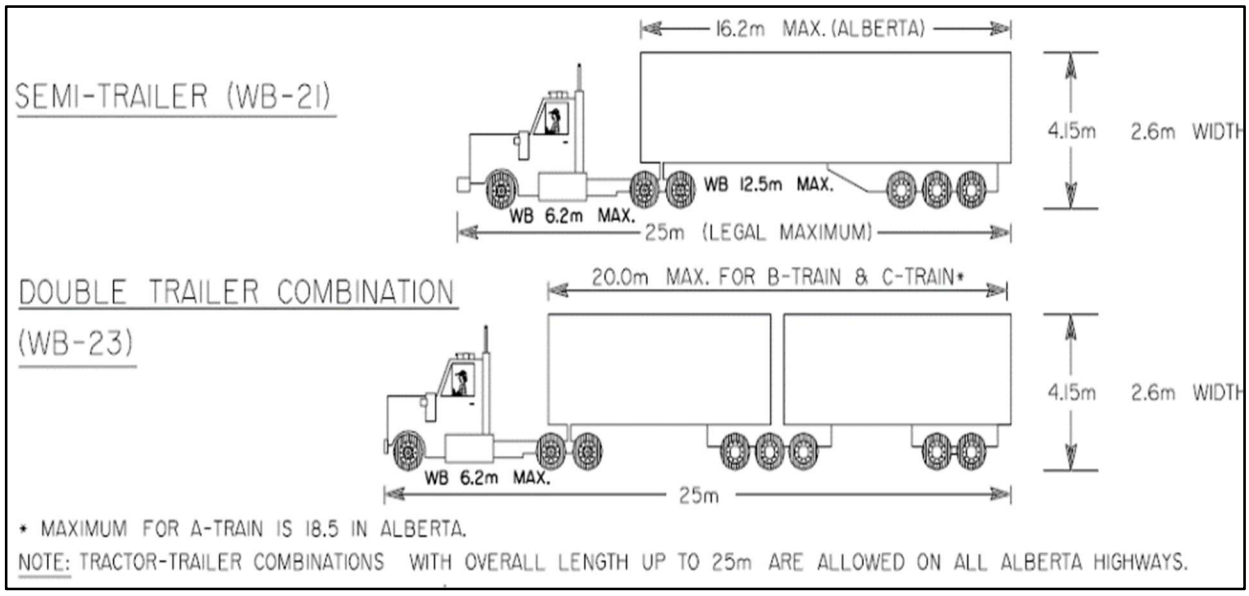


Figure 2.1: Semitrailer Combination (WB-21 and WB-23) Design Vehicle

Table 2.3: Intersection Sight Distance (ISD)

Intersection	Major Road (Design Speed)	Design Vehicle on Minor Road	Intersection Sight Distance		Sufficient?
			Required	Available	
Hwy 36 and Twp Rd 80	Hwy 36 (110 km/h)	P	215 m	N ≥ 615 m	*Yes*
				S ≥ 565 m	*Yes*
		SU	325 m	N ≥ 665 m	*Yes*
				S ≥ 565 m	*Yes*
		WB-21/WB-23	565 m	N ≥ 615 m	*Yes*
				S ≥ 565 m	*Yes*

As shown in **Table 2.3 – Intersection Sight Distance (ISD)**, the minimum ISD requirements are met at the study intersection of Hwy 36 and Twp Rd 80 on both the north and south approaches for all design vehicles, including private vehicles, single-unit trucks, and WB-21/WB-23 trucks. However, it is noted that the available ISD on the south approach seems to be marginally compliant with the minimum requirement for WB-21/WB-23 design vehicles. This limitation is primarily due to the presence of a horizontal curve combined with a northbound ascending grade, which restricts the available sight distances.

Mitigation measures are already in place to enhance road safety performance at the horizontal curve including a reduction of the posted speed limit along Hwy 36 from 100 kph to 90 kph approximately 465 m south of the intersection of Hwy 36 and Twp Rd 80; a *Left-turn Curve Warning Sign (WA-3-L)* installed for the northbound traffic approximately 1.10 km south of the Hwy 36 and Twp Rd 80 intersection; and a *Hill Warning Sign (WA-21)* installed for the southbound traffic approximately 580 m south of the Hwy 36 and Twp Rd 80 intersection.

No further mitigation measurements are recommended based on the ISD review at this time. A sight distance worksheet is provided in **Appendix D – Sight Distance Review**.

3.0 TRAFFIC VOLUMES

3.1 Background Traffic

The volume of traffic on the road network adjacent to the construction site will change over time whether the proposed development is constructed or not. Establishing background traffic volumes provides a baseline for comparison with post-development (construction) traffic conditions, which in this case only includes the temporary proposed development's construction traffic. Background traffic volumes associated with the 2029 study horizon were developed and are shown in **Appendix B – Traffic Diagrams**.

3.2 Site Traffic (Construction Traffic)

Due to the nature of the proposed infrastructure development where the anticipated construction traffic is temporal, it can be expected that traffic volumes on Hwy 36 and Twp Rd 80 will change temporarily from the background traffic data during the construction phases. To accurately estimate the movement and orientation of new vehicles entering/exiting the proposed development site, information regarding the anticipated construction material supply plan and the anticipated construction schedule were used to estimate temporary site traffic.

The anticipated truck traffic during Phase 4 includes daily movement of materials between two pit locations and the construction site. A total of approximately 770,000 tonnes of construction material is expected to be hauled from the pit locations to the construction site, during Phase 1 to Phase 4. It is estimated that approximately 22,000 truck trips will be required throughout the project (based on 35-tonne trucks), excluding any contingency allowance. The estimated duration for the transportation of materials from the pit sources to the site is approximately 26 months. The higher number of truck daily trips is anticipated during Phase 4, with an estimated 55 truck-trips in and 55 truck-trips out daily. Furthermore, 10% of the truck daily trips are anticipated during each peak hour, or approximately 6 trucks in and 6 trucks out during each of the AM and PM peak hours.

Regarding the construction personnel traffic, it is anticipated that approximately 50 people will be on site, including engineers and project management staff. The construction work-day schedule is from 7:00 AM to 6:00 PM. However, most of the construction personnel (approximately 30 people) are anticipated to arrive and leave the site before the AM peak hour and after the PM peak hour, respectively. The remaining personnel are expected to arrive and leave throughout the day as part of general construction-related traffic. In addition, it was assumed that an additional 20 entering and 20 exiting vehicle trips will occur during a typical day. Therefore, for the purpose of this analysis, a conservative estimate of 10 entering and 10 exiting vehicles during each the AM and PM peak hour is assumed.

Based on these assumptions, the proposed development is anticipated to generate:

- 12 new truck trips (6 in and 6 out) during the AM and PM peak hours, and 110 new truck daily trips (55 in and 55 out), during Phase 4 by 2029. These truck trips are anticipated between the pit locations and the construction site.

- 20 new trips (10 in and 10 out) during the AM and PM peak hours, and 140 new daily trips (70 in and 70 out), during Phase 4 by 2029. These trips are anticipated between the construction site and two key urban centres (City of Lethbridge and Town of Taber).

3.2.1 Construction Traffic Distribution

The specific locations of the material source pits to be utilized during the various phases of construction have not been confirmed. However, it is anticipated that the most viable options will be pits situated to the north and south of the construction site, both with access to Highway 36 (Hwy 36). For the purposes of this analysis, it is assumed that two material pits (designated as the North Pit and the South Pit) will be employed, each connecting to Hwy 36. In addition, three haul options were considered for how construction truck traffic is distributed across the road network, as follows:

- Option 1: Construction materials are hauled only from the North Pit.
- Option 2: Construction materials are hauled only from the South Pit.
- Option 3: Construction materials are hauled equally from both pits (50/50 distribution).

Finally, it is assumed that most personnel traffic will come from and/or through the City of Lethbridge and the Town of Taber.

The assumed trip distribution for the construction truck traffic and construction personnel traffic is illustrated on **Appendix E – Construction Traffic Distribution.** Trip distribution details are provided in **Appendix B – Traffic Diagrams**. For the purpose of traffic forecasting, the high end of the trip generation range has been assumed.

3.3 Post-Development Traffic (Construction Traffic)

2029 post-development traffic volumes were obtained by combining site traffic (construction truck traffic and construction personnel traffic) with background traffic and are representative of traffic conditions at the proposed development during the construction stage. It is noted that after the completion of the Chin Reservoir Expansion, no significant changes to the number of staff working at the site is anticipated and the traffic volumes and traffic patterns are anticipated to return to those observed for the background traffic. Post-development traffic volumes associated with the 2029 study horizon are shown in **Appendix B – Traffic Diagrams**.

4.0 TRAFFIC ANALYSIS

4.1 Turn Lane Warrant Review

Turn lane warrant analysis was undertaken in accordance with the TEC Highway Geometric Design Guide. Typically, the purpose of a turn lane warrant analysis is to determine the appropriate left and right turn treatment for the study intersection based on the study horizon traffic conditions. It is noted that in this case, the 2029 post-development traffic conditions are temporary, and traffic volumes will resume to background traffic conditions after construction is completed. A schematic drawing showing standard TEC intersection treatments along with detailed worksheets for the turn lane analysis are provided in **Appendix F – Turn Lane Warrants**. Turn warrant analysis was undertaken for the 2029 post-development traffic conditions (construction traffic) assuming the existing traffic controls remain unchanged.

4.1.1 Left Turn Warrant

The left turn warrant considers the operational and safety impacts of left turning vehicles on the highway. When making a left turn onto the side street, a turning vehicle may be delayed by a vehicle or vehicles in the opposing stream. Through vehicles in the advancing stream following the left turning vehicle may be delayed by, or exposed to, a collision with the turning vehicle. The interference caused by the standing left turning vehicles in the through advancing traffic can reduce capacity and create a safety hazard. Therefore, inputs in the left turn warrant include the opposing volume, advancing volume, and the number of left-turning vehicles.

Table 4.1: Left Turn Warrant Summary

Intersection	Movement	Analysis Period	Traffic Conditions	Left Turn Warrant [2]	Additional Storage (m)	
					S	St
Hwy 36 and Twp Rd 80	SB-L	2029	PD Opt01	**Type I**	N/A	N/A
			PD Opt02	**Type I**	N/A	N/A
			PD Opt03	**Type I**	N/A	N/A

EB = Eastbound; **WB** = Westbound; **NB** = Northbound; **SB** = Southbound; **L** = Left; **T** = Through; **R** = Right; **BG** = Background; **PD** = Post-Development; **N/A** = Not Applicable; **S** = Additional storage length required in addition to the standard storage length provided in a Type IV intersection treatment; $\mathbf{S_t}$ = Additional storage length required for trucks for a Type IV intersection treatment.

1. Results are shown in **bold and red** where the warrant indicates that the existing left-turn treatment is inadequate and may require improvements.
2. Left-Turn Warrant based on peak hour volumes (ATEC Highway Geometric Design Guide, D-7.6 figures).

As shown in **Table 4.1 – Left Turn Warrant Summary** for the study intersection, an upgrade to the existing left-turn treatments is not warranted under 2029 post-development (construction) traffic conditions. Further upgrades to the current intersection layout are not anticipated based on the additional temporary construction traffic by 2029.

4.1.2 Right Turn Warrant

Right turning vehicles can cause interference to through movements in the advancing lane as they decelerate and turn. To warrant an exclusive right turn lane at a two-lane highway intersection in Alberta, the following three conditions must all be met:

1. Main (or through) road AADT ≥ 1800
2. Intersecting road AADT ≥ 900
3. Right turn daily traffic volume ≥ 360 for the movement in question

As with the left turn warrant analysis, it was assumed that the existing traffic controls remain in place for the analysis period. Results of the analysis are summarized in **Table 4.2 – Right Turn Warrant Summary**.

Table 4.2: Right Turn Warrant Summary

Intersection	Movement	Analysis Period	Traffic Conditions	Right Turn Warrant Met
Hwy 36 and Twp Rd 80	NB-R	2029	PD R01	***No***
			PD R02	***No***
			PD R03	***No***
	SB-R	2029	PD R01	***No***
			PD R02	***No***
			PD R03	***No***

***EB** = Eastbound; **WB** = Westbound; **NB** = Northbound; **SB** = Southbound; **L** = Left; **T** = Through; **R** = Right*

Results are shown in **bold and red** where the warrant indicates that the existing right turn treatment is inadequate and may require improvements.

Assuming that existing traffic controls remain in place at the study intersection, upgrades to the current intersection layout to provide auxiliary right-turn lanes are not warranted for the study intersection under 2029 post-development traffic conditions (temporary construction traffic).

5.0 SWEPT PATH ANALYSIS

A swept path analysis was conducted for the study intersection of Hwy 36 and Twp Rd 80 to confirm if the intersection layout can accommodate the anticipated design vehicle. The intersection geometry most resembles TEC's *Standard Type I-b* intersection treatment and connects the Provincial with the MD road network. This analysis simulates the turning movements of the design vehicle to ensure it can maneuver through the intersection. A semitrailer combination (WB-23) was selected as the design vehicle for the analysis. For the analysis, inbound trips are those trips moving from the pit to the construction site, while outbound trips are the opposite. A schematic drawing showing the swept path analysis is provided in **Appendix G – Swept Path Analysis**.

The analysis shows that the design vehicle can turn at the study intersection, although there is an overlap on the opposite lane in one case. Allowing only one direction at a time (either inbound or outbound) at each intersection may improve vehicle accommodation. The swept path analysis at the intersection of Hwy 36 and Twp Rd 80 indicated the following:

- For the design vehicle from/to the North Pit, both the inbound trips (southbound left-turn from Hwy 36 on to Twp Rd 80) and the outbound trips (westbound right-turn from Twp Rd 80 on to Hwy 36) are accommodated with a minor overlapping.
- For the design vehicle from/to the South Pit, the inbound trips (northbound right-turn from Hwy 36 on to Twp Rd 80) require overlapping the opposite lane at Twp Rd 80. Similarly, the outbound trips (westbound left-turn from Twp Rd 80 on to Hwy 36) require overlapping the opposite lane at Hwy 36.

Based on the results of the swept path analysis, the following temporary mitigation measures are recommended to improve the safety and efficiency of truck operations at the intersection of Hwy 36 and Twp Rd 80:

- Implement a temporary speed reduction of the posted speed limit to 90 kph along Hwy 36 in the vicinity of the intersection with Twp Rd 80.
- Install temporary advance warning signage, such as a *Truck Entrance Sign (WC-8)*, to alert drivers of increased truck activity where unusual manoeuvres or geometric constraints may pose an uncommon degree of hazard.
- Deploy temporary traffic control (TTC) measures, including flagging personnel or portable traffic signals, to facilitate one-direction-at-a-time truck movement during peak hauling operations.
- As part of the Traffic Accommodation Strategy (TAS), provide targeted instruction to construction personnel and truck drivers regarding the geometric limitations at the intersection, and emphasize the need for staggered turning movements, ensuring that only one truck navigates the intersection at a time to avoid conflicts.

6.0 OTHER CONSIDERATIONS

The following items are identified for future consideration:

- This project requires a development permit approval by the approving authorities (the Municipal District of Taber and Alberta Transportation and Economic Corridors). At the time of submitting the development permit, both approving authorities must be contacted to identify any further requirements as a condition for approval (if any).
- A Traffic Accommodation Strategy (TAS) including provisions for traffic detours and public access during the temporary construction traffic conditions (if any) may be required by the approving authorities.
- Mitigation measures for dust and noise control along Twp Rd 80 to minimize potential impact to the locals may be required by the approving authorities.
- A pavement condition assessment on the project roadways within the Municipal District of Taber's limits may be required to ensure roadway structures are adequate for the anticipated construction traffic.
- The project owner should discuss road bans with the approving authorities.

7.0 CONCLUSIONS

7.1 Findings

Key findings of the study are as follows:

- Intersection Geometry:
  - The geometry of the Hwy 36 and Twp Rd 80 intersection most resembles that of TEC's *Standard Type I-b* intersection treatment.
- Intersection Sight Distance:
  - Minimum requirements for Intersection Sight Distance (ISD) are met at the study intersection of Hwy 36 and Twp Rd 80 on both the north and south approaches for all design vehicles, including private vehicles, single-unit trucks, and WB-21/WB-23 trucks. It is noted that the available ISD on the south approach seems to be marginally compliant with the minimum requirement for WB-21/WB-23 design vehicles. This limitation is primarily due to the presence of a horizontal curve combined with a northbound ascending grade, which restricts the available sight distances. Existing mitigation measures include reduction of the posted speed limit along Hwy 36 from 100 kph to 90 kph approximately 465 m south of the intersection of Hwy 36 and Twp Rd 80; a *Left-turn Curve Warning Sign (WA-3-L)* installed for the northbound traffic approximately 1.10 km south of the Hwy 36 and Twp Rd 80 intersection; and a *Hill Warning Sign (WA-21)* installed for the southbound traffic approximately 580 m south of the Hwy 36 and Twp Rd 80 intersection. No further mitigation measurements are recommended at this time.
- Historical Collision Data Review:
  - Collision rates were found to be below the provincial benchmark, with frequency and collision costs well below the provincial benchmark for the study intersection.
- Traffic Volumes (Temporary Construction Traffic):
  - The proposed development is anticipated to generate similar traffic volumes consistently across all construction phases from 2026 to 2029; however, the peak of construction traffic is anticipated by Phase 4 in 2029.
  - After completion of the Chin Reservoir Expansion East Dam, no significant changes in the number of staff working at the site are anticipated; therefore, changes in current traffic patterns and volumes are not anticipated for the long-term horizon.
  - By Phase 4 (2029), the proposed development is anticipated to generate:
    - 12 new truck trips (6 in and 6 out) during the AM and PM peak hours, and 110 new truck daily trips (55 in and 55 out), during Phase 4 by 2029. These truck trips are anticipated between the pit locations and the construction site.
    - 20 new trips (10 in and 10 out) during the AM and PM peak hours, and 140 new daily trips (70 in and 70 out), during Phase 4 by 2029. These trips are anticipated between the construction site and two key urban centres (City of Lethbridge and Town of Taber).

- Turn Lane Warrant Analysis:
  - Upgrades to the current intersection layout to provide auxiliary right-turn or left-turn lanes are not warranted for the intersection of Hwy 36 and Twp Rd 80 under 2029 post-development traffic conditions (temporary construction traffic).
- Swept Path Analysis:
  - For the design vehicle from/to the North Pit, both the inbound trips (southbound left-turn from Hwy 36 on to Twp Rd 80) and the outbound trips (westbound right-turn from Twp Rd 80 on to Hwy 36) are accommodated with a minor overlapping.
  - For the design vehicle from/to the South Pit, the inbound trips (northbound right-turn from Hwy 36 on to Twp Rd 80) require overlapping the opposite lane at Twp Rd 80. Similarly, the outbound trips (westbound left-turn from Twp Rd 80 on to Hwy 36) require overlapping the opposite lane at Hwy 36.
  - Potential countermeasures include: (a) temporary speed reduction; (b) advance warning signage; (c) temporary traffic control (TTC), and (d) driver awareness and coordination.
- Other Considerations:
  - This project requires a development permit approval by the approving authorities (the Municipal District of Taber and Alberta Transportation and Economic Corridors). Both authorities must be contacted at the time of submitting the development permit.
  - A Traffic Accommodation Strategy (TAS) may be required by the approving authorities.
  - Mitigation measures for dust and noise control along Twp Rd 80 to minimize potential impact to the locals may be required by the approving authorities.
  - A pavement condition assessment on the M.D.'s project roadways may be required.
  - The project owner should discuss road bans with the approving authorities.

7.2 Recommendations

Based on these findings, the following recommendations are made:

- It is recommended to maintain the Hwy 36 and Twp Rd 80 intersection layout to accommodate the post-development traffic conditions (temporary construction traffic).
- It is recommended to implement the following temporary mitigation measures to improve the safety and efficiency of truck operations at the intersection of Hwy 36 and Twp Rd 80:
  - Implement a temporary speed reduction of the posted speed limit to 90 kph along Hwy 36 in the vicinity of the intersection with Twp Rd 80.
  - Install temporary advance warning signage, such as a *Truck Entrance Sign (WC-8)*, to alert drivers of increased truck activity where unusual manoeuvres or geometric constraints may pose an uncommon degree of hazard.

  - Deploy temporary traffic control (TTC) measures, including flagging personnel or portable traffic signals, to facilitate one-direction-at-a-time truck movements during peak hauling operations.
  - As part of the Traffic Accommodation Strategy (TAS), provide targeted instruction to construction personnel and truck drivers regarding the geometric limitations at the intersection and emphasize the need for staggered turning movements, ensuring that only one truck navigates the intersection at a time to avoid conflicts.

- It is recommended to contact the approving authorities to identify any further requirements as part of the development permit approval, to identify further requirements as condition of approval. These requirements may include:
  - A Traffic Accommodation Strategy (TAS) including provisions for traffic detours and public access during the temporary construction traffic conditions (if any).
  - Mitigation measures for dust and noise control along Twp Rd 80 to minimize potential impact to the locals.
  - A pavement condition assessment on the project roadways within the Municipal District of Taber's limits
- It is recommended that the project owner discuss road bans with the approving authorities.

APPENDIX A

Location and Site Plan

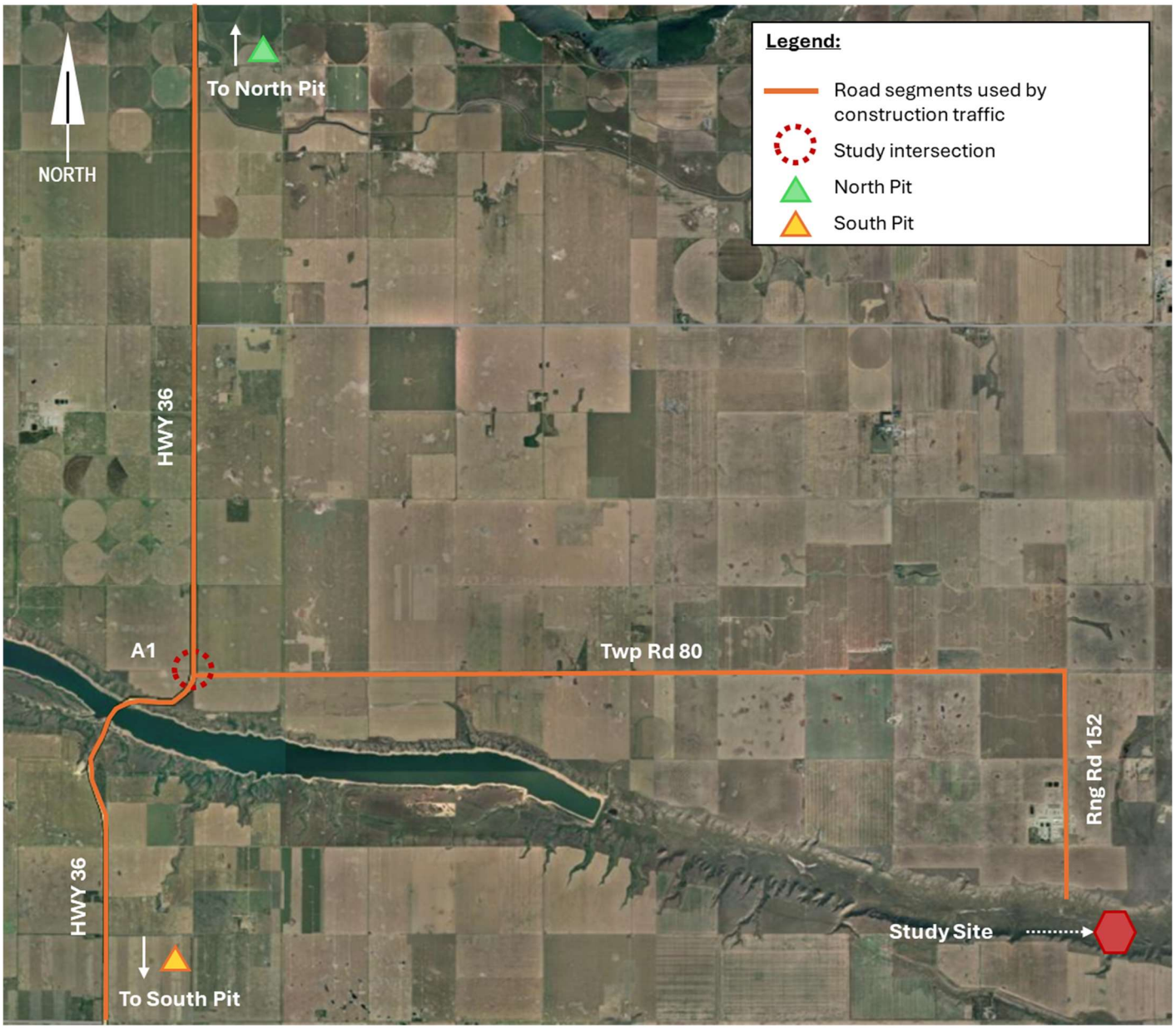


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ST. MARY IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION – EAST DAM
TRAFFIC IMPACT ASSESSMENT
LOCATION AND SITE PLAN

SCALE: NTS	DATE: July 18, 2025	JOB: 1520-167-00	FIGURE: A1



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ST. MARY IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION – EAST DAM
TRAFFIC IMPACT ASSESSMENT
LOCATION AND SITE PLAN

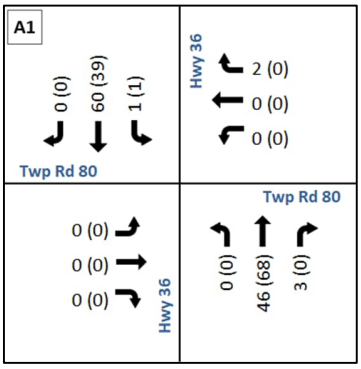
SCALE: NTS	DATE: July 18, 2025	JOB: 1520-167-00	FIGURE: A2

APPENDIX B

Traffic Diagrams

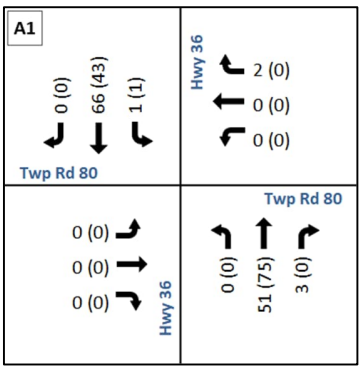
Format for traffic volumes is **AM PEAK HOUR (PM PEAK HOUR)**

2024 EXISTING TRAFFIC:



AADT Estimates	Intersection	South	North	West	East
	A1	940	970	20	90

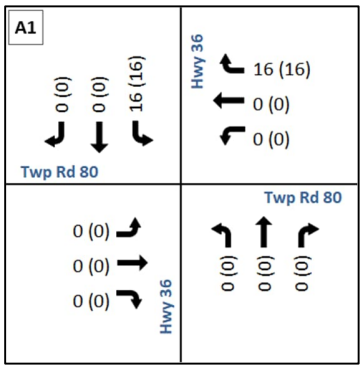
2029 BACKGROUND TRAFFIC:



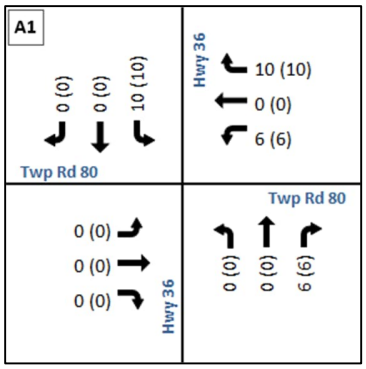
AADT Estimates	Intersection	South	North	West	East
	A1	1030	1070	20	100

SITE TRAFFIC

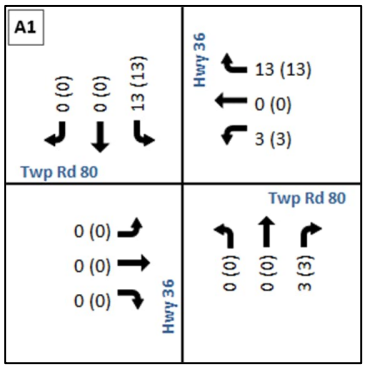
2029 HORIZON – SITE TRIPS (OPTION 1):



2029 HORIZON – SITE TRIPS (OPTION 2):

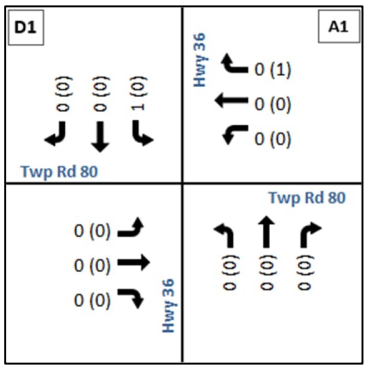


2029 HORIZON – SITE TRIPS (OPTION 3):

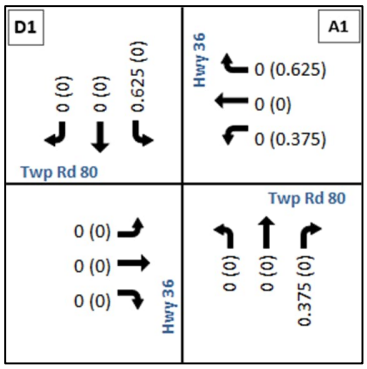


TRIP DISTRIBUTION

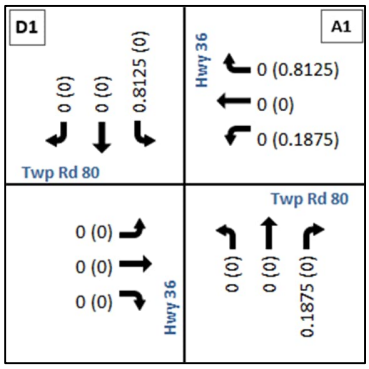
2029 HORIZON – SITE TRIPS (OPTION 1):



2029 HORIZON – SITE TRIPS (OPTION 2):

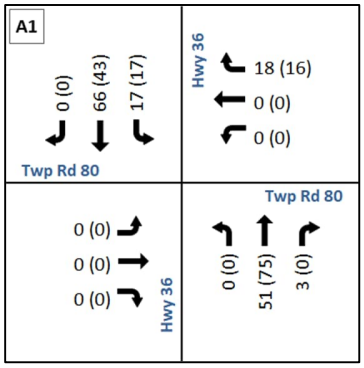


2029 HORIZON – SITE TRIPS (OPTION 3):



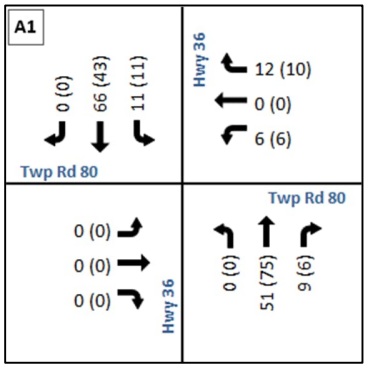
2029 POST-DEVELOPMENT TRAFFIC (WITH CONSTRUCTION TRAFFIC)

OPTION 1



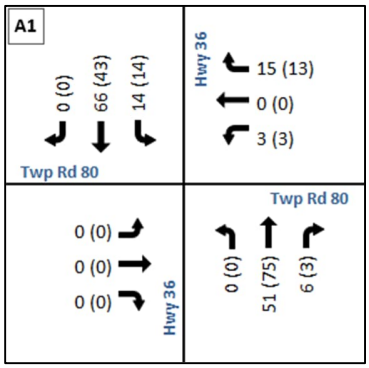
AADT Estimates	Intersection	South	North	West	East
	A1	1030	1320	20	350

OPTION 2



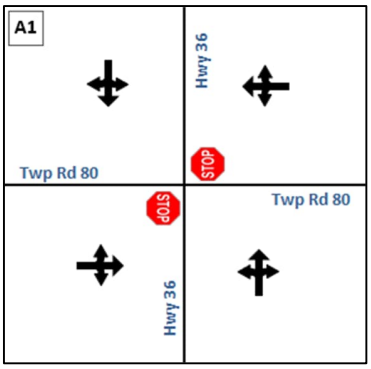
AADT Estimates	Intersection	South	North	West	East
	A1	1140	1210	20	350

OPTION 3



AADT Estimates	Intersection	South	North	West	East
	A1	1090	1260	20	350

INTERSECTION LAYOUT AND TRAFFIC CONTROL



TRAFFIC VOLUMES

A1: HIGHWAY 36 AND TOWNSHIP ROAD 80 (OPTION 1)

Horizon Year	Type of Trip	Time Period	Movement Volumes												Intersection Leg ADT Estimates			
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR	South	North	West	East
2024 Existing	Existing	AM Peak	0	46	3	1	60	0	0	0	0	0	0	2	109	109	0	6
		PM Peak	0	68	0	1	39	0	0	0	0	0	0	0	107	108	0	1
		Weekday	0	460	10	30	460	0	0	0	0	10	20	20	940	970	20	90
2025	Background	AM Peak	0	47	3	1	61	0	0	0	0	0	0	2	111	111	0	6
		PM Peak	0	69	0	1	40	0	0	0	0	0	0	0	109	110	0	1
		Weekday	0	469	10	31	469	0	0	0	0	10	20	20	960	990	20	90
2029	Background	AM Peak	0	51	3	1	66	0	0	0	0	0	0	2	120	120	0	6
		PM Peak	0	75	0	1	43	0	0	0	0	0	0	0	118	119	0	1
		Weekday	0	506	11	33	506	0	0	0	0	11	22	22	1030	1070	20	100
	Site Trips	AM Peak	0	0	0	16	0	0	0	0	0	0	0	16	0	32	0	32
		PM Peak	0	0	0	16	0	0	0	0	0	0	0	16	0	32	0	32
		Weekday	0	0	0	125	0	0	0	0	0	0	0	125	0	250	0	250
	Post-Development	AM Peak	0	51	3	17	66	0	0	0	0	0	0	18	120	152	0	38
		PM Peak	0	75	0	17	43	0	0	0	0	0	0	16	118	151	0	33
		Weekday	0	506	11	158	506	0	0	0	0	11	22	147	1030	1320	20	350

A1: HIGHWAY 36 AND TOWNSHIP ROAD 80 (OPTION 2)

Horizon Year	Type of Trip	Time Period	Movement Volumes												Intersection Leg ADT Estimates			
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR	South	North	West	East
2024 Existing	Existing	AM Peak	0	46	3	1	60	0	0	0	0	0	0	2	109	109	0	6
		PM Peak	0	68	0	1	39	0	0	0	0	0	0	0	107	108	0	1
		Weekday	0	460	10	30	460	0	0	0	0	10	20	20	940	970	20	90
2025	Background	AM Peak	0	47	3	1	61	0	0	0	0	0	0	2	111	111	0	6
		PM Peak	0	69	0	1	40	0	0	0	0	0	0	0	109	110	0	1
		Weekday	0	469	10	31	469	0	0	0	0	10	20	20	960	990	20	90
2029	Background	AM Peak	0	51	3	1	66	0	0	0	0	0	0	2	120	120	0	6
		PM Peak	0	75	0	1	43	0	0	0	0	0	0	0	118	119	0	1
		Weekday	0	506	11	33	506	0	0	0	0	11	22	22	1030	1070	20	100
	Site Trips	AM Peak	0	0	6	10	0	0	0	0	0	6	0	10	12	20	0	32
		PM Peak	0	0	6	10	0	0	0	0	0	6	0	10	12	20	0	32
		Weekday	0	0	55	70	0	0	0	0	0	55	0	70	110	140	0	250
	Post-Development	AM Peak	0	51	9	11	66	0	0	0	0	6	0	12	132	140	0	38
		PM Peak	0	75	6	11	43	0	0	0	0	6	0	10	130	139	0	33
		Weekday	0	506	66	103	506	0	0	0	0	66	22	92	1140	1210	20	350

A1: HIGHWAY 36 AND TOWNSHIP ROAD 80 (OPTION 3)

Horizon Year	Type of Trip	Time Period	Movement Volumes												Intersection Leg ADT Estimates			
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR	South	North	West	East
2024 Existing	Existing	AM Peak	0	46	3	1	60	0	0	0	0	0	0	2	109	109	0	6
		PM Peak	0	68	0	1	39	0	0	0	0	0	0	0	107	108	0	1
		Weekday	0	460	10	30	460	0	0	0	0	10	20	20	940	970	20	90
2025	Background	AM Peak	0	47	3	1	61	0	0	0	0	0	0	2	111	111	0	6
		PM Peak	0	69	0	1	40	0	0	0	0	0	0	0	109	110	0	1
		Weekday	0	469	10	31	469	0	0	0	0	10	20	20	960	990	20	90
2029	Background	AM Peak	0	51	3	1	66	0	0	0	0	0	0	2	120	120	0	6
		PM Peak	0	75	0	1	43	0	0	0	0	0	0	0	118	119	0	1
		Weekday	0	506	11	33	506	0	0	0	0	11	22	22	1030	1070	20	100
	Site Trips	AM Peak	0	0	3	13	0	0	0	0	0	3	0	13	6	26	0	32
		PM Peak	0	0	3	13	0	0	0	0	0	3	0	13	6	26	0	32
		Weekday	0	0	28	98	0	0	0	0	0	28	0	98	60	200	0	250
	Post-Development	AM Peak	0	51	6	14	66	0	0	0	0	3	0	15	126	146	0	38
		PM Peak	0	75	3	14	43	0	0	0	0	3	0	13	124	145	0	33
		Weekday	0	506	39	131	506	0	0	0	0	39	22	120	1090	1260	20	350

APPENDIX C

Traffic Data

Roadway Summary

Segments included within the Report

LRS	Length
36:02 C1 34.000 - 44.000	10.000
Total	**10.000**

Length of Roadway (in Km) by Service Class

Service Class	Length
LV 2	10.000

Length of Paved and Gravel Roads (in Km)

Surface	Length
PAVED	10.000
Total	10.000

Collision Summary for years 2016-2020

	Total	Non Animal
Collision Rate in C/100MVKM	121.53	60.76
# of Fatal Collisions	0	0
# of Injury Collisions	5	5
# of Property Damage Only Collisions	19	7
Total # of collisions	24	12

Existing Width and Curve Summary

	Typical	Weighted	Max	Min	Total
Existing Width	10.40	10.1	11.00	10.40	
Existing WAADT	855.00	800	855.00	670.00	
Growth Rate %	1.3	1.3	1.4	1.2	
Speed	100		100	100	
Horizontal Curve Radius			1,680	580	5
Vertical Curve k (Crest)			1,140	73	8
Vertical Curve k (Sag)			420	34	7

Paving History

	Typical Year	Average Year	Max Year	Min Year
Last Paved	2023	1921	2023	0

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NESS Work Activity Summary

Refresh was last successfully run at 2024 Oct 30 00:28

NESS Scheduled Year	WA Scheduled Year	LRS	Length	Int #	Location	Direction	Work
2073		36:02 C1 44.000 - 57.258	13.258		12 Km S of VILLAGE of Barnwell - Hwy 3		GRADE WIDENING
2033		36:02 C1 37.299 - 38.330	1.031		10 Km N of Hwy 61 - 11 Km N of Hwy 61		HORIZONTAL CURVE RECONSTRUCTION
2024		36:02 C1 35.087 - 35.626	0.539		8 Km N of Hwy 61 - 8 Km N of Hwy 61		INSTALL SPEED ADVISORY
2024		36:02 C1 36.210 - 37.090	0.88		9 Km N of Hwy 61 - 10 Km N of Hwy 61		INSTALL SPEED ADVISORY
2024		36:02 C1 37.299 - 38.330	1.031		10 Km N of Hwy 61 - 11 Km N of Hwy 61		INSTALL SPEED ADVISORY
2024		36:02 C1 33.999 - 34.582	0.583		7 Km N of Hwy 61 - 7 Km N of Hwy 61		SUPERELEVATION ADJUSTMENT
2024		36:02 C1 35.087 - 35.626	0.539		8 Km N of Hwy 61 - 8 Km N of Hwy 61		SUPERELEVATION ADJUSTMENT
2024		36:02 C1 35.781 - 36.011	0.23		8 Km N of Hwy 61 - 9 Km N of Hwy 61		SUPERELEVATION ADJUSTMENT
2033		36:02 C1 36.210 - 37.090	0.88		9 Km N of Hwy 61 - 10 Km N of Hwy 61		SUPERELEVATION ADJUSTMENT
2033		36:02 C1 37.299 - 38.330	1.031		10 Km N of Hwy 61 - 11 Km N of Hwy 61		SUPERELEVATION ADJUSTMENT
2024		36:02 C1 33.810 - 36.266	2.456		6 Km N of Hwy 61 - 9 Km N of Hwy 61		SAFETY ASSESSMENT
2024		36:02 C1 35.087 - 35.626	0.539		8 Km N of Hwy 61 - 8 Km N of Hwy 61		SAFETY ASSESSMENT - HORIZONTAL CURVE
2024		36:02 C1 36.210 - 37.090	0.88		9 Km N of Hwy 61 - 10 Km N of Hwy 61		SAFETY ASSESSMENT - HORIZONTAL CURVE

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Multilane Report

Report Notes

Number of results found	2
4 Lane - Lv 1	7500
4 Lane - Lv 2	9300
4 Lane - Lv 3	11200
4 Lane - Lv 4	11200
6 Lane	31000
8 Lane	50000
Growth Rate in %	
Collision Cost in $/km (M) over 5 years	
Collision Rate in C/100MVKM	

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

				WAADT		LOS			NESS Sched		4 lane		6 lane		8 lane			
LRS	Len	Serv Class	# Lanes	Year 0	Year 20	Year 0	Year 20	Growth Rate	1st Work Year	WAADT	Need Year	WAADT	Need Year	WAADT	Need Year	WAADT	Notes	Region
36:02 C1 27.376 - 38.364	10.988	LV 2	2	670	831	A	A	1.20										1
36:02 C1 38.364 - 57.258	18.894	LV 2	2	900	1,150	A	A	1.39										1

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Pave Gravel Roads Report

Report Notes

Number of results found	0
ASSIGN PAVE GRAVEL MIN AADT	400
Growth Rate in %	

Gravel Road collision data is obtained from the overlapping safety segment

Collision Cost in $/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

			WAADT		Growth					
LRS	Length	Service Classification	Year 0	Year 20	Rate	Width	Sched Year	% CM	Notes	Region
No data found										

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Intersection Report

Report Notes

Number of results found 1

The number of collisions in this report are collisions at and near the intersection and are collisions within the intersection polygon in TIMS

For details on individual collisions, see the "Collision Details" section within Excel report

The Signalization Work Activity Trigger is Traffic Score (TS) > 79 or TS >= 60 with 5 or more angle collisions

Interchange Trigger - Signalization trigger met on Level 1 divided highway with 100+ km/h, or left turn volume >= 700 vehicles per hour

Collision Cost in $ (M) over 5 years

Collision Rate in C/100MEV

Intersection collision rate is calculated as (sum of intersection collisions over 5 years * 100 Mil) / (sum of AADT entering over 5 years * 365.25)

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)

Va, Vo and Vl in VPH

LT & RT Length in m

Pk = Peak Hour

Year LT = Scheduled Year of Left Turn Lane Construction

Year LTR = Scheduled Year of Left Turn Lane Reconstruction

Year RT = Scheduled Year of Right Turn Lane Construction

Year RTR = Scheduled Year of Right Turn Lane Reconstruction

INT #:8479 **LRS: 36:02 C1 38.363**

Location: HIGHWAY 36:02 AND TOWNSHIP ROAD 80

Lv 2 Work Activity Summary | Lv 3 Work Activity Summary

Major Road Details — TMD Ref: 70000182

			Veh/day	Growth
Int. Type: AG	Posted Speed: 100	Maj Rd: 36-NB/SB	760	1.4%
Service Class: LV 2	Lit: N Sig: N Div: N Radius:	Min Rd: Twp Rd 80-EB/WB	60	

Collision Frequency				Collision Rate				Collision Cost	
Total	Fatal	Inj	Non-An	Total	BM	Non-An	BM	Cost (in $M)	BM
1	0	0	1	71.2	233.7	71.2	227.9	0.006	0.246

Approach	LT Lane	LT Len	LT BM	RT Lane	RT Len	RT BM	Chan	Yr LT	Vo	Vl	BM	Va	Undiv BM	Pk	Yr RT	RT AADT	Yr Chan
36-NB																10	
36-SB																0	

Yr Signal	TS	Ang. Coll	Yr IC	TS	LT vph	Yr Light.	Day	Night	N/D Col%	Near VC
	3	0					1	0	0.00	

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Horizontal Curve Report

Report Notes

Number of results found 5

Collision Cost in $/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

e in %

Deflection Angle in degrees

			Geometric Analysis						Collision Frequency				Safety Analysis				Work Activity Year		Region
LRS	Len	Exist WAADT	Type	Actual	BM	Δ	Defl Angle	Int On Curve	Total	Fatal	Injury	Non Animal	Type	Actual	BM	Δ	Safety Assess	Recon	
36:02 C1 33.999 - 34.582	0.583	670	R	1,680	600	1,080	19.9 L	Y	0	0	0	0	Total Rate	0	329.4	329.4	2024		1
			e Max	2.3									Non Animal Rate	0	279.1	279.10			
			e Min	2.3	2.4	***-0***							Coll Cost	0	0.754	0.754			
36:02 C1 35.087 - 35.626	0.539	670	R	600	600	0	49.1 R	N	4	0	0	1	Total Rate	483.8	325.4	***-158.4***	2024		1
			e Max	5.7	7.9	2.2							Non Animal Rate	120.9	295.5	174.50			
			e Min	5.7	5.8	***-0***							Coll Cost	0.043	0.842	0.799			
36:02 C1 35.781 - 36.011	0.23	670	R	1,370	600	770	9.6 L	N	0	0	0	0	Total Rate	0	281.3	281.3	2024		1
			e Max	2.5	6	3.5							Non Animal Rate	0	252	252.00			
			e Min	2.5	2.9	***-0***							Coll Cost	0	0.844	0.844			
36:02 C1 36.210 - 37.090	0.88	670	R	610	600	10	82.4 R	N	6	0	1	1	Total Rate	444.5	325.4	***-119.1***	2024		1
			e Max	4.7	7.9	3.2							Non Animal Rate	74.1	295.5	221.40			
			e Min	4.7	5.8	***-1***							Coll Cost	0.109	0.842	0.733			
36:02 C1 37.299 - 38.330	1.031	670	R	580	600	***-20***	102.2 L	N	3	0	2	2	Total Rate	189.7	385	195.3		2033	1
			e Max	4.7	7.9	3.2							Non Animal Rate	126.5	360.9	234.50			
			e Min	4.7	5.9	***-1***							Coll Cost	0.135	1.079	0.944			

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Vertical Curve Report

Report Notes

Number of results found 0

Gradient in %

Collision Rate in C/100MVKM

Collision rate is calculated as (sum segment collisions over 5 years * 100 Mil) / (sum of AADT 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $9,120,367) + (sum of collisions involving a serious injury * $66,744) + (sum of collisions involving a minor injury * $66,744) + (sum of the property damage only collisions * $5,851)/km)

					K-Value					Running Speed			Total Collision Rate				Region
LRS	Len	Existing WAADT	Type	Grad	k	3R4R BM	Δ	NC BM	Δ	Estimated	Design	Δ	H Curve	INT	WA Year	Heavy Truck %	
36:02 C1 29.844 - 35.017	5.173		TAN	-0.40													1
36:02 C1 35.017 - 35.659	0.642	670	CREST		91	50	41	100	-9	105	110	-5				34.0	1
36:02 C1 35.659 - 35.991	0.332		TAN	-7.40													1
36:02 C1 35.991 - 36.281	0.29	670	SAG		39	31	8	60	-21	90	110	-20				34.0	1
36:02 C1 36.281 - 36.698	0.417		TAN	0.00													1
36:02 C1 36.698 - 36.903	0.205	670	SAG		34	31	3	60	-26	80	110	-30				34.0	1
36:02 C1 36.903 - 37.425	0.522		TAN	6.00													1
36:02 C1 37.425 - 37.889	0.464	670	CREST		73	50	23	100	-27	100	110	-10				34.0	1
36:02 C1 37.889 - 37.986	0.097		TAN	-0.40													1
36:02 C1 37.986 - 38.233	0.247		CREST		1,140												1
36:02 C1 38.233 - 38.897	0.664		TAN	-0.60													1
36:02 C1 38.897 - 39.056	0.159		SAG		168												1
36:02 C1 39.056 - 39.187	0.131		TAN	0.30													1
36:02 C1 39.187 - 39.592	0.405		CREST		250												1
36:02 C1 39.592 - 39.875	0.283		TAN	-1.30													1
36:02 C1 39.875 - 40.065	0.19		SAG		184												1
36:02 C1 40.065 - 41.164	1.099		TAN	-0.20													1
36:02 C1 41.164 - 41.332	0.168		CREST		260												1
36:02 C1 41.332 - 41.853	0.521		TAN	-0.90													1
36:02 C1 41.853 - 42.049	0.196		SAG		420												1
36:02 C1 42.049 - 42.212	0.163		TAN	-0.40													1
36:02 C1 42.212 - 42.339	0.127		CREST		159												1
36:02 C1 42.339 - 42.594	0.255		TAN	-1.20													1
36:02 C1 42.594 - 42.784	0.19		SAG		175												1
36:02 C1 42.784 - 43.018	0.234		TAN	-0.10													1
36:02 C1 43.018 - 43.204	0.186	900	CREST		118	50	68	100	18	115	110	5				29.0	1
36:02 C1 43.204 - 43.369	0.165		TAN	-1.70													1
36:02 C1 43.369 - 43.526	0.157		SAG		96												1
36:02 C1 43.526 - 43.596	0.07		TAN	-0.10													1
36:02 C1 43.596 - 43.768	0.172		CREST		178												1
36:02 C1 43.768 - 44.119	0.351		TAN	-1.00													1

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Posted Speed Summary

LRS	Length	Speed Km/Hr
36:02 C1 34.000 - 44.000	10	100
36:02 C1 38.262 - 38.363	0.101	100
36:02 C1 38.363 - 38.462	0.099	100

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Traffic Growth

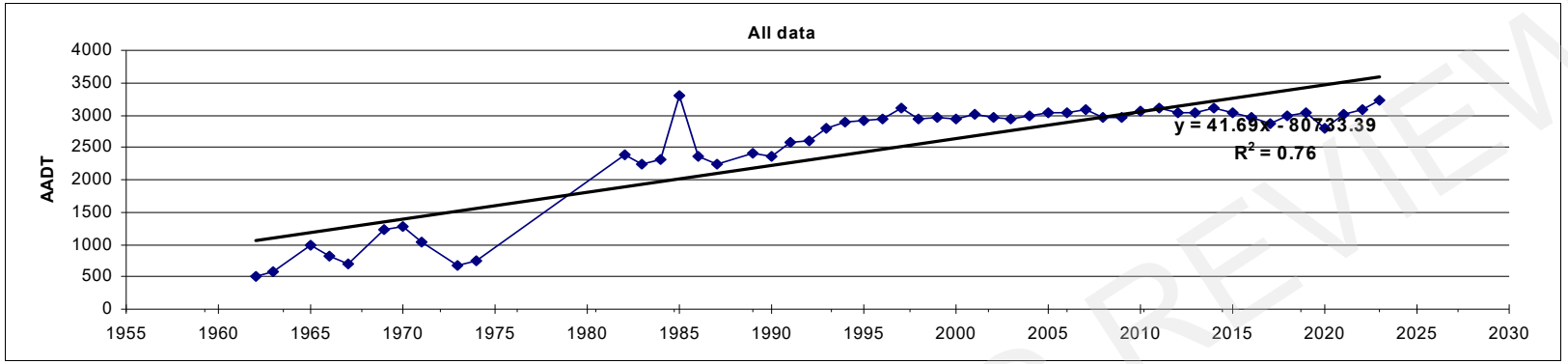
Table of ATR's included within the report by location

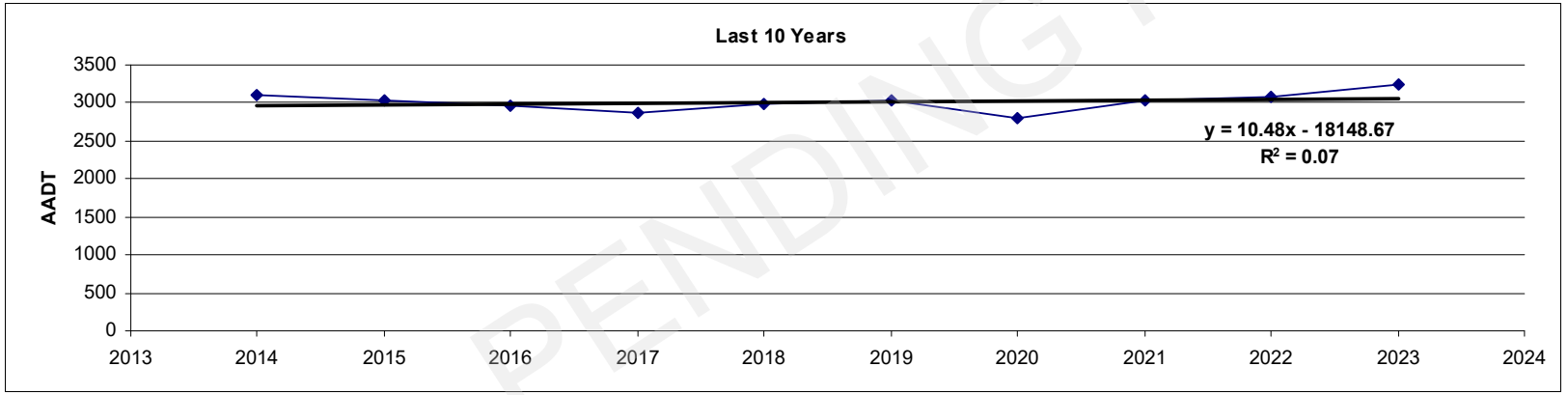
Hwy	CS	Label	From	To	ATR #
36	2	C1	27.377	38.364	60360260
36	2	C1	38.364	57.258	60360450

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ATR NUMBER: 60360450 36:04:C1 km 4.875 4.8 KM N OF 3 & 36 TABER EJ





Growth rate	Since	Two points	Diff to historical	linear regression	Diff to historical	r square
Historical:	1962	1.39		1.16		0.757
20 yrs:	2004	0.39	-1	0.02	-1.14	0.001
10 yrs:	2014	0.46	-0.93	0.34	-0.82	0.068
5 yrs:	2019	1.49	0.1	2.1	0.94	0.462

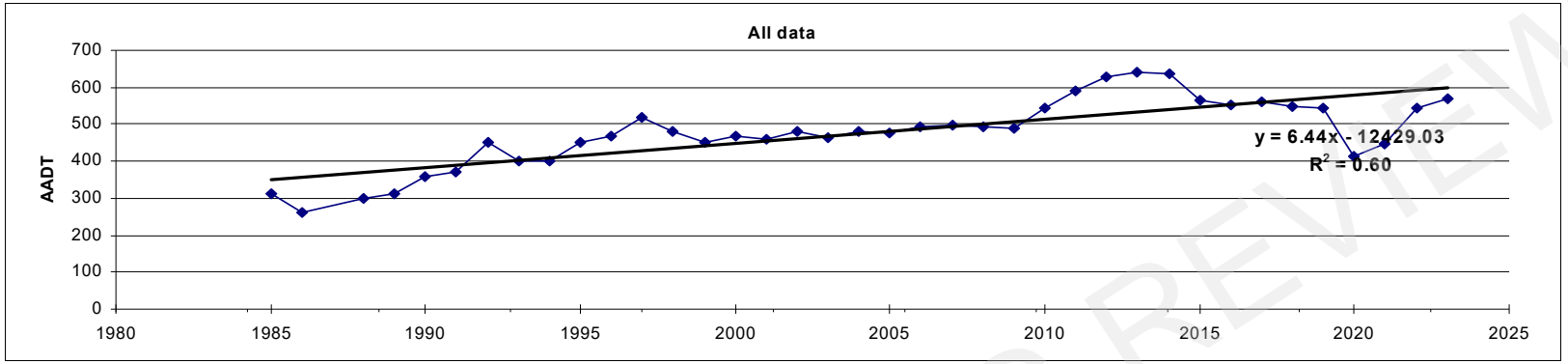
Other Calculation	Two points	Diff to historical	linear regression	Diff to historical	r square
Start yr:					
End yr:					
# yr:					

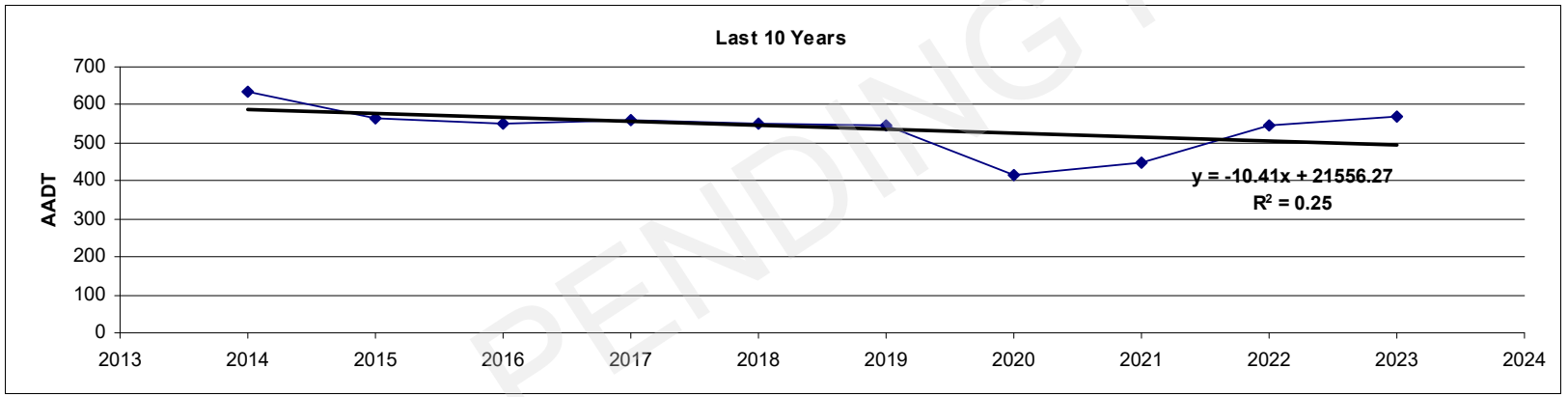
Year	AADT	ASDT	% diff
2023	3,238	3,496	8
2022	3,087	3,242	5
2021	3,022	3,227	6.8
2020	2,807	3,075	9.5
2019	3,045	3,238	6.3
2018	2,979	3,204	7.6
2017	2,872	2,977	3.7
2016	2,953	3,108	5.2
2015	3,043	3,269	7.4
2014	3,104	3,318	6.9

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ATR NUMBER: 60360260 36:02:C1 km 25.42 1.9 KM S OF 36 & 61 WRENTHAM





Growth rate	Since	Two points	Diff to historical	linear regression	Diff to historical	r square
Historical:	1985	1.2		1.08		0.602
20 yrs:	2004	0.81	-0.39	0.27	-0.81	0.02
10 yrs:	2014	-1.31	-2.51	-2.11	-3.19	0.248
5 yrs:	2019	1.05	-0.15	3.33	2.25	0.17

Other Calculation	Two points	Diff to historical	linear regression	Diff to historical	r square
Start yr:					
End yr:					
# yr:					

Year	AADT	ASDT	% diff
2023	570	622	9.1
2022	546	605	10.8
2021	449	475	5.8
2020	414	407	-1.7
2019	546	556	1.8
2018	550	563	2.4
2017	562	590	5
2016	553	575	4
2015	567	555	-2.1
2014	637	669	5

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INT # **8479-1** INT type AT GRADE - TYPE UNKNOWN Region: SOUTHERN REGION INT Effective Date: 01-Oct-00

Location: **HIGHWAY 36:02 AND TOWNSHIP ROAD 80**

Classification: LV 2 Signalized: N Last paved yr: 2023 Divided: N

Posted speed: 100 Lit: N Last paved road name: 36 TM number: 70000182

NESS Safety Calculations (2016 - 2020)

	Actual	BM	Deltas
Total rate:	71.224	233.7	162.5
Non animal rate:	71.224	227.9	156.7
Collision cost ($ x M):	0.006	0.246	0.24

Total (ani + non ani)		Non-animal	2016	2017	2018	2019	2020
# Daytime:	1	Daytime					1
# Nightime:	0	Nightime					
		Unknown					

Modify Outliners for Non Animal Collision

	2016	2017	2018	2019	2020
F and Maj Inj.	0	0	0	0	0
Min. Inj.	0	0	0	0	0
Non ani	0	0	0	0	0.3

Three Similar Collisions Over Five Yrs Period

(excluding off road and animal collision)

Year:

Prim. evt.:

Collision Frequency Over Last 15 Yrs

Severity - non ani.	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Last 5 yr
FATAL																**0**
MAJOR			1			1										**0**
MINOR									1							**0**
PDO															1	**1**
TOTAL	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
TOTAL-non ani.	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**

Collision Summary Last 5 Yrs (2016 - 2020)

(Non animal collisions)

Month	Freq	Hour	AM	PM	Weekday	Freq
Jan:		0:			Mon:	
Feb:		1:			Tue:	
Mar:		2:			Wed:	
Apr:		3:			Thu:	
May:		4:			Fri:	
Jun:		5:			Sat:	
Jul:		6:		1	Sun:	1
Aug:	1	7:			unknown:	
Sep:		8:				
Oct:		9:				
Nov:		10:				
Dec:		11:				
unknown:		unknown:				

INT polygon yr: 31-Mar-2024

Collision event	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Last 5 yr
ANIMAL																**0**
BACKING																**0**
HEAD ON																**0**
LEFT TURN:ACROSS PATH																**0**
OFF ROAD LEFT									1							**0**
OFF ROAD RIGHT			1													**0**
OTHER															1	**1**
PASSING:LEFT TURN																**0**
PASSING:RIGHT TURN																**0**
PEDESTRIAN																**0**
REAR END						1										**0**
RIGHT ANGLE																**0**
SIDESWIPE:OPP DIR																**0**
SIDESWIPE:SAME DIR																**0**
STRUCK OBJECT																**0**
UNKNOWN																**0**

*The number of collision in this report are collisions at and near the intersection and is calculated using intersection polygon in TIMS.

*Cost of PDO collision had increased from $1,000 to $2,000 in 2011 and to $5,000 in 2024

DRAFT - PENDING REVIEW

INT #: 8479 LOCATION: HIGHWAY 36:02 AND TOWNSHIP ROAD 80

2016 - 2020 Collision Objects: Vehicle 1 and 2 Travel Direction Summary

All non animal:	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL									
MAJOR									
MINOR									
PDO	1								
Total	1	0	0	0	0	0	0	0	0

Right angle	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL									
MAJOR									
MINOR									
PDO									
Total	0	0	0	0	0	0	0	0	0

Left turn across path	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL									
MAJOR									
MINOR									
PDO									
Total	0	0	0	0	0	0	0	0	0

Rear end	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
FATAL									
MAJOR									
MINOR									
PDO									
Total	0	0	0	0	0	0	0	0	0

Other collisions	**NB**	NE	**EB**	SE	**SB**	SW	**WB**	NW	U
BACKING	0	0	0	0	0	0	0	0	0
HEAD ON	0	0	0	0	0	0	0	0	0
OFF ROAD LEFT	0	0	0	0	0	0	0	0	0
OFF ROAD RIGHT	0	0	0	0	0	0	0	0	0
OTHER	1	0	0	0	0	0	0	0	0
PASSING:LEFT TURN	0	0	0	0	0	0	0	0	0
PASSING:RIGHT TURN	0	0	0	0	0	0	0	0	0
PEDESTRIAN	0	0	0	0	0	0	0	0	0
SIDESWIPE:OPP DIR	0	0	0	0	0	0	0	0	0
SIDESWIPE:SAME DIR	0	0	0	0	0	0	0	0	0
STRUCK OBJECT	0	0	0	0	0	0	0	0	0
UNKNOWN	0	0	0	0	0	0	0	0	0

Collision with no dir. data # coll

*U: unknown direction

DRAFT - PENDING REVIEW

The information provided herein is considered 'calculated data' for network screening purposes, based on the best available information within the TIMS inventory at the time of publishing. Project level engineering assessment is required to further develop the identified locations into strategies and engineering solutions for programming purposes.

Reference Number:
70000182

Intersection of:
36 & TWP RD 80 36-7-17-400000000

North On: 36

Vehicle Type	Volume	%
A: Passenger Vehicle	668	68.9%
B: Recreational Vehicle	23	2.4%
C: Bus	0	0.0%
D: Single Unit Truck	64	6.6%
E: Tractor Trailer Unit	215	22.2%
AADT	**970**	
ASDT	1,060	

2024 AADT / ASDT Estimates

Leg AADT Volumes

970 / 20 / 100 / 940

Total Entering Volume: **1,010**

From North

	Right	Thru	Left
	490		
	0	**460**	**30**
A	0	305	27
B	0	10	3
C	0	0	0
D	0	34	0
E	0	111	0

To North

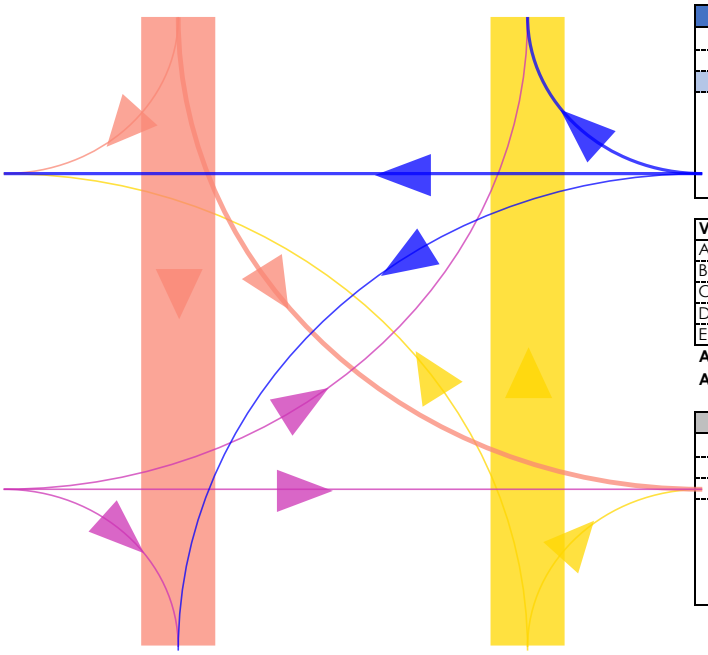
	480
A	336
B	10
C	0
D	30
E	104

To West

	20
A	10
B	0
C	0
D	10
E	0

From East

	Left	Thru	Right
	50		
	10	**20**	**20**
A	10	10	15
B	0	0	0
C	0	0	0
D	0	10	1
E	0	0	4



West On: Twp Rd 80

	Volume	%
A	10	50.0%
B	0	0.0%
C	0	0.0%
D	10	50.0%
E	0	0.0%
AADT	**20**	
ASDT	10	

East On: Twp Rd 80

Vehicle Type		
A	72	80.0%
B	3	3.3%
C	0	0.0%
D	11	12.2%
E	4	4.4%
AADT	**100**	
ASDT	100	

From West

	Left	Thru	Right
	0		
	0	**0**	**0**
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
E	0	0	0

To East

	40
A	37
B	3
C	0
D	0
E	0

To South

	470
A	315
B	10
C	0
D	34
E	111

From South

	Left	Thru	Right
	470		
	0	**460**	**10**
A	0	321	10
B	0	10	0
C	0	0	0
D	0	29	0
E	0	100	0

South On: 36

Vehicle Type	Volume	%
A: Passenger Vehicle	646	68.7%
B: Recreational Vehicle	20	2.1%
C: Bus	0	0.0%
D: Single Unit Truck	63	6.7%
E: Tractor Trailer Unit	211	22.4%
AADT	**940**	
ASDT	1,030	

ABBREVIATIONS:

AADT: Annual Average Daily Traffic. Average daily traffic expressed as vehicles per day for the period from January 1 to December 31 (inclusive), 365 days.

ASDT: Average Summer Daily Traffic. Average daily traffic expressed as vehicles per day for the period from May 1 to September 30 (inclusive), 153 days.

NOTE:
Coloured line thickness corresponds to turning movement volume.

Reference Number:
70000182

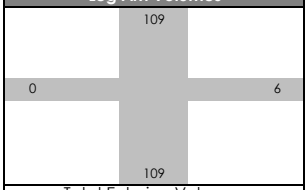
Intersection of:
36 & TWP RD 80 36-7-17-400000000

North On: 36

Vehicle Type	Volume	%
A: Passenger Vehicle	65	59.6%
B: Recreational Vehicle	0	0.0%
C: Bus	0	0.0%
D: Single Unit Truck	18	16.5%
E: Tractor Trailer Unit	26	23.9%
AM	**109**	

2024 AM 100th Highest Hour Estimates

Leg AM Volumes



Total Entering Volume:
112

From North

	Right	Thru	Left
	61		
	0	**60**	**1**
A	0	35	1
B	0	0	0
C	0	0	0
D	0	8	0
E	0	17	0

To North

	48
A	29
B	0
C	0
D	10
E	9

To West

	0
A	0
B	0
C	0
D	0
E	0

From East

	Left	Thru	Right
	2		
	0	**0**	**2**
A	0	0	1
B	0	0	0
C	0	0	0
D	0	0	1
E	0	0	0

West On: Twp Rd 80

	Volume	%
A	0	-
B	0	-
C	0	-
D	0	-
E	0	-
AM	**0**	

East On: Twp Rd 80

Vehicle Type		
A	5	83.3%
B	0	0.0%
C	0	0.0%
D	1	16.7%
E	0	0.0%
AM	**6**	

From West

	Left	Thru	Right
	0		
	0	**0**	**0**
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
E	0	0	0

To East

	4
A	4
B	0
C	0
D	0
E	0

To South

	60
A	35
B	0
C	0
D	8
E	17

From South

	Left	Thru	Right
	0	**46**	**3**
A	0	28	3
B	0	0	0
C	0	0	0
D	0	9	0
E	0	9	0

South On: 36

Vehicle Type	Volume	%
A: Passenger Vehicle	66	60.6%
B: Recreational Vehicle	0	0.0%
C: Bus	0	0.0%
D: Single Unit Truck	17	15.6%
E: Tractor Trailer Unit	26	23.9%
AM	**109**	

NOTE:
Coloured line thickness corresponds to turning movement volume.

Reference Number:
70000182

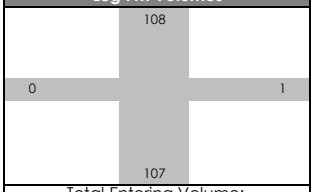
Intersection of:
36 & TWP RD 80 36-7-17-400000000

North On: 36

Vehicle Type	Volume	%
A: Passenger Vehicle	85	78.7%
B: Recreational Vehicle	3	2.8%
C: Bus	0	0.0%
D: Single Unit Truck	2	1.9%
E: Tractor Trailer Unit	18	16.7%
PM	**108**	

2024 PM 100th Highest Hour Estimates

Leg PM Volumes



Total Entering Volume:
108

From North

	Right	Thru	Left
	0	**39**	**1**
A	0	29	1
B	0	0	0
C	0	0	0
D	0	1	0
E	0	9	0

To North

	68
A	55
B	3
C	0
D	1
E	9

To West

	0
A	0
B	0
C	0
D	0
E	0

From East

	Left	Thru	Right	
	0	**0**	**0**	
A	0	0	0	A
B	0	0	0	B
C	0	0	0	C
D	0	0	0	D
E	0	0	0	E

West On: Twp Rd 80

	Volume	%
A	0	-
B	0	-
C	0	-
D	0	-
E	0	-
PM	**0**	

East On: Twp Rd 80

Vehicle Type		
A	1	100.0%
B	0	0.0%
C	0	0.0%
D	0	0.0%
E	0	0.0%
PM	**1**	

From West

	Left	Thru	Right
	0	**0**	**0**
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
E	0	0	0

To East

	1
A	1
B	0
C	0
D	0
E	0

To South

	39
A	29
B	0
C	0
D	1
E	9

From South

	Left	Thru	Right
	0	**68**	**0**
A	0	55	0
B	0	3	0
C	0	0	0
D	0	1	0
E	0	9	0

South On: 36

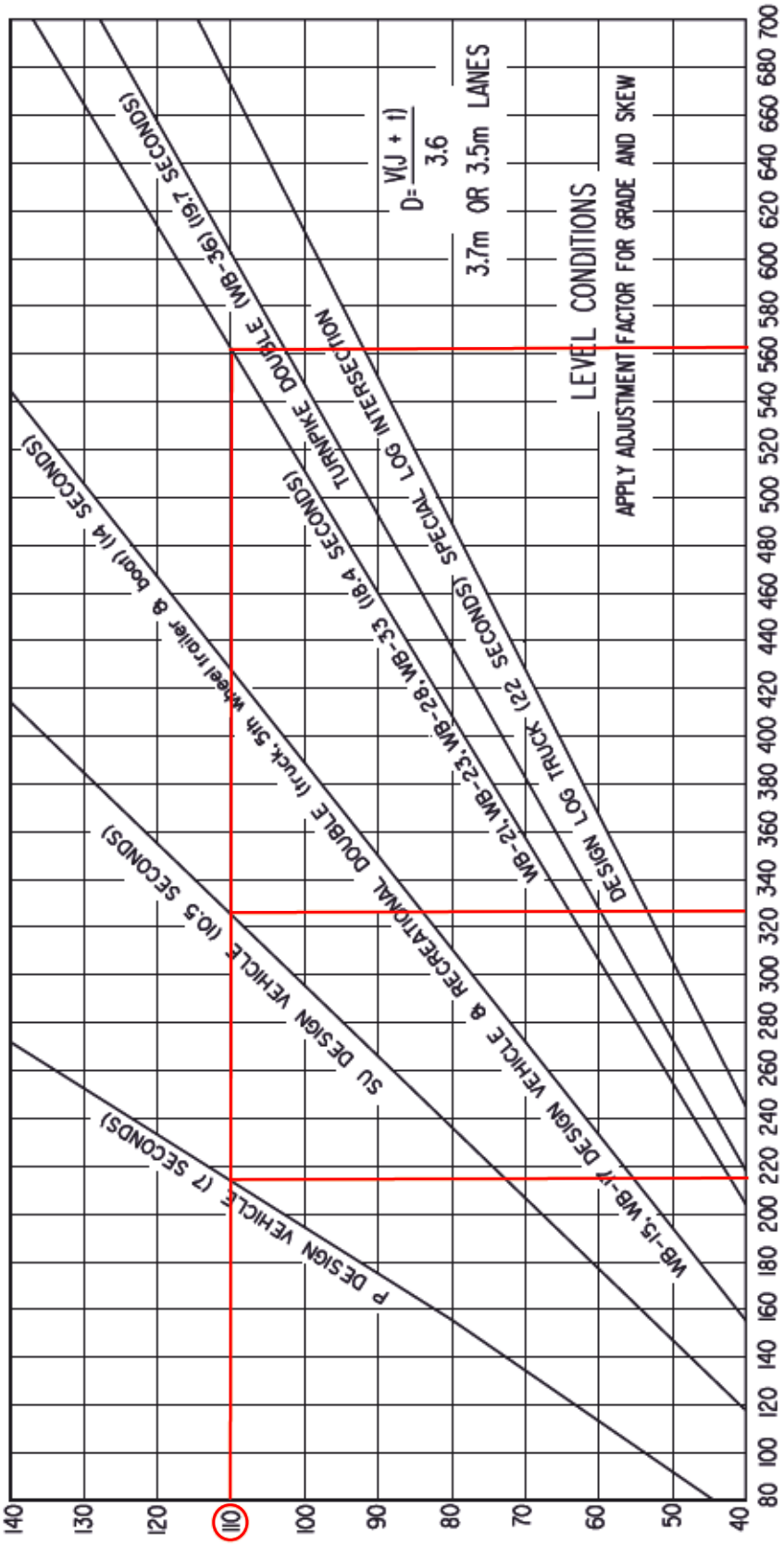
Vehicle Type	Volume	%
A: Passenger Vehicle	84	78.5%
B: Recreational Vehicle	3	2.8%
C: Bus	0	0.0%
D: Single Unit Truck	2	1.9%
E: Tractor Trailer Unit	18	16.8%
PM	**107**	

NOTE:
Coloured line thickness corresponds to turning movement volume.

APPENDIX D

Sight Distance Review

FIGURE D-4.2.2.2 SIGHT DISTANCES FOR LEFT TURN ONTO HIGHWAY*



NOTES:

1. To determine the sight distance requirements at an intersection, the designer should select the longest vehicle or vehicle with the greatest I.S.D. need, that uses the intersection on a regular basis, i.e., daily. Because of the various eye heights, the I.S.D. available for several design vehicles may have to be checked.
2. The usefulness of intersection sight distances in excess of 500m has been debated and will be the subject of future research into gap acceptance by large trucks on rural highways in Alberta. Changes to this table may be made based on that research.

* INTERSECTION SIGHT DISTANCE (I.S.D.)

- THE I.S.D.'s SHOWN IN THIS FIGURE ARE BASED ON THE DISTANCE TRAVELLED AT DESIGN SPEED DURING A CRITICAL TIME (SHOWN ON THE FIGURE IN SECONDS). THE CRITICAL TIME INCLUDES THE TIME TAKEN FOR THE MANOEUVRE (LEFT TURN FROM THE MINOR ROAD) PLUS 2 SECONDS FOR PERCEPTION/REACTION TIME.
- THE INTERSECTION SIGHT DISTANCE AVAILABLE IS TO BE DETERMINED USING AN EYE HEIGHT (BASED ON THE DESIGN VEHICLE) LOCATED AT THE JUNCTION AND AN OBJECT HEIGHT OF 1.3m (REPRESENTING THE ROOF OF A PASSENGER VEHICLE) ON THE THROUGH ALIGNMENT. THE EYE HEIGHTS TO BE USED ARE SHOWN IN FIGURE D-5a.

Design Vehicle	Eye Height	Required Sight Distance (D)
P	1.05m (3.4')	215m (705')
SU	1.80m (5.9')	325m (1066')
WB-21	2.10m (6.9')	565m (1854')
WB-23	2.10M (6.9')	565M (1854')

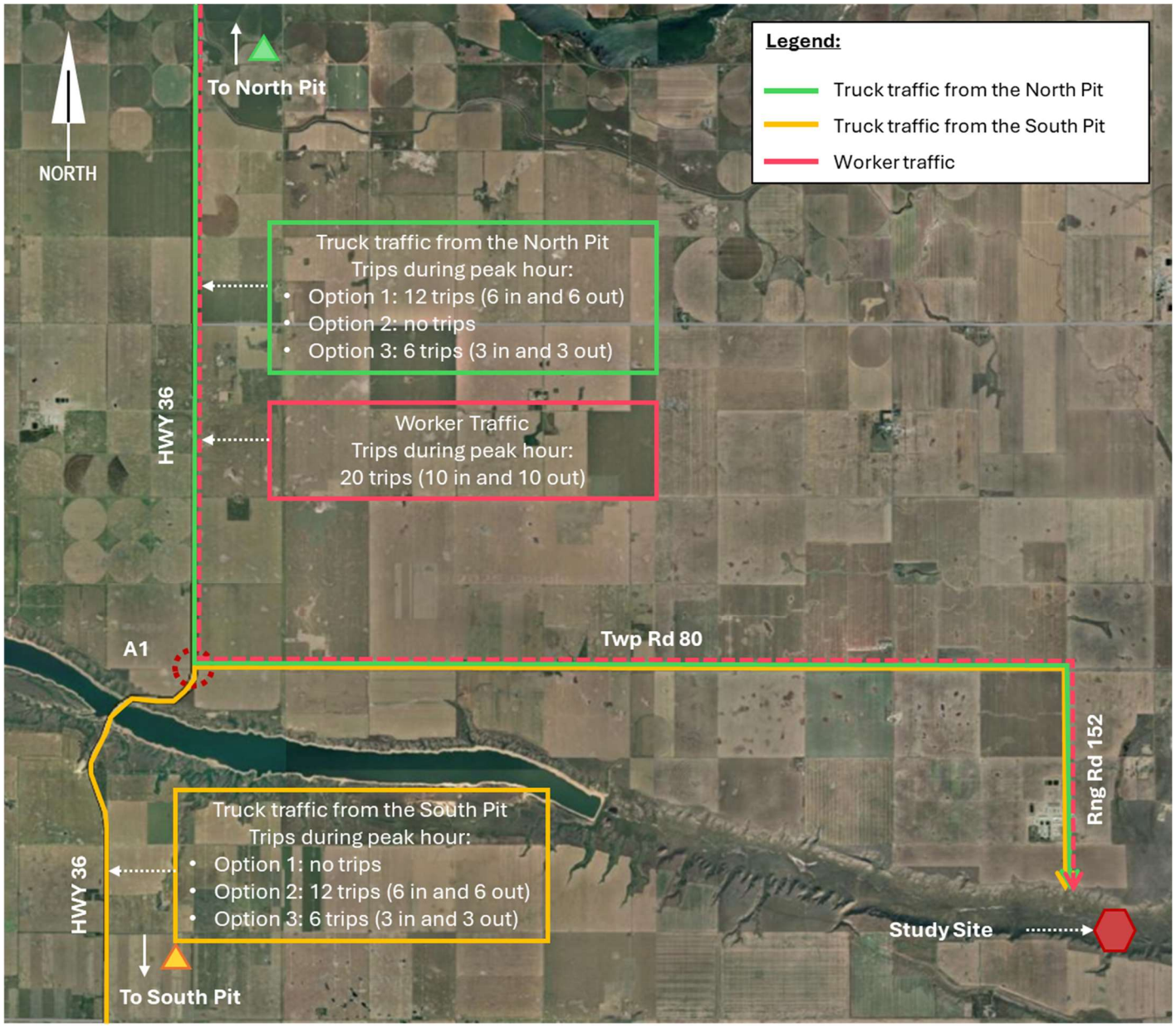
* THIS CHART IS BASED ON CRITERIA USED BY AASHTO FOR "SIGHT DISTANCE" AT STOP LOCATIONS. THE SET OF CRITERIA IS DESCRIBED AS CASE IIIB IN THE AASHTO PUBLICATION "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS, 1994"

REVISIONS				
	No. 2	BY		DATE
	No. 1	BY BK	ADDED NOTE	DATE AUG / 99

GRAPHICS FILE: debd4222.mon

APPENDIX E

Construction Traffic Distribution



a division of Englobe

ST. MARY IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION – EAST DAM
TRAFFIC IMPACT ASSESSMENT
DISTRIBUTION OF TRUCK TRAFFIC DURING PEAK HOURS

SCALE: NTS	DATE: July 18, 2025	JOB: 1520-167-00	FIGURE: E1

APPENDIX F

Turn Lane Warrants

Alberta Transportation Turn Lane Warrant Analysis

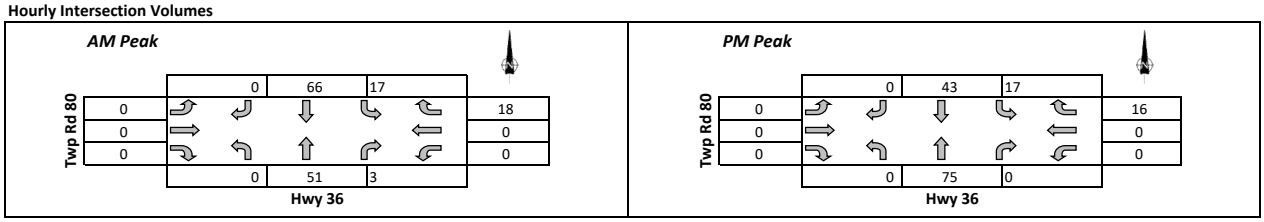
ANALYSIS DETAILS

Analysis Horizon: ***2029***
Traffic Conditions: ***Post-Development (Construction)***
Analysis Date: ***21/7/2025***
Analyst: ***AB***

INTERSECTION

Main Street: ***Hwy 36***
Side Street: ***Twp Rd 80***
Design Speed: ***110 km/h***
Direction (EW or NS): ***NS***
Direction (EW or NS): ***EW***
OPTION 1

Hourly Intersection Volumes

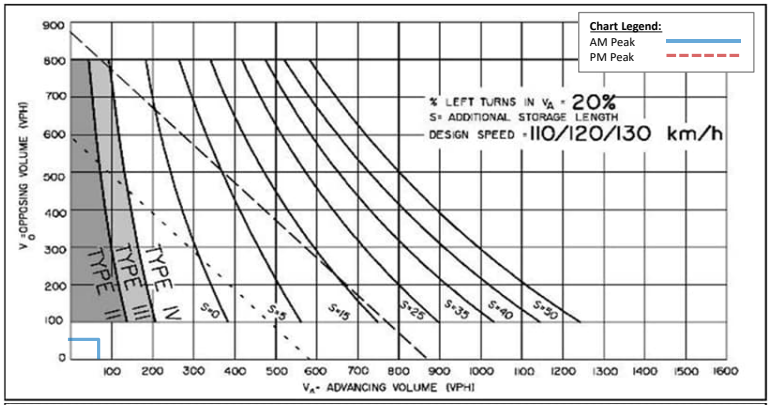


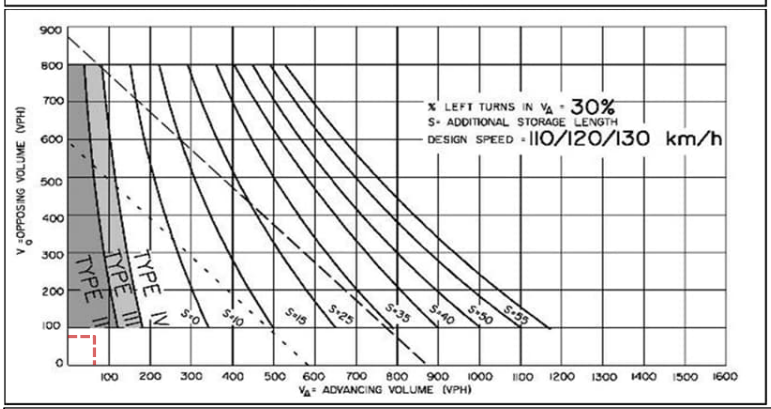
Warrant for Left Turn Lane (Hwy 36)

When making a left turn onto the side street, a turning vehicle may be delayed by a vehicle or vehiclesin the opposing stream. Through vehicles in the advancing stream following the left-turning vehicle may be delayed by, or exposed to collision with the turning vehicle. The interference caused by the standing left turning vehicles in the through advancing traffic can reduce capacity and create a safety hazard.

The amount of interference is dependent onthe opposing volume (Vo), advancing volume (Va), and the number of left-turning vehicles (V*l*). The proportion of left turning vehicles (L) is used when entering the appropriate design chart in the Alberta Transportation Highway Geometric Design Guide.

Direction	Period	V*l*	Va	L	Vo	Chart L	Chart Reference	Treatment Warranted
SB	AM Peak	17	83	20%	54	20%	D-7.6-7b	Type I
SB	PM Peak	17	60	28%	75	30%	D-7.6-7c	Type I





S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.
- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.
— — — — Traffic signals may be warranted in "free flow" urban areas.

Notes:
1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

Warrant for Right Turn Lane

To warrant an exclusive right turn lane at a two-lane highway intersection in Alberta, three conditions must be met as shown below. All three conditions must be met for the right turn lane to be warranted.

Direction: Hwy 36 NB — Hwy 36 SB

Condition	Estimated Value	Condition Met?	Estimated Value	Condition Met?
a. Main Road (Hwy 36) AADT ≥ 1800	1030	FALSE	1320	FALSE
b. Intersecting Road (Twp Rd 80) AADT ≥ 900	350	FALSE	350	FALSE
c. Right-Turn Daily Traffic ≥ 360	11	FALSE	0	FALSE

Result: An exclusive right-turn lane is NOT warranted — **Direction** Hwy 36 NB
An exclusive right-turn lane is NOT warranted — **Direction** Hwy 36 SB

Alberta Transportation Turn Lane Warrant Analysis

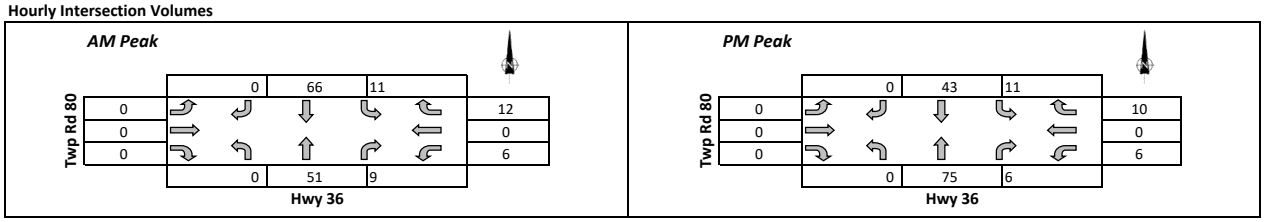
ANALYSIS DETAILS

Analysis Horizon: ***2029***
Traffic Conditions: ***Post-Development (Construction)***
Analysis Date: ***3/7/2025***
Analyst: ***AB***

INTERSECTION

Main Street: ***Hwy 36***
Side Street: ***Twp Rd 80***
Design Speed: ***110 km/h***
Direction (EW or NS): ***NS***
Direction (EW or NS): ***EW***
OPTION 2

Hourly Intersection Volumes

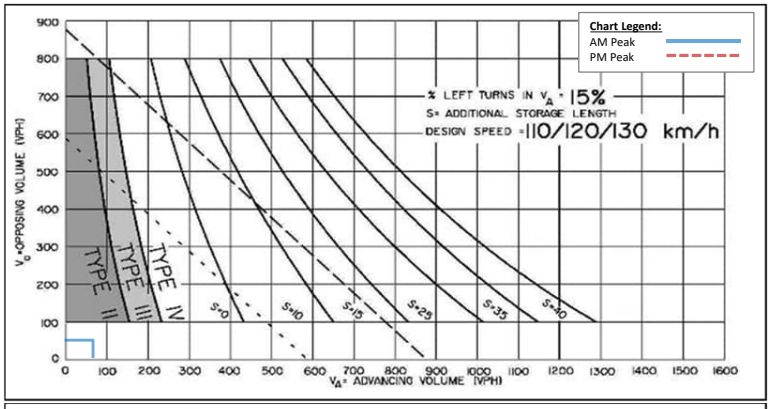


Warrant for Left Turn Lane (Hwy 36)

When making a left turn onto the side street, a turning vehicle may be delayed by a vehicle or vehiclesin the opposing stream. Through vehicles in the advancing stream following the left-turning vehicle may be delayed by, or exposed to collision with the turning vehicle. The interference caused by the standing left turning vehicles in the through advancing traffic can reduce capacity and create a safety hazard.

The amount of interference is dependent onthe opposing volume (Vo), advancing volume (Va), and the number of left-turning vehicles (V*l*). The proportion of left turning vehicles (L) is used when entering the appropriate design chart in the Alberta Transportation Highway Geometric Design Guide.

Direction	Period	V*l*	Va	L	Vo	Chart L	Chart Reference	Treatment Warranted
SB	AM Peak	11	77	14%	60	15%	D-7.6-7b	Type I
SB	PM Peak	11	54	20%	81	20%	D-7.6-7b	Type I



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.
- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.
— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:
1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

Warrant for Right Turn Lane

To warrant an exclusive right turn lane at a two-lane highway intersection in Alberta, three conditions must be met as shown below. All three conditions must be met for the right turn lane to be warranted.

Direction: Hwy 36 NB

Condition	Estimated Value	Condition Met?
a. Main Road (Hwy 36) AADT ≥ 1800	1140	FALSE
b. Intersecting Road (Twp Rd 80) AADT ≥ 900	350	FALSE
c. Right-Turn Daily Traffic ≥ 360	66	FALSE

Result: An exclusive right-turn lane is NOT warranted

Hwy 36 SB

Condition	Estimated Value	Condition Met?
a. Main Road (Hwy 36) AADT ≥ 1800	1210	FALSE
b. Intersecting Road (Twp Rd 80) AADT ≥ 900	350	FALSE
c. Right-Turn Daily Traffic ≥ 360	0	FALSE

Direction Hwy 36 NB

An exclusive right-turn lane is NOT warranted

Direction Hwy 36 SB

Alberta Transportation Turn Lane Warrant Analysis

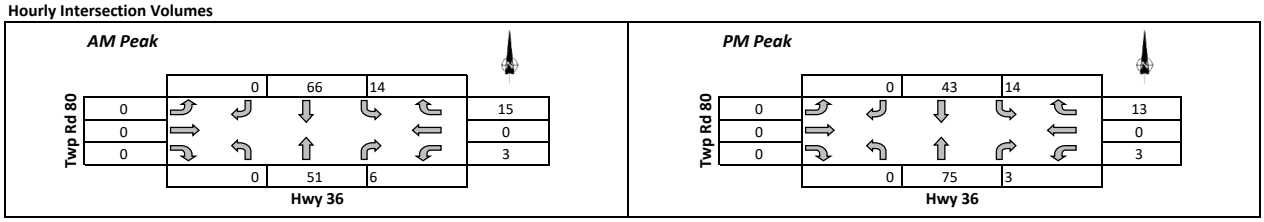
ANALYSIS DETAILS

Analysis Horizon: ***2029***
Traffic Conditions: ***Post-Development (Construction)***
Analysis Date: ***3/7/2025***
Analyst: ***AB***

INTERSECTION

Main Street: ***Hwy 36***
Side Street: ***Twp Rd 80***
Design Speed: ***110 km/h***
Direction (EW or NS): ***NS***
Direction (EW or NS): ***EW***
OPTION 3

Hourly Intersection Volumes

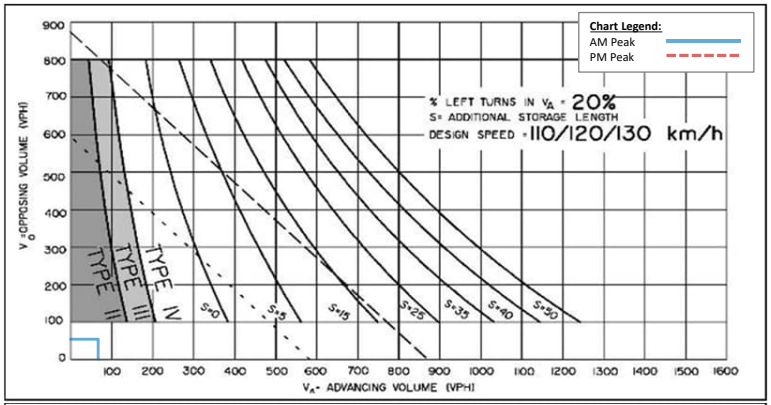


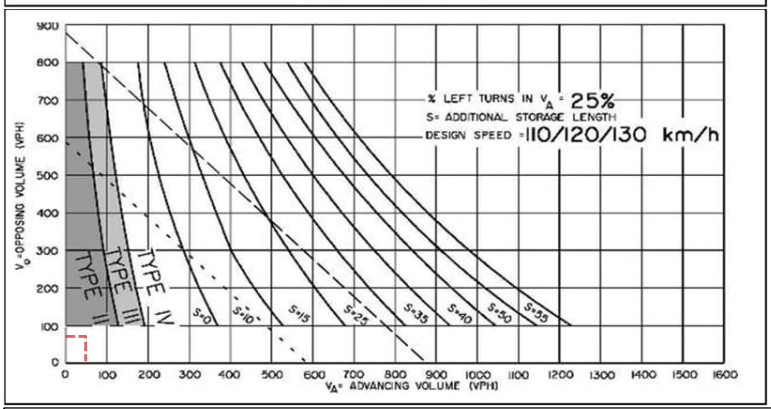
Warrant for Left Turn Lane (Hwy 36)

When making a left turn onto the side street, a turning vehicle may be delayed by a vehicle or vehiclesin the opposing stream. Through vehicles in the advancing stream following the left-turning vehicle may be delayed by, or exposed to collision with the turning vehicle. The interference caused by the standing left turning vehicles in the through advancing traffic can reduce capacity and create a safety hazard.

The amount of interference is dependent onthe opposing volume (Vo), advancing volume (Va), and the number of left-turning vehicles (V*l*). The proportion of left turning vehicles (L) is used when entering the appropriate design chart in the Alberta Transportation Highway Geometric Design Guide.

Direction	Period	V*l*	Va	L	Vo	Chart L	Chart Reference	Treatment Warranted
SB	AM Peak	14	80	18%	57	20%	D-7.6-7b	Type I
SB	PM Peak	14	57	25%	78	25%	D-7.6-7c	Type I





S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.
- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.
— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:
1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

Warrant for Right Turn Lane

To warrant an exclusive right turn lane at a two-lane highway intersection in Alberta, three conditions must be met as shown below. All three conditions must be met for the right turn lane to be warranted.

Direction: Hwy 36 NB

Condition	Estimated Value	Condition Met?
a. Main Road (Hwy 36) AADT ≥ 1800	1090	FALSE
b. Intersecting Road (Twp Rd 80) AADT ≥ 900	350	FALSE
c. Right-Turn Daily Traffic ≥ 360	39	FALSE

Result: An exclusive right-turn lane is NOT warranted

Hwy 36 SB

Condition	Estimated Value	Condition Met?
a. Main Road (Hwy 36) AADT ≥ 1800	1260	FALSE
b. Intersecting Road (Twp Rd 80) AADT ≥ 900	350	FALSE
c. Right-Turn Daily Traffic ≥ 360	0	FALSE

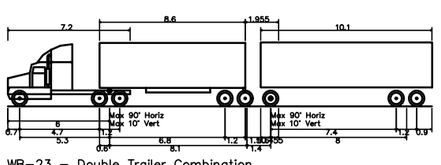
Direction Hwy 36 NB

An exclusive right-turn lane is NOT warranted

Direction Hwy 36 SB

APPENDIX G

Swept Path Analysis



WB–23 – Double Trailer Combination

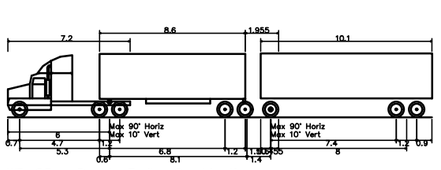
Overall Length	25.000m
Overall Width	2.600m
Overall Body Height	3.755m
Min Body Ground Clearance	0.435m
Track Width	2.600m
Lock–to–lock time	4.00s
Curb to Curb Turning Radius	12.200m

a division of Englobe

ST. MARY RIVER IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION - EAST DAM
TRAFFIC IMPACT ASSESSMENT
SWEPT PATH ANALYSIS FOR TRUCK TRAFFIC
ROUTE FROM/TO THE NORTH PIT

SCALE:	1:300	DATE:	JUJY 2025	JOB:	1520-167-00	FIGURE:	1



WB-23 – Double Trailer Combination

Overall Length	25.000m
Overall Width	2.600m
Overall Body Height	3.755m
Min Body Ground Clearance	0.435m
Track Width	2.600m
Lock-to-lock time	4.00s
Curb to Curb Turning Radius	12.200m

a division of Englobe

ST. MARY RIVER IRRIGATION DISTRICT

CHIN RESERVOIR EXPANSION - EAST DAM
TRAFFIC IMPACT ASSESSMENT
SWEPT PATH ANALYSIS FOR TRUCK TRAFFIC
ROUTE FROM/TO THE SOUTH PIT

SCALE:	1:300	DATE:	JUJY 2025	JOB:	1520-167-00	FIGURE:	2

APPENDIX 105.1

Hydrogeology Supplemental Technical Report (KCB 2025)

Appendix 105.1
Hydrogeology – Supplemental Technical Report

I-1 ACRONYMS

Abbreviation/Acronym	Definition
AWWID	Alberta Water Well Information Database
EIA	Environmental Impact Assessment
FSL	Full Supply Level
GoA	Government of Alberta
GIC	Groundwater Information Centre
GIN	Groundwater Information Network
GOWN	Groundwater Observation Well Network
HCL	Hydrogeological Consultants Ltd.
HSUs	Hydrostratigraphic units
KCB	Klohn Crippen Berger Ltd.
LSA	Local Study Area
m	metre
masl	metres above sea level
m/s	metre per second
m/yr	metre per year
mg/L	milligrams per liter
m^3/yr	cubic metres per year
mm/yr	millimeters per year
RSA	Hydrogeology Regional Study Area
TBR	Technical Baseline Report
TDS	Total Dissolved Solids
USA	United States of America
uS/cm	microSiemens per centimetre

I-2 INTRODUCTION

This report provides supplemental information regarding the hydrogeological baseline conditions for the Chin Reservoir Expansion Project. It is intended as a companion to the Hydrogeology - Technical Baseline Report (TBR) (Volume 4-3 of the Environmental Impact Assessment (EIA) submission). Additional information is presented with references to appropriate portions of the Hydrogeology - TBR to avoid content duplication. This document does not replace the original Hydrogeology - TBR.

I-3 METHODOLOGY

I-3.1 Information Review

The following information was reviewed and incorporated as a supplement to the Hydrogeology - TBR. The study areas, methods and analyses described in Volume 4-3 remain applicable.

- The Alberta Water Well Information Database (AWWID) was queried for all records within the Regional Study Area (RSA) (GoA 2025a).
- The Hydrogeological Consultants Ltd. report (HCL 2007) was used to provide a geological framework for much of the RSA and to assign a completion formation to water well records with depth information available.
- Potentiometric maps were prepared for the Upper Surficial, Foremost Formation and Milk River Formation using water levels from monitoring wells reported in Volume 4-3 and water well records from the AWWID for the RSA and a buffer area outside the RSA. In locations with multiple wells in the same completion formation, the shallowest well within the completion formation was included. Misrepresentation of the groundwater elevations could occur primarily due to errors in water well location, recorded ground elevation or temporal variations in groundwater levels.
- Review of available literature included the following key documents.
  - Paper titled: A unified hydrogeological conceptual model of the Milk River transboundary aquifer, traversing Alberta (Canada) and Montana (USA) (Pétré et al. 2015).
  - Masters' thesis titled: Hydrogeology and Hydrogeochemistry of Buried Preglacial Valleys in the Lethbridge Area, Southern Alberta (Sracek 1993).
- Additional information from geotechnical investigations (KCB 2023).
- Government of Alberta Observation Well Network (GOWN) information near the RSA (GoA 2025b).
- Groundwater licenses and registrations within the RSA (GoA 2025c and 2025d).

I-3.2 Groundwater Velocity

Estimates of average linear groundwater velocities provided in Sections I-4.1 to I-4.3 and Section I-4.5 are calculated using the following equation.

$V = Ki/n_e$

Where: V is the average linear velocity (m/yr)
K is the hydraulic conductivity (m/yr)
i is the estimated hydraulic gradient (m/m)
n_e is the assumed effective porosity

I-4 HYDROGEOLOGY

The surficial and bedrock geology within the RSA is described in Volume 4-3, Section 3.3 and in Volume 2, Section 2.1.2.2. Key supporting figures include (a) Volume 4-3, Figure 3.2 Regional Bedrock Geology and (b) Volume 4-3, Figure 3.5 Regional Surficial Geology. These figures show that the uppermost bedrock throughout the Local Study Area (LSA) and almost entire RSA is the Foremost Formation. The surficial geology is characterized by fluvial, stream and slopewash deposits within the Chin Coulee and the upland areas are dominated by glacial moraine deposits. An area of coarse lacustrine deposits is mapped outside the coulee to the east of the New East Dam.

The hydrostratigraphic units (HSUs) identified in Volume 4-3, Section 3.5 are summarized in Table 4.1 (only units present in the RSA are included). Several cross-sections (HCL 2007) display the distribution of these HSUs across the RSA. Figure I.4.1 identifies three cross-section alignments (A-A', F-F' and G-G') relevant to the RSA and the cross-sections are included in Figures I.4.2 to I.4.4. These cross-sections demonstrate the north dipping structure of the bedrock units, variable thickness of the Upper Surficial unit and limited distribution of the Lower Surficial unit. The hydrogeology of each unit is discussed in the following subsections.

Table 4.1 Hydrostratigraphic Unit Designations

Stratigraphic Unit		Lithology	Designation
Surficial Deposits	Upper Surficial	Upper Sand and Gravel	Local Aquifer
		Till	Aquitard
	Lower Surficial	Lower Sand and Gravel	Local Aquifer
Foremost Formation		Sandstone, shale	Local Aquifer
Lee Park Formation		Shale, Siltstone	Aquitard
Milk River Formation		Sandstone, Siltstone, shale and coal	Regional Aquifer
Colorado Shales		Shale and siltstone	Aquitard

I-4.1 Upper Surficial Deposits

Outside of the Chin Coulee the Upper Surficial deposits are dominated by glacial moraine deposits. The thickness of the Upper Surficial unit generally ranges between 15 m to 40 m across the RSA (Figures I.4.2 to I.4.4). An area of thicker deposits, locally over 90 m, is identified to the east of the RSA in Township 7, Range 13, West of the 4th Meridian. The Chin Coulee transects the RSA from northwest to southeast cutting down 40 m to 50 m and separating the Upper Surficial deposits to the north and south.

The till material within the Upper Surficial unit is identified as having low hydraulic conductivities of 10^{-8} m/s to 10^{-10} m/s in the oxidized portion and 10^{-10} m/s to 10^{-11} m/s in the unoxidized portion (Sracek 1993). The permeable portion of the Upper Surficial unit is expected to occur mainly as localized deposits of sand and gravel (HCL 2007). A horizontal hydraulic conductivity of 8.6×10^{-7} m/s was obtained at one location (MW22-04) in the LSA for an interval of sand and gravel in the Upper

Surficial unit. The hydrograph from this location demonstrates the hydraulic isolation of this deposit (Volume 4-3, Section 4.5).

The groundwater elevation was plotted using information primarily from local water wells (Figure I.4.5). The overall groundwater contours seem representative as they mimic topography and demonstrate a regional groundwater flow direction to the northeast. The regional hydraulic gradient is approximately 0.003 m/m to 0.008 m/m.

An average groundwater velocity of 0.3 m/yr to 0.7 m/yr was calculated assuming an effective porosity of 0.3, the site-specific hydraulic conductivity of 8.6×10^{-7} m/s and the regional hydraulic gradients. Using a bulk hydraulic conductivity of 1×10^{-9} m/s as representative of the dominant till deposits with the same values for the remaining parameters, the average groundwater velocity is reduced to less than 1 mm/yr.

The detailed topography of the Chin Coulee was not considered in the interpretation of groundwater elevations primarily as the data was outside the coulee. Groundwater levels within 1 km of the coulee are within 5 m of ground surface and substantially above the elevation of the reservoir or coulee bottom. This information supports an interpretation of predominantly low hydraulic conductivity deposits that limit groundwater flow from the Upper Surficial unit in the surrounding upland down into the Chin Coulee.

Groundwater elevations in the Upper Surficial unit on both sides of the current and proposed reservoir are measured at 877 masl to 914 masl, which is above the current and proposed FSL elevation of 861.4 masl and 864 masl, respectively. Groundwater from the Upper Surficial unit will potentially recharge the proposed reservoir, although the gradient and potential groundwater velocity will decrease as the reservoir level increases and the groundwater gradient is reduced.

I-4.2 Lower Surficial Deposits

The Lower Surficial deposits are permeable materials, potentially pre-glacial deposits, located at the base of the surficial deposits and directly overlying bedrock. Regional mapping indicates a limited extent of the Lower Surficial unit with an area at the easternmost end of the LSA (Township 7, Range 14, West of the 4th Meridian) and near Horsefly Lake Reservoir (Township 9, Ranges 15 and 16, West of the 4th Meridian) (Figures I.4.2 to I.4.4) (HCL 2007). A deposit consistent with this description was identified with a thickness of 2.9 m, located approximately 700 m east of the New East Dam at the base of the Chin Coulee in the LSA (MW22-01), and underneath more than 30 m of alluvium.

Hydraulic conductivity testing at one location (MW22-01, Figure 4.2 in Volume 4-3) in the LSA resulted in horizontal hydraulic conductivity of 6.3×10^{-4} m/s for the sand and gravel unit. Another location (BH21-03/VT21-01) completed in sand close to, but not in direct contact with, the underlying bedrock resulted in a hydraulic conductivity of 1.8×10^{-6} m/s. A hydraulic gradient for this unit was calculated in Section 4.5 of Volume 4-3 as 0.002 m/m to the southeast. Assuming an effective porosity of 0.3 and utilizing the higher, more conservative, horizontal hydraulic conductivity, the calculated groundwater flow rate is 130 m/yr.

A study of the Lethbridge Aquifer, which is a buried preglacial aquifer located just west of the RSA, identified hydraulic conductivity values on the order of 10^{-6} m/s to 10^{-7} m/s (Sracek 1993), which is considerably lower than the result from MW22-01. The Lethbridge Aquifer is hypothesized to have a range of hydraulic conductivities and flow velocities on the order of 0.003 m/yr to 0.03 m/yr.

A laboratory permeability test was conducted on a Shelby tube sample of alluvium. Results from the sample at a depth of 1.83 m to 2.44 m from BH21-3 analyzed at a pressure of 20 kPa returned a vertical hydraulic conductivity of 1.7×10^{-9} m/s (KCB 2023). This information demonstrates the low vertical conductivity of alluvium overlying the Lower Surficial unit within the Chin Coulee that will limit the rate of infiltration downwards to the Lower Surficial unit. This is consistent with findings from Sracek (1993), where analyses of tritium identified very low concentrations in the Lethbridge Aquifer consistent with a groundwater age of 50 years or more. Tritium was present to about 12 m depth in the till demonstrating slow infiltration through overlying deposits.

I-4.3 Foremost Formation

Regional mapping shows the Foremost Formation is generally 140 m to 150 m thick across the RSA except where it has been eroded within the Chin Coulee to potentially less than 50 m in thickness (Figures I.4.2 to I.4.4). The hydraulic conductivity has been found regionally to range from 2×10^{-5} m/s to 2×10^{-10} m/s (Sracek 1993) but is best approximated by a geometric mean hydraulic conductivity of 1×10^{-8} m/s (Sracek 1993) or in the range of 9.0×10^{-8} m/s to 8.8×10^{-7} m/s (GIN 2021).

Hydraulic conductivity was determined at two locations (MW22-03 and MW22-02) completed in the upper Foremost Formation in the LSA. These tests returned horizontal hydraulic conductivity values of 8.8×10^{-6} m/s and 6.3×10^{-6} m/s.

Packer testing was completed in two boreholes located near the north (BH21-04) and south (BH21-01) abutments of the proposed New East Dam (KCB 2023) as illustrated in Volume 4-3, Figures 2.2 and 4.3. Based on the locations and depths investigated, these tests are within the Foremost Formation and demonstrate a range of estimated hydraulic conductivity from 1.9×10^{-5} m/s to 1.7×10^{-8} m/s, which is within the range of published regional values. Hydraulic conductivities at BH21-01 in the south abutment are generally higher than in BH21-04. Several of the tests in BH21-01 were not able to reach full pressure and therefore the formation may be more permeable at this location. The packer test results are summarized in Table 4.2.

Table 4.2 Summary of Packer Test Results

Borehole	Depth Range[1] (m)	Bedrock Unit	Apparent Permeability (m/s)
BH21-01	14.3 – 16.0	Sandstone	1.9×10^{-5}
	17.2 – 18.8	Siltstone	4.2×10^{-7}
	18.9 – 21.8	Siltstone	9.5×10^{-6}
	21.8 – 24.7	Sandstone	8.9×10^{-6}
	24.8 – 27.7	Siltstone/Clay Shale	8.4×10^{-6}
BH21-04	16.7 – 18.7	Siltstone/Clay Shale	1.7×10^{-7}
	20.1 – 23.1	Siltstone	2.0×10^{-6}
	22.8 – 26.0	Siltstone/Sandstone	3.4×10^{-6}
	25.8 – 29.0	Sandstone	1.7×10^{-8}
	28.7 – 31.9	Siltstone/Sandstone/Carbonaceous Shale	7.6×10^{-8}

Note:
1 Depths corrected for inclination of boreholes (15 degrees from vertical)

Regional groundwater elevations were plotted using information primarily from water well records (Figure I.4.6). The overall groundwater contours indicate a groundwater flow direction to the north or northeast. This is consistent with the groundwater flow direction reported by Sracek (1993). Most of the available water well records for the Foremost Formation are clustered in two areas, one north central in and around the south half of Township 9, Range 16, West of the 4th Meridian and another on the northwestern boundary of the RSA in the northeast corner of Township 8, Range 19, West of the 4th Meridian. The regional hydraulic gradient focusing on these areas with higher data density is approximately 0.004 m/m to 0.01 m/m.

Using a geometric mean horizontal hydraulic conductivity of 1.7×10^{-6} m/s derived from the packer and slug tests, an assumed effective porosity of 0.3, and the regional hydraulic gradients, a groundwater flow rate of 0.7 m/yr to 2 m/yr was calculated. Regionally, groundwater flow rates would be expected to be slightly lower, reflecting the lower regional hydraulic conductivity.

I-4.4 Lea Park Formation

As shown in the regional cross-sections, the Lea Park Formation extends across the RSA, with a thickness of 20 m to 30 m, separating the overlying surficial deposits and Foremost Formation from the underlying Milk River Formation. As discussed in Volume 4-3, Section 4.6, the groundwater chemistry of the Milk River Formation is distinct from that observed in the surficial and bedrock units above the Lea Park and demonstrates the effectiveness of the Lea Park Formation as an aquitard limiting groundwater movement between these two hydrostratigraphic zones. Estimates of hydraulic conductivity for the Lea Park Formation are on the order of 10^{-9} m/s and 10^{-11} m/s (Sracek 1993; GIN 2021).

I-4.5 Milk River Formation

The extent of the Milk River Aquifer is illustrated on Figure 3.4 in Volume 4-3 and extends across the RSA. Groundwater elevations within the RSA for the Milk River Formation are shown in Figure I.4.7. The overall groundwater contours indicate a groundwater flow direction to the north or northeast. This is consistent with the regional flow direction reported in regional studies (Meyboom 1960; Pétré 2015). The regional hydraulic gradient is variable across the RSA from approximately 0.002 m/m to 0.02 m/m. Using a regional horizontal hydraulic conductivity of 1.8×10^{-7} m/s (GIN 2021), an assumed effective porosity of 0.3 and the hydraulic gradients identified within the RSA, a groundwater flow rate of 0.04 m/yr to 0.4 m/yr was calculated. These groundwater velocities overlap but are at the lower end of the range reported in regional studies (Meyboom 1960; Riemersma 2012) which extend up to 2 m/yr.

Low groundwater elevations are noted at several locations along the Chin Coulee to the east of the New East Dam in Township 7, Range 14, West of the 4th Meridian (Figure I.4.7). Two of these locations had water levels below ground level, but two were above ground, one by more than 6 m. Although the accuracy of these measurements is uncertain, if correct, they suggest potential depressurization of the aquifer in this area possibly because of flowing artesian water wells. Groundwater elevations above ground were also observed at one or two water wells near Sherburne and Horsefly Lakes.

In general, groundwater elevations from the Milk River Aquifer adjacent to the Chin Coulee are higher than those presented by Meyboom (1960) and higher than the current and proposed reservoir FSL of 861.36 masl and 864 masl, respectively (Figure I.4.7). These groundwater elevations indicate a consistent upward gradient from the Milk River Aquifer to either the coulee base or reservoir due to the relatively lower topography or reservoir levels along the Chin Coulee.

Analysis by Pétré et al. (2015) demonstrates generally downward flow in the RSA from surficial deposits to the Milk River Aquifer and from the Milk River Aquifer to the underlying Bow Island Sandstone, with gradients of 0.3 to 0.67 and 0.15 to 0.3, respectively. This interpretation likely excludes the Chin Coulee itself where flowing artesian conditions from the Milk River Aquifer have been observed in water wells and an upward gradient results from the low topography along the coulee (Volume 4-3, Section 4.3).

Isotopic analyses (Pétré et al. 2015) including tritium, ^{14}C and $^{36}Cl/Cl$ ratio demonstrate that groundwater in the Milk River Aquifer in the RSA is over a million years old. The conceptual model developed for the Milk River Aquifer includes recharge primarily near the Montana border, discharge of some flow along the Milk River and low groundwater movement north of the Milk River as demonstrated by long residence time. Indirect discharge occurs through vertical leakage upwards underneath buried valleys and downwards into the underlying Colorado Group, but this discharge is low as indicated by the very long residence time.

I-4.6 Groundwater Flow System

I-4.6.1 Hydrostratigraphic Unit (HSU) Properties

Properties of the HSUs determined through regional studies and the investigation associated with the proposed reservoir expansion are summarized in Table 4.3. In general, the aquifer units are moderately to poorly conductive. The exception to this generalization is the Lower Surficial unit, which at one location has a high horizontal conductivity. Connectivity between the Lower Surficial unit and the Foremost Formation is expected as the Lower Surficial unit is in contact with the upper bedrock. Locally, permeable portions of the Upper Surficial unit could be in contact with the Foremost Formation, but the Upper Surficial unit is characterized as located in pockets and therefore most likely to be contained within till deposits. The continuity and low permeability of the Lea Park Formation provides separation between the Milk River Formation and all other overlying aquifer units.

Table 4.3 Summary of Hydrostratigraphic Unit Characteristics

Stratigraphic Unit		Hydrostratigraphic Designation	Regional Hydrogeology			This Study (Vol 4-3 and this report)		
			Horizontal Hydraulic Conductivity (m/s)	Groundwater Elevation (masl)	Groundwater Flow rate (m/yr)	Horizontal Hydraulic Conductivity (m/s)	Groundwater Elevations (masl)	Groundwater Flow rate and direction (m/yr)
Surficial Deposits	Upper Sand and Gravel	Aquifer	-	-	-	8.6×10^{-7}	920 - 860	0.3 to 0.7 Northeast
	Till	Aquitard	(2) Oxidized 10^{-8} to 10^{-10}, Unoxidized 10^{-10} to 10^{-11}	-	(2) 0.001 to 0.006	*1×10^{-9}*		<0.001 Northeast
	Lower Sand and Gravel	Aquifer, confined	(2) 10-6 to 10-7 Lethbridge Aquifer	-	(2) 0.003 - 0.03 Lethbridge Aquifer	3.2×10^{-4}	823	130 Southeast along coulee
Foremost Formation		Aquifer	(1) 9×10^{-8} to $8.8. \times 10^{-7}$ (2) 2×10^{-5} to 2×10^{-10} with geometric mean: 1×10^{-8}	-	-	range: 1.9×10^{-5} to 1.7×10^{-8} geomean: 1.7×10^{-6}	930 - 820	0.7 to 2 North or Northeast
Lea Park/Pakowki Formation		Aquitard	(1) 10^{-11} (2) 3×10^{-9}	-	-	*1×10^{-10}*	-	-
Milk River Formation		Aquifer, confined and inclined	(1) 1.8×10^{-7} (Virgelle Member)	(3) 869 to 853	(3) 0.15 to 1.5 (4) 2	*1.8×10^{-7}*	910 - 820	0.04 to 0.4 North or Northeast
Colorado Group		Aquitard	(1) 10^{-10} to 10^{-14}	-	-	*1×10^{-12}*	-	-

Notes:
References: (1) GIN 2021, (2) Sracek 1993, (3) Meyboom 1960, (4) Riemersma 2012, (5) Petre et al. 2015
Italics are values based on regional data

I-4.6.2 Groundwater Chemistry

Groundwater chemistry of the hydrostratigraphic units was discussed in Volume 4-3, Section 4.6 with the "Shallow" system containing samples from the surficial units and Foremost Formation and the "Deep" system including samples from the Milk River Formation. The groundwater chemistry in the surficial units and Foremost Formation was found to have conductivities ranging between 3,550 µS/cm and 12,200 µS/cm and predominantly sodium-sulphate type water. Groundwater within the Upper and Lower Surficial units was locally found to be saline with Total Dissolved Solids (TDS) concentrations from 4,640 mg/L to 10,800 mg/L, whereas the TDS concentrations are lower within the Foremost Formation with TDS from 2,760 mg/L to 3,470 mg/L. Groundwater from the Milk River Formation was found to be sodium-bicarbonate type with TDS concentration of 2,440 mg/L or less, and higher concentrations of fluoride, boron and barium as compared to groundwater from the shallower units.

The isotopic results from regional studies support a general characterization of a slow-moving groundwater system, with penetration of modern (<50-year-old) waters to depths of less than 12 m (Pétré et al. 2015; Sracek 1993). The TDS concentrations observed in groundwater from the surficial units are consistent with a generally slow-moving groundwater system. Historical and recent chemical analyses from one water well (GIC Well ID 2096581), located within the LSA in the Chin Coulee, and interpreted as completed in the Milk River Aquifer, demonstrate consistent chemistry over a period of more than 80 years and are summarized in Table 4.4.

Table 4.4 Groundwater Chemistry Analyses from GIC Well ID 2096581 (mg/L)

Sample Date	1937-06-30[1]	2021-10-20	2022-05-16	2022-10-13
Total Alkalinity	1,305	1,350	1,390	1,380
TDS	2,020	1,980	2,120	2,040
Calcium[2]	21	2.19	2.98	2.49
Chloride	327	360	332	339
Sodium[2]	789	799	932	851
Magnesium[2]	9	0.933	1.11	1.03
Sulphate	33	<1.5	<1.50	<1.50
Total Hardness	20	9.3	12.0	10.4

Notes:
1 Analysis date as no sampling date was provided.
2 Results from 2021 and 2022 are dissolved. 1937 laboratory report is total.

I-4.6.3 Interactions between HSUs

A comparison of the groundwater elevations in the Upper Surficial unit, Foremost Formation and Milk River Formation demonstrate the following.

- Groundwater elevations in the Upper Surficial unit are generally higher than those in either the Foremost Formation or Milk River Formation indicating an overall downward hydraulic

gradient from the Upper Surficial unit. This is consistent with regional mapping from Pétré et al. (2015).

- The Milk River Formation has a regional downward gradient towards the deeper Bow Island Sandstone (Pétré et al. 2015) but has local upward gradients in the low topography along the Chin Coulee and in the northern central portion of the RSA, which is towards the northern limit of the Milk River Aquifer and coincides with lower topography. This is demonstrated by the artesian groundwater conditions observed near Sherburne and Horsefly Lakes.
- Groundwater elevations in the Foremost Formation appear lower relative to both the Upper Surficial unit and the Milk River Aquifer and therefore there is a downward gradient from the Upper Surficial unit and upward gradient from the Milk River Aquifer. These observations support a potential connection between the Foremost Formation and the Lower Surficial unit, where low groundwater elevations have been observed locally at MW22-01.

I-4.6.4 Groundwater and Surface Water Interactions

Groundwater interactions with surface water were described in Volume 4-3, Section 5.1 with groundwater recharge from precipitation at higher elevations and discharge at the base of the coulee. The estimated mean annual runoffs are low with a deficit annual water balance resulting from annual evapotranspiration that exceeds annual precipitation (Volume 4-1). Only a fraction of the generated runoff is estimated to discharge into water bodies, with a runoff coefficient of 0.1 to 0.25, because of local depressions in the ground surface that need to be filled before runoff occurs. The watercourse within the coulee is ephemeral and dry most of the year demonstrating the limited recharge from runoff or groundwater into the Chin Coulee (Volume 4-1, Section 3.1.1), coupled with high potential for evaporation of discharged water.

I-4.7 Historical Groundwater Fluctuations

Three long-term observation wells in the Alberta GOWN are located outside the RSA but provide an indication of long-term changes in key bedrock units (GoA 2025a). The locations of these wells are shown on Figure 3.8. Wells completed in surficial units in the GOWN at similar distances were reviewed but not included as these shallower deposits would more strongly reflect local conditions and are unlikely to provide insight into long-term groundwater conditions in the RSA. One well in the Foremost Formation and two in the Milk River Formation were identified. The records for one well (0954) do not provide a completion aquifer but based on available information from the well record and regional mapping, is interpreted as likely completed in the Milk River Formation. Time-series hydrographs for the water elevation recorded at each of these observation wells are included as Figure I.4.9 to Figure I.4.11.

The monitoring well completed in the Foremost Formation (0214) is located to the south of the RSA and shows a consistent increase in groundwater elevation for the period of record from 1986 to 2024. The total increase in groundwater elevation over this period is about 1.5 m.

The two observation wells completed in the Milk River are both located to the east of the RSA, one to the northeast (0286) and the other to the southeast (0954). The piezometric levels in observation well 0286 show some fluctuations over the period of record from 1990 to 2024 that ranges slightly

more than 3 m. A significant decline and recovery in groundwater elevation is noted between 2000 and 2003 that may be related to local pumping. Piezometric levels in observation well 0954 show a fairly consistent decline from 2006 to 2017 with recharge occurring over 2018 to 2019, before beginning to decline again. The total fluctuation in groundwater elevation for the period of record is about 4 m. Despite the observed fluctuations the net change in groundwater elevation in the Milk River Formation over the past twenty to thirty years is less than 1 m at these locations.

I-5 GROUNDWATER USE

Water well records from the AWWID were queried for the RSA (GoA 2025b). A total of 712 individual water well records were identified within the RSA. Water well records for uses such as abandoned test holes, seismic test holes, dry or decommissioned holes, oil exploration or chemistry only records were removed from this data set as not representative of water wells for groundwater use. A total of 421 water well records were identified within the RSA with the proposed uses as summarized in the following:

- 155 for domestic and stock use;
- 110 for stock use;
- 72 for domestic use;
- 4 for industrial use;
- 4 for irrigation use;
- 4 for observation;
- 3 for other use;
- 1 for municipal use; and,
- 68 unknown use.

Settlement of the region in the early part of the 20th century is evident in the numbers of wells drilled per year (Figure I.5.1). From 1940 onwards, the number of new wells drilled stabilized at fewer than two per year (on an average basis).

A summary of the well depth by completion date for the 311 well records with this information is provided in Table 5.1. This summary shows that the wells installed prior to 1960 were dominantly shallow with 44% of the installed wells having a depth of less than 10 m, likely hand dug. Between 1940 and 2000 more than 50% of new wells were completed at depths of 200 m to 300 m, likely targeting the Milk River Aquifer.

A summary of the groundwater licenses and registrations within the RSA is provided in Table 5.2 (GoA 2025c and 2025d).

Figure I.5.1 Count of Well Records within RSA by Completion Date

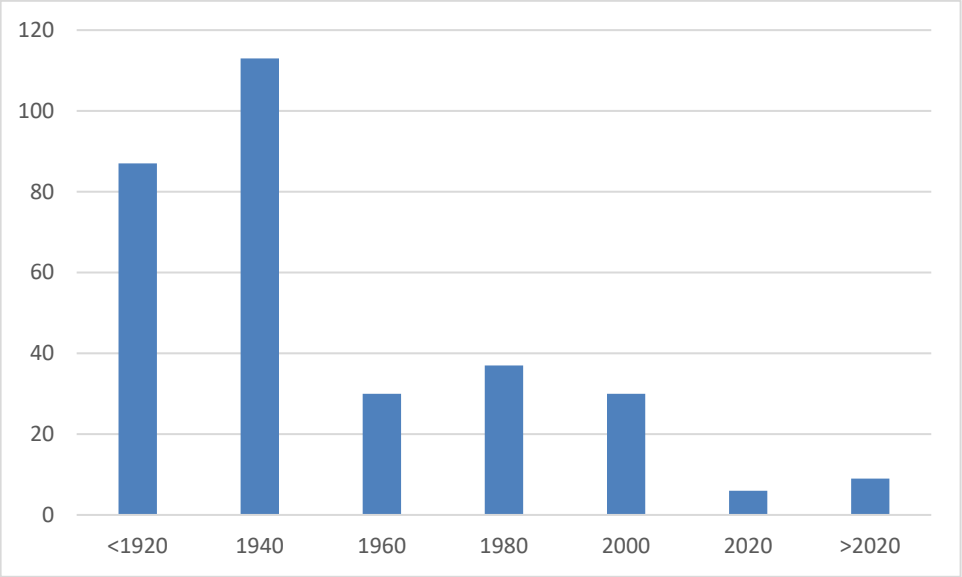


Table 5.1 Summary of Well Depth by Completion Date

Period / Depth Range (m)	<1920	1920 - 1940	1940 - 1960	1960 - 1980	1980 - 2000	2000 - 2020	>2020	Total
0 - 10	33	55	1	2	3	1	-	**95**
10 – 50	19	31	1	8	8	0	0	**67**
50 - 100	26	8	1	5	5	3	1	**49**
100 - 150	5	0	1	1	2	-	-	**9**
150 - 200	-	3	-	2	1	-	1	**7**
200 - 250	2	13	7	10	9	1	1	**43**
250 - 300	2	3	18	8	-	1	4	**36**
>300	-	0	1	1	1	-	2	**5**
Total	**87**	**113**	**30**	**37**	**29**	**6**	**9**	**-**

Table 5.2 Groundwater Licenses and Registrations within the RSA

Legal Land location	Authorization	License Number	Maximum Diversion (m3/year)	Document No	Production Top Depth (m)	Production Bottom Depth(m)
SE-34-006-14-W4	Registration		457	00165686-00-00		
12-30-007-14-W4	License	9995	3,785	00032475-00-00	?	182.9
SW-13-007-14-W4	Registration		4,570	00162532-00-00		
NW-06-007-14-W4	Registration		366	00165317-00-00		
NW-22-008-14-W4	Registration		1,095	00161710-00-00		
NE-10-008-14-W4	Registration		240	00169011-00-00		
SE-11-009-14-W4	Registration		2,369	00168997-00-00		
NE-15-009-14-W4	Registration		373	00168997-00-00		
NW-15-009-14-W4	Registration		6,222	00168997-00-00		
SE-22-009-14-W4	Registration		2,263	00168997-00-00		
NW-08-009-14-W4	Registration		3,210	00169138-00-00		
SE-09-009-14-W4	Registration		519	00169274-00-00		
NW-08-009-14-W4	Registration		3,210	00169336-00-00		
SW-14-009-14-W4	Registration		1,186	00169336-00-00		
NE-15-009-14-W4	Registration		373	00225682-00-00		
NW-15-009-14-W4	Registration		6,222	00225682-00-00		
3-3-007-15-W4	License	21558	19,090	0048475-00-00	201.2	249.9
NE-11-007-15-W4	Registration		123	00164160-00-00		
SW-01-007-15-W4	Registration		1,319	00164661-00-00		
NE-30-007-15-W4	Registration		1,136	00164974-00-00		
SW-15-007-15-W4	License	16783	3,650	00502823-00-00	236.2	254.5
4-15-008-15-W4	License	9960	6,813	00031747-00-00	271.3	280.4
NE-17-008-15-W4	Registration		2,500	00164974-00-00		
NW-05-009-15-W4M	Registration		1,250	00164974-00-00		
NW-10-008-15-W4	Registration		455	00181590-00-00		
SW-15-008-15-W4	Registration		455	00181590-00-00		

Legal Land location	Authorization	License Number	Maximum Diversion (m3/year)	Document No	Production Top Depth (m)	Production Bottom Depth(m)
2-19-007-16-W4	License	10572	7,949	00031493-00-00	243.8	259.7
12-008-16-W4	Registration		1,473	00181583-00-00		
13-33-009-16-W4	License	9853	5,678	00031823-00-00	?	?
17-009-16-W4	Registration		4,640	00165666-00-00		
5-36-006-17-W4	License	10977	5,678	00035156-00-00	?	296.9
NW-09-007-18-W4	Registration		125	00159533-00-00		
12-20-006-18-W4M	License	20982	8,706	00023892-00-00	?	38.1

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FIGURES



Legend

- Line of Section
- All Weather Road
- Township Boundary (ATS)
- Approximate Expansion Area
- Project Area (PA)
- Regional Study Area (RSA)
- Local Study Area (LSA)

0 10 Kilometres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: TOWN OF PINCHER CREEK, MAXAR
4. FULL SUPPLY LEVEL OF EXISTING RESERVOIR TO INCREASE FROM 861.4 MASL TO 864 MASL

CLIENT: SMRID

Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: STUDY AREAS AND CROS-SECTION ALIGNMENTS

SCALE	PROJECT No.	FIG No.
1:160,000	A03701E05	I.4.1

File: \\nt.klohn.com\ProjData\AICGY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\Chin Reservoir TBR Figures\Chin Reservoir EGDB aprx Creator: : HMarandyan

A

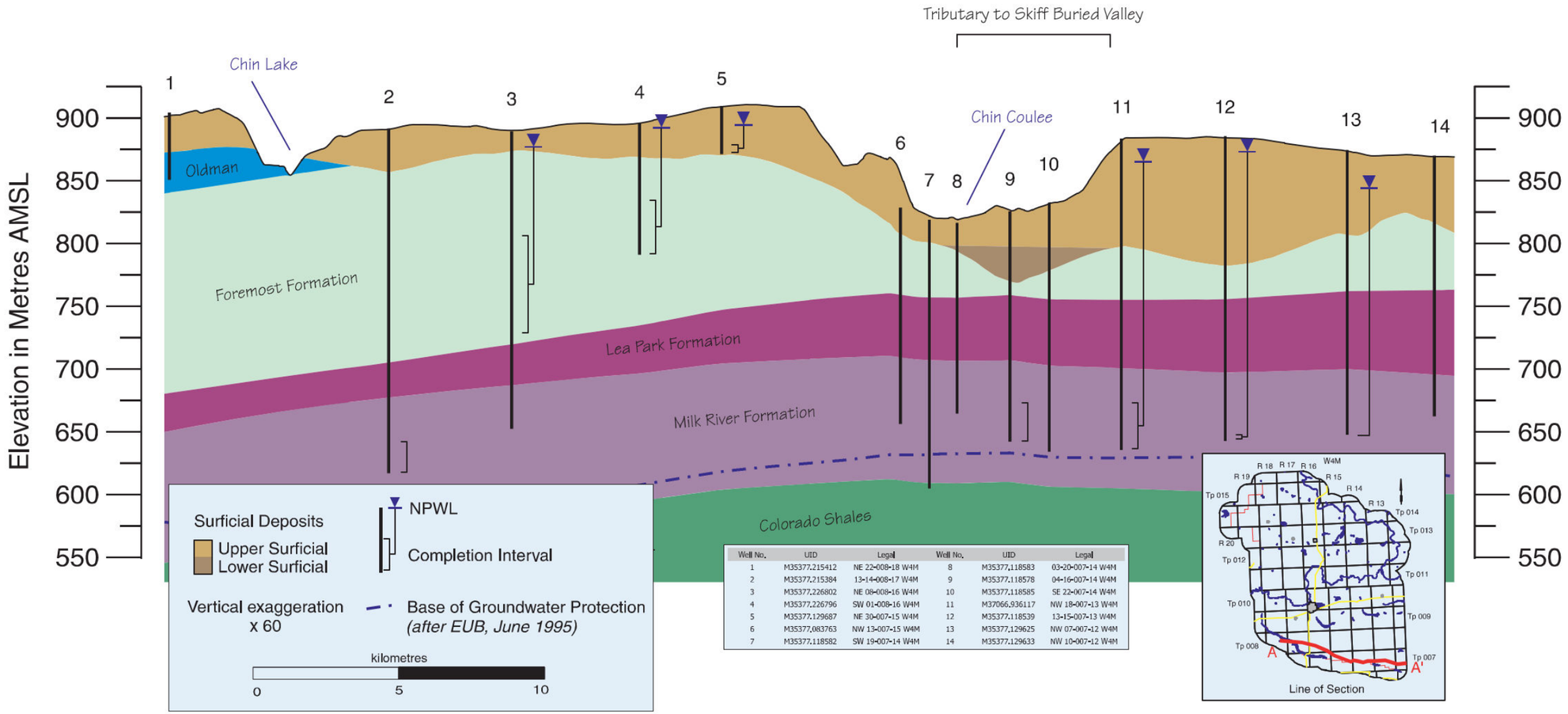
RSA

A'

West

M.D. of Taber

East



Well No.	UID	Legal	Well No.	UID	Legal
1	M35377,215412	NE 22-008-18 W4M	8	M35377,118583	03-20-007-14 W4M
2	M35377,215384	13-14-008-17 W4M	9	M35377,118578	04-16-007-14 W4M
3	M35377,226802	NE 08-008-16 W4M	10	M35377,118585	SE 22-007-14 W4M
4	M35377,226796	SW 01-008-16 W4M	11	M37066,936117	NW 18-007-13 W4M
5	M35377,129687	NE 30-007-15 W4M	12	M35377,118539	13-15-007-13 W4M
6	M35377,083763	NW 13-007-15 W4M	13	M35377,129625	NW 07-007-12 W4M
7	M35377,118582	SW 19-007-14 W4M	14	M35377,129633	NW 10-007-12 W4M

NOTES:
1. REGIONAL CROSS-SECTION GRAPHIC TAKEN FROM HCL PFRA REPORT

CLIENT: SMRID

Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: REGIONAL CROSS-SECTION A-A'

SCALE	PROJECT No.	FIG No.
N/A	A03701E05	I.4.2

File: \\int.klohn.com\ProjData\AICGY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\Chin Reservoir TBR Figures\Chin Reservoir EGDB aprx Creator: : HMarandyan

F

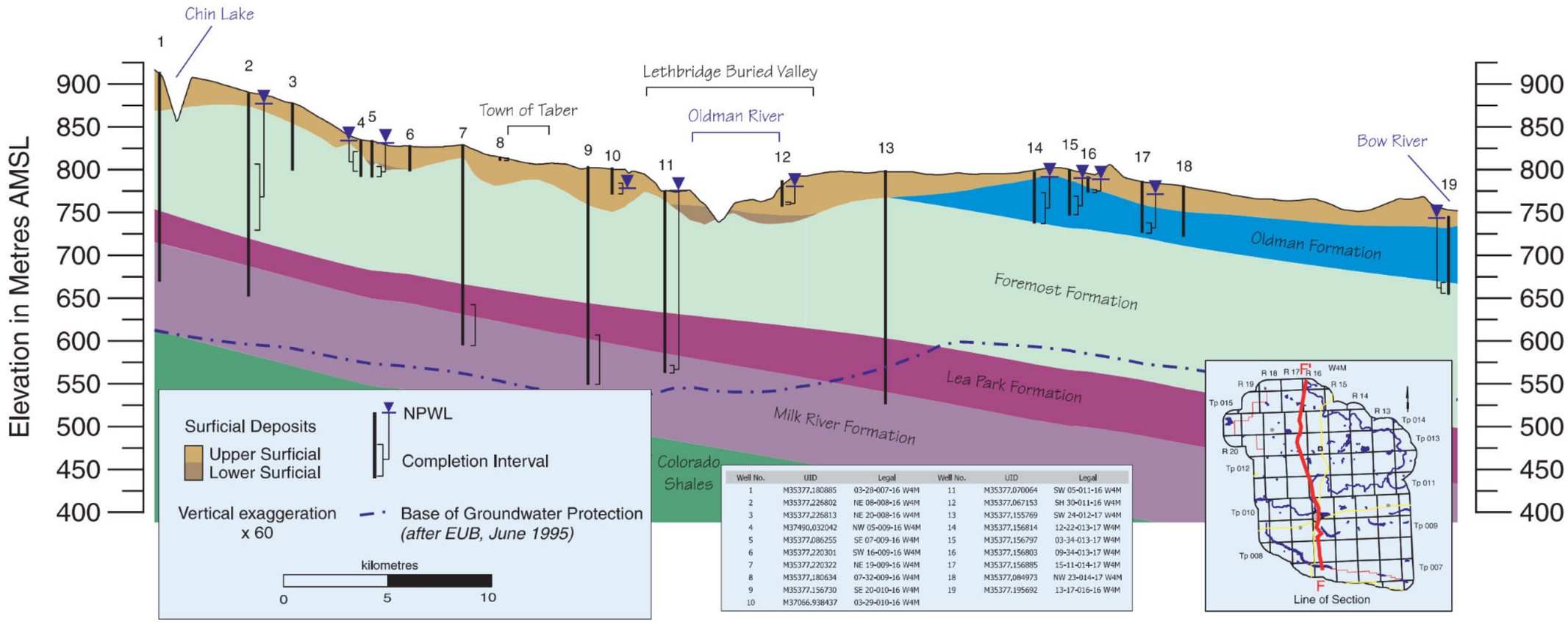
RSA

F'

South

M.D. of Taber

North



Well No.	UID	Legal	Well No.	UID	Legal
1	M35377,180885	03-28-007-16 W4M	11	M35377,070064	SW 05-011-16 W4M
2	M35377,226802	NE 08-008-16 W4M	12	M35377,067153	SH 30-011-16 W4M
3	M35377,226813	NE 20-008-16 W4M	13	M35377,155769	SW 24-012-17 W4M
4	M37490,032042	NW 05-009-16 W4M	14	M35377,156814	12-22-013-17 W4M
5	M35377,086255	SE 07-009-16 W4M	15	M35377,156797	03-34-013-17 W4M
6	M35377,220301	SW 16-009-16 W4M	16	M35377,156803	09-34-013-17 W4M
7	M35377,220322	NE 19-009-16 W4M	17	M35377,156885	15-11-014-17 W4M
8	M35377,180634	07-32-009-16 W4M	18	M35377,084973	NW 23-014-17 W4M
9	M35377,156730	SE 20-010-16 W4M	19	M35377,195692	13-17-016-16 W4M
10	M37066,938437	03-29-010-16 W4M			

NOTES:
1. REGIONAL CROSS-SECTION GRAPHIC TAKEN FROM HCL PFRA REPORT

CLIENT: SMRID

Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: REGIONAL CROSS-SECTION F-F'

SCALE: N/A | PROJECT No.: A03701E05 | FIG No.: I.4.3

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G

RSA

G'

South

North

M.D. of Taber

Chin Coulee

Lethbridge Buried Valley

Vauxhall Buried Valley

Tee Pee Buried Valley

Oldman River

AENV Obs WW No. 279

Bow River

Oldman

Foremost Formation

Milk River Formation

Lea Park Formation

Colorado Shales

Elevation in Metres AMSL

900 850 800 750 700 650 600 550 500 450

Surficial Deposits

Upper Surficial

Lower Surficial

NPWL

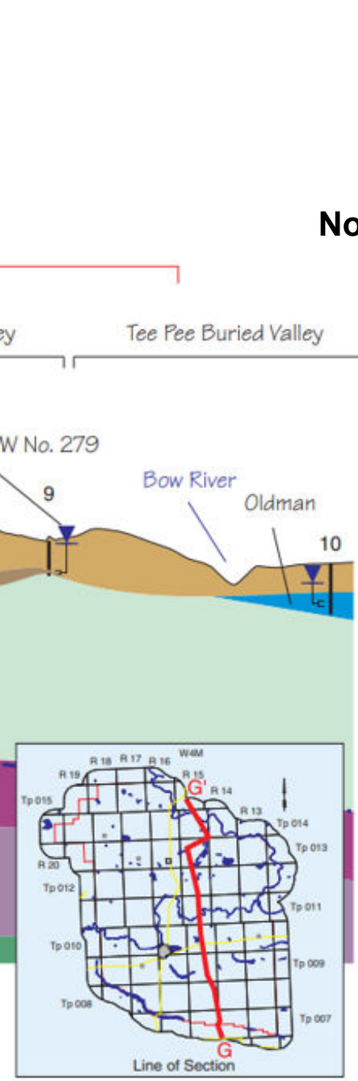
Completion Interval

Vertical exaggeration x 60

Base of Groundwater Protection (after EUB, June 1995)

kilometres 0 5 10

Well No.	UID	Legal
1	M35377.118562	SE 06-007-14 W4M
2	M35377.083763	NW 13-007-15 W4M
3	M35377.118582	SW 19-007-14 W4M
4	M35377.130182	SW 25-008-15 W4M
5	M35377.135186	01-10-009-15 W4M
6	M35377.135679	NE 21-010-15 W4M
7	M35377.137712	SW 03-012-15 W4M
8	M35377.091538	NW 20-013-15 W4M
9	M35377.128889	16-36-013-15 W4M
10	M35377.138310	13-09-015-15 W4M



NOTES:
1. REGIONAL CROSS-SECTION GRAPHIC TAKEN FROM HCL PFRA REPORT

CLIENT: SMRID

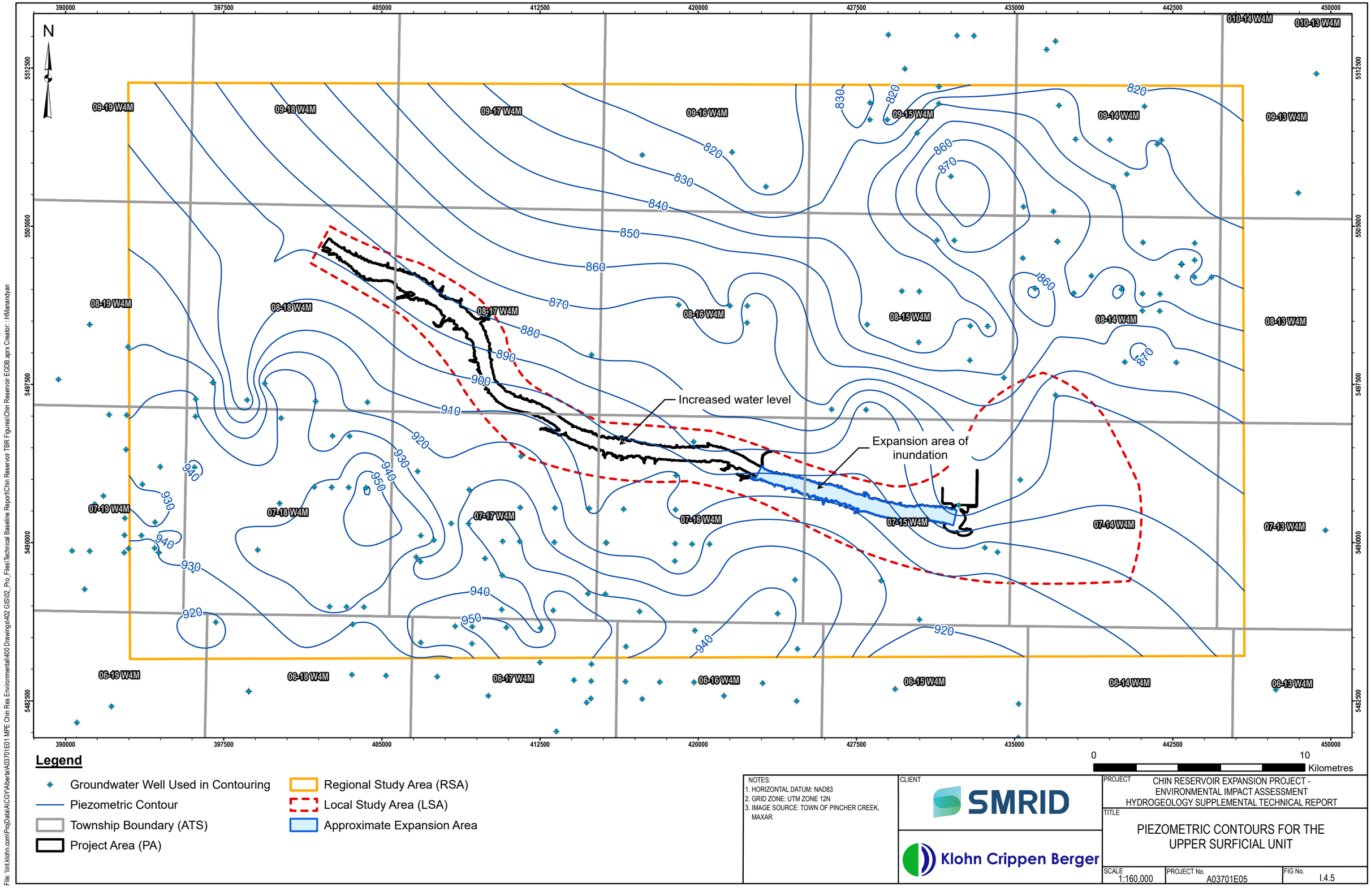
Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: REGIONAL CROSS-SECTION G-G'

SCALE: N/A | PROJECT No.: A03701E05 | FIG No.: I.4.4

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Legend

- Groundwater Well Used in Contouring
- Piezometric Contour
- Township Boundary (ATS)
- Project Area (PA)
- Regional Study Area (RSA)
- Local Study Area (LSA)
- Approximate Expansion Area

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: TOWN OF PINCHER CREEK, MAXAR

CLIENT: SMRID

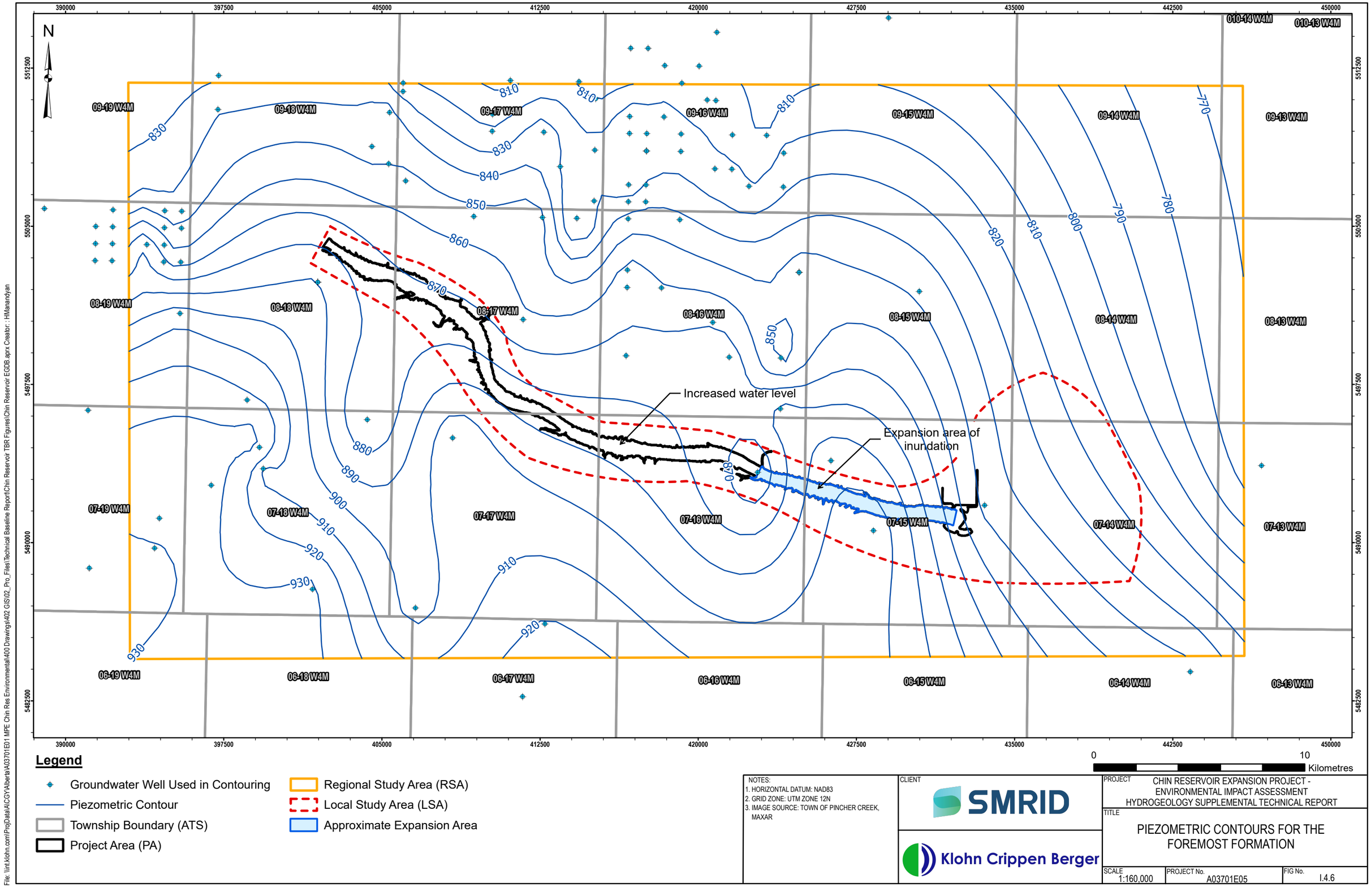
Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: PIEZOMETRIC CONTOURS FOR THE UPPER SURFICIAL UNIT

SCALE: 1:160,000 | PROJECT No.: A03701E05 | FIG No.: I.4.5

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Legend

- Groundwater Well Used in Contouring
- Piezometric Contour
- Township Boundary (ATS)
- Project Area (PA)
- Regional Study Area (RSA)
- Local Study Area (LSA)
- Approximate Expansion Area

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: TOWN OF PINCHER CREEK, MAXAR

CLIENT: SMRID

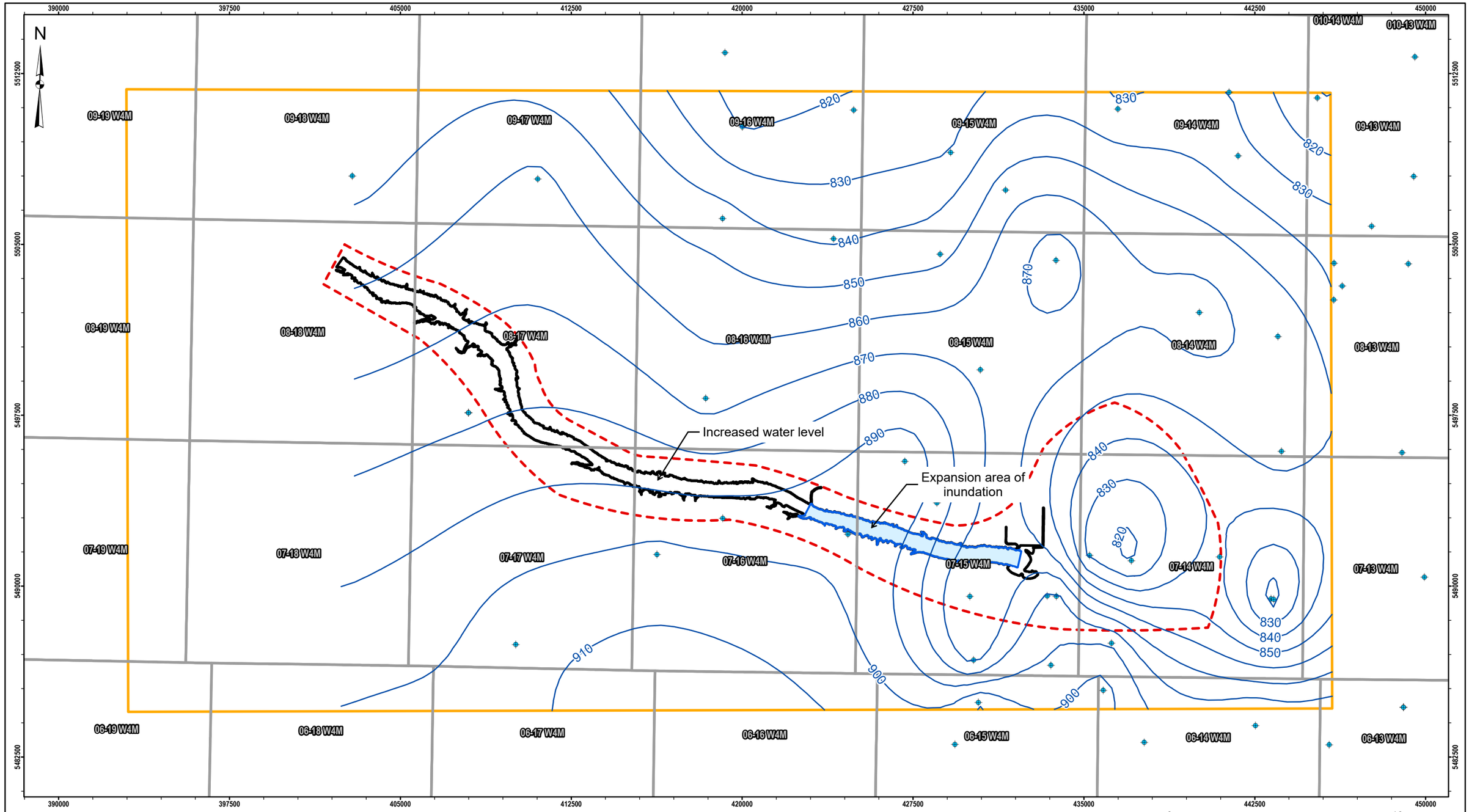
Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: PIEZOMETRIC CONTOURS FOR THE FOREMOST FORMATION

SCALE	PROJECT No.	FIG No.
1:160,000	A03701E05	I.4.6

File: \\int.klohn.com\Proj\Data\AC\GY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\Chin Reservoir TBR Figures\Chin Reservoir EGDB aprx Creator: : HMarandyan



Legend

- Groundwater Well Used in Contouring
- Piezometric Contour
- Township Boundary (ATS)
- Project Area (PA)
- Regional Study Area (RSA)
- Local Study Area (LSA)
- Approximate Expansion Area

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: TOWN OF PINCHER CREEK, MAXAR

CLIENT: SMRID

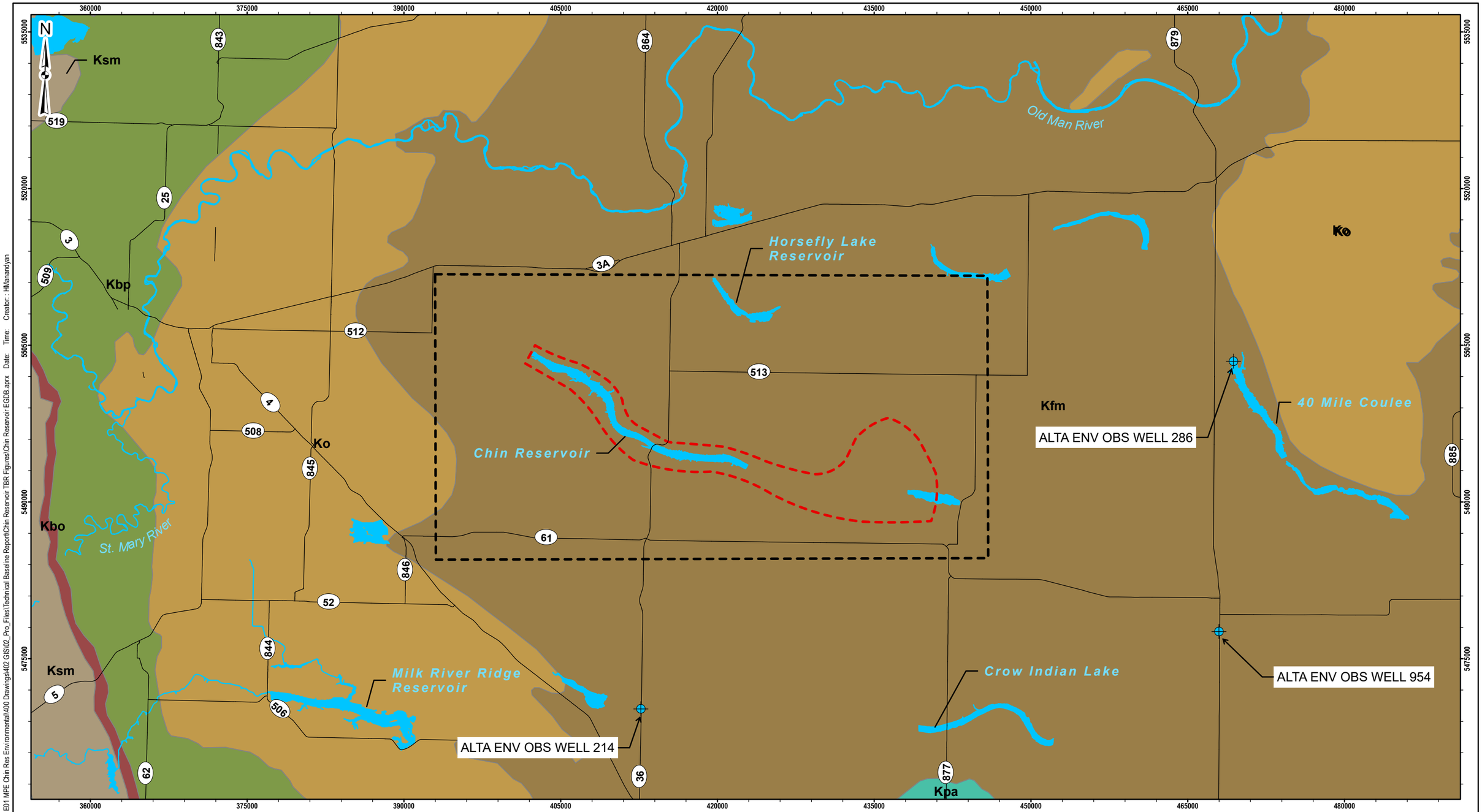
Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: PIEZOMETRIC CONTOURS FOR THE MILK RIVER FORMATION

SCALE	PROJECT No.	FIG No.
1:160,000	A03701E05	I.4.7

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Legend

- Observation Water Well
- All Weather Road
- Local Study Area
- Regional Study Area
- Water Feature

Bedrock Geology - Formation

- Bearpaw Formation (Kbp)
- Blood Reserve Formation (Kbo)
- Foremost Formation (Kfm)
- Oldman Formation (Ko)
- Pakowki Formation (Kpa)
- St. Mary River Formation (Ksm)
- Willow Creek Formation

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. BEDROCK GEOLOGY OF ALBERTA, ALBERTA GEOLOGICAL SURVEY, UPDATED 2016.

CLIENT: SMRID

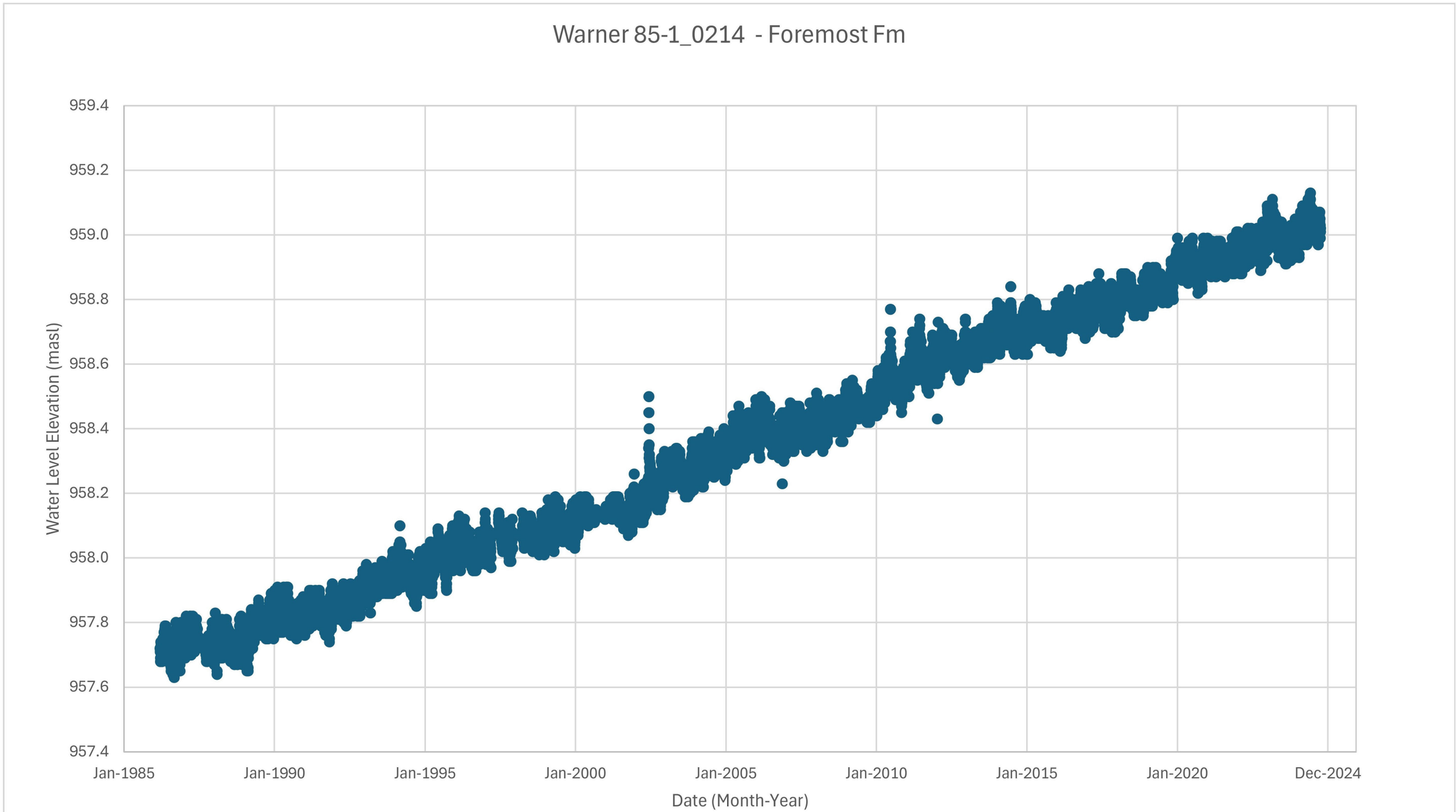
Klohn Crippen Berger

PROJECT: CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE: REGIONAL BEDROCK GEOLOGY AND GOWN WELL LOCATIONS

SCALE	PROJECT No.	FIG No.
1:350,000	A03701E05	I.4.8

File: \\int.klohn.com\ProjData\ALCGY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\Chin Reservoir TBR Figures\Chin Reservoir EGDB.aprx Date: Time: Creator: HMkanardyan



NOTES:

CLIENT

SMRID

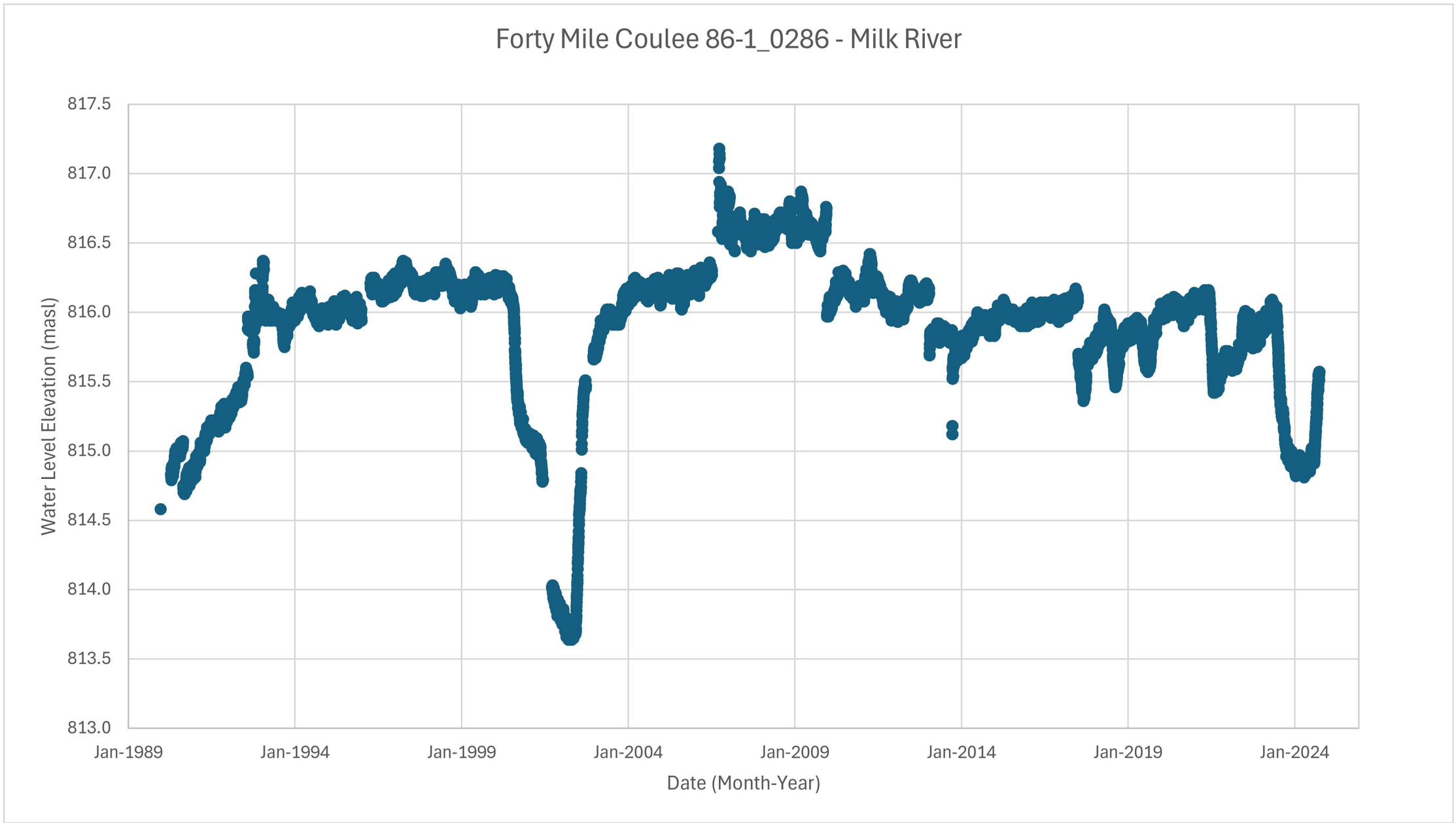
Klohn Crippen Berger

PROJECT
CHIN RESERVOIR EXPANSION PROJECT -
ENVIRONMENTAL IMPACT ASSESSMENT
HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE
GOWN HYDROGRAPHS –
FOREMOST FORMATION 0214

SCALE	PROJECT No.	FIG No.
N/A	A03701E05	I.4.9

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NOTES:

CLIENT

SMRID

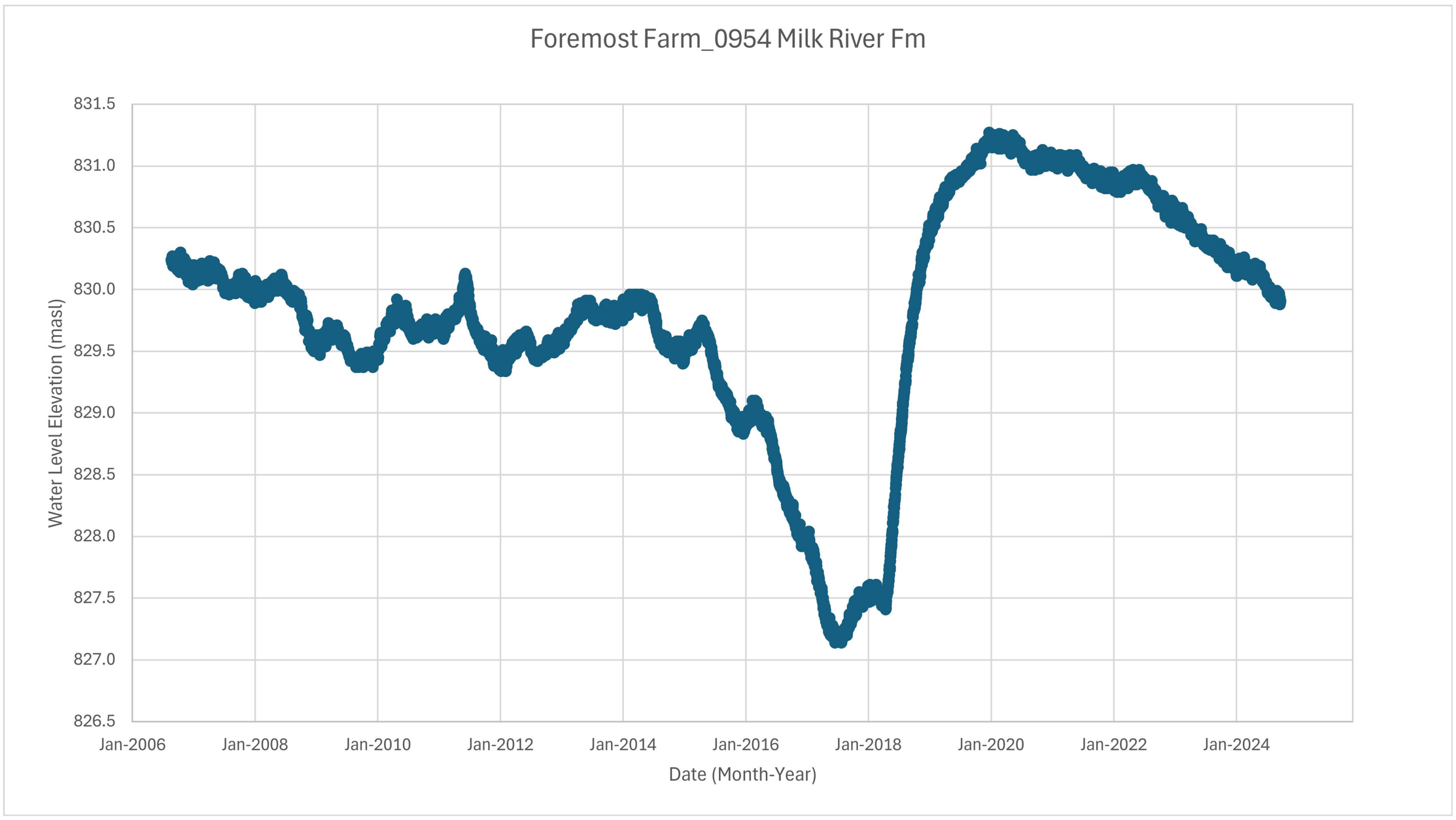
Klohn Crippen Berger

PROJECT
CHIN RESERVOIR EXPANSION PROJECT -
ENVIRONMENTAL IMPACT ASSESSMENT
HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE
GOWN HYDROGRAPHS –
MILK RIVER FORMATION 0286

SCALE	PROJECT No.	FIG No.
N/A	A03701E05	I.4.10

File: \\int.klohn.com\ProjData\AICGY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\Chin Reservoir TBR Figures\Chin Reservoir EGDB aprx Creator: : HMarandyan



NOTES:

CLIENT

SMRID

Klohn Crippen Berger

PROJECT CHIN RESERVOIR EXPANSION PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT HYDROGEOLOGY SUPPLEMENTAL TECHNICAL REPORT

TITLE GOWN HYDROGRAPHS – MILK RIVER FORMATION 0954

SCALE N/A | PROJECT No. A03701E05 | FIG No. I.4.11

File: \\int.klohn.com\ProjData\AI\CGY\Alberta\A03701E01 MPE Chin Res Environmental\400 Drawings\402 GIS\02_Pro_Files\Technical Baseline Report\Chin Reservoir TBR Figures\Chin Reservoir EGDB aprx Creator: : HMarandyan

APPENDIX 144.1

Naturalized Flow Data

grdcon Natural Weekly Mean Flows Calculated (m³/s) Data Revision Oct. 20, 2004

Year	Mean	Dam3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1912	341.5	10,799,244	34.0	50.4	52.6	58.9	63.0	68.3	62.0	71.7	66.1	63.1	55.5	59.9	116.5	278.5	284.2	338.4	229.4	261.0	390.7	421.9	644.6	610.4	455.1	449.9	1065.0	797.7	728.3	1089.0	977.8	932.2	831.8	588.9	474.8	501.3	554.3	484.7	466.7	365.7	324.8	276.0	258.9	267.8	254.2	230.3	206.6	194.4	198.1	155.4	107.6	91.0	76.1	73.1
1913	332.8	10,494,398	69.8	56.1	43.8	54.5	72.5	61.9	63.6	71.2	71.6	65.6	77.9	83.2	70.5	118.8	459.6	597.1	390.5	278.2	317.9	519.8	528.6	948.6	1071.0	1064.0	895.1	1043.0	1004.0	660.6	543.6	487.5	458.7	438.7	616.6	453.5	343.9	365.9	332.5	237.3	217.5	206.2	201.1	209.1	218.4	198.3	173.8	152.5	149.8	141.3	126.0	116.0	96.1	61.2
1914	262.5	8,279,201	88.4	100.3	83.7	61.7	50.5	46.9	53.1	52.8	58.7	85.4	135.3	160.8	149.7	133.9	150.8	212.9	260.0	302.2	418.9	506.4	620.8	567.3	731.9	710.5	813.2	657.0	586.0	610.1	524.8	381.3	281.3	265.6	246.5	255.6	238.7	199.0	180.7	161.7	190.7	198.0	249.4	291.9	333.1	236.7	206.0	189.3	161.7	164.4	112.2	61.9	49.0	63.0
1915	487.2	15,365,789	87.0	84.2	69.7	64.0	57.0	63.6	61.7	62.6	63.9	67.0	69.6	322.7	382.4	252.0	178.6	157.9	218.3	293.3	596.3	907.6	821.3	827.4	1014.0	972.7	1187.0	2181.0	1600.0	1218.0	1893.0	1239.0	1262.0	813.7	582.1	910.6	556.5	447.5	409.3	347.4	374.4	355.6	341.3	305.6	276.3	233.9	243.2	182.3	145.1	123.1	122.6	105.2	97.7	88.7
1916	536.9	16,978,194	69.8	61.5	67.8	68.3	66.2	72.0	92.1	362.7	191.6	117.4	157.9	270.3	283.5	289.1	307.8	340.2	283.3	281.4	481.8	409.8	363.3	660.5	1490.0	1350.0	1968.0	1981.0	2325.0	1806.0	1263.0	912.5	740.5	576.8	584.2	1010.0	777.5	796.1	1028.0	570.2	406.9	347.8	333.0	302.7	344.5	356.3	266.1	183.3	200.1	202.1	171.6	123.0	102.5	102.1
1917	402.3	12,686,126	81.8	77.2	85.9	86.9	76.0	78.2	87.3	76.8	63.6	66.1	75.3	81.4	99.1	142.3	486.1	661.7	354.6	302.1	357.6	986.0	1429.0	1832.0	1879.0	1741.0	1480.0	1104.0	945.1	886.2	670.5	537.6	384.6	329.8	327.3	300.7	280.6	251.0	245.7	214.0	196.7	191.9	185.5	197.5	189.0	157.0	152.7	128.9	99.3	97.3	49.2	33.5	35.6	40.3
1918	242.9	7,660,416	91.1	110.3	63.6	88.3	81.7	60.7	109.3	73.0	48.4	87.2	77.0	233.6	562.8	299.5	242.8	291.8	246.2	243.4	436.6	377.1	389.4	306.5	402.9	932.5	1019.0	680.8	426.4	368.4	366.6	349.6	294.0	268.9	278.0	296.3	249.5	217.8	203.8	189.7	180.5	183.4	160.5	137.6	159.7	134.6	118.4	105.3	84.8	65.7	55.5	61.7	55.8	63.5
1919	203.7	6,425,369	51.1	49.7	50.8	59.6	60.1	48.5	41.2	58.5	47.4	38.9	46.2	57.5	75.9	186.8	280.2	298.8	212.2	258.2	310.0	414.4	498.4	911.9	603.2	474.2	409.7	544.9	422.5	300.5	285.4	253.7	249.7	498.8	362.0	282.5	230.6	191.3	181.6	190.6	148.6	118.1	107.6	94.2	65.0	53.3	46.9	52.6	78.3	74.4	45.9	49.3	57.1	66.2
1920	345.2	10,914,526	69.5	50.0	50.0	48.5	46.9	57.2	75.4	71.5	67.1	62.1	69.9	168.9	267.0	165.7	140.2	478.2	781.4	892.1	999.1	1160.0	973.8	587.7	463.0	743.8	917.6	889.6	812.9	1086.0	999.5	770.4	576.3	429.6	341.6	310.3	255.6	204.0	172.0	160.0	163.0	163.5	164.0	147.6	143.8	125.2	115.3	89.4	75.4	84.4	82.9	62.2	61.7	55.1
1921	243.3	7,674,267	69.5	64.3	53.8	46.0	46.4	55.8	68.9	54.7	92.2	105.3	63.7	72.2	87.9	161.8	233.8	433.9	380.1	225.6	279.0	448.0	698.7	934.4	856.8	973.1	705.4	687.6	652.3	507.4	395.6	339.3	325.6	282.7	234.8	234.9	185.1	144.0	139.7	137.0	108.2	114.9	93.5	91.9	93.2	103.8	115.1	105.0	56.5	43.7	57.9	86.4	71.5	35.2
1922	225.8	7,119,725	46.4	59.0	61.9	47.9	34.9	45.0	39.5	32.4	35.0	36.3	45.1	80.8	73.4	97.2	197.9	162.1	268.8	374.2	385.9	288.2	681.9	696.6	957.9	848.8	792.1	584.3	510.6	535.7	421.8	320.7	277.7	275.3	264.1	287.8	249.0	206.1	177.4	158.1	147.4	118.7	122.7	99.3	86.4	88.1	86.1	73.8	58.1	55.7	40.5	31.1	23.5	50.9
1923	363.2	11,454,973	55.2	49.5	43.0	37.8	38.0	32.0	36.7	34.9	40.0	54.8	49.6	51.8	79.1	108.7	117.5	153.5	207.1	175.5	169.8	389.7	425.8	947.2	2603.0	1694.0	1411.0	2015.0	1223.0	829.7	675.2	517.2	472.4	410.9	451.1	425.2	423.1	295.7	259.5	219.8	202.4	221.7	150.0	167.0	138.1	129.7	115.9	100.0	107.6	85.2	76.5	67.3	53.0	50.9
1924	242.8	7,677,341	34.4	28.4	39.3	53.7	55.7	75.0	67.7	53.1	65.9	79.8	67.7	63.8	65.1	68.0	142.9	155.1	118.3	191.2	328.3	394.8	673.1	541.7	453.5	776.6	961.4	765.3	785.7	670.7	385.5	292.7	337.8	476.8	535.6	395.0	297.9	246.8	212.9	198.2	177.0	144.3	142.1	123.4	103.0	114.3	96.3	70.6	109.0	107.8	95.7	72.7	57.5	55.6
1925	315.3	9,944,720	76.3	75.2	60.5	65.0	65.5	71.0	78.8	65.0	62.7	79.4	110.1	131.1	465.9	419.6	665.5	573.4	462.0	323.3	326.8	477.3	939.1	837.9	603.4	718.2	984.7	868.6	644.1	492.4	385.7	314.5	289.6	263.1	255.1	460.6	328.8	217.3	228.1	288.2	281.9	315.6	251.5	250.0	258.7	231.9	172.1	173.7	146.6	98.8	101.3	135.5	116.3	90.2
1926	275.9	8,699,830	77.5	70.2	67.5	59.4	58.3	69.2	72.6	56.2	82.1	132.6	195.7	376.9	271.1	115.8	97.2	367.8	376.4	290.4	333.4	221.9	228.4	202.5	195.1	223.9	441.2	796.3	551.0	432.4	323.7	248.3	218.7	188.6	185.8	197.9	165.3	617.3	1026.0	767.8	546.9	513.1	454.7	402.3	438.5	338.2	236.4	222.6	175.4	132.5	103.2	146.7	115.1	117.2
1927	471.2	14,861,043	123.4	111.0	84.6	70.5	71.5	85.0	83.4	64.6	65.6	72.6	93.7	146.8	266.9	434.5	419.8	530.5	466.6	648.8	436.6	497.7	924.1	1230.0	1209.0	1943.0	1479.0	1240.0	1015.0	807.2	937.0	830.7	670.7	530.2	482.1	577.6	618.6	415.7	533.6	908.5	545.6	373.9	319.4	282.6	347.0	302.2	260.7	125.9	118.0	224.8	185.9	101.0	77.0	114.4
1928	430.4	13,609,728	110.1	223.2	380.9	169.8	127.7	115.3	125.6	129.9	107.3	102.0	113.6	432.0	930.1	422.7	267.6	252.8	247.8	486.8	396.3	600.2	755.9	993.5	558.7	1200.0	1835.0	1803.0	2030.0	1414.0	887.2	604.5	485.9	404.4	301.5	284.5	294.4	288.8	259.8	242.2	203.2	183.8	166.2	262.4	217.7	179.6	156.6	153.5	119.8	97.5	62.5	61.1	64.8	66.2
1929	237.1	7,475,857	63.6	61.4	57.6	53.8	49.4	48.5	49.6	52.4	58.2	69.5	139.6	162.9	182.8	144.4	88.4	114.8	161.8	237.3	265.8	420.3	741.4	750.8	2114.0	1335.0	851.4	476.2	403.8	385.7	284.9	238.7	202.4	208.1	195.4	172.8	141.5	145.7	144.0	113.2	107.7	104.2	87.2	89.3	60.8	54.9	72.0	62.6	46.8	48.6	57.3	49.7	29.4	69.7
1930	238.7	7,529,050	76.3	42.7	38.8	41.1	43.7	68.7	68.7	208.9	195.6	115.6	148.4	110.5	175.3	255.8	272.4	280.7	299.5	432.1	478.5	409.6	511.5	491.4	768.2	854.1	596.8	650.7	621.4	481.6	481.9	444.7	284.9	221.6	201.2	211.9	149.2	135.4	141.8	152.7	149.9	135.7	105.0	79.4	100.2	96.6	80.5	81.7	63.4	78.8	81.9	76.8	57.0	64.0
1931	165.4	5,215,127	70.4	47.4	35.4	51.6	60.9	49.2	41.2	52.2	53.4	52.9	51.6	85.0	70.7	106.4	116.8	108.4	89.7	83.6	176.4	275.1	395.4	278.1	414.8	501.1	621.9	551.9	447.8	420.9	318.0	249.8	209.8	214.3	181.8	150.0	152.6	153.2	171.2	152.9	144.0	140.2	143.6	123.1	108.0	95.9	84.9	94.1	92.7	82.0	70.4	49.6	47.6	59.5
1932	291.7	9,225,124	81.8	62.7	60.3	48.7	55.9	51.4	56.7	64.1	95.5	176.7	106.5	130.0	148.8	200.4	175.0	168.7	218.4	275.4	382.2	637.4	756.9	794.1	2111.0	1119.0	1014.0	812.0	671.2	538.3	357.5	300.1	273.1	226.2	219.8	244.4	293.2	275.2	217.0	203.9	164.2	132.2	150.1	124.5	154.3	124.3	123.3	104.2	71.7	107.5	94.2	62.0	53.9	80.0
1933	266.4	8,402,270	73.0	68.0	68.9	55.7	60.6	56.8	52.8	39.6	49.4	54.8	61.1	77.5	107.9	175.3	151.7	168.2	331.2	406.0	530.7	626.0	589.9	758.2	896.4	788.8	1071.0	872.9	736.9	569.1	468.9	342.4	283.7	235.8	233.0	225.4	203.7	204.4	162.9	154.2	145.7	144.6	129.9	123.8	108.2	177.4	212.2	180.6	137.2	102.9	121.2	86.0	82.6	89.7
1934	258.5	8,153,202	101.3	106.6	106.8	99.4	113.9	156.1	116.7	103.3	62.3	83.0	106.6	140.5	131.9	134.2	234.7	288.6	473.3	671.2	596.8	635.8	689.2	838.3	844.8	1062.0	690.4	465.6	396.8	382.7	296.5	268.9	245.0	228.9	187.2	176.3	164.9	157.2	144.5	129.0	125.5	109.0	99.4	105.5	121.6	108.7	115.8	206.1	159.7	130.1	103.7	91.2	80.6	56.0
1935	230.5	7,270,467	41.1	67.0	63.2	47.2	89.8	166.4	91.4	85.4	73.3	86.7	75.2	98.8	86.0	51.9	91.5	285.4	294.6	203.6	218.3	276.7	491.7	633.9	673.6	724.3	944.5	680.8	649.1	562.0	490.7	495.4	499.1	398.2	286.0	227.9	178.6	164.0	163.1	152.8	126.5	116.2	98.6	97.7	139.2	69.6	39.6	80.7	55.7	68.1	70.3	50.1	37.2	29.6
1936	190.7	6,029,364	33.4	40.8	52.2	27.6	41.0	31.9	20.3	21.2	24.8	113.8	175.8	133.1	94.7	81.3	229.0	698.2	607.0	311.4	357.2	497.7	541.5	496.2	843.5	608.1	537.8	368.4	307.2	253.3	222.9	205.2	185.2	166.5	164.3	167.3	153.8	138.6	132.8	106.4	104.8	98.3	68.1	76.1	72.8	63.1	38.3	26.3	66.7	44.3	20.2	4.5	6.6	33.3
1937	193.9	6,113,260	17.8	9.6	7.0	15.5	19.4	19.7	28.2	29.6	33.6	47.5	62.2	75.0	70.5	81.9	176.8	173.8	137.3	127.1	261.2	277.0	339.9	441.9	518.6	895.9	1082.0	608.6	444.4	357.9	391.9	314.2	276.6	302.3	234.2	192.9	148.2	146.1	138.3	132.9	139.3	139.6	120.2	112.4	115.4	124.1	153.2	113.9	79.0	85.2	56.4	74.5	60.8	68.7
1938	272.3	8,586,525	59.5	79.1	69.9	58.7	54.8	35.7	31.8	34.3	48.7	65.2	95.2	148.9	136.0	148.0	301.5	264.0	282.1	256.5	342.1	366.4	757.6	1206.0	946.9	835.8	916.3	885.3	927.8	743.2	468.8	379.2	318.6	268.7	245.6	219.7	199.8	184.2	204.1	174.1	166.4	156.5	156.0	133.8	147.6	134.7	108.7	73.2	60.9	58.3	53.8	61.9	46.7	39.9
1939	214.0	6,749,881	32.1	42.5	43.1	43.6	39.3	35.9	26.2	19.0	36.1	41.5	35.4	90.2	250.7	165.6	162.3	154.5	187.0	279.9	351.0	296.2	428.8	399.1	471.7	541.5	1154.0	1059.0	786.8	523.0	409.7	282.6	251.1	229.1	200.8	172.9	154.2	138.3	132.3	131.3	123.4	128.1	120.7	104.8	87.4	122.8	115.6	100.3	98.7	79.4	79.9	64.4	57.4	48.9
1940	205.5	6,499,972	27.6	44.0	37.8	27.9	17.9	38.5	45.4	42.0	50.1	53.8	103.1	110.2	132.6	128.6	122.2	395.7	532.0	433.2	417.3	483.8	500.7	639.9	540.6	461.5	459.4	375.8	300.9	300.1	295.0	282.5	313.1	235.4	171.0	148.3	136.9	142.7	218.6	234.4	234.3	234.9	200.1	152.4	137.4	136.7	113.5	73.4	64.9	83.9	85.5	79.3	46.3	45.6
1941	162.3	5,117,947	61.4	36.0	50.1	50.3	34.8	51.4	59.6	48.5	30.7	38.4	72.0	102.3	266.9	194.6	152.3	132.6	124.3	146.5	207.7	189.0	258.1	281.1	485.1	408.4	330.8	265.6	335.9	273.5	244.2	221.5	186.0	172.4	162.1	191.9	243.3	197.9	184.6	168.5	182.9	195.9	182.5	164.2	172.8	144.2	129.1	112.2	106.8	58.6	88.6	95.9	74.3	70.9
1942	354.9	11,190,944	55.7	49.5	38.4	61.2	69.1	60.1	36.5	38.7	39.7	57.0	74.4	74.7	54.6	101.2	115.2	167.8	201.7	198.8	220.2	1176.0	742.1	1195.0	1271.0	1262.0	805.3	1074.0	1229.0	996.7	775.6	570.2	660.5	553.7	456.5	357.5	347.7	378.8	325.7	327.7	351.4	316.3	258.4	212.9	207.7	169.7	131.5	109.3	96.8	91.3	82.7	65.2	79.2	59.1
1943	286.2	9,024,032	57.8	41.9	64.1	38.5	36.2	58.1	50.5	84.3	103.8	61.4	57.6	81.6	329.2	577.1	854.2	562.1	457.1	312.0	308.4	309.6	454.3	761.0	713.3	763.4	886.2	828.0	890.1	830.5	679.2	555.3	427.6	369.9	295.3	248.9	207.5	178.5	146.7	131.5	132.9	112.4	104.9	104.9	89.2	108.6	75.6	59.8	55.5	43.7	54.5	46.6	45.5	33.3
1944	176.4	5,577,522	51.4	47.7	42.6	52.2	42.6	31.6	42.5	38.1	37.3	33.5	43.8	50.3	74.8	96.6	184.4	134.1	73.7	61.3	108.2	149.1	282.2	338.3	476.5	499.2	744.4	566.1	442.9	362.7	347.4	232.1	261.2	496.5	326.0	322.3	253.3	207.6	186.9	165.7	141.0	141.6	135.9	121.8	104.7	109.2	95.6	85.8	57.7	59.5	56.9	65.2	47.9	42.1
1945	256.7	8,094,624	33.0	43.4	47.2	44.7	37.7	36.3	51.8	40.4	35.2	39.9	65.1	126.2	197.8	139.2	107.1	90.2	109.0	102.7	245.1	351.0	551.5	840.1	1210.0	976.9	738.9	947.5	952.7	596.9	496.4	355.4	273.7	247.4	240.5	204.8	200.3	237.9	203.6	198.6	237.0	222.1	214.5	196.0	185.5	161.7	130.1	67.4	83.3	103.8	109.8	90.0	62.3	67.7
1946	273.3	8,617,600	82.5	84.1	78.2	72.1	58.7	58.0	58.9	58.5	66.1	84.9	111.1	135.3	181.3	290.7	240.2	169.3	209.1	287.7	324.8	422.5	494.8	835.7	968.8	1037.0	785.2	905.1	676.7	567.9	485.6	325.3	260.2	246.3	197.1	201.1	249.0	322.0	336.0	248.7	200.5	222.8	204.3	170.3	156.3	152.4	154.4	131.2	77.7	89.4	132.7	123.0	86.3	92.0
1947	298.4	9,411,149	83.2	93.5	89.8	87.7	87.1	64.4	93.6	185.4	133.5	71.9	77.6	538.8	449.4	285.8	226.1	268.2	349.2	499.2	694.5	930.8	557.8	553.8	751.9	901.9	722.6	608.5	605.5	462.0	408.2	317.0	253.4	221.2	172.1	159.6	241.8	191.8	173.9	160.1	252.8	247.2	238.4	205.0	396.1	313.9	253.0	200.4	137.4	97.9	100.2	92.9	98.3	111.8
1948	385.6	12,192,448	109.6	93.9	82.8	72.8	78.9	64.7	50.8	64.7	74.4	65.4	78.3	114.3	156.6	182.4	162.2	297.1	1054.0	545.2	712.9	734.6	1158.0	2027.0	1474.0	1500.0	1857.0	1396.0	872.5	539.0	416.2	378.6	517.0	442.5	365.4	313.7	239.4	184.2	174.7	148.7	131.0	107.1	97.8	111.6	103.1	111.9	106.0	100.1	91.3	78.0	58.6	40.0	45.5	68.0
1949	159.2	5,020,343	93.2	85.2	75.4	65.2	45.1	46.5	46.8	62.2	63.0	66.4	56.1	45.8	55.5	89.4	252.8	195.7	171.7	171.4	160.2	399.5	596.9	637.8	631.1	497.3	362.8	292.8	250.8	194.7	216.0	201.8	171.6	143.8	140.6	98.2	89.5	86.3	101.0	108.3	107.1	106.9	89.7	84.9	88.1	91.7	103.5	91.3	89.4	88.4	95.0	68.8	57.3	47.9
1950	253.6	7,998,360	54.4	56.9	57.7	56.9	59.2	69.5	73.8	74.2	80.9	96.0	100.3	90.2	124.8	241.8	197.0	250.7	207.0	150.8	145.7	426.1	524.0	558.7	582.6	715.9	1237.0	1096.0	895.4	757.1	543.3	393.2	353.2	283.8	268.4	208.7	189.3	180.2	152.8	128.3	104.9	97.4	98.4	106.2	161.7	156.3	162.1	97.5	90.5	67.9	80.5	79.4	105.2	98.8
1951	447.2	14,104,300	101.4	77.0	73.3	64.9	50.9	51.4	65.3	89.2	88.9	81.6	63.4	79.4	206.5	616.1	348.3	233.4	191.6	559.8	687.3	1053.0	993.9	803.9	594.7	1084.0	1242.0	1425.0	1147.0	1346.0	1058.0	756.9	551.1	397.8	356.1	319.5	462.4	1109.0	643.2	400.9	374.2	498.4	495.1	378.2	316.1	288.2	285.5	237.7	177.2	214.8	163.5	121.8	116.2	115.9
1952	285.4	9,023,823	130.8	121.5	113.3	92.8	84.4	115.1	129.2	111.9	85.2	87.7	84.0	80.3	274.0	769.0	709.2	524.7	482.3	514.6	420.3	412.8	693.0	599.4	515.0	645.0	658.8	773.6	721.1	490.2	436.7	515.1	341.5	296.4	378.9	328.3	228.9	190.0	165.5	180.3	145.2	132.9	131.0	119.4	123.7	111.4	101.4	91.2	91.0	54.2	54.7	73.9	61.1	46.9
1953	360.7	11,373,865	55.8	56.6	35.9	58.9	94.8	77.0	89.3	81.4	71.9	59.1	89.2	104.5	93.3	203.8	167.6	117.1	290.0	516.7	549.8	480.3	577.4	972.0	2144.0	2710.0	1464.0	893.4	949.5	823.0	787.5	531.9	406.0	316.3	328.1	273.3	231.8	219.2	198.8	170.7	146.7	139.1	136.3	128.1	123.9	118.0	109.7	100.7	92.2	94.9	85.8	76.8	55.3	57.1
1954	447.4	14,109,485	74.8	76.4	61.7	31.2	45.6	89.9	109.6	96.3	109.1	92.8	89.2	91.7	70.4	53.2	198.7	532.4	352.3	189.3	379.2	1014.0	1332.0	1125.0	1119.0	1415.0	1118.0	1027.0	1235.0	1149.0	843.6	674.1	428.0	481.0	461.5	509.7	1352.0	987.9	697.9	454.3	391.2	343.3	327.6	294.6	295.0	284.4	230.0	206.0	179.5	171.4	101.5	98.9	100.3	73.8
1955	325.9	10,276,564	48.3	45.8	54.3	72.0	91.0	77.9	62.3	49.6	31.2	20.2	78.3	76.0	69.8	544.4	658.6	397.2	344.4	457.4	501.3	361.5	1007.0	954.5	794.8	1008.0	1045.0	1063.0	820.1	838.9	829.0	653.7	459.0	355.6	278.8	235.3	235.2	184.3	175.1	163.9	179.4	156.0	143.3	173.5	187.9	220.1	168.6	116.4	60.3	86.3	97.3	91.5	70.5	51.3
1956	315.7	9,983,830	98.6	91.7	75.4	71.4	67.3	55.6	60.6	50.4	51.1	54.8	66.6	125.6	370.6	384.4	535.8	575.3	438.4	313.4	217.6	384.1	1012.0	1195.0	1225.0	910.4	863.3	768.6	678.5	757.5	673.6	541.5	480.1	393.1	299.2	249.7	239.4	241.2	188.7	166.3	170.6	138.2	129.2	121.2	137.2	144.7	107.8	103.0	63.7	75.7	71.0	46.7	47.0	90.1
1957	259.7	8,189,014	87.7	64.1	36.7	53.4	47.6	41.9	58.7	56.8	72.8	163.4	134.5	132.2	197.6	270.4	201.4	194.9	275.9	365.9	823.4	861.1	1007.0	798.1	822.8	883.9	615.1	548.5	420.6	347.2	313.1	282.2	238.1	209.5	218.7	204.3	200.9	166.4	150.9	156.8	151.9	138.1	154.2	150.9	139.1	134.8	173.0	143.7	113.7	121.4	110.4	128.9	80.2	38.2
1958	304.4	9,598,861	26.5	55.5	61.4	54.4	47.5	50.4	34.3	44.3	106.2	97.0	73.2	47.7	101.2	535.4	778.6	578.2	278.0	215.

05BN01 Natural Weekly Mean Flows Extended (m³/s) Data Revision Oct. 20, 2004

Year	Mean	Dam3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1912	149.1	4,715,812	11.2	21.7	28.2	29.9	34.9	33.8	35.7	35.6	34.2	29.0	26.3	27.0	41.2	89.9	85.9	76.0	58.5	70.7	100.6	122.8	203.0	204.3	139.1	166.4	607.7	404.9	317.4	454.6	457.3	466.0	383.4	286.0	226.8	281.9	318.8	229.0	201.1	181.4	151.9	129.1	124.9	123.4	121.7	105.2	96.0	91.7	87.1	60.1	44.8	34.0	29.4	33.2
1913	141.0	4,447,061	28.8	25.7	18.4	42.1	45.5	36.5	45.3	49.7	43.5	40.9	52.5	44.6	42.3	37.0	169.1	164.5	97.2	71.0	70.6	147.2	129.4	264.4	380.3	472.8	396.5	438.4	398.5	291.6	211.8	227.9	218.1	243.3	325.4	226.9	187.0	202.9	175.4	120.3	114.8	98.0	93.4	108.3	107.2	83.4	81.8	62.5	87.7	72.0	71.2	73.0	47.3	48.9
1914	122.2	3,852,365	71.8	60.9	47.8	29.1	25.9	26.3	31.8	30.0	32.0	50.8	90.4	88.8	90.4	60.5	82.7	72.7	74.7	89.6	120.6	178.8	224.9	240.4	356.4	346.8	407.4	323.0	311.8	326.8	296.5	204.7	154.5	154.2	152.5	136.5	122.5	103.7	76.2	91.7	90.2	95.6	94.7	112.0	109.1	86.0	68.1	61.8	67.7	66.0	38.5	20.0	24.5	31.9
1915	212.9	6,713,044	39.3	41.7	34.8	32.3	34.7	37.5	35.2	37.2	37.8	38.3	42.8	224.3	174.5	103.2	36.2	35.4	58.0	109.2	238.3	386.0	283.0	330.5	363.4	348.8	480.7	993.3	727.8	749.9	907.0	555.1	576.6	377.6	279.2	384.3	244.7	206.5	180.8	146.8	159.9	126.4	124.1	105.1	96.2	97.1	85.8	54.1	58.7	66.9	53.4	44.8	47.0	37.0
1916	229.0	7,242,503	27.2	32.3	32.5	32.1	39.0	41.8	76.0	61.2	44.9	33.7	37.2	88.8	97.7	93.6	110.3	90.2	82.9	83.3	133.2	112.0	123.0	376.0	593.2	576.2	941.4	947.1	1028.0	775.1	597.6	396.2	286.2	265.2	281.5	515.6	339.2	441.3	329.6	250.1	176.0	157.7	149.0	131.3	140.0	157.0	106.7	81.3	97.0	91.3	75.8	50.1	34.8	49.2
1917	154.5	4,873,222	43.2	41.3	46.8	41.5	37.5	41.9	47.2	39.2	33.0	38.1	42.7	45.2	66.3	57.6	70.0	74.4	74.4	75.4	91.8	269.4	329.0	508.4	702.2	594.6	574.4	414.0	422.8	391.3	334.3	301.2	220.3	191.5	193.0	185.1	169.1	151.0	125.0	111.6	113.5	107.3	114.2	99.8	89.8	73.1	72.1	54.0	45.5	40.6	8.7	6.0	6.0	9.2
1918	109.1	3,441,002	38.6	14.6	8.0	37.3	29.2	18.8	52.9	22.1	23.6	40.4	55.9	112.8	152.9	76.3	76.1	57.0	51.9	47.8	101.8	105.3	129.4	128.4	151.7	494.7	470.1	324.1	201.1	219.7	217.0	203.5	169.5	171.4	186.4	176.1	145.6	120.4	111.7	100.6	113.5	104.9	83.9	85.6	70.0	63.2	54.7	50.3	40.7	35.9	37.0	29.9	30.8	28.8
1919	98.1	3,094,955	25.5	33.9	37.7	36.0	32.1	23.2	30.0	33.7	29.0	24.0	33.1	35.9	44.3	78.3	83.6	78.5	56.5	63.0	78.8	92.6	212.4	360.2	216.9	179.0	218.5	301.0	204.5	172.6	183.5	150.4	164.7	379.1	206.5	164.9	129.8	123.0	103.9	96.9	81.6	72.4	59.5	52.3	39.5	28.2	22.8	31.6	47.7	28.5	23.7	30.5	28.3	39.2
1920	136.6	4,319,863	28.4	21.8	23.2	25.6	22.0	29.0	31.9	31.1	31.8	27.9	34.8	66.1	89.2	63.0	54.0	84.7	194.9	179.9	324.3	221.1	199.8	128.2	141.4	236.5	357.6	361.7	456.1	597.6	517.9	413.8	306.7	230.8	203.3	175.0	133.7	104.8	106.8	93.2	86.6	89.8	77.7	73.6	70.0	60.1	56.1	31.7	42.3	40.1	38.4	29.0	33.3	25.3
1921	107.4	3,385,450	38.8	34.5	27.1	23.3	35.0	35.7	32.0	28.4	44.3	26.0	19.2	24.5	41.9	75.0	52.0	100.9	62.5	54.5	89.2	97.6	316.6	327.8	379.6	394.6	284.6	345.3	329.6	235.0	204.5	207.7	193.9	160.5	162.5	139.2	102.6	87.0	81.0	71.4	62.0	67.1	52.3	51.7	54.2	59.9	62.4	40.7	19.8	12.8	43.1	45.3	26.9	18.3
1922	99.8	3,146,808	31.4	34.8	35.0	23.8	24.5	27.0	21.6	21.9	24.8	26.9	32.4	39.2	30.1	50.5	69.4	52.3	106.5	96.8	74.7	96.2	198.1	236.4	394.3	336.3	318.0	255.3	262.4	255.7	190.1	163.0	148.2	166.3	157.5	148.7	126.7	117.7	93.3	96.7	80.5	74.4	77.2	55.5	52.2	50.1	42.8	35.8	28.8	30.6	20.4	11.9	12.0	32.1
1923	162.9	5,137,154	32.7	26.8	24.5	23.3	21.8	23.0	24.4	21.2	30.4	28.1	25.4	32.2	40.1	48.7	43.5	72.3	43.2	44.2	44.6	98.1	131.8	598.9	785.0	817.2	758.4	825.5	476.6	351.3	309.5	288.5	265.1	217.7	213.4	225.4	184.8	155.7	138.3	111.5	121.9	120.6	85.5	79.5	72.2	61.0	51.2	51.4	52.8	40.3	40.7	33.0	33.6	23.9
1924	118.2	3,736,247	16.4	21.2	32.4	31.1	39.0	42.8	35.5	31.3	36.0	34.4	31.2	30.3	28.6	31.3	70.5	58.2	37.0	68.8	82.9	157.5	261.6	221.8	201.1	304.0	389.5	323.9	426.0	317.7	206.3	164.7	233.5	354.9	268.1	221.8	173.0	138.5	135.1	110.9	98.4	82.8	88.8	64.3	57.8	61.5	44.0	37.4	59.3	54.8	48.3	33.9	19.9	23.9
1925	137.0	4,319,462	43.1	35.5	28.0	33.3	34.0	39.0	35.3	29.4	30.4	42.1	44.8	91.9	211.8	180.8	171.1	102.2	91.4	66.7	71.8	167.6	404.8	287.5	228.3	410.4	440.6	394.2	290.6	241.4	203.4	172.6	174.1	157.1	181.3	232.1	141.0	108.7	125.2	132.0	141.4	133.4	121.4	117.3	135.0	103.2	74.6	82.8	64.9	47.1	64.4	70.3	51.8	39.3
1926	118.6	3,739,321	30.6	33.6	34.8	32.1	33.0	41.7	36.0	30.9	45.2	65.2	74.6	66.3	45.9	33.8	66.8	126.3	84.7	107.3	109.1	87.3	92.6	81.2	75.4	121.0	292.3	350.4	271.6	247.6	183.5	137.7	131.6	113.9	114.5	112.1	105.9	331.3	407.9	282.4	215.7	194.9	176.5	142.2	148.0	122.0	82.1	102.6	55.1	44.3	50.2	74.5	50.6	69.0
1927	171.7	5,413,640	63.5	47.0	37.2	38.0	42.8	53.7	41.1	33.4	37.5	42.2	60.4	65.0	126.0	93.7	82.3	114.5	74.7	87.2	83.7	108.1	199.5	265.4	339.6	689.1	508.3	511.7	378.5	322.4	442.7	337.3	317.2	260.2	224.5	313.4	241.0	180.9	335.6	301.9	210.8	185.8	137.5	133.8	134.1	136.3	98.2	26.6	64.7	112.0	62.0	26.5	42.2	54.9
1928	163.9	5,183,824	48.3	119.3	109.2	48.4	47.8	50.3	57.5	52.9	35.5	37.7	42.5	256.0	187.8	96.8	61.6	61.4	109.0	116.1	83.1	144.6	301.5	400.5	234.5	530.2	723.5	700.8	657.6	462.5	349.7	255.7	265.6	201.9	183.3	145.0	168.4	138.5	133.5	116.6	92.3	100.2	78.5	85.1	66.2	63.5	58.8	57.1	43.1	34.7	19.5	25.8	31.0	33.4
1929	111.7	3,523,360	31.8	30.8	31.5	25.2	25.7	27.8	30.1	30.8	33.7	40.2	48.0	54.0	63.3	35.6	40.2	61.8	72.1	106.3	71.1	125.4	279.2	251.1	1167.0	588.9	340.5	219.1	202.5	182.3	140.3	144.0	133.7	139.4	126.3	111.6	92.3	102.3	77.9	68.4	67.0	56.5	42.9	37.0	19.7	20.0	36.2	34.6	16.1	30.8	16.7	12.8	22.8	44.4
1930	116.6	3,677,037	36.7	19.2	24.7	23.8	34.2	37.0	35.0	101.7	64.8	65.1	67.9	60.8	87.1	101.8	70.6	75.6	69.1	103.1	114.9	130.2	181.4	220.9	363.9	431.1	315.4	355.3	312.3	298.4	326.0	235.4	176.4	148.6	160.3	140.7	88.4	92.3	101.2	90.1	85.8	84.7	65.8	46.5	58.2	41.5	41.6	42.0	35.3	42.8	42.2	35.2	33.3	46.8
1931	77.0	2,428,636	36.7	19.6	24.0	28.4	25.3	17.9	30.0	28.4	34.6	32.6	34.7	55.2	52.1	77.6	66.1	46.2	39.8	21.3	31.0	61.3	107.9	70.4	184.9	268.2	307.9	227.5	180.0	180.2	151.7	137.6	118.6	111.4	86.6	85.6	92.7	75.8	114.0	74.7	72.0	85.7	79.9	67.9	71.3	46.2	44.1	36.3	40.2	32.5	23.2	10.5	22.7	33.6
1932	135.9	4,296,754	42.1	27.9	28.7	23.3	30.2	22.0	25.5	29.0	45.4	35.8	21.3	28.9	45.1	59.2	49.9	53.0	58.5	77.0	131.5	202.4	261.3	246.0	1180.0	533.5	487.2	404.5	331.7	250.3	174.8	159.8	153.9	117.8	136.4	142.1	170.1	167.1	139.1	115.4	90.9	95.8	89.3	101.5	81.1	70.8	64.2	36.4	33.5	62.1	43.0	17.4	29.1	42.8
1933	111.6	3,520,509	35.8	37.0	35.1	32.2	36.2	36.3	25.6	26.3	31.8	28.0	31.8	47.7	58.3	79.9	61.7	65.2	164.5	130.6	162.3	188.2	218.6	280.2	328.9	269.6	511.1	379.3	362.6	263.0	219.5	152.2	146.5	120.1	129.6	118.0	100.1	98.3	81.7	76.6	71.8	73.9	61.8	53.5	40.9	50.6	47.4	56.0	26.3	33.6	41.0	32.3	13.9	31.6
1934	100.5	3,169,489	34.2	40.1	34.1	34.0	31.4	33.1	37.6	26.0	15.5	23.3	28.1	35.0	30.3	56.3	45.1	47.3	90.1	197.3	160.0	214.5	249.5	456.0	324.1	347.6	273.8	186.8	194.2	208.9	158.7	146.5	150.0	125.7	106.8	100.5	94.1	89.9	81.3	73.5	65.0	53.8	52.0	62.0	55.7	51.2	45.9	44.9	44.8	40.5	38.6	35.2	35.6	19.8
1935	106.1	3,347,486	14.4	30.6	21.5	24.4	41.8	39.9	27.3	30.9	32.5	22.5	17.8	49.2	26.5	19.5	66.8	138.0	103.9	53.9	64.9	75.2	182.4	240.9	285.0	341.9	469.8	302.3	294.2	270.6	298.6	266.4	254.4	217.8	168.3	114.9	101.5	91.1	95.1	69.5	68.6	53.2	52.7	58.8	68.1	18.8	36.7	32.2	35.3	40.0	31.7	26.2	15.3	15.9
1936	83.3	2,632,930	27.6	18.6	30.4	25.0	19.5	15.1	8.1	14.6	21.4	44.8	83.9	77.4	36.7	49.9	153.9	149.9	102.3	68.5	107.7	141.5	171.9	245.3	395.4	255.6	228.1	169.0	149.1	140.5	127.1	123.8	105.7	104.4	103.0	106.7	91.0	87.2	78.1	60.2	59.7	56.6	36.4	42.6	37.2	26.0	15.3	18.9	33.0	18.7	2.2	2.0	19.6	22.5
1937	83.0	2,616,639	4.4	2.5	2.8	11.7	12.1	13.2	18.9	19.3	23.2	26.0	31.1	38.6	35.1	44.5	89.0	72.1	46.3	47.9	87.0	78.5	77.9	145.9	199.4	285.8	330.9	201.5	189.2	162.7	232.1	173.5	171.6	170.6	127.8	107.8	88.3	78.1	75.5	77.3	77.3	68.3	47.1	50.7	65.2	76.0	77.0	48.6	37.2	36.5	30.6	34.5	27.2	24.3	12.4
1938	121.7	3,839,326	39.6	35.1	33.2	24.3	27.0	10.1	17.4	16.5	24.6	5.0	26.1	69.4	74.3	96.7	163.6	100.5	64.2	77.9	83.1	115.6	248.7	399.8	347.8	372.9	428.8	438.3	441.4	333.5	238.6	205.0	165.5	147.4	130.3	106.7	100.5	111.5	122.0	97.8	106.7	94.2	87.6	86.1	84.1	76.7	55.8	36.9	35.9	22.9	32.9	33.0	21.5	15.7
1939	99.0	3,120,730	13.4	20.2	17.1	16.5	12.3	6.6	17.9	22.8	14.6	14.7	72.3	97.1	70.0	68.1	59.8	54.4	67.6	75.8	87.0	160.8	192.6	188.5	261.5	491.7	451.9	398.6	273.0	230.6	148.0	158.3	134.0	115.0	101.2	94.8	76.8	79.8	76.7	75.3	66.9	58.4	53.5	40.5	78.6	55.4	56.0	44.6	41.7	40.8	27.3	23.6	14.3
1940	97.0	3,067,251	9.8	21.4	14.8	6.8	16.6	24.7	25.8	26.4	26.0	42.8	65.4	34.5	65.9	51.0	52.6	185.6	146.8	137.1	117.9	154.0	181.6	288.7	239.1	215.4	227.7	189.9	165.4	174.9	186.6	168.4	166.6	109.1	94.9	82.4	85.5	90.6	151.4	163.2	138.1	122.6	95.6	62.7	65.4	71.6	54.7	25.3	30.6	47.2	38.8	39.3	11.5	33.1
1941	75.0	2,365,928	22.7	9.9	29.9	24.1	11.8	31.7	28.1	21.3	5.2	28.6	42.9	88.3	141.2	83.7	72.3	44.1	43.8	47.3	54.7	65.6	90.0	132.1	253.6	199.5	159.0	137.0	130.1	120.3	123.7	124.4	96.3	94.5	92.1	97.2	145.1	97.6	107.7	79.9	99.4	78.3	61.7	70.6	65.4	55.9	56.6	49.9	40.1	18.1	50.5	23.3	24.4	29.7
1942	145.9	4,599,768	15.3	6.0	18.8	27.5	41.5	24.2	16.5	22.7	26.6	30.9	27.4	18.7	38.9	55.8	56.1	64.8	49.7	32.8	159.3	360.3	337.9	460.8	265.3	418.9	304.0	479.6	504.9	406.5	316.6	263.4	356.3	258.8	231.2	191.1	171.8	191.5	164.4	171.8	160.3	145.6	119.3	115.1	104.2	71.3	47.5	41.7	43.2	42.6	26.4	20.1	37.8	20.9
1943	104.4	3,293,026	21.9	24.5	28.4	9.3	21.6	28.3	21.4	72.9	39.8	16.5	27.5	45.7	134.2	208.4	230.5	108.5	90.3	47.8	56.1	60.5	124.6	198.5	186.4	196.2	224.8	244.0	374.8	361.9	339.8	293.2	212.7	190.6	157.3	128.3	111.8	97.9	73.1	75.1	71.4	56.9	56.9	51.0	47.1	48.5	31.6	27.5	25.4	24.4	31.1	28.2	17.4	27.4
1944	75.3	2,381,471	28.7	25.8	32.2	28.0	15.2	26.9	22.5	21.0	21.4	17.5	32.0	33.9	22.8	45.3	68.4	39.4	15.1	22.5	43.5	49.6	123.9	134.6	211.2	245.1	236.0	197.5	165.6	135.9	125.4	124.1	153.5	160.6	157.5	151.7	113.2	108.1	95.8	85.6	68.5	77.7	59.3	50.8	46.4	51.1	44.8	32.4	21.9	27.1	33.1	30.1	20.6	15.3
1945	113.2	3,568,298	18.5	24.9	28.1	15.6	14.2	23.1	25.5	10.0	23.9	18.3	27.1	83.7	70.5	42.8	37.5	42.0	48.5	21.7	61.9	66.9	157.2	389.7	374.3	366.5	364.4	481.1	441.1	281.4	253.3	178.8	163.0	138.4	138.9	116.2	148.2	129.1	115.0	112.2	112.9	100.8	99.1	89.7	88.0	77.2	27.9	19.2	27.8	43.8	43.7	32.7	28.7	38.8
1946	121.4	3,827,682	45.2	38.8	41.3	32.7	29.1	31.4	31.2	31.5	36.4	50.2	75.5	76.8	74.4	62.7	41.3	43.8	49.0	68.4	95.3	160.0	179.8	426.2	440.4	392.7	340.4	370.7	275.3	263.9	219.6	172.9	155.2	135.2	124.1	121.0	176.5	182.2	169.6	134.0	104.6	114.2	91.9	81.1	69.8	51.5	54.2	43.6	24.0	60.6	73.6	52.8	40.4	54.5
1947	151.7	4,783,041	34.1	43.9	27.7	44.9	28.0	24.0	32.4	82.3	37.4	6.9	35.3	254.9	193.4	128.5	101.6	110.8	127.2	182.0	297.0	388.3	233.9	296.0	453.0	544.4	386.2	411.2	314.2	294.7	266.9	214.7	167.6	176.1	118.6	119.5	154.6	131.6	115.2	118.9	167.5	136.9	139.7	136.1	129.5	100.0	81.9	68.2	29.1	30.8	35.3	36.1	45.1	52.7
1948	178.2	5,634,199	43.6	30.0	25.0	23.3	22.4	11.3	11.9	24.7	36.8	38.5	49.2	66.4	63.5	96.9	74.6	226.4	524.1	254.5	380.5	321.0	591.8	884.0	649.1	584.5	333.4	629.3	398.1	265.2	252.0	230.3	317.5	256.6	238.7	191.0	156.8	117.0	109.7	99.1	72.4	67.8	66.2	59.9	61.2	58.5	41.9	49.3	31.1	31.1	13.6	13.9	23.0	46.3
1949	74.8	2,358,468	53.6	46.2	40.7	22.7	14.9	18.9	24.2	32.8	38.6	31.9	20.6	23.1	17.9	81.2	128.7	94.2	59.5	48.7	44.5	189.2	225.4	236.7	260.1	209.2	151.0	156.7	124.0	110.2	126.4	117.9	109.7	105.7	88.3	66.2	64.3	63.0	69.4	67.5	57.3	60.6	44.9	46.4	51.7	44.9	45.5	39.0	37.7	34.1	9.5	13.9	11.3	8.3
1950	117.1	3,692,441	19.3	26.2	22.8	26.8	29.1	39.8	38.1	36.2	40.1	41.1	45.9	48.4	83.2	152.7	92.6	108.4	56.3	41.2	42.3	134.1	120.9	149.4	184.1	336.0	683.2	488.4	443.0	375.9	277.4	219.8	218.4	174.3	168.8	132.9	131.7	117.8	97.2	80.8	68.2	67.7	70.7	57.9	70.8	50.0	25.7	11.7	10.0	16.0	15.5	36.2	29.7	33.8
1951	210.3	6,630,929	32.3	19.0	24.7	18.2	7.0	16.4	27.8	35.5	34.7	32.7	27.3	31.8	155.5	261.7	99.7	54.3	67.0	179.1	190.6	397.9	380.1	289.1	310.9	591.3	581.3	580.9	614.9	710.8	615.9	405.1	301.1	213.1	223.8	179.9	448.2	542.0	337.0	194.7	169.3	205.7	186.8	175.6	148.5	155.0	144.2	95.3	86.2	114.2	50.7	54.7	48.3	66.0
1952	163.4	5,165,945	62.8	65.2	56.5	41.5	45.7	64.7	61.9	51.0	41.6	37.1	36.4	32.7	263.0	426.3	355.0	274.5	176.4	153.1	117.2	209.6	325.1	293.6	283.6	424.5	337.4	622.5	452.7	322.8	320.2	327.1	232.2	223.8	260.6	197.6	143.0	116.5	102.1	123.1	93.5	101.4	81.2	76.7	85.4	67.5	59.9	54.7	49.5	13.2	39.8	38.4	28.5	24.6
1953	165.4	5,217,146	28.4	16.9	15.3	38.7	45.9	34.9	42.1	46.1	26.1	24.4	41.6	45.1	60.9	89.7	75.8	64.0	157.3	187.5	190.7	160.3	249.8	335.2	767.9	899.7	600.5	445.7	521.5	463.4	445.6	288.8	219.1	198.6	206.3	167.6	153.1	150.8	124.6	103.8	93.2	96.5	87.9	85.4	88.3	62.2	68.7	55.1	39.8	50.9	46.8	36.2	23.6	34.3
1954	170.0	5,360,392	43.1	40.3	23.7	10.6	37.7	61.3	47.0	68.3	42.6	43.8	31.2	39.4	16.3	15.6	116.1	170.1	66.8	35.1	148.4	260.6	357.9	398.9	440.9	481.1	393.9	490.3	584.9	541.7	401.8	309.0	218.8	242.9	198.2	258.8	441.6	270.3	191.0	188.4	149.0	137.6	152.7	106.8	119.3	88.6	75.6	73.2	52.3	60.7	12.4	34.6	33.7	13.9
1955	125.0	3,943,516	15.3	22.0	34.6	43.0	53.4	30.8	27.7	14.1	10.9	24.5	43.1	36.8	48.3	153.3	133.9	75.1	77.7	112.8	88.0	114.1	281.5	231.4	225.4	415.4	371.2	476.6	381.7	392.3	392.0	295.2	206.5	167.9	146.8	134.1	134.6	96.4	106.5	96.7	91.2	74.4	66.9	76.8	74.5	86.2	62.8	21.6	29.7	35.0	56.2	53.4	23.7	38.5
1956	136.7	4,323,329	65.9	48.9	38.9	42.3	31.3	31.9	33.2	24.4	25.9	29.2	40.1	104.8	198.5	129.9	115.7	124.7	90.9	68.7	68.9	143.2	408.6	469.3	548.0	414.0	386.5	317.8	331.0	317.1	344.3	278.8	232.2	182.5	150.7	139.6	148.6	124.4	98.8	89.4	85.8	79.0	72.1	66.5	71.9	52.8	51.8	38.2	13.7	13.5	19.7	11.6	38.1	55.7
1957	112.2	3,539,734	44.5	25.7	10.9	36.1	21.2	19.5	35.4	27.2	67.2	61.0	61.0	63.9	71.0	57.4	81.3	82.0	97.4	136.2	235.4	308.6	345.2	284.8	365.9	375.2	248.3	251.2	197.8	182.5	181.4	148.5	133.6	125.1	125.4	114.9	115.6	89.2	88.5	90.4	83.8	78.2	86.6	74.1	59.9	57.6	56.1	47.7	56.1	56.1	69.3	71.8	24.6	8.4
1958	137.2	4,325,405	10.3	41.1	32.8	30.7	22.2	27.9	19.0	39.1	63.7	41.8	32.1	21.6	61.5	211.3	246.7	159.6	64.1	85.4	162.1	265.9	385.1	436.1	390.7	361.0	272.2	278.8	322.4	400.9	346.5	268.4	234.3	178.3	147.3	142.8	132.

05AG006 Natural Weekly Mean Flows Extended (m³/s) Data Revision Oct. 20, 2004

Year	Mean	Dam3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1912	96.0	3,034,960	26.1	26.6	25.8	26.7	27.3	26.0	25.6	25.5	22.7	20.5	20.9	21.8	140.1	115.2	92.9	104.7	102.5	105.5	127.7	237.1	330.7	290.4	211.0	219.2	296.9	214.3	210.4	196.9	201.3	200.4	156.8	125.5	93.1	71.6	59.2	56.9	59.5	53.5	52.7	44.6	42.1	43.4	49.5	55.8	49.9	56.1	59.3	42.8	35.9	32.7	30.1	27.0
1913	118.1	3,724,705	23.7	18.0	16.0	15.3	13.2	11.1	11.2	13.0	12.8	13.3	14.3	13.5	14.2	56.9	151.1	185.8	187.6	144.2	132.2	204.5	314.7	645.8	571.2	486.0	328.5	359.6	291.2	201.6	137.0	120.9	117.4	122.9	137.3	95.5	83.1	83.4	70.5	54.0	51.4	53.5	57.2	70.9	69.2	62.5	56.0	50.4	48.9	44.3	34.4	32.8	24.6	13.1
1914	96.4	3,039,888	20.0	21.4	19.9	18.0	17.2	16.3	16.1	17.3	23.3	33.2	41.3	38.5	29.4	48.7	61.2	113.2	152.8	181.2	228.3	291.5	302.2	240.6	301.8	207.6	257.7	200.1	177.9	153.6	123.8	81.6	69.8	61.0	50.5	87.1	69.2	52.5	48.8	48.4	69.8	71.6	86.4	165.5	143.1	97.5	107.8	80.1	76.9	70.3	42.0	21.4	24.0	33.1
1915	137.8	4,346,631	35.1	30.0	25.3	21.6	19.3	20.7	20.9	20.0	19.6	18.8	31.1	140.6	68.1	80.1	71.0	105.0	132.1	213.9	284.4	378.4	316.8	286.0	414.1	383.6	460.9	516.3	387.2	217.9	183.4	195.8	276.4	166.0	128.1	154.6	94.3	102.7	95.8	95.0	106.1	99.6	119.0	108.7	95.0	92.0	82.9	62.1	47.0	34.0	31.7	27.0	25.3	25.9
1916	164.7	5,209,608	24.5	20.1	24.0	22.9	19.8	20.8	96.4	192.8	75.3	57.1	184.5	127.1	99.3	99.9	106.5	117.2	103.9	158.0	264.7	193.9	212.8	327.8	444.3	488.3	982.3	725.4	736.9	449.2	331.7	212.9	144.7	119.5	129.9	113.8	92.1	145.8	118.1	79.7	67.8	65.7	61.4	55.8	58.7	52.3	48.4	31.1	56.8	49.5	38.5	26.7	67.2	22.9
1917	140.3	4,424,925	19.6	19.3	21.7	19.5	18.3	21.4	23.5	20.1	18.8	19.7	21.1	22.5	23.4	59.0	200.4	84.3	92.6	91.4	203.8	528.0	558.6	805.5	609.9	799.9	653.7	440.6	362.9	293.6	212.6	134.8	93.9	87.6	75.7	63.2	55.5	49.2	49.2	39.5	39.6	36.8	38.8	40.7	37.0	32.0	32.8	29.3	26.0	20.5	7.8	6.9	14.0	19.8
1918	89.7	2,827,627	79.3	56.5	49.2	44.5	31.0	38.4	37.6	22.5	31.3	30.3	30.5	80.6	85.1	45.7	70.9	102.6	125.0	190.0	283.9	244.4	182.9	150.0	218.2	524.8	340.0	223.0	135.8	110.9	98.4	86.1	74.2	63.5	71.9	60.8	51.0	53.9	60.2	47.3	43.1	36.8	31.8	47.9	52.2	40.9	34.8	28.6	19.7	13.8	22.0	19.4	17.9	21.4
1919	69.1	2,179,259	18.8	17.9	15.9	18.1	16.5	15.7	18.5	14.7	10.8	14.8	14.9	15.2	25.8	83.9	51.7	45.3	71.3	185.6	148.9	150.5	358.2	481.8	272.2	206.0	195.1	186.1	124.3	86.7	74.1	56.9	55.4	55.6	44.3	38.4	31.3	29.0	29.0	26.8	20.7	22.5	20.9	20.2	16.6	20.0	18.5	18.6	32.9	17.5	14.1	15.3	20.2	29.4
1920	117.4	3,713,990	20.6	19.5	17.6	13.5	23.9	30.1	25.9	23.1	18.4	17.1	51.3	122.7	97.6	39.7	46.5	165.4	160.5	157.6	268.2	371.1	386.3	285.8	279.2	428.7	477.6	366.9	353.7	309.5	257.0	193.6	136.2	96.0	77.0	64.9	52.0	44.6	40.8	43.4	50.0	50.0	56.6	58.8	49.9	40.2	34.3	24.0	34.5	33.4	27.7	23.4	18.2	22.1
1921	101.7	3,208,363	25.4	19.6	19.3	17.2	14.2	19.0	25.0	26.7	39.3	45.2	38.3	41.8	50.0	65.2	60.1	120.1	136.3	97.9	208.4	244.6	456.5	444.3	473.3	464.7	320.7	300.5	245.3	174.9	131.2	105.3	85.0	65.1	56.8	49.9	42.5	34.0	37.0	34.0	33.6	39.1	32.8	48.8	39.6	41.3	43.0	33.9	21.2	25.5	28.8	27.9	22.7	17.5
1922	91.9	2,898,644	20.4	20.9	18.1	15.9	15.8	14.3	11.7	12.8	12.0	12.0	16.2	20.2	16.9	32.1	57.1	39.2	112.0	175.8	178.7	248.6	427.0	425.6	539.7	419.5	351.8	253.6	192.7	206.1	141.5	103.5	75.3	64.4	50.8	44.5	37.8	34.5	34.7	31.2	26.2	22.8	24.1	21.5	18.9	34.2	25.8	24.0	23.7	19.7	7.6	10.8	16.0	19.4
1923	133.0	4,194,955	17.9	17.5	16.3	15.7	12.2	10.8	10.9	12.0	18.6	19.0	19.1	21.1	31.1	38.1	33.1	61.1	74.4	115.9	158.3	266.8	300.1	828.9	1042.0	619.1	547.6	605.6	369.2	251.0	192.7	137.3	114.7	90.2	73.0	113.7	86.6	61.9	50.7	45.0	38.5	35.0	41.9	42.4	36.8	39.6	34.4	31.6	27.0	21.7	19.4	17.0	18.2	14.4
1924	89.2	2,821,569	13.3	12.1	15.6	16.3	17.4	20.9	20.9	21.8	31.9	33.8	25.8	28.6	29.7	36.5	81.7	52.9	38.1	73.3	166.0	305.3	282.2	248.6	281.2	466.1	431.9	321.2	252.8	171.2	107.3	74.7	64.2	91.4	112.4	79.3	57.9	45.8	41.8	39.9	35.7	32.5	34.7	30.4	32.6	32.4	27.7	28.8	42.9	28.2	19.8	19.9	26.1	36.3
1925	118.7	3,743,869	37.1	34.6	34.2	32.1	30.2	34.6	33.8	30.4	30.9	47.8	38.6	65.5	160.4	121.3	193.5	227.8	215.3	181.2	236.2	379.3	554.8	408.0	288.7	345.0	382.6	330.0	241.3	158.9	116.7	91.9	72.9	60.6	60.6	60.8	49.6	41.5	48.2	55.2	64.8	66.7	60.1	63.4	67.3	48.5	44.1	41.0	30.9	26.1	37.3	36.3	31.5	23.2
1926	73.0	2,301,946	27.7	22.4	17.6	15.8	19.1	18.6	17.4	16.2	21.7	24.9	24.0	21.1	22.8	18.1	25.8	96.4	166.5	164.1	139.0	94.7	95.0	72.1	64.1	71.7	187.8	204.3	127.4	95.3	65.2	51.7	38.5	35.5	38.1	34.3	31.5	86.1	174.1	132.8	114.2	117.3	154.6	172.8	179.3	115.6	77.6	64.9	35.9	40.6	40.8	41.5	30.2	31.0
1927	202.3	6,380,764	30.7	27.4	21.5	18.8	22.2	23.1	22.5	20.0	23.0	27.1	44.0	59.7	71.0	64.3	40.7	97.8	182.8	275.1	194.4	318.1	645.0	872.3	782.0	1048.0	719.4	581.4	425.4	332.8	385.8	233.3	179.9	142.2	131.6	189.8	141.0	121.8	256.1	338.9	190.3	128.8	144.0	174.6	169.0	125.9	103.2	41.1	71.7	83.8	60.4	36.3	41.4	39.9
1928	160.9	5,087,314	35.5	166.9	138.8	73.4	57.5	46.1	48.3	42.2	40.2	42.6	47.3	236.8	164.5	102.2	82.1	75.8	100.2	222.1	296.5	443.2	511.2	473.5	271.7	309.5	477.5	499.8	826.3	427.2	280.4	198.5	157.4	111.0	79.4	66.0	101.2	85.5	72.7	64.0	56.2	49.5	92.1	143.6	121.2	87.2	73.3	60.8	51.3	40.2	23.9	34.5	29.2	27.6
1929	95.4	3,008,292	20.3	21.1	22.5	21.3	17.1	16.2	16.5	18.0	22.3	34.6	92.3	70.4	63.9	44.4	39.5	52.5	68.9	146.9	150.6	318.6	451.8	395.9	749.9	457.2	298.6	179.7	153.8	160.4	113.0	78.6	60.8	51.9	42.2	34.1	28.9	33.8	32.3	28.2	29.9	28.5	36.1	35.2	27.8	34.0	27.0	23.5	13.4	19.2	21.3	18.0	14.6	22.9
1930	95.4	3,008,413	20.3	14.3	14.8	13.7	15.1	26.0	36.5	104.9	39.6	38.4	35.8	38.6	65.8	92.7	127.0	177.6	220.6	322.6	293.2	247.1	313.6	324.7	358.9	330.7	244.9	244.7	183.5	132.5	120.8	104.5	64.6	50.5	45.9	35.5	29.0	24.3	29.0	35.8	38.2	33.4	35.2	28.4	32.5	27.1	22.9	15.2	13.4	23.7	24.4	19.9	13.5	14.8
1931	52.7	1,662,918	16.0	12.5	11.6	14.9	20.8	14.6	13.2	15.2	12.6	8.3	18.6	24.6	14.2	19.4	31.2	29.4	27.1	65.5	148.3	247.1	188.1	200.3	205.9	174.4	145.6	105.1	73.4	66.9	54.9	45.2	54.1	51.4	36.4	29.7	28.6	26.8	31.7	34.0	36.6	41.0	36.6	28.9	23.7	20.0	30.1	39.0	36.2	32.9	27.0	23.2	24.2	25.0
1932	99.8	3,156,889	22.8	19.1	25.0	19.5	19.0	18.1	24.1	32.0	100.5	87.1	62.3	61.8	65.9	68.7	65.9	76.4	105.3	105.0	226.0	378.3	433.6	263.7	561.1	348.2	364.7	290.9	213.6	147.1	96.8	82.8	73.3	53.8	50.0	55.0	63.4	45.9	39.0	31.6	24.2	19.9	24.1	19.3	30.1	33.7	34.2	33.0	32.1	33.1	29.1	26.2	28.1	26.8
1933	110.4	3,480,665	23.7	22.6	20.0	18.0	16.5	14.9	12.5	14.9	15.4	17.5	19.8	23.1	41.0	62.8	37.7	45.3	88.9	185.6	223.6	250.8	273.0	391.3	446.8	410.2	446.2	337.6	286.8	223.7	173.4	115.1	81.9	66.0	55.2	51.7	61.9	57.8	46.5	45.1	45.7	45.7	44.9	47.9	46.3	173.2	134.2	102.4	80.7	73.4	61.4	36.8	61.2	60.7
1934	126.0	3,974,385	64.9	58.3	61.3	62.5	93.9	108.6	67.4	47.2	39.8	46.2	70.3	71.3	63.2	80.7	176.9	217.6	406.7	369.9	405.9	399.0	320.0	356.5	505.0	494.7	259.8	184.9	155.9	117.9	87.7	71.5	60.1	50.4	43.6	38.3	34.3	34.4	33.8	31.8	35.3	31.8	29.6	39.5	44.8	44.7	103.7	133.8	93.0	68.1	47.6	41.7	30.0	17.6
1935	81.9	2,583,405	31.8	40.0	23.9	25.6	102.1	78.8	52.1	50.3	36.4	66.7	68.2	38.7	27.5	24.4	59.0	120.8	95.6	102.7	131.2	147.4	340.4	320.2	303.5	302.3	264.9	206.1	168.3	137.2	124.3	120.3	92.0	60.6	50.7	39.5	31.9	29.5	30.5	26.7	24.8	23.4	20.9	23.1	27.3	15.9	21.4	23.7	21.4	23.0	20.6	16.5	10.8	14.9
1936	63.2	1,998,049	13.1	11.9	10.7	9.2	8.6	7.4	6.8	6.3	14.9	112.2	49.1	32.2	18.2	16.2	110.0	102.8	148.8	128.1	215.2	315.6	242.1	234.2	293.9	226.5	176.0	123.2	92.7	65.5	51.4	41.0	33.3	29.3	25.6	27.2	25.1	21.7	24.5	21.0	17.8	17.5	16.5	16.7	17.3	20.0	12.7	21.5	17.6	14.1	5.1	3.7	7.0	6.6
1937	82.4	2,597,657	7.6	8.9	9.2	8.2	7.0	8.4	9.2	10.1	13.0	20.0	23.6	22.8	19.0	29.1	56.7	57.3	45.2	79.4	165.2	179.0	236.2	272.5	270.3	678.5	504.3	282.5	198.0	129.8	106.9	70.4	62.0	60.7	44.9	34.0	29.5	27.9	30.9	25.6	24.0	29.2	33.0	31.0	33.7	39.4	49.7	36.9	34.6	29.6	22.9	20.4	29.8	25.6
1938	107.3	3,383,631	28.7	30.4	25.6	24.8	17.1	17.0	16.0	15.7	39.9	72.8	71.9	42.0	32.1	40.4	84.8	126.6	157.5	193.1	191.3	282.7	498.7	679.9	480.0	314.8	357.0	320.8	269.2	198.0	129.8	104.5	77.7	55.0	46.5	61.4	41.6	30.7	34.8	30.3	26.8	26.3	28.5	29.4	33.8	30.2	26.1	18.6	23.1	20.5	21.5	19.9	16.5	17.0
1939	69.3	2,184,293	16.5	17.2	18.7	19.9	19.2	14.4	9.7	9.1	14.1	15.7	17.3	62.8	64.2	51.1	48.9	53.3	126.9	225.2	220.3	210.4	217.3	199.1	174.1	185.6	311.6	219.3	156.3	108.1	82.6	56.9	47.2	41.4	36.9	29.5	26.3	24.8	28.6	25.9	28.3	36.1	33.0	28.4	27.1	34.1	27.3	33.7	27.6	25.5	25.2	23.1	31.1	14.8
1940	68.1	2,154,094	20.8	19.0	16.7	12.3	11.2	13.4	14.5	15.1	15.9	18.7	23.9	70.5	40.8	40.4	34.3	65.7	115.3	127.8	182.6	278.3	253.6	265.3	215.6	191.2	156.8	120.8	82.7	68.7	52.9	44.0	101.4	57.2	35.7	28.7	24.6	23.1	42.8	44.6	75.2	73.8	60.8	59.4	52.1	49.6	29.9	29.2	34.2	31.9	31.3	25.4	18.3	24.2
1941	61.1	1,925,394	21.5	20.8	20.2	18.6	20.0	21.7	20.4	16.2	13.8	16.7	17.1	46.0	40.0	37.5	44.8	59.5	66.3	116.5	131.2	133.3	139.1	156.6	201.5	144.4	113.8	90.1	153.0	95.6	67.1	48.3	40.8	31.2	27.0	25.6	41.8	31.1	40.7	58.3	56.9	85.9	82.2	73.9	70.9	62.5	50.8	46.5	40.6	33.8	56.0	46.6	50.3	29.8
1942	151.7	4,784,739	32.5	33.2	29.5	26.8	24.8	23.0	15.1	12.2	14.7	30.9	45.5	29.6	23.9	59.7	49.7	90.2	144.0	113.3	308.0	627.3	427.8	501.0	1083.0	605.4	355.5	591.2	497.1	298.6	194.8	159.4	173.6	136.2	107.6	73.5	68.2	75.0	58.7	80.6	111.0	90.1	69.7	55.5	47.2	44.1	36.1	37.4	22.1	32.8	30.4	31.8	32.5	27.8
1943	121.2	3,821,375	23.2	21.4	19.1	16.3	20.3	23.8	23.2	30.4	27.4	24.1	23.4	29.5	168.0	167.5	169.0	282.0	263.6	214.2	204.8	189.0	324.0	480.5	377.8	409.7	526.2	390.6	397.3	315.4	203.9	164.3	120.6	93.2	63.2	48.7	41.7	35.7	32.1	28.9	29.3	25.7	27.3	28.5	31.1	26.8	25.7	22.8	19.8	13.6	15.9	14.4	14.7	11.5
1944	44.8	1,416,379	9.6	11.2	11.6	12.7	9.6	9.7	9.7	10.7	11.8	11.3	12.6	15.1	15.2	34.6	36.5	26.0	23.5	35.7	70.5	91.2	192.3	131.4	153.2	142.5	162.3	142.2	148.6	97.4	64.1	47.8	37.7	32.3	33.1	48.3	38.0	33.5	28.0	25.1	19.9	18.7	16.8	17.3	16.2	14.4	12.8
1945	96.5	3,043,709	13.2	13.1	14.0	14.9	14.3	14.6	13.8	12.6	13.6	13.8	24.0	29.2	29.8	23.1	20.4	17.5	27.6	48.8	220.0	267.2	269.9	406.9	659.8	444.9	366.2	379.4	285.7	200.9	148.1	90.0	63.8	47.0	44.7	32.0	33.7	25.0	43.9	46.3	53.7	49.6	49.0	46.7	39.3	42.2	54.0	45.7	47.3	48.7	40.2	26.4	19.9	22.4
1946	96.6	3,046,863	25.0	24.7	20.5	17.0	13.0	14.4	14.9	18.4	24.0	29.0	32.0	34.3	39.1	50.9	36.9	64.6	126.3	178.2	211.9	260.2	287.7	444.1	438.0	367.2	293.5	256.3	187.7	180.4	137.2	91.0	67.6	53.5	41.6	37.0	87.2	56.9	65.4	50.6	41.6	53.7	57.0	48.5	56.1	73.7	65.9	48.3	23.5	42.0	43.1	39.6	27.2	25.6
1947	135.9	4,286,531	25.8	28.4	32.2	30.9	24.3	27.2	74.3	75.6	48.7	49.6	136.3	332.8	120.0	97.8	90.3	158.0	211.8	372.1	487.8	430.7	282.2	303.3	335.8	380.4	291.3	261.3	221.1	170.4	130.0	100.8	72.9	59.7	51.2	83.0	85.4	56.6	45.3	58.5	115.8	96.5	99.2	98.0	260.6	162.0	104.2	76.8	50.6	36.2	29.9	28.1	32.2	34.2
1948	190.2	6,015,189	31.6	31.2	31.3	31.1	28.7	24.9	22.8	21.6	18.8	19.2	20.1	47.5	71.0	53.3	67.9	355.4	277.1	250.0	339.1	340.4	940.3	910.7	797.7	858.4	1620.0	655.3	367.9	213.0	147.3	141.1	226.4	160.9	119.5	83.3	65.9	52.6	46.9	42.2	37.2	36.2	35.2	38.6	34.1	31.0	26.6	26.1	22.1	17.6	14.3	13.1	13.0	13.9
1949	79.4	2,502,988	13.7	12.5	12.3	10.9	11.7	11.1	11.4	11.7	15.3	18.1	15.9	16.5	35.7	54.3	82.4	77.9	91.8	120.0	123.6	310.6	384.8	410.4	349.8	252.5	187.8	148.2	110.5	101.1	110.0	81.1	68.4	56.3	44.3	36.8	35.6	31.7	34.2	45.0	51.3	44.0	40.3	35.1	37.8	37.1	43.5	41.8	39.7	47.4	68.5	33.9	32.1	28.8
1950	132.3	4,172,395	25.7	22.2	20.8	20.5	19.3	20.4	19.7	26.9	34.0	43.9	33.5	34.2	40.1	73.5	68.8	138.6	118.3	92.5	120.5	394.6	379.0	420.0	449.5	480.7	618.7	495.6	454.8	330.6	222.2	166.0	138.2	104.7	92.3	73.0	67.4	50.1	44.1	36.5	31.4	29.9	33.4	59.4	99.4	103.0	106.1	86.1	66.0	63.3	42.4	52.6	55.4	60.1
1951	225.6	7,116,038	48.5	36.6	37.6	29.9	26.5	31.9	34.9	47.4	34.6	28.0	27.3	55.8	171.3	235.0	147.6	138.6	135.7	444.5	517.0	705.7	594.6	387.4	344.3	624.0	564.8	854.6	606.9	550.0	412.3	280.4	207.3	165.1	144.7	110.5	283.2	395.2	244.7	174.2	224.8	320.2	268.2	180.3	137.1	124.5	116.4	110.6	74.5	80.3	76.9	52.2	44.8	44.3
1952	107.8	3,409,624	45.7	41.2	33.7	31.6	36.2	42.7	47.7	33.0	33.9	35.2	35.9	38.9	150.9	214.7	167.0	221.9	258.9	330.9	240.1	285.3	345.6	289.7	245.1	293.7	247.3	212.0	205.7	155.0	143.5	147.9	93.6	91.8	131.9	88.8	63.0	64.1	54.3	49.4	39.8	34.8	35.1	34.3	33.3	28.5	25.4	24.0	20.7	15.3	17.5	19.3	17.6	13.4
1953	183.7	5,793,406	20.5	15.1	15.9	32.4	31.9	31.3	28.2	26.1	25.5	28.0	50.0	34.4	60.3	83.8	44.2	39.9	196.3	303.8	384.3	287.9	376.6	724.1	1771.0	1571.0	673.2	416.6	389.8	343.5	276.9	192.0	141.3	118.4	106.5	80.4	59.5	56.6	53.0	45.0	42.8	34.1	34.3	31.7	26.6	30.3	33.0	32.9	33.7	36.1	23.5	18.8	20.8	19.0
1954	146.1	4,607,834	19.8	21.1	14.7	11.8	17.6	34.9	32.7	27.3	32.4	37.5	35.3	27.7	22.8	56.0	98.7	111.3	81.8	76.4	196.2	483.0	764.8	517.5	470.1	434.3	391.9	453.7	443.1	404.6	310.5	209.2	133.8	106.1	93.5	91.0	131.9	110.9	83.1	77.2	85.6	84.0	72.6	84.5	94.1	97.3	71.8	64.6	57.3	54.0	47.5	48.2	40.4	29.8
2000	62.6	1,978,822	21.2	23.0	24.4	29.6	31.6	27.0	24.0	27.0	33.5	33.1	28.8	33.9	38.9	40.6	43.7	63.5	116.7	133.0	171.3	119.4	166.5	234.2	163.4	195.9	244.3	205.7	152.7	113.7	83.8	69.3	44.0	40.3	33.4	28.2	22.4	26.9	27.3	27.6	31.5	30.6	36.7	36.6	32.5	27.7	23.1	19.3	16.1	14.3	15.6	5.4	9.3	11.8
2001	56.9	1,793,388	14.5	14.4	13.7	13.6	11.8	11.0	9.5	11.7	10.2	14.9	18.1	19.1	24.3	23.3	27.0	25.1	34.3	117.3	135.0	193.1	187.4	258.9	341.1	269.7	242.0	184.1	129.0	95.0	66.2	44.9	33.8	27.1	25.3	22.8	21.8	16.8	14.6	13.8	13.1	16.8	13.1	10.9	14.6	15.6	19.5	20.2	20.3	15.1	14.8	17.2	16.1	13.8
	109.4	3,452,211																																																				

05CK004 Natural Weekly Mean Flows Extended (m^3/s) Data Revision Oct. 20, 2004

Year	Mean	Dam3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1912	95.1	3,006,077	5.7	5.6	5.3	5.4	5.7	6.0	6.4	7.1	7.4	10.7	9.8	12.0	26.1	74.6	73.4	73.0	53.8	103.7	189.6	121.1	111.1	96.0	59.9	112.2	245.2	126.3	180.1	470.0	336.9	332.1	188.7	150.8	135.1	164.2	189.9	157.7	205.5	111.8	110.0	85.3	95.9	98.1	82.1	58.2	54.3	45.0	46.6	23.2	23.6	19.5	12.7	12.8
1913	73.1	2,306,615	11.2	11.0	11.2	10.9	9.5	10.2	11.2	10.3	9.7	15.9	16.1	15.2	16.5	44.6	240.1	192.2	66.3	47.5	125.6	222.3	137.3	136.1	120.5	128.6	141.7	305.9	218.3	133.8	155.3	151.4	100.9	125.2	133.0	89.2	77.1	75.5	58.5	49.3	43.5	45.8	42.9	39.4	36.8	32.3	31.7	27.7	20.0	16.5	11.6	10.1	7.4	2.8
1914	40.8	1,285,128	5.3	6.7	7.1	7.0	7.1	6.6	7.2	7.5	8.4	14.0	14.7	15.6	15.2	15.6	16.3	51.7	48.8	56.9	73.6	72.0	69.7	54.0	124.2	168.3	118.7	109.8	103.9	84.8	69.9	51.4	48.8	45.9	42.0	40.8	37.2	34.6	38.9	35.7	35.9	37.4	67.1	51.5	38.9	32.9	23.4	22.0	23.4	21.4	9.9	4.8	6.8	8.2
1915	141.4	4,457,653	7.6	6.7	6.6	5.8	6.2	6.4	6.4	6.3	6.7	11.8	13.7	26.0	50.1	62.3	40.6	35.1	40.3	61.2	109.8	188.9	193.3	197.7	273.9	239.2	255.0	861.1	355.1	338.0	954.2	438.3	397.0	199.4	154.2	423.6	164.3	143.1	126.5	117.3	117.8	121.8	101.8	87.1	79.6	37.9	61.0	46.1	34.0	25.1	29.1	29.5	27.4	22.3
1916	146.6	4,634,731	17.8	14.2	12.9	11.8	10.4	10.7	11.1	12.8	13.6	12.5	15.5	25.8	51.9	89.9	87.7	110.4	86.9	66.8	118.0	79.7	66.0	153.0	473.9	336.2	377.5	327.5	520.1	500.6	256.4	243.8	279.2	204.4	162.2	441.6	316.4	344.8	473.2	226.9	140.9	117.4	114.8	103.4	136.9	139.4	89.0	50.6	37.9	32.0	25.8	23.3	22.8	23.0
1917	108.4	3,419,867	20.1	18.8	19.3	20.3	21.3	19.9	22.2	21.3	18.1	18.9	19.5	20.3	21.8	41.4	230.1	408.9	173.3	131.5	139.1	326.7	646.9	557.0	577.2	318.5	210.3	180.1	166.3	156.2	107.9	86.6	71.0	67.9	67.0	59.3	57.9	56.5	69.2	58.0	47.9	35.6	35.6	49.4	44.0	30.7	35.1	33.4	27.7	23.4	11.6	11.9	14.6	11.6
1918	44.8	1,412,500	13.4	13.3	12.5	12.5	9.5	15.3	12.1	10.4	11.9	10.0	13.0	47.4	286.0	136.3	101.1	117.1	80.5	58.3	56.6	51.4	52.7	49.9	63.7	94.1	123.0	80.5	59.4	48.0	46.8	48.9	38.9	30.5	37.3	45.3	43.9	35.4	31.7	30.5	30.1	35.8	29.8	28.7	30.6	32.3	26.6	23.7	16.6	11.0	10.1	8.8	8.4	7.6
1919	37.2	1,173,171	6.3	6.0	6.0	6.5	6.1	6.1	6.2	6.0	6.0	6.4	6.7	8.5	15.8	44.1	122.9	180.1	83.1	54.2	76.3	164.9	65.0	62.8	67.1	47.8	36.3	45.7	45.9	32.3	33.3	31.8	42.2	89.3	78.0	53.8	46.5	40.1	46.5	54.2	36.7	27.2	23.7	21.1	6.0	9.1	9.7	9.0	11.8	12.7	10.0	7.1	6.7	7.0
1920	87.8	2,775,459	7.5	8.8	8.8	8.4	9.7	10.2	11.3	11.1	10.6	10.5	10.8	8.9	15.6	25.1	40.8	288.9	411.4	417.7	528.3	526.9	342.7	133.6	82.0	102.5	142.0	162.0	113.3	220.3	195.9	122.3	75.8	61.6	52.9	50.1	42.7	38.5	30.5	27.7	28.0	27.6	21.7	17.3	17.1	15.6	13.7	10.7	9.3	9.9	9.3	7.2	4.7	3.9
1921	35.3	1,112,441	3.9	4.0	3.7	4.4	4.7	6.5	4.3	4.4	10.7	11.8	9.1	9.6	10.8	27.6	131.6	254.9	151.0	70.5	63.8	78.7	79.1	100.9	77.4	67.9	51.0	40.6	55.8	61.5	46.1	35.2	37.5	40.4	34.1	35.4	29.2	22.0	23.4	21.9	14.9	10.5	7.9	7.9	9.2	10.3	11.4	10.5	5.5	4.5	4.9	4.7	3.8	3.1
1922	35.1	1,107,203	2.8	2.3	1.2	0.6	1.0	1.0	1.0	1.0	1.4	3.7	5.3	7.9	12.5	36.1	50.3	38.0	64.1	121.4	100.5	53.1	89.6	76.5	96.8	71.9	75.1	51.3	51.7	74.5	65.8	47.0	45.8	52.1	57.8	96.1	73.7	51.3	40.7	34.4	30.2	23.4	18.7	16.1	15.4	15.9	10.8	8.7	7.3	6.7	5.8	3.9	3.0	2.3
1923	69.7	2,197,845	1.8	1.6	1.8	1.4	1.7	1.8	1.5	1.2	1.3	0.9	2.2	3.9	7.9	11.5	33.3	53.2	69.8	33.5	24.5	36.0	52.8	72.4	462.7	296.1	257.4	430.0	239.6	164.3	135.1	94.5	89.3	102.0	168.1	121.6	121.3	77.3	66.1	51.4	45.7	45.2	38.8	29.3	27.6	22.8	23.5	20.1	20.7	18.6	13.4	12.0	8.7	4.9
1924	40.9	1,293,405	2.9	2.1	2.9	5.4	5.6	5.5	6.2	5.1	5.7	6.4	6.9	6.6	7.2	11.0	20.5	39.8	46.3	112.8	109.9	59.7	89.2	56.2	55.5	53.2	119.4	88.7	141.0	116.7	53.2	45.7	73.8	118.0	99.3	76.9	57.1	49.9	40.6	48.1	35.2	30.4	28.9	24.2	23.4	24.8	19.9	19.1	15.0	14.8	13.2	11.0	8.6	7.1
1925	60.6	1,911,801	4.6	4.4	5.0	4.5	4.6	4.0	4.3	4.2	5.4	8.1	9.8	12.5	25.4	100.5	296.6	219.0	129.9	82.2	45.4	34.3	51.9	82.1	54.5	76.9	157.0	101.5	72.3	70.1	52.8	49.8	48.1	47.6	43.7	163.7	108.2	71.9	84.0	106.2	93.1	99.8	75.5	69.1	70.8	54.8	45.6	44.7	40.7	27.1	23.2	22.4	20.4	18.1
1926	88.3	2,784,138	16.0	14.9	14.8	13.8	13.1	15.5	14.5	16.7	29.0	51.9	87.3	296.6	179.4	63.2	46.1	201.0	105.3	57.0	51.8	44.8	41.3	35.1	64.4	60.7	90.5	201.0	114.2	75.8	60.8	58.4	53.8	47.7	45.9	53.0	48.8	294.7	466.0	307.6	203.7	186.0	133.3	111.1	91.5	79.4	71.6	58.3	51.2	45.3	32.4	27.7	24.1	22.6
1927	99.6	3,140,829	21.2	19.9	14.6	11.3	9.1	7.6	7.2	7.2	7.3	7.7	8.7	12.8	83.4	222.3	271.4	334.9	279.9	243.1	146.7	146.4	132.0	133.9	193.1	234.4	186.7	145.1	160.7	134.9	154.6	200.0	142.3	104.3	92.2	106.2	162.3	91.3	96.5	176.4	103.5	79.6	74.5	72.1	62.2	56.9	42.8	31.4	28.2	27.0	26.6	23.4	20.9	20.3
1928	113.1	3,577,136	19.5	22.4	23.4	17.4	16.3	17.5	19.7	19.0	20.3	21.2	21.9	102.1	360.9	199.7	106.0	105.0	114.7	162.7	85.6	65.6	63.0	72.9	61.4	518.1	731.1	619.6	595.6	468.7	251.7	133.9	94.7	83.0	69.2	60.3	60.1	62.9	58.6	50.9	43.2	37.3	32.0	25.3	22.5	23.6	18.6	22.4	19.1	16.0	12.4	11.8	11.4	9.8
1929	35.3	1,113,001	7.9	7.3	6.0	4.7	3.9	3.9	3.8	3.8	4.2	4.9	14.9	19.0	44.0	39.1	31.5	31.0	57.8	51.9	40.4	61.1	97.2	104.8	326.4	192.7	91.6	52.5	38.0	38.7	33.6	22.9	19.4	29.3	35.3	30.9	25.2	29.5	31.3	23.4	21.5	19.5	15.8	13.8	9.4	11.6	14.1	16.9	10.6	11.2	9.3	6.0	4.7	7.2
1930	29.5	930,012	6.6	4.2	3.2	3.0	4.2	8.2	9.1	19.2	25.3	18.2	20.2	22.0	35.6	59.7	72.6	44.8	48.4	55.1	50.0	40.8	37.9	32.8	67.3	83.7	58.1	77.0	81.4	44.3	42.6	41.3	28.0	19.0	20.7	30.4	25.4	24.6	27.4	28.8	29.3	18.2	10.5	4.3	16.5	24.0	22.3	21.5	19.0	15.3	12.5	7.7	5.7	5.5
1931	33.8	1,065,073	4.8	4.4	5.1	8.2	9.5	6.6	4.6	4.2	6.3	7.1	7.3	13.6	10.6	16.6	17.6	26.4	20.5	18.7	32.1	33.3	42.3	27.0	26.8	50.4	175.6	146.5	163.0	172.9	90.0	56.5	49.7	44.6	43.8	37.7	38.1	35.2	40.7	38.4	30.1	25.8	20.1	17.1	15.7	15.9	15.7	15.4	13.2	10.5	9.9	10.0	10.0	10.0
1932	57.6	1,822,800	9.1	8.7	7.7	7.4	6.7	6.2	6.1	7.0	6.9	15.3	14.9	15.0	16.1	25.4	33.0	35.5	50.1	110.5	99.9	66.3	147.2	212.6	584.0	227.8	142.7	121.4	120.2	92.1	61.7	56.0	48.4	41.8	47.1	71.5	59.2	50.1	44.8	41.5	34.7	30.5	30.2	28.4	25.7	25.1	21.2	14.1	15.8	16.7	11.6	4.0	9.2	12.3
1933	46.6	1,468,885	10.4	10.4	9.3	8.0	6.5	6.2	5.0	3.9	3.6	9.1	10.7	14.5	18.7	21.5	17.0	65.2	157.6	84.9	178.4	219.1	147.7	117.4	103.3	112.7	122.8	133.6	67.7	65.0	58.9	50.8	51.5	50.6	51.0	55.1	50.5	46.4	40.1	33.6	27.8	24.9	21.8	19.9	15.9	14.1	12.4	13.4	12.8	11.7	10.2	7.5	6.4	4.8
1934	31.2	983,547	6.8	7.4	7.0	6.6	6.7	6.6	6.6	6.3	5.8	19.4	25.0	31.1	27.0	33.1	40.6	36.3	61.9	72.2	52.3	63.9	69.3	110.4	98.1	104.1	88.3	67.2	40.6	40.6	35.2	33.0	40.5	33.1	32.4	31.3	31.6	27.1	25.8	22.2	19.8	18.1	16.7	17.6	13.9	12.2	11.6	9.9	9.5	9.1	8.9	8.1	7.5	5.7
1935	42.4	1,338,289	4.3	5.4	4.2	4.6	5.7	5.6	5.3	5.4	5.3	14.2	13.7	14.8	13.8	8.0	9.9	43.7	58.2	28.6	34.5	70.2	68.9	62.7	58.7	113.1	196.2	116.8	191.0	132.8	91.0	101.2	136.2	89.7	60.2	44.5	39.8	42.9	43.9	40.7	36.2	31.3	29.0	30.0	25.2	12.4	8.0	8.9	7.1	7.3	8.0	7.0	5.5	4.9
1936	42.8	1,353,975	4.4	3.9	3.8	3.9	4.4	4.6	4.4	4.2	3.6	2.8	4.9	8.9	14.6	11.4	70.7	390.0	329.4	96.9	71.4	75.2	77.8	95.7	132.0	100.8	101.6	66.4	44.7	39.5	40.2	41.9	34.3	33.8	35.7	35.3	28.9	29.0	26.2	19.7	20.9	19.4	16.7	15.0	15.2	10.6	4.5	6.5	8.1	6.2	1.5	1.5	1.9	2.1
1937	29.8	938,966	1.9	2.0	2.0	2.1	1.8	1.7	1.8	2.1	2.4	6.5	11.5	10.3	13.4	13.7	43.9	33.0	23.9	33.0	37.5	29.8	39.3	50.2	72.7	129.8	100.1	64.9	64.2	48.3	61.7	48.9	51.3	48.5	49.9	36.0	31.4	35.5	33.5	34.3	39.0	41.6	34.9	30.9	26.2	24.8	16.7	10.3	12.6	10.1	15.8	16.7	11.6	4.0
1938	42.5	1,339,080	7.1	7.3	7.1	6.2	4.5	3.5	3.7	3.9	5.4	12.3	19.8	18.7	16.9	20.9	55.2	37.8	23.1	30.5	35.9	37.1	135.2	124.0	92.5	159.0	144.1	117.0	233.9	125.2	82.6	63.9	52.2	57.3	52.3	47.2	44.6	48.8	41.5	35.5	33.1	30.5	25.4	21.3	19.1	18.6	9.3	6.9	5.8	5.9	6.1	4.7	4.1	3.6
1939	45.7	1,439,808	4.0	4.8	5.4	5.1	4.6	3.7	3.9	4.4	3.8	6.8	7.0	30.5	44.8	24.4	34.0	33.6	28.0	29.4	29.4	34.9	43.0	47.0	74.1	193.0	375.8	339.9	179.2	105.5	72.2	58.7	55.6	43.1	39.5	35.7	34.4	29.4	32.3	26.3	27.1	27.4	24.7	22.7	20.4	22.3	20.0	18.4	16.5	12.4	12.0	9.5	7.6	6.1
1940	40.0	1,265,521	5.2	4.4	3.7	2.9	3.2	3.8	4.1	4.3	4.5	9.1	11.1	16.8	13.0	24.1	42.3	207.2	218.8	176.4	110.2	75.9	84.4	83.0	74.2	66.4	57.4	51.6	45.7	45.6	64.5	57.6	52.3	38.5	35.3	32.4	29.8	38.9	42.0	40.7	28.5	26.1	22.8	18.2	19.8	18.7	9.9	9.2	9.5	7.9	8.0	7.6	6.8	6.8
1941	26.8	844,182	5.5	4.9	4.9	5.4	5.0	6.5	5.9	5.6	5.3	9.4	8.4	27.2	51.7	38.6	26.0	18.2	15.7	18.2	17.7	23.7	19.3	27.3	49.7	46.5	41.3	55.2	55.6	45.7	52.1	37.9	41.2	42.0	46.1	69.0	85.2	52.9	39.4	35.2	36.1	35.9	32.5	28.5	25.1	20.9	14.3	12.6	7.5	8.8	7.8	5.9	5.6	5.0
1942	58.3	1,837,601	4.1	4.1	4.5	4.8	4.4	3.9	3.3	3.0	3.2	6.8	7.2	6.5	6.0	5.5	6.5	21.2	34.5	33.0	42.0	45.4	96.1	143.9	129.9	117.9	86.4	170.7	142.1	239.7	217.6	134.9	147.2	109.6	94.8	82.2	99.9	117.0	87.6	91.3	77.6	59.6	48.9	41.9	39.2	35.2	36.8	29.8	25.4	20.5	17.9	15.9	14.0	8.9
1943	61.0	1,924,128	7.2	7.1	6.6	6.4	6.3	7.0	7.8	7.1	8.2	12.8	14.8	16.9	77.1	221.2	436.9	157.7	59.0	40.6	54.0	63.0	98.2	109.3	119.5	199.2	154.6	203.2	151.1	121.4	107.8	85.0	65.4	78.7	54.4	54.7	46.8	37.5	31.1	31.5	26.8	24.4	25.7	23.6	22.9	19.1	12.3	11.0	8.1	6.8	6.9	6.7	6.0	5.4
1944	57.7	1,823,134	7.3	6.8	6.2	6.2	6.5	6.7	6.4	6.1	4.8	3.5	4.3	9.1	30.0	53.8	72.1	42.0	31.6	22.9	18.1	24.3	35.3	71.5	128.9	139.3	341.4	219.7	107.2	119.2	134.8	61.8	112.5	274.4	143.7	117.6	85.4	65.8	55.5	50.5	41.9	42.6	45.0	40.5	35.2	29.4	25.3	22.0	19.0	16.3	12.9	13.0	12.5	9.3
1945	48.6	1,532,199	8.1	5.8	7.9	8.9	8.8	9.0	8.9	9.3	7.0	6.2	28.9	47.8	57.3	61.1	38.6	29.6	42.0	37.3	51.1	44.4	146.2	206.3	161.7	90.8	71.5	93.4	147.4	77.9	73.5	63.7	37.7	55.7	55.0	41.1	49.0	59.7	45.0	45.3	67.8	66.8	63.9	52.9	49.7	40.3	29.0	18.9	16.4	18.0	19.4	16.7	14.0	13.6
1946	55.2	1,741,309	12.3	13.3	13.6	14.6	13.3	12.4	11.6	11.1	11.9	12.9	13.0	12.8	80.0	166.3	135.6	81.5	71.4	50.2	42.6	38.9	37.0	65.8	132.9	198.7	157.4	234.0	192.1	116.0	94.8	46.6	31.9	41.8	30.6	36.9	39.1	87.5	82.5	51.4	41.7	66.1	43.1	36.0	30.3	29.7	26.7	22.3	17.6	13.5	12.4	13.1	11.5	11.2
1947	69.4	2,189,675	9.2	8.6	9.4	9.5	9.1	8.2	8.4	8.5	8.6	8.0	9.0	61.8	288.7	250.0	171.7	174.0	135.4	99.9	67.3	109.5	69.5	88.8	176.9	126.7	89.9	138.1	86.5	65.0	60.0	52.6	40.7	37.3	59.7	83.0	74.8	58.3	74.9	83.0	71.0	61.9	71.6	55.1	40.8	32.5	25.6	21.8	24.5	22.5	18.3	16.0	15.0
1948	121.6	3,845,717	14.7	14.6	14.0	12.6	11.5	11.2	11.4	10.5	9.9	10.4	10.4	10.8	11.4	11.7	14.4	144.9	1079.0	841.7	688.3	470.4	432.1	493.7	239.9	194.0	180.3	166.1	142.1	91.4	96.6	82.7	95.3	88.6	80.4	85.3	61.2	45.6	40.1	37.2	34.1	31.4	30.1	28.7	26.8	22.3	18.3	15.1	17.5	14.2	9.8	6.8	5.4	7.0
1949	24.0	757,970	8.0	6.6	7.2	7.4	7.3	6.9	6.5	6.3	9.2	11.9	13.1	16.1	27.3	58.0	73.8	72.8	45.8	34.0	27.8	43.3	56.7	54.2	43.5	36.7	24.0	22.2	24.9	17.6	23.1	60.3	64.1	42.5	28.6	21.9	16.3	13.5	16.8	16.9	13.8	9.2	9.9	14.2	16.7	17.1	18.1	17.6	14.6	20.5	13.4	6.4	2.8	2.6
1950	29.6	932,943	2.4	2.7	2.9	3.5	2.8	3.4	3.7	3.5	3.4	4.5	4.9	5.4	6.2	10.3	22.5	89.3	84.7	51.3	43.3	34.5	52.2	33.5	30.5	30.5	113.2	139.6	90.2	93.9	84.3	60.7	51.0	48.3	44.9	39.2	29.4	26.1	23.0	18.1	14.6	17.0	24.9	17.9	19.0	16.1	9.2	5.3	4.0	3.1	2.5	3.3	3.6	3.6
1951	87.0	2,742,508	4.3	4.2	4.0	3.6	3.7	4.0	4.2	4.0	3.8	3.7	4.1	2.8	4.3	206.5	239.0	140.0	110.6	191.7	271.4	130.7	106.2	74.0	74.1	156.7	165.6	139.4	120.1	190.9	197.9	152.3	124.9	97.8	86.9	95.4	89.2	309.4	166.6	105.4	82.3	86.6	79.7	73.3	65.8	58.4	53.4	47.2	39.6	35.1	36.4	26.2	28.2	16.7
1952	97.5	3,084,710	15.0	16.5	16.4	12.9	11.4	12.0	13.6	14.6	11.6	12.3	15.3	16.4	70.1	429.1	631.0	417.0	251.7	123.0	79.9	57.7	77.9	82.7	77.1	87.8	302.6	529.7	309.4	148.4	113.4	132.1	140.7	94.8	92.5	92.6	61.8	51.6	52.6	50.9	44.8	38.7	34.4	32.9	35.3	33.3	28.0	27.3	18.0	8.6	8.1	10.1	12.8	14.3
1953	83.3	2,626,180	9.0	7.6	5.9	5.6	8.0	8.6	8.0	10.1	10.0	12.8	12.5	14.6	17.3	46.8	55.1	53.3	104.4	155.6	161.3	129.9	96.4	145.1	508.6	358.3	264.3	233.6	274.7	220.1	156.7	119.4	110.1	155.1	105.6	65.8	91.1	110.2	65.3	48.5	44.1	39.7	37.3	34.6	33.9	29.8	28.2	26.8	18.1	18.4	21.7	13.6	9.2	9.7
1954	130.4	4,110,926	12.3	11.2	7.9	9.8	9.6	9.4	10.8	11.6	17.0	19.3	18.5	18.1	17.9	14.1	46.7	227.1	148.2	62.3	160.4	367.4	220.6	179.3	224.0	515.9	245.6	157.4	204.6	160.0	103.9	89.4	64.2	121.3	171.1	186.6	812.6	572.1	375.4	184.3	147.3	113.7	101.1	98.8	91.3	77.3	70.7	66.6	58.2	51.6	32.1	38.6	23.7	19.8
1955	74.1	2,338,002	14.4	8.9	9.9	12.7	15.6	17.3	15.5	14.1	12.5	11.8	13.0	14.8	23.0	321.3	290.9	207.9	204.3	281.0	221.4	114.0	150.0	266.3	149.3	120.7	142.4	105.8	108.5	143.3	116.3	92.3	82.3	62.3	48.3	42.7	42.8	34.2	33.7	36.4	42.6	36.2	35.3	30.4	28.3	15.4	9.4	12.7	10.6	6.8	5.7	7.0	6.4	6.4
1956	63.9	2,020,952	5.6	5.6	6.7	7.4	8.7	9.2	9.2	7.0	8.8	13.3	13.5	18.5	107.6	142.9	339.0	366.0	197.3	97.4	68.5	81.0	91.5	92.7	102.6	98.5	103.8	119.5	114.9	120.2	88.6	80.0	102.8	83.3	63.4	42.4	47.4	52.0	43.0	37.1	39.4	32.3	27.6	23.8	25.0	25.6	25.5	25.0	23.9	27.5	26.5	9.3	6.0	9.0
1957	43.1	1,360,756	11.7	8.4	6.9	6.0	6.2	6.0	6.1	7.4	7.2	11.1	19.9	24.2	60.5	146.9	82.3	76.0	125.1	105.6	102.9	86.0	104.2	78.9	69.0	60.5	77.3	76.1	60.4	47.8	45.1	44.9	39.4	37.5	51.2	45.0	39.9	42.0	36.7	37.8	31.6	27.4	31.3	28.5	27.2	34.2	36.4	32.8	17.7	20.6	19.8	15.0	11.7	9.4
1958	55.9	1,763,330	7.1	6.3	5.5	4.7	6.0	6.7	6.3	5.6	7.0	10.4	9.1	10.3	24.2	209.9	345.0	191.3	88.6	68.0	82.1	110.0	99.7	110.0	112.1	103.8	83.8	90.3	123.7	141.6	120.6	91.6	72.9	61.0	49.2	44.7	42.8	34.4	30.5

Response to Supplemental Information Request #1
Appendix 144.1 - Naturalized Flow Data

05CK004 Red Deer River + South Saskatchewan River at Confluence

05CK004 Natural Weekly Mean Flows Extended (m³/s) Data Revision Oct. 20, 2004

Year	Mean	Dam3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1912	437	13,805,321	40	56	58	64	69	74	68	79	73	74	65	72	143	353	358	411	283	365	580	543	756	706	515	562	1310	924	908	1559	1315	1264	1021	740	610	666	744	642	672	478	435	361	355	366	336	288	261	239	245	179	131	111	89	86
1913	406	12,801,014	81	67	55	65	82	72	75	82	81	81	94	98	87	163	700	789	457	326	444	742	666	1085	1192	1193	1037	1349	1222	794	699	639	560	564	750	543	421	441	391	287	261	252	244	248	255	231	205	180	170	158	138	126	103	64
1914	303	9,564,329	94	107	91	69	58	53	60	60	67	99	150	176	165	149	167	265	309	359	493	578	690	621	856	879	932	767	690	695	595	433	330	311	288	296	276	234	220	197	227	235	316	343	372	270	229	211	185	186	122	67	56	71
1915	629	19,823,442	95	91	76	70	63	70	68	69	71	79	83	349	433	314	219	193	259	355	706	1097	1015	1025	1288	1212	1442	3042	1955	1556	2847	1677	1659	1013	736	1334	721	591	536	465	492	477	443	393	356	272	304	228	179	148	152	135	125	111
1916	683	21,612,925	88	76	81	80	77	83	103	376	205	130	173	296	335	379	396	451	370	348	600	489	429	814	1964	1686	2346	2309	2845	2307	1519	1156	1020	781	746	1452	1094	1141	1501	797	548	465	448	406	481	496	355	234	238	234	197	146	125	125
1917	511	16,105,993	102	96	105	107	97	98	109	98	82	85	95	102	121	184	716	1071	528	434	497	1313	2076	2389	2456	2060	1690	1284	1111	1042	778	624	456	398	394	360	338	308	315	272	245	227	221	247	233	188	188	162	127	121	61	45	50	52
1918	288	9,072,916	105	124	76	101	91	76	121	83	60	97	90	281	849	436	344	409	327	302	493	428	442	356	467	1027	1142	761	486	416	413	399	333	299	315	342	293	253	236	220	211	219	190	166	190	167	145	129	101	77	66	70	64	71
1919	241	7,598,540	57	56	57	66	66	55	47	64	53	45	53	66	92	231	403	479	295	312	386	579	563	975	670	522	446	591	468	333	319	286	292	588	440	336	277	231	228	245	185	145	131	115	71	62	57	62	90	87	56	56	64	73
1920	433	13,689,985	77	59	59	57	57	67	87	83	78	73	81	178	283	191	181	767	1193	1310	1527	1687	1317	721	545	846	1060	1052	926	1306	1195	893	652	491	394	360	298	243	203	188	191	191	166	165	161	141	129	100	85	94	92	69	66	59
1921	279	8,786,708	73	68	57	50	51	62	73	59	103	117	73	82	99	189	365	689	531	296	343	527	778	1035	934	1041	756	728	708	569	442	375	363	323	269	270	214	166	163	159	123	125	101	100	102	114	126	116	62	48	63	91	75	38
1922	261	8,226,928	49	61	63	49	36	46	40	33	36	40	50	89	86	133	248	200	333	496	486	341	772	773	1055	921	867	636	562	610	488	368	324	327	322	384	323	257	218	192	178	142	141	115	102	104	97	82	65	62	46	35	26	53
1923	433	13,652,817	57	51	45	39	40	34	38	36	41	56	52	56	87	120	151	207	277	209	194	426	479	1020	3066	1990	1668	2445	1463	994	810	612	562	513	619	547	544	373	326	271	248	267	189	196	166	153	139	120	128	104	90	79	62	56
1924	284	8,970,746	37	31	42	59	61	81	74	58	72	86	75	70	72	79	163	195	165	304	438	454	762	598	509	830	1081	854	927	787	439	338	412	595	635	472	355	297	254	246	212	175	171	148	126	139	116	90	124	123	109	84	66	63
1925	376	11,856,521	81	80	65	70	70	75	83	69	68	87	120	144	491	520	962	792	592	405	372	512	991	920	658	795	1142	970	716	562	439	364	338	311	299	624	437	289	312	394	375	415	327	319	329	287	218	218	187	126	125	158	137	108
1926	364	11,483,968	94	85	82	73	71	85	87	73	111	185	283	674	451	179	143	569	482	347	385	267	270	238	260	285	532	997	665	508	384	307	272	236	232	251	214	912	1492	1075	751	699	588	513	530	418	308	281	227	178	136	174	139	140
1927	571	18,001,872	145	131	99	82	81	93	91	72	73	80	102	160	350	657	691	937	721	543	680	644	1056	1364	1402	2177	1666	1385	1176	942	1092	1031	813	635	574	684	781	507	630	1085	649	454	394	355	409	359	303	257	216	223	213	124	98	135
1928	544	17,186,863	130	246	404	187	144	133	145	149	128	123	135	534	1291	622	374	358	363	650	482	666	819	1066	620	1718	2566	2423	2626	1883	1139	738	581	487	371	345	355	352	318	293	246	221	198	288	240	203	175	176	139	114	75	73	76	76
1929	272	8,588,859	72	69	64	58	53	52	53	56	62	74	154	182	227	183	120	146	220	289	306	481	839	856	2440	1528	943	529	442	424	318	262	222	237	231	204	167	175	175	137	129	124	103	103	70	67	86	80	57	60	67	56	34	77
1930	268	8,459,062	83	47	42	44	48	77	78	228	221	134	169	133	211	316	345	326	348	487	529	450	549	524	835	938	655	728	703	526	525	486	313	241	222	242	175	160	169	182	179	154	116	84	117	121	103	103	82	94	94	85	63	70
1931	199	6,280,199	75	52	40	60	70	56	46	56	60	60	59	99	81	123	134	135	110	102	208	308	438	305	442	552	798	698	611	594	408	306	259	259	226	188	191	188	212	191	174	166	164	140	124	112	101	109	106	93	80	60	58	70
1932	349	11,047,924	91	71	68	56	63	58	63	71	102	192	121	145	165	226	208	204	268	386	482	704	904	1007	2695	1347	1157	933	791	630	419	356	322	268	267	316	352	325	262	245	199	163	180	153	180	149	145	118	88	124	106	66	63	92
1933	313	9,871,155	83	78	78	64	67	63	58	44	53	64	72	92	127	197	169	233	489	491	709	845	738	876	1000	902	1194	1007	805	634	528	393	335	286	284	281	254	251	203	188	173	169	152	144	124	192	225	194	150	115	131	94	89	95
1934	290	9,136,749	108	114	114	106	121	163	123	110	68	102	132	172	159	167	275	325	535	743	649	700	758	949	943	1166	779	533	437	423	332	302	285	262	220	208	196	184	170	151	145	127	116	123	136	121	127	216	169	139	113	99	88	62
1935	273	8,608,756	45	72	67	52	95	172	97	91	79	101	89	114	100	60	101	329	353	232	253	347	561	697	732	837	1141	798	840	695	582	597	635	488	346	272	218	207	207	193	163	148	128	128	164	82	48	90	63	75	78	57	43	35
1936	233	7,383,339	38	45	56	31	45	36	25	25	28	117	181	142	109	93	300	1088	936	408	429	573	619	592	976	709	639	435	352	293	263	247	219	200	200	203	183	168	159	126	126	118	85	91	88	74	43	33	75	50	22	6	8	35
1937	224	7,052,226	20	12	9	18	21	21	30	32	36	54	74	85	84	96	221	207	161	160	299	307	379	492	591	1026	1182	674	509	406	454	363	328	351	284	229	180	182	172	167	178	181	155	143	142	149	170	124	92	95	63	80	68	75
1938	315	9,925,605	67	86	77	65	59	39	35	38	54	78	115	168	153	169	357	302	305	287	378	404	893	1330	1039	995	1060	1002	1162	868	551	443	371	326	298	267	244	233	246	210	200	187	181	155	167	153	118	80	67	64	60	67	51	44
1939	260	8,189,689	36	47	49	49	44	40	30	23	40	48	42	121	295	190	196	188	215	309	380	331	472	446	546	735	1530	1399	966	629	482	341	307	272	240	209	189	168	165	158	151	156	145	128	108	145	136	119	115	92	92	74	65	55
1940	246	7,765,493	33	48	41	31	21	42	49	46	55	63	114	127	146	153	165	603	751	610	528	560	585	723	615	528	517	427	347	346	359	340	365	274	206	181	167	182	261	275	263	261	223	171	157	155	123	83	74	92	94	87	53	52
1941	189	5,962,129	67	41	55	56	40	58	65	54	36	48	80	130	319	233	178	151	140	165	225	213	277	308	535	455	372	321	392	319	296	259	227	214	208	261	329	251	224	204	219	232	215	193	198	165	143	125	114	67	96	102	80	76
1942	413	13,028,545	60	54	43	66	74	64	40	42	43	64	82	81	61	107	122	189	236	232	262	1221	838	1339	1401	1380	892	1245	1371	1236	993	705	808	663	551	440	448	496	413	419	429	376	307	255	247	205	168	139	124	112	101	81	93	68
1943	347	10,948,161	65	49	71	45	42	65	58	91	112	74	72	98	406	798	1291	720	516	353	362	373	552	870	833	963	1041	1031	1041	952	787	640	493	449	350	304	254	216	178	163	160	137	131	129	112	128	88	71	64	50	61	53	52	39
1944	234	7,400,656	59	54	49	58	49	38	49	44	42	37	48	59	105	150	256	176	105	84	126	173	318	410	605	639	1086	786	550	482	482	294	374	771	470	440	339	273	242	216	183	184	181	162	140	139	121	108	77	76	70	78	60	51
1945	305	9,626,823	41	49	55	54	46	45	61	50	42	46	94	174	255	200	146	120	151	140	296	395	698	1046	1372	1068	810	1041	1100	675	570	419	311	303	296	246	249	298	249	244	305	289	278	249	235	202	159	86	100	122	129	107	76	81
1946	328	10,358,909	95	97	92	87	72	70	71	70	78	98	124	148	261	457	376	251	280	338	367	461	532	901	1102	1236	943	1139	869	684	580	372	292	288	228	238	288	409	418	300	242	289	247	206	187	182	181	153	95	103	145	136	98	103
1947	368	11,600,824	92	102	99	97	96	73	102	194	142	80	87	601	738	536	398	442	485	599	762	1145	667	623	841	1079	849	698	744	548	473	377	306	262	209	219	325	267	232	235	336	318	300	277	451	355	286	226	159	122	123	111	114	127
1948	507	16,038,165	124	108	97	85	90	76	62	75	84	76	89	125	168	194	177	442	2133	1387	1401	1205	1590	2521	1714	1694	2037	1562	1015	630	513	461	612	531	446	399	301	230	215	186	165	138	128	140	130	134	124	115	109	92	68	47	51	75
1949	183	5,778,313	101	92	83	73	52	53	53	68	72	78	69	62	83	147	327	269	217	205	188	443	654	692	675	534	387	315	276	212	239	262	236	186	169	120	106	100	99	105	109	122	109	104	109	108	75	60	50
1950	283	8,931,304	57	60	61	60	62	73	77	78	84	101	105	96	131	252	219	340	292	202	189	461	576	592	613	746	1350	1236	986	851	628	454	404	332	313	248	219	206	176	146	120	114	123	124	181	172	171	103	94	71	83	83	109	102
1951	534	16,846,808	106	81	77	68	55	55	70	93	93	85	67	82	211	823	587	373	302	752	959	1184	1100	878	669	1241	1408	1564	1267	1537	1256	909	676	496	443	415	552	1418	810	506	456	585	575	451	382	347	339	285	217	250	200	148	144	133
1952	383	12,108,533	146	138	130	106	96	127	143	127	97	100	99	97	344	1198	1340	942	734	638	500	471	771	682	592	733	961	1303	1031	639	550	647	482	391	471	421	291	242	218	231	190	172	165	152	159	145	129	118	109	63	63	84	74	61
1953	444	14,000,045	65	64	42	65	103	86	97	91	82	72	102	119	111	251	223	170	394	672	711	610	674	1117	2653	3068	1728	1127	1224	1043	944	651	516	471	434	339	323	329	264	219	191	179	174	163	158	148	138	127	110	113	107	90	64	67
1954	578	18,220,412	87	88	70	41	55	99	120	108	126	112	108	110	88	67	245	760	501	252	540	1381	1553	1304	1343	1931	1364	1184	1440	1309	948	764	492	602	633	696	2165	1560	1073	639	539	457	429	393	386	362	301	273	238	223	134	138	124	94
1955	400	12,614,566	63	55	64	85	107	95	78	64	44	32	91	91	93	866	950	605	549	738	723	476	1157	1221	944	1129	1187	1169	929	982	945	746	541	418	327	278	278	218	209	200	222	192	179	204	216	235	178	129	71	93	103	99	77	58
1956	380	12,004,782	104	97	82	79	76	65	70	57	60	68	80	144	478	527	875	941	636	411	286	465	1104	1288	1328	1009	967	888	793	878	762	622	583	476	363	292	287	293	232	203	210	171	157	145	162	170	133	128	88	103	97	56	53	99
1957	303	9,549,770	99	73	44	59	54	48	65	64	80	174	154	156	258	417	284	271	401	472	926	947	1111	877	892	944	692	625	481	395	358	327	278	247	270	249	241	208	188	195	184	166	186	179	166	169	209	177	131	142	130	144	92	48
1958	360	11,362,191	34	62	67	59	53	57	41	50	113	107	82	58	125	745	1124	770	367	284	536	951	1001	1111	998	977	784	694	773	863	808	601	504	402	311	286	274	230	184	260	239	192	163	175	158	158	129	123	119	110	157	79	83	107
1959	345	10,864,751	103	49	59	67	62	83	67	62	62	79	133	188	282	239	241	254	243	287	371	449	705	717	959	964	1102	1301	1310	828	691	545	538	397	314	298	274	260	243	308	297	258	240	240	257	266	213	168	114	160	169	145	130	120
1960	299	9,466,440	93	74	82	75	79	90	81	78	65	53	62	160	806	836	697	404	254	225	334	587	565	619	806	769	798	661	784	685	556	472	338	407	381	301	261	223	194	165	160	169	142	145	128	114	119	85	74	60	46	75	74	55
1961	284	8,951,313	73	63	88	80	49	52	83	57	84	88	80	164	231	187	159	124	141	126	238	375	725	1491	1367	1097	923	687	470	348	337	350	462	377	301	321	290	235	191	176	173	170	166	210	302	243	197	158	140	77	49	81	46	60
1962	270	8,506,888	81	97	65	58	79	156	106	94	64	44	70	148	253	360	444	379	431	359	244	261	559	712	672	609	865	754	579	494	524	372	396	394	353	263	246	283	246	214	166	159	155	151	168	154	141	127	98	86	65	83	96	49
1963	314	9,909,948	31	81	45	45	49	48	103	113	138	194	183	189	247	225	205	295	329	223	267	285	345	640	767	1034	1001	947	1493	1014	720	598	599	444	391	351	284	248	199	280	229	188	176	158	150	136	130	113	65	33	107	69	52	88
1964	362	11,432,536	97	69	57	61	54	70	71	72	69	68	61	67	47	149	204	228	178	190	864	742	793	643	871	2140	1795	1472	916	1026	781	514	388	345	300	293	253	230	225	211	235	266	254	236	225	182	172	156	148	95	27	70	81	41
1965	522	16,473,170	79	80	58	67	51	62	67	112	119	102	166	138	96	201	1048	1202	644	832	466	435	492	611	1216	1206	2126	1541	1824	1773	1438	882	640	722	560	423	415	501	424	430	565	501	442	412	358	299	271	220	182	177	160	174	81	72
1966	400	12,612,078	40	64	102	84	67	80	97	70	71	82	332	560	677	1163	621	341	267	255	514	851	565	849	1533	1272	907	758	1025	1193	781	533	519	488	455	369	346	348	256	212	204	213	206	219	201	183	180	109	91	113	60	57	108	104
1967	445	14,039,380	83	77	83	70	58	62	81	72	89	153	86	77	308	310	463	588	535	672	781	829	1308	1552	2242	1808	1766	1508	1218	931	717	555	459	403	367	311	282	228	223	175	159	168	174	151	155	144	135	140	134	82	43	59	37	40
1968	295	9,324,894	64	36	54	100	70	54	82	64	99	181	233	219	190	163	137	155	140	134	242	240	363	736	822	1079	831	744	759	661	571	516	493	409	395	386	337	282	259	231	391	414	342	304	268	210	208	180	112	109	83	49	59	75
1969	440	13,862,418	49	74	80	75	76	76	78	73	69	58	60	222	293	885	1590	596	459	535	620	857	703	909	954	1059	699	1490	2282	1918	927	621	541	426	360	292	264	269	236	206	220	185	221	214	188	147	140	128	78	86	87	58	58	67
1970	320	10,096,084	64	46	46	43	59	55	64	59	72	62	76	106	174	339	628	369	243	208	360	495	709	805	850	1181	2299	1085	1103	690	500	421	382	329	276	224	199	192	193	171	148	147	175	165	155	136	121	116	92	31	23	39	68	55
1971	383	12,075,904	71	42	41	51	63	74	95	236	121	73	119	180	119	224	1256	1484	985	594	647	742	612	1047	1302	1566	916	948	674	550	578	586	537	424	357	280	243	216	197	176	170	159	153	160	155	108	91	129	137	75	47	40	22	40
1972	421	13,301,042	41	30	24	30	21	31	47	55	51	51	224	604	514	356	542	378	279	337	396	520	1009	1125	1654	1635	1189	1248	1210	902	794	791	745	594	523	418	379	324	312	317	270	261	225	223	227	190	186	155	134	92	57	28	40	81
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1975	338	10,668,359	49	58	52	45	45	34	30	49	61	71	64	74	78	72	77	177	834	600	622	829	782	559	883	814	1598	1483	830	994	770	502	458	437	312	298	328	290	233	213	207	178	177	190	175	150	145	147	108	28	46	127	91	115
1976	307	9,714,099	78	46	101	162	118	105	95	89	98	65	79	196	329	257	269	436	257	196	355	774	640	648	551	464	602	699	593	640	602	511	435	680	884	629	431	360	364	332	282	243	215	184	183	152	132	97	52	34	44	35	78	75
1977	202	6,363,962	51	37	50	57	59	64	71	82	93	98	103	102	95	93	261	185	121	140	244	451	489	437	512	603	459	392	326	265	256	233	237	262	266	373	341	298	279	258	262	254	212	188	164	146	128	96	57	40	39	50	53	61
1978	342	10,797,646	44	37	44	28	39	25	40	51	62	54	80	178	413	645	401	273	303	428	497	498	710	710	999	1292	840	859	797	749	655	626	485	380	302	460	407	295	377	440	326	308	249	208	208	187	146	70	72	114	141	90	91	69
1979	233	7,362,772	39	24	32	37	36	33	29	26	35	69	286	286	189	132	185	268	331	395	405	421	651	948	735

APPENDIX 163.1

Chin Reservoir Expansion – Sediment Modeling Technical Memorandum (INTERA 2025d)

INTERA Incorporated
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TECHNICAL MEMORANDUM

To: Jeffrey Olitch, P.Eng., PE

From: INTERA Incorporated

Date: June 30, 2025

Re: Chin Reservoir Expansion – Sediment Modeling

1.0 Introduction

INTERA Incorporated, subcontracted by MPE (a division of Englobe), evaluated the benefits and risks of expanding the Chin Reservoir for the benefit of the St. Mary River Irrigation District (SMRID). The Chin Reservoir Expansion (see **Figures 1** and **2**) would increase storage capacity and water supply reliability within the SMRID, Taber Irrigation District (TID), and Raymond Irrigation District (RID). INTERA's analysis provides additional information to support the response to Supplemental Information Request (SIR) #1 and the project Environmental Impact Assessment (EIA), particularly regarding the fate of total suspended solids (TSS) in the reservoir. Wind-wave erosion of the reservoir shoreline represents the primary component of TSS that could be influenced by Chin Reservoir Expansion. The wind-wave erosion calculation methods and TSS mass balance modeling are summarized in the following sections.

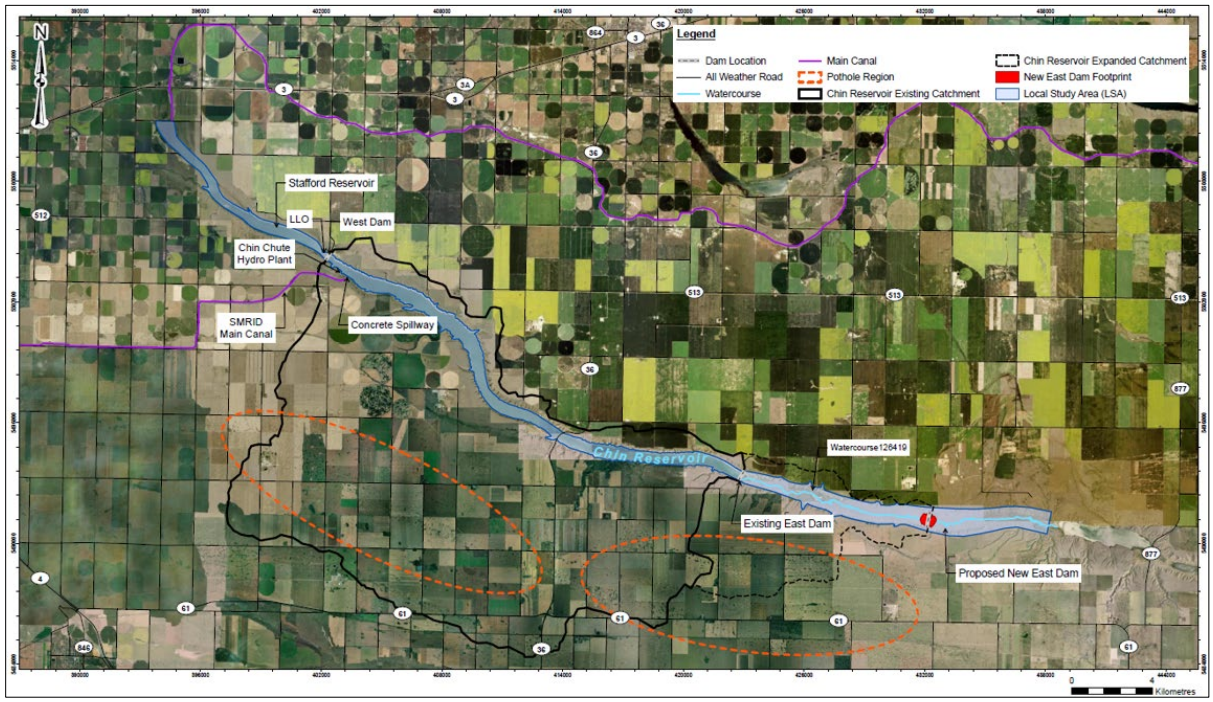


Figure 1. Chin Reservoir base case and proposed project case extents.

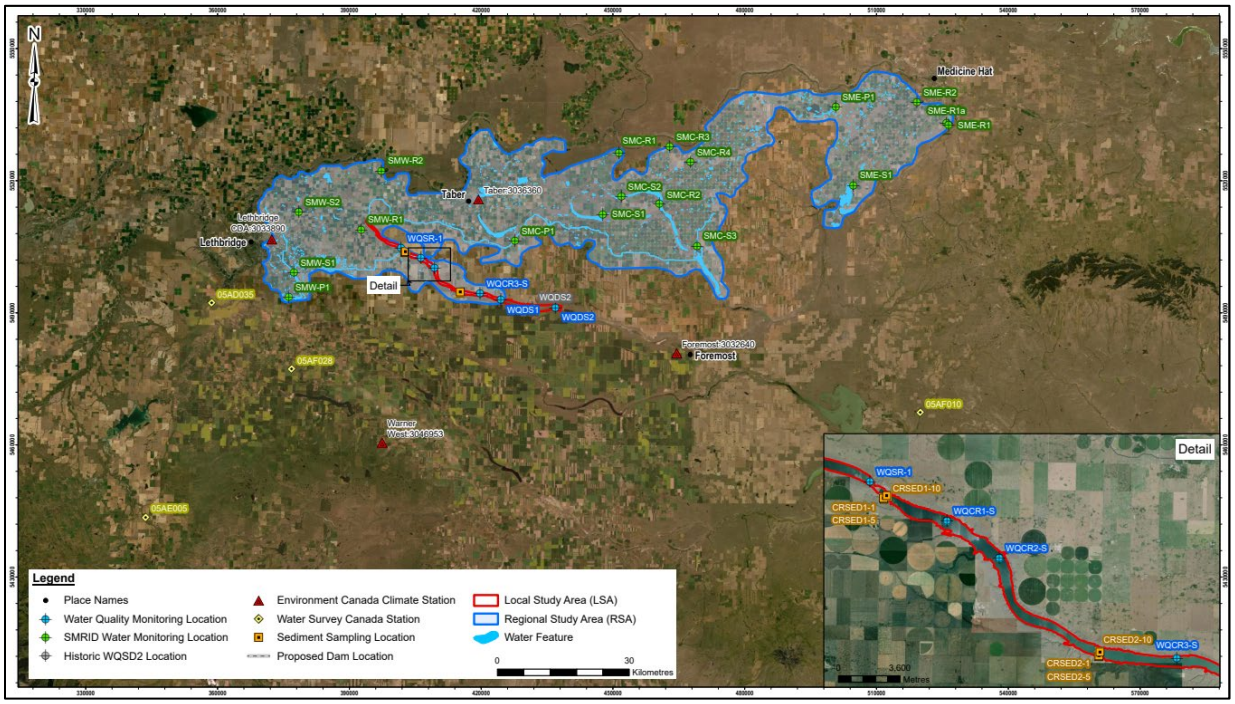


Figure 2. **Surface water quality stations on the Chin Reservoir and surrounding areas (Klohn Crippen Berger).**

2.0 Erosion and Suspended Soils

As part of the Chin Reservoir Expansion project, INTERA has proposed an Adaptive Management Plan to address potential water quality impacts during filling of the Reservoir Expansion Area. During initial operation, inundated soils may be prone to erosion and could leach metals or salts. Filling of the Reservoir Expansion Area will occur in isolation to mitigate these potential effects. We employed a conservative mass balancing approach to model water quality during future operation, following commissioning of the expanded reservoir. The model also simulated TSS concentration in both the base case and the future project case reservoir. In addition to the inflow and outflow of mass defined by the Hydrologic and Hydraulic (H&H) models, erosion and settling also impact sediment in the reservoir. Section 3.0 details the methodology to determine the erosion of soil as implemented in the mass balance modeling.

3.0 Methodology

Penner (1993) presented a method for calculating a volumetric erosion rate as the product of effective wave energy in tonne-meter/meter of shoreline and the material erodibility coefficient in cubic meters/tonne-meter. One calculates wave energy (E) as:

$$E = \frac{\rho g^2}{32\pi} He^2 T t \cos^2(\varphi) \quad (1)$$

where ρ is the mass density of water, g is the acceleration due to gravity, ϕ is the angle between the wind (or wave) direction and a line normal to the shoreline (relative angle of approach), *He* is the equivalent wave height, *T* is the wave period, and *t* is the wind duration. The effective wave energy corresponds to a percentage of the wave energy. It accounts for wave energy dissipated by the foreshore underwater slope. Milder slopes dissipate more wave energy. For this analysis, an assumed 7.5-degree slope corresponds to a 55% reduction in wave energy such that the effective wave energy (i.e., energy that erodes the beach) equals 45% of the wave energy. Penner cited a variety of other authors' ranges of material erodibility coefficients. The cited coefficients vary by more than an order of magnitude depending on the author and material type. For this study, INTERA applied a value of 0.0004 cubic meters/tonne-meter, which roughly corresponds to till with sand or gravel surficial overlay.

INTERA applied the 2-D wave model, SWAN (Simulating Waves Nearshore) ((http://swanmodel.sourceforge.net/), to determine the wave heights and periods at 14 locations around the existing reservoir. INTERA selected the locations to represent shoreline segments of similar orientation. The simplistic model mesh contains over 300 elements, with 230 vertices at the corners of the elements. The inputs to the SWAN model include a bathymetric/topographic unstructured mesh, wind speed and direction, and constant water surface elevation. The model assumed a constant reservoir depth of 14 meters (m). Note that the waves in the reservoir are not depth-limited. Wind speed, direction, and duration limit wave growth at the reservoir banks. For this application, SWAN utilized a discretized time series of wind speed and direction to drive it.

Wind data originated from Lethbridge Airport (49.630278°, -112.79972°) (https://climate.weather.gc.ca/). Available data spanned from April 1, 1953, to November 30, 2024; however, a large data gap exists between 1975 and 2018. After examining the historical record for winds during open water season (assumed to run from April through November) and adjusting the remaining wind speeds from overland speeds to over water speeds via Hsu (1981), as found in Bishop et al. (1988), INTERA jointly binned the records by wind direction into 16, 22.5-degree increments from 0 to 360 degrees and wind speed into 7.5-meters-per-second (m/s) increments from 3.5 to 42 m/s. Because 3.5 m/s winds produce no waves capable of erosion, eliminating those cases produced 49 distinct cases for simulation in SWAN.

SWAN simulated each case to determine the wave height, period, and direction at each of the 14 locations discussed above. The following sentences describe the calculation procedure for a single location. Multiplying the significant wave height, as generated by SWAN, by 0.71 produced the equivalent wave height, as per the Penner method. Subtracting the difference between the wave direction and the shore normal direction (measured from aerials) produced the relative angle of approach. Angles of approach greater than 90 degrees from a given shoreline imply offshore directed waves that cause no erosion of that shoreline. Entering the equivalent wave height, wave period, and relative angle of approach—along with the value of one hour for *t* in Equation 1 (because the wind data corresponded to hourly data)—INTERA calculated the wave energy at a location. Multiplying this energy by 45% yielded the effective wave energy at that location. Following the same procedure at the other locations and then summing the effective wave energies produced a total effective wave energy for a case (particular wind direction and speed combination). Multiplying the total effective wave energy by a material erodibility coefficient (0.0004 cubic meters/tonne-meter) produced the total volume of material eroded for that case. By multiplying that value by an assumed soil density of 1,900 kilograms

per cubic meter (considered representative for glacial till), the resulting mass of the eroded material (in kilograms) can be calculated.

3.1 Mass Balance Model

INTERA constructed a water quality model of the Chin Reservoir earlier in this project to predict impacts of the reservoir expansion on water quality. This was a simple mass-balance model that evaluated the Chin Reservoir system as a continually stirred reactor (CSR), which incorporates all elements and then distributes them uniformly throughout the entire system. The mass balance model represents the Chin Reservoir in two distinct ways, (1) as the extent of the base case footprint and current inflows/outflows (base case) and (2) as the proposed project case footprint and associated inflows/outflows (project case). While INTERA originally created the model to simulate constituent flux throughout the Chin Reservoir system, we amended it to include inputs from erosion and sediment settling. The erosion was constrained to only the open-water period, from April to November, while no erosion was assumed to occur during the remaining months.

The mass balance model analyzes water quality constituents as a conservative substance. The model considers total inflows and total outflows to the system, which were provided in the Hydrologic and Hydraulic model developed by WaterSMART Water Management Solutions (Paquette, 2024) for Chin Reservoir (H&H Model). The inflows and outflows span a range of years from 1928 to 2010 and contain both high and low flow conditions for the system. The theoretical fluxes present in the Chin Reservoir system are illustrated in **Figure 3**. The water budget—and consequently the mass balance model—consolidates the physical processes into a single total inflow and total outflow interaction, as provided by the reservoir inflow and outflow data from the H&H Model.

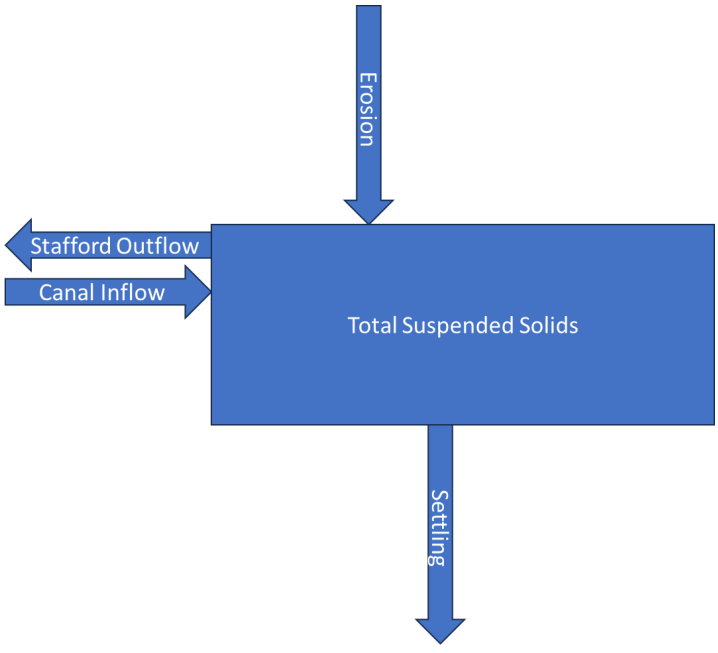


Figure 3. Sediment processes simulated within the Chin Reservoir system.

3.2 Results

Upon determining the hourly eroded mass within the reservoir for each binned wind direction and speed case in Section 3.0, INTERA utilized a lookup table to assign the eroded mass to each hour of the available wind record during open water season. Summing the values over each year yielded the annual eroded mass entering the reservoir from wave action for a given year. **Table 1** shows the annual eroded mass statistics. Note that the eroded mass per day values correspond to the annual eroded mass divided by 365 days. Additionally, a large data gap exists between 1975 and 2018. Therefore, the statistics cover only 30 years.

Table 1. Annual (April – November) Eroded Mass Statistics (1953-1975 and 2018-2024).

Statistic	Annual Eroded Mass (kg)	Average Eroded Mass per Day (kg/day)
Mean	244,159,720	668,931
Median	213,674,150	585,409
Maximum	565,088,073	1,548,187
Minimum	94,917,694	260,048

Note: n = 30

With this erosion analysis providing a starting concentration of TSS for the model, INTERA ran the analysis assuming a settling rate of 1 meter/day as a conservative estimate (based on Stoke's law and particle size) of average rates of settling in a system. As shown in **Table 2**, although peak TSS concentration in the Chin Reservoir vary greatly between the Base Case and Project Case footprints—due to the behavior of sediment erosion (highly seasonal) at peak flow events (again seasonal) (as illustrated in **Figure 4** through **Figure 7**)—the average concentration of TSS is only slightly lower in the Project Case. **Figure 4** through **Figure 7** show the model results. The annual swings in mass happen because the erosion input occurs only in the warm months while the settling occurs all year long.

Table 2. Modeled TSS concentrations in the Chin Reservoir, Base Case and Project Case footprints. All values in mg/L.

Footprint	Min	Max	Average
Base	.0029	462.10	51.02
Project	.0023	240.07	48.38

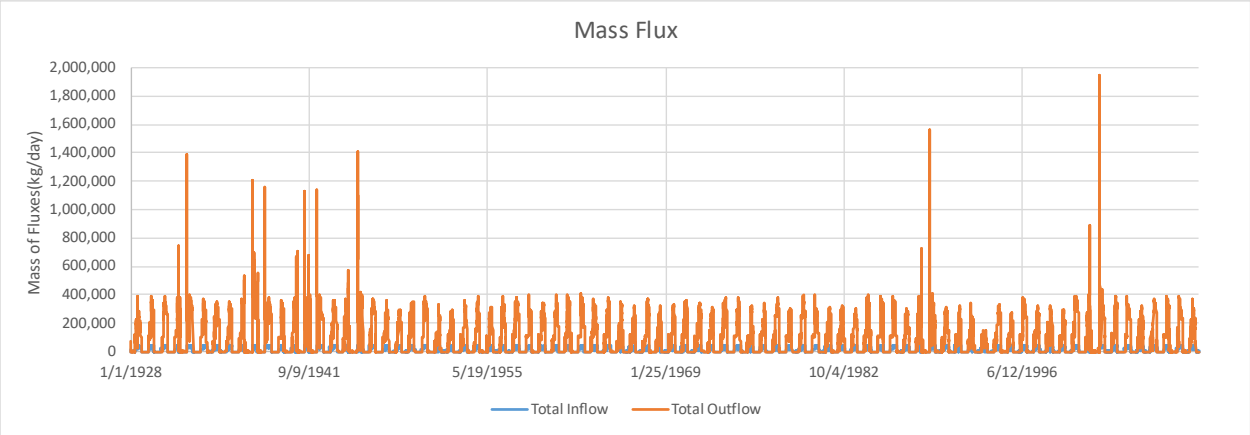


Figure 4. Modeled TSS mass flux, Base Case Footprint.

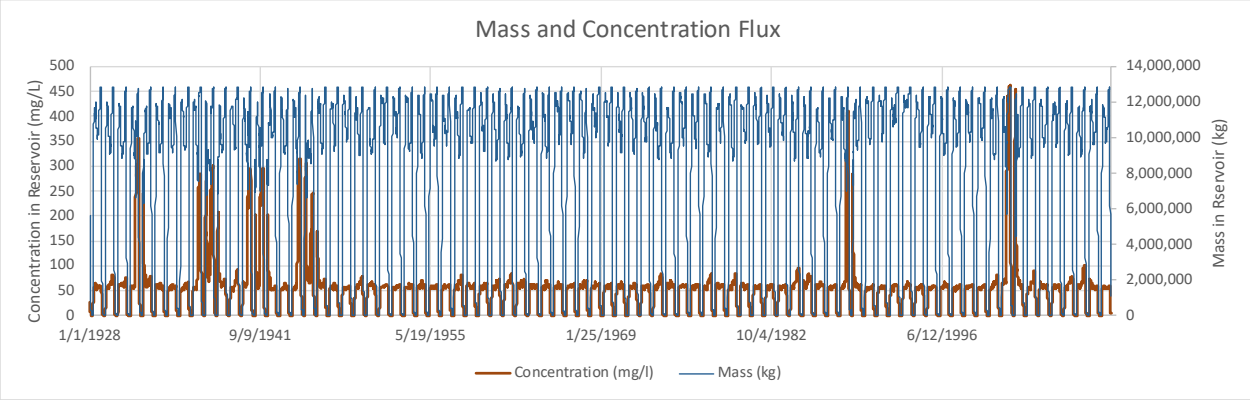


Figure 5. Modeled TSS mass and concentration flux, Base Case Footprint.

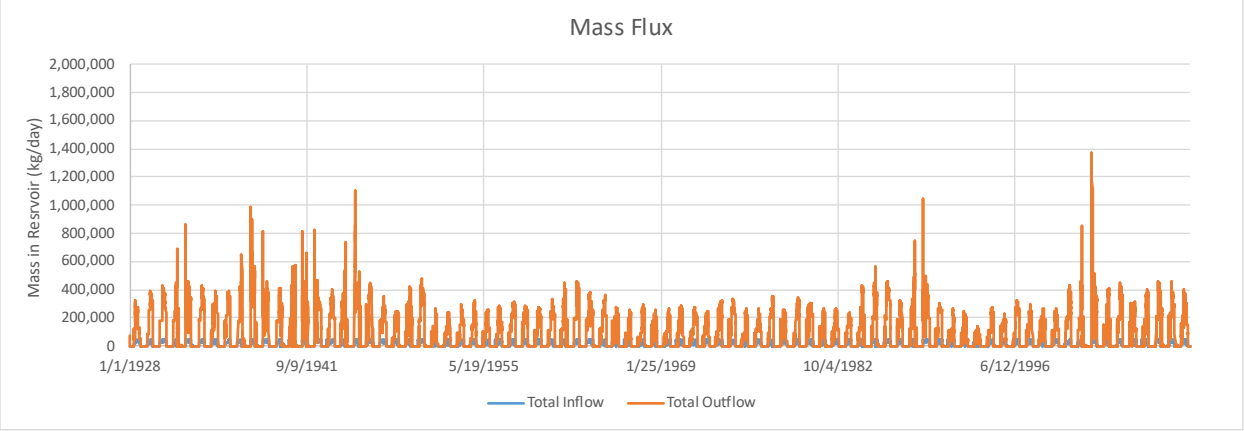


Figure 6. Modeled TSS mass flux, Project Case Footprint.

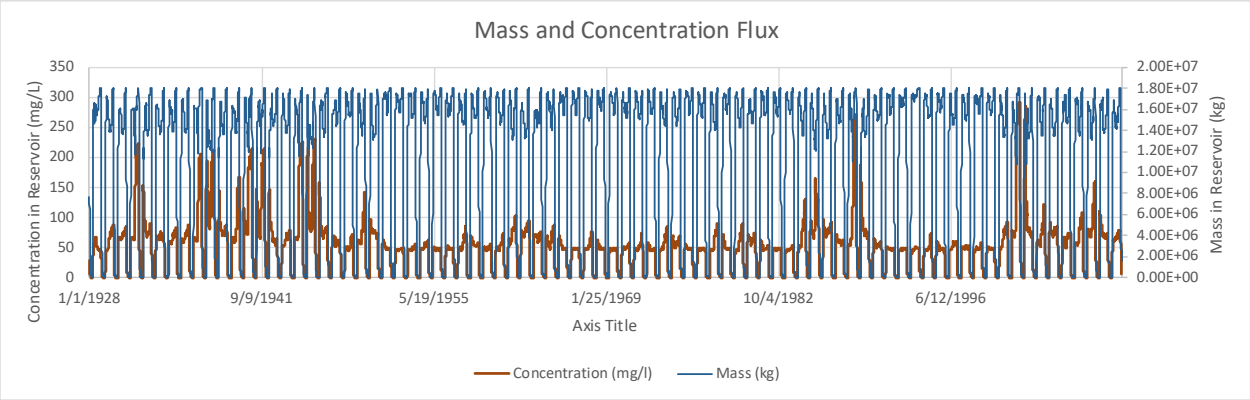


Figure 7. Modeled TSS mass and concentration flux, Project Case Footprint.

4.0 Conclusions

The settling rates and total suspended solids demonstrated by the numerical analyses and mass balance model indicate that the expansion of the Chin Reservoir from the base case to the project case is unlikely to have a large impact on the overall mass of sediment in the system. As the reservoir is expanded the shoreline erosion increases but so does the settling. There is a significant seasonal signature since erosion occurs when there is no ice cover and seasonal winds cause wind wave erosion. Settling is a process that occurs throughout the year.

5.0 References

Bishop, C.T., Donelan, M.A., and Kahma, K.K. 1988. *Shore Protection Manual's Wave Prediction Reviewed*. National Water Research Institute (Canada), Environment Canada.

Paquette, Randy. "Chin Reservoir- Data Files." Received by (Patrick Tara), April 16, 2024.

Penner, L.A. 1993. *Shore Erosion and Slumping on Western Canadian Lakes and Reservoirs, a Methodology for Estimating Future Bank Recession Rates*. JD Mollard and Associates Limited, Regina, Saskatchewan, Canada.

APPENDIX 164.1

Chin Reservoir Expansion – Adaptive Management Plan for Water Quality Technical Memorandum (INTERA 2025e)

INTERA Incorporated
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TECHNICAL MEMORANDUM

To: Jeffrey Olitch, P.Eng., PE

From: INTERA Incorporated

Date: May 30, 2025

Re: Chin Reservoir Expansion – Adaptive Management Plan for Water Quality

1.0 Introduction

INTERA, under subcontract to MPE (a division of Englobe) evaluated the benefits and risks of a potential expansion of the Chin Reservoir for the benefit of the St. Mary River Irrigation District (SMRID). The Chin Reservoir Expansion (see **Figures 1** and **2**) would increase irrigation capacity and water supply reliability within the SMRID, Taber Irrigation District (TID), and Raymond Irrigation District (RID). INTERA's analysis provides additional information to support the response to Supplemental Information Request (SIR) #1 and the project Environmental Impact Assessment (EIA).

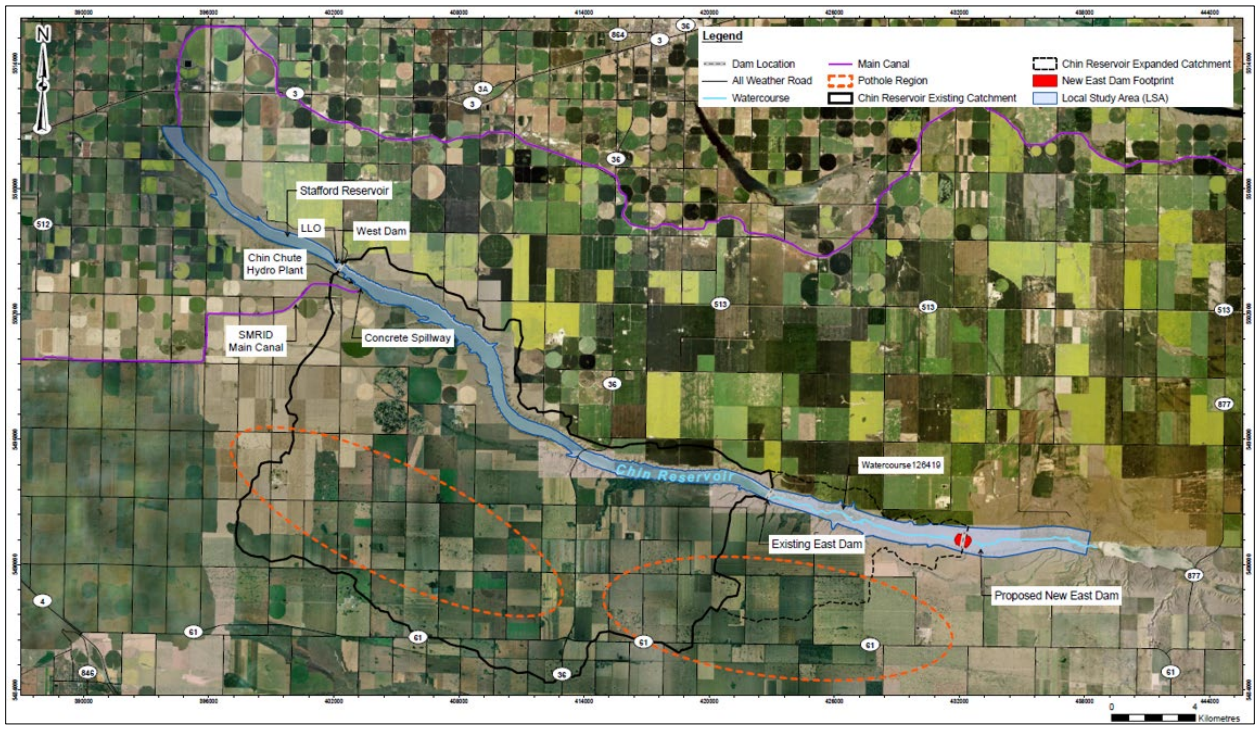
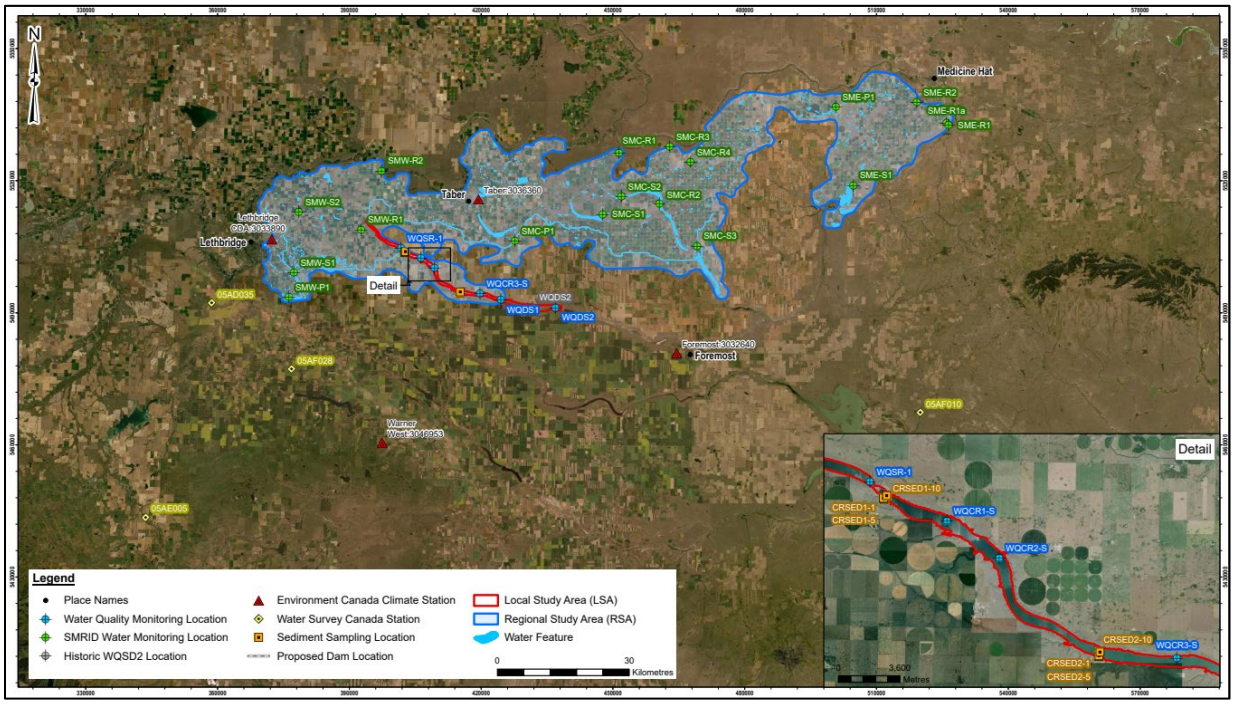


Figure 1. Chin Reservoir current and proposed expanded extent.



Note: WQDS = Water Quality Downstream; WQCR = Water Quality Chin Reservoir; WQSR = Water Quality Stafford Reservoir

Figure 2. Surface water quality stations on the Chin Reservoir and surrounding areas (WQCR sites are in the Chin Reservoir, WQDS are in the expansion area, and WQSR site is in the Stafford Reservoir)

2.0 Adaptive Management Plan

As part of the Chin Reservoir Expansion project, INTERA is proposing an Adaptive Management Plan to address potential water quality impacts. During initial filling and operation of the Reservoir Expansion Area, inundated soils may be prone to erosion, soils could leach metals or salts, and uncertainty of future climate conditions could have unforeseen impacts on the water quality of the expanded reservoir. The primary mechanism for mitigating the potential for adverse effects on water quality will be to fill the expanded portion of the reservoir in isolation from the existing reservoir. The evolution of water quality in the expanded portion of the reservoir cannot be precisely characterized through modeling; therefore, we propose monitoring to inform adaptive management and confirm that adverse effects have been avoided.

The adaptive management plan is comprised of three major components, (1) collecting data and identifying concerns, (2) working with regulators to develop a specific adaptive management plan to address the concerns, and (3) executing the proposed plan. By definition, the plan is designed to adjust future activities based on observed conditions to meet regulatory objectives.

The construction and commissioning of the Reservoir Expansion Area will follow a phased approach that includes preparing the site, constructing the New East Dam, filling the Reservoir Expansion Area, decommissioning the Existing East Dam, and finally connecting the existing and expanded portions of

the reservoir to commission. Phase one of the adaptive management plan will initiate upon the completion of the New East Dam. As water accumulates in the Reservoir Expansion Area, water quality data will be collected and reported. Phase Two will commence as water levels in the Expansion Area approach the stage identified as a target for decommissioning of the Existing East Dam at approximately El. 850 m. During this phase water quality will be measured and compared against regulatory metrics and any water quality concerns will be identified. Based on the findings, the adaptive management plan (presented in the following subsections) will be adjusted and implemented as needed to address concerns. The adapted plan will outline identified water quality concerns and the corrective measures necessary to address the concerns and maintain compliance with regulatory requirements. Finalization of the plan will occur in close coordination with regulatory authorities. Monitoring will continue through the first three years of operation following commissioning of the expanded reservoir, to confirm that the conditions of the plan have been met and that adverse effects have been avoided.

2.1 Data Collection

The water quality of the reservoir will be sampled and the results of analysis will be presented in a report. Sample collection will occur in the existing portion of the Chin Reservoir and the expanded portion of the reservoir. Sampling will continue at the existing data collection sites CR1, CR2, and CR3 so they can be compared to the new stations in the Reservoir Expansion Area: EX1, EX2, and EX3 (**Figure 3**). Collecting additional data at the existing stations will improve confidence in the average values and help identify potential trends in the background conditions of the existing reservoir. This data will be used for direct comparison to the data from the Reservoir Expansion Area. Water quality sampling will occur on a quarterly basis to characterize seasonal trends and water quality evolution as the filling process progresses. Sampling will commence once reservoir filling begins and will continue for three years after commissioning. Sampling will follow the same standard procedures used in the previous Chin Reservoir data collection efforts (Volume 4-2, Water Quality Technical Baseline Report). Field parameters (i.e., temperature, pH, EC, DO and ORP) will be measured in a depth profile at each sampling location during each sampling event. Two water samples will be collected at each sampling location during each sampling event: a shallow sample at 0.5 m below the water surface and a deep sample at 1 m above measured sediment depth. The surface water samples that are collected will be analyzed for the following parameters:

- Routine inorganic parameters including: pH, alkalinity, conductivity, hardness, total dissolved solids (TDS), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), carbonate (CO3), bicarbonate (HCO3), hydroxide (OH), chloride (Cl), sulphate (SO4), and fluoride (F).

- Nutrient parameters including: nitrate (NO2) and nitrite (NO3) as N, nitrate as N (NO3-N), nitrite as N (NO2-N), Total Kjeldahl Nitrogen (TKN), total nitrogen, dissolved orthophosphate, total phosphorus (TP), and sulphide (S).

- Dissolved metals by full ICP scan including: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), phosphorus (P), rubidium (Rb), selenium (Se), silver (Ag), strontium (Sr), sulphur (S), tellurium (Te), thallium (Tl), tin (Sn), thorium (Th), titanium (Ti), tungsten (W), uranium (U), vanadium (V), zinc (Zn) and zirconium (Zr).

- Total metals by full ICP scan including: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), phosphorus (P), rubidium (Rb), selenium (Se), silver (Ag), strontium (Sr), sulphur (S), tellurium (Te), thallium (Tl), tin (Sn), thorium (Th), titanium (Ti), tungsten (W), uranium (U), vanadium (V), zinc (Zn) and zirconium (Zr).
- Bacteriological parameters including total coliforms, total fecal coliforms, and E. coli.
- Polycyclic aromatic hydrocarbons (PAH): acenaphthene, acenaphthylene, acridine, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b&j)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, perylene, phenanthrene, pyrene, quinoline, and B(a)P Total Potency Equivalent (TPE).
- Volatile Organic Carbons (VOCs) including benzene, ethylbenzene, toluene, xylenes (BTEX) and styrene.
- Phenols.
- Total mercury and methylmercury (Me-Hg).
- Pesticides.

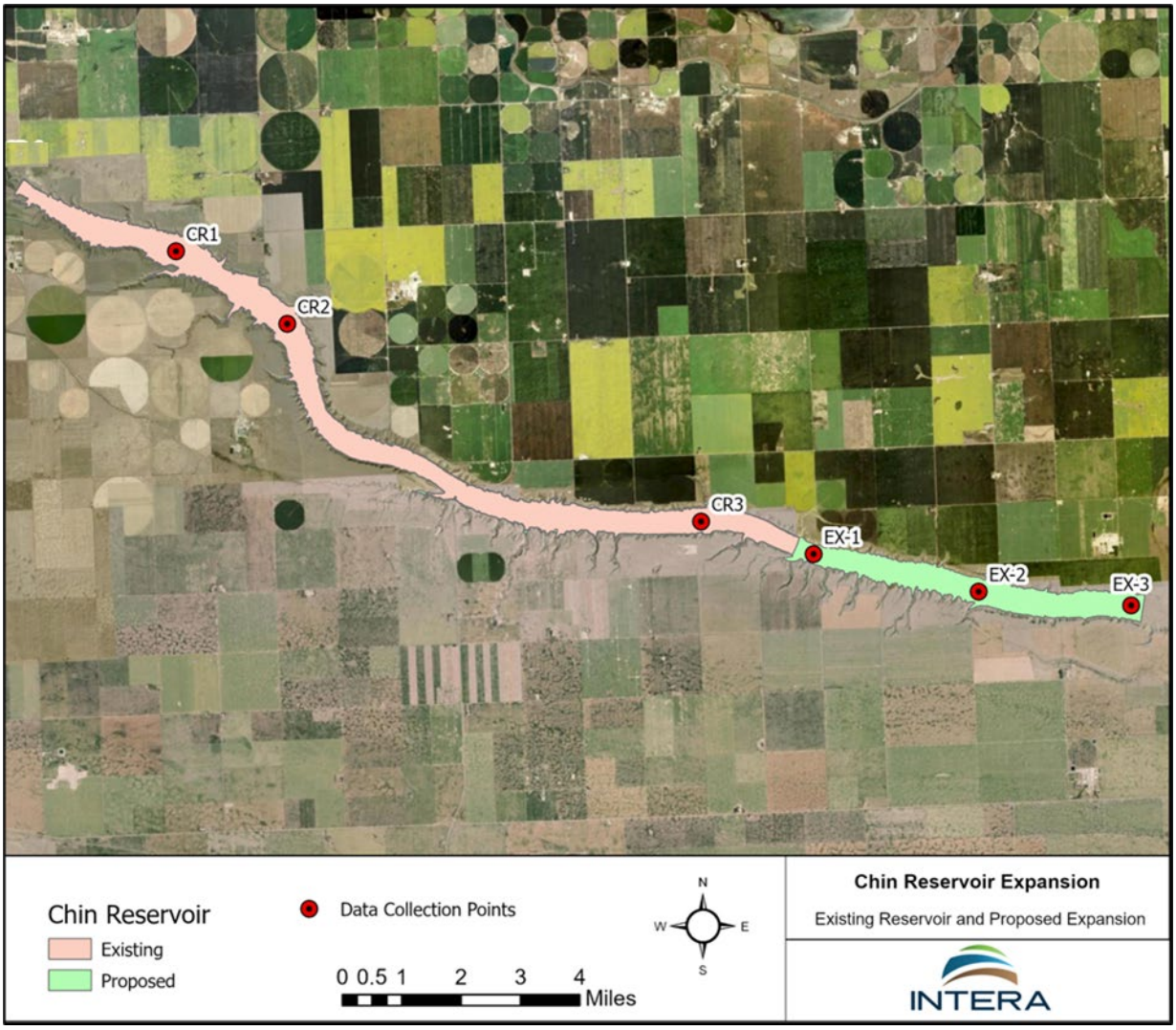


Figure 3. Water Quality Data Collection Stations.

2.2 Adaptive Management

As water quality data is collected during monitoring, the results will be assessed to detect undesirable changes. Specifically, water quality parameter concentrations that indicate undesirable trends, approach or exceed regulatory thresholds (as applicable), or greater than an agreed upon change from the baseline condition or background condition in the existing reservoir, will be flagged for further evaluation or plan adaptation.

As the filling process nears completion, INTERA will further assess parameters of concern that have not trended towards a decline in concentration. This will include assessing the potential mass balance that would be achieved through mixing of the existing and expanded portions of the reservoir. Residual

concerns that are identified may be addressed through the adaptive management plan, if required, to confirm that adverse effects will be avoided.

The Reservoir Expansion Area integration with the existing reservoir will occur in a controlled and planned manner. The water quality in the expanded portion of the Chin Reservoir can be managed using various techniques to address any water quality concerns identified, before connecting the basins. As part of the adaptive management of the reservoir expansion, three potential strategies are outlined in the following subsections that could be applied to address water quality concerns prior to commissioning the Expanded Chin Reservoir. Other options will be evaluated if the data collection identifies concerns that were not anticipated.

Monitoring will continue for the first three years of operation following commissioning to confirm that management measures, if required, have been effective. Additional adaptive management would be considered based on discussion with regulatory agencies if the results of operational monitoring identify an unanticipated concern.

2.2.1 Strategy 1: Settling Time

The simplest management option is to allow time for the filled reservoir to settle. Suspended solids, including sediment with bound constituents and organics, can settle out of suspension after the expanded portion of the reservoir has been filled. While this management approach would require no additional effort, it could extend the time needed before the expanded portion of the reservoir is considered fully operational. The multi-year filling process will naturally incorporate periods of promoted settling through ice-covered winters. As the reservoir is being filled, data collection will occur to determine if additional time for settling is warranted and if this is a viable option to address the noted concerns.

2.2.2 Strategy 2: Flocculation

Flocculation is a water treatment process used in reservoirs to reduce sediment and algal biomass (organic nutrients) by promoting the aggregation of fine particles into larger clumps or flocs, which then settle out of the water column. Essentially, flocculation accelerates the natural settling process. This process improves water clarity and reduces nutrient availability for algal growth.

Process of Flocculation in a Reservoir:

1. **Coagulant Addition** – A coagulant, such as aluminum sulfate (alum), ferric chloride, or polyaluminum chloride, is introduced into the water. These chemicals neutralize the negative charges on suspended particles, allowing them to come together. Coagulant addition can occur in the reservoir body or the inflow structure of the Reservoir Expansion Area.
2. **Flocculation** – Gentle mixing encourages the fine particles, including sediments and organic matter, to collide and form larger aggregates (flocs). In a large, well-mixed reservoir like Chin, this would presumably occur through wind activity.
3. **Sedimentation** – The larger flocs settle to the bottom of the reservoir due to gravity, removing suspended sediment and associated nutrients like phosphorus.

Flocculation, a widely used technique in drinking water reservoirs, aquaculture ponds, and stormwater retention basins, effectively improves water quality and mitigates eutrophication. It may be considered as a potential adaptive management strategy for the Chin Reservoir expansion, if further measures are deemed necessary before allowing mixing between the basins.

2.2.3 Strategy 3: Dilution

While settling time and flocculation address excess sediment and nutrients by removing suspended solids from suspension, dilution addresses other concerns such as elevated concentrations of salts or other dissolved constituents. Dilution will be an inherent component of the multi-year filling process, which will utilize the water held in the current Chin Reservoir. If concentrations of constituents of concern rise in the Reservoir Expansion Area during initial filling, such as from salt leaching from the inundated soils, introducing additional water from the existing reservoir will dilute these high concentrations.

Further dilution will occur at the time of reservoir commissioning when the Reservoir Expansion Area is allowed to mix with the existing reservoir. A component of the adaptive management plan will be to assess the anticipated concentrations at the time of mixing.

For dilution to be effective as an enhanced adaptive management strategy prior to commissioning, the water level within the Reservoir Expansion Area would need to be raised incrementally, which would require adaptation of the plan for decommissioning of the Existing East Dam.

As an example of dilution, **Figure 4** and **Figure 5** depict high and low flow rates in which the Reservoir Expansion Area is initialized at 1.0 milligrams per Liter (mg/L) and the inflow water is at 0.0 mg/L. This example shows that a 10% reduction in concentration is achievable at about one year with the higher flow rate.

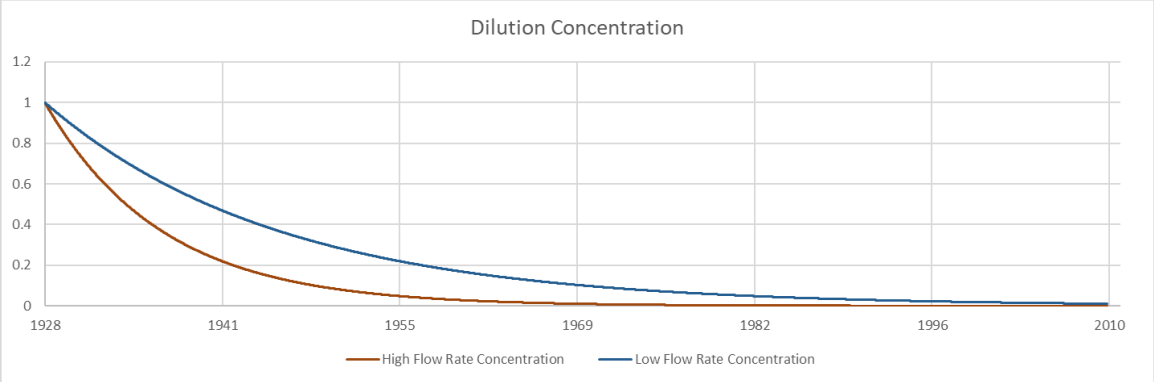


Figure 4. Comparison of dilution over time between an assumed flow rate of 8,000 and 4,000 m^3 per day.

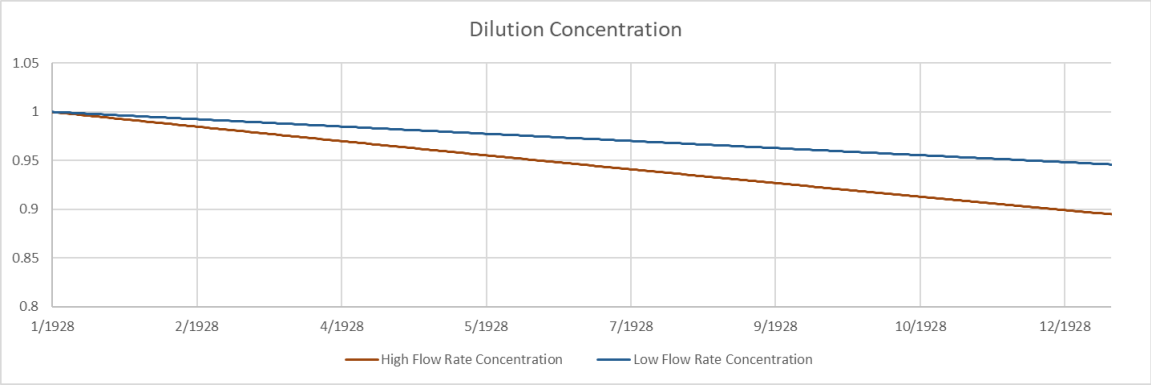


Figure 5. Comparison of dilution over a year between an assumed flow rate of 8,000 and 4,000 m^3 per day.

2.2.4 Strategy 4: Aeration

Aeration can serve as an effective adaptive management strategy for the expanded Chin Reservoir if water quality concerns are noted prior to the decommissioning of the existing dam. By increasing dissolved oxygen levels throughout the water column, aeration can help prevent stratification, reduce internal nutrient loading—particularly phosphorus release from sediments—and support the breakdown of organic matter. This, in turn, can limit conditions that favor harmful algal blooms and improve overall ecosystem health. Aeration systems, such as diffused air or surface aerators, can be strategically deployed to target specific zones where water quality issues are most pronounced. Aeration can also minimize methylation of mercury. Implementing aeration before merging the expansion with the existing reservoir offers a flexible and controllable means of maintaining water quality while the system adjusts to the new hydrologic and ecological dynamics introduced by the expansion.

2.3 Reporting

An annual report will be prepared to document the monitoring results, assessment of trends, and identified parameters of concern. This report will identify how noted concerns will continue to be monitored and any recommended adaptive management measures to be applied or changes to the plan. The annual report will be submitted to Alberta Environment and Protected Areas (EPA) and any other relevant regulatory agencies to provide an update on the adaptive management plan. Review of the submitted reports is expected to facilitate feedback, where required, on the plan and proposed activities. Additional communication will be initiated as required to support a collaborative approach for adaptive management.

3.0 Conclusions

The mass balance model that INTERA developed for the Chin Reservoir can be used to reassess predictions based on observed conditions during filling of the Reservoir Expansion Area to inform the adaptive management. The isolated multi-year filling process is the basis for adaptive management and will be applied to address water quality concerns before the Existing East Dam is decommissioned and the reservoir basins connected. Data collection and monitoring of conditions will be necessary to assess

the strategy's success quantitatively both for internal and regulatory stakeholders. Collection of these data will occur in both the existing Chin Reservoir and the Reservoir Expansion Area. The data, combined with the mass balance models, will help to select and fine-tune the management strategies to ensure that undesirable trends are detected and addressed so that the reservoir meets water quality standards set by the regulatory agencies. Data collection reports will be shared with the regulatory agencies, and any management plans will be developed with regulatory staff involvement.

APPENDIX 165.1

Summary of Analytical Results for Baseline Surface Water Quality

General			Guidelines													
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQSR1-S	WQSR1-S (D)	WQSR1-S	WQSR1-S	WQSR1-S
Date Sampled:												26-May-2021	26-May-2021	28-Jul-2021	4-Oct-2021	02-Mar-2022
Time Sampled:												10:15	10:15	14:30	12:00	15:40
ALS Sample ID:												L2593381-7	L2593381-8	L2620338-7	L2648073-8	CG2202368-005
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	0.5 m	Duplicate	0.5 m	0.5 m	0.5
Field Parameters																
Temperature		°C	-	-	-	-	-	-	-	-	-	10.32	-	20.4	12.3	1
Conductivity (EC)		uS/cm [2c]	-	-	-	-	-	-	-	-	-	300	-	248.9	236.3	837
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	11.19	-	8.72	10.01	17.02
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	7.9	-	8.6	8.6	8.45
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	93.7	-	215.1	110	200.5
Secchi Depth		m					-					0.97	-	1.15	-	-
Anions and Nutrients (Water)																
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	133	121	125	151
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	<0.050	0.0208
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	165	164	147	153	185
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<5.0	4.8
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	1.02	1.01	0.51	0.51	2.29
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	306	305	236	235	807
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.048	0.047	0.038	0.042	0.047
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	139	139	122	111	112
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	96.5	97.2	96.6	83.4	50.8
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	<0.022	<0.022	0.061	0.988
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	<0.020	<0.020	0.061	0.978
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010	0.01
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.25	0.921
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.31	1.91
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.29	8.29	8.15	8.17	8.59
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	0.0277	0.0103	0.0088	0.0121	0.0424
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	173	172	138	138	485
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	31.8	31.7	17.1	19.1	292
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015	0.0025
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	8.5
Organic / Inorganic Carbon (Water)																
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	2.4	2.5	3.5	1.7	-
Bacteriological Tests (Water)																
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		3	4	23	18	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	91	110	850	260	205
Total Metals (Water)																
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	**0.1190**	**0.1140**	**0.110**	**0.140**	**0.324**
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0001	0.0001	<0.00010	<0.00010	0.00018
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00092	0.00098	0.00096	0.00098	0.00101
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.121	0.121	0.137	0.154	0.0762
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.00010	0.000023
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	0.011	0.011	<0.010	<0.010	0.024
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000168	0.0000130	0.0000084	0.0000090	0.0000247
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	34.4	34.2	30.4	28.8	47.6
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.00018	0.00017	0.00021	0.00024	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	0.00011	0.00010	<0.00010	0.00011	0.00039
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00090	0.00087	0.00078	0.00086	0.00225
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.1410	0.1350	0.148	0.186	**0.443**
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0001	0.0001	0.000090	0.000147	0.000376
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0060	0.0060	0.0028	0.0035	0.0124
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	13.9	13.8	11.9	11.3	24.2
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0112	0.0108	0.0125	0.00983	0.11
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	0.0006	0.0006	<0.00050	0.00063	0.00169
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000718	0.000703	0.000616	0.000557	0.00115
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00068	0.00070	0.00107	0.00053	0.00168
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.26	1.24	0.750	0.656	1.66
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000283	0.000269	0.000199	0.000217	**0.00112**
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	11.20	10.90	5.58	4.64	104
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00232	0.00214	0.00256	0.00243	0.00604
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000854	0.000848	0.000566	0.000457	0.00678
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00100	0.00097	0.00176	0.00123	0.00153
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.0030	<0.0030	<0.0030	<0.0030	0.0047
Dissolved Metals (Water)																
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0011	0.0011	0.0012	0.0136	0.0029
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.00011	0.00011	<0.00010	<0.00010	0.0001
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0009	0.0008	0.00080	0.00080	0.00052
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.1130	0.1140	0.117	0.144	0.0434
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	0.011
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	33.6	34.0	29.9	27.3	25.3
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.0007	0.00055	0.00070	0.00226
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0054	0.0056	0.0034	0.0032	0.0059
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	13.4	13.2	11.4	10.5	11.9
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.0007	0.00207	0.00099	0.00713
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.0007	0.000579	0.000596	0.00067
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0005	0.0005	<0.00050	<0.00050	0.00072
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.1900	1.1900	0.702	0.608	0.852
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.0003	0.000199	0.000230	0.000693
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	10.8000	10.8000	5.46	4.59	55.7
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	0.00029
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.0008	0.000467	0.000441	0.0033
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	<0.00050	0.00060	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0010	0.0015	0.0014
Speciated Metals (Water)																
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	0.000035	0.000030	0.000051	0.000035	0.000248
Aggregate Organics (Water)																
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	<0.0010	0.0012	<0.0010	**0.0081**
Volatile Organic Compounds (Water)																
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00052
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00071	<0.00092
Polycyclic Aromatic Hydrocarbons (Water)																
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	0.011
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	0.02
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines									Analytical Results				
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQCR1-S	WQCR1-S	WQCR1-S (D)	WQCR1-S	WQCR1-S
Date Sampled:												25-May-2021	28-Jul-2021	28-Jul-2021	5-Oct-2021	02-Mar-2022
Time Sampled:												14:25	11:25	12:00	9:23	13:45
ALS Sample ID:												L2593381-1	L2620338-5	L2620338-10	L2648073-1	CG2202368-003
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	0.5 m	0.5 m	Duplicate	0.5 m	0.5 m
Field Parameters																
Temperature		°C	-	-	-	-	-	-	-	-	-	10.61	20.4	-	13.2	1.8
Conductivity (EC)		uS/cm [°C]	-	-	-	-	-	-	-	-	-	298	263.4	-	224.9	201.2
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	10.95	8.44	-	9.61	13.69
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	7.68	8.67	-	8.72	8.39
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	104	178.5	-	227.8	184.5
Secchi Depth		m					-					1.85	3	-	2.1	4.52
Anions and Nutrients (Water)																
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	122	121	129	133
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.0050
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	162	149	147	157	156
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0		<5.0	<5.0	2.8
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	0.93	0.59	0.59	0.61	0.72
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	292	251	250	212	268
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.047	0.039	0.039	0.047	0.04
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	134	129	132	116	129
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	95.4	99.7	103	86.8	93.3
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	<0.022	<0.022	<0.022	<0.0500
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	0.28	<0.20	<0.20	0.45	0.116
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	0.28	<0.20	<0.20	0.45	0.116
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.24	8.21	8.11	8.06	8.36
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	0.0053	0.0067	0.0044
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	166	145	147	190	156
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	28.6	20.4	20.9	17.2	21.7
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0
Organic / Inorganic Carbon (Water)																
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	3.4	2.4	3.4	1.8	-
Bacteriological Tests (Water)																
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		<1	2	1	28	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	56	79	62	110	<1
Total Metals (Water)																
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	0.0413	0.0490	0.0350	0.0409	0.0232
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0001	0.00013	<0.00010	<0.00010	0.00011
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00068	0.00084	0.00081	0.00095	0.00074
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.105	0.132	0.123	0.136	0.115
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	<0.01	<0.010	0.010	<0.010	0.012
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000095	0.0000056	0.0000054	<0.0000050	<0.0000050
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	31.7	32.7	30.9	29.6	33.4
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	<0.0001	0.00014	0.00011	0.00011	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00081	0.00073	0.00069	0.00075	0.0009
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.0500	0.044	0.037	0.055	0.024
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.00005	<0.000050	<0.000050	0.000079	<0.000050
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0051	0.0030	0.0031	0.0037	0.0046
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.7	12.6	11.9	11.4	12.7
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0064	0.00387	0.00366	0.00452	0.00145
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	<0.00050	<0.00050	<0.00050	<0.00050	<0.002
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000719	0.000656	0.000611	0.000667	0.00473
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00058	0.00108	0.00104	0.00052	<0.00050
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.14	0.829	0.783	0.728	0.934
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000259	0.000224	0.000210	0.000199	0.000274
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.61	6.54	6.40	5.25	7.36
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00099	0.00126	0.00097	0.00094	0.00044
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000754	0.000631	0.000576	0.000448	0.000674
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00076	0.00154	0.00124	0.00102	0.00077
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.0030	<0.0030	<0.0030	0.0038	<0.0030
Dissolved Metals (Water)																
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0011	0.0012	0.0013	<0.0010	0.0014
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00075	0.00077	0.00089	0.00065
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.1050	0.119	0.118	0.131	0.111
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	0.01
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.0000051	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	32.8	31.2	32.6	28.2	32.2
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00061	0.00063	0.00060	0.00079
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0051	0.0039	0.0041	0.0034	0.0044
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.7	12.4	12.4	11.0	11.9
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0004	0.00066	0.00063	0.00027	<0.00500
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000635	0.000651	0.000607	0.00429
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0006	<0.00050	0.00056	<0.00050	<0.00050
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.15	0.794	0.815	0.715	0.888
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.000200	0.000235	0.000231	0.0003
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.6	6.41	6.56	5.31	7.19
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000515	0.000523	0.000456	0.000635
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00062	0.00062	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0015	<0.0010	<0.0010	0.0017	<0.0010
Speciated Metals (Water)																
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	0.000020	0.000023	0.000022	0.000021	<0.000020
Aggregate Organics (Water)																
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	<0.0010	0.0017	<0.0010	**0.0068**
Volatile Organic Compounds (Water)																
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00071	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)																
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines												
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQCR1-D	WQCR1-D	WQCR1-D	WQCR1-D
Date Sampled:												25-May-2021	28-Jul-2021	5-Oct-2021	02-Mar-2022
Time Sampled:												14:48	12:10	9:55	13:08
ALS Sample ID:												L2593381-2	L2620338-6	L2648073-2	CG2202368-004
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	20 m	14 m	17 m	17 m
Field Parameters															
Temperature		°C	-	-	-	-	-	-	-	-	-	9.94	15.5	12.5	3
Conductivity (EC)		uS/cm[°C]	-	-	-	-	-	-	-	-	-	299	303.1	217	246.7
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	10.68	1.78	9.44	2.25
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	7.7	7.66	8.21	7.34
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	1017	188.2	237.3	217.5
Secchi Depth		m					-					-	-	-	-
Anions and Nutrients (Water)															
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	137	125	138
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	0.0422
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	160	168	152	169
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	0.93	0.83	0.55	0.89
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	295	287	221	296
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.048	0.045	0.047	0.043
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	132	145	113	144
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	94.7	98.9	86.9	99.1
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	0.027	0.036	0.088
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	0.027	0.036	0.088
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.152
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.24
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.27	8.13	8.01	8.22
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	0.0163	0.0098	0.007
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	163	169	134	174
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	28.7	26.9	15.0	25
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0
Organic / Inorganic Carbon (Water)															
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	2.7	3.3	1.6	-
Bacteriological Tests (Water)															
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		<1	194	91	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	5	370	390	4
Total Metals (Water)															
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	**0.1050**	**0.174**	0.0905	**0.104**
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0001	0.00012	<0.00010	0.00011
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00082	0.00184	0.00087	0.00067
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.106	0.129	0.144	0.119
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	0.010	0.011	<0.010	0.01
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000290	0.0000179	<0.0000050	0.0000112
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	32.2	36.9	28.8	36
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.00024	0.00030	0.00018	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.00010	0.00015	<0.00010	<0.00010
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00110	0.00101	0.00070	0.00095
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.1340	0.234	0.107	0.139
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0001	0.000098	0.000083	0.000058
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0052	0.0039	0.0034	0.0046
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.8	13.8	11.0	13
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0156	0.124	0.00771	0.0622
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	<0.00050	0.00052	<0.00050	<0.00050
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000720	0.000742	0.000584	0.000804
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00081	0.00166	<0.00050	0.00074
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.22	1.08	0.646	1.02
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000283	0.000272	0.000195	0.000275
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.89	9.16	4.29	8.4
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	0.000012	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00268	0.00432	0.00151	0.00154
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000774	0.000724	0.000425	0.000741
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00094	0.00201	0.00106	0.00102
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	0.0060	<0.0030	<0.0030	<0.0030
Dissolved Metals (Water)															
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0012	<0.0010	0.0011	0.0017
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00167	0.00085	0.00059
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.1030	0.112	0.140	0.118
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.0000061	<0.0000050	<0.0000050	0.0000075
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	31.7	36.2	27.6	35.6
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00070	0.00054	0.00081
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0049	0.0045	0.0034	0.0048
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.8	13.2	10.6	13.3
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0039	0.00069	0.00062	0.0514
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000749	0.000608	0.000786
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0006	0.00068	<0.00050	0.0006
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.14	1.01	0.627	1.04
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.000246	0.000240	0.000259
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.5	8.84	4.30	8.72
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000587	0.000443	0.000698
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00067	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010
Speciated Metals (Water)															
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	0.000030	0.000037	0.000028	<0.000020
Aggregate Organics (Water)															
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	0.0020	<0.0010	**0.0075**
Volatile Organic Compounds (Water)															
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)															
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines													
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQCR2-S	WQCR2-S	WQCR2-S	WQCR2-S	WQCR2-S (D)
Date Sampled:												25-May-2021	28-Jul-2021	5-Oct-2021	02-Mar-2022	02-Mar-2022
Time Sampled:												12:45	10:00	11:40	10:20	10:50
ALS Sample ID:												L2593381-3	L2620338-3	L2648073-3	CG2202368-001	CG2202368-006
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	0.5 m	0.5 m	0.5 m	0.5 m	Duplicate
Field Parameters																
Temperature		°C	-	-	-	-	-	-	-	-	-	10.4	20.4	13.3	1.7	-
Conductivity (EC)		uS/cm [°C]	-	-	-	-	-	-	-	-	-	299	287	231.7	177.3	-
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	10.9	8.26	9.49	15.24	-
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	7.81	8.67	8.81	8.08	-
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	86	175.2	163.1	263	-
Secchi Depth		m					-					1.52	3.2	2.17	6.26	-
Anions and Nutrients (Water)																
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	136	130	129	127
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	<0.0050	<0.0050
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	163	166	158	152	148
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	2.5	3
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	0.95	0.74	1.03	0.68	0.67
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	295	274	237	260	265
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.050	0.043	0.048	0.04	0.038
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	136	139	118	128	130
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	95.5	95.8	87.3	95.7	98
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	<0.022	<0.022	<0.0500	<0.0500
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.106	0.084
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.106	0.084
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.27	8.22	8.24	8.36	8.39
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	-	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	0.0065	0.004	0.0049
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	168	165	145	152	151
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	29.6	26.2	18.9	20.7	20.4
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0
Organic / Inorganic Carbon (Water)																
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	2.5	2.8	1.7	-	-
Bacteriological Tests (Water)																
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		<1	3	11	<1	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	5	69	66	<1	<1
Total Metals (Water)																
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	0.0523	0.0385	0.0495	0.0176	0.016
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0001	0.00020	0.00011	0.00011	0.00011
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00073	0.00079	0.00092	0.00072	0.00074
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.105	0.126	0.135	0.111	0.112
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.000020	<0.000020
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	0.011	0.010	<0.010	0.014	<0.010
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000115	0.0000065	0.0000062	<0.0000050	<0.0000050
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	33.6	35.3	30.6	31.6	32.4
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.00011	0.00012	0.00013	<0.00050	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00087	0.00079	0.00075	0.00082	0.00075
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.0640	0.038	0.062	0.016	0.016
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0001	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0054	0.0037	0.0041	0.0044	0.0043
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	13.3	13.3	11.3	11.8	12.2
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0056	0.00318	0.00446	0.00103	0.00102
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000744	0.000700	0.000688	0.00074	0.000718
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00066	0.00100	<0.00050	<0.00050	<0.00050
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.22	0.972	0.781	0.879	0.889
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000302	0.000246	0.000228	0.000262	0.000251
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	10.20	8.17	5.65	6.7	6.94
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00121	0.00112	0.00123	0.00046	<0.00030
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000793	0.000729	0.000481	0.00063	0.000653
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00074	0.00141	0.00096	0.00072	0.00071
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals (Water)																
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0010	0.0014	<0.0010	0.0017	0.0012
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00071	0.00086	0.00067	0.00075
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.1010	0.113	0.126	0.114	0.115
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.000020	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.0000068	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	33.2	33.7	29.0	31.7	32
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00050	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.00072	0.00064	0.00078	0.00076
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.030	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0052	0.0046	0.0038	0.0041	0.0042
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.8	13.2	11.1	12	12.1
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.00052	0.00023	<0.00500	<0.00500
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.000685	0.000629	0.000704	0.0008
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0006	<0.00050	<0.00050	<0.00050	<0.00050
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.18	0.956	0.763	0.913	0.912
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.000248	0.000221	0.00025	0.000284
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.8	8.25	5.75	7.19	7.05
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.000619	0.000464	0.000616	0.000599
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00062	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0010	0.0011	<0.0010
Speciated Metals (Water)																
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	<0.000020	0.000020	0.000030	<0.000020	<0.000020
Aggregate Organics (Water)																
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	0.0013	<0.0010	**0.0074**	**0.0081**
Volatile Organic Compounds (Water)																
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00050	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)																
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.010	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.010	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.0050	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.010	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.050	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.010	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines												
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQCR2-D	WQCR2-D	WQCR2-D	WQCR2-D
Date Sampled:												25-May-2021	28-Jul-2021	5-Oct-2021	02-Mar-2022
Time Sampled:												13:05	10:30	12:00	09:40
ALS Sample ID:												L2593381-4	L2620338-4	L2648073-4	CG2202368-002
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	19 m	13 m	16 m	16 m
Field Parameters															
Temperature		°C	-	-	-	-	-	-	-	-	-	10.04	15.1	13.3	3.2
Conductivity (EC)		uS/cm [°C]	-	-	-	-	-	-	-	-	-	301	306.6	235.1	241.6
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	10.63	1.16	9.25	4.58
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	7.84	7.65	8.38	7.17
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	83.4	198.7	-	267.7
Secchi Depth		m					-					-	-	-	-
Anions and Nutrients (Water)															
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	137	129	147
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	0.0179
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	162	167	158	179
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	0.95	0.85	0.71	0.92
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	296	291	247	303
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.049	0.047	0.049	0.043
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	135	142	121	150
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	96.0	97.5	89.2	98.3
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	0.028	<0.022	0.138
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	0.028	<0.020	0.138
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	0.23	<0.20	0.298
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	0.26	<0.20	0.436
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.27	8.09	8.09	8.14
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	0.0141	0.0067	0.008
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	167	169	147	187
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	29.5	27.5	20.7	26.9
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0
Organic / Inorganic Carbon (Water)															
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	2.3	2.1	1.7	-
Bacteriological Tests (Water)															
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		1	*267*	4	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	3	690	100	3
Total Metals (Water)															
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	0.0965	**0.188**	0.0550	**0.109**
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0001	0.00016	0.00010	0.00012
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00076	0.00241	0.00098	0.00064
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.105	0.133	0.129	0.123
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	5	5	0.010	0.011	<0.010	0.012
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000115	0.0000265	0.0000054	0.0000151
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	33.6	37.3	31.5	37.3
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.00020	0.00029	0.00014	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.00010	0.00027	<0.00010	<0.00010
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00097	0.00100	0.00086	0.001
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.1250	0.245	0.069	0.145
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0001	0.000091	<0.000050	0.00006
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0053	0.0039	0.0041	0.0052
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	13.2	13.8	12.0	13.5
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0086	0.513	0.00521	0.0662
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	<0.00050	0.00056	<0.00050	0.0005
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000731	0.000894	0.000725	0.000851
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00081	0.00191	0.00059	0.00087
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.23	1.08	0.843	1.06
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000335	0.000232	0.000216	0.000248
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	10.10	9.07	6.56	9.3
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00268	0.00386	0.00126	0.00196
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000783	0.000706	0.000513	0.00075
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00089	0.00203	0.00108	0.00104
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals (Water)															
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0010	<0.0010	<0.0010	0.0012
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	0.00011
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00208	0.00091	0.00054
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.1000	0.115	0.123	0.127
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.0000055	0.0000159	<0.0000050	0.0000094
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	33.1	34.7	29.4	36.2
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	0.00013	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00068	0.00069	0.00088
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0052	0.0044	0.0039	0.0049
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.8	13.4	11.5	14.5
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0006	0.391	0.00031	0.0563
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.000855	0.000667	0.000861
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0006	0.00095	<0.00050	0.00078
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.19	1.03	0.823	1.19
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.000251	0.000250	0.000376
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.9	9.02	6.45	10.3
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000599	0.000507	0.0005
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00074	0.00051	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0015	0.0012	<0.0010	0.0026
Speciated Metals (Water)															
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	0.000020	0.000123	<0.000020	<0.000020
Aggregate Organics (Water)															
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	0.0012	<0.0010	**0.0056**
Volatile Organic Compounds (Water)															
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)															
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines												
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQCR3-D	WQCR3-D	WQCR3-D	WQCR3-D
Date Sampled:												25-May-2021	28-Jul-2021	5-Oct-2021	01-Mar-2022
Time Sampled:												10:20	8:40	12:00	13:00
ALS Sample ID:												L2593381-6	L2620338-2	L2648073-6	CG2202300-002
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	13 m	7 m	10 m	10 m
Field Parameters															
Temperature		°C	-	-	-	-	-	-	-	-	-	10.82	20.4	12.8	3
Conductivity (EC)		uS/cm [1c]	-	-	-	-	-	-	-	-	-	296	315.1	280.9	175.1
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	10.52	8.01	9.25	12.92
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	7.92	8.47	8.34	8.62
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	38.6	208.1	119.2	180.9
Secchi Depth		m					-					-	-	-	-
Anions and Nutrients (Water)															
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	139	148	140
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	<0.0050
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	159	169	181	170
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	0.89	0.94	1.04	0.88
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	291	302	293	299
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.049	0.049	0.059	0.047
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	133	151	139	147
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	95.9	100	88.7	99.7
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	<0.022	<0.022	<0.0500
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	<0.020	<0.020	0.032
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.135
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.167
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.30	8.25	8.16	8.2
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	0.0052	0.0063	0.0064
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	162	180	179	175
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	27.5	32.8	31.1	26.3
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0
Organic / Inorganic Carbon (Water)															
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	2.5	3.7	2.4	-
Bacteriological Tests (Water)															
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		<1	*228*	7	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	11	610	62	10
Total Metals (Water)															
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	0.0822	0.0972	0.0618	0.0369
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0001	0.00010	0.00014	0.0001
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00073	0.00074	0.00071	0.00069
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.095	0.113	0.112	0.106
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	0.010	0.011	0.013	0.012
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000114	0.0000110	0.0000092	0.0000089
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	32.4	37.7	38.6	34.8
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.00017	0.00019	0.00017	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00096	0.00105	0.00105	0.00098
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.0980	0.090	0.074	0.03
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0001	0.000053	0.000053	<0.000050
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0050	0.0045	0.0058	0.0049
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.8	14.1	13.4	13
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0056	0.0106	0.00494	0.00274
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	<0.00050	<0.00050	0.00052	<0.00050
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000743	0.000809	0.000950	0.00452
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00071	0.00141	0.00073	0.00058
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.21	1.17	1.13	1
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000272	0.000285	0.000321	0.000252
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.56	10.3	10.1	9.08
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00192	0.00271	0.00136	0.00094
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000744	0.000889	0.000772	0.00074
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00075	0.00213	0.00106	0.00075
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals (Water)															
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0016	0.0017	0.0011	<0.0010
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	0.00010	0.00012	0.0001
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.00062	0.00066	0.00063
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0924	0.106	0.106	0.105
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	0.010	0.010	0.01
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.0000075	<0.0000050	<0.0000050	0.0000058
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	33.0	37.6	34.2	36.8
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.00087	0.00086	0.00086
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0050	0.0048	0.0061	0.0053
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.2	13.9	13.0	13.5
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0002	0.00047	0.00025	<0.00500
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000835	0.000844	0.000796
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0006	0.00064	0.00058	0.00054
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.18	1.13	1.10	1
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.000312	0.000282	0.000285
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.1	10.1	9.87	8.9
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000745	0.000686	0.000688
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00059	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0015	0.0012	<0.0010	0.0012
Speciated Metals (Water)															
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	<0.000020	0.000029	<0.000020	<0.000020
Aggregate Organics (Water)															
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	0.0011	<0.0010	**0.0113**
Volatile Organic Compounds (Water)															
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)															
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines									WQCR3-S	WQCR3-S	WQCR3-S	WQCR3-S (D)	WQCR3-S
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQCR3-S	WQCR3-S	WQCR3-S	WQCR3-S (D)	WQCR3-S
Date Sampled:												25-May-2021	28-Jul-2021	5-Oct-2021	5-Oct-2021	01-Mar-2022
Time Sampled:												9:55	7:55	12:00	12:00	13:35
ALS Sample ID:												L2593381-5	L2620338-1	L2648073-5	L2648073-7	CG2202300-001
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	0.5 m	0.5 m	0.5 m	Duplicate	0.5 m
Field Parameters																
Temperature		°C	-	-	-	-	-	-	-	-	-	10.98	20.6	13.1		2.1
Conductivity (EC)		uS/cm [°C]	-	-	-	-	-	-	-	-	-	295	314.8	280.6		148.7
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	10.7	8.13	9.48		14.77
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.08	8.55	8.73		8.83
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	8	202.9	93.5		141.7
Secchi Depth		m					-					1.4	2.4	2.05		1.98
Anions and Nutrients (Water)																
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	133	140	146	147	130
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.0050
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	162	170	178	180	159
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<5.0	<1.0
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	0.90	0.94	1.07	1.03	0.75
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	289	300	290	295	274
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	0.050	0.050	0.059	0.058	0.043
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	134	151	136	136	125
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	95.7	99.3	88.1	85.4	91.8
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.022	<0.022	<0.022	<0.022	<0.0500
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.010	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.26	0.096
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	<0.20	<0.20	<0.20	0.26	0.096
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.29	8.24	8.17	8.27	8.22
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	0.0065	0.0055	0.004
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	164	180	177	182	152
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	27.3	32.8	31.1	35.5	21.6
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0
Organic / Inorganic Carbon (Water)																
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	2.4	4.1	2.3	2.1	-
Bacteriological Tests (Water)																
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		2	46	7	10	<1
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	10	81	70	46	30
Total Metals (Water)																
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	0.0595	0.0636	0.0657	0.0640	0.0777
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0001	<0.00010	0.00012	0.00013	<0.00010
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.00073	0.00078	0.00075	0.00079	0.00068
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.094	0.114	0.113	0.113	0.103
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	0.010	0.011	0.011	0.011	<0.010
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.0000131	0.0000107	0.0000069	0.0000091	<0.0000050
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	33.2	38.0	35.5	34.8	31.9
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	0.00013	0.00020	0.00015	0.00014	<0.00050
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	0.00097	0.00102	0.00107	0.00105	0.00082
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.0740	0.058	0.075	0.074	0.055
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0001	<0.000050	0.000055	<0.000050	<0.000050
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.0052	0.0046	0.0049	0.0050	0.0042
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.9	14.3	13.3	13.3	11.8
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0054	0.00709	0.00437	0.00446	0.00298
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.000731	0.000819	0.000847	0.000848	0.000715
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.00070	0.00136	0.00074	0.00079	0.00051
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.22	1.16	1.12	1.13	0.873
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.000318	0.000275	0.000269	0.000303	0.000213
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.49	10.4	9.93	9.92	7.23
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.00140	0.00203	0.00143	0.00120	0.00162
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.000739	0.000841	0.000689	0.000688	0.000637
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00069	0.00204	0.00097	0.00102	0.00078
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.0030	<0.0030	<0.0030	0.0058	<0.0030
Dissolved Metals (Water)																
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.0019	0.0019	0.0018	0.0020	0.002
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	0.00012	0.00012	0.00012
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0006	0.00063	0.00067	0.00067	0.00076
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0920	0.105	0.105	0.107	0.105
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	0.011	<0.010	0.01	<0.010
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.0000092	0.0000079	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	33.1	37.2	33.1	33.3	31.2
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.00020	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.00086	0.00097	0.00094	0.00076
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.030
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0050	0.0049	0.0056	0.0058	0.0048
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	12.5	14.0	12.9	12.9	11.4
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.00045	0.00023	0.00025	<0.00500
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0008	0.000765	0.000839	0.000829	0.000742
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0006	0.00059	0.00059	0.00056	<0.00050
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	1.18	1.13	1.11	1.11	0.881
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.0003	0.000305	0.000300	0.000314	0.000271
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	9.2	10.0	9.80	9.79	6.85
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0007	0.000722	0.000670	0.000667	0.000618
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00064	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0021	0.0012	0.0011	0.0016	<0.0010
Speciated Metals (Water)																
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Aggregate Organics (Water)																
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	<0.0010	<0.0010	<0.0010	<0.0010	**0.0107**
Volatile Organic Compounds (Water)																
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	<0.00071	<0.00071	<0.00071
Polycyclic Aromatic Hydrocarbons (Water)																
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines												
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQDS-1	WQDS-1	WQDS-1	WQDS-1
Date Sampled:												26-May-2021	28-Jul-2021	28-Sep-2021	01-Mar-2022
Time Sampled:												15:45	17:50	12:30	10:58
ALS Sample ID:												L2593744-1	L2620338-8	L2645097-1	CG2202300-003
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	Surface Water	Surface Water	Surface Water	Surface Water
Field Parameters															
Temperature		°C	-	-	-	-	-	-	-	-	-	16.56	26.1	15.4	3
Conductivity (EC)		uS/cm [7c]	-	-	-	-	-	-	-	-	-	5421	7789	9506	273.3
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	12.38	15	7.96	11.21
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.52	**9.78**	8.54	8.88
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	90.4	104.9	235.2	124.8
Secchi Depth		m					-					-	-	-	-
Anions and Nutrients (Water)															
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	410	242	353	109
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	<0.050	**0.062**	**0.50**	**0.229**
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	452	112	384	133
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	24	90.2	37.4	<1.0
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	12.1	22.9	33	2.77
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	5370	7380	9390	410
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	<0.20	<0.10	<0.40	0.05
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	1390	1870	2470	97.1
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	96.4	99.6	98.7	83.7
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.22	<0.11	<0.45	0.05
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.20	<0.10	<0.40	0.05
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	<0.10	<0.050	<0.20	<0.010
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	1.84	3.99	3.33	3.42
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	1.84	3.99	3.33	3.47
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	8.60	**9.57**	8.58	7.97
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	0.108	0.385	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	0.0394	0.181	0.526	0.762
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	4440	6390	8640	262
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	2890	4360	5880	103
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	0.0058	0.0080	0.0174	0.0186
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	<2.0	12.4		6.4
Organic / Inorganic Carbon (Water)															
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	27.1	39.0	220	-
Bacteriological Tests (Water)															
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		13	<2	<5	70
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	1700	160000	2400	2490
Total Metals (Water)															
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	**0.174**	**0.435**	**0.359**	**6.37**
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	0.0015	<0.0020	<0.00050
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	0.0032	**0.0251**	**0.0361**	**0.00606**
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0485	0.0518	0.0660	0.124
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.0010	<0.0010	<0.0020	0.000335
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	0.25	0.38	0.44	<0.050
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.000196	<0.000050	<0.00010	0.000247
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	170	154	201	29
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	<0.0010	<0.0010	<0.0020	0.00817
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	<0.0010	0.0010	<0.0020	0.00422
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	<0.0050	**0.0055**	<0.010	**0.0177**
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	0.26	**0.46**	**0.50**	**8.06**
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	<0.00050	<0.00050	<0.0010	0.00476
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.193	0.278	0.383	0.0162
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	255	426	522	17.1
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	0.0475	0.0376	0.334	0.226
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	<0.0000050	<0.0000050	<0.0000050	0.0000087
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	0.00131	0.00051	0.00144	0.0124
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.00372	0.00641	0.0048	0.00215
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	0.0052	**0.0102**	<0.010	**0.0128**
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	10.1	25.5	27.3	11.5
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	0.00052	0.00089	<0.0010	0.000492
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	<0.00010	<0.00010	<0.00020	0.00007
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	906	1550	2020	42.2
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	<0.00010	<0.00010	<0.00020	0.000107
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0020	<0.00050
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.0055	0.0154	0.0127	0.099
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	***0.0402***	**0.0307**	**0.0266**	0.00401
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	<0.0050	0.0099	<0.010	0.0179
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	<0.030	<0.030	<0.060	**0.0346**
Dissolved Metals (Water)															
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.020	0.0235
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	0.0011	<0.0020	<0.00050
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0028	0.0207	0.0325	0.00293
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0476	0.0365	0.0522	0.0318
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0020	<0.000100
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	0.22	0.34	0.41	<0.050
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.00010	0.0000284
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	163	138	189	20.4
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0020	<0.00250
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0020	0.00053
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0025	0.0033	<0.0040	0.0051
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	<0.10	<0.10	<0.20	<0.150
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	<0.00050	<0.0010	<0.000250
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.176	0.271	0.329	0.0084
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	239	371	485	11.2
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0388	0.0061	0.247	0.0367
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	<0.0000050	0.0000065
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.00365	0.00519	0.0042	0.00191
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0050	0.0058	<0.010	0.00268
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	10.3	22.0	25.1	10
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.00071	0.0011	0.000308
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00020	<0.000050
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	878	1330	1820	34
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	<0.00010	<0.00020	<0.000050
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0020	<0.00050
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	<0.0030	<0.0030	<0.0060	0.00857
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.0426	0.0213	0.0245	0.00286
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.010	0.00294
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.020	<0.0050
Speciated Metals (Water)															
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	0.000083	0.000136	0.000423	0.00018
Aggregate Organics (Water)															
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	-	0.0017	<0.0010	**0.0097**
Volatile Organic Compounds (Water)															
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	-	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	-	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	-	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	-	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	-	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)															
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

General			Guidelines												
Sample ID:			Alberta Surface Water Quality Guidelines					CCME Guidelines				WQDS-2	WQDS-2	WQDS-2	WQDS-2
Date Sampled:												26-May-2021	28-Jul-2021	28-Sep-2021	01-Mar-2022
Time Sampled:												17:30	18:15	13:35	08:52
ALS Sample ID:												L2593744-2	L2620338-9	L2645097-2	CG2202300-004
Parameter	**Lowest Detection Limit**	**Units**	**Freshwater Aquatics - Chronic [1a]**	**Freshwater Aquatics - Acute [1b]**	**Irrigation [1c]**	**Livestock [1d]**	**Recreation and Aesthetics [1e]**	**Freshwater Aquatics - Chronic [1f]**	**Freshwater Aquatics - Acute [1g]**	**Irrigation [1h]**	**Livestock [1d]**	Surface Water	Surface Water	Surface Water	Surface Water
Field Parameters															
Temperature		°C	-	-	-	-	-	-	-	-	-	20.85	27	15.1	0.8
Conductivity (EC)		uS/cm[°C]	-	-	-	-	-	-	-	-	-	2819	6528	5492	3911
Dissolved Oxygen (DO)		mg/L	Variable	-	-	-	-	**Variable**	-	-	-	8.45	9.63	9.84	24.09
pH			6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	**9.39**	**9.38**	**9.04**	**9.18**
Oxidation-Reduction Potential (ORP)		mV	-	-	-	-	-	-	-	-	-	72.9	99.6	216.9	88.3
Secchi Depth		m					-					-	-	-	-
Anions and Nutrients (Water)															
Alkalinity, Total (as CaCO3)	2.0	mg/L	<20	-	-	-	-	-	-	-	-	1090	2610	2120	3070
Ammonia, Total (as N)	0.050	mg/L	Equation	-	-	-	-	**Equation**	-	-	-	**0.251**	<0.050	<0.050	0.0131
Bicarbonate (HCO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	1090	2430	2030	3180
Carbonate (CO3)	5.0	mg/L	-	-	-	-	-	-	-	-	-	120	370	452	283
Chloride (Cl)	0.50	mg/L	120	640	100	-	-	**120**	640	100	-	**325**	**779**	**660**	**861**
Conductivity (EC)	2.0	uS/cm	-	-	-	-	-	-	-	-	-	2950	6170	5490	7040
Fluoride (F)	0.020	mg/L	-	-	1	1	-	**120**	-	1	1	4.060	7.17	6.67	7.58
Hardness (as CaCO3)		mg/L	-	-	-	-	-	-	-	-	-	24	37.1	35.9	67.8
Hydroxide (OH)	5.0	mg/L	-	-	-	-	-	-	-	-	-	<5.0	<5.0	<5.0	<1.0
Ion Balance		%	-	-	-	-	-	-	-	-	-	87.7	87.5	90.6	90.6
Nitrate and Nitrite (as N)	0.022	mg/L	-	-	-	100	-	-	-	100	100	<0.22	<0.22	<0.22	<0.224
Nitrate (as N)	0.020	mg/L	3	124	-	-	-	**13**	550	-	-	<0.20	<0.20	<0.20	<0.200
Nitrite (as N)	0.010	mg/L	Equation	Equation	-	10	-	**0.06**	-	-	10	**0.11**	<0.10	<0.10	<0.10
Total Kjeldahl Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	3.52	6.06	2.20	2.01
Total Nitrogen	0.20	mg/L	-	-	-	-	-	-	-	-	-	3.63	6.06	2.2	2.01
pH	0.10	pH	6.5-9	-	-	-	5-9	**6.5-9**	-	-	-	**9.12**	**9.21**	**9.15**	8.95
Orthophosphate-Dissolved (as P)	0.0050	mg/L	-	-	-	-	-	-	-	-	-	0.239	0.333	0.0834	-
Phosphorus (P)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	1.4600	1.84	0.603	0.463
TDS (Calculated)		mg/L	-	-	500	3000	-	-	-	-	3000	1740	3890	3370	4520
Sulfate (SO4)	0.30	mg/L	128 - 429	-	-	1000	-	-	-	-	1000	86.9	30.8	19.8	13.9
Sulphide as S	0.0015	mg/L	0.0019	-	-	-	-	-	-	-	-	0.0149	0.0246	0.0034	0.049
Biochemical Oxygen Demand	2	mg/L	-	-	-	-	-	-	-	-	-	8.5	20.1		15.4
Organic / Inorganic Carbon (Water)															
Total Organic Carbon	1.0	mg/L	-	-	-	-	-	-	-	-	-	74.0	14.0	5.9	-
Bacteriological Tests (Water)															
Coliform Bacteria - Fecal	1	CFU/100mL	-	-	100	-	100	-	-	100		300	200	270	<5
MPN - Total Coliforms	1	MPN/100mL	-	-	-	-	-	-	-	1000	-	37000	>241960	>241960	3
Total Metals (Water)															
Aluminum (Al)-Total	0.0030	mg/L	-	-	5	5	-	**0.1**	-	5	5	**69.3**	**53.7**	**16.6**	**8.35**
Antimony (Sb)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.00061	<0.0010	<0.0010	<0.00200
Arsenic (As)-Total	0.00010	mg/L	0.005	-	0.16	0.025	-	**0.005**	-	0.1	0.025	**0.0307**	**0.0274**	**0.0140**	**0.00807**
Barium (Ba)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.891	1.19	0.482	0.438
Beryllium (Be)-Total	0.00010	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.00312	0.0022	<0.0010	<0.000400
Boron (B)-Total	0.010	mg/L	1.5	29	0.5	5	-	**1.5**	29	0.5	5	**2.60**	**5.85**	**4.14**	**5.03**
Cadmium (Cd)-Total	0.0000050	mg/L	Equation	Equation	0.0082	0.08	-	**Equation**	Equation	0.0051	0.08	0.00143	0.00136	0.000320	0.000359
Calcium (Ca)-Total	0.050	mg/L	-	-	-	1000	-	-	-	-	1000	34.2	33.8	12.9	15.3
Chromium (Cr)-Total	0.00010	mg/L	0.0089	-	0.0049	0.05	-	**0.001**	-	0.0049	0.05	**0.0823**	**0.0592**	**0.0200**	**0.00995**
Cobalt (Co)-Total	0.00010	mg/L	Equation	-	0.05	1	-	-	-	0.05	1	0.0359	0.0271	0.0085	0.00487
Copper (Cu)-Total	0.00050	mg/L	0.007	Equation	0.2	0.5	-	**Equation**	-	0.2	0.5	**0.0780**	**0.0487**	**0.0233**	**0.0246**
Iron (Fe)-Total	0.010	mg/L	-	-	5	-	-	**0.3**	-	5	-	**78.0**	**62.2**	**20.7**	**9.45**
Lead (Pb)-Total	0.000050	mg/L	Equation	-	0.2	0.1	-	**Equation**	-	0.2	0.1	0.0340	0.0255	0.0106	0.00622
Lithium (Li)-Total	0.0010	mg/L	-	-	2.5	-	-	-	-	2.5	-	0.103	0.151	0.136	0.178
Magnesium (Mg)-Total	0.0050	mg/L	-	-	-	-	-	-	-	-	-	32.8	29.7	11.8	17
Manganese (Mn)-Total	0.00010	mg/L	-	-	0.2	-	-	**Equation**	Equation	0.2	-	1.65	0.991	0.262	0.18
Mercury (Hg)-Total	0.0000050	mg/L	0.000005	0.000013	-	0.003	-	**0.000026**	-	-	0.003	**0.000111**	**0.000259**	**0.000192**	0.0000099
Mercury (Hg)-Total	0.00050	ug/L	0.005	0.013	-	3	-	**0.026**	-	-	3	**0.0405**	**0.034**	**0.0136**	0.00940
Molybdenum (Mo)-Total	0.000050	mg/L	0.073	-	0.01	0.5	-	**0.073**	-	-	0.5	0.00300	0.00372	0.00350	0.00404
Nickel (Ni)-Total	0.00050	mg/L	Equation	Equation	0.2	1	-	**Equation**	-	0.2	1	**0.0923**	**0.0658**	**0.0222**	**0.0159**
Potassium (K)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	21.5	25.6	11.4	11.8
Selenium (Se)-Total	0.000050	mg/L	0.002	-	0.02	0.05	-	**0.001**	-	0.02	0.05	**0.00166**	**0.00134**	<0.00050	<0.00100
Silver (Ag)-Total	0.000010	mg/L	0.00025	-	-	-	-	**0.00025**	-	-	-	**0.000319**	0.00020	<0.00010	<0.000200
Sodium (Na)-Total	0.050	mg/L	-	-	-	-	-	-	-	-	-	733	1760	1410	1920
Thallium (Tl)-Total	0.000010	mg/L	0.0008	-	-	-	-	**0.0008**	-	-	-	0.000524	0.00041	0.00015	<0.000200
Tin (Sn)-Total	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	0.0010	<0.0010	<0.00200
Titanium (Ti)-Total	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.238	0.422	0.130	0.133
Uranium (U)-Total	0.000010	mg/L	0.015	0.033	0.01	0.2	-	**0.015**	0.033	0.01	0.2	0.00362	0.00220	0.00103	0.0026
Vanadium (V)-Total	0.00050	mg/L	-	-	0.1	0.1	-	-	-	0.1	0.1	0.157	0.0985	0.0423	0.0391
Zinc (Zn)-Total	0.0030	mg/L	0.03	-	1	50	-	**Equation**	-	5	50	**0.321**	**0.253**	**0.084**	<0.0600
Dissolved Metals (Water)															
Aluminum (Al)-Dissolved	0.0010	mg/L	0.05	-	-	-	-	-	-	-	-	0.202	0.203	0.016	0.0134
Antimony (Sb)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.00110	<0.0010	<0.0010	<0.00100
Arsenic (As)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0130	0.0198	0.0118	0.00705
Barium (Ba)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0705	0.193	0.206	0.256
Beryllium (Be)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	<0.0010	<0.0010	<0.000200
Boron (B)-Dissolved	0.010	mg/L	-	-	-	-	-	-	-	-	-	2.01	5.08	3.74	4.82
Cadmium (Cd)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	0.000125	0.000121	<0.000050	<0.0000500
Calcium (Ca)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	4.69	6.86	5.76	7.71
Chromium (Cr)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.00098	<0.0010	<0.0010	<0.00500
Cobalt (Co)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.00268	<0.0010	<0.0010	<0.00100
Copper (Cu)-Dissolved	0.00020	mg/L	-	-	-	-	-	-	-	-	-	0.0312	0.0129	0.0143	0.0132
Iron (Fe)-Dissolved	0.010	mg/L	0.3	-	-	-	-	-	-	-	-	0.806	0.17	<0.10	<0.300
Lead (Pb)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.00117	0.00081	<0.00050	<0.000500
Lithium (Li)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	0.0312	0.106	0.104	0.169
Magnesium (Mg)-Dissolved	0.0050	mg/L	-	-	-	-	-	-	-	-	-	3.05	4.86	5.23	11.8
Manganese (Mn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	0.0273	0.0060	0.0011	<0.0500
Mercury (Hg)-Dissolved	0.0000050	mg/L	-	-	-	-	-	-	-	-	-	<0.0000050	<0.0000050	0.0000058	0.000008
Molybdenum (Mo)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.00520	0.00409	0.00353	0.00444
Nickel (Ni)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0153	0.0094	<0.0050	0.00553
Potassium (K)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	5.64	7.85	6.84	9.51
Selenium (Se)-Dissolved	0.000050	mg/L	-	-	-	-	-	-	-	-	-	0.00116	0.00068	<0.00050	0.000676
Silver (Ag)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.000097	<0.00010	<0.00010	<0.000100
Sodium (Na)-Dissolved	0.050	mg/L	-	-	-	-	-	-	-	-	-	652	1490	1390	1760
Thallium (Tl)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	<0.00010	<0.00010	<0.000100
Tin (Sn)-Dissolved	0.00010	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	<0.0010	<0.0010	<0.00100
Titanium (Ti)-Dissolved	0.00030	mg/L	-	-	-	-	-	-	-	-	-	0.110	0.0110	0.0054	0.0118
Uranium (U)-Dissolved	0.000010	mg/L	-	-	-	-	-	-	-	-	-	0.00255	0.00098	0.00081	0.00215
Vanadium (V)-Dissolved	0.00050	mg/L	-	-	-	-	-	-	-	-	-	0.0260	0.0215	0.0151	0.0224
Zinc (Zn)-Dissolved	0.0010	mg/L	-	-	-	-	-	-	-	-	-	<0.0050	<0.010	<0.010	<0.0100
Speciated Metals (Water)															
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.001	0.002	-	-	-	**0.004**	-	-	-	<0.00080	0.00058	0.000114	0.000132
Aggregate Organics (Water)															
Phenols (4AAP)	0.0010	mg/L	0.004	-	-	0.002	-	**0.004**	-	-	0.002	-	<0.010	<0.0010	**0.0050**
Volatile Organic Compounds (Water)															
Benzene	0.00050	mg/L	0.04	-	-	-	-	**0.37**	-	-	-	<0.00050	<0.00050	-	<0.00050
Ethylbenzene	0.00050	mg/L	0.09	-	-	0.0024	-	**0.09**	-	-	0.0024	<0.00050	<0.00050	-	<0.00050
Styrene	0.00050	mg/L	0.072	-	-	-	-	**0.072**	-	-	-	<0.00050	<0.00050	-	<0.00050
Toluene	0.00050	mg/L	0.0005	-	-	0.024	-	**0.002**	-	-	0.024	<0.00050	<0.00050	-	<0.00050
Xylenes	0.00071	mg/L	0.03	-	-	-	-	-	-	-	-	<0.00071	<0.00071	-	<0.00050
Polycyclic Aromatic Hydrocarbons (Water)															
Acenaphthene	0.020	ug/L	5.8	-	-	-	-	**5.8**	-	-	-	<0.020	<0.020	<0.020	<0.010
Acenaphthylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Acridine	0.010	ug/L	4.4	-	-	-	-	**4.4**	-	-	-	<0.010	<0.010	<0.010	<0.010
Anthracene	0.012	ug/L	0.012	-	-	-	-	**0.012**	-	-	-	<0.012	<0.012	<0.012	<0.010
Benz(a)anthracene	0.018	ug/L	0.018	-	-	-	-	**0.018**	-	-	-	<0.018	<0.018	<0.018	<0.010
Benzo(a)pyrene	0.0050	ug/L	0.015	-	-	-	-	**0.015**	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(g,h,i)perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Benzo(k)fluoranthene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Chrysene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Dibenz(a,h)anthracene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.0050
Fluoranthene	0.020	ug/L	0.04	-	-	-	-	**0.04**	-	-	-	<0.020	<0.020	<0.020	<0.010
Fluorene	0.020	ug/L	3	-	-	-	-	**3**	-	-	-	<0.020	<0.020	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
1-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
2-Methylnaphthalene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.010
Naphthalene	0.050	ug/L	1	-	-	-	-	**1.1**	-	-	-	<0.050	<0.050	<0.050	<0.050
Perylene	0.020	ug/L	-	-	-	-	-	-	-	-	-	<0.020	<0.020	<0.020	<0.020
Phenanthrene	0.020	ug/L	0.4	-	-	-	-	**0.4**	-	-	-	<0.020	<0.020	<0.020	<0.020
Pyrene	0.020	ug/L	0.025	-	-	-	-	**0.025**	-	-	-	<0.020	<0.020	<0.020	<0.010
Quinoline	0.040	ug/L	3.4	-	-	-	-	**3.4**	-	-	-	<0.040	<0.040	<0.040	<0.050
B(a)P Total Potency Equivalent	0.060	ug/L	-	-	-	-	-	-	-	-	-	<0.060	<0.060	<0.060	<0.010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.
   - 4d. Dissolved aluminum concentrations are pH dependent.
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

| GENERAL | | | pH | | | PARTICLE SIZE | | | CARBON | | | | METALS | | | |

General																			
Sample ID:			WQSR1-S	WQSR1-S (D)	Absolute Difference	Relative Percent Difference	WQCR1-S	WQCR1-S (D)	Absolute Difference	Relative Percent Difference	WQCR3-S	WQCR3-S (D)	Absolute Difference	Relative Percent Difference	WQCR2-S	WQCR2-S (D)	Absolute Difference	Relative Percent Difference
Date Sampled:			44342	44342			28-Jul-2021	28-Jul-2021			5-Oct-2021	5-Oct-2021			02-Mar-2022	02-Mar-2022		
Time Sampled:			0-Jan-1900	0-Jan-1900			11:25	12:00			12:00	12:00			10:20	10:50		
ALS Sample ID:			L2593381-7	L2593381-8			L2620338-5	L2620338-10			L2648073-5	L2648073-7			CG2202368-001	CG2202368-006		
Parameter	**Lowest Detection Limit**	**Units**	0.5 m	Duplicate			0.5 m	Duplicate			0.5 m	Duplicate			0.5 m	Duplicate		
Anions and Nutrients (Water)																		
Alkalinity, Total (as CaCO3)	2.0	mg/L	133.00	133.00	0	**0.0%**	122	121	**1**	0.8%	146	147	1.0	**0.7%**	129	127	2	**1.6%**
Ammonia, Total (as N)	0.050	mg/L	<0.050	<0.050	-	-	<0.050	<0.050	-	-	<0.050	<0.050	-	-	<0.0050	<0.0050	-	-
Bicarbonate (HCO3)	5.0	mg/L	165.00	164.00	1	**0.6%**	149	147	**2**	1.4%	178	180	2.0	**1.1%**	152	148	4	**2.7%**
Carbonate (CO3)	5.0	mg/L	<5.0	<5.0	-	-	<5.0	<5.0	-	-	<5.0	<5.0	-	-	2.5	3	**0.5**	18.2%
Chloride (Cl)	0.50	mg/L	1.02	1.01	**0.01**	1.0%	0.59	0.59	0	**0.0%**	1.07	1.03	**0.04**	3.8%	0.68	0.67	**0.01**	1.5%
Conductivity (EC)	2.0	uS/cm	306	305	1	**0.3%**	251	250	**1**	0.4%	290	295	5.0	**1.7%**	260	265	5	**1.9%**
Fluoride (F)	0.020	mg/L	0.048	0.047	**0.001**	2.1%	0.039	0.039	0	**0.0%**	0.06	0.06	**0.001**	1.7%	0.040	0.038	**0.002**	5.1%
Hardness (as CaCO3)	-	mg/L	139	139	0.00	**0.0%**	129	132	3	**2.3%**	136.00	136.00	0.0	**0.0%**	128	130	2	**1.6%**
Hydroxide (OH)	5.0	mg/L	<5.0	<5.0	-	-	<5.0	<5.0	-	-	<5.0	<5.0	-	-	<1.0	<1.0	-	-
Ion Balance	-	%	96.50	97.20	0.70	**0.7%**	99.7	103	3.3	**3.3%**	88.10	85.40	2.7	**3.1%**	95.7	98	2.3	**2.4%**
Nitrate and Nitrite (as N)	0.022	mg/L	<0.022	<0.022	-	-	<0.022	<0.022	-	-	<0.022	<0.022	-	-	<0.0500	<0.0500	-	-
Nitrate (as N)	0.020	mg/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-
Nitrite (as N)	0.010	mg/L	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-
Total Kjeldahl Nitrogen	0.05	mg/L	<0.20	<0.20	-	-	<0.20	<0.20	-	-	<0.20	0.26	-	-	0.106	0.084	**0.022**	23.2%
Total Nitrogen	0.05	mg/L	<0.20	<0.20	-	-	<0.20	<0.20	-	-	<0.20	0.26	-	-	0.106	0.084	**0.022**	23.2%
pH	0.10	pH	8.29	8.29	0.00	**0.0%**	8.21	8.11	0.1	**1.2%**	8.17	8.27	0.1	**1.2%**	8.36	8.39	0.03	**0.4%**
Orthophosphate-Dissolved (as P)	0.0050	mg/L	<0.0050	<0.0050	-	-	<0.0050	<0.0050	-	-	<0.0050	<0.0050	-	-	-	-	-	-
Phosphorus (P)-Total	0.0050	mg/L	0.03	0.01	**0.02**	91.6%	<0.0050	0.0053	-	-	0.01	0.01	**0.0**	16.7%	0.004	0.0049	0.0009	20.2%
TDS (Calculated)	-	mg/L	173.00	172.00	1	**0.6%**	145	147	2	**1.4%**	177.00	182.00	5.0	**2.8%**	152	151	1	0.7%
Sulfate (SO4)	0.30	mg/L	31.80	31.70	0.10	**0.3%**	20.4	20.9	0.5	**2.4%**	31.10	35.50	4.4	**13.2%**	20.7	20.4	0.3	1.5%
Sulphide as S	0.0015	mg/L	<0.0015	<0.0015	-	-	<0.0015	<0.0015	-	-	<0.0015	<0.0015	-	-	<0.0015	<0.0015	-	-
Biochemical Oxygen Demand	2	mg/L	<2.0	<2.0	-	-	<2.0	<2.0	-	-	<2.0	<2.0	-	-	<2.0	<2.0	-	-
Organic / Inorganic Carbon (Water)																		
Total Organic Carbon	1.0	mg/L	2.40	2.50	**0.10**	4%	2.4	3.4	**1.0**	34.5%	2.30	2.10	0.2	9.1%	-	-	-	-
Bacteriological Tests (Water)																		
Coliform Bacteria - Fecal	1	CFU/100mL	3	4	**1**	29%	2	1	**1**	66.7%	7	10	3.0	**35.3%**	<1	<1	-	-
MPN - Total Coliforms	1	MPN/100mL	91	110	19	**19%**	79	62	17	**24.1%**	70	46	24.0	**41.4%**	<1	<1	-	-
Total Metals (Water)																		
Aluminum (Al)-Total	0.0030	mg/L	0.12	0.11	0.0050	**4.3%**	0.0490	0.0350	0.014	**33.3%**	0.07	0.06	0.002	**2.6%**	0.0176	0.016	0.0016	**9.5%**
Antimony (Sb)-Total	0.00010	mg/L	0.0001	0.0001	**0**	8.7%	0.00013	<0.00010	**0.00008**	-	0.00012	0.00013	**0.00001**	8.0%	0.00011	0.0001	**0**	0.0%
Arsenic (As)-Total	0.00010	mg/L	0.0009	0.0010	0.0001	**6.3%**	0.00084	0.00081	0.000030	**3.6%**	0.00075	0.00079	0.00004	**5.2%**	0.00072	0.00074	0.00002	**2.7%**
Barium (Ba)-Total	0.00010	mg/L	0.12	0.12	0.00	**0.0%**	0.132	0.123	0.009	**7.1%**	0.11	0.11	**0**	0.0%	0.111	0.1120	0.001	**0.9%**
Beryllium (Be)-Total	0.00010	mg/L	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.000020	<0.000020	-	-
Boron (B)-Total	0.010	mg/L	0.01	0.01	**0.00**	0.0%	<0.010	0.010	**0.005**	-	0.01	0.01	**0.0**	0.0%	0.014	<0.010	**0.009**	-
Cadmium (Cd)-Total	0.0000050	mg/L	0.00002	0.00001	**0.00**	25.5%	0.0000056	0.0000054	**0.0000002**	3.6%	0.0000069	0.0000091	**0.000002**	27.5%	<0.0000050	<0.0000050	-	-
Calcium (Ca)-Total	0.050	mg/L	34.40	34.20	0.20	**0.6%**	32.7	30.9	1.8	**5.7%**	35.50	34.80	**0.7**	2.0%	31.6	32.40	0.8	**2.5%**
Chromium (Cr)-Total	0.00010	mg/L	0.00018	0.00017	**0.000010**	5.7%	0.00014	0.00011	**0.00003**	24.0%	0.00015	0.00014	0.0	**6.9%**	<0.00050	<0.00050	-	-
Cobalt (Co)-Total	0.00010	mg/L	0.00011	0.00010	**0.000010**	9.5%	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-
Copper (Cu)-Total	0.00050	mg/L	0.00090	0.00087	**0.000030**	3.4%	0.00073	0.00069	**0.00004**	5.6%	0.00107	0.00105	**0.00002**	1.9%	0.00082	0.00075	**0.00007**	8.9%
Iron (Fe)-Total	0.010	mg/L	0.141	0.135	0.01	**4.3%**	0.044	0.037	**0.007**	17.3%	0.075	0.074	**0.001**	1.3%	0.016	0.0160	**0**	0.0%
Lead (Pb)-Total	0.000050	mg/L	0.00013	0.00013	**0.0**	0.0%	<0.000050	<0.000050	-	-	0.000055	<0.000050	-	-	<0.000050	<0.000050	-	-
Lithium (Li)-Total	0.0010	mg/L	0.006	0.006	**0.0**	0.0%	0.0030	0.0031	**0.00010**	3.3%	0.0049	0.0050	**0.0001**	2.0%	0.0044	0.0043	**0.0001**	2.3%
Magnesium (Mg)-Total	0.0050	mg/L	13.90	13.80	0.10	**0.7%**	12.6	11.9	0.7	**5.7%**	13.30	13.30	**0**	0.0%	11.8	12.2	0.4	**3.3%**
Manganese (Mn)-Total	0.00010	mg/L	0.01	0.01	0.00	**3.6%**	0.00387	0.00366	0.00021	**5.6%**	0.00437	0.00446	**0.0001**	2.0%	0.00103	0.0010	0.00001	**1.0%**
Mercury (Hg)-Total	0.0000050	mg/L	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-
Mercury (Hg)-Total	0.00050	ug/L	0.00060	0.00062	**0.00**	3.3%	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-
Molybdenum (Mo)-Total	0.000050	mg/L	0.00072	0.00070	0.000015	**2.1%**	0.000656	0.000611	0.000045	**7.1%**	0.000847	0.000848	0.000001	**0.1%**	0.00074	0.000718	0.000022	**3.0%**
Nickel (Ni)-Total	0.00050	mg/L	0.00068	0.00070	**0.00002**	2.9%	0.00108	0.00104	**0.000040**	3.8%	0.000740	0.000790	**0.000050**	6.5%	<0.00050	<0.00050	-	-
Potassium (K)-Total	0.050	mg/L	1.26	1.24	0.02	**1.6%**	0.829	0.783	0.046	**5.7%**	1.12	1.13	0.01	0.9%	0.879	0.889	0.01	**1.1%**
Selenium (Se)-Total	0.000050	mg/L	0.00028	0.00027	0.00	**5.1%**	0.000224	0.000210	**0.000014**	6.5%	0.000269	0.000303	0.000034	**11.9%**	0.000262	0.0003	0.00001	**4.3%**
Silver (Ag)-Total	0.000010	mg/L	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-
Sodium (Na)-Total	0.050	mg/L	11.20	10.90	0.30	**2.7%**	6.54	6.40	0.14	**2.2%**	9.93	9.92	0.01	**0.1%**	6.7	6.9400	0.24	**3.5%**
Thallium (Tl)-Total	0.000010	mg/L	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-
Tin (Sn)-Total	0.00010	mg/L	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-
Titanium (Ti)-Total	0.00030	mg/L	0.00232	0.00214	0.000180	**8.1%**	0.00126	0.00097	**0.00029**	26.0%	0.00143	0.00120	0.0002	17.5%	0.00046	<0.00030	**0.00104**	-
Uranium (U)-Total	0.000010	mg/L	0.000854	0.000848	0.000006	**0.7%**	0.000631	0.000576	0.000055	**9.1%**	0.00069	0.00069	**0**	0.0%	0.00063	0.0007	0.000023	3.6%
Vanadium (V)-Total	0.00050	mg/L	0.00100	0.00097	**0.000030**	3.0%	0.00154	0.00124	**0.0003**	21.6%	0.00097	0.00102	**0.0001**	5.0%	0.00072	0.00071	0.00001	1.4%
Zinc (Zn)-Total	0.0030	mg/L	<0.0030	<0.0030	-	-	<0.0030	<0.0030	-	-	<0.0030	0.01	-	-	<0.0030	<0.0030	-	-
Dissolved Metals (Water)																		
Aluminum (Al)-Dissolved	0.0010	mg/L	0.00	0.00	**0.00**	0.0%	0.0012	0.0013	**0.0001**	8.0%	0.00180	0.00200	**0.0002**	10.5%	0.0017	0.0012	**0.0005**	34.5%
Antimony (Sb)-Dissolved	0.00010	mg/L	0.0001	0.0001	**0**	0.0%	<0.00010	<0.00010	-	-	0.00012	0.00012	**0**	0.0%	<0.00010	<0.00010	-	-
Arsenic (As)-Dissolved	0.00010	mg/L	0.0009	0.0008	0.0001	**5.8%**	0.00075	0.00077	0.000020	**2.6%**	0.00067	0.00067	**0**	0.0%	0.00067	0.00075	0.00008	**11.3%**
Barium (Ba)-Dissolved	0.00010	mg/L	0.113	0.114	0.001	**0.9%**	0.119	0.118	0.001	**0.8%**	0.11	0.11	**0.0020**	1.9%	0.114	0.1150	0.001	**0.9%**
Beryllium (Be)-Dissolved	0.00010	mg/L	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.000020	<0.000020	-	-
Boron (B)-Dissolved	0.010	mg/L	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	0.01	-	-	<0.010	<0.010	-	-
Cadmium (Cd)-Dissolved	0.0000050	mg/L	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-
Calcium (Ca)-Dissolved	0.050	mg/L	33.60	34.00	0.40	**1.2%**	31.2	32.6	1.4	4.4%	33.10	33.30	0.2	**0.6%**	31.7	32.0	0.3	**0.9%**
Chromium (Cr)-Dissolved	0.00010	mg/L	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00050	<0.00050	-	-
Cobalt (Co)-Dissolved	0.00010	mg/L	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-
Copper (Cu)-Dissolved	0.00020	mg/L	0.00065	0.00068	**0.00003**	4.5%	0.00061	0.00063	**0.000020**	3.2%	0.00097	0.00094	**0.00003**	3.1%	0.00078	0.00076	**0.00002**	2.6%
Iron (Fe)-Dissolved	0.010	mg/L	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.030	<0.030	-	-
Lead (Pb)-Dissolved	0.000050	mg/L	<0.000050	<0.000050	-	-	<0.000050	<0.000050	-	-	<0.000050	<0.000050	-	-	<0.000050	<0.000050	-	-
Lithium (Li)-Dissolved	0.0010	mg/L	0.005	0.006	0.00	**3.6%**	0.0039	0.0041	**0.0002**	5.0%	0.006	0.006	**0.0**	3.5%	0.0041	0.0042	**0.0001**	2.4%
Magnesium (Mg)-Dissolved	0.0050	mg/L	13.40	13.20	0.20	**1.5%**	12.4	12.4	0	0.0%	12.90	12.90	**0.0**	0.0%	12	12.1	0.1	**0.8%**
Manganese (Mn)-Dissolved	0.00010	mg/L	0.00069	0.00069	**0.00**	0.0%	0.00066	0.00063	0.00003	**4.7%**	0.00023	0.00025	**0.00002**	8.3%	<0.00500	<0.00500	-	-
Mercury (Hg)-Dissolved	0.0000050	mg/L	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	-	-
Molybdenum (Mo)-Dissolved	0.000050	mg/L	0.00074	0.00073	0.00001	**1.6%**	0.000635	0.000651	0.000016	**2.5%**	0.00084	0.00083	0.00001	**1.2%**	0.000704	0.0008	0.0001	**12.8%**
Nickel (Ni)-Dissolved	0.00050	mg/L	0.00050	0.00050	**0.00**	0.0%	<0.00050	0.00056	**0.00031**	-	0.00059	0.00056	**0.00003**	5.2%	<0.00050	<0.00050	-	-
Potassium (K)-Dissolved	0.050	mg/L	1.19	1.19	**0.00**	0.0%	0.794	0.815	0.021	**2.6%**	1.11	1.11	**0.0**	0.0%	0.913	0.9120	0.001	**0.1%**
Selenium (Se)-Dissolved	0.000050	mg/L	0.000266	0.000279	0.00	**4.8%**	0.000200	0.000235	0.000035	**16.1%**	0.00030	0.00031	0.00001	**4.6%**	0.00025	0.000284	**0.000034**	12.7%
Silver (Ag)-Dissolved	0.000010	mg/L	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-
Sodium (Na)-Dissolved	0.050	mg/L	10.80	10.80	**0.00**	0.0%	6.41	6.56	0.15	**2.3%**	9.80	9.79	0.01	**0.1%**	7.19	7.05	0.14	**2.0%**
Thallium (Tl)-Dissolved	0.000010	mg/L	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-
Tin (Sn)-Dissolved	0.00010	mg/L	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	-
Titanium (Ti)-Dissolved	0.00030	mg/L	<0.00030	<0.00030	-	-	<0.00030	<0.00030	-	-	<0.00030	<0.00030	-	-	<0.00030	<0.00030	-	-
Uranium (U)-Dissolved	0.000010	mg/L	0.00077	0.00078	0.00	**1.3%**	0.000515	0.000523	0.000008	**1.5%**	0.00067	0.00067	**0.0**	0.4%	0.000616	0.000599	0.000017	**2.8%**
Vanadium (V)-Dissolved	0.00050	mg/L	<0.00050	<0.00050	-	-	0.00062	0.00062	**0**	0.0%	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-
Zinc (Zn)-Dissolved	0.0010	mg/L	<0.0010	<0.0010	-	-	<0.0010	<0.0010	-	-	0.0011	0.0016	**0.0005**	37.0%	0.0011	<0.0010	**0.0006**	-
Speciated Metals (Water)																		
Methylmercury (as MeHg)-Total	0.000020	ug/L	0.000035	0.00003	**0.000005**	15%	0.000023	0.000022	0.000001	4.4%	<0.000020	<0.000020	-	-	<0.000020	<0.000020	-	-
Aggregate Organics (Water)																		
Phenols (4AAP)	0.0010	mg/L	<0.0010	<0.0010	-	-	<0.0010	0.0017	**0.0012**	-	<0.0010	<0.0010	-	-	0.0074	0.0081	0.0007	**2.3%**
Volatile Organic Compounds (Water)																		
Benzene	0.00050	mg/L	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-
Ethylbenzene	0.00050	mg/L	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-
Styrene	0.00050	mg/L	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-
Toluene	0.00050	mg/L	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	-
Xylenes	0.00071	mg/L	<0.00071	<0.00071	-	-	<0.00071	<0.00071	-	-	<0.00071	<0.00071	-	-	<0.00050	<0.00050	-	-
Polycyclic Aromatic Hydrocarbons (Water)																		
Acenaphthene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Acenaphthylene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Acridine	0.010	ug/L	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-
Anthracene	0.012	ug/L	<0.012	<0.012	-	-	<0.012	<0.012	-	-	<0.012	<0.012	-	-	<0.010	<0.010	-	-
Benz(a)anthracene	0.018	ug/L	<0.018	<0.018	-	-	<0.018	<0.018	-	-	<0.018	<0.018	-	-	<0.010	<0.010	-	-
Benzo(a)pyrene	0.0050	ug/L	<0.0050	<0.0050	-	-	<0.0050	<0.0050	-	-	<0.0050	<0.0050	-	-	<0.0050	<0.0050	-	-
Benzo(b&j)fluoranthene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Benzo(g,h,i)perylene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Benzo(k)fluoranthene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Chrysene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Dibenz(a,h)anthracene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.0050	<0.0050	-	-
Fluoranthene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Fluorene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Indeno(1,2,3-c,d)pyrene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
1-Methylnaphthalene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
2-Methylnaphthalene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Naphthalene	0.050	ug/L	<0.050	<0.050	-	-	<0.050	<0.050	-	-	<0.050	<0.050	-	-	<0.050	<0.050	-	-
Perylene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-
Phenanthrene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-
Pyrene	0.020	ug/L	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.020	<0.020	-	-	<0.010	<0.010	-	-
Quinoline	0.040	ug/L	<0.040	<0.040	-	-	<0.040	<0.040	-	-	<0.040	<0.040	-	-	<0.050	<0.050	-	-
B(a)P Total Potency Equivalent	0.060	ug/L	<0.060	<0.060	-	-	<0.060	<0.060	-	-	<0.060	<0.060	-	-	<0.010	<0.010	-	-

Notes:

1. - No results
2. **BOLD** highlights the applicable Zeiner Criteria
3. (yellow highlight) = Exceeds applicable Zeiner Criteria

APPENDIX 165.2

Summary of Analytical Results for Historical Surface Water Quality

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SMC-P1	04-Jul-2006	8.70	34.6	209	132	145	8	153.0	<0.05	<0.05	-	<0.05	0.0200	34.9	17.0	15.4	1.9	1.50	57.1	-	-
	17-Jul-2006	8.60	32.1	188	128	142	7	147.0	0.0600	<0.05	-	<0.05	<0.02	34.6	12.0	12.8	1.4	1.50	45.7	-	-
	14-Aug-2006	8.60	27.6	151	117	130	6	124.0	<0.05	<0.05	-	<0.05	<0.02	28.9	9.0	11.5	1.2	1.00	26.8	-	-
	28-Aug-2006	8.70	25.5	140	117	128	7	108.0	<0.05	<0.05	-	<0.05	<0.02	24.0	8.0	11.0	1.2	0.80	23.3	-	-
	25-Jun-2007	8.40	27.4	145	109	128	<5	114.0	<0.05	<0.05	-	<0.05	<0.02	27.2	10.0	12.1	1.2	0.80	30.3	-	-
	09-Jul-2007	8.20	28.4	191	143	175	<5	174.0	<0.05	<0.05	-	<0.05	<0.02	43.6	10.0	11.8	1.3	0.90	33.7	-	-
	07-Aug-2007	8.10	27.4	178	124	151	<5	136.0	<0.05	<0.05	-	<0.05	<0.02	30.9	9.0	11.4	1.2	0.90	28.2	-	-
	20-Aug-2007	7.40	26.0	169	132	161	<5	116.0	<0.05	<0.05	-	<0.05	<0.02	27.2	7.0	11.1	1.00	0.80	24.4	-	-
	06-Jul-2011	8.45	51.5	322	158	193	<6	199.0	<0.005	0.010	1.33	<0.05	0.120	44.5	-	-	-	3.60	119	-	-
	20-Jul-2011	8.55	42.9	258	146	179	<6	170.0	<0.005	0.010	0.41	<0.05	<0.05	40.2	-	-	-	2.70	81.8	-	-
	10-Aug-2011	8.55	36.7	215	133	149	6	155.0	<0.005	<0.01	0.36	<0.05	<0.05	36.3	-	-	-	1.60	59.9	-	-
	31-Aug-2011	8.24	32.6	185	122	149	<6	139.0	<0.005	<0.01	0.35	<0.05	<0.05	32.8	-	-	-	2.20	45.7	-	-
	06-Jun-2012	8.30	33.1	207	131	160	<6	155.0	<0.005	0.030	0.30	<0.05	0.025	37.0	-	-	-	1.80	54.3	-	-
	04-Jul-2012	8.61	34.3	214	141	172	<6	149.0	<0.005	<0.01	0.33	<0.05	0.024	34.8	-	-	-	2.10	58.3	-	-
	01-Aug-2012	8.64	27.5	168	117	129	7	130.0	<0.005	<0.01	0.25	<0.05	0.016	30.8	-	-	-	1.10	38.9	-	-
	29-Aug-2012	8.42	28.4	169	115	140	<6	134.0	<0.005	<0.01	0.23	<0.05	0.015	32.6	-	-	-	0.90	39.0	-	-
	12-Jun-2013	8.39	30.5	172	119	145	<6	135.0	<0.005	<0.01	0.22	<0.05	0.012	33.1	-	-	-	1.20	39.4	-	-
	03-Jul-2013	8.41	28.2	160	117	142	<6	125.0	<0.005	<0.01	0.19	<0.05	0.036	30.7	-	-	-	1.10	34.0	-	-
	31-Jul-2013	8.30	25.5	160	125	153	<6	119.0	<0.005	<0.01	0.22	<0.05	0.011	29.1	-	-	-	0.90	28.0	-	-
	28-Aug-2013	8.40	24.6	140	116	141	<6	117.0	<0.005	<0.01	0.24	<0.05	0.011	28.7	-	-	-	0.80	26.0	-	-
	10-Jun-2014	8.38	31.3	191	132	160	6	142.0	<0.005	<0.01	0.23	<0.05	0.022	34.3	-	-	-	1.60	45.5	-	-
	07-Jul-2014	8.60	32.6	199	126	141	6	143.0	0.0090	0.070	0.46	<0.05	0.134	34.2	-	-	-	3.00	52.1	-	-
	05-Aug-2014	8.56	31.0	175	128	156	6	132.0	<0.005	<0.01	0.41	<0.05	0.037	32.5	-	-	-	1.40	37.4	-	-
	08-Jun-2015	8.87	48.2	302	125	122	15	167.0	<0.005	<0.01	0.24	<0.05	0.015	30.6	-	-	-	4.30	126	-	-
	06-Jul-2015	8.18	29.6	176	132	161	<6	136.0	<0.005	<0.01	0.19	<0.05	0.021	33.1	-	-	-	1.10	35.9	-	-
	27-Jul-2015	8.47	26.9	150	115	140	<6	125.0	<0.005	<0.01	0.17	<0.025	0.011	30.3	-	-	-	0.90	27.9	-	-
	31-Aug-2015	8.47	26.2	152	122	148	<6	125.0	<0.005	<0.01	0.15	<0.025	0.014	30.6	-	-	-	0.90	25.6	-	-
	06-Jun-2016	8.37	28.4	162	121	148	<6	134.0	<0.005	<0.01	0.25	<0.025	0.017	32.4	-	-	-	1.10	32.1	-	-
	04-Jul-2016	8.46	25.7	150	122	149	<6	119.0	<0.005	<0.01	0.22	<0.025	<0.005	29.0	-	-	-	1.00	26.0	-	-
	08-Aug-2016	8.25	22.8	130	109	133	<6	109.0	<0.005	0.020	0.20	0.027	0.005	26.5	-	-	-	0.70	20.0	-	-
	29-Aug-2016	8.35	24.5	140	115	140	<6	118.0	<0.005	<0.01	0.28	<0.025	0.006	29.0	-	-	-	0.90	23.0	-	-
	29-May-2017	8.27	29.5	171	126	153	<6	137.0	<0.005	<0.01	1.06	-	0.015	34.1	-	-	-	1.30	34.0	-	-
	26-Jun-2017	8.16	25.4	149	120	146	<6	122.0	<0.005	<0.01	0.13	-	0.015	29.9	-	-	-	0.90	26.0	-	-
	24-Jul-2017	8.24	24.0	147	123	150	<6	121.0	<0.005	<0.01	0.14	-	0.017	29.9	-	-	-	0.80	23.0	-	-
	28-Aug-2017	8.08	21.5	118	103	125	<6	108.0	<0.005	<0.01	0.15	-	0.010	27.2	-	-	-	0.60	13.0	-	-
	30-May-2018	8.14	31.9	195	138	168	<6	147.0	<0.005	<0.01	0.33	-	0.037	36.5	-	-	-	1.60	43.9	-	-
	27-Jun-2018	8.28	26.6	165	121	148	<6	127.0	<0.005	<0.01	0.47	-	0.013	32.2	-	-	-	11.4	27.0	-	-
	07-Aug-2018	8.29	25.3	137	112	137	<6	116.0	<0.005	<0.01	0.30	-	0.011	29.4	-	-	-	0.90	21.0	-	-
	22-Aug-2018	8.21	23.4	131	113	138	<6	113.0	<0.005	<0.01	0.17	-	0.014	29.0	-	-	-	0.70	17.0	-	-
	29-May-2019	8.41	29.5	173	139	170	<7	133.0	<0.005	<0.01	1.11	-	0.018	33.5	-	-	-	1.50	30.9	-	-
	26-Jun-2019	8.20	27.0	153	125	153	<6	126.0	<0.005	<0.01	0.18	-	0.009	31.9	-	-	-	0.90	24.0	-	-
	31-Jul-2019	8.30	24.2	132	116	141	<6	113.0	<0.005	<0.01	0.26	-	0.008	28.6	-	-	-	0.70	17.0	-	-
	28-Aug-2019	8.24	23.2	129	112	136	<6	117.0	<0.005	<0.01	0.14	-	<0.005	29.0	-	-	-	0.70	15.0	-	-
	02-Jun-2020	8.56	33.4	189	130	140	9	153.0	<0.005	<0.01	0.35	-	0.017	37.5	-	-	-	2.60	41.0	-	-
	22-Jun-2020	8.34	29.1	165	130	159	<6	138.0	<0.005	0.010	0.25	-	0.015	33.8	-	-	-	1.30	28.0	-	-
	27-Jul-2020	8.29	26.8	152	124	151	<6	123.0	<0.005	<0.01	0.20	-	0.025	30.6	-	-	-	1.00	25.0	-	-
	24-Aug-2020	8.44	24.6	139	115	140	<6	122.0	<0.005	0.010	0.27	-	0.013	30.2	-	-	-	0.70	20.0	-	-
SMC-R1	04-Jul-2006	8.60	38.0	237	134	148	7.00	157	<0.05	<0.05	-	<0.05	0.030	32.1	21	17.9	3.0	3.30	77.1	-	-
	17-Jul-2006	8.60	37.6	221	130	144	7.00	159	<0.05	<0.05	-	<0.05	0.030	32.6	19	16.7	2.5	2.90	63.9	-	-
	14-Aug-2006	**9.10**	35.7	211	121	116	16.00	142	<0.05	<0.05	-	<0.05	0.040	28.0	20	16.5	2.7	2.40	65.1	-	-
	28-Aug-2006	**9.10**	38.2	224	132	128	16.00	148	<0.05	<0.05	-	<0.05	0.050	27.8	23	18.2	3.5	3.10	67.7	-	-
	25-Jun-2007	8.50	44.4	265	145	167	<5	179	<0.05	<0.05	-	0.0700	<0.02	36.0	25	20.4	3.6	2.70	88.0	-	-
	09-Jul-2007	8.10	41.0	279	164	200	<5	215	<0.05	<0.05	-	<0.05	<0.02	44.3	24	20.2	3.2	2.60	80.6	-	-
	07-Aug-2007	8.00	39.6	257	136	166	<5	166	<0.05	<0.05	-	<0.05	0.110	30.4	22	18.5	3.0	2.40	73.1	-	-
	20-Aug-2007	8.20	40.8	265	149	182	<5	155	<0.05	<0.05	-	<0.05	0.100	29.4	23	19.3	3.3	2.90	81.9	-	-
	06-Jul-2011	8.39	48.8	296	154	188	<6	197	<0.005	0.010	0.810	<0.05	0.120	44.0	-	-	-	5.40	97.4	-	-
	20-Jul-2011	8.29	52.5	326	158	192	<6	204	<0.005	0.040	0.790	<0.05	0.150	45.2	-	-	-	6.70	116	-	-
	10-Aug-2011	8.62	55.0	348	168	184	10.00	222	<0.005	<0.01	2.770	<0.05	0.280	46.9	-	-	-	7.20	122	-	-
	31-Aug-2011	8.83	61.9	388	187	198	15.00	235	<0.005	0.040	1.430	<0.05	0.410	47.2	-	-	-	8.50	137	-	-
	06-Jun-2012	8.16	50.1	333	174	212	<6	209	<0.005	0.050	0.790	<0.05	0.107	46.2	-	-	-	4.10	116	-	-
	04-Jul-2012	8.34	45.0	280	153	186	<6	183	<0.005	<0.01	0.630	<0.05	0.055	40.4	-	-	-	3.90	92.9	-	-
	01-Aug-2012	8.48	39.8	256	144	176	<6	172	<0.005	<0.01	0.600	<0.05	0.043	36.7	-	-	-	3.00	80.7	-	-
	29-Aug-2012	8.21	39.0	240	141	172	<6	161	<0.005	<0.01	0.570	<0.05	0.046	35.1	-	-	-	2.90	72.8	-	-
	12-Jun-2013	8.30	39.1	229	137	167	<6	162	<0.005	0.010	0.450	<0.05	0.023	37.2	-	-	-	2.30	66.0	-	-
	03-Jul-2013	8.39	36.5	216	132	161	<6	148	<0.005	<0.01	0.370	<0.05	0.025	33.0	-	-	-	2.20	62.3	-	-
	31-Jul-2013	8.41	33.9	200	124	151	<6	138	<0.005	<0.01	0.360	<0.05	0.029	30.2	-	-	-	2.00	56.7	-	-
	28-Aug-2013	8.46	31.1	186	122	149	<6	129	<0.005	<0.01	0.410	<0.05	0.024	28.2	-	-	-	1.70	50.0	-	-
	12-Jun-2014	8.30	36.2	204	131	160	6.00	149	<0.005	<0.01	0.330	<0.05	0.029	34.7	-	-	-	2.20	53.7	-	-
	09-Jul-2014	8.34	42.4	249	136	166	6.00	167	<0.005	0.350	0.840	<0.05	0.065	37.2	-	-	-	4.20	79.1	-	-
	07-Aug-2014	8.43	32.5	188	114	139	6.00	126	<0.005	0.010	0.660	<0.05	0.048	25.8	-	-	-	4.10	53.4	-	-
	03-Sep-2014	8.24	32.8	198	127	154	6.00	143	<0.005	0.010	0.500	<0.05	0.054	33.0	-	-	-	2.50	51.9	-	-
	10-Jun-2015	8.03	39.6	241	144	176	<6	165	<0.005	<0.01	0.370	<0.05	0.046	38.5	-	-	-	2.70	71.4	-	-
	08-Jul-2015	8.15	35.4	215	133	162	<6	149	<0.005	<0.01	0.440	<0.05	0.030	33.4	-	-	-	2.00	61.3	-	-
	29-Jul-2015	8.46	34.0	207	129	144	7.00	149	<0.005	0.030	0.520	<0.05	0.030	33.7	-	-	-	2.00	56.5	-	-
	02-Sep-2015	8.33	33.3	200	132	161	<6	145	<0.005	<0.01	0.350	<0.025	0.029	32.8	-	-	-	1.70	51.3	-	-
	08-Jun-2016	8.12	35.6	215	150	183	<6	157	<0.005	<0.01	0.340	<0.025	0.016	37.1	-	-	-	1.80	51.5	-	-
	06-Jul-2016	8.10	32.2	187	128	155	<6	142	<0.005	<0.01	0.330	<0.025	0.025	32.3	-	-	-	1.30	45.1	-	-
	10-Aug-2016	8.13	32.7	195	125	152	<6	144	<0.005	0.080	0.410	<0.025	0.032	31.9	-	-	-	2.00	52.2	-	-
	31-Aug-2016	8.20	29.9	172	119	146	<6	132	<0.005	<0.01	0.350	<0.025	0.017	29.1	-	-	-	1.70	40.2	-	-
	29-May-2017	8.25	34.5	201	135	165	<6	153	<0.005	<0.01	0.380	-	0.009	36.5	-	-	-	1.80	47.2	-	-
	29-Jun-2017	7.98	33.0	184	127	154	<6	143	<0.005	<0.01	0.310	-	0.012	33.6	-	-	-	1.60	42.4	-	-
	27-Jul-2017	8.16	28.7	166	117	143	<6	137	<0.005	<0.01	0.270	-	0.031	31.1	-	-	-	1.30	35.0	-	-
	30-Aug-2017	8.34	24.9	149	109	133	<6	119	<0.005	0.010	0.510	-	0.047	27.2	-	-	-	1.20	31.0	-	-
	30-May-2018	8.21	41.9	258	149	182	<6	177	<0.005	0.020	0.590	-	0.121	39.6	-	-	-	3.50	77.2	-	-
	27-Jun-2018	8.02	32.8	192	133	162	<6	145	<0.005	0.020	0.840	-	0.036	35.2	-	-	-	1.90	43.7	-	-
	07-Aug-2018	8.25	28.7	158	118	143	<6	124	0.0100	0.060	0.490	-	0.016	30.0	-	-	-	1.50	30.9	-	-
	22-Aug-2018	8.11	34.7	202	136	166	<6	146	<0.005	0.040	0.510	-	0.081	33.8	-	-	-	2.20	50.1	-	-
	29-May-2019	8.16	33.8	199	153	187	<7	152	<0.005	<0.01	0.330	-	0.027	38.8	-	-	-	1.70	38.7	-	-
	26-Jun-2019	7.97	31.2	176	129	158	<6	143	<0.005	0.010	0.520	-	0.017	35.9	-	-	-	1.50	34.9	-	-
	31-Jul-2019	8.10	29.0	162	128	157	<6	130	<0.005	<0.01	0.300	-	0.018	32.2	-	-	-	1.30	28.0	-	-
	28-Aug-2019	8.08	26.7	159	128	156	<6	124	<0.005	<0.01	0.260	-	0.011	29.5	-	-	-	3.40	26.0	-	-
	22-Jun-2020	8.09	43.4	260	150	183	<6	186	0.0240	0.110	1.100	-	0.101	42.4	-	-	-	4.20	81.2	-	-
	27-Jul-2020	8.35	30.6	176	119	146	<6	129	<0.005	0.090	0.670	-	0.087	28.0	-	-	-	2.00	43.0	-	-
	24-Aug-2020	8.29	28.0	166	121	148	<6	129	<0.005	<0.01	0.480	-	0.024	29.2	-	-	-	4.30	32.5	-	-
SMC-R2	04-Jul-2006	**9.40**	52.5	356	165	131	34.0	192	<0.05	<0.05	-	<0.05	0.120	32.5	42	25.8	5.8	6.60	140	-	-
	17-Jul-2006	**9.20**	38.4	236	128	112	22.0	157	<0.05	<0.05	-	<0.05	0.030	29.4	22	17.9	3.1	3.30	78.40	-	-
	14-Aug-2006	**9.90**	44.7	278	143	61	56.0	152	<0.05	<0.05	-	<0.05	0.270	24.9	38	20.7	5.2	4.40	92.80	-	-
	28-Aug-2006	**9.90**	42.6	256	134	59	51.0	140	<0.05	<0.05	-	<0.05	0.540	20.6	38	20.5	5.6	4.70	86.50	-	-
	25-Jun-2007	**9.10**	47.9	294	148	140	20.0	172	<0.05	<0.05	-	<0.05	0.050	27.0	37	24.0	4.9	3.90	104	-	-
	09-Jul-2007	**9.60**	42.5	289	146	101	38.0	183	<0.05	<0.05	-	<0.05	0.070	25.9	38	24.0	4.2	3.60	102	-	-
	07-Aug-2007	**9.60**	45.8	298	138	87	40.0	176	<0.05	<0.05	-	<0.05	0.240	24.8	38	22.8	5.1	3.70	97.00	-	-
	20-Aug-2007	**9.20**	45.5	296	159	86	53.0	150	<0.05	<0.05	-	**0.1600**	0.250	22.6	36	21.6	4.7	3.90	96.30	-	-

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic

1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-

1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
1i. Value (i) Concentration is less than guidelines

2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
4a. Nitrite-N guidelines are chloride dependent.
4b. Total ammonia concentrations are pH and temperature dependent.
4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SMC-R3	04-Jul-2006	8.90	40.5	249.0	131.00	136.00	12.00	157.0	<0.05	<0.05	-	<0.05	0.0300	30.0	23.00	18.90	3.50	3.60	89.00	-	-
	17-Jul-2006	9.90	49.8	314.0	152.00	67.00	58.00	182.0	<0.05	0.0600	-	<0.05	0.2300	29.9	40.00	23.30	5.20	5.20	111.00	-	-
	14-Aug-2006	9.30	37.5	224.0	120.00	98.00	23.00	137.0	**0.140**	<0.05	-	<0.05	0.0400	24.5	23.00	17.80	3.50	3.00	76.70	-	-
	28-Aug-2006	9.20	41.0	246.0	135.00	118.00	23.00	154.0	<0.05	<0.05	-	<0.05	0.0900	27.9	27.00	20.20	4.30	3.90	81.10	-	-
	25-Jun-2007	8.50	35.8	211.0	137.00	156.00	5.00	151.0	<0.05	<0.05	-	<0.05	<0.02	32.7	17.00	16.00	2.20	1.90	56.50	-	-
	09-Jul-2007	8.00	33.7	225.0	155.00	189.00	<5	183.0	<0.05	<0.05	-	<0.05	<0.02	40.8	16.00	16.00	2.00	1.80	50.50	-	-
	07-Aug-2007	8.00	33.6	218.0	132.00	161.00	<5	149.0	<0.05	<0.05	-	<0.05	<0.02	28.9	16.00	15.70	2.20	1.90	51.90	-	-
	20-Aug-2007	9.00	45.3	294.0	144.00	82.00	46.00	161.0	<0.05	<0.05	-	<0.05	0.1200	26.5	30.00	22.10	4.40	3.70	107.00	-	-
	06-Jul-2011	8.67	57.8	360.0	173.00	184.00	14.00	225.0	0.020	0.0050	1.090	<0.05	0.1900	47.8	-	-	-	8.10	128.00	-	-
	20-Jul-2011	8.51	51.1	323.0	165.00	201.00	<6	201.0	0.030	<0.005	0.760	<0.05	0.1400	44.5	-	-	-	6.70	111.00	-	-
	10-Aug-2011	8.68	54.1	342.0	168.00	179.00	12.00	217.0	0.060	0.0140	1.240	<0.05	0.2600	46.1	-	-	-	6.40	118.00	-	-
	31-Aug-2011	8.80	63.1	402.0	203.00	217.00	15.00	238.0	0.030	<0.005	1.920	<0.05	0.4400	47.9	-	-	-	9.20	137.00	-	-
	06-Jun-2012	8.33	82.6	572.0	230.00	280.00	<6	337.0	0.050	<0.005	1.350	<0.05	0.2430	69.3	-	-	-	11.30	237.00	-	-
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	8.36	57.8	385.0	166.00	203.00	<6	250.0	0.070	<0.005	0.710	<0.05	0.0710	56.3	-	-	-	5.60	158.00	-	-
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	8.46	40.2	256.0	145.00	177.00	<6	170.0	<0.01	<0.005	0.520	<0.05	0.0440	36.2	-	-	-	3.00	81.70	-	-
	29-Aug-2012	8.29	37.6	235.0	137.00	167.00	<6	157.0	<0.01	<0.005	0.460	<0.05	0.0480	34.4	-	-	-	3.00	71.60	-	-
	12-Jun-2013	8.30	38.6	233.0	149.00	181.00	<6	159.0	<0.01	<0.005	0.390	<0.05	0.0270	36.4	-	-	-	2.20	64.60	-	-
	03-Jul-2013	8.52	37.0	215.0	130.00	158.00	<6	147.0	0.010	<0.005	0.340	<0.05	0.0350	32.8	-	-	-	2.30	63.10	-	-
	31-Jul-2013	8.70	33.0	198.0	122.00	127.00	11.00	136.0	<0.01	<0.005	0.380	<0.05	0.0340	29.6	-	-	-	2.00	55.80	-	-
	28-Aug-2013	8.63	30.6	184.0	119.00	130.00	8.00	127.0	<0.01	<0.005	0.430	<0.05	0.0250	27.2	-	-	-	1.90	50.10	-	-
	12-Jun-2014	8.29	36.2	205.0	132.00	161.00	6.00	149.0	<0.01	<0.005	0.300	0.2200	0.0350	35.0	-	-	-	3.10	52.50	-	-
	09-Jul-2014	8.37	35.5	205.0	130.00	159.00	6.00	144.0	<0.01	<0.005	0.510	<0.05	0.0500	32.8	-	-	-	2.50	54.40	-	-
	07-Aug-2014	8.32	21.5	181.0	109.00	133.00	6.00	123.0	<0.01	<0.005	0.810	<0.05	0.0660	24.8	-	-	-	2.40	52.30	-	-
	03-Sep-2014	8.23	31.8	195.0	129.00	157.00	6.00	140.0	0.030	<0.005	0.550	<0.05	0.0610	32.3	-	-	-	2.20	48.50	-	-
	10-Jun-2015	8.01	38.9	233.0	136.00	166.00	<6	160.0	<0.01	<0.005	0.490	<0.05	0.0420	37.0	-	-	-	2.70	70.20	-	-
	08-Jul-2015	8.06	35.1	210.0	131.00	160.00	<6	145.0	<0.01	<0.005	0.370	<0.05	0.0300	33.0	-	-	-	2.10	59.80	-	-
	29-Jul-2015	9.23	31.8	200.0	125.00	105.00	23.00	142.0	0.020	<0.005	0.380	<0.05	0.0360	32.0	-	-	-	2.10	54.10	-	-
	02-Sep-2015	8.35	33.2	199.0	132.00	161.00	<6	146.0	<0.01	<0.005	0.310	<0.025	0.0250	33.1	-	-	-	1.80	50.80	-	-
	08-Jun-2016	8.12	35.7	211.0	145.00	176.00	<6	156.0	0.010	<0.005	0.400	0.0310	0.0230	36.8	-	-	-	2.00	50.90	-	-
	06-Jul-2016	8.06	31.9	188.0	131.00	160.00	<6	141.0	<0.01	<0.005	0.330	<0.025	0.0330	32.0	-	-	-	1.40	44.40	-	-
	10-Aug-2016	8.13	29.8	172.0	119.00	146.00	<6	132.0	0.020	<0.005	0.370	<0.025	0.0330	29.3	-	-	-	1.60	39.80	-	-
	31-Aug-2016	8.10	30.0	173.0	123.00	150.00	<6	133.0	0.010	<0.005	0.430	<0.025	0.0260	29.2	-	-	-	1.70	39.00	-	-
	29-May-2017	8.17	34.3	196.0	129.00	157.00	<6	151.0	<0.01	<0.005	0.740	-	0.0090	36.0	-	-	-	1.80	47.10	-	-
	29-Jun-2017	8.05	32.6	185.0	132.00	161.00	<6	140.0	<0.01	<0.005	0.280	-	0.0150	33.0	-	-	-	1.50	41.30	-	-
	27-Jul-2017	8.20	28.7	166.0	118.00	143.00	<6	136.0	0.010	<0.005	0.280	-	0.0250	30.8	-	-	-	1.30	35.10	-	-
	30-Aug-2017	8.30	25.3	161.0	128.00	156.00	<6	120.0	0.010	<0.005	0.650	-	0.0560	27.2	-	-	-	1.30	31.10	-	-
	30-May-2018	8.32	72.3	477.0	192.00	234.00	<6	272.0	<0.01	<0.005	0.880	-	0.1590	49.2	-	-	-	8.80	200.00	-	-
	27-Jun-2018	8.18	50.4	308.0	157.00	191.00	<6	200.0	0.030	<0.005	0.820	-	0.0810	41.9	-	-	-	4.60	107.00	-	-
	25-Jul-2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2018	8.27	28.8	158.0	118.00	144.00	<6	124.0	**0.110**	0.0240	0.540	-	0.0230	29.8	-	-	-	1.50	30.60	-	-
	22-Aug-2018	8.41	64.8	400.0	183.00	223.00	<6	239.0	**0.100**	<0.005	1.600	-	0.3490	46.2	-	-	-	7.40	151.00	-	-
	29-May-2019	8.35	33.5	196.0	151.00	184.00	<7	151.0	<0.01	<0.005	0.340	-	0.0060	38.4	-	-	-	1.70	37.90	-	-
	26-Jun-2019	8.08	31.3	174.0	128.00	155.00	<6	137.0	0.010	<0.005	0.370	-	0.0380	34.4	-	-	-	1.50	35.90	-	-
	31-Jul-2019	8.10	29.0	164.0	130.00	159.00	<6	134.0	0.010	<0.005	0.370	-	0.0210	33.0	-	-	-	1.30	28.00	-	-
	28-Aug-2019	8.13	26.6	153.0	123.00	150.00	<6	124.0	<0.01	<0.005	0.270	-	0.0060	29.6	-	-	-	1.10	26.00	-	-
	22-Jun-2020	8.25	30.3	172.0	127.00	155.00	<6	136.0	<0.01	<0.005	0.350	-	0.0310	32.2	-	-	-	1.70	34.90	-	-
	27-Jul-2020	8.36	27.8	161.0	118.00	144.00	<6	121.0	<0.01	<0.005	0.560	-	0.0430	26.9	-	-	-	1.70	34.00	-	-
	24-Aug-2020	8.43	27.5	159.0	118.00	144.00	<6	127.0	0.010	<0.005	0.320	-	0.0210	28.7	-	-	-	1.40	31.80	-	-
SMC-R4	04-Jul-2006	8.60	36.2	211.0	131.00	148.00	6.00	156.0	<0.05	<0.05	-	<0.05	<0.02	35.5	18.0	15.7	2.0	2.10	58.00	-	-
	17-Jul-2006	8.60	32.5	191.0	128.00	143.00	7.00	150.0	<0.05	<0.05	-	<0.05	<0.02	35.1	13.0	13.7	1.6	1.50	46.80	-	-
	14-Aug-2006	8.70	27.7	155.0	117.00	129.00	7.00	123.0	<0.05	<0.05	-	<0.05	<0.02	28.0	10.0	12.0	1.4	1.10	30.60	-	-
	28-Aug-2006	8.60	27.5	152.0	121.00	137.00	5.00	124.0	<0.05	<0.05	-	<0.05	<0.02	28.9	9.0	12.2	1.3	0.90	27.20	-	-
	25-Jun-2007	8.40	29.1	173.0	129.00	152.00	<5	130.0	<0.05	<0.05	-	<0.05	<0.02	30.6	11.0	12.5	1.1	0.90	39.20	-	-
	09-Jul-2007	7.80	29.6	183.0	150.00	183.00	<5	127.0	<0.05	<0.05	-	<0.05	<0.02	30.3	11.0	13.0	1.3	1.00	35.80	-	-
	07-Aug-2007	8.70	28.1	183.0	119.00	132.00	7.00	140.0	<0.05	<0.05	-	<0.05	<0.02	31.9	9.0	12.1	1.2	0.90	29.40	-	-
	20-Aug-2007	7.40	27.2	177.0	137.00	167.00	<5	123.0	<0.05	<0.05	-	<0.05	0.0200	29.3	8.0	11.3	1.2	1.00	27.20	-	-
	06-Jul-2011	8.32	53.8	339.0	156.00	191.00	<6	210.0	0.010	<0.005	0.680	<0.05	0.0500	46.7	-	-	-	5.20	128.00	-	-
	20-Jul-2011	8.20	44.7	273.0	146.00	178.00	<6	180.0	0.030	<0.005	0.460	<0.05	<0.05	42.1	-	-	-	3.20	90.00	-	-
	10-Aug-2011	8.46	37.3	225.0	138.00	168.00	<6	160.0	<0.01	<0.005	0.390	<0.05	<0.05	37.3	-	-	-	1.90	64.00	-	-
	31-Aug-2011	8.27	32.5	195.0	135.00	165.00	<6	140.0	0.010	<0.005	0.290	<0.05	<0.05	32.3	-	-	-	2.40	47.50	-	-
	06-Jun-2012	8.19	35.3	220.0	137.00	168.00	<6	160.0	<0.01	<0.005	0.330	<0.05	0.0190	37.8	-	-	-	1.90	60.80	-	-
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	8.52	35.4	231.0	141.00	172.00	<6	160.0	<0.01	<0.005	0.370	<0.05	0.0210	36.5	-	-	-	2.40	67.00	-	-
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	8.44	28.9	180.0	131.00	159.00	<6	137.0	<0.01	<0.005	0.290	<0.05	0.0180	32.4	-	-	-	1.10	40.00	-	-
	29-Aug-2012	8.29	29.9	178.0	122.00	148.00	<6	134.0	<0.01	<0.005	0.250	<0.05	0.0150	32.6	-	-	-	1.30	42.90	-	-
	12-Jun-2013	8.39	30.2	169.0	117.00	142.00	<6	130.0	<0.01	<0.005	0.240	<0.05	0.0130	30.1	-	-	-	1.10	40.60	-	-
	24-Jun-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Jul-2013	8.32	28.0	175.0	130.00	159.00	<6	133.0	<0.01	<0.005	0.340	<0.05	0.0290	32.6	-	-	-	1.40	36.60	-	-
	31-Jul-2013	8.27	27.4	158.0	118.00	144.00	<6	123.0	<0.01	<0.005	0.220	<0.05	0.0150	29.9	-	-	-	1.10	32.90	-	-
	26-Aug-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Aug-2013	8.25	26.0	150.0	121.00	147.00	<6	119.0	<0.01	<0.005	0.220	<0.05	0.0140	29.0	-	-	-	0.90	28.00	-	-
	12-Jun-2014	8.26	34.2	192.0	130.00	158.00	6.00	147.0	<0.01	<0.005	0.220	<0.05	0.0380	35.4	-	-	-	1.90	45.90	-	-
	09-Jul-2014	8.31	35.5	214.0	135.00	164.00	6.00	152.0	0.020	<0.005	0.410	<0.05	0.0970	36.6	-	-	-	2.70	56.70	-	-
	21-Jul-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2014	8.34	34.6	181.0	129.00	158.00	6.00	137.0	<0.01	<0.005	0.400	<0.05	0.0480	33.6	-	-	-	1.50	39.70	-	-
	25-Aug-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Sep-2014	8.26	27.5	167.0	129.00	157.00	6.00	129.0	<0.01	<0.005	0.300	<0.05	0.0230	32.3	-	-	-	1.40	32.20	-	-
	10-Jun-2015	8.10	34.3	203.0	139.00	169.00	<6	155.0	<0.01	<0.005	0.310	<0.05	0.0490	37.8	-	-	-	1.40	48.40	-	-
	08-Jul-2015	8.18	30.7	181.0	132.00	160.00	<6	141.0	<0.01	<0.005	0.250	<0.05	0.0180	34.6	-	-	-	1.20	38.70	-	-
	20-Jul-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Jul-2015	8.41	27.5	157.0	123.00	149.00	<6	118.0	<0.01	<0.005	0.200	<0.05	0.0260	28.3	-	-	-	1.10	31.10	-	-
	24-Aug-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	02-Sep-2015	8.34	27.9	160.0	121.00	147.00	<6	137.0	<0.01	<0.005	0.180	<0.025	0.0110	33.0	-	-	-	0.80	29.50	-	-
	08-Sep-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08-Jun-2016	8.14	30.5	180.0	138.00	168.00	<6	143.0	<0.01	<0.005	0.300	<0.025	0.0300	34.3	-	-	-	1.20	35.50	-	-
	06-Jul-2016	7.96	27.4	160.0	122.00	148.00	<6	129.0	<0.01	<0.005	0.220	<0.025	0.0180	31.2	-	-	-	0.80	28.00	-	-
	10-Aug-2016	8.14	27.1	158.0	120.00	146.00	<6	130.0	0.020	<0.005	0.210	<0.025	0.0210	31.6	-	-	-	0.90	31.20	-	-
	31-Aug-2016	8.07	25.7	150.0	119.00	146.00	<6	125.0	<0.01	<0.005	0.170	<0.025	0.0070	30.6	-	-	-	0.90	24.00	-	-
	29-May-2017	8.14	30.7	176.0	130.00	158.00	<6	141.0	<0.01	<0.005	0.480	-	0.0050	35.1	-	-	-	1.30	35.50	-	-
	29-Jun-2017	8.03	26.6	148.0	115.00	141.00	<6	124.0	<0.01	<0.005	0.150	-	<0.005	30.7	-	-	-	0.80	26.00	-	-
	27-Jul-2017	8.11	25.5	148.0	118.00	144.00	<6	130.0	<0.01	<0.005	0.160	-	0.0220	32.0	-	-	-	0.90	23.00	-	-
	30-Aug-2017	8.36	20.8	122.0	107.00	130.00	<6	108.0	<0.01	<0.005	0.280	-	0.0110	27.1	-	-	-	0.60	15.00	-	-
	30-May-2018	8.26	37.9	230.0	143.00	175.00	<6	160.0	<0.01	<0.005	0.340	-	0.0300	38.7	-	-	-	2.10	63.20	-	-
	27-Jun-2018	7.98	26.8	159.0	128.00	156.00	<6	128.0	<0.01	<0.005	0.240	-	0.0230	32.2	-	-	-	1.00	26.00	-	-
	25-Jul-2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2018	8.23	25.9	141.0	116.00	141.00	<6	118.0	<0.01	<0.005	0.240	-	0.0160	29.7	-	-	-	0.90	22.00	-	-
	22-Aug-2018	8.14	24.5	138.0	116.00	142.00	<6	119.0	<0.01	<0.005	0.180	-	0.0200	30.5	-	-	-	0.80	19.00	-	-
	29-May-2019	8.22	37.2	217.0	141.00	172.00	<7	151.0	<0.01	<0.005	0.780	-	0.0120	36.7	-	-	-	2.00	57.10	-	-
	26-Jun-2019	8.09	31.3	182.0	134.00	164.00	<6	138.0	<0.01	<0.005	0.220	-	0.0120	34.4	-	-	-	1.40	37.60	-	-
	31-Jul-2019	8.15	25.4	141.0	123.00	150.00	<6	123.0	<0.01	<0.005	0.180	-	0.0090	31.4	-	-	-	1.00	17.00	-	-
	28-Aug-2019	8.09	24.5	133.0	114.00	139.00	<6	121.0	<0.01	<0.005	0.140	-	0.0060	29.9	-	-	-	0.70	16.00	-	-
	22-Jun-2020	8.18	30.8	175.0	136.00	165.00	<6	144.0	<0.01	<0.005	0.240	-	0.0210	34.7	-	-	-	1.30	31.90	-	-
	27-Jul-2020	8.20	30.7	173.0	128.00	156.00	<6	134.0	<0.01	<0.005	0.880	-	0.0160	33.0	-	-	-	1.90	34.50	-	-
	24-Aug-2020	8.25	24.7	142.0	123.00	150.00	<6	122.0	<0.01	<0.005	0.190	-	0.0120	30.1	-	-	-	0.70	19.00	-	-

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SMC-S1	04-Jul-2006	8.60	33.9	205.0	129.00	143.00	7.00	148.0	<0.05	<0.05	-	<0.05	<0.02	33.0	16.00	15.20	2.10	2.70	57.10	-	-
	17-Jul-2006	8.50	34.1	201.0	126.00	142.00	5.00	148.0	<0.05	<0.05	-	<0.05	0.0200	32.7	16.00	14.40	1.90	4.50	53.10	-	-
	14-Aug-2006	8.40	33.4	188.0	124.00	144.00	<5	135.0	<0.05	<0.05	-	<0.05	<0.02	29.2	16.00	14.10	2.00	2.00	48.30	-	-
	28-Aug-2006	8.50	33.1	189.0	128.00	145.00	5.00	138.0	<0.05	<0.05	-	<0.05	0.0300	30.4	16.00	14.30	2.10	2.00	46.80	-	-
	25-Jun-2007	8.40	34.0	203.0	133.00	156.00	<5	143.0	<0.05	<0.05	-	<0.05	<0.02	31.6	16.00	14.90	1.90	1.90	53.80	-	-
	09-Jul-2007	8.20	33.0	220.0	153.00	186.00	<5	178.0	<0.05	<0.05	-	<0.05	<0.02	40.4	17.00	15.30	1.90	1.70	49.30	-	-
	07-Aug-2007	7.90	32.0	208.0	128.00	156.00	<5	147.0	<0.05	<0.05	-	<0.05	0.0200	29.7	14.00	14.40	1.80	1.60	44.60	-	-
	20-Aug-2007	7.60	32.4	211.0	143.00	175.00	<5	131.0	<0.05	<0.05	-	<0.05	0.0300	28.7	14.00	13.70	1.60	1.70	43.70	-	-
	06-Jul-2011	8.35	37.6	229.0	126.00	153.00	<6	146.0	0.070	0.0200	0.580	<0.05	0.2800	30.4	-	-	-	5.90	71.70	-	-
	20-Jul-2011	8.21	43.8	279.0	142.00	173.00	<6	203.0	0.020	<0.005	0.540	0.0600	<0.05	45.0	-	-	-	6.90	88.90	-	-
	10-Aug-2011	8.48	44.3	268.0	142.00	160.00	6.00	182.0	<0.01	<0.005	0.480	<0.05	<0.05	40.6	-	-	-	4.00	88.40	-	-
	31-Aug-2011	8.34	43.7	267.0	147.00	180.00	<6	175.0	0.020	<0.005	0.580	<0.05	<0.05	38.2	-	-	-	6.00	84.30	-	-
	06-Jun-2012	8.30	43.8	282.0	149.00	182.00	<6	187.0	<0.01	<0.005	0.510	<0.05	0.0180	42.2	-	-	-	4.20	93.30	-	-
	04-Jul-2012	8.54	42.4	274.0	152.00	186.00	<6	182.0	<0.01	<0.005	0.750	<0.05	0.0280	40.2	-	-	-	3.30	88.80	-	-
	01-Aug-2012	8.71	39.6	249.0	140.00	152.00	9.00	161.0	<0.01	<0.005	0.490	<0.05	0.0190	35.8	-	-	-	3.00	80.60	-	-
	29-Aug-2012	8.41	37.2	233.0	135.00	165.00	<6	156.0	0.030	<0.005	0.460	<0.05	0.0320	34.1	-	-	-	2.70	71.70	-	-
	12-Jun-2013	8.47	37.8	230.0	144.00	175.00	<6	158.0	<0.01	<0.005	0.320	<0.05	0.0080	36.3	-	-	-	2.10	64.90	-	-
	03-Jul-2013	8.62	36.1	212.0	130.00	143.00	8.00	144.0	<0.01	<0.005	0.330	<0.05	0.0070	32.2	-	-	-	2.20	61.20	-	-
	31-Jul-2013	8.46	32.8	196.0	122.00	148.00	<6	133.0	<0.01	<0.005	0.360	<0.05	0.0370	29.2	-	-	-	2.20	56.80	-	-
	28-Aug-2013	8.59	30.5	182.0	120.00	132.00	7.00	125.0	<0.01	<0.005	0.400	<0.05	0.0190	27.1	-	-	-	1.80	48.40	-	-
	12-Jun-2014	8.35	35.7	201.0	128.00	156.00	6.00	147.0	<0.01	<0.005	0.350	<0.05	0.0180	34.3	-	-	-	2.30	53.70	-	-
	09-Jul-2014	8.54	34.8	204.0	130.00	158.00	6.00	142.0	<0.01	<0.005	0.330	<0.05	0.0290	32.6	-	-	-	2.40	55.10	-	-
	07-Aug-2014	8.70	32.5	189.0	121.00	134.00	7.00	126.0	<0.01	<0.005	0.590	<0.05	0.0210	26.9	-	-	-	2.40	52.30	-	-
	03-Sep-2014	8.42	33.9	200.0	138.00	169.00	6.00	138.0	<0.01	<0.005	0.480	<0.05	0.0660	31.7	-	-	-	2.20	49.30	-	-
	10-Jun-2015	8.22	38.2	236.0	141.00	172.00	<6	161.0	<0.01	<0.005	0.330	<0.05	0.0140	37.4	-	-	-	2.50	70.20	-	-
	08-Jul-2015	8.36	34.1	205.0	125.00	152.00	<6	145.0	<0.01	<0.005	0.350	<0.05	0.0080	32.9	-	-	-	2.00	59.00	-	-
	29-Jul-2015	8.48	32.9	201.0	126.00	142.00	6.00	144.0	<0.01	<0.005	0.300	<0.05	0.0190	32.3	-	-	-	2.00	54.30	-	-
	02-Sep-2015	8.61	32.5	194.0	126.00	139.00	7.00	144.0	<0.01	<0.005	0.340	<0.025	0.0270	32.9	-	-	-	1.70	50.60	-	-
	08-Jun-2016	8.33	34.3	207.0	142.00	173.00	<6	152.0	<0.01	<0.005	0.300	<0.025	<0.005	35.6	-	-	-	1.80	50.70	-	-
	06-Jul-2016	8.24	31.4	187.0	130.00	158.00	<6	140.0	<0.01	<0.005	0.350	<0.025	0.0070	32.0	-	-	-	1.20	44.70	-	-
	10-Aug-2016	8.14	29.4	172.0	119.00	145.00	<6	131.0	<0.01	<0.005	0.300	<0.025	0.0220	29.2	-	-	-	1.50	39.90	-	-
	31-Aug-2016	8.31	29.4	170.0	119.00	145.00	<6	132.0	<0.01	<0.005	0.360	<0.025	0.0120	29.0	-	-	-	1.70	38.60	-	-
	29-May-2017	8.30	34.1	195.0	130.00	158.00	<6	150.0	<0.01	<0.005	0.590	-	<0.005	35.9	-	-	-	1.60	46.40	-	-
	29-Jun-2017	8.13	32.1	181.0	125.00	152.00	<6	142.0	<0.01	<0.005	0.260	-	0.0090	33.4	-	-	-	1.40	41.30	-	-
	27-Jul-2017	8.26	28.4	164.0	118.00	144.00	<6	133.0	<0.01	<0.005	0.260	-	0.0250	30.0	-	-	-	1.40	34.30	-	-
	30-Aug-2017	8.39	25.0	156.0	121.00	148.00	<6	120.0	0.010	<0.005	0.500	-	0.0420	27.7	-	-	-	1.20	30.60	-	-
	30-May-2018	8.16	30.8	179.0	128.00	156.00	<6	140.0	<0.01	<0.005	0.370	-	0.0150	34.8	-	-	-	1.80	37.40	-	-
	27-Jun-2018	8.54	30.1	177.0	127.00	123.00	16.00	137.0	<0.01	<0.005	0.220	-	0.0140	33.9	-	-	-	1.60	36.80	-	-
	25-Jul-2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2018	8.43	28.2	156.0	115.00	126.00	7.00	122.0	0.020	<0.005	0.470	-	0.0070	29.4	-	-	-	1.50	30.80	-	-
	22-Aug-2018	8.17	27.8	154.0	116.00	142.00	<6	124.0	0.030	0.0100	0.470	-	0.0420	30.6	-	-	-	1.30	29.00	-	-
	29-May-2019	8.40	32.7	189.0	144.00	175.00	<7	146.0	<0.01	<0.005	0.370	-	0.0230	37.3	-	-	-	1.80	36.90	-	-
	26-Jun-2019	8.36	30.8	182.0	141.00	172.00	<6	140.0	<0.01	<0.005	0.310	-	0.0130	35.0	-	-	-	1.40	35.10	-	-
	31-Jul-2019	8.27	28.2	159.0	125.00	153.00	<6	129.0	<0.01	<0.005	0.250	-	0.0150	31.9	-	-	-	1.20	27.00	-	-
	28-Aug-2019	8.30	26.5	150.0	119.00	145.00	<6	124.0	<0.01	<0.005	0.290	-	0.0170	29.6	-	-	-	1.10	25.00	-	-
	22-Jun-2020	8.32	30.0	175.0	132.00	161.00	<6	137.0	<0.01	<0.005	0.290	-	0.0150	32.5	-	-	-	1.60	34.80	-	-
	27-Jul-2020	8.92	27.5	158.0	111.00	110.00	13.00	124.0	<0.01	<0.005	0.520	-	0.0530	27.8	-	-	-	1.60	34.40	-	-
	24-Aug-2020	8.68	27.5	161.0	122.00	135.00	7.00	127.0	<0.01	<0.005	0.330	-	0.0190	28.8	-	-	-	1.40	31.90	-	-
SMC-S2	04-Jul-2006	8.70	36.6	226.0	132.00	145.00	8.00	152.0	<0.05	<0.05	-	<0.05	<0.02	32.0	19.00	16.90	2.70	3.20	71.40	-	-
	17-Jul-2006	8.60	35.8	209.0	128.00	142.00	7.00	153.0	<0.05	<0.05	-	<0.05	0.0300	32.7	17.00	15.60	2.10	2.90	57.30	-	-
	14-Aug-2006	8.40	35.5	202.0	127.00	149.00	<5	139.0	<0.05	<0.05	-	<0.05	0.0200	28.8	18.00	15.70	2.60	2.40	56.90	-	-
	28-Aug-2006	8.50	36.9	211.0	132.00	150.00	5.00	142.0	<0.05	<0.05	-	<0.05	0.0700	28.8	20.00	16.90	3.00	2.60	60.40	-	-
	25-Jun-2007	8.40	42.5	261.0	142.00	166.00	<5	174.0	<0.05	<0.05	-	<0.05	<0.02	35.4	24.00	19.80	3.40	2.70	88.90	-	-
	09-Jul-2007	8.00	40.6	270.0	163.00	199.00	<5	200.0	<0.05	<0.05	-	<0.05	0.0200	41.7	24.00	19.70	3.30	2.60	79.10	-	-
	07-Aug-2007	8.00	39.0	254.0	134.00	164.00	<5	166.0	<0.05	<0.05	-	<0.05	0.0400	30.0	21.00	18.00	3.00	2.50	73.30	-	-
	20-Aug-2007	7.90	41.1	267.0	148.00	181.00	<5	154.0	<0.05	<0.05	-	<0.05	0.1000	29.2	23.00	19.60	3.40	2.90	81.30	-	-
	06-Jul-2011	8.32	45.9	286.0	154.00	188.00	<6	188.0	<0.01	<0.005	0.670	<0.05	0.0800	42.1	-	-	-	6.20	92.70	-	-
	20-Jul-2011	8.17	51.3	280.0	159.00	194.00	<6	179.0	<0.01	<0.005	0.780	<0.05	0.1500	41.7	-	-	-	7.10	86.80	-	-
	10-Aug-2011	8.77	54.6	346.0	167.00	175.00	14.00	218.0	<0.01	<0.005	1.780	<0.05	0.2300	45.9	-	-	-	6.00	124.00	-	-
	31-Aug-2011	8.89	61.9	395.0	191.00	194.00	19.00	236.0	0.050	<0.005	2.040	<0.05	0.4600	47.0	-	-	-	10.10	138.00	-	-
	06-Jun-2012	8.24	49.1	326.0	171.00	208.00	<6	208.0	<0.01	<0.005	0.710	<0.05	0.0530	46.0	-	-	-	5.00	111.00	-	-
	04-Jul-2012	8.35	43.1	273.0	149.00	182.00	<6	181.0	<0.01	<0.005	0.550	<0.05	0.0350	40.4	-	-	-	3.70	89.50	-	-
	01-Aug-2012	8.66	39.2	253.0	142.00	158.00	8.00	169.0	<0.01	<0.005	0.480	<0.05	0.0190	36.3	-	-	-	2.90	80.10	-	-
	29-Aug-2012	8.39	37.3	232.0	135.00	165.00	<6	158.0	<0.01	<0.005	0.390	<0.05	0.0250	34.6	-	-	-	2.70	70.30	-	-
	12-Jun-2013	8.40	37.9	224.0	134.00	163.00	<6	158.0	<0.01	<0.005	0.350	<0.05	0.0080	36.4	-	-	-	2.20	64.70	-	-
	03-Jul-2013	8.52	36.1	216.0	131.00	160.00	<6	148.0	<0.01	<0.005	0.280	<0.05	0.0430	33.2	-	-	-	2.20	62.20	-	-
	31-Jul-2013	8.35	33.3	197.0	123.00	150.00	<6	137.0	<0.01	<0.005	0.340	<0.05	0.0870	30.2	-	-	-	2.00	55.30	-	-
	28-Aug-2013	8.54	30.8	186.0	124.00	138.00	6.00	128.0	<0.01	<0.005	0.460	<0.05	0.0190	27.8	-	-	-	1.80	48.90	-	-
	12-Jun-2014	8.34	35.5	202.0	129.00	157.00	6.00	144.0	0.020	<0.005	0.250	<0.05	0.0260	33.6	-	-	-	2.10	55.10	-	-
	09-Jul-2014	8.58	34.8	204.0	129.00	143.00	7.00	144.0	<0.01	<0.005	0.410	<0.05	0.0390	33.2	-	-	-	2.30	54.90	-	-
	07-Aug-2014	8.71	31.7	183.0	113.00	122.00	8.00	124.0	<0.01	<0.005	0.550	<0.05	0.0260	25.6	-	-	-	2.30	51.70	-	-
	03-Sep-2014	8.33	33.0	195.0	128.00	156.00	6.00	138.0	<0.01	<0.005	0.460	<0.05	0.0490	32.0	-	-	-	2.10	49.30	-	-
	10-Jun-2015	8.10	38.8	234.0	136.00	166.00	<6	161.0	<0.01	<0.005	0.300	<0.05	0.0220	37.6	-	-	-	2.70	70.70	-	-
	08-Jul-2015	8.26	34.2	210.0	134.00	163.00	<6	146.0	<0.01	<0.005	0.360	<0.05	0.0160	33.0	-	-	-	1.90	58.60	-	-
	29-Jul-2015	8.36	33.1	200.0	127.00	155.00	<6	142.0	<0.01	<0.005	0.370	<0.05	0.0190	32.1	-	-	-	2.10	53.80	-	-
	02-Sep-2015	8.48	32.7	196.0	128.00	156.00	<6	143.0	<0.01	<0.005	0.360	<0.025	0.0290	32.7	-	-	-	1.70	50.60	-	-
	08-Jun-2016	8.24	34.4	204.0	140.00	171.00	<6	149.0	<0.01	<0.005	0.330	<0.025	<0.005	34.9	-	-	-	1.70	50.30	-	-
	06-Jul-2016	8.07	30.1	193.0	142.00	173.00	<6	139.0	<0.01	<0.005	0.270	<0.025	0.0400	31.7	-	-	-	1.40	44.40	-	-
	10-Aug-2016	8.15	29.6	169.0	116.00	141.00	<6	130.0	<0.01	<0.005	0.330	<0.025	0.0110	28.7	-	-	-	1.50	39.80	-	-
	31-Aug-2016	8.27	29.7	173.0	125.00	153.00	<6	131.0	<0.01	<0.005	0.390	<0.025	0.0120	28.8	-	-	-	1.50	38.60	-	-
	29-May-2017	8.26	34.1	200.0	138.00	168.00	<6	150.0	<0.01	<0.005	0.360	-	0.0120	35.7	-	-	-	1.80	46.90	-	-
	29-Jun-2017	8.12	32.0	183.0	130.00	158.00	<6	142.0	<0.01	<0.005	0.240	-	0.0130	33.4	-	-	-	1.50	41.00	-	-
	27-Jul-2017	8.18	28.4	164.0	116.00	141.00	<6	136.0	<0.01	<0.005	0.240	-	0.0450	30.8	-	-	-	1.20	34.80	-	-
	30-Aug-2017	8.45	24.7	148.0	115.00	141.00	<6	118.0	<0.01	<0.005	0.600	-	0.0320	27.2	-	-	-	1.20	30.00	-	-
	30-May-2018	8.24	31.5	185.0	135.00	165.00	<6	142.0	<0.01	<0.005	0.400	-	0.0440	35.2	-	-	-	1.90	37.80	-	-
	27-Jun-2018	8.41	30.6	182.0	129.00	141.00	8.00	138.0	<0.01	<0.005	0.430	-	0.0340	34.1	-	-	-	1.70	37.90	-	-
	25-Jul-2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2018	8.35	28.2	155.0	115.00	140.00	<6	122.0	0.020	<0.005	0.490	-	0.0100	29.4	-	-	-	1.50	30.60	-	-
	22-Aug-2018	8.17	29.1	164.0	121.00	148.00	<6	128.0	0.030	0.0080	0.470	-	0.0400	31.3	-	-	-	1.50	32.50	-	-
	29-May-2019	8.31	33.0	188.0	140.00	171.00	<7	148.0	0.030	<0.005	0.470	-	0.0510	38.0	-	-	-	1.80	37.60	-	-
	26-Jun-2019	8.30	31.0	172.0	124.00	152.00	<6	137.0	<0.01	<0.005	0.270	-	0.0130	34.4	-	-	-	1.50	36.10	-	-
	31-Jul-2019	8.29	28.3	160.0	128.00	156.00	<6	128.0	<0.01	<0.005	0.240	-	0.0200	31.6	-	-	-	1.30	28.00	-	-
	28-Aug-2019	8.23	26.3	156.0	129.00	158.00	<6	124.0	<0.01	<0.005	0.310	-	0.0220	29.7	-	-	-	1.10	25.00	-	-
	22-Jun-2020	8.31	30.1	174.0	130.00	158.00	<6	137.0	<0.01	<0.005	0.270	-	0.0160	32.5	-	-	-	1.70	34.70	-	-
	27-Jul-2020	8.77	25.1	159.0	112.00	120.00	8.00	124.0	<0.01	<0.005	0.520	-	0.0320	28.1	-	-	-	1.60	34.40	-	-
	24-Aug-2020	8.52	27.4	162.0	122.00	149.00	<6	127.0	<0.01	<0.005	0.410	-	0.0280	29.0	-	-	-	1.30	31.70	-	-

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-

1i. Value (i) Concentration is less than guidelines

2. - no guideline

3. - data not recorded or analyzed

4. Guidelines dependent on other parameters are summarized below:

4a. Nitrite-N guidelines are chloride dependent.

4b. Total ammonia concentrations are pH and temperature dependent.

4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SMC-S3	04-Jul-2006	8.50	35.7	208.0	130.00	147.00	5.00	151.0	<0.05	<0.05	-	<0.05	0.0400	34.5	17.00	15.50	2.20	2.10	57.30	-	-
	17-Jul-2006	8.60	31.7	187.0	126.00	141.00	6.00	145.0	<0.05	<0.05	-	<0.05	0.0200	34.0	13.00	14.40	1.70	1.50	45.30	-	-
	14-Aug-2006	8.70	27.7	155.0	121.00	131.00	8.00	126.0	<0.05	<0.05	-	<0.05	<0.02	29.2	9.00	11.60	1.20	1.00	28.40	-	-
	28-Aug-2006	8.50	26.3	148.0	117.00	134.00	<5	122.0	<0.05	<0.05	-	<0.05	<0.02	28.5	8.00	11.90	1.30	0.90	25.60	-	-
	25-Jun-2007	8.40	28.1	158.0	120.00	141.00	<5	125.0	<0.05	<0.05	-	<0.05	0.0300	29.6	10.00	12.70	1.40	0.90	32.30	-	-
	09-Jul-2007	8.00	28.9	194.0	145.00	177.00	<5	171.0	<0.05	<0.05	-	<0.05	<0.02	28.9	11.00	13.20	1.40	1.00	34.90	-	-
	07-Aug-2007	8.40	27.0	176.0	121.00	141.00	<5	133.0	<0.05	<0.05	-	<0.05	<0.02	30.1	9.00	11.80	1.20	0.90	27.90	-	-
	20-Aug-2007	7.40	26.0	169.0	132.00	161.00	<5	115.0	<0.05	<0.05	-	<0.05	<0.02	27.1	7.00	11.50	1.10	0.80	26.10	-	-
	06-Jul-2011	8.23	52.6	336.0	159.00	194.00	<6	208.0	0.050	<0.005	0.630	<0.05	0.1100	46.6	-	-	-	5.20	125.00	-	-
	20-Jul-2011	8.36	44.0	267.0	143.00	175.00	<6	176.0	0.010	<0.005	0.390	<0.05	<0.05	41.2	-	-	-	3.20	88.20	-	-
	10-Aug-2011	8.62	36.1	217.0	133.00	143.00	9.00	154.0	<0.01	<0.005	0.390	<0.05	<0.05	35.6	-	-	-	2.00	62.40	-	-
	31-Aug-2011	8.36	31.5	185.0	124.00	152.00	<6	135.0	0.040	<0.005	0.340	<0.05	<0.05	31.2	-	-	-	2.40	45.30	-	-
	06-Jun-2012	8.30	33.8	219.0	146.00	178.00	<6	156.0	<0.01	<0.005	0.320	<0.05	0.0240	37.3	-	-	-	1.80	56.40	-	-
	04-Jul-2012	8.59	33.5	210.0	126.00	154.00	<6	153.0	<0.01	<0.005	0.380	<0.05	0.0260	35.2	-	-	-	2.10	60.40	-	-
	01-Aug-2012	8.61	27.7	166.0	114.00	127.00	6.00	132.0	<0.01	<0.005	0.310	**0.1900**	0.0150	31.3	-	-	-	1.10	38.10	-	-
	29-Aug-2012	8.43	29.2	181.0	131.00	159.00	<6	134.0	0.030	<0.005	0.240	<0.05	0.0090	32.5	-	-	-	1.30	41.10	-	-
	12-Jun-2013	8.73	27.9	169.0	117.00	126.00	8.00	131.0	<0.01	<0.005	0.310	<0.05	0.0070	31.4	-	-	-	1.10	39.20	-	-
	03-Jul-2013	8.33	28.0	164.0	117.00	142.00	<6	128.0	<0.01	<0.005	0.240	<0.05	0.0340	31.3	-	-	-	1.20	36.00	-	-
	31-Jul-2013	8.44	25.9	150.0	113.00	138.00	<6	119.0	<0.01	<0.005	0.300	<0.05	0.0230	28.8	-	-	-	1.00	30.00	-	-
	28-Aug-2013	8.39	25.0	140.0	117.00	142.00	<6	114.0	0.010	<0.005	0.220	<0.05	0.0110	27.7	-	-	-	0.90	25.00	-	-
	12-Jun-2014	8.42	33.1	186.0	126.00	154.00	6.00	142.0	<0.01	<0.005	0.240	<0.05	0.0150	34.0	-	-	-	1.70	44.60	-	-
	09-Jul-2014	8.56	35.6	209.0	130.00	147.00	6.00	147.0	**0.120**	0.0060	0.480	<0.05	0.1330	35.6	-	-	-	2.60	56.20	-	-
	07-Aug-2014	8.54	30.7	176.0	126.00	154.00	6.00	133.0	0.010	<0.005	0.440	<0.05	0.0430	32.6	-	-	-	1.50	38.60	-	-
	03-Sep-2014	8.53	27.4	156.0	122.00	149.00	6.00	127.0	<0.01	<0.005	0.210	0.0600	0.0230	31.7	-	-	-	1.10	27.50	-	-
	10-Jun-2015	8.38	31.4	187.0	133.00	162.00	<6	143.0	<0.01	<0.005	0.190	<0.05	0.0210	34.8	-	-	-	1.40	41.90	-	-
	08-Jul-2015	8.21	30.1	178.0	131.00	159.00	<6	139.0	<0.01	<0.005	0.220	<0.05	0.0240	33.9	-	-	-	1.10	37.80	-	-
	29-Jul-2015	8.52	26.4	150.0	112.00	121.00	8.00	128.0	0.020	<0.005	0.200	<0.05	0.0230	31.2	-	-	-	1.10	27.50	-	-
	02-Sep-2015	8.47	26.9	158.0	124.00	151.00	<6	133.0	<0.01	<0.005	0.170	<0.025	0.0120	32.1	-	-	-	0.80	27.50	-	-
	08-Jun-2016	8.10	29.2	172.0	129.00	157.00	<6	141.0	<0.01	<0.005	0.200	<0.025	<0.005	34.0	-	-	-	1.10	32.90	-	-
	06-Jul-2016	8.05	26.9	150.0	121.00	147.00	<6	127.0	<0.01	<0.005	0.150	<0.025	0.0130	30.9	-	-	-	0.70	28.00	-	-
	10-Aug-2016	8.27	23.7	130.0	107.00	130.00	<6	115.0	<0.01	<0.005	0.160	<0.025	0.0270	27.7	-	-	-	0.80	22.00	-	-
	31-Aug-2016	8.30	24.8	140.0	118.00	144.00	<6	120.0	<0.01	<0.005	0.200	<0.025	<0.005	29.1	-	-	-	1.00	23.00	-	-
	29-May-2017	8.32	29.9	170.0	121.00	148.00	<6	139.0	<0.01	<0.005	0.320	-	<0.005	34.7	-	-	-	1.40	34.80	-	-
	29-Jun-2017	7.98	26.1	148.0	118.00	144.00	<6	124.0	<0.01	<0.005	0.160	-	0.0080	30.7	-	-	-	1.00	25.00	-	-
	27-Jul-2017	8.09	25.0	141.0	112.00	137.00	<6	124.0	<0.01	<0.005	0.150	-	0.0200	30.3	-	-	-	0.80	23.00	-	-
	30-Aug-2017	8.49	20.8	125.0	115.00	140.00	<6	106.0	<0.01	<0.005	0.190	-	0.0070	26.6	-	-	-	0.60	14.00	-	-
	30-May-2018	8.37	36.9	225.0	140.00	170.00	<6	156.0	<0.01	<0.005	0.360	-	0.0500	37.3	-	-	-	2.10	62.10	-	-
	27-Jun-2018	8.09	35.7	217.0	132.00	161.00	<6	145.0	0.020	<0.005	0.380	-	0.0180	34.0	-	-	-	1.90	60.80	-	-
	25-Jul-2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2018	8.28	25.0	136.0	111.00	135.00	<6	115.0	<0.01	<0.005	0.340	-	0.0100	29.4	-	-	-	1.00	21.00	-	-
	22-Aug-2018	8.26	23.8	129.0	106.00	130.00	<6	115.0	<0.01	<0.005	0.160	-	0.0200	29.4	-	-	-	0.80	18.00	-	-
	29-May-2019	8.31	45.3	276.0	156.00	190.00	<7	165.0	0.050	<0.005	0.460	-	0.0110	37.6	-	-	-	3.10	88.50	-	-
	26-Jun-2019	8.21	29.7	173.0	135.00	164.00	<6	131.0	<0.01	<0.005	0.280	-	0.0160	32.5	-	-	-	1.20	33.60	-	-
	31-Jul-2019	8.25	27.1	151.0	122.00	149.00	<6	121.0	<0.01	<0.005	0.180	-	0.0110	30.0	-	-	-	1.20	26.00	-	-
	28-Aug-2019	8.22	23.6	128.0	110.00	134.00	<6	117.0	<0.01	<0.005	0.190	-	<0.005	29.2	-	-	-	0.70	15.00	-	-
	22-Jun-2020	8.35	29.5	171.0	134.00	164.00	<6	141.0	0.010	<0.005	0.220	-	0.0190	34.4	-	-	-	1.30	30.00	-	-
	27-Jul-2020	8.35	27.4	153.0	123.00	150.00	<6	123.0	<0.01	<0.005	0.250	-	0.0330	30.8	-	-	-	1.10	26.00	-	-
	24-Aug-2020	8.50	23.9	136.0	114.00	139.00	<6	119.0	<0.01	<0.005	0.190	-	0.0130	29.1	-	-	-	0.70	19.00	-	-
SME-P1	04-Jul-2006	8.60	34.6	209.0	125.00	138.00	7.00	149.0	<0.05	<0.05	-	<0.05	0.0200	33.1	18.00	14.80	2.40	2.10	60.70	-	-
	17-Jul-2006	8.60	35.2	209.0	122.00	136.00	6.00	148.0	<0.05	<0.05	-	<0.05	0.0200	31.9	18.00	15.00	2.20	2.30	63.30	-	-
	14-Aug-2006	8.90	31.9	182.0	112.00	115.00	11.00	124.0	<0.05	<0.05	-	<0.05	0.0300	24.5	17.00	14.20	2.20	1.90	52.50	-	-
	28-Aug-2006	8.90	30.2	170.0	110.00	116.00	9.00	116.0	<0.05	<0.05	-	<0.05	0.0400	22.5	16.00	13.70	2.10	1.70	47.40	-	-
	25-Jun-2007	8.50	30.6	181.0	108.00	123.00	<5	124.0	<0.05	<0.05	-	<0.05	<0.02	23.9	16.00	15.10	1.30	1.40	57.40	-	-
	09-Jul-2007	8.10	29.3	-	127.00	154.00	<5	-	<0.05	<0.05	-	<0.05	0.0300	29.5	16.00	15.30	1.50	1.50	52.00	-	-
	07-Aug-2007	8.90	28.7	187.0	113.00	114.00	12.00	131.0	<0.05	<0.05	-	<0.05	0.0300	24.6	14.00	13.80	1.70	1.30	41.10	-	-
	20-Aug-2007	7.80	32.7	213.0	134.00	163.00	<5	125.0	<0.05	<0.05	-	<0.05	0.1100	20.8	19.00	16.80	2.60	2.10	56.00	-	-
	06-Jul-2011	8.46	60.1	384.0	149.00	181.00	<6	226.0	<0.01	<0.005	0.700	<0.05	<0.05	49.4	-	-	-	7.40	162.00	-	-
	20-Jul-2011	8.45	60.2	378.0	146.00	178.00	<6	221.0	<0.01	<0.005	0.620	<0.05	<0.05	48.0	-	-	-	7.50	162.00	-	-
	10-Aug-2011	8.56	51.3	322.0	143.00	155.00	10.00	197.0	<0.01	<0.005	0.960	<0.05	0.0600	41.8	-	-	-	5.10	125.00	-	-
	31-Aug-2011	8.24	46.0	272.0	136.00	166.00	<6	173.0	0.020	<0.005	0.490	<0.05	<0.05	36.8	-	-	-	3.90	95.20	-	-
	06-Jun-2012	8.43	38.2	246.0	137.00	167.00	<6	163.0	<0.01	<0.005	0.350	<0.05	0.0180	34.7	-	-	-	2.40	81.20	-	-
	04-Jul-2012	8.67	35.0	215.0	112.00	123.00	6.00	144.0	<0.01	<0.005	0.560	<0.05	0.0410	29.0	-	-	-	2.20	74.90	-	-
	01-Aug-2012	8.67	34.8	220.0	117.00	129.00	7.00	142.0	<0.01	<0.005	0.600	<0.05	0.0530	28.6	-	-	-	2.40	74.10	-	-
	29-Aug-2012	8.28	34.2	205.0	122.00	148.00	<6	141.0	<0.01	<0.005	0.540	<0.05	0.0610	30.2	-	-	-	2.20	60.40	-	-
	12-Jun-2013	8.54	36.5	214.0	135.00	165.00	<6	158.0	<0.01	<0.005	0.420	<0.05	0.0140	37.4	-	-	-	1.50	59.00	-	-
	03-Jul-2013	8.75	30.4	189.0	117.00	127.00	8.00	129.0	<0.01	<0.005	0.350	<0.05	0.0210	27.9	-	-	-	1.70	54.80	-	-
	31-Jul-2013	8.43	30.3	178.0	114.00	139.00	<6	126.0	<0.01	<0.005	0.370	<0.05	0.0220	27.3	-	-	-	1.60	48.40	-	-
	28-Aug-2013	9.28	97.3	663.0	286.00	223.00	62.00	312.0	0.010	<0.005	2.300	<0.05	0.4100	48.7	-	-	-	11.60	261.00	-	-
	12-Jun-2014	8.47	36.6	209.0	128.00	156.00	6.00	148.0	<0.01	<0.005	0.600	<0.05	0.0300	34.8	-	-	-	2.40	59.90	-	-
	09-Jul-2014	8.72	33.9	199.0	114.00	119.00	10.00	132.0	<0.01	<0.005	0.470	<0.05	0.0440	27.8	-	-	-	2.60	60.90	-	-
	07-Aug-2014	8.19	34.1	191.0	112.00	137.00	6.00	126.0	<0.01	<0.005	0.830	0.1000	0.0830	25.7	-	-	-	3.00	56.90	-	-
	04-Sep-2014	8.20	32.2	190.0	119.00	145.00	6.00	134.0	0.030	0.0080	0.700	0.1900	0.0600	30.6	-	-	-	3.00	51.30	-	-
	11-Jun-2015	8.32	38.6	238.0	132.00	161.00	<6	163.0	<0.01	<0.005	0.310	<0.05	0.0170	37.2	-	-	-	2.20	77.10	-	-
	09-Jul-2015	8.18	34.0	205.0	127.00	155.00	<6	143.0	<0.01	<0.005	0.310	<0.05	0.0110	31.9	-	-	-	1.70	58.90	-	-
	30-Jul-2015	8.43	30.4	179.0	120.00	146.00	<6	129.0	<0.01	<0.005	0.360	<0.05	0.0200	28.8	-	-	-	1.60	45.90	-	-
	03-Sep-2015	8.47	28.3	166.0	120.00	146.00	<6	127.0	0.020	<0.005	0.380	<0.025	0.0360	28.8	-	-	-	1.20	36.40	-	-
	09-Jun-2016	8.33	30.7	198.0	142.00	173.00	<6	145.0	<0.01	<0.005	0.390	<0.025	<0.005	32.9	-	-	-	1.30	46.40	-	-
	07-Jul-2016	8.40	29.9	172.0	121.00	147.00	<6	132.0	<0.01	<0.005	0.530	<0.025	0.0110	28.6	-	-	-	1.30	40.80	-	-
	11-Aug-2016	8.11	28.1	167.0	128.00	156.00	<6	129.0	<0.01	<0.005	0.360	<0.025	0.0240	29.7	-	-	-	1.20	33.80	-	-
	01-Sep-2016	8.34	28.6	162.0	119.00	145.00	<6	133.0	<0.01	<0.005	0.540	<0.025	0.0190	31.2	-	-	-	0.60	32.70	-	-
	01-Jun-2017	8.24	32.3	176.0	125.00	152.00	<6	145.0	<0.01	<0.005	0.390	-	<0.005	34.5	-	-	-	1.40	36.00	-	-
	26-Jun-2017	8.43	30.9	173.0	113.00	138.00	<6	135.0	<0.01	<0.005	0.440	-	0.0180	30.0	-	-	-	1.30	43.00	-	-
	24-Jul-2017	8.49	-	166.0	108.00	132.00	<6	121.0	<0.01	<0.005	0.710	-	0.0370	25.6	-	-	-	1.40	43.60	-	-
	28-Aug-2017	8.22	31.9	183.0	117.00	143.00	<6	136.0	<0.01	<0.005	0.440	-	0.0310	30.8	-	-	-	1.40	46.90	-	-
	29-May-2018	8.07	52.2	326.0	181.00	220.00	<6	214.0	0.020	<0.005	0.530	-	0.0260	49.7	-	-	-	5.10	102.00	-	-
	26-Jun-2018	8.39	35.8	211.0	130.00	158.00	<6	149.0	<0.01	<0.005	0.530	-	0.0340	35.9	-	-	-	3.00	56.70	-	-
	24-Jul-2018	8.35	33.3	191.0	128.00	156.00	<6	139.0	0.010	<0.005	0.470	-	0.0190	33.3	-	-	-	1.80	46.70	-	-
	21-Aug-2018	8.10	32.3	189.0	122.00	149.00	<6	140.0	<0.01	<0.005	0.410	-	0.0320	33.3	-	-	-	1.50	47.00	-	-
	28-May-2019	8.26	31.8	186.0	130.00	158.00	<6	149.0	<0.01	<0.005	0.290	-	<0.005	35.7	-	-	-	1.40	41.90	-	-
	25-Jun-2019	8.48	30.2	179.0	122.00	149.00	<6	127.0	<0.01	<0.005	0.260	-	<0.005	28.0	-	-	-	1.60	45.80	-	-
	30-Jul-2019	8.41	25.7	148.0	104.00	127.00	<6	115.0	<0.01	<0.005	0.450	-	0.0240	24.6	-	-	-	1.10	33.20	-	-
	27-Aug-2019	8.17	24.6	137.0	107.00	131.00	<6	113.0	0.010	<0.005	0.890	-	<0.005	26.0	-	-	-	1.00	23.00	-	-
	23-Jun-2020	7.94	33.9	198.0	132.00	160.00	<6	152.0	<0.01	<0.005	0.440	-	0.0220	34.9	-	-	-	2.00	49.10	-	-
	28-Jul-2020	8.65	31.2	187.0	129.00	157.00	<6	137.0	<0.01	<0.005	0.880	-	0.0250	28.8	-	-	-	2.30	45.30	-	-
	24-Aug-2020	8.45	28.7	170.0	124.00	151.00	<6	129.0	<0.01	<0.005	0.560	-	0.0420	28.9	-	-	-	1.50	36.70	-	-
SME-R1	04-Jul-2006	8.60	38.8	231.0	134.00	150.00	7.00	154.0	<0.05	<0.05	-	<0.05	0.0600	30.8	23.00	18.70	4.00	3.80	70.10	-	-
	17-Jul-2006	8.60	43.3	258.0	125.00	139.00	7.00	158.0	<0.05	<0.05	-	0.1000	0.1400	28.8	28.00	18.90	4.40	3.70	95.40	-	-
	14-Aug-2006	9.10	35.4	204.0	105.00	102.00	13.00	122.0	<0.05	<0.05	-	<0.05	0.1100	21.8	24.00	16.30	3.60	3.00	70.10	-	-
	28-Aug-2006	9.20	38.4	226.0	114.00	102.00	18.00	126.0	<0.05	<0.05	-	<0.05	0.1800	21.0	28.00	17.60	4.10	3.30	79.40	-	-
	25-Jun-2007	8.50	38.3	229.0	147.00	168.00	5.00	156.0	<0.05	<0.05	-	<0.05	0.0600	29.9	22.00	19.20	3.50	2.70	60.90	-	-
	09-Jul-2007	8.70	33.8	-	148.00	166.00	7.00	-	<0.05	<0.05	-	<0.05	0.0800	27.9	21.00	18.50	2.80	2.30	57.00	-	-
	07-Aug-2007	9.10	32.9	214.0	110.00	105.00	14.00	135.0	<0.05	<0.05	-	<0.05	0.0400	18.8	21.00	17.30	2.90	2.30	57.80	-	-
	20-Aug-2007	7.90	33.4	217.0	135.00	164.00	<5	125.0	<0.05	<0.05	-	<0.05	0.1100	19.9	20.00	17.50	2.80	2.20	58.30	-	-

Notes:
1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
1i. Value (i) Concentration is less than guidelines

2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
4a. Nitrite-N guidelines are chloride dependent.
4b. Total ammonia concentrations are pH and temperature dependent.
4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SME-R1A	06-Jul-2011	8.45	65.6	421.0	176.00	215.00	<6	234.0	<0.01	<0.005	0.880	<0.05	<0.05	51.0	-	-	-	6.20	171.00	-	-
	20-Jul-2011	8.59	63.2	393.0	144.00	176.00	<6	211.0	0.020	<0.005	0.730	<0.05	0.0600	44.1	-	-	-	7.00	169.00	-	-
	10-Aug-2011	8.86	58.2	372.0	121.00	120.00	13.00	189.0	<0.01	<0.005	1.380	<0.05	0.1000	31.4	-	-	-	7.20	173.00	-	-
	31-Aug-2011	8.30	56.9	349.0	112.00	136.00	<6	173.0	<0.01	<0.005	0.770	<0.05	<0.05	28.5	-	-	-	6.50	164.00	-	-
	06-Jun-2012	8.32	49.8	326.0	163.00	199.00	<6	200.0	<0.01	<0.005	0.620	<0.05	0.0380	41.3	-	-	-	4.30	117.00	-	-
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	8.58	44.9	284.0	144.00	176.00	<6	175.0	<0.01	<0.005	0.800	<0.05	0.0490	33.2	-	-	-	3.60	101.00	-	-
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	9.46	36.5	232.0	94.00	68.00	23.00	127.0	<0.01	<0.005	2.660	<0.05	0.1410	16.1	-	-	-	3.40	96.60	-	-
	29-Aug-2012	8.22	43.1	272.0	128.00	156.00	<6	146.0	**0.360**	0.1160	1.600	0.1800	0.1370	24.3	-	-	-	4.10	102.00	-	-
	12-Jun-2013	8.44	49.9	304.0	174.00	212.00	<6	194.0	<0.01	<0.005	0.570	<0.05	0.0360	41.2	-	-	-	3.70	95.80	-	-
	24-Jun-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Jul-2013	8.62	41.0	267.0	150.00	169.00	7.00	159.0	<0.01	<0.005	0.630	<0.05	0.0380	30.5	-	-	-	3.40	87.40	-	-
	31-Jul-2013	8.73	34.5	207.0	112.00	112.00	12.00	123.0	<0.01	<0.005	0.860	<0.05	0.0900	20.8	-	-	-	2.60	68.60	-	-
	26-Aug-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Aug-2013	8.97	33.7	206.0	123.00	123.00	13.00	124.0	<0.01	<0.005	0.840	<0.05	0.0520	21.7	-	-	-	2.60	63.20	-	-
	12-Jun-2014	8.56	43.4	251.0	155.00	189.00	6.00	162.0	<0.01	<0.005	0.670	<0.05	0.0510	36.1	-	-	-	4.60	64.90	-	-
	09-Jul-2014	8.99	35.6	215.0	127.00	126.00	14.00	128.0	0.020	<0.005	0.750	<0.05	0.1060	23.8	-	-	-	3.80	60.50	-	-
	21-Jul-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2014	8.74	34.2	198.0	116.00	125.00	8.00	117.0	<0.01	<0.005	2.260	0.0500	0.2030	19.8	-	-	-	3.70	58.40	-	-
	25-Aug-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Sep-2014	8.18	38.2	224.0	124.00	151.00	6.00	146.0	**0.230**	0.0190	1.470	<0.05	0.1450	30.8	-	-	-	5.30	67.80	-	-
	11-Jun-2015	8.22	48.2	293.0	158.00	192.00	<6	181.0	0.020	<0.005	0.890	0.0500	0.0920	37.0	-	-	-	4.20	95.80	-	-
	09-Jul-2015	8.40	38.1	232.0	122.00	148.00	<6	137.0	0.030	<0.005	0.930	<0.05	0.1560	25.0	-	-	-	4.40	78.10	-	-
	20-Jul-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Jul-2015	9.44	31.4	193.0	111.00	80.00	27.00	115.0	0.020	<0.005	0.840	<0.05	0.1790	20.8	-	-	-	2.90	60.80	-	-
	24-Aug-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Sep-2015	8.99	31.1	183.0	118.00	112.00	15.00	125.0	0.020	<0.005	0.830	<0.025	0.1430	23.7	-	-	-	1.80	49.90	-	-
	08-Sep-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	09-Jun-2016	8.30	35.8	224.0	144.00	175.00	<6	159.0	<0.01	<0.005	0.730	<0.025	0.0240	32.6	-	-	-	3.50	58.50	-	-
	07-Jul-2016	8.35	34.7	200.0	134.00	163.00	<6	138.0	0.030	<0.005	1.190	<0.025	0.1180	25.5	-	-	-	2.20	51.00	-	-
	11-Aug-2016	8.04	54.4	340.0	158.00	192.00	<6	204.0	**0.220**	0.0080	1.170	0.0310	0.1980	40.8	-	-	-	7.90	125.00	-	-
	01-Sep-2016	8.20	33.2	198.0	139.00	170.00	<6	147.0	**0.140**	<0.005	0.770	<0.025	0.0700	31.0	-	-	-	1.00	47.00	-	-
	01-Jun-2017	8.25	43.4	246.0	161.00	197.00	<6	183.0	<0.01	<0.005	0.710	-	0.0230	43.4	-	-	-	2.90	58.40	-	-
	26-Jun-2017	8.51	38.3	224.0	144.00	175.00	<6	157.0	<0.01	<0.005	0.700	-	0.0900	34.0	-	-	-	2.40	57.90	-	-
	24-Jul-2017	8.66	27.2	170.0	115.00	125.00	7.00	113.0	0.060	0.0090	1.280	-	0.0950	20.0	-	-	-	1.90	44.70	-	-
	28-Aug-2017	8.32	31.0	177.0	119.00	145.00	<6	130.0	0.050	<0.005	0.880	-	0.0550	25.7	-	-	-	1.50	42.70	-	-
	29-May-2018	8.08	39.1	244.0	151.00	184.00	<6	162.0	<0.01	<0.005	0.930	-	0.0900	39.2	-	-	-	3.80	62.50	-	-
	26-Jun-2018	8.58	36.4	210.0	122.00	133.00	7.00	136.0	0.050	0.0060	1.050	-	0.0950	29.5	-	-	-	3.30	58.80	-	-
	24-Jul-2018	9.09	31.0	183.0	111.00	72.00	31.00	113.0	0.060	<0.005	0.790	-	0.2430	21.7	-	-	-	3.10	51.00	-	-
	21-Aug-2018	8.86	30.6	185.0	117.00	120.00	10.00	125.0	<0.01	<0.005	0.900	-	0.1570	23.6	-	-	-	2.20	47.40	-	-
	28-May-2019	8.25	39.3	230.0	162.00	198.00	<6	178.0	<0.01	<0.005	0.680	-	0.0690	40.3	-	-	-	2.50	49.20	-	-
	25-Jun-2019	8.65	31.3	180.0	121.00	134.00	7.00	127.0	<0.01	<0.005	0.670	-	0.0730	24.8	-	-	-	2.20	44.00	-	-
	30-Jul-2019	9.14	26.1	152.0	91.00	75.00	17.00	103.0	0.040	<0.005	0.640	-	0.1100	17.4	-	-	-	1.80	43.40	-	-
	27-Aug-2019	8.86	25.5	149.0	110.00	100.00	14.00	104.0	<0.01	<0.005	0.630	-	0.0250	19.1	-	-	-	1.50	31.90	-	-
	23-Jun-2020	8.63	35.6	211.0	149.00	168.00	7.00	160.0	<0.01	<0.005	1.180	-	0.0630	35.9	-	-	-	2.50	44.50	-	-
	28-Jul-2020	8.60	30.3	173.0	113.00	137.00	<6	126.0	0.020	<0.005	1.010	-	0.1600	22.4	-	-	-	2.40	42.10	-	-
	24-Aug-2020	8.96	28.8	176.0	116.00	120.00	11.00	114.0	0.080	<0.005	1.850	-	0.1390	19.9	-	-	-	6.60	42.30	-	-
SME-R2	06-Jul-2011	8.20	92.8	610.0	204.00	249.00	<6	322.0	0.030	0.0090	1.260	<0.05	0.2200	67.6	-	-	-	11.20	280.00	-	-
	20-Jul-2011	8.16	79.9	509.0	190.00	232.00	<6	272.0	0.040	<0.005	0.880	<0.05	0.2200	57.9	-	-	-	10.50	222.00	-	-
	10-Aug-2011	8.34	67.9	440.0	178.00	217.00	<6	251.0	0.060	<0.005	0.970	<0.05	0.1900	51.1	-	-	-	7.70	181.00	-	-
	31-Aug-2011	8.00	60.2	362.0	158.00	193.00	<6	210.0	0.050	<0.005	0.740	<0.05	0.0800	42.0	-	-	-	7.10	141.00	-	-
	06-Jun-2012	8.19	64.4	450.0	186.00	227.00	<6	269.0	<0.01	<0.005	0.690	<0.05	0.0830	55.8	-	-	-	6.70	187.00	-	-
	04-Jul-2012	8.36	73.6	500.0	183.00	223.00	<6	280.0	<0.01	<0.005	0.920	<0.05	0.0900	58.5	-	-	-	7.90	224.00	-	-
	01-Aug-2012	8.31	48.8	317.0	152.00	185.00	<6	190.0	<0.01	<0.005	0.820	<0.05	0.1360	36.7	-	-	-	4.00	118.00	-	-
	29-Aug-2012	8.18	46.1	283.0	148.00	181.00	<6	174.0	0.040	0.0070	0.730	<0.05	0.1090	35.4	-	-	-	3.70	94.80	-	-
	12-Jun-2013	8.34	57.9	352.0	176.00	215.00	<6	223.0	0.020	<0.005	0.650	<0.05	0.0780	47.3	-	-	-	5.00	124.00	-	-
	03-Jul-2013	8.28	49.3	310.0	169.00	206.00	<6	189.0	0.050	<0.005	0.670	<0.05	0.1570	39.2	-	-	-	4.90	99.60	-	-
	31-Jul-2013	8.12	45.4	278.0	145.00	177.00	<6	172.0	0.010	<0.005	0.760	<0.05	0.1070	35.1	-	-	-	3.60	94.30	-	-
	28-Aug-2013	8.27	39.3	240.0	150.00	182.00	<6	154.0	0.030	<0.005	0.550	<0.05	0.0860	31.0	-	-	-	3.20	68.00	-	-
	12-Jun-2014	8.36	54.8	331.0	173.00	211.00	6.00	217.0	0.030	<0.005	0.770	0.0700	0.0830	47.4	-	-	-	5.20	112.00	-	-
	09-Jul-2014	8.33	50.3	303.0	152.00	185.00	6.00	181.0	0.040	<0.005	0.640	<0.05	0.1520	36.4	-	-	-	5.20	105.00	-	-
	07-Aug-2014	8.27	50.6	298.0	159.00	193.00	6.00	177.0	0.090	<0.005	0.970	<0.05	0.1970	35.1	-	-	-	5.60	98.20	-	-
	04-Sep-2014	8.11	75.5	492.0	187.00	228.00	6.00	240.0	**0.240**	0.0080	2.220	<0.05	0.5000	45.7	-	-	-	22.00	194.00	-	-
	11-Jun-2015	8.10	55.9	342.0	170.00	207.00	<6	215.0	**0.130**	<0.005	0.660	<0.05	0.1470	46.5	-	-	-	4.50	122.00	-	-
	09-Jul-2015	8.15	51.1	308.0	151.00	184.00	<6	181.0	0.030	<0.005	0.600	<0.05	0.1040	36.5	-	-	-	4.30	113.00	-	-
	30-Jul-2015	8.24	44.0	258.0	141.00	172.00	<6	165.0	**0.130**	0.0120	0.660	<0.05	0.1130	34.0	-	-	-	3.80	83.90	-	-
	03-Sep-2015	8.09	40.1	240.0	148.00	181.00	<6	157.0	**0.240**	<0.005	0.830	<0.025	0.0920	33.2	-	-	-	3.10	69.20	-	-
	09-Jun-2016	8.18	46.5	302.0	184.00	225.00	<6	199.0	**0.720**	<0.005	1.470	<0.025	0.2090	43.5	-	-	-	3.60	88.90	-	-
	07-Jul-2016	8.13	45.3	268.0	156.00	191.00	<6	176.0	**0.490**	0.0050	1.420	<0.025	0.1780	35.8	-	-	-	3.70	80.10	-	-
	11-Aug-2016	8.03	26.7	156.0	110.00	134.00	<6	106.0	**0.140**	0.0120	0.830	0.0310	0.1710	19.0	-	-	-	1.90	35.80	-	-
	01-Sep-2016	8.03	42.5	260.0	166.00	203.00	<6	174.0	0.050	<0.005	0.580	<0.025	0.0740	36.1	-	-	-	2.50	72.70	-	-
	01-Jun-2017	8.15	56.5	341.0	183.00	223.00	<6	233.0	**0.120**	<0.005	0.680	-	0.0940	51.8	-	-	-	4.10	114.00	-	-
	26-Jun-2017	8.30	45.9	270.0	154.00	188.00	<6	182.0	**0.080**	<0.005	0.540	-	0.1000	39.2	-	-	-	2.90	82.00	-	-
	24-Jul-2017	8.12	38.7	243.0	141.00	171.00	<6	158.0	0.060	0.0090	0.720	-	0.1310	31.5	-	-	-	3.00	76.10	-	-
	28-Aug-2017	8.21	41.7	250.0	150.00	183.00	<6	172.0	0.030	<0.005	0.580	-	0.0630	36.1	-	-	-	2.80	72.10	-	-
	29-May-2018	8.03	34.3	204.0	125.00	153.00	<6	147.0	<0.01	<0.005	1.090	-	0.1080	37.2	-	-	-	2.50	53.60	-	-
	26-Jun-2018	8.14	46.5	280.0	162.00	198.00	<6	180.0	0.040	<0.005	0.720	-	0.0960	41.0	-	-	-	4.40	82.20	-	-
	24-Jul-2018	8.11	42.7	248.0	148.00	181.00	<6	165.0	**0.380**	<0.005	0.680	-	0.1210	36.6	-	-	-	5.00	70.10	-	-
	21-Aug-2018	8.03	38.7	232.0	144.00	175.00	<6	160.0	0.020	<0.005	0.510	-	0.0670	36.2	-	-	-	2.40	62.10	-	-
	28-May-2019	8.08	50.2	307.0	178.00	217.00	<6	216.0	0.010	<0.005	0.540	-	0.0350	47.1	-	-	-	4.10	91.90	-	-
	25-Jun-2019	8.13	42.9	252.0	148.00	181.00	<6	170.0	<0.01	<0.005	0.540	-	0.0670	37.1	-	-	-	2.90	76.50	-	-
	30-Jul-2019	7.98	34.4	209.0	130.00	159.00	<6	141.0	0.030	<0.005	0.630	-	0.1060	29.1	-	-	-	2.40	53.40	-	-
	27-Aug-2019	7.85	33.9	196.0	133.00	162.00	<6	140.0	0.040	<0.005	0.470	-	0.0460	29.7	-	-	-	2.30	46.90	-	-
	23-Jun-2020	8.26	46.5	287.0	174.00	212.00	<6	194.0	**0.170**	0.0070	1.040	-	0.2040	42.1	-	-	-	3.70	83.90	-	-
	28-Jul-2020	8.22	43.7	268.0	169.00	206.00	<6	184.0	**0.140**	0.0070	0.750	-	0.1950	37.7	-	-	-	3.60	73.90	-	-
	24-Aug-2020	8.27	37.6	222.0	142.00	173.00	<6	156.0	**0.120**	0.0080	0.640	-	0.1090	32.6	-	-	-	2.70	58.20	-	-

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SME-S1	04-Jul-2006	8.80	36.3	217.0	135.00	142.00	11.00	154.0	<0.05	<0.05	-	<0.05	0.0400	32.9	19.00	16.60	3.60	2.80	59.80	-	-
	17-Jul-2006	9.00	34.2	203.0	118.00	118.00	13.00	137.0	<0.05	<0.05	-	0.0500	0.0900	26.5	18.00	15.30	3.10	2.50	62.10	-	-
	14-Aug-2006	9.50	32.1	188.0	103.00	74.00	25.00	116.0	<0.05	<0.05	-	<0.05	0.1300	20.4	21.00	14.90	3.50	2.70	60.70	-	-
	28-Aug-2006	9.40	33.2	194.0	111.00	92.00	21.00	120.0	<0.05	<0.05	-	<0.05	0.1800	22.0	22.00	15.40	3.70	2.70	60.30	-	-
	25-Jun-2007	8.60	37.8	225.0	145.00	164.00	7.00	152.0	<0.05	<0.05	-	<0.05	0.0600	29.6	22.00	18.90	3.40	2.70	60.50	-	-
	09-Jul-2007	8.50	33.1	209.0	145.00	168.00	<5	141.0	<0.05	<0.05	-	<0.05	0.0900	24.3	20.00	18.10	3.00	2.30	55.70	-	-
	07-Aug-2007	9.30	32.6	212.0	116.00	103.00	19.00	138.0	<0.05	<0.05	-	<0.05	0.0900	20.7	20.00	17.30	2.70	2.10	55.90	-	-
	20-Aug-2007	7.70	29.0	189.0	134.00	164.00	<5	124.0	<0.05	<0.05	-	<0.05	0.0400	26.7	12.00	13.10	1.70	1.30	37.90	-	-
	06-Jul-2011	8.50	64.9	421.0	178.00	202.00	7.00	236.0	<0.01	<0.005	0.920	<0.05	<0.05	52.0	-	-	-	6.50	170.00	-	-
	20-Jul-2011	8.54	63.6	402.0	160.00	195.00	<6	214.0	0.030	<0.005	0.750	<0.05	0.0800	45.6	-	-	-	7.10	167.00	-	-
	10-Aug-2011	9.00	56.6	360.0	111.00	106.00	14.00	177.0	<0.01	<0.005	1.940	<0.05	0.1000	27.7	-	-	-	7.20	173.00	-	-
	31-Aug-2011	8.49	55.6	342.0	109.00	132.00	<6	166.0	<0.01	<0.005	0.850	<0.05	<0.05	27.0	-	-	-	8.60	159.00	-	-
	06-Jun-2012	8.32	50.2	329.0	172.00	209.00	<6	205.0	<0.01	<0.005	0.570	<0.05	0.0350	43.4	-	-	-	4.30	114.00	-	-
	04-Jul-2012	8.58	44.1	282.0	147.00	180.00	<6	169.0	<0.01	<0.005	0.930	<0.05	0.0930	32.6	-	-	-	3.50	101.00	-	-
	01-Aug-2012	9.29	36.4	244.0	113.00	64.00	36.00	138.0	<0.01	<0.005	2.100	<0.05	0.0880	18.8	-	-	-	3.50	93.80	-	-
	29-Aug-2012	8.33	42.4	270.0	128.00	156.00	<6	142.0	**0.090**	0.0430	1.800	**0.6600**	0.1520	23.4	-	-	-	4.00	102.00	-	-
	12-Jun-2013	8.47	48.9	299.0	166.00	202.00	<6	193.0	<0.01	<0.005	0.590	<0.05	0.0230	41.3	-	-	-	3.70	95.40	-	-
	03-Jul-2013	8.81	39.8	258.0	140.00	148.00	11.00	155.0	<0.01	<0.005	0.520	<0.05	0.0280	29.2	-	-	-	3.20	86.20	-	-
	31-Jul-2013	8.85	33.9	206.0	113.00	106.00	16.00	122.0	<0.01	<0.005	0.660	<0.05	0.0840	20.1	-	-	-	2.50	68.60	-	-
	28-Aug-2013	8.93	33.2	202.0	120.00	119.00	14.00	124.0	0.010	<0.005	0.720	<0.05	0.0540	21.5	-	-	-	2.40	61.00	-	-
	12-Jun-2014	8.68	42.4	249.0	156.00	172.00	9.00	163.0	<0.01	<0.005	0.750	0.0600	0.0580	36.4	-	-	-	4.40	63.50	-	-
	09-Jul-2014	9.10	36.0	213.0	125.00	120.00	16.00	129.0	<0.01	<0.005	0.760	<0.05	0.1500	24.2	-	-	-	3.70	60.30	-	-
	07-Aug-2014	8.91	33.9	195.0	113.00	112.00	13.00	116.0	<0.01	<0.005	3.100	<0.05	0.2340	19.3	-	-	-	3.60	58.00	-	-
	04-Sep-2014	8.41	37.4	220.0	135.00	165.00	6.00	132.0	0.040	<0.005	1.600	<0.05	0.1530	29.5	-	-	-	4.40	63.30	-	-
	11-Jun-2015	8.48	47.2	284.0	150.00	171.00	6.00	177.0	<0.01	<0.005	0.550	<0.05	0.0680	36.2	-	-	-	4.10	93.90	-	-
	09-Jul-2015	8.96	36.8	225.0	113.00	108.00	15.00	130.0	<0.01	<0.005	0.680	<0.05	0.1270	22.9	-	-	-	3.40	79.40	-	-
	30-Jul-2015	9.57	30.6	192.0	111.00	71.00	32.00	115.0	0.020	0.0050	1.050	<0.05	0.1930	20.9	-	-	-	3.30	60.20	-	-
	03-Sep-2015	9.12	29.9	184.0	119.00	105.00	20.00	124.0	0.010	<0.005	1.220	0.0270	0.1530	23.9	-	-	-	2.40	49.60	-	-
	09-Jun-2016	8.31	35.6	230.0	158.00	193.00	<6	158.0	<0.01	<0.005	0.770	<0.025	0.0470	32.4	-	-	-	2.60	57.70	-	-
	07-Jul-2016	8.63	33.7	198.0	131.00	138.00	11.00	136.0	<0.01	<0.005	1.110	<0.025	0.1240	24.8	-	-	-	2.10	51.20	-	-
	11-Aug-2016	8.62	26.7	156.0	106.00	117.00	6.00	109.0	0.030	<0.005	1.550	0.0390	0.1310	18.4	-	-	-	1.60	38.40	-	-
	01-Sep-2016	8.60	32.6	197.0	130.00	128.00	15.00	141.0	<0.01	<0.005	0.930	<0.025	0.0640	29.6	-	-	-	5.70	45.90	-	-
	01-Jun-2017	8.22	42.3	244.0	167.00	204.00	<6	175.0	<0.01	<0.005	0.680	-	0.0330	41.3	-	-	-	2.80	56.80	-	-
	26-Jun-2017	8.47	38.3	227.0	152.00	186.00	<6	158.0	<0.01	<0.005	0.570	-	0.0660	34.8	-	-	-	2.40	56.20	-	-
	24-Jul-2017	8.89	26.7	164.0	107.00	100.00	15.00	111.0	<0.01	<0.005	1.320	-	0.1290	19.5	-	-	-	1.80	43.90	-	-
	28-Aug-2017	8.38	30.2	176.0	120.00	147.00	<6	128.0	0.010	<0.005	0.580	-	0.0540	25.3	-	-	-	1.50	42.00	-	-
	29-May-2018	8.00	41.0	242.0	150.00	183.00	<6	161.0	0.010	<0.005	1.050	-	0.1390	39.3	-	-	-	3.50	62.00	-	-
	26-Jun-2018	8.80	35.7	214.0	130.00	134.00	12.00	132.0	0.010	<0.005	0.970	-	0.2000	28.2	-	-	-	3.40	58.30	-	-
	24-Jul-2018	9.31	30.6	183.0	112.00	66.00	35.00	111.0	<0.01	<0.005	0.720	-	0.2770	21.1	-	-	-	3.00	50.60	-	-
	21-Aug-2018	9.08	30.2	179.0	107.00	100.00	15.00	124.0	<0.01	<0.005	0.830	-	0.1720	23.4	-	-	-	2.10	47.60	-	-
	28-May-2019	8.35	39.1	232.0	166.00	203.00	<6	178.0	<0.01	<0.005	0.690	-	0.0340	40.7	-	-	-	2.50	49.00	-	-
	25-Jun-2019	8.73	30.6	186.0	132.00	142.00	9.00	125.0	<0.01	<0.005	0.520	-	0.0790	24.4	-	-	-	2.00	44.10	-	-
	30-Jul-2019	9.34	25.5	151.0	91.00	66.00	22.00	101.0	<0.01	<0.005	0.550	-	0.1220	16.8	-	-	-	1.60	43.30	-	-
	27-Aug-2019	9.06	24.9	145.0	106.00	90.00	19.00	102.0	<0.01	<0.005	0.580	-	0.0590	18.7	-	-	-	1.50	31.10	-	-
	23-Jun-2020	8.66	35.0	209.0	151.00	168.00	8.00	157.0	<0.01	<0.005	0.770	-	0.0380	35.6	-	-	-	2.30	43.40	-	-
	28-Jul-2020	8.83	29.8	177.0	121.00	126.00	11.00	124.0	<0.01	<0.005	1.280	-	0.0940	22.2	-	-	-	2.30	41.80	-	-
	24-Aug-2020	9.00	29.1	178.0	113.00	110.00	13.00	116.0	<0.01	<0.005	1.240	-	0.1120	21.2	-	-	-	2.50	46.80	-	-
SMW-P1	04-Jul-2006	8.70	28.1	169.0	120.00	131.00	8.00	132.0	**0.250**	<0.05	-	<0.05	0.0200	30.9	10.00	12.10	1.40	1.20	37.80	-	-
	17-Jul-2006	8.40	26.9	151.0	115.00	136.00	<5	128.0	**0.110**	<0.05	-	<0.05	<0.02	30.5	8.00	11.00	1.00	1.00	27.70	-	-
	14-Aug-2006	8.50	23.1	125.0	111.00	125.00	<5	111.0	0.050	<0.05	-	<0.05	<0.02	26.5	5.00	10.00	0.80	0.60	14.50	-	-
	28-Aug-2006	8.40	23.6	126.0	111.00	130.00	<5	110.0	<0.05	<0.05	-	<0.05	<0.02	26.5	5.00	10.20	0.90	0.60	15.60	-	-
	25-Jun-2007	8.40	22.2	120.0	100.00	117.00	<5	110.0	<0.05	<0.05	-	<0.05	<0.02	27.0	5.00	10.10	0.70	0.50	16.00	-	-
	09-Jul-2007	8.30	25.1	167.0	124.00	149.00	<5	169.0	<0.05	<0.05	-	<0.05	0.0200	39.0	7.00	10.90	1.00	0.70	23.80	-	-
	07-Aug-2007	7.80	25.1	163.0	121.00	148.00	<5	121.0	<0.05	<0.05	-	<0.05	<0.02	27.5	7.00	10.20	1.00	0.70	21.00	-	-
	20-Aug-2007	7.10	21.6	140.0	127.00	155.00	<5	104.0	<0.05	<0.05	-	<0.05	0.0200	25.8	3.00	9.40	0.70	0.40	11.10	-	-
	06-Jul-2011	8.45	41.7	254.0	151.00	184.00	<6	174.0	**0.110**	0.0080	0.590	<0.05	<0.05	38.5	-	-	-	2.40	76.70	-	-
	20-Jul-2011	8.28	24.9	140.0	110.00	134.00	<6	117.0	**0.140**	<0.005	0.330	<0.05	<0.05	29.0	-	-	-	1.00	21.00	-	-
	10-Aug-2011	8.41	23.2	130.0	110.00	134.00	<6	112.0	0.030	0.0140	0.300	<0.05	<0.05	27.1	-	-	-	0.70	17.00	-	-
	31-Aug-2011	7.80	22.6	120.0	100.00	122.00	<6	96.0	0.020	<0.005	0.200	<0.05	<0.05	23.5	-	-	-	1.10	16.00	-	-
	06-Jun-2012	8.22	23.2	140.0	116.00	141.00	<6	120.0	0.020	<0.005	0.190	<0.05	0.0180	29.7	-	-	-	0.90	18.00	-	-
	04-Jul-2012	8.43	31.0	197.0	114.00	138.00	<6	140.0	<0.01	<0.005	0.400	<0.05	0.0210	31.0	-	-	-	1.30	60.60	-	-
	01-Aug-2012	8.30	21.1	130.0	106.00	129.00	<6	100.0	0.010	<0.005	0.410	<0.05	0.0120	25.8	-	-	-	0.50	20.00	-	-
	29-Aug-2012	8.21	21.0	130.0	110.00	134.00	<6	110.0	<0.01	<0.005	0.180	<0.05	0.0130	26.6	-	-	-	0.50	17.00	-	-
	12-Jun-2013	8.24	24.3	140.0	108.00	132.00	<6	115.0	<0.01	<0.005	0.530	<0.05	0.0100	28.6	-	-	-	0.70	23.00	-	-
	03-Jul-2013	8.33	21.4	120.0	104.00	127.00	<6	100.0	0.010	<0.005	0.190	<0.05	0.0100	25.8	-	-	-	0.60	15.00	-	-
	31-Jul-2013	8.32	19.9	110.0	107.00	130.00	<6	100.0	0.010	<0.005	0.150	<0.05	<0.005	25.3	-	-	-	0.50	11.00	-	-
	28-Aug-2013	8.21	19.2	109.0	103.00	126.00	<6	97.0	<0.01	<0.005	0.210	<0.05	0.0100	24.6	-	-	-	0.50	9.50	-	-
	12-Jun-2014	8.26	25.3	135.0	115.00	140.00	6.00	120.0	<0.01	<0.005	0.170	<0.05	0.0220	30.1	-	-	-	1.20	16.80	-	-
	09-Jul-2014	8.15	33.7	191.0	121.00	147.00	6.00	138.0	**0.200**	0.0070	0.550	<0.05	0.0410	32.0	-	-	-	1.90	50.50	-	-
	07-Aug-2014	8.33	22.0	125.0	109.00	133.00	6.00	110.0	**0.080**	<0.005	0.250	<0.05	0.0140	27.5	-	-	-	0.70	14.40	-	-
	04-Sep-2014	8.22	21.9	134.0	118.00	143.00	6.00	114.0	0.040	<0.005	0.210	<0.05	0.0130	28.7	-	-	-	0.80	16.90	-	-
	09-Jun-2015	8.14	27.9	159.0	125.00	153.00	<6	133.0	0.020	<0.005	0.210	<0.05	0.0190	33.0	-	-	-	1.00	26.80	-	-
	07-Jul-2015	7.82	25.9	149.0	123.00	150.00	<6	126.0	0.020	<0.005	0.190	<0.05	0.0110	31.3	-	-	-	0.80	22.80	-	-
	28-Jul-2015	8.41	21.4	128.0	116.00	141.00	<6	114.0	<0.01	<0.005	0.130	<0.05	0.0110	28.6	-	-	-	0.50	13.40	-	-
	01-Sep-2015	8.02	23.3	129.0	112.00	137.00	<6	115.0	0.010	<0.005	0.300	<0.025	0.0070	28.9	-	-	-	0.50	16.00	-	-
	08-Jun-2016	8.15	23.5	140.0	121.00	147.00	<6	117.0	0.040	<0.005	0.280	<0.025	0.0050	28.9	-	-	-	0.80	18.00	-	-
	06-Jul-2016	8.00	22.0	120.0	108.00	132.00	<6	110.0	<0.01	<0.005	0.430	<0.025	0.0090	27.4	-	-	-	0.70	13.00	-	-
	10-Aug-2016	8.07	21.1	120.0	104.00	127.00	<6	110.0	<0.01	<0.005	0.100	<0.025	0.0080	27.2	-	-	-	0.60	12.00	-	-
	31-Aug-2016	7.96	23.7	130.0	107.00	131.00	<6	117.0	<0.01	<0.005	0.120	<0.025	<0.005	29.1	-	-	-	0.70	17.00	-	-
	31-May-2017	8.14	24.9	135.0	113.00	137.00	<6	117.0	<0.01	<0.005	0.270	-	0.0260	29.4	-	-	-	0.60	19.00	-	-
	28-Jun-2017	8.22	22.6	121.0	98.30	120.00	<6	113.0	<0.01	<0.005	0.300	-	0.0050	28.5	-	-	-	0.70	16.00	-	-
	26-Jul-2017	8.06	21.7	121.0	101.00	123.00	<6	114.0	<0.01	<0.005	0.140	-	0.0180	28.6	-	-	-	0.60	15.00	-	-
	30-Aug-2017	8.34	19.5	119.0	112.00	137.00	<6	103.0	0.010	<0.005	0.100	-	0.0090	26.2	-	-	-	0.60	11.00	-	-
	28-May-2018	7.96	27.4	161.0	124.00	151.00	<6	130.0	0.020	<0.005	0.250	-	0.0350	32.3	-	-	-	1.00	30.00	-	-
	25-Jun-2018	7.95	20.9	114.0	101.00	123.00	<6	104.0	0.010	<0.005	0.210	-	0.0090	26.2	-	-	-	0.70	12.00	-	-
	23-Jul-2018	8.26	30.2	118.0	103.00	125.00	<6	106.0	<0.01	<0.005	0.190	-	<0.005	27.1	-	-	-	0.70	14.00	-	-
	20-Aug-2018	8.22	21.0	117.0	107.00	130.00	<6	107.0	0.010	<0.005	0.150	-	0.0140	27.4	-	-	-	0.50	11.00	-	-
	27-May-2019	7.92	29.8	173.0	131.00	159.00	<6	130.0	**0.160**	0.0140	0.640	-	0.0340	31.7	-	-	-	2.10	34.10	-	-
	24-Jun-2019	8.06	24.1	138.0	119.00	145.00	<6	126.0	0.050	<0.005	0.250	-	<0.005	31.3	-	-	-	0.80	16.00	-	-
	29-Jul-2019	8.23	21.6	107.0	109.00	132.00	<6	109.0	0.020	<0.005	0.140	-	0.0110	27.6	-	-	-	0.50	<0.9	-	-
	26-Aug-2019	8.18	22.1	120.0	113.00	138.00	<6	110.0	0.020	<0.005	0.120	-	0.0100	28.0	-	-	-	0.50	10.00	-	-
	22-Jun-2020	8.30	24.9	137.0	119.00	145.00	<6	123.0	**0.120**	<0.005	0.340	-	0.0130	30.4	-	-	-	0.90	16.00	-	-
	27-Jul-2020	8.27	22.1	122.0	110.00	134.00	<6	109.0	0.040	<0.005	0.220	-	0.0180	27.7	-	-	-	0.70	12.00	-	-
	24-Aug-2020	7.96	20.4	117.0	107.00	131.00	<6	107.0	0.010	<0.005	0.160	-	0.0150	27.1	-	-	-	0.60	11.00	-	-

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
1i. Value (i) Concentration is less than guidelines

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-

2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SMW-R1	04-Jul-2006	8.60	30.6	185.0	121.00	136.00	6.00	139.0	<0.05	<0.05	-	<0.05	0.0300	31.2	13.00	13.80	1.80	1.50	49.80	-	-
	17-Jul-2006	8.30	29.8	166.0	121.00	143.00	<5	137.0	<0.05	<0.05	-	<0.05	0.0400	32.3	10.00	12.20	1.40	1.30	34.10	-	-
	14-Aug-2006	8.40	23.9	129.0	114.00	134.00	<5	114.0	<0.05	<0.05	-	<0.05	<0.02	27.4	5.00	10.20	1.00	0.70	15.30	-	-
	28-Aug-2006	8.40	24.6	133.0	115.00	135.00	<5	114.0	<0.05	<0.05	-	<0.05	0.0300	27.1	6.00	11.10	1.30	0.60	17.80	-	-
	25-Jun-2007	8.30	23.4	124.0	103.00	124.00	<5	118.0	<0.05	<0.05	-	<0.05	<0.02	28.9	5.00	10.70	1.00	0.50	15.60	-	-
	09-Jul-2007	8.20	25.8	171.0	130.00	158.00	<5	167.0	<0.05	<0.05	-	<0.05	<0.02	38.1	7.00	11.40	1.30	0.70	25.10	-	-
	07-Aug-2007	7.80	26.8	174.0	123.00	150.00	<5	129.0	<0.05	<0.05	-	<0.05	<0.02	29.1	8.00	11.70	1.30	0.80	25.70	-	-
	20-Aug-2007	7.30	22.6	147.0	129.00	158.00	<5	107.0	<0.05	<0.05	-	<0.05	0.0300	26.4	3.00	9.80	0.80	0.40	12.60	-	-
	06-Jul-2011	8.58	48.4	294.0	154.00	173.00	7.00	202.0	0.020	<0.005	0.760	<0.05	0.1200	42.1	-	-	-	6.10	98.90	-	-
	20-Jul-2011	8.19	29.2	172.0	131.00	160.00	<6	135.0	**0.100**	<0.005	0.450	<0.05	0.0800	31.8	-	-	-	1.70	34.50	-	-
	10-Aug-2011	8.38	24.8	140.0	116.00	142.00	<6	121.0	<0.01	<0.005	0.270	<0.05	0.0600	29.4	-	-	-	0.80	20.00	-	-
	31-Aug-2011	8.06	24.1	130.0	109.00	133.00	<6	112.0	<0.01	<0.005	0.240	<0.05	<0.05	27.3	-	-	-	0.70	18.00	-	-
	06-Jun-2012	8.09	30.6	185.0	134.00	164.00	<6	141.0	**0.860**	0.0290	1.320	<0.05	0.1990	33.8	-	-	-	4.50	37.20	-	-
	04-Jul-2012	8.19	29.1	181.0	126.00	154.00	<6	133.0	<0.01	<0.005	0.460	<0.05	0.0640	30.7	-	-	-	1.30	44.60	-	-
	01-Aug-2012	8.12	21.6	120.0	104.00	126.00	<6	100.0	<0.01	<0.005	0.400	<0.05	0.0450	25.8	-	-	-	0.60	17.00	-	-
	29-Aug-2012	8.15	22.4	130.0	105.00	128.00	<6	112.0	<0.01	<0.005	0.230	<0.05	0.0320	28.1	-	-	-	0.70	20.00	-	-
	12-Jun-2013	8.16	28.2	159.0	113.00	138.00	<6	129.0	0.020	<0.005	0.270	<0.05	0.0300	31.6	-	-	-	2.40	33.80	-	-
	03-Jul-2013	8.26	27.5	158.0	114.00	139.00	<6	127.0	0.020	<0.005	0.290	<0.05	0.0640	30.5	-	-	-	2.00	34.90	-	-
	31-Jul-2013	8.07	22.5	130.0	110.00	134.00	<6	111.0	<0.01	<0.005	0.180	<0.05	0.0230	27.7	-	-	-	0.70	18.00	-	-
	28-Aug-2013	8.21	20.3	120.0	108.00	131.00	<6	100.0	<0.01	<0.005	0.160	<0.05	0.0170	25.9	-	-	-	0.50	12.00	-	-
	12-Jun-2014	8.22	27.3	149.0	122.00	149.00	6.00	130.0	0.010	<0.005	0.190	<0.05	0.0460	32.5	-	-	-	1.10	21.20	-	-
	09-Jul-2014	8.20	36.8	221.0	133.00	162.00	6.00	156.0	0.040	0.0060	0.480	<0.05	0.1740	35.5	-	-	-	4.50	61.50	-	-
	07-Aug-2014	8.19	24.2	138.0	118.00	144.00	6.00	116.0	**0.070**	<0.005	0.290	<0.05	0.0590	29.2	-	-	-	1.00	18.10	-	-
	04-Sep-2014	8.23	28.7	167.0	114.00	139.00	6.00	137.0	0.050	0.0060	0.330	<0.05	0.0360	32.4	-	-	-	2.70	37.60	-	-
	09-Jun-2015	8.03	29.1	169.0	136.00	166.00	<6	139.0	<0.01	<0.005	0.220	<0.05	0.0410	34.2	-	-	-	1.10	28.10	-	-
	07-Jul-2015	7.92	27.0	156.0	126.00	154.00	<6	132.0	<0.01	<0.005	0.180	<0.05	0.0330	32.7	-	-	-	0.80	24.90	-	-
	28-Jul-2015	8.47	22.7	134.0	115.00	141.00	<6	121.0	<0.01	<0.005	0.160	<0.05	0.0240	30.0	-	-	-	0.60	16.80	-	-
	01-Sep-2015	8.12	24.0	142.0	125.00	153.00	<6	123.0	<0.01	<0.005	0.130	<0.025	0.0140	30.7	-	-	-	0.60	17.90	-	-
	08-Jun-2016	8.21	28.7	169.0	120.00	147.00	<6	142.0	0.010	<0.005	0.310	<0.025	0.0120	34.2	-	-	-	1.50	37.70	-	-
	06-Jul-2016	7.88	22.7	120.0	109.00	133.00	<6	114.0	<0.01	<0.005	0.310	<0.025	0.0140	28.8	-	-	-	0.60	14.00	-	-
	10-Aug-2016	7.93	27.8	161.0	109.00	133.00	<6	135.0	0.010	<0.005	0.220	<0.025	0.0110	31.9	-	-	-	1.40	40.00	-	-
	31-Aug-2016	7.96	24.4	140.0	115.00	140.00	<6	122.0	<0.01	<0.005	0.210	<0.025	0.0070	30.0	-	-	-	0.90	19.00	-	-
	31-May-2017	8.18	28.4	161.0	126.00	154.00	<6	133.0	<0.01	<0.005	1.260	-	0.0270	32.8	-	-	-	1.30	28.00	-	-
	28-Jun-2017	8.32	23.1	134.0	117.00	143.00	<6	116.0	<0.01	<0.005	0.160	-	<0.005	29.2	-	-	-	0.70	17.00	-	-
	26-Jul-2017	8.13	22.3	127.0	108.00	131.00	<6	118.0	<0.01	<0.005	0.150	-	0.0220	29.6	-	-	-	0.60	15.00	-	-
	30-Aug-2017	8.31	21.4	125.0	109.00	132.00	<6	113.0	<0.01	<0.005	0.300	-	0.0140	28.9	-	-	-	0.70	15.00	-	-
	28-May-2018	8.13	29.8	173.0	125.00	152.00	<6	141.0	<0.01	<0.005	0.280	-	0.0540	35.2	-	-	-	1.30	35.70	-	-
	25-Jun-2018	8.06	22.5	123.0	106.00	129.00	<6	111.0	<0.01	<0.005	0.200	-	0.0210	27.9	-	-	-	0.90	15.00	-	-
	23-Jul-2018	8.27	23.2	127.0	109.00	133.00	<6	113.0	<0.01	<0.005	0.140	-	0.0140	28.8	-	-	-	0.80	16.00	-	-
	20-Aug-2018	8.27	22.0	123.0	111.00	135.00	<6	112.0	<0.01	<0.005	0.130	-	0.0120	28.8	-	-	-	0.60	13.00	-	-
	27-May-2019	7.85	27.4	156.0	122.00	149.00	<6	128.0	<0.01	<0.005	0.270	-	0.0190	31.2	-	-	-	1.50	27.00	-	-
	24-Jun-2019	8.02	25.4	146.0	121.00	148.00	<6	132.0	0.020	0.0060	0.220	-	0.0250	33.1	-	-	-	0.90	19.00	-	-
	29-Jul-2019	8.25	22.8	115.0	115.00	140.00	<6	117.0	<0.01	<0.005	0.150	-	0.0170	29.4	-	-	-	0.90	<0.9	-	-
	26-Aug-2019	8.02	23.5	130.0	120.00	147.00	<6	116.0	<0.01	<0.005	0.190	-	0.0060	29.4	-	-	-	0.80	13.00	-	-
	22-Jun-2020	8.33	28.3	163.0	137.00	167.00	<6	137.0	<0.01	<0.005	0.420	-	0.0370	33.5	-	-	-	1.20	25.00	-	-
	27-Jul-2020	8.33	25.0	141.0	119.00	145.00	<6	122.0	<0.01	<0.005	0.200	-	0.0160	30.6	-	-	-	1.00	20.00	-	-
	24-Aug-2020	8.20	22.5	126.0	113.00	138.00	<6	114.0	<0.01	<0.005	0.150	-	0.0200	28.5	-	-	-	0.70	13.00	-	-
SMW-R2	04-Jul-2006	8.90	34.3	221.0	97.00	99.00	10.00	130.0	<0.05	<0.05	-	<0.05	0.0700	22.9	23.00	17.30	2.00	2.90	92.90	-	-
	17-Jul-2006	9.00	24.6	138.0	96.00	98.00	10.00	110.0	<0.05	<0.05	-	<0.05	0.0500	21.7	10.00	12.30	1.20	1.00	32.30	-	-
	14-Aug-2006	8.60	22.4	120.0	102.00	114.00	5.00	103.0	<0.05	<0.05	-	<0.05	0.0200	21.5	6.00	11.20	1.20	0.60	16.80	-	-
	28-Aug-2006	8.70	21.7	115.0	100.00	110.00	6.00	93.0	<0.05	<0.05	-	<0.05	0.0400	18.3	6.00	11.20	1.20	0.70	17.20	-	-
	25-Jun-2007	8.90	18.3	97.0	75.00	79.00	6.00	86.0	<0.05	<0.05	-	<0.05	<0.02	16.2	6.00	11.00	0.70	0.50	17.60	-	-
	09-Jul-2007	8.60	21.1	141.0	101.00	114.00	<5	139.0	<0.05	<0.05	-	<0.05	0.0200	26.8	8.00	11.60	1.10	0.70	23.60	-	-
	07-Aug-2007	7.70	23.1	150.0	108.00	132.00	<5	104.0	<0.05	<0.05	-	<0.05	0.0300	20.0	7.00	11.50	1.30	0.80	22.00	-	-
	20-Aug-2007	7.20	23.6	153.0	125.00	153.00	<5	103.0	<0.05	<0.05	-	<0.05	0.0300	21.9	6.00	11.40	1.20	0.80	20.40	-	-
	06-Jul-2011	9.13	55.2	352.0	120.00	107.00	19.00	202.0	0.050	<0.005	1.000	<0.05	0.0600	30.7	-	-	-	7.90	162.00	-	-
	20-Jul-2011	8.74	29.7	171.0	98.00	104.00	8.00	120.0	**0.080**	<0.005	0.520	<0.05	0.0500	21.8	-	-	-	2.70	51.70	-	-
	10-Aug-2011	8.74	24.3	140.0	104.00	110.00	8.00	109.0	<0.01	<0.005	0.520	<0.05	0.0500	21.0	-	-	-	1.30	28.00	-	-
	31-Aug-2011	8.22	23.1	120.0	99.00	121.00	<6	102.0	0.020	<0.005	0.520	<0.05	<0.05	20.8	-	-	-	0.90	21.00	-	-
	06-Jun-2012	8.91	21.5	128.0	91.00	93.00	9.00	97.0	0.020	0.0060	0.390	<0.05	0.0660	17.5	-	-	-	0.60	31.80	-	-
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	9.40	21.3	132.0	85.00	67.00	18.00	96.0	<0.01	<0.005	0.500	<0.05	0.0670	16.7	-	-	-	1.30	36.50	-	-
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	8.82	16.7	95.0	80.00	82.00	8.00	84.0	<0.01	<0.005	0.410	<0.05	0.0350	16.3	-	-	-	0.50	14.00	-	-
	29-Aug-2012	8.56	20.3	120.0	91.00	111.00	<6	98.0	0.010	<0.005	0.370	<0.05	0.0330	21.7	-	-	-	0.70	21.00	-	-
	12-Jun-2013	9.08	18.5	100.0	72.00	67.00	10.00	86.1	0.020	<0.005	0.410	<0.05	0.0360	16.1	-	-	-	0.80	25.00	-	-
	03-Jul-2013	9.03	32.3	195.0	95.00	92.00	12.00	138.0	**0.090**	<0.005	0.550	**0.1000**	0.0400	25.6	-	-	-	2.30	73.70	-	-
	31-Jul-2013	8.42	19.1	110.0	91.00	111.00	<6	88.5	0.010	<0.005	0.340	<0.05	0.0250	17.4	-	-	-	1.00	17.00	-	-
	28-Aug-2013	8.43	18.8	110.0	95.00	116.00	<6	94.0	0.020	<0.005	0.270	<0.05	0.0270	21.0	-	-	-	0.60	14.00	-	-
	12-Jun-2014	9.14	22.7	124.0	83.00	78.00	12.00	93.8	0.020	<0.005	0.350	<0.05	0.0520	15.8	-	-	-	1.70	31.50	-	-
	09-Jul-2014	9.07	43.6	269.0	148.00	140.00	20.00	193.0	0.030	<0.005	0.930	<0.05	0.2460	45.2	-	-	-	8.90	77.90	-	-
	07-Aug-2014	8.28	24.4	137.0	113.00	138.00	6.00	114.0	0.010	<0.005	0.350	<0.05	0.0590	27.1	-	-	-	1.20	19.10	-	-
	04-Sep-2014	8.12	22.1	130.0	109.00	133.00	6.00	111.0	0.020	<0.005	0.370	<0.05	0.0370	26.7	-	-	-	1.00	18.10	-	-
	09-Jun-2015	9.32	22.7	130.0	90.00	71.00	19.00	97.5	<0.01	<0.005	0.180	<0.05	0.0340	17.5	-	-	-	1.10	32.30	-	-
	07-Jul-2015	8.35	22.5	130.0	104.00	127.00	<6	106.0	<0.01	<0.005	0.240	<0.05	0.0310	22.3	-	-	-	0.90	23.20	-	-
	28-Jul-2015	8.39	19.0	111.0	93.00	113.00	<6	94.1	0.010	<0.005	0.170	<0.05	0.0220	18.7	-	-	-	0.80	16.90	-	-
	01-Sep-2015	7.99	22.7	130.0	108.00	132.00	<6	111.0	<0.01	<0.005	0.270	0.0350	0.0230	24.6	-	-	-	0.80	19.80	-	-
	08-Jun-2016	8.79	19.7	110.0	85.60	89.00	8.00	93.1	<0.01	<0.005	0.390	<0.025	0.0180	17.0	-	-	-	0.80	25.00	-	-
	06-Jul-2016	8.73	17.9	99.0	83.10	84.00	8.00	84.8	0.010	<0.005	0.430	<0.025	0.0310	16.4	-	-	-	0.70	16.00	-	-
	10-Aug-2016	8.08	17.7	96.0	83.20	101.00	<6	83.8	0.020	<0.005	0.370	0.0270	0.0340	16.6	-	-	-	0.80	12.00	-	-
	31-Aug-2016	7.94	20.0	110.0	97.20	119.00	<6	97.5	0.010	<0.005	0.370	<0.025	0.0520	20.6	-	-	-	0.90	16.00	-	-
	31-May-2017	8.56	22.8	129.0	89.30	109.00	<6	97.0	0.020	<0.005	1.820	-	0.0290	18.7	-	-	-	1.20	31.90	-	-
	28-Jun-2017	8.66	18.8	101.0	78.10	95.00	<6	90.0	<0.01	<0.005	0.280	-	0.0080	18.7	-	-	-	0.70	18.00	-	-
	26-Jul-2017	7.98	20.4	114.0	92.90	113.00	<6	98.7	**0.290**	<0.005	1.550	-	0.0580	21.7	-	-	-	1.00	19.00	-	-
	30-Aug-2017	8.33	17.8	102.0	89.60	109.00	<6	93.0	<0.01	<0.005	0.260	-	0.0210	20.7	-	-	-	0.60	12.00	-	-
	28-May-2018	8.34	31.7	188.0	117.00	142.00	<6	140.0	<0.01	<0.005	0.440	-	0.0640	31.7	-	-	-	2.80	49.90	-	-
	25-Jun-2018	8.95	17.3	95.0	71.90	51.00	18.00	81.6	0.010	<0.005	0.310	-	0.0270	15.5	-	-	-	0.80	19.00	-	-
	23-Jul-2018	8.69	18.9	103.0	86.00	89.00	8.00	89.0	<0.01	<0.005	0.380	-	0.0120	19.1	-	-	-	0.80	15.00	-	-
	20-Aug-2018	8.31	19.8	112.0	103.00	125.00	<6	97.6	<0.01	<0.005	0.290	-	0.0190	22.4	-	-	-	0.70	12.00	-	-
	27-May-2019	8.16	27.9	163.0	120.00	146.00	<6	121.0	<0.01	<0.005	0.600	-	0.0240	26.7	-	-	-	1.70	36.40	-	-
	24-Jun-2019	8.40	21.1	120.0	96.00	117.00	<6	102.0	0.020	<0.005	0.490	-	0.0270	20.5	-	-	-	0.90	21.00	-	-
	29-Jul-2019	8.30	19.2	90.0	90.00	110.00	<6	91.1	0.010	<0.005	0.320	-	0.0140	19.2	-	-	-	0.70	<0.9	-	-
	26-Aug-2019	8.67	18.6	102.0	92.00	95.00	8.00	91.1	0.020	<0.005	0.700	-	0.0070	18.9	-	-	-	0.70	11.00	-	-
	22-Jun-2020	8.82	21.6	120.0	92.00	98.00	7.00	95.1	0.030	<0.005	0.650	-	0.0360	16.5	-	-	-	1.20	25.00	-	-
	27-Jul-2020	8.53	20.7	114.0	93.00	113.00	<6	92.9	0.030	<0.005	0.360	-	0.0240	18.8	-	-	-	1.30	19.00	-	-
	24-Aug-2020	8.49	18.5	104.0	91.00	111.00	<6	92.5	0.020	<0.005	0.360	-	0.0200	19.0	-	-	-	0.80	12.00	-	-
SMW-S1	04-Jul-2006	8.60	29.0	175.0	120.00	133.00	6.00	131.0	**0.260**	<0.05	-	<0.05	0.0200	30.6	11.00	12.80	1.60	1.30	43.50	-	-
	17-Jul-2006	8.40	28.2	159.0	117.00	137.00	<5	131.0	**0.130**	<0.05	-	<0.05	<0.02	31.2	9.00	11.70	1.30	1.10	31.70	-	-
	14-Aug-2006	8.50	23.2	126.0	110.00	125.00	<5	112.0	0.050	<0.05	-	<0.05	<0.02	26.9	5.00	10.30	0.90	0.70	14.70	-	-
	28-Aug-2006	8.40	24.0	130.0	112.00	131.00	<5	111.0	<0.05	<0.05	-	<0.05	<0.02	26.6	6.00	10.50	1.00	0.70	17.30	-	-
	25-Jun-2007	8.30	23.1	124.0	100.00	119.00	<5	112.0	<0.05	<0.05	-	<0.05	<0.02	27.2	6.00	10.30	0.70	0.50	18.60	-	-
	09-Jul-2007	8.20	24.7	165.0	125.00	152.00	<5	162.0	<0.05	<0.05	-	<0.05	<0.02	36.7	7.00	11.00	1.10	0.70	23.70	-	-
	07-Aug-2007	7.90	27.3	177.0	120.00	147.00	<5	124.0	<0.05	<0.05	-	<0.05	0.0200	28.2	9.00	11.40	1.20	0.90	28.70	-	-
	20-Aug-2007	7.30	21.7	141.0	126.00	154.00	<5	103.0	<0.05	<0.05	-	<0.05	<0.02	25.6	3.00	9.40	0.70	0.40	11.10	-	-

Notes:
1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
1i. Value (i) Concentration is less than guidelines

2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
4a. Nitrite-N guidelines are chloride dependent.
4b. Total ammonia concentrations are pH and temperature dependent.
4c. Sulphate guidelines are hardness dependent.

GENERAL		PHYSICAL PARAMETERS							NUTRIENTS					MACRO PARAMETERS						BACTERIA	
Location	Sample Date (dd-mmm-yyyy)	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO_3	Carbonate - CO_3	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Ammonia	Total Phosphorus	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fecal Coliforms	Escherichia coli
Units		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	#/100mL	#/100mL
GUIDELINES																					
Freshwater Aquatics - Chronic [1a]		6.5-9	-	-	<20	-	-	-	Calc	3	-	Calc	-	-	-	-	-	120	Calc	-	-
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	-	Calc	124	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1c]		-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	100
Livestock [1d]		-	-	3000	-	-	-	-	10	-	-	-	-	1000	-	-	-	-	1000	-	-
Recreation and Aesthetics [1e]		5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Freshwater Aquatics - Chronic [1f]		**6.5-9**	-	-	-	-	-	-	**0.06**	**13**	-	**Calc**	-	-	-	-	-	**120**	-	-	-
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	-	-	550	-	-	-	-	-	-	-	640	-	-	-
Irrigation [1h]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-
Livestock [1d]		-	-	3000	-	-	-	-	-	-	-	-	-	1000	-	-	-	-	1000	-	-
SWM-S2	06-Jul-2011	8.68	40.6	246.0	147.00	155.00	11.00	172.0	<0.01	<0.005	0.500	<0.05	<0.05	38.1	-	-	-	2.40	72.80	-	-
	20-Jul-2011	8.26	26.0	150.0	120.00	146.00	<6	120.0	**0.090**	0.0070	0.320	<0.05	<0.05	29.6	-	-	-	1.10	25.00	-	-
	10-Aug-2011	8.42	22.9	130.0	110.00	134.00	<6	113.0	0.010	0.0090	0.290	<0.05	<0.05	27.6	-	-	-	0.60	16.00	-	-
	31-Aug-2011	8.05	22.6	120.0	104.00	127.00	<6	100.0	<0.01	<0.005	0.170	<0.05	<0.05	25.8	-	-	-	0.70	16.00	-	-
	06-Jun-2012	8.23	24.2	150.0	123.00	150.00	<6	127.0	<0.01	<0.005	0.200	<0.05	0.0250	31.1	-	-	-	1.00	21.00	-	-
	04-Jul-2012	8.60	27.2	165.0	114.00	139.00	<6	125.0	<0.01	<0.005	0.330	<0.05	0.0360	28.8	-	-	-	1.10	39.70	-	-
	01-Aug-2012	8.39	21.0	120.0	100.00	122.00	<6	100.0	<0.01	<0.005	0.210	<0.05	0.0150	24.7	-	-	-	0.70	18.00	-	-
	29-Aug-2012	8.28	19.9	120.0	102.00	124.00	<6	100.0	0.010	<0.005	0.190	<0.05	0.0170	25.9	-	-	-	0.60	14.00	-	-
	12-Jun-2013	8.26	24.2	140.0	119.00	145.00	<6	115.0	<0.01	<0.005	0.220	<0.05	0.0140	28.4	-	-	-	0.60	23.00	-	-
	03-Jul-2013	8.41	7.1	120.0	104.00	126.00	<6	100.0	0.010	<0.005	0.160	<0.05	0.0210	26.2	-	-	-	0.70	15.00	-	-
	31-Jul-2013	8.16	19.7	110.0	102.00	124.00	<6	95.0	<0.01	<0.005	0.140	<0.05	<0.005	23.9	-	-	-	0.50	12.00	-	-
	28-Aug-2013	8.31	19.6	110.0	103.00	126.00	<6	99.0	<0.01	<0.005	0.150	<0.05	0.0100	25.2	-	-	-	0.50	11.00	-	-
	12-Jun-2014	8.24	25.1	134.0	116.00	141.00	6.00	120.0	0.020	<0.005	0.140	<0.05	0.0280	30.4	-	-	-	0.90	15.30	-	-
	09-Jul-2014	8.25	34.4	197.0	126.00	154.00	6.00	142.0	**0.180**	0.0060	0.560	0.0600	0.0720	32.4	-	-	-	2.30	51.10	-	-
	07-Aug-2014	8.34	22.8	131.0	115.00	140.00	6.00	112.0	0.060	<0.005	0.280	<0.05	0.0260	28.3	-	-	-	0.70	15.70	-	-
	04-Sep-2014	8.22	23.6	137.0	106.00	130.00	6.00	121.0	0.040	<0.005	0.210	<0.05	0.0160	30.3	-	-	-	1.10	22.20	-	-
	09-Jun-2015	8.30	27.0	156.0	132.00	160.00	<6	130.0	<0.01	<0.005	0.310	<0.05	0.0270	32.3	-	-	-	0.90	22.70	-	-
	07-Jul-2015	8.03	25.4	149.0	126.00	154.00	<6	125.0	0.020	<0.005	0.210	<0.05	0.0170	31.1	-	-	-	0.80	21.80	-	-
	28-Jul-2015	8.39	22.1	127.0	112.00	137.00	<6	115.0	<0.01	<0.005	0.330	<0.05	0.0100	28.7	-	-	-	0.60	14.70	-	-
	01-Sep-2015	7.93	23.7	135.0	122.00	148.00	<6	120.0	<0.01	<0.005	0.120	<0.025	0.0060	29.9	-	-	-	0.50	15.40	-	-
	08-Jun-2016	8.06	24.2	140.0	122.00	149.00	<6	123.0	0.020	<0.005	0.290	<0.025	0.0150	30.4	-	-	-	0.70	20.00	-	-
	06-Jul-2016	8.14	21.7	120.0	107.00	131.00	<6	110.0	0.010	<0.005	0.340	<0.025	0.0140	27.4	-	-	-	0.40	13.00	-	-
	10-Aug-2016	8.02	21.7	120.0	108.00	132.00	<6	107.0	0.010	<0.005	0.160	<0.025	<0.005	26.4	-	-	-	0.60	15.00	-	-
	31-Aug-2016	8.08	23.9	130.0	109.00	133.00	<6	118.0	<0.01	<0.005	0.150	<0.025	<0.005	29.0	-	-	-	0.70	19.00	-	-
	31-May-2017	8.16	26.3	141.0	111.00	135.00	<6	122.0	<0.01	<0.005	0.450	-	0.0310	30.5	-	-	-	1.10	23.00	-	-
	28-Jun-2017	8.19	22.7	125.0	102.00	124.00	<6	115.0	<0.01	<0.005	0.170	-	0.0080	29.0	-	-	-	0.60	17.00	-	-
	26-Jul-2017	8.10	21.6	120.0	101.00	123.00	<6	115.0	<0.01	<0.005	0.120	-	0.0120	28.9	-	-	-	0.50	15.00	-	-
	30-Aug-2017	8.32	19.9	122.0	112.00	137.00	<6	106.0	<0.01	<0.005	0.110	-	0.0090	27.0	-	-	-	0.60	13.00	-	-
	28-May-2018	8.13	31.3	165.0	119.00	145.00	<6	135.0	<0.01	<0.005	0.270	-	0.0360	33.5	-	-	-	1.40	33.80	-	-
	25-Jun-2018	7.96	21.4	120.0	108.00	131.00	<6	106.0	0.020	<0.005	0.190	-	0.0140	26.7	-	-	-	0.80	13.00	-	-
	23-Jul-2018	8.24	22.5	122.0	106.00	129.00	<6	110.0	<0.01	<0.005	0.160	-	0.0070	27.9	-	-	-	0.70	15.00	-	-
	20-Aug-2018	8.18	21.6	118.0	106.00	129.00	<6	109.0	<0.01	<0.005	0.130	-	0.0100	27.9	-	-	-	0.60	12.00	-	-
	27-May-2019	8.22	27.2	156.0	126.00	153.00	<7	124.0	<0.01	<0.005	0.300	-	0.0070	30.5	-	-	-	1.30	26.00	-	-
	24-Jun-2019	8.15	24.6	141.0	121.00	147.00	<6	127.0	0.030	<0.005	0.190	-	0.0150	31.7	-	-	-	0.80	17.00	-	-
	29-Jul-2019	8.22	21.7	110.0	113.00	137.00	<6	110.0	<0.01	<0.005	0.170	-	0.0100	27.7	-	-	-	0.50	<0.9	-	-
	26-Aug-2019	8.11	22.4	121.0	113.00	138.00	<6	111.0	<0.01	<0.005	0.500	-	<0.005	28.3	-	-	-	0.60	11.00	-	-
	22-Jun-2020	8.27	25.1	140.0	124.00	151.00	<6	126.0	<0.01	<0.005	0.390	-	0.0250	31.0	-	-	-	1.00	16.00	-	-
	27-Jul-2020	8.01	22.2	121.0	110.00	134.00	<6	107.0	0.030	<0.005	0.250	-	0.0090	27.2	-	-	-	0.70	12.00	-	-
	24-Aug-2020	8.33	21.2	120.0	110.00	134.00	<6	109.0	<0.01	<0.005	0.150	-	0.0190	27.5	-	-	-	0.70	11.00	-	-
AB05AG0261 (Chin Reservoir)	18-Jun-2008	8.20	300.0	180.0	130.00	160.00	<0.5	150.0	<0.003	0.0340	0.500	0.1000	0.0210	36.0	12.00	14.00	1.10	2.80	38.00	-	-
	06-Aug-2008	8.40	290.0	180.0	120.00	150.00	1.60	140.0	<0.003	<0.003	0.140	<0.05	0.0150	36.0	11.00	13.00	1.40	2.40	40.00	-	-
	03-Sep-2008	8.20	310.0	170.0	120.00	150.00	<0.5	140.0	<0.003	0.0160	0.180	<0.05	0.0100	35.0	12.00	13.00	1.20	4.00	25.00	-	-
	23-Sep-2008	8.70	290.0	170.0	130.00	140.00	11.00	140.0	<0.003	<0.003	2.000	<0.05	0.0090	34.0	9.70	13.00	1.20	2.10	30.00	-	-
AB05AG0262 (Chin Reservoir)	18-Jun-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
	06-Aug-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
	03-Sep-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47	47
	23-Sep-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74	74
AB05AG0250 (Stafford Reservoir)	16-Jun-1983	7.99	311.0	-	124.00	-	-	-	-	-	0.200	0.0200	0.0130	32.2	12.00	11.90	1.36	2.70	38.00	-	-
	13-Sep-1983	8.05	279.0	-	116.00	-	-	-	-	-	0.400	<0.01	0.0170	29.7	9.20	12.00	1.09	1.10	28.00	-	-
	18-Jun-2013	8.29	290.0	170.0	110.00	140.00	<0.5	140.0	<0.003	<0.003	0.220	0.1100	0.0100	36.0	12.00	13.00	1.20	1.20	37.00	-	-
	16-Jul-2013	8.15	280.0	160.0	110.00	130.00	<0.5	130.0	<0.003	<0.003	0.170	<0.05	0.0086	31.0	11.00	13.00	1.20	1.10	33.00	-	-
	14-Aug-2013	8.10	250.0	150.0	100.00	120.00	<0.5	120.0	<0.003	<0.003	0.150	0.0540	0.0085	31.0	9.00	11.00	1.10	1.80	28.00	-	-
	10-Sep-2013	7.94	250.0	150.0	110.00	130.00	<0.5	130.0	<0.003	<0.003	0.120	<0.05	0.0110	33.0	8.10	12.00	1.10	1.00	24.00	-	-
AB05AG0260 (Stafford Reservoir)	18-Jun-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<2	<1
	16-Jul-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	<1
	14-Aug-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	155
	10-Sep-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1999). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Nitrite-N guidelines are chloride dependent.
   - 4b. Total ammonia concentrations are pH and temperature dependent.
   - 4c. Sulphate guidelines are hardness dependent.

GENERAL		TOTAL METALS																												
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																														
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SMC-P1	04-Jul-2006	**0.440**	0.0007	0.0011	0.135	<0.001	-	0.250	<0.0002	<0.0002	<0.002	0.00200	**0.357**	0.0002000	0.0100	0.021	<0.0002	<0.005	0.00900	0.000800	<0.0004	-	<0.0001	<0.05	0.0360	0.0012	0.0020	0.014
	17-Jul-2006	**0.380**	0.0008	0.0010	0.104	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.363**	0.0002000	<0.01	0.017	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.0110	0.0010	0.0020	0.015
	14-Aug-2006	**0.130**	0.0011	0.0009	0.093	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.111	<0.0001	<0.01	0.009	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.0030	0.0007	<0.001	<0.004
	28-Aug-2006	0.050	0.0008	0.0009	0.105	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.102	<0.0001	<0.01	0.010	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.0030	0.0006	<0.001	<0.004
	25-Jun-2007	**0.370**	<0.0004	0.0007	0.114	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.250	0.0002000	<0.01	0.018	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.0090	0.0008	0.0010	0.022
	09-Jul-2007	**0.360**	<0.0004	0.0007	0.109	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	**0.323**	0.0003000	<0.01	0.015	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.0090	0.0010	0.0010	0.007
	07-Aug-2007	**0.190**	0.0009	0.0008	0.101	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.151	<0.0001	<0.01	0.011	<0.0002	<0.005	<0.002	0.000900	<0.0004	-	<0.0001	<0.05	0.0060	0.0007	<0.001	<0.004
	20-Aug-2007	0.070	<0.0004	0.0008	0.108	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.084	<0.0001	<0.01	0.008	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.0030	0.0006	<0.001	0.010
	06-Jul-2011	**1.200**	<0.0002	0.0017	0.118	<0.0001	<0.0005	0.032	0.00004	0.00004	0.00060	0.00300	**1.020**	0.0006000	0.019	0.080	<0.0001	0.001	0.00230	<0.0002	0.00001	0.248	<0.00005	<0.001	0.0232	0.0018	0.0037	0.007
	20-Jul-2011	**0.540**	0.0003	0.0014	0.104	<0.0001	<0.0005	0.022	0.00002	0.00002	0.00030	0.00200	**0.520**	0.0004000	0.014	0.032	<0.0001	<0.001	0.00110	0.000300	<0.00001	0.226	<0.00005	<0.001	0.0145	0.0016	0.0023	0.004
	10-Aug-2011	**0.120**	<0.0002	0.0012	0.105	<0.0001	<0.0005	0.017	0.00002	0.00002	0.00010	0.00200	0.110	0.0001000	0.009	0.012	<0.0001	<0.001	0.00100	<0.0002	0.00001	0.185	<0.00005	<0.001	0.0038	0.0012	0.0011	0.002
	31-Aug-2011	0.040	<0.0002	0.0012	0.099	<0.0001	<0.0005	0.016	0.00002	0.00002	<0.0001	0.00100	**<0.05**	<0.0001	0.007	0.010	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.152	<0.00005	<0.001	0.0024	0.0008	0.0008	0.002
	06-Jun-2012	**0.420**	<0.0002	0.0008	0.108	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00020	0.00100	**0.430**	0.0002000	0.010	0.036	<0.0001	<0.001	0.00090	0.000500	<0.00001	0.175	<0.00005	<0.001	0.0088	0.0012	0.0016	0.002
	04-Jul-2012	**0.120**	<0.0002	0.0009	0.096	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00020	0.00200	0.110	<0.0001	0.010	0.021	<0.0001	<0.001	0.00080	0.000500	<0.00001	0.178	<0.00005	<0.001	0.0040	0.0013	0.0012	0.002
	01-Aug-2012	**0.150**	<0.0002	0.0007	0.098	<0.0001	<0.0005	0.014	<0.00001	<0.00001	<0.0001	0.00100	0.130	<0.0001	0.007	0.011	<0.0001	<0.001	<0.0005	0.000200	<0.00001	0.148	<0.00005	<0.001	0.0032	0.0009	0.0009	0.002
	29-Aug-2012	0.080	<0.0002	0.0010	0.102	<0.0001	<0.0005	0.013	<0.00001	<0.00001	<0.0001	0.00100	0.090	<0.0001	0.007	0.009	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.151	<0.00005	<0.001	0.0018	0.0009	0.0008	0.002
	12-Jun-2013	0.090	<0.0002	0.0008	0.100	<0.0001	<0.0005	0.012	<0.00001	<0.00001	<0.0001	0.00100	0.110	<0.0001	0.007	0.022	<0.0001	<0.001	0.00060	0.000300	<0.00001	0.154	<0.00005	<0.001	0.0016	0.0009	0.0006	<0.001
	03-Jul-2013	**0.390**	<0.0002	0.0008	0.106	<0.0001	<0.0005	0.012	0.00001	0.00001	0.00020	0.00200	**0.400**	0.0002000	0.006	0.027	<0.0001	<0.001	0.00100	0.000400	<0.00001	0.134	<0.00005	<0.001	0.0070	0.0008	0.0014	0.002
	31-Jul-2013	0.080	<0.0002	0.0010	0.112	<0.0001	<0.0005	0.012	<0.00001	<0.00001	<0.0001	<0.001	0.090	<0.0001	0.006	0.015	<0.0001	<0.001	<0.0005	0.000300	0.00001	0.144	<0.00005	<0.001	0.0016	0.0007	0.0007	0.001
	28-Aug-2013	0.040	<0.0002	0.0008	0.098	<0.0001	<0.0005	0.010	<0.00001	<0.00001	<0.0001	<0.001	**<0.05**	<0.0001	0.004	0.010	<0.0001	<0.001	<0.0005	0.000300	<0.00001	0.122	<0.00005	<0.001	0.0012	0.0006	0.0005	0.001
	10-Jun-2014	0.090	<0.0002	0.0010	0.104	<0.0001	<0.0005	0.013	<0.00001	<0.00001	0.00010	0.00100	0.120	<0.0001	0.007	0.026	<0.000005	<0.001	0.00100	0.000400	<0.00001	0.173	<0.00005	<0.001	0.0019	0.0010	0.0005	0.004
	07-Jul-2014	**0.350**	<0.0002	0.0018	0.116	<0.0001	<0.0005	0.017	0.00002	0.00002	0.00030	0.00200	**0.480**	0.0004000	0.009	0.062	<0.000005	<0.001	0.00170	0.000700	<0.00001	0.173	<0.00005	<0.001	0.0086	0.0011	0.0018	0.006
	08-Jun-2015	**0.160**	<0.0002	0.0008	0.110	<0.0001	<0.0005	0.013	<0.00001	<0.00001	0.00010	0.00300	0.200	0.0001000	0.007	0.016	<0.000005	<0.001	0.00080	0.000400	<0.00001	0.172	<0.00005	<0.001	0.0042	0.0011	0.0011	0.001
	06-Jul-2015	**0.190**	<0.0002	0.0010	0.111	<0.0001	<0.0005	0.011	0.00001	0.00001	0.00020	0.00100	0.290	0.0002000	0.006	0.016	<0.000005	<0.001	0.00120	0.000300	<0.00001	0.148	<0.00005	<0.001	0.0050	0.0009	0.0014	0.003
	27-Jul-2015	0.060	<0.0002	0.0010	0.115	<0.0001	<0.0005	0.011	<0.00001	<0.00001	<0.0001	<0.001	0.110	<0.0001	0.005	0.011	**0.00001000**	<0.001	0.00050	0.000300	<0.00001	0.130	<0.00005	<0.001	0.0018	0.0007	0.0007	<0.001
	31-Aug-2015	**0.120**	<0.0002	0.0012	0.112	<0.0001	<0.0005	0.011	<0.00001	<0.00001	<0.0001	<0.001	0.120	<0.0001	0.005	0.012	<0.000005	<0.001	<0.0005	0.000300	<0.00001	0.128	<0.00005	<0.001	0.0027	0.0007	0.0008	<0.001
SMC-R1	04-Jul-2006	**0.2200**	0.00070	0.00170	0.1260	<0.001	-	0.160	<0.0002	<0.0002	<0.002	0.00100	0.164	0.0002000	<0.0002	0.02700	**0.0100**	<0.005	<0.002	0.000400	<0.0004		0.000100	<0.05	0.03400	0.001100	0.00100	0.0110
	17-Jul-2006	**0.2500**	0.00090	0.00160	0.0910	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.186	0.0001000	<0.0002	0.02600	<0.01	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00500	0.001000	0.00100	<0.004
	14-Aug-2006	0.0600	0.00110	0.00200	0.0830	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	0.057	<0.0001	<0.0002	0.01700	<0.01	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	0.00100	0.0060
	28-Aug-2006	0.0400	0.00130	0.00200	0.0900	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.049	<0.0001	<0.0002	0.01800	**0.0100**	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.00200	0.000800	<0.001	<0.004
	25-Jun-2007	**0.1600**	<0.0004	0.00130	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.141	<0.0001	<0.0002	0.01900	**0.0100**	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.00400	0.001200	<0.001	0.0180
	09-Jul-2007	0.0600	<0.0004	0.00140	0.0960	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.091	<0.0001	<0.0002	0.01500	<0.01	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.00200	0.001200	<0.001	0.0050
	07-Aug-2007	**0.1800**	<0.0004	0.00200	0.0930	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.178	0.0001000	<0.0002	0.02300	**0.0100**	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.00300	0.001000	0.00100	<0.004
	20-Aug-2007	**0.1800**	<0.0004	0.00250	0.0930	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.178	0.0001000	<0.0002	0.03600	**0.0100**	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00300	0.001000	<0.001	0.0060
	06-Jul-2011	**0.4600**	<0.0002	0.00220	0.1080	<0.0001	<0.0005	0.042	0.0000600	0.00006	0.00040	0.00200	**0.430**	0.0003000	<0.0001	0.05500	**0.0190**	<0.001	0.00180	<0.0002	<0.00001	0.2510	<0.00005	<0.001	0.01000	0.001400	0.00230	0.0070
	20-Jul-2011	**0.4000**	0.00020	0.00250	0.1080	<0.0001	<0.0005	0.040	0.0000200	0.00002	0.00040	0.00200	**0.470**	0.0003000	<0.0001	0.05400	**0.0190**	0.00100	0.00110	0.000400	0.00001	0.2550	<0.00005	<0.001	0.01260	0.001400	0.00260	0.0050
	10-Aug-2011	**0.2100**	<0.0002	0.00340	0.1100	<0.0001	<0.0005	0.040	0.0000300	0.00003	0.00030	0.00200	0.240	0.0002000	<0.0001	0.05300	**0.0200**	0.00100	0.00100	<0.0002	<0.00001	0.2460	<0.00005	<0.001	0.00700	0.001300	0.00260	0.0050
	31-Aug-2011	**0.1800**	<0.0002	0.00360	0.1040	<0.0001	<0.0005	0.050	0.0000200	0.00002	0.00020	<0.001	0.190	0.0001000	<0.0001	0.08500	**0.0240**	0.00100	<0.0005	<0.0002	<0.00001	0.2680	<0.00005	<0.001	0.00780	0.001100	0.00240	0.0030
	06-Jun-2012	**0.4800**	<0.0002	0.00160	0.0940	<0.0001	<0.0005	0.036	<0.00001	<0.00001	0.00030	0.00100	**0.490**	0.0003000	<0.0001	0.04400	**0.0190**	0.00100	0.00160	<0.0002	<0.00001	0.2460	<0.00005	<0.001	0.01630	0.001700	0.00210	0.0040
	04-Jul-2012	**0.1200**	<0.0002	0.00160	0.0840	0.000100	<0.0005	0.025	<0.00001	<0.00001	0.00020	0.00200	0.140	<0.0001	<0.0001	0.03100	**0.0130**	0.00100	0.00110	0.000400	<0.00001	0.1610	<0.00005	<0.001	0.00380	0.001500	0.00120	0.0030
	01-Aug-2012	**0.1800**	<0.0002	0.00150	0.0850	<0.0001	<0.0005	0.022	0.0000100	0.00001	0.00010	0.00100	0.180	<0.0001	<0.0001	0.02900	**0.0110**	0.00100	<0.0005	0.000200	<0.00001	0.2030	<0.00005	<0.001	0.00440	0.001400	0.00130	0.0030
	29-Aug-2012	0.0600	<0.0002	0.00140	0.0950	<0.0001	<0.0005	0.021	<0.00001	<0.00001	<0.0001	0.00100	0.070	<0.0001	<0.0001	0.01900	**0.0100**	0.00100	0.00070	<0.0002	<0.00001	0.1920	<0.00005	<0.001	0.00170	0.001200	0.00080	0.0020
	12-Jun-2013	0.0400	<0.0002	0.00110	0.0840	<0.0001	<0.0005	0.019	<0.00001	<0.00001	<0.0001	<0.001	0.050	<0.0001	<0.0001	0.01400	**0.0090**	<0.001	0.00080	0.000300	<0.00001	0.1940	<0.00005	<0.001	0.00060	0.001100	0.00050	0.0020
	03-Jul-2013	**0.1500**	<0.0002	0.00140	0.0830	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	0.00100	0.190	0.0001000	<0.0001	0.02100	**0.0090**	<0.001	0.00100	0.000400	<0.00001	0.1800	<0.00005	<0.001	0.00300	0.001100	0.00100	0.0020
	31-Jul-2013	0.0500	<0.0002	0.00130	0.0760	<0.0001	<0.0005	0.015	<0.00001	<0.00001	<0.0001	<0.001	0.080	<0.0001	<0.0001	0.01400	**0.0080**	<0.001	0.00050	0.000300	<0.00001	0.1570	<0.00005	<0.001	0.00110	0.000900	0.00070	<0.001
	28-Aug-2013	0.0400	0.00060	0.00150	0.0770	<0.0001	<0.0005	0.014	<0.00001	<0.00001	<0.0001	<0.001	0.050	<0.0001	<0.0001	0.01700	**0.0060**	<0.001	<0.0005	0.000200	0.00001	0.1440	<0.00005	<0.001	0.00100	0.000800	0.00050	0.0010
	12-Jun-2014	0.0400	<0.0002	0.00140	0.0930	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	0.00200	0.090	<0.0001	<0.000005	0.02200	**0.0080**	<0.001	<0.0005	0.000300	0.00004	0.1810	<0.00005	<0.001	0.00110	0.001100	0.00060	0.0030
	09-Jul-2014	0.0900	<0.0002	0.00180	0.0910	<0.0001	<0.0005	0.019	<0.00001	<0.00001	0.00020	0.00100	0.210	0.0001000	<0.000005	0.03900	**0.0090**	<0.001	0.00110	0.000600	0.00001	0.1810	<0.00005	<0.001	0.00220	0.001200	0.00100	0.0060
	07-Aug-2014	0.0500	<0.0002	0.00220	0.0800	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00020	0.00100	0.100	<0.0001	<0.000005	0.02800	**0.0080**	<0.001	0.00090	0.000400	0.00001	0.1620	<0.00005	<0.001	0.00160	0.000900	0.00100	0.0020
	03-Sep-2014	<0.02	<0.0002	0.00230	0.0940	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	0.00100	0.100	<0.0001	<0.000005	0.03300	**0.0080**	<0.001	0.00140	0.000300	<0.00001	0.1630	<0.00005	<0.001	0.00150	0.000900	0.00070	0.0060
	10-Jun-2015	**0.2300**	<0.0002	0.00130	0.0940	<0.0001	<0.0005	0.016	0.0000100	0.00001	0.00020	0.00100	**0.340**	0.0002000	<0.000005	0.03800	**0.0090**	<0.001	0.00110	0.000400	<0.00001	0.1870	<0.00005	<0.001	0.00500	0.001300	0.00100	0.0030
	08-Jul-2015	0.0300	<0.0002	0.00140	0.0940	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00020	0.00200	0.070	<0.0001	<0.000005	0.02100	**0.0080**	<0.001	0.00090	0.000400	<0.00001	0.1740	<0.00005	<0.001	0.00130	0.001100	0.00090	0.0010
	29-Jul-2015	0.0400	<0.0002	0.00150	0.1030	<0.0001	<0.0005	0.017	<0.00001	<0.00001	<0.0001	<0.001	0.090	<0.0001	<0.000005	0.02200	**0.0080**	<0.001	0.00090	0.000400	<0.00001	0.1730	<0.00005	<0.001	0.00150	0.001100	0.00070	0.0020
	02-Sep-2015	**0.1100**	<0.0002	0.00180	0.0980	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	<0.001	0.170	0.0001000	<0.000005	0.02400	**0.0070**	<0.001	0.00080	0.000300	<0.00001	0.1660	<0.00005	<0.001	0.00270	0.000900	0.00080	0.0030
SMC-R2	04-Jul-2006	0.0500	0.00060	0.00280	0.0600	<0.001	-	0.150	<0.0002	<0.0002	<0.002	0.00200	0.037	<0.0001	0.0200	0.01700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	0.000100	<0.05	0.02800	0.001100	0.00200	0.0090
	17-Jul-2006	0.0700	0.00080	0.00200	0.0750	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.065	<0.0001	0.0100	0.03100	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	0.00100	0.0070
	14-Aug-2006	0.0500	0.00090	0.00320	0.0760	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.040	<0.0001	0.0200	0.03900	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	0.00200	0.0100
	28-Aug-2006	0.0700	0.00100	0.00310	0.0710	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.063	<0.0001	0.0200	0.04100	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	0.00200	<0.004
	25-Jun-2007	0.0200	<0.0004	0.00200	0.0710	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.030	<0.0001	0.0200	0.03600	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	<0.001	0.001000	<0.001	<0.004
	09-Jul-2007	0.0100	<0.0004	0.00210	0.0500	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.026	0.0001000	0.0100	0.01500	<0.0002	<0.005	<0.002	0.000800	<0.0004	-	<0.0001	<0.05	<0.001	0.001000	0.00100	<0.004
	07-Aug-2007	0.0300	<0.0004	0.00300	0.0800	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.026	<0.0001	0.0200	0.08300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	<0.001	0.000700	0.00100	<0.004
	20-Aug-2007	**0.1100**	<0.0004	0.00300	0.0830	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.106	<0.0001	0.0100	0.08700	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.00300	0.000800	0.00100	0.0070
SMC-R3	04-Jul-2006	**0.1400**	0.00080	0.00180	0.1130	<0.001	-	0.140	<0.0002	<0.0002	<0.002	0.00100	0.108	<0.0001	0.0200	0.02300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	0.000100	<0.05	0.02800	0.001100	0.00100	0.0080
	17-Jul-2006	0.0800	0.00080	0.00340	0.0500	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.055	<0.0001	0.0200	0.02400	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	0.00200	<0.004
	14-Aug-2006	0.0800	0.00100	0.00240	0.0780	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.075	<0.0001	0.0100	0.02100	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.00300	0.000900	0.00100	0.0080
	28-Aug-2006	0.0900	0.00110	0.00280	0.0860	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00400	0.092	<0.0001	0.0100	0.02900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	0.00100	0.0060
	25-Jun-2007	0.1000	<0.0004	0.00130	0.0910	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.095	<0.0001	<0.01	0.00900	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.00400	0.001000	<0.001	<0.004
	09-Jul-2007	0.0600	<0.0004	0.00140	0.0900	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.087	<0.0001	<0.01	0.01000	<0.0002	<0.005	<0.002	0.000800	<0.0004	-	<0.0001	<0.05	0.00200	0.001000	<0.001	0.0050
	07-Aug-2007	0.0700	<0.0004	0.00170	0.0870	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.068	<0.0001	<0.01	0.00900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00200	0.000900	<0.001	<0.004
	20-Aug-2007	0.0800	<0.0004	0.00310	0.0800	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.096	<0.0001	0.0200	0.03800	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00200	0.001000	<0.001	0.0100
	06-Jul-2011	**0.1910**	<0.0002	0.00260	0.0950	<0.0001	<0.0005	0.053	0.0000100	0.00001	0.00030	0.00200	0.210	0.0001000	0.0230	0.05300	<0.0001	<0.001	0.00140	<0.0002	0.00002	0.2710	<0.00005	<0.001	0.00530	0.001400	0.00220	0.0040
	20-Jul-2011	**0.1200**	<0.0002	0.00250	0.0960	<0.0001	<0.0005	0.034	0.0000100	0.00001	0.00020	0.00100	0.150	<0.0001	0.0180	0.04300	<0.0001	0.00100	0.00080	<0.0002	<0.00001	0.2420	<0.00005	<0.001	0.00450	0.001300	0.00190	0.0030
	10-Aug-2011	**0.1200**	<0.0002	0.00360	0.0930	<0.0001	<0.0005	0.034	0.0000100	0.00001	0.00030	0.00200	0.120	0.0001000	0.0160	0.06200	<0.0001	0.00100	0.00080	0.000600	<0.00001	0.2140	<0.00005	<0.001	0.00470	0.001200	0.00230	0.0030
	31-Aug-2011	**0.2200**	<0.0002	0.00420	0.1040	<0.0001	<0.0005	0.047	0.0000200	0.00002	0.00030	0.00100	0.240	0.0002000	0.0240	0.08700	<0.0001	0.00100	0.00130	<0.0002	<0.00001	0.2620	<0.00005	<0.001	0.01060	0.001200	0.00280	0.0030
	06-Jun-2012	**0.1400**	<0.0002	0.00310	0.1030	<0.0001	<0.0005	0.074	<0.00001	<0.00001	0.00030	0.00100	0.230	0.0001000	0.0390	0.05700	<0.0001	0.00100	0.00170	0.000400	<0.00001	0.4060	<0.00005	<0.001	0.00760	0.002300	0.00240

GENERAL		TOTAL METALS																											
Location	**Sample Date (dd-mmm-yyyy)**	**Aluminum**	**Antimony**	**Arsenic**	**Barium**	**Beryllium**	**Bismuth**	**Boron**	**Cadmium**	**Chromium (Trivalent)**	**Cobalt**	**Copper**	**Iron**	**Lead**	**Lithium**	**Manganese**	**Mercury**	**Molybdenum**	**Nickel**	**Selenium**	**Silver**	**Strontium**	**Thallium**	**Tin**	**Titanium**	**Uranium**	**Vanadium**	**Zinc**
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																													
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1h]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
	29-Aug-2012	0.0900	0.00020	0.00150	0.0880	<0.0001	<0.0005	0.019	<0.00001	<0.00001	<0.0001	0.00100	0.090	<0.0001	0.0100	0.01500	<0.0001	0.00100	0.00070	0.000200	<0.00001	0.1890	<0.00005	<0.001	0.00200	0.001200	0.00090	0.0030
	12-Jun-2013	**0.1400**	0.00070	0.00110	0.0730	<0.0001	<0.0005	0.014	<0.00001	<0.00001	0.00010	<0.001	0.190	<0.0001	0.0080	0.02800	<0.0001	<0.001	0.00080	0.000200	<0.00001	0.1740	<0.00005	<0.001	0.00240	0.001000	0.00070	0.0020
	03-Jul-2013	**0.1800**	<0.0002	0.00140	0.0820	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00030	0.00100	0.270	0.0002000	0.0090	0.03000	<0.0001	<0.001	0.00100	0.000200	<0.00001	0.1700	<0.00005	<0.001	0.00320	0.001100	0.00110	0.0040
	31-Jul-2013	**0.1400**	<0.0002	0.00170	0.0910	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	<0.001	0.140	<0.0001	0.0090	0.01600	<0.0001	0.00100	0.00080	0.000300	<0.00001	0.1900	<0.00005	<0.001	0.00310	0.001000	0.00110	0.0020
	28-Aug-2013	**0.1500**	0.00030	0.00150	0.0800	<0.0001	<0.0005	0.014	<0.00001	<0.00001	0.00010	<0.001	0.150	<0.0001	0.0070	0.02700	<0.0001	<0.001	0.00100	0.000200	<0.00001	0.1490	<0.00005	<0.001	0.00300	0.000800	0.00080	0.0020
	12-Jun-2014	0.1000	<0.0002	0.00150	0.0940	<0.0001	<0.0005	0.015	<0.00001	<0.00001	0.00020	0.00100	0.210	0.0001000	0.0070	0.03400	<0.000005	<0.001	0.00070	0.000300	0.00003	0.1790	<0.00005	<0.001	0.00270	0.001000	0.00070	0.0040
	09-Jul-2014	**0.1400**	<0.0002	0.00190	0.0910	<0.0001	<0.0005	0.015	0.0000100	0.00001	0.00020	0.00200	0.240	0.0002000	0.0080	0.04500	<0.000005	<0.001	0.00150	0.000400	<0.00001	0.1670	<0.00005	<0.001	0.00330	0.001100	0.00110	0.0060
	07-Aug-2014	**0.1600**	<0.0002	0.00240	0.0800	<0.0001	<0.0005	0.019	<0.00001	<0.00001	0.00030	0.00100	0.300	0.0002000	0.0080	0.04200	<0.000005	<0.001	0.00120	0.000400	0.00001	0.1550	<0.00005	<0.001	0.00430	0.000900	0.00140	0.0030
	03-Sep-2014	0.0400	<0.0002	0.00210	0.1010	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00010	<0.001	0.130	<0.0001	0.0070	0.01900	<0.000005	<0.001	0.00290	0.000300	<0.00001	0.1640	<0.00005	<0.001	0.00210	0.000900	0.00070	0.0050
	10-Jun-2015	0.0900	<0.0002	0.00150	0.0900	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00010	0.00100	0.160	<0.0001	0.0090	0.04400	<0.000005	<0.001	0.00170	0.000400	<0.00001	0.1870	<0.00005	<0.001	0.00210	0.001300	0.00080	0.0020
	08-Jul-2015	0.0700	<0.0002	0.00140	0.0950	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00010	0.00200	0.170	<0.0001	0.0080	0.02800	<0.000005	<0.001	0.00100	0.000300	<0.00001	0.1680	<0.00005	<0.001	0.00240	0.001100	0.00100	0.0020
	29-Jul-2015	0.0200	<0.0002	0.00160	0.0930	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00010	<0.001	0.080	<0.0001	0.0080	0.01100	0.00000500	<0.001	0.00700	0.000300	<0.00001	0.1610	<0.00005	<0.001	0.00140	0.000900	0.00080	0.0020
	02-Sep-2015	0.0900	<0.0002	0.00180	0.0950	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	<0.001	0.150	<0.0001	0.0070	0.02800	<0.000005	<0.001	0.00090	0.000300	<0.00001	0.1680	<0.00005	<0.001	0.00240	0.000900	0.00080	0.0020

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1987). Exceedances are highlighted as:

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
1i. Value (i) Concentration is less than guidelines

2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   4a. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

GENERAL		TOTAL METALS																										
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																												
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SMC-R4	04-Jul-2006	**0.2100**	0.00070	0.00110	0.1460	<0.001	-	0.170	<0.0002	<0.0002	<0.002	0.00200	0.197	0.0002000	0.0100	0.01700	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.04100	0.001300	0.00100	0.0180
	17-Jul-2006	**0.3200**	0.00070	0.00110	0.1420	<0.001	-	0.170	<0.0002	<0.0002	<0.002	0.00100	**0.397**	0.0006000	0.0100	0.01600	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.03700	0.001100	0.00200	0.0160
	14-Aug-2006	**0.2400**	0.00100	0.00080	0.0930	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.206	0.0001000	<0.01	0.01000	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.00600	0.000800	0.00100	0.0060
	28-Aug-2006	**0.3700**	0.00100	0.00090	0.1100	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.359**	0.0002000	<0.01	0.01300	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.01200	0.000700	0.00200	0.0040
	25-Jun-2007	**0.2300**	<0.0004	0.00070	0.1100	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.189	0.0001000	<0.01	0.01400	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.00600	0.000900	<0.001	0.0080
	09-Jul-2007	**0.2900**	<0.0004	0.00090	0.1140	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.334**	0.0004000	<0.01	0.02000	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.00700	0.001000	0.00100	0.0050
	07-Aug-2007	**0.4500**	<0.0004	0.00100	0.1120	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.429**	0.0003000	<0.01	0.01700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.01500	0.000800	0.00100	0.0050
	20-Aug-2007	**0.3900**	0.00050	0.00070	0.1130	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.323**	0.0002000	<0.01	0.01100	<0.0002	<0.005	<0.002	0.000900	<0.0004	-	<0.0001	<0.05	0.01300	0.000700	<0.001	0.0110
	06-Jul-2011	**0.1260**	<0.0002	0.00190	0.1060	<0.0001	<0.0005	0.030	0.0000100	0.00001	0.00020	0.00200	0.120	<0.0001	0.0200	0.01500	<0.0001	<0.001	0.00150	0.000500	0.00002	0.2800	<0.00005	<0.001	0.00430	0.002100	0.00160	0.0030
	20-Jul-2011	**0.2500**	<0.0002	0.00150	0.1020	<0.0001	<0.0005	0.023	0.0000100	0.00001	0.00020	0.00200	0.240	0.0002000	0.0150	0.03600	<0.0001	0.00100	0.00110	0.000400	<0.00001	0.2520	<0.00005	<0.001	0.01040	0.001700	0.00190	0.0040
	10-Aug-2011	**0.1900**	0.00030	0.00120	0.0970	<0.0001	<0.0005	0.017	0.0000200	0.00002	0.00010	0.00200	0.190	0.0001000	0.0090	0.02500	<0.0001	<0.001	0.00080	0.000300	0.00001	0.1780	<0.00005	<0.001	0.00500	0.001100	0.00140	0.0030
	31-Aug-2011	**0.2900**	<0.0002	0.00120	0.0980	<0.0001	<0.0005	0.015	0.0000100	0.00001	0.00010	0.00100	0.240	0.0001000	0.0080	0.01700	<0.0001	<0.001	<0.0005	0.000300	<0.00001	0.1600	<0.00005	<0.001	0.01080	0.000900	0.00130	0.0020
	06-Jun-2012	**0.1500**	<0.0002	0.00080	0.0910	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00010	0.00100	0.200	0.0001000	0.0100	0.01900	<0.0001	<0.001	0.00080	0.000400	<0.00001	0.1910	<0.00005	<0.001	0.00410	0.001400	0.00090	0.0020
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	0.0400	<0.0002	0.00110	0.0950	0.000100	<0.0005	0.017	<0.00001	<0.00001	0.00010	0.00200	0.100	<0.0001	0.0110	0.01200	<0.0001	<0.001	0.00100	0.000400	<0.00001	0.2110	<0.00005	<0.001	0.00190	0.001500	0.00070	0.0020
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	**0.1800**	<0.0002	0.00100	0.1040	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	0.00100	0.190	0.0001000	0.0080	0.01600	<0.0001	<0.001	<0.0005	0.000400	<0.00001	0.1630	<0.00005	<0.001	0.00440	0.001000	0.00120	0.0020
	29-Aug-2012	**0.1100**	<0.0002	0.00090	0.1100	<0.0001	<0.0005	0.014	<0.00001	<0.00001	0.00010	0.00200	0.150	<0.0001	0.0080	0.01700	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1650	<0.00005	<0.001	0.00350	0.001000	0.00090	0.0030
	12-Jun-2013	**0.1800**	0.00020	0.00090	0.0880	<0.0001	<0.0005	0.013	<0.00001	<0.00001	0.00020	<0.001	0.210	<0.0001	0.0070	0.02000	<0.0001	<0.001	0.00090	0.000300	<0.00001	0.1600	<0.00005	<0.001	0.00310	0.001000	0.00080	0.0010
	24-Jun-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Jul-2013	**0.3400**	<0.0002	0.00120	0.1160	<0.0001	<0.0005	0.013	0.0000200	0.00002	0.00030	0.00200	**0.440**	0.0002000	0.0070	0.03000	<0.0001	<0.001	0.00130	0.000400	<0.00001	0.1560	<0.00005	<0.001	0.00790	0.000900	0.00150	0.0030
	31-Jul-2013	0.1000	<0.0002	0.00090	0.1040	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00010	<0.001	0.140	0.0001000	0.0060	0.02300	<0.0001	<0.001	0.00060	0.000300	<0.00001	0.1420	<0.00005	<0.001	0.00180	0.000800	0.00080	0.0020
	26-Aug-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Aug-2013	**0.1700**	<0.0002	0.00080	0.1070	<0.0001	<0.0005	0.011	<0.00001	<0.00001	0.00010	0.00100	0.170	<0.0001	0.0050	0.01400	<0.0001	<0.001	0.00080	0.000300	<0.00001	0.1310	<0.00005	<0.001	0.00420	0.000700	0.00080	0.0020
	12-Jun-2014	**0.2600**	<0.0002	0.00110	0.1010	<0.0001	<0.0005	0.013	0.0000100	0.00001	0.00030	0.00200	**0.390**	0.0003000	0.0070	0.03100	<0.0000005	<0.001	0.00090	0.000400	0.00002	0.1740	<0.00005	<0.001	0.00660	0.001100	0.00110	0.0050
	09-Jul-2014	**0.4100**	<0.0002	0.00220	0.1120	<0.0001	<0.0005	0.018	0.0000200	0.00002	0.00040	0.00200	**0.480**	0.0003000	0.0090	0.04700	<0.0000005	<0.001	0.00200	0.000600	<0.00001	0.1800	<0.00005	<0.001	0.00910	0.001200	0.00220	0.0060
	21-Jul-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2014	**0.2600**	<0.0002	0.00160	0.1070	<0.0001	<0.0005	0.016	0.0000200	0.00002	0.00030	0.00200	**0.410**	0.0003000	0.0060	0.04100	<0.0000005	<0.001	0.00130	0.000500	0.00001	0.1620	<0.00005	<0.001	0.00650	0.000900	0.00150	0.0030
	25-Aug-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Sep-2014	**0.1500**	<0.0002	0.00100	0.1110	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00020	0.00100	0.210	0.0001000	0.0060	0.01700	<0.0000005	<0.001	0.00110	0.000400	<0.00001	0.1580	<0.00005	<0.001	0.00470	0.001000	0.00080	0.0060
	10-Jun-2015	**0.6800**	<0.0002	0.00130	0.1170	<0.0001	<0.0005	0.013	0.0000200	0.00002	0.00040	0.00200	**0.770**	0.0004000	0.0070	0.05500	<0.0000005	<0.001	0.00160	0.000500	<0.00001	0.1810	<0.00005	<0.001	0.01190	0.001100	0.00180	0.0050
	08-Jul-2015	**0.1400**	<0.0002	0.00100	0.1120	<0.0001	<0.0005	0.013	<0.00001	<0.00001	0.00010	0.00200	0.220	0.0001000	0.0060	0.02000	<0.0000005	<0.001	0.00090	0.000400	<0.00001	0.1540	<0.00005	<0.001	0.00360	0.000900	0.00110	0.0020
	20-Jul-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Jul-2015	**0.5200**	<0.0002	0.00110	0.1250	<0.0001	<0.0005	0.011	0.0000100	0.00001	0.00030	<0.001	**0.580**	0.0003000	0.0050	0.02600	<0.0000005	<0.001	0.00130	0.000300	<0.00001	0.1420	<0.00005	<0.001	0.01170	0.000800	0.00180	0.0030
	24-Aug-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	02-Sep-2015	**0.2300**	<0.0002	0.00100	0.1160	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00010	0.00100	0.240	0.0002000	0.0050	0.01100	<0.0000005	<0.001	0.00110	0.000300	<0.00001	0.1400	<0.00005	<0.001	0.00590	0.000800	0.00110	0.0020
SMC-S1	04-Jul-2006	0.0700	0.00050	0.00130	0.1270	<0.001	-	0.140	<0.0002	<0.0002	<0.002	0.00100	0.041	<0.0001	0.0100	0.01000	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	0.000100	<0.05	0.02900	0.001100	<0.001	0.0090
	17-Jul-2006	0.0400	0.00080	0.00140	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.024	<0.0001	<0.01	0.01100	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	<0.001	0.000900	<0.001	0.0050
	14-Aug-2006	0.0300	0.00100	0.00160	0.0940	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.026	<0.0001	<0.01	0.01300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00100	0.000900	<0.001	0.0070
	28-Aug-2006	0.0300	0.00080	0.00170	0.0930	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.039	<0.0001	<0.01	0.02300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00100	0.000800	<0.001	<0.004
	25-Jun-2007	0.0300	<0.0004	0.00130	0.0990	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.024	<0.0001	<0.01	0.01800	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	<0.001	0.000900	<0.001	0.0110
	09-Jul-2007	0.0200	<0.0004	0.00130	0.0990	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.026	<0.0001	<0.01	0.01200	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	<0.001	0.001000	<0.001	<0.004
	07-Aug-2007	0.0300	<0.0004	0.00150	0.0890	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.025	<0.0001	<0.01	0.01900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	<0.001	0.000800	<0.001	<0.004
	20-Aug-2007	0.0200	<0.0004	0.00200	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.019	<0.0001	<0.01	0.02700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	<0.001	0.000800	<0.001	0.0070
	06-Jul-2011	0.0320	<0.0002	0.00130	0.1040	<0.0001	<0.0005	0.028	<0.00001	<0.00001	0.00010	0.00200	<0.05	<0.0001	0.0120	0.01600	<0.0001	<0.001	0.00120	<0.0002	0.00012	0.2110	<0.00005	<0.001	0.00160	0.001300	0.00110	0.0010
	20-Jul-2011	0.0600	<0.0002	0.00180	0.1090	<0.0001	<0.0005	0.027	0.0000100	0.00001	0.00010	0.00200	0.060	<0.0001	0.0140	0.01800	<0.0001	0.00100	0.00060	<0.0002	<0.00001	0.2200	<0.00005	<0.001	0.00260	0.001400	0.00120	0.0020
	10-Aug-2011	0.0400	<0.0002	0.00130	0.1000	<0.0001	<0.0005	0.023	0.0000100	0.00001	<0.0001	0.00100	<0.05	<0.0001	0.0110	0.01100	<0.0001	0.00100	0.00060	0.000600	<0.00001	0.1910	<0.00005	<0.001	0.00230	0.001300	0.00100	0.0020
	31-Aug-2011	0.0200	<0.0002	0.00210	0.0920	<0.0001	<0.0005	0.024	<0.00001	<0.00001	<0.0001	<0.001	0.060	<0.0001	0.0120	0.02300	<0.0001	<0.001	<0.0005	0.000200	<0.00001	0.1830	<0.00005	<0.001	0.00200	0.001000	0.00090	0.0030
	06-Jun-2012	0.0500	<0.0002	0.00110	0.0720	<0.0001	<0.0005	0.023	<0.00001	<0.00001	<0.0001	0.00100	<0.05	<0.0001	0.0120	0.01000	<0.0001	0.00100	0.00090	0.000200	<0.00001	0.1890	<0.00005	<0.001	0.00250	0.001400	0.00080	<0.001
	04-Jul-2012	0.0500	<0.0002	0.00150	0.0810	<0.0001	<0.0005	0.022	<0.00001	<0.00001	0.00010	0.00100	<0.05	<0.0001	0.0120	0.01200	<0.0001	0.00100	0.00100	0.000400	<0.00001	0.1740	<0.00005	<0.001	0.00210	0.001400	0.00110	0.0020
	01-Aug-2012	0.0300	<0.0002	0.00140	0.0800	<0.0001	<0.0005	0.022	<0.00001	<0.00001	<0.0001	0.00400	<0.05	<0.0001	0.0120	0.01000	<0.0001	0.00100	<0.0005	0.000300	<0.00001	0.1930	<0.00005	<0.001	0.00100	0.001300	0.00090	0.0020
	29-Aug-2012	<0.02	<0.0002	0.00190	0.0880	<0.0001	<0.0005	0.019	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0110	0.01400	<0.0001	0.00100	<0.0005	<0.0002	<0.00001	0.1880	<0.00005	<0.001	0.00060	0.001200	0.00080	0.0010
	12-Jun-2013	<0.02	<0.0002	0.00100	0.0760	<0.0001	<0.0005	0.017	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0090	0.00900	<0.0001	<0.001	0.00070	0.000200	<0.00001	0.1840	<0.00005	<0.001	<0.0005	0.001100	0.00050	<0.001
	03-Jul-2013	<0.02	<0.0002	0.00120	0.0780	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0090	0.00600	<0.0001	<0.001	0.00080	0.000300	<0.00001	0.1830	<0.00005	<0.001	<0.0005	0.001000	0.00060	0.0010
	31-Jul-2013	<0.02	0.00040	0.00160	0.0760	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00020	0.00200	<0.05	0.0001000	0.0080	0.01500	<0.0001	0.00200	0.00100	0.000400	<0.00001	0.1540	0.000050	0.00100	0.00080	0.001400	0.00060	0.0010
	28-Aug-2013	<0.02	<0.0002	0.00160	0.0780	<0.0001	<0.0005	0.014	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.01500	<0.0001	<0.001	0.00050	0.000300	<0.00001	0.1480	<0.00005	<0.001	<0.0005	0.000800	0.00050	<0.001
	12-Jun-2014	<0.02	<0.0002	0.00130	0.0950	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.01400	<0.0000005	0.00100	<0.0005	0.000300	<0.00001	0.1730	<0.00005	<0.001	<0.0005	0.001000	0.00050	0.0020
	09-Jul-2014	<0.02	<0.0002	0.00160	0.0860	<0.0001	<0.0005	0.015	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0080	0.01900	<0.0000005	<0.001	0.00080	0.000300	<0.00001	0.1710	<0.00005	<0.001	<0.0005	0.000900	0.00070	0.0040
	07-Aug-2014	<0.02	<0.0002	0.00190	0.0800	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00010	<0.001	<0.05	<0.0001	0.0070	0.01100	<0.0000005	<0.001	0.00090	0.000300	0.00001	0.1540	<0.00005	<0.001	<0.0005	0.001000	0.00080	<0.001
	03-Sep-2014	<0.02	<0.0002	0.00240	0.0900	<0.0001	<0.0005	0.015	<0.00001	<0.00001	<0.0001	0.00100	<0.05	<0.0001	0.0070	0.03600	<0.0000005	<0.001	0.00060	0.000300	<0.00001	0.1570	<0.00005	<0.001	<0.0005	0.000600	0.00070	0.0050
	10-Jun-2015	<0.02	<0.0002	0.00110	0.0910	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	0.00100	<0.05	<0.0001	0.0090	0.01100	<0.0000005	<0.001	0.00090	0.000400	<0.00001	0.1840	<0.00005	<0.001	<0.0005	0.001300	0.00050	0.0010
	08-Jul-2015	<0.02	<0.0002	0.00120	0.0970	<0.0001	<0.0005	0.017	<0.00001	<0.00001	<0.0001	0.00200	<0.05	<0.0001	0.0080	0.01300	<0.0000005	<0.001	0.00070	0.000400	<0.00001	0.1670	<0.00005	<0.001	<0.0005	0.001100	0.00070	0.0010
	29-Jul-2015	<0.02	<0.0002	0.00150	0.0950	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.01300	<0.0000005	<0.001	0.00090	0.000300	<0.00001	0.1650	<0.00005	<0.001	<0.0005	0.001100	0.00060	<0.001
	02-Sep-2015	0.0400	<0.0002	0.00200	0.0910	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.02800	<0.0000005	<0.001	0.00050	0.000300	<0.00001	0.1680	<0.00005	<0.001	0.00050	0.000900	0.00060	0.0010
SMC-S2	04-Jul-2006	**0.1600**	0.00080	0.00150	0.1260	<0.001	-	0.140	<0.0002	<0.0002	<0.002	0.00100	0.104	<0.0001	0.0100	0.01600	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	0.000100	<0.05	0.03000	0.001100	0.00100	0.0080
	17-Jul-2006	**0.1300**	0.00090	0.00150	0.0980	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.066	<0.0001	<0.01	0.01500	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00500	0.000900	0.00100	0.0200
	14-Aug-2006	0.0300	0.00140	0.00180	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.037	<0.0001	<0.01	0.01700	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.00100	0.000900	<0.001	0.0060
	28-Aug-2006	0.0200	0.00330	0.00220	0.0890	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.036	<0.0001	<0.01	0.02300	**0.002**	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00100	0.000800	<0.001	0.0090
	25-Jun-2007	0.0800	<0.0004	0.00140	0.0880	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	0.068	<0.0001	0.0100	0.02500	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.00700	0.001100	<0.001	0.0090
	09-Jul-2007	0.0400	<0.0004	0.00150	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.051	<0.0001	<0.01	0.02000	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.00200	0.001200	<0.001	0.0040
	07-Aug-2007	0.0700	<0.0004	0.00200	0.0930	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.056	<0.0001	0.0100	0.02300	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	<0.001	0.001000	<0.001	<0.004
	20-Aug-2007	0.0400	<0.0004	0.00250	0.0880	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.059	<0.0001	0.0100	0.05100	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	<0.001	0.000900	<0.001	0.0270
	06-Jul-2011	0.0780	<0.0002	0.00180	0.1040	<0.0001	<0.0005	0.032	<0.00001	<0.00001	0.00020	0.00200	0.090	<0.0001	0.0150	0.02800	<0.0001	<0.001	0.00120	0.000300	0.00006	0.2240	<0.00005	<0.001	0.00270	0.001300	0.00130	0.0020
	20-Jul-2011	**0.1400**	<0.0002	0.00240	0.1110	<0.0001	<0.0005	0.036	0.0000100	0.00001	0.00020	0.00100	0.150	<0.0001	0.0190	0.10700	<0.0001	0.00100	0.00080	<0.0002	<0.00001	0.2630	<0.00005	<0.001	0.00510	0.001400	0.00150	0.0030
	10-Aug-2011	0.0700	<0.0002	0.00270	0.0980	<0.0001	<0.0005	0.036	0.0000100	0.00001	0.00020	0.00100	<0.05	<0.0001	0.0170	0.04400	<0.0001	0.00100	0.00050	<0.0002	<0.00001	0.2200	<0.00005	<0.001	0.00310	0.001200	0.00170	0.0020
	31-Aug-2011	**0.1400**	<0.0002	0.00400	0.1060	<0.0001	<0.0005	0.052	0.0000200	0.00002	0.00020	0.00100	0.150	0.0001000	0.0250	0.15200	<0.0001	0.00100	0.00060	<0.0002	<0.00001	0.2730	<0.00005	<0.001	0.00510	0.001000	0.00220	0.0040
	06-Jun-2012	0.0600	<0.0002	0.00140	0.0880	<0.0001	<0.0005	0.029	<0.00001	<0.00001	<0.0001	<0.001	0.060	<0.0001	0.0160	0.01500	<0.0001	<0.001	0.00060	0.000300	<0.00001	0.2340	<0.00005	<0.001	0.00280	0.001300	0.00100	0.0020
	04-Jul-2012	0.0700	<0.0002	0.00160	0.0860	<0.0001	<0.0005	0.024	0.0000100	0.00001	0.00020	0.00100	0.080	<0.0001	0.0130	0.01900	<0.0001	0.00100	0.00100	0.000300	<0.00001	0.2070	<0.00005	<0.001	0.00300	0.001500	0.00120	0.0020
	01-Aug-2012	0.0700	<0.0002	0.00140	0.0830	<0.0001	<0.0005	0.022	<0.00001	<0.00001	<0.0001	0.00100	0.070	<0.0001	0.0120	0.01100	<0.0001	0.00100	<0.0005	0.000400	<0.00001	0.2090	<0.00005	<0.001	0.00200	0.001400	0.00100	0.0020
	29-Aug-2012

GENERAL		TOTAL METALS																											
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																													
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
	31-Jul-2013	0.0300	<0.0002	0.00140	0.0720	<0.0001	<0.0005	0.015	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.01500	<0.0001	<0.001	<0.0005	0.000200	<0.00001	0.1480	<0.00005	<0.001	0.00060	0.000800	0.00060	<0.001
	28-Aug-2013	0.0400	<0.0002	0.00160	0.0780	<0.0001	<0.0005	0.014	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.01400	<0.0001	<0.001	0.00060	0.000300	<0.00001	0.1470	<0.00005	<0.001	0.00100	0.000800	0.00060	0.0010
	12-Jun-2014	0.0400	<0.0002	0.00130	0.0970	<0.0001	<0.0005	0.015	<0.00001	<0.00001	0.00010	<0.001	0.090	<0.0001	0.0070	0.01500	<0.000005	<0.001	<0.0005	0.000300	0.00004	0.1770	<0.00005	<0.001	0.00120	0.001000	0.00060	0.0030
	09-Jul-2014	**0.1100**	<0.0002	0.00170	0.0890	<0.0001	<0.0005	0.015	<0.00001	<0.00001	0.00020	0.00100	0.150	0.0001000	0.0080	0.02300	<0.000005	<0.001	0.00100	0.000400	<0.00001	0.1680	<0.00005	<0.001	0.00310	0.001000	0.00100	0.0060
	07-Aug-2014	0.0500	<0.0002	0.00200	0.0790	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00020	0.00100	0.060	<0.0001	0.0080	0.01100	<0.000005	<0.001	0.00100	0.000400	0.00002	0.1550	<0.00005	<0.001	0.00150	0.001000	0.00100	0.0010
	03-Sep-2014	<0.02	<0.0002	0.00230	0.0920	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00010	<0.001	<0.05	<0.0001	0.0070	0.01800	<0.000005	<0.001	0.00090	0.000300	<0.00001	0.1620	<0.00005	<0.001	<0.0005	0.000800	0.00070	0.0050
	10-Jun-2015	**0.1500**	<0.0002	0.00120	0.0970	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00020	0.00100	0.200	0.0001000	0.0080	0.02000	<0.000005	<0.001	0.00100	0.000400	<0.00001	0.1890	<0.00005	<0.001	0.00400	0.001300	0.00080	0.0030
	08-Jul-2015	0.0500	<0.0002	0.00130	0.0920	<0.0001	<0.0005	0.017	<0.00001	<0.00001	<0.0001	0.00100	0.120	<0.0001	0.0080	0.01600	<0.000005	<0.001	0.00080	0.000400	<0.00001	0.1650	<0.00005	<0.001	0.00200	0.001100	0.00080	0.0010
	29-Jul-2015	<0.02	<0.0002	0.00150	0.0970	<0.0001	<0.0005	0.016	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.01200	<0.000005	<0.001	0.00080	0.000300	<0.00001	0.1610	<0.00005	<0.001	0.00070	0.001100	0.00060	<0.001
	02-Sep-2015	**0.1400**	<0.0002	0.00190	0.0980	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00010	<0.001	0.180	0.0001000	0.0070	0.02900	<0.000005	<0.001	0.00070	0.000300	<0.00001	0.1660	<0.00005	<0.001	0.00570	0.000900	0.00090	0.0010

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1987). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

GENERAL		TOTAL METALS																											
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																													
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SMC-S3	04-Jul-2006	**0.8800**	0.00080	0.00130	0.1490	<0.001	-	0.140	<0.0002	<0.0002	<0.002	0.00300	**0.924**	0.0006000	0.0100	0.03600	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.05500	0.001300	0.00300	0.0290
	17-Jul-2006	**0.7900**	0.00070	0.00110	0.1410	<0.001	-	0.110	<0.0002	<0.0002	<0.002	0.00200	**0.719**	0.0004000	<0.01	0.02100	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.04100	0.001000	0.00300	0.0220
	14-Aug-2006	**0.2200**	0.00080	0.00090	0.1040	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.189	0.0001000	<0.01	0.01100	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00600	0.000700	0.00100	0.0070
	28-Aug-2006	**0.2100**	0.00080	0.00100	0.1070	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.200	0.0002000	<0.01	0.01200	<0.0002	<0.005	<0.002	**0.001200**	<0.0004	-	<0.0001	<0.05	0.00600	0.000600	0.00100	<0.004
	25-Jun-2007	**1.2100**	0.00080	0.00100	0.1180	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.932**	0.0005000	<0.01	0.03900	<0.0002	<0.005	0.00200	0.000600	<0.0004	-	<0.0001	<0.05	0.02900	0.000900	0.00300	0.0270
	09-Jul-2007	**0.7200**	<0.0004	0.00100	0.1180	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.757**	0.0004000	<0.01	0.02700	<0.0002	<0.005	0.00200	0.000700	<0.0004	-	<0.0001	<0.05	0.02200	0.001000	0.00200	0.0050
	07-Aug-2007	**0.3000**	<0.0004	0.00090	0.1080	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.323**	0.0002000	<0.01	0.01500	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.00800	0.000800	<0.001	0.0040
	20-Aug-2007	**0.3000**	<0.0004	0.00090	0.1060	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.250	0.0002000	<0.01	0.01100	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.00600	0.000700	<0.001	0.0090
	06-Jul-2011	**0.6250**	<0.0002	0.00180	0.1150	0.000100	<0.0005	0.030	0.0000400	0.00004	0.00040	0.00300	**0.590**	0.0004000	0.0180	0.06200	<0.0001	<0.001	0.00200	0.000700	0.00002	0.2740	<0.00005	<0.001	0.01280	0.001900	0.00280	0.0050
	20-Jul-2011	**0.7900**	<0.0002	0.00150	0.1080	<0.0001	<0.0005	0.024	0.0000300	0.00003	0.00050	0.00300	**0.760**	0.0005000	0.0140	0.03800	<0.0001	0.00100	0.00170	0.000400	<0.00001	0.2430	<0.00005	<0.001	0.02250	0.001700	0.00310	0.0060
	10-Aug-2011	**0.1400**	<0.0002	0.00120	0.0940	<0.0001	<0.0005	0.018	0.0000200	0.00002	0.00010	0.00200	0.120	0.0001000	0.0090	0.01500	<0.0001	<0.001	0.00050	<0.0002	<0.00001	0.1740	<0.00005	<0.001	0.00380	0.001100	0.00120	0.0030
	31-Aug-2011	**0.2100**	<0.0002	0.00140	0.0940	<0.0001	<0.0005	0.014	0.0000100	0.00001	0.00010	<0.001	0.160	<0.0001	0.0080	0.01400	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1480	<0.00005	<0.001	0.00610	0.000800	0.00100	0.0020
	06-Jun-2012	**0.2200**	<0.0002	0.00070	0.0990	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00020	0.00100	0.230	0.0002000	0.0100	0.02300	<0.0001	<0.001	0.00110	<0.0002	<0.00001	0.1770	<0.00005	<0.001	0.00560	0.001200	0.00100	0.0020
	04-Jul-2012	0.0700	<0.0002	0.00090	0.1000	<0.0001	<0.0005	0.016	0.0000100	0.00001	0.00020	0.00200	0.080	<0.0001	0.0090	0.02600	<0.0001	<0.001	0.00080	0.000400	<0.00001	0.1870	<0.00005	<0.001	0.00200	0.001200	0.00100	0.0020
	01-Aug-2012	**0.1200**	<0.0002	0.00080	0.1000	<0.0001	<0.0005	0.015	<0.00001	<0.00001	<0.0001	0.00100	0.110	<0.0001	0.0080	0.01300	<0.0001	<0.001	<0.0005	0.000300	<0.00001	0.1500	<0.00005	<0.001	0.00380	0.000900	0.00090	0.0020
	29-Aug-2012	0.0500	<0.0002	0.00100	0.1020	<0.0001	<0.0005	0.013	<0.00001	<0.00001	<0.0001	0.00100	0.050	<0.0001	0.0070	0.01200	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1530	<0.00005	<0.001	0.00140	0.001000	0.00060	0.0020
	12-Jun-2013	0.0500	0.00040	0.00080	0.0920	<0.0001	<0.0005	0.012	<0.00001	<0.00001	<0.0001	<0.001	0.050	<0.0001	0.0060	0.01500	<0.0001	<0.001	0.00060	0.000200	<0.00001	0.1520	<0.00005	<0.001	0.00070	0.000900	0.00050	<0.001
	03-Jul-2013	**0.2200**	<0.0002	0.00100	0.1130	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00020	0.00100	0.280	0.0002000	0.0060	0.03500	**0.0002**	<0.001	0.00100	0.000400	<0.00001	0.1480	<0.00005	<0.001	0.00500	0.000900	0.00120	0.0020
	31-Jul-2013	0.0800	<0.0002	0.00090	0.1040	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00010	<0.001	0.160	<0.0001	0.0060	0.01600	<0.0001	<0.001	<0.0005	0.000300	<0.00001	0.1400	<0.00005	<0.001	0.00180	0.000700	0.00070	<0.001
	28-Aug-2013	0.0600	<0.0002	0.00080	0.0940	<0.0001	<0.0005	0.010	0.0000100	0.00001	<0.0001	<0.001	0.070	<0.0001	0.0040	0.01000	<0.0001	<0.001	<0.0005	0.000300	<0.00001	0.1180	<0.00005	<0.001	0.00170	0.000600	0.00050	0.0010
	12-Jun-2014	0.0200	<0.0002	0.00100	0.0970	<0.0001	<0.0005	0.013	<0.00001	<0.00001	<0.0001	<0.001	0.100	<0.0001	0.0070	0.01500	<0.0000005	<0.001	<0.0005	0.000400	0.00002	0.1720	<0.00005	<0.001	0.00070	0.001000	0.00040	0.0030
	09-Jul-2014	**0.3600**	<0.0002	0.00210	0.1060	<0.0001	<0.0005	0.017	0.0000200	0.00002	0.00040	0.00200	**0.500**	0.0004000	0.0080	0.06000	<0.0000005	<0.001	0.00210	0.000600	0.00001	0.1730	<0.00005	<0.001	0.00890	0.001200	0.00200	0.0070
	07-Aug-2014	**0.2600**	<0.0002	0.00160	0.1050	<0.0001	<0.0005	0.014	0.0000100	0.00001	0.00030	0.00200	**0.400**	0.0003000	0.0060	0.03200	<0.0000005	<0.001	0.00120	0.000400	0.00002	0.1560	<0.00005	<0.001	0.00730	0.000900	0.00150	0.0030
	03-Sep-2014	0.1000	<0.0002	0.00120	0.1070	<0.0001	<0.0005	0.011	0.0000100	0.00001	0.00010	0.00100	0.180	0.0001000	0.0050	0.01900	<0.0000005	<0.001	0.00100	0.000300	<0.00001	0.1410	<0.00005	<0.001	0.00320	0.000700	0.00090	0.0050
	10-Jun-2015	**0.2700**	<0.0002	0.00100	0.1150	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00020	0.00200	0.290	0.0002000	0.0060	0.02400	<0.0000005	<0.001	0.00140	0.000400	<0.00001	0.1660	<0.00005	<0.001	0.00520	0.001000	0.00100	0.0030
	08-Jul-2015	**0.3300**	<0.0002	0.00110	0.1190	<0.0001	<0.0005	0.013	0.0000100	0.00001	0.00030	0.00200	**0.510**	0.0003000	0.0060	0.02600	<0.0000005	<0.001	0.00120	0.000300	<0.00001	0.1530	<0.00005	<0.001	0.00910	0.000900	0.00160	0.0030
	29-Jul-2015	**0.2900**	<0.0002	0.00100	0.1350	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00020	<0.001	**0.390**	0.0003000	0.0060	0.01800	**0.00000600**	<0.001	0.00100	0.000300	<0.00001	0.1290	<0.00005	<0.001	0.00730	0.000900	0.00120	0.0020
	02-Sep-2015	**0.1900**	<0.0002	0.00130	0.1130	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00010	<0.001	0.200	0.0002000	0.0050	0.01300	<0.0000005	<0.001	0.00070	0.000300	<0.00001	0.1350	<0.00005	<0.001	0.00530	0.000700	0.00100	0.0020
SME-P1	04-Jul-2006	**0.1400**	0.00070	0.00140	0.1180	<0.001	-	0.150	<0.0002	<0.0002	<0.002	0.00100	0.092	0.0001000	0.0100	0.02200	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.02800	0.001200	<0.001	0.0110
	17-Jul-2006	0.0800	0.00070	0.00200	0.0880	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.072	0.0001000	<0.01	0.03400	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.00200	0.001100	<0.001	0.0050
	14-Aug-2006	0.1000	0.00110	0.00250	0.0740	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.088	<0.0001	<0.01	0.04600	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.00300	0.000900	0.00100	<0.004
	28-Aug-2006	**0.1900**	0.00080	0.00280	0.0810	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.123	<0.0001	<0.01	0.05500	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00500	0.001000	0.00100	<0.004
	25-Jun-2007	0.0600	<0.0004	0.00100	0.0710	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.047	<0.0001	<0.01	0.01400	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.00200	0.001100	<0.001	0.0190
	09-Jul-2007	0.0700	<0.0004	0.00150	0.0660	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.057	<0.0001	<0.01	0.05600	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00300	0.001100	0.00100	<0.004
	07-Aug-2007	**0.1800**	<0.0004	0.00210	0.0720	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.129	<0.0001	<0.01	0.02700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00300	0.000900	<0.001	0.0070
	20-Aug-2007	**0.7200**	<0.0004	0.00320	0.0800	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.649**	0.0004000	0.0100	0.10400	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.02500	0.001000	0.00300	0.0090
	06-Jul-2011	0.0560	0.00020	0.00170	0.1310	<0.0001	<0.0005	0.039	0.0000200	0.00002	0.00020	0.00200	0.050	<0.0001	0.0250	0.01400	<0.0001	0.00200	0.00190	0.000600	0.00016	0.2920	<0.00005	<0.001	0.00360	0.002400	0.00150	0.0040
	20-Jul-2011	0.0800	0.00030	0.00180	0.1220	<0.0001	<0.0005	0.037	0.0000100	0.00001	0.00020	0.00200	0.100	<0.0001	0.0240	0.01900	<0.0001	0.00100	0.00100	0.001000	<0.00001	0.2880	<0.00005	<0.001	0.00500	0.002100	0.00160	0.0020
	10-Aug-2011	0.0700	<0.0002	0.00240	0.0950	<0.0001	<0.0005	0.029	0.0000200	0.00002	0.00020	0.00200	0.060	<0.0001	0.0160	0.01500	<0.0001	0.00100	0.00080	0.000800	0.00001	0.2250	<0.00005	<0.001	0.00340	0.001600	0.00160	0.0020
	31-Aug-2011	0.1000	<0.0002	0.00250	0.0970	<0.0001	<0.0005	0.027	0.0000200	0.00002	0.00020	0.00100	0.130	<0.0001	0.0150	0.03100	<0.0001	0.00100	0.00120	0.000400	0.00001	0.2220	<0.00005	<0.001	0.00380	0.001400	0.00140	0.0030
	06-Jun-2012	0.0700	<0.0002	0.00090	0.0700	<0.0001	<0.0005	0.020	<0.00001	<0.00001	<0.0001	0.00100	0.070	<0.0001	0.0130	0.01100	<0.0001	<0.001	0.00070	0.000400	<0.00001	0.1970	<0.00005	<0.001	0.00270	0.001700	0.00080	0.0010
	04-Jul-2012	**0.2000**	<0.0002	0.00140	0.0610	<0.0001	<0.0005	0.020	<0.00001	<0.00001	0.00020	0.00100	0.180	0.0002000	0.0120	0.02100	<0.0001	0.00100	0.00130	0.000800	<0.00001	0.1800	<0.00005	<0.001	0.03670	0.001500	0.00160	0.0020
	01-Aug-2012	0.0400	<0.0002	0.00240	0.0750	<0.0001	<0.0005	0.023	<0.00001	<0.00001	0.00010	0.00100	<0.05	<0.0001	0.0130	0.03400	<0.0001	0.00100	<0.0005	0.000500	<0.00001	0.1830	<0.00005	<0.001	0.00100	0.001400	0.00090	0.0010
	29-Aug-2012	**0.1800**	<0.0002	0.00260	0.0930	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00020	<0.001	0.190	0.0001000	0.0100	0.03200	<0.0001	0.00100	0.00090	<0.0002	<0.00001	0.1810	<0.00005	<0.001	0.00440	0.001200	0.00140	0.0020
	12-Jun-2013	0.0400	<0.0002	0.00100	0.0840	<0.0001	<0.0005	0.014	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0100	0.02500	<0.0001	<0.001	0.00150	0.000300	<0.00001	0.1910	<0.00005	<0.001	0.00080	0.001200	0.00070	<0.001
	03-Jul-2013	0.0300	<0.0002	0.00130	0.0770	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00020	<0.001	<0.05	<0.0001	0.0090	0.02000	<0.0001	<0.001	0.00080	0.000400	<0.00001	0.1660	<0.00005	<0.001	0.00050	0.001100	0.00080	0.0010
	31-Jul-2013	<0.02	<0.0002	0.00210	0.0740	<0.0001	-	0.014	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0070	0.02700	<0.0001	<0.001	<0.0005	0.000300	<0.00001	-	<0.00005	<0.001	0.00050	0.000900	0.00080	<0.001
	28-Aug-2013	**0.1100**	0.00040	**0.01270**	0.0740	<0.0001	<0.0005	0.082	<0.00001	<0.00001	0.00060	<0.001	0.140	0.0001000	0.0830	0.06100	<0.0001	0.00200	0.00250	0.000300	<0.00001	0.3500	<0.00005	<0.001	0.00320	0.002700	0.00560	0.0020
	12-Jun-2014	0.0200	<0.0002	0.00140	0.0910	<0.0001	<0.0005	0.015	<0.00001	<0.00001	0.00010	<0.001	0.080	<0.0001	0.0080	0.02900	**0.000035**	<0.001	0.00050	0.000400	<0.00001	0.1870	<0.00005	<0.001	<0.0005	0.001200	0.00040	0.0020
	09-Jul-2014	0.0200	<0.0002	0.00210	0.0760	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00020	<0.001	<0.05	<0.0001	0.0090	0.03100	<0.0000005	<0.001	0.00120	0.000400	<0.00001	0.1670	<0.00005	<0.001	0.00060	0.001200	0.00080	0.0040
	07-Aug-2014	0.0300	<0.0002	0.00430	0.0810	<0.0001	<0.0005	0.019	<0.00001	<0.00001	0.00020	<0.001	0.060	<0.0001	0.0090	0.16600	<0.0000005	<0.001	0.00100	0.000500	<0.00001	0.1570	<0.00005	<0.001	0.00130	0.001000	0.00120	0.0010
	04-Sep-2014	0.0400	<0.0002	0.00120	0.0970	<0.0001	<0.0005	0.008	<0.00001	<0.00001	0.00010	<0.001	0.070	<0.0001	0.0040	0.18000	<0.0000005	<0.001	0.00130	<0.0002	<0.00001	0.1260	<0.00005	<0.001	0.00090	<0.0005	0.00050	0.0060
	11-Jun-2015	0.0300	<0.0002	0.00100	0.0980	<0.0001	<0.0005	0.021	<0.00001	<0.00001	<0.0001	0.00100	0.050	<0.0001	0.0100	0.01600	<0.0000005	0.00100	0.00090	0.000500	<0.00001	0.2010	<0.00005	<0.001	0.00090	0.001500	0.00080	0.0020
	09-Jul-2015	0.0200	<0.0002	0.00140	0.0920	<0.0001	<0.0005	0.017	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0080	0.02900	<0.0000005	<0.001	0.00080	0.000400	<0.00001	0.1700	<0.00005	<0.001	0.00100	0.001100	0.00080	0.0010
	30-Jul-2015	0.0500	<0.0002	0.00160	0.0860	<0.0001	<0.0005	0.014	<0.00001	<0.00001	<0.0001	<0.001	<0.05	<0.0001	0.0060	0.03300	<0.0000005	<0.001	0.00080	0.000400	<0.00001	0.1540	<0.00005	<0.001	<0.0005	0.000900	0.00090	0.0040
	03-Sep-2015	0.0400	<0.0002	0.00200	0.0930	<0.0001	<0.0005	0.014	<0.00001	<0.00001	0.00010	<0.001	0.070	<0.0001	0.0060	0.07800	**0.000071**	<0.001	<0.0005	0.000300	<0.00001	0.1450	<0.00005	<0.001	0.00130	0.000800	0.00100	<0.001
SME-R1	04-Jul-2006	**0.2600**	0.00060	0.00320	0.1080	<0.001	-	0.160	<0.0002	<0.0002	<0.002	0.00200	0.241	0.0002000	0.0200	0.06300	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	0.000100	<0.05	0.03000	0.001100	0.00200	0.0110
	17-Jul-2006	**2.8400**	0.00070	0.00470	0.1170	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00400	**2.440**	0.0015000	0.0200	0.20500	<0.0002	<0.005	0.00300	0.000800	<0.0004	-	<0.0001	<0.05	0.05900	0.001400	0.00700	0.0170
	14-Aug-2006	**0.9600**	0.00110	**0.00700**	0.0740	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.914**	0.0005000	0.0100	0.06800	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.02200	0.001100	0.00500	0.0070
	28-Aug-2006	**0.8300**	0.00100	**0.00710**	0.0830	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.558**	0.0004000	0.0200	0.04800	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.01800	0.001300	0.00600	0.0060
	25-Jun-2007	**0.1600**	<0.0004	0.00220	0.0750	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.202	0.0001000	0.0100	0.04700	<0.0002	<0.005	<0.002	0.000400	<0.0004	-	<0.0001	<0.05	0.00700	0.001100	<0.001	0.0250
	09-Jul-2007	**0.1500**	<0.0004	0.00290	0.0700	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.197	0.0001000	0.0100	0.09500	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.00600	0.001000	<0.001	0.0070
	07-Aug-2007	**0.6600**	<0.0004	0.00430	0.0700	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.536**	0.0003000	0.0100	0.09000	<0.0002	<0.005	0.00200	**0.001200**	<0.0004	-	<0.0001	<0.05	0.01000	0.001000	0.00300	0.0090
	20-Aug-2007	**0.6900**	<0.0004	0.00300	0.0820	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.723**	0.0004000	0.0100	0.10500	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.02000	0.001000	0.00200	0.0110
	06-Jul-2011	**0.1480**	<0.0002	0.00260	0.1110	<0.0001	<0.0005	0.046	0.0000100	0.00001	0.00030	0.00200	0.200	0.0001000	0.0350	0.04300	<0.0001	0.00200	0.00170	<0.0002	0.00015	0.2600	<0.00005	<0.001	0.00570	0.001600	0.00160	0.0040
	20-Jul-2011	**0.3200**	<0.0002	0.00310	0.1030	<0.0001	<0.0005	0.050	0.0000200	0.00002	0.00040	0.00200	**0.330**	0.0002000	0.0430	0.10600	<0.0001	0.00100	0.00190	<0.0002	<0.00001	0.2780	<0.00005	<0.001	0.01170	0.001600	0.00240	0.0040
	10-Aug-2011	0.1000	<0.0002	0.00350	0.0840	<0.0001	<0.0005	0.040	0.0000200	0.00002	0.00030	0.00200	0.190	0.0002000	0.0310	0.11100	<0.0001	0.00100	0.00160	0.000400	0.00001	0.2170	<0.00005	<0.001	0.00570	0.001200	0.00160	0.0040
	31-Aug-2011	**0.1700**	<0.0002	0.00400	0.0840	<0.0001	<0.0005	0.040	0.0000100	0.00001	0.00030	0.00100	0.170	0.0001000	0.0320	0.05000	<0.0001	0.00100	0.00140	0.000300	<0.00001	0.1980	<0.00005	<0.001	0.00970	0.001300	0.00240	0.0030
	06-Jun-2012	0.0700	<0.0002	0.00120	0.0910	<0.0001	<0.0005	0.031	<0.00001	<0.00001	0.00020	0.00100	0.130	<0.0001	0.0220	0.05600	<0.0001	0.00100	0.00120	0.000200	<0.00001	0.2480	<0.00005	<0.001	0.00350	0.001700	0.00070	0.0020
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	**0.1900**	<0.0002	0.00220	0.0700	<0.0001	<0.0005	0.031	<0.00001	<0.00001	0.00040	0.00200	**0.440**	<0.0001	0.0200	0.07100	<0.0001	0.00100	0.00160	0.000400	<0.00001	0.2260	<0.00005	<0.001	0.00550	0.001700	0.00140	0.0030
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	**0.3600**	<0.0002	0.00430	0.0500	<0.0001	<0.0005	0.029	0.0000100	0.00001	0.00040	0.00200	**0.320**	0.0002000	0.0200	0.04800	<0.0001	0.00100	0.00130	0.000300	<0.00001	0.1520	<0.00005	<0.001	0.00950	0.001200	0.00280	0.0120
	29-Aug-2012	**0.2600**	<0.0002	**0.00570**	0.0810	<0.0001	<0.0005	0.029	<0.00001	<0.00001	0.00040	0.00100	0.280	0.0002000	0.0230	0.02800	<0.0001	0.00100	0.00150	<0.0002	<0.00001	0.1720	<0.00005	<0.001	0.00850	0.001500	0.00320	0.0030
	12-Jun-2013	0.0200	<0.0002	0.00170	0.0920	<0.0001	<0.0005	0.029	<0.00001	<0.00001	0.00020	<0.001	0.050	<0.0001	0.0230	0.02400	<0.0001	0.00100	0.00160	0.000300	<0.00001	0.2540	<0.00005	<0.001	0.00060

GENERAL		TOTAL METALS																											
Location	**Sample Date (dd-mmm-yyyy)**	**Aluminum**	**Antimony**	**Arsenic**	**Barium**	**Beryllium**	**Bismuth**	**Boron**	**Cadmium**	**Chromium (Trivalent)**	**Cobalt**	**Copper**	**Iron**	**Lead**	**Lithium**	**Manganese**	**Mercury**	**Molybdenum**	**Nickel**	**Selenium**	**Silver**	**Strontium**	**Thallium**	**Tin**	**Titanium**	**Uranium**	**Vanadium**	**Zinc**
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																													
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1h]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SME-R1A	03-Jul-2013	<0.02	<0.0002	0.00220	0.0700	<0.0001	<0.0005	0.026	<0.00001	<0.00001	0.00020	0.00100	0.060	<0.0001	0.0190	0.04800	<0.0001	0.00100	0.00140	<0.0002	<0.00001	0.2070	<0.00005	<0.001	0.00080	0.001200	0.00090	0.0020
	31-Jul-2013	**0.2100**	0.00020	0.00380	0.0630	<0.0001	<0.0005	0.027	<0.00001	<0.00001	0.00030	<0.001	0.210	0.0001000	0.0170	0.08200	<0.0001	0.00100	0.00120	0.000300	<0.00001	0.1610	<0.00005	<0.001	0.00330	0.001100	0.00210	0.0030
	26-Aug-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Aug-2013	0.0600	<0.0002	0.00370	0.0630	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00020	<0.001	0.080	<0.0001	0.0120	0.02600	<0.0001	<0.001	0.00100	0.000200	<0.00001	0.1560	<0.00005	<0.001	0.00160	0.000900	0.00120	0.0010
	12-Jun-2014	<0.02	<0.0002	0.00270	0.0780	<0.0001	<0.0005	0.025	<0.00001	<0.00001	0.00030	0.00100	0.080	<0.0001	0.0170	0.04100	**0.000076**	0.00100	0.00110	0.000200	0.00001	0.2060	<0.00005	<0.001	<0.0005	0.000900	0.00060	0.0030
	09-Jul-2014	0.0800	<0.0002	0.00480	0.0650	<0.0001	<0.0005	0.023	<0.00001	<0.00001	0.00040	0.00100	0.160	0.0001000	0.0150	0.09600	<0.000005	<0.001	0.00150	0.000300	<0.00001	0.1640	<0.00005	<0.001	0.00230	0.001000	0.00180	0.0060
	21-Jul-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	07-Aug-2014	**0.2200**	<0.0002	**0.00590**	0.0690	<0.0001	<0.0005	0.022	<0.00001	<0.00001	0.00050	0.00100	0.280	0.0002000	0.0150	0.08500	<0.000005	0.00100	0.00160	0.000400	0.00001	0.1570	<0.00005	<0.001	0.00390	0.001000	0.00250	0.0030
	25-Aug-2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Sep-2014	0.0800	<0.0002	0.00120	0.1130	<0.0001	<0.0005	0.009	<0.00001	<0.00001	<0.0001	<0.001	**0.520**	<0.0001	0.0040	0.07100	<0.000005	<0.001	0.00070	0.000200	<0.00001	0.1330	<0.00005	<0.001	0.00200	0.000600	0.00060	0.0050
	11-Jun-2015	**0.2200**	<0.0002	0.00220	0.0910	<0.0001	<0.0005	0.029	<0.00001	<0.00001	0.00030	0.00100	**0.320**	0.0002000	0.0190	0.11100	<0.000005	0.00100	0.00170	0.000300	<0.00001	0.2330	<0.00005	<0.001	0.00690	0.001500	0.00130	0.0040
	09-Jul-2015	0.1000	<0.0002	**0.00520**	0.0640	<0.0001	<0.0005	0.025	<0.00001	<0.00001	0.00030	0.00200	0.210	0.0001000	0.0150	0.14600	<0.000005	0.00100	0.00140	0.000400	<0.00001	0.1730	<0.00005	<0.001	0.00270	0.001100	0.00190	0.0110
	20-Jul-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Jul-2015	**0.1800**	0.00030	**0.00630**	0.0600	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00030	0.00400	0.300	0.0005000	0.0100	0.07000	<0.000005	0.00100	0.00130	0.000400	<0.00001	0.1430	<0.00005	<0.001	0.00370	0.001000	0.00290	0.0080
	24-Aug-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03-Sep-2015	**0.2600**	<0.0002	0.00480	0.0770	<0.0001	<0.0005	0.018	0.0000100	0.00001	0.00040	0.00100	**0.310**	0.0003000	0.0100	0.06800	<0.000005	0.00100	0.00140	0.000300	<0.00001	0.1600	<0.00005	<0.001	0.00730	0.001100	0.00320	0.0050

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1987). Exceedances are highlighted as:
   - 1a. Value — (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value — (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value — (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value — (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value — (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** — (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value — (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value — (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value — (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4a. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

GENERAL		TOTAL METALS																										
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																												
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2		-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SME-R2	06-Jul-2011	**0.5830**	0.00030	0.00350	0.0910	<0.0001	<0.0005	0.059	0.0000200	0.00002	0.00060	0.00200	**0.780**	0.0004000	0.0490	0.26400	<0.0001	0.00200	0.00290	0.000800	0.00004	0.4070	<0.00005	<0.001	0.01940	0.004300	0.00380	0.0050
	20-Jul-2011	**0.4100**	<0.0002	0.00380	0.0870	<0.0001	<0.0005	0.065	0.0000200	0.00002	0.00040	0.00200	**0.520**	0.0003000	0.0430	0.13700	<0.0001	0.00200	0.00220	<0.0002	<0.00001	0.3640	<0.00005	<0.001	0.01630	0.003100	0.00330	0.0050
	10-Aug-2011	**0.1900**	<0.0002	0.00310	0.0870	<0.0001	<0.0005	0.046	0.0000200	0.00002	0.00030	0.00200	0.300	0.0003000	0.0310	0.15200	<0.0001	0.00200	0.00190	<0.0002	<0.00001	0.3020	<0.00005	<0.001	0.00740	0.002400	0.00230	0.0070
	31-Aug-2011	**0.3900**	<0.0002	0.00260	0.0850	<0.0001	<0.0005	0.042	0.0000200	0.00002	0.00040	0.00100	**0.520**	0.0003000	0.0280	0.10300	<0.0001	0.00100	0.00170	0.000400	<0.00001	0.2570	<0.00005	<0.001	0.01450	0.002100	0.00220	0.0040
	06-Jun-2012	**0.4100**	<0.0002	0.00210	0.0840	<0.0001	<0.0005	0.052	<0.00001	<0.00001	0.00050	0.00100	**0.760**	0.0004000	0.0350	0.15000	<0.0001	0.00200	0.00260	0.000200	<0.00001	0.3560	<0.00005	<0.001	0.01450	0.003100	0.00230	0.0030
	04-Jul-2012	**0.4000**	<0.0002	0.00300	0.0660	<0.0001	<0.0005	0.053	0.0000100	0.00001	0.00060	0.00200	**0.590**	0.0004000	0.0520	0.09500	<0.0001	0.00200	0.00410	0.000800	<0.00001	0.3760	<0.00005	<0.001	0.01600	0.003900	0.00290	0.0040
	01-Aug-2012	**0.5800**	<0.0002	0.00310	0.0700	<0.0001	<0.0005	0.037	0.0000200	0.00002	0.00050	0.00200	**0.670**	0.0004000	0.0250	0.08200	<0.0001	0.00100	0.00180	0.000400	<0.00001	0.2560	<0.00005	<0.001	0.01430	0.001800	0.00310	0.0040
	29-Aug-2012	**0.1900**	<0.0002	0.00340	0.0720	<0.0001	<0.0005	0.030	0.0000100	0.00001	0.00020	0.00100	0.290	0.0002000	0.0200	0.04300	<0.0001	0.00100	0.00120	0.000200	<0.00001	0.2280	<0.00005	<0.001	0.00550	0.001700	0.00180	0.0080
	12-Jun-2013	**0.3500**	<0.0002	0.00260	0.0720	<0.0001	<0.0005	0.034	<0.00001	<0.00001	0.00030	0.00200	**0.510**	0.0002000	0.0250	0.09000	<0.0001	0.00100	0.00200	0.000400	<0.00001	0.2990	<0.00005	<0.001	0.00980	0.002100	0.00170	0.0040
	03-Jul-2013	**0.5900**	<0.0002	**0.00550**	0.0720	<0.0001	<0.0005	0.039	0.0000200	0.00002	0.00060	0.00100	**0.940**	0.0005000	0.0220	0.21000	<0.0001	0.00200	0.00260	0.000500	<0.00001	0.2620	<0.00005	<0.001	0.01220	0.001600	0.00290	0.0040
	31-Jul-2013	**0.2300**	0.00020	0.00270	0.0720	<0.0001	-	0.028	<0.00001	<0.00001	0.00030	<0.001	**0.380**	0.0002000	0.0160	0.06300	<0.0001	0.00100	0.00150	0.000500	<0.00001	-	<0.00005	<0.001	0.00570	0.001400	0.00170	0.0020
	28-Aug-2013	**0.3200**	<0.0002	0.00280	0.0710	<0.0001	<0.0005	0.025	<0.00001	<0.00001	0.00030	0.00100	**0.450**	0.0002000	0.0140	0.05200	<0.0001	0.00100	0.00150	0.000500	<0.00001	0.2120	<0.00005	<0.001	0.00880	0.001300	0.00180	0.0020
	12-Jun-2014	0.0800	<0.0002	0.00270	0.0720	<0.0001	<0.0005	0.032	<0.00001	<0.00001	0.00030	0.00100	0.270	0.0002000	0.0200	0.07000	**0.00000600**	0.00100	0.00150	0.000500	<0.00001	0.2880	<0.00005	<0.001	0.00220	0.001900	0.00120	0.0030
	09-Jul-2014	**0.2300**	<0.0002	0.00440	0.0690	<0.0001	<0.0005	0.032	0.0000100	0.00001	0.00050	0.00100	**0.560**	0.0004000	0.0210	0.10800	<0.000005	0.00100	0.00230	0.000600	<0.00001	0.2540	<0.00005	<0.001	0.00750	0.001700	0.00230	0.0060
	07-Aug-2014	**0.2400**	<0.0002	0.00500	0.0840	<0.0001	<0.0005	0.035	0.0000200	0.00002	0.00050	0.00200	**0.660**	0.0004000	0.0210	0.09900	<0.000005	0.00100	0.00240	0.000600	<0.00001	0.2370	<0.00005	<0.001	0.00800	0.001700	0.00230	0.0040
	04-Sep-2014	0.0500	<0.0002	0.00120	0.1090	<0.0001	<0.0005	0.011	<0.00001	<0.00001	<0.0001	<0.001	**0.700**	<0.0001	0.0050	0.09100	**0.00000600**	<0.001	0.00070	0.000400	<0.00001	0.1420	<0.00005	<0.001	0.00170	0.000700	0.00080	0.0040
	11-Jun-2015	**0.2400**	<0.0002	0.00300	0.0790	<0.0001	<0.0005	0.037	<0.00001	<0.00001	0.00030	0.00100	**0.460**	0.0002000	0.0200	0.10100	<0.000005	0.00100	0.00210	0.000600	<0.00001	0.2910	<0.00005	<0.001	0.00590	0.002100	0.00190	0.0030
	09-Jul-2015	0.1000	<0.0002	0.00330	0.0730	<0.0001	<0.0005	0.033	<0.00001	<0.00001	0.00030	<0.001	**0.350**	0.0002000	0.0190	0.07600	<0.000005	0.00100	0.00170	0.000500	<0.00001	0.2400	<0.00005	<0.001	0.00320	0.001600	0.00160	0.0020
	30-Jul-2015	**0.1400**	<0.0002	0.00330	0.0690	<0.0001	<0.0005	0.026	<0.00001	<0.00001	0.00030	0.00200	**0.350**	0.0002000	0.0130	0.05600	<0.000005	0.00100	0.00160	0.000500	<0.00001	0.2140	<0.00005	<0.001	0.00340	0.001500	0.00170	0.0090
	03-Sep-2015	**0.1400**	<0.0002	0.00270	0.0780	<0.0001	<0.0005	0.024	0.0000100	0.00001	0.00030	<0.001	**0.320**	0.0002000	0.0130	0.05500	<0.000005	0.00100	0.00130	0.000400	<0.00001	0.2110	<0.00005	<0.001	0.00370	0.001500	0.00160	0.0020
SME-S1	04-Jul-2006	**0.3100**	0.00080	0.00310	0.1100	<0.001	-	0.140	<0.0002	<0.0002	<0.002	0.00200	0.245	0.0002000	0.0100	0.04800	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	0.000100	<0.05	0.02800	0.001100	0.00200	0.0090
	17-Jul-2006	**0.4600**	0.00070	0.00490	0.0730	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.433**	0.0002000	0.0100	0.09000	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.01800	0.001000	0.00200	0.0050
	14-Aug-2006	**0.6900**	0.00100	**0.00730**	0.0670	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.640**	0.0003000	0.0100	0.06300	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.01900	0.000900	0.00500	0.0040
	28-Aug-2006	**1.6700**	0.00100	**0.00710**	0.0910	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**1.110**	0.0006000	0.0100	0.08500	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.04200	0.001100	0.00700	0.0050
	25-Jun-2007	**0.2600**	<0.0004	0.00280	0.0850	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.365**	0.0001000	0.0100	0.15500	<0.0002	<0.005	<0.002	0.000800	<0.0004	-	<0.0001	<0.05	0.00900	0.001200	<0.001	0.0090
	09-Jul-2007	**0.3100**	<0.0004	0.00340	0.0630	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.390**	0.0002000	<0.01	0.22100	**0.000500**	<0.005	0.00200	<0.0004	<0.0004	-	0.000400	<0.05	0.00700	0.001100	0.00200	<0.004
	07-Aug-2007	**0.4200**	<0.0004	0.00430	0.0710	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.414**	0.0002000	0.0100	0.10500	<0.0002	<0.005	<0.002	0.000800	<0.0004	-	<0.0001	<0.05	0.00600	0.000900	0.00200	0.0040
	20-Aug-2007	**0.1100**	<0.0004	0.00180	0.0850	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.102	<0.0001	<0.01	0.04000	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000800	<0.001	0.0060
	06-Jul-2011	**0.1170**	<0.0002	0.00240	0.1220	<0.0001	<0.0005	0.052	0.0000100	0.00001	0.00020	0.00200	0.190	<0.0001	0.0390	0.07200	<0.0001	0.00200	0.00150	0.000200	0.00026	0.2800	<0.00005	0.00200	0.00430	0.001600	0.00140	0.0020
	20-Jul-2011	**0.2900**	<0.0002	0.00340	0.1090	<0.0001	<0.0005	0.050	0.0000100	0.00001	0.00030	0.00200	**0.390**	0.0001000	0.0410	0.16400	<0.0001	0.00100	0.00140	<0.0002	<0.00001	0.2780	<0.00005	<0.001	0.01030	0.001500	0.00200	0.0040
	10-Aug-2011	0.0400	<0.0002	0.00330	0.0770	<0.0001	<0.0005	0.038	0.0000200	0.00002	0.00020	0.00200	0.080	<0.0001	0.0300	0.05500	<0.0001	0.00100	0.00120	0.000200	0.00002	0.2120	<0.00005	<0.001	0.00420	0.001100	0.00140	0.0020
	31-Aug-2011	**0.1300**	<0.0002	0.00440	0.0920	<0.0001	<0.0005	0.038	0.0000200	0.00002	0.00030	0.00100	0.200	<0.0001	0.0310	0.12700	<0.0001	0.00100	0.00120	0.000200	<0.00001	0.2020	<0.00005	<0.001	0.00660	0.001200	0.00220	0.0030
	06-Jun-2012	**0.1600**	<0.0002	0.00120	0.1000	<0.0001	<0.0005	0.031	<0.00001	<0.00001	0.00020	0.00100	0.250	0.0001000	0.0220	0.03800	<0.0001	0.00100	0.00130	<0.0002	<0.00001	0.2540	<0.00005	<0.001	0.00560	0.001700	0.00100	0.0010
	04-Jul-2012	**0.6600**	<0.0002	0.00230	0.0810	<0.0001	<0.0005	0.033	0.0000200	0.00002	0.00060	0.00200	**0.660**	0.0003000	0.0210	0.07000	<0.0001	0.00100	0.00250	0.000500	<0.00001	0.2240	<0.00005	<0.001	0.02860	0.001600	0.00310	0.0040
	01-Aug-2012	0.0600	<0.0002	0.00420	0.0460	<0.0001	<0.0005	0.029	<0.00001	<0.00001	0.00020	0.00100	0.090	<0.0001	0.0200	0.07400	<0.0001	0.00100	0.00080	<0.0002	<0.00001	0.1630	<0.00005	<0.001	0.00180	0.001200	0.00160	0.0010
	29-Aug-2012	**0.2100**	<0.0002	**0.00590**	0.0790	<0.0001	<0.0005	0.026	<0.00001	<0.00001	0.00040	0.00100	0.240	0.0002000	0.0210	0.04400	<0.0001	0.00100	0.00130	0.000200	<0.00001	0.1650	<0.00005	<0.001	0.00540	0.001400	0.00320	0.0020
	12-Jun-2013	0.0600	<0.0002	0.00140	0.0960	<0.0001	<0.0005	0.027	<0.00001	<0.00001	0.00020	0.00100	0.110	<0.0001	0.0190	0.03800	<0.0001	0.00100	0.00140	0.000300	<0.00001	0.2440	<0.00005	<0.001	0.00130	0.001400	0.00070	<0.001
	03-Jul-2013	0.0400	<0.0002	0.00180	0.0650	<0.0001	<0.0005	0.022	<0.00001	<0.00001	0.00020	0.00200	0.080	<0.0001	0.0180	0.02800	<0.0001	0.00100	0.00130	0.000300	<0.00001	0.2010	<0.00005	<0.001	0.00100	0.001200	0.00080	0.0010
	31-Jul-2013	**0.1300**	<0.0002	0.00360	0.0600	<0.0001	-	0.022	<0.00001	<0.00001	0.00030	<0.001	0.160	<0.0001	0.0140	0.07100	<0.0001	0.00100	0.00100	0.000300	<0.00001	-	<0.00005	<0.001	0.00300	0.001000	0.00190	<0.001
	28-Aug-2013	0.0400	<0.0002	0.00360	0.0590	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00020	<0.001	0.070	<0.0001	0.0110	0.02600	<0.0001	<0.001	0.00090	0.000200	<0.00001	0.1430	<0.00005	<0.001	0.00100	0.000900	0.00130	<0.001
	12-Jun-2014	<0.02	<0.0002	0.00280	0.0760	<0.0001	<0.0005	0.024	<0.00001	<0.00001	0.00020	<0.001	0.120	<0.0001	0.0150	0.06600	**0.000076**	<0.001	0.00110	0.000300	0.00001	0.2010	<0.00005	<0.001	<0.0005	0.000800	0.00060	0.0020
	09-Jul-2014	0.0600	<0.0002	0.00480	0.0650	<0.0001	<0.0005	0.022	<0.00001	<0.00001	0.00030	<0.001	0.130	0.0001000	0.0150	0.09900	<0.000005	<0.001	0.00120	0.000300	<0.00001	0.1660	<0.00005	<0.001	0.00150	0.000900	0.00150	0.0040
	07-Aug-2014	**0.1500**	<0.0002	**0.00580**	0.0660	<0.0001	<0.0005	0.024	<0.00001	<0.00001	0.00040	0.00100	0.190	0.0001000	0.0140	0.08100	<0.000005	0.00100	0.00140	0.000400	0.00002	0.1560	<0.00005	<0.001	0.00250	0.001100	0.00220	0.0010
	04-Sep-2014	**0.2400**	<0.0002	0.00130	0.1230	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00020	0.00100	**0.330**	0.0002000	0.0070	0.02300	<0.000005	<0.001	0.00110	0.000300	<0.00001	0.1530	<0.00005	<0.001	0.00690	0.000700	0.00110	0.0060
	11-Jun-2015	**0.1500**	<0.0002	0.00210	0.0880	<0.0001	<0.0005	0.029	<0.00001	<0.00001	0.00030	0.00100	0.230	0.0001000	0.0180	0.06300	<0.000005	0.00100	0.00160	0.000300	<0.00001	0.2340	<0.00005	<0.001	0.00390	0.001400	0.00110	0.0020
	09-Jul-2015	**0.1100**	<0.0002	0.00500	0.0610	<0.0001	<0.0005	0.024	<0.00001	<0.00001	0.00030	<0.001	0.270	0.0001000	0.0150	0.12300	<0.000005	0.00100	0.00130	0.000300	<0.00001	0.1640	<0.00005	<0.001	0.00310	0.001100	0.00180	0.0010
	30-Jul-2015	**0.2100**	<0.0002	**0.00620**	0.0600	<0.0001	<0.0005	0.018	<0.00001	<0.00001	0.00030	0.00100	**0.370**	0.0002000	0.0100	0.05300	<0.000005	0.00100	0.00120	0.000400	<0.00001	0.1460	<0.00005	<0.001	0.00440	0.001100	0.00280	0.0100
	03-Sep-2015	**0.4400**	<0.0002	0.00470	0.0810	<0.0001	<0.0005	0.016	0.0000200	0.00002	0.00050	0.00100	**0.590**	0.0004000	0.0090	0.07500	<0.000005	0.00100	0.00150	0.000300	<0.00001	0.1600	<0.00005	<0.001	0.01730	0.001100	0.00370	0.0050
SMW-P1	04-Jul-2006	**0.4900**	0.00080	0.00090	0.1450	<0.001	-	0.150	<0.0002	<0.0002	<0.002	0.00200	**0.370**	0.0003000	0.0100	0.01700	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.03600	0.000800	0.00200	0.0120
	17-Jul-2006	**0.2600**	0.00110	0.00080	0.1110	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.272	0.0002000	<0.01	0.01300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00700	0.000700	0.00100	<0.004
	14-Aug-2006	**0.2400**	0.00050	0.00070	0.1040	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.168	0.0001000	<0.01	0.00900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000400	<0.001	<0.004
	28-Aug-2006	0.0800	0.00080	0.00070	0.1210	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.129	0.0002000	<0.01	0.00900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00300	0.000500	<0.001	<0.004
	25-Jun-2007	**0.1900**	<0.0004	0.00050	0.1200	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.147	<0.0001	<0.01	0.01100	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00500	0.000500	<0.001	0.0160
	09-Jul-2007	**0.3400**	<0.0004	0.00070	0.1160	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.217	0.0001000	<0.01	0.01200	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.01300	0.000600	<0.001	<0.004
	07-Aug-2007	**0.2900**	<0.0004	0.00070	0.1120	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.218	0.0002000	<0.01	0.01200	<0.0002	<0.005	<0.002	**0.001200**	<0.0004	-	<0.0001	<0.05	0.00600	0.000600	<0.001	0.0090
	20-Aug-2007	**0.1500**	<0.0004	0.00060	0.1220	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.146	0.0001000	<0.01	0.00900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000400	<0.001	0.0130
	06-Jul-2011	**0.4170**	0.00150	0.00120	0.1050	<0.0001	<0.0005	0.026	0.0000200	0.00002	0.00020	0.00200	0.240	0.0003000	0.0140	0.03100	<0.0001	<0.001	0.00070	0.000600	0.00001	0.2410	<0.00005	<0.001	0.00630	0.001600	0.00140	0.0070
	20-Jul-2011	**0.4400**	<0.0002	0.00100	0.1110	<0.0001	<0.0005	0.014	0.0000100	0.00001	0.00020	0.00100	**0.320**	0.0002000	0.0060	0.02500	<0.0001	<0.001	<0.0005	0.000400	<0.00001	0.1440	<0.00005	<0.001	0.01040	0.000700	0.00160	0.0030
	10-Aug-2011	**0.2500**	<0.0002	0.00080	0.1070	<0.0001	<0.0005	0.009	0.0000300	0.00003	0.00010	<0.001	0.190	0.0002000	0.0040	0.01800	<0.0001	<0.001	<0.0005	<0.0002	0.00001	0.1060	<0.00005	<0.001	0.00410	<0.0005	0.00100	0.0030
	31-Aug-2011	**0.2400**	<0.0002	0.00080	0.1140	<0.0001	<0.0005	0.013	0.0000200	0.00002	0.00010	<0.001	0.210	0.0002000	0.0050	0.02200	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1020	<0.00005	<0.001	0.00450	<0.0005	0.00100	0.0030
	06-Jun-2012	**0.4100**	<0.0002	0.00050	0.1220	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00020	<0.001	**0.340**	0.0002000	0.0060	0.01800	<0.0001	<0.001	0.00070	<0.0002	<0.00001	0.1210	<0.00005	<0.001	0.00770	0.000700	0.00130	0.0020
	04-Jul-2012	**0.2200**	<0.0002	0.00110	0.1120	<0.0001	<0.0005	0.019	<0.00001	<0.00001	0.00020	0.00100	0.150	0.0001000	0.0100	0.01500	<0.0001	<0.001	0.00060	0.000400	<0.00001	0.1620	<0.00005	<0.001	0.00590	0.001100	0.00120	0.0020
	01-Aug-2012	**0.2900**	<0.0002	0.00080	0.1080	<0.0001	<0.0005	0.012	<0.00001	<0.00001	<0.0001	0.00100	0.200	0.0001000	0.0040	0.01100	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1000	<0.00005	<0.001	0.00770	0.000500	0.00100	0.0020
	29-Aug-2012	**0.1300**	<0.0002	0.00100	0.1080	<0.0001	<0.0005	0.011	<0.00001	<0.00001	<0.0001	0.00100	0.110	0.0001000	0.0040	0.01200	<0.0001	<0.001	<0.0005	0.000200	<0.00001	0.0910	<0.00005	<0.001	0.00430	<0.0005	0.00080	0.0020
	12-Jun-2013	**0.1100**	<0.0002	0.00060	0.1120	<0.0001	<0.0005	0.011	<0.00001	<0.00001	<0.0001	<0.001	0.100	<0.0001	0.0060	0.01100	<0.0001	<0.001	0.00050	<0.0002	<0.00001	0.1320	<0.00005	<0.001	0.00160	0.000600	0.00050	<0.001
	03-Jul-2013	**0.1700**	<0.0002	0.00060	0.1090	<0.0001	<0.0005	0.009	<0.00001	<0.00001	<0.0001	<0.001	0.140	<0.0001	0.0040	0.01400	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0900	<0.00005	<0.001	0.00270	<0.0005	0.00060	0.0040
	31-Jul-2013	**0.1200**	<0.0002	0.00070	0.1140	<0.0001	<0.0005	0.009	<0.00001	<0.00001	<0.0001	<0.001	0.110	<0.0001	0.0030	0.00900	<0.0001	<0.001	<0.0005	<0.0002	0.00002	0.0870	<0.00005	<0.001	0.00140	<0.0005	0.00050	<0.001
	28-Aug-2013	0.1000	<0.0002	0.00070	0.1110	<0.0001	<0.0005	0.008	<0.00001	<0.00001	<0.0001	<0.001	0.080	<0.0001	0.0020	0.00800	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0790	<0.00005	<0.001	0.00240	<0.0005	0.00050	<0.001
	12-Jun-2014	**0.1400**	<0.0002	0.00080	0.1260	<0.0001	<0.0005	0.008	<0.00001	<0.00001	0.00010	<0.001	0.150	0.0002000	0.0040	0.01400	**0.000028**	<0.001	<0.0005	0.000200	0.00002	0.1240	<0.00005	<0.001	0.00340	0.000600	0.00070	0.0030
	09-Jul-2014	**0.3100**	<0.0002	0.00150	0.1140	<0.0001	<0.0005	0.019	0.0000100	0.00001	0.00020	0.00200	0.280	0.0002000	0.0080	0.01700	<0.000005	<0.001	0.00110	0.000500	<0.00001	0.1920	<0.00005	<0.001	0.00620	0.001100	0.00140	0.0060
	07-Aug-2014	**0.1800**	<0.0002	0.00110	0.1180	<0.0001	<0.0005	0.010	0.0000100	0.00001	0.00020	0.00100	0.160	0.0001000	0.0040	0.01400	<0.000005	<0.001	0.00060	0.000200	0.00001	0.1230	<0.00005	<0.001	0.00440	<0.0005	0.00070	0.0020
	04-Sep-2014	**0.1300**	<0.0002	0.00110	0.1140	<0.0001	<0.0005	0.008	<0.00001	<0.00001	0.00010	<0.001	0.150	<0.0001	0.0030	0.01400	<0.000005	<0.001	0.00050	0.000200	<0.00001	0.1180	<0.00005	<0.001	0.00240	<0.0005	0.00070	0.0040
	09-Jun-2015	**0.2700**	<0.0002	0.00070	0.1220	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00010	0.00400	0.220	0.0002000	0.0050	0.01400	<0.000005	<0.001	0.00050	0.000300	<0.00001	0.1350	<0.00005	<0.001	0.00730	0.000800	0.00110	<0.001

GENERAL		TOTAL METALS																											
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																													
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1h]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SMW-R1	04-Jul-2006	**0.6200**	0.00070	0.00120	0.1400	<0.001	-	0.150	<0.0002	<0.0002	<0.002	0.00200	**0.509**	0.0003000	0.0100	0.02400	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.04200	0.001000	0.00200	0.0150
	17-Jul-2006	**0.7000**	0.00070	0.00110	0.1270	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00200	**0.737**	0.0005000	<0.01	0.02900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.01700	0.000800	0.00200	0.0090
	14-Aug-2006	**0.4700**	0.00080	0.00080	0.1120	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.375**	0.0003000	<0.01	0.01700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.01100	0.000500	0.00200	<0.004
	28-Aug-2006	**1.2200**	0.00090	0.00080	0.1330	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.733**	0.0004000	<0.01	0.02500	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.02600	0.000600	0.00300	0.0050
	25-Jun-2007	**0.9600**	<0.0004	0.00090	0.1350	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.778**	0.0004000	<0.01	0.02700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.02800	0.000700	0.00300	0.0170
	09-Jul-2007	**0.7700**	<0.0004	0.00090	0.1230	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	**0.571**	0.0003000	<0.01	0.01900	<0.0002	<0.005	<0.002	0.001000	<0.0004	-	<0.0001	<0.05	0.02000	0.000700	0.00200	0.0060
	07-Aug-2007	**0.4200**	<0.0004	0.00080	0.1160	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.335**	0.0002000	<0.01	0.01600	<0.0002	<0.005	<0.002	0.000900	<0.0004	-	<0.0001	<0.05	0.00900	0.001300	0.00100	0.0060
	20-Aug-2007	**0.2600**	<0.0004	0.00060	0.1220	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.240	0.0002000	<0.01	0.01400	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00800	0.000500	<0.001	0.0100
	06-Jul-2011	**0.2500**	<0.0002	0.00280	0.0910	<0.0001	<0.0005	0.032	0.0000200	0.00002	0.00030	0.00200	0.240	0.0002000	0.0200	0.03400	<0.0001	0.00100	0.00140	0.000500	0.00001	0.2890	<0.00005	<0.001	0.00590	0.001900	0.00250	0.0050
	20-Jul-2011	**0.4900**	<0.0002	0.00160	0.1020	<0.0001	<0.0005	0.016	0.0000200	0.00002	0.00020	0.00100	**0.420**	0.0003000	0.0090	0.03000	<0.0001	<0.001	0.00060	0.000300	<0.00001	0.1660	<0.00005	<0.001	0.01270	0.000900	0.00220	0.0050
	10-Aug-2011	**0.6200**	<0.0002	0.00140	0.1110	<0.0001	<0.0005	0.011	0.0000200	0.00002	0.00030	0.00100	**0.580**	0.0004000	0.0050	0.03400	<0.0001	<0.001	0.00070	<0.0002	0.00001	0.1240	<0.00005	<0.001	0.01260	0.000600	0.00240	0.0050
	31-Aug-2011	**0.5900**	<0.0002	0.00100	0.1160	<0.0001	<0.0005	0.012	0.0000300	0.00003	0.00030	0.00100	**0.550**	0.0004000	0.0060	0.03700	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1120	<0.00005	<0.001	0.01030	0.000600	0.00210	0.0040
	06-Jun-2012	**0.6100**	<0.0002	0.00120	0.1310	<0.0001	<0.0005	0.016	0.0000300	0.00003	0.00050	0.00200	**0.650**	0.0006000	0.0090	0.05900	<0.0001	<0.001	0.00500	<0.0002	<0.00001	0.1480	<0.00005	<0.001	0.01260	0.001000	0.00250	0.0070
	04-Jul-2012	**0.8300**	<0.0002	0.00120	0.1200	<0.0001	<0.0005	0.015	0.0000200	0.00002	0.00050	0.00200	**0.720**	0.0005000	0.0090	0.04600	<0.0001	<0.001	0.00120	0.000400	0.00001	0.1480	<0.00005	<0.001	0.05980	0.001100	0.00320	0.0060
	01-Aug-2012	**0.6800**	<0.0002	0.00100	0.1220	<0.0001	<0.0005	0.013	0.0000100	0.00001	0.00030	0.00100	**0.560**	0.0003000	0.0040	0.03600	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1070	<0.00005	<0.001	0.01750	0.000600	0.00230	0.0050
	29-Aug-2012	**0.5900**	<0.0002	0.00110	0.1150	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00030	0.00200	**0.520**	0.0003000	0.0050	0.03000	<0.0001	<0.001	0.00070	0.000300	<0.00001	0.0940	<0.00005	<0.001	0.03840	0.000600	0.00200	0.0070
	12-Jun-2013	**0.4500**	<0.0002	0.00090	0.1180	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00020	0.00100	**0.420**	0.0002000	0.0060	0.03100	<0.0001	<0.001	0.00080	0.000300	<0.00001	0.1370	<0.00005	<0.001	0.00700	0.000700	0.00130	0.0030
	03-Jul-2013	**0.4800**	<0.0002	0.00140	0.1200	<0.0001	<0.0005	0.015	0.0000200	0.00002	0.00040	0.00200	**0.510**	0.0003000	0.0080	0.04900	<0.0001	<0.001	0.00150	0.000400	<0.00001	0.1340	<0.00005	<0.001	0.01240	0.000700	0.00210	0.0050
	31-Jul-2013	**0.2600**	<0.0002	0.00090	0.1160	<0.0001	<0.0005	0.008	<0.00001	<0.00001	0.00010	<0.001	0.300	0.0001000	0.0040	0.02400	<0.0001	<0.001	<0.0005	<0.0002	0.00002	0.1070	<0.00005	<0.001	0.00390	0.000500	0.00100	0.0030
	28-Aug-2013	**0.1700**	<0.0002	0.00080	0.1140	<0.0001	<0.0005	0.008	<0.00001	<0.00001	0.00010	<0.001	0.190	<0.0001	0.0030	0.01500	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0900	<0.00005	<0.001	0.00340	<0.0005	0.00080	0.0020
	12-Jun-2014	**0.2300**	<0.0002	0.00100	0.1290	<0.0001	<0.0005	0.010	0.0000100	0.00001	0.00020	0.00100	**0.320**	0.0003000	0.0050	0.03700	**0.000022**	<0.001	<0.0005	0.000300	<0.00001	0.1410	<0.00005	<0.001	0.00480	0.000700	0.00100	0.0070
	09-Jul-2014	**0.5000**	<0.0002	0.00240	0.1040	<0.0001	<0.0005	0.025	0.0000300	0.00003	0.00050	0.00200	**0.690**	0.0004000	0.0120	0.05200	<0.000005	<0.001	0.00210	0.000600	<0.00001	0.2020	<0.00005	<0.001	0.01080	0.001300	0.00270	0.0100
	07-Aug-2014	**0.4700**	<0.0002	0.00150	0.1210	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00030	0.00200	**0.620**	0.0004000	0.0050	0.03700	<0.000005	<0.001	0.00130	0.000300	0.00001	0.1330	<0.00005	<0.001	0.01080	0.000600	0.00170	0.0040
	04-Sep-2014	**0.2100**	<0.0002	0.00380	0.0880	<0.0001	<0.0005	0.024	0.0000100	0.00001	0.00040	0.00100	**0.370**	0.0003000	0.0130	0.06600	<0.000005	<0.001	0.00160	0.000400	<0.00001	0.1870	<0.00005	<0.001	0.00510	0.001000	0.00210	0.0050
	09-Jun-2015	**0.3400**	<0.0002	0.00100	0.1250	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00020	0.00400	**0.340**	0.0002000	0.0060	0.04100	<0.000005	<0.001	0.00080	0.000300	<0.00001	0.1460	<0.00005	<0.001	0.00950	0.000900	0.00150	0.0020
	07-Jul-2015	**0.6900**	<0.0002	0.00090	0.1040	<0.0001	<0.0005	0.010	0.0000100	0.00001	0.00030	<0.001	**0.690**	0.0003000	0.0040	0.02900	<0.000005	<0.001	0.00070	<0.0002	<0.00001	0.1090	<0.00005	<0.001	0.01300	0.000600	0.00180	0.0040
	28-Jul-2015	**0.3800**	<0.0002	0.00100	0.1300	<0.0001	<0.0005	0.008	0.0000100	0.00001	0.00020	<0.001	**0.430**	0.0002000	0.0040	0.01900	<0.000005	<0.001	0.00090	0.000200	<0.00001	0.1180	<0.00005	<0.001	0.00890	0.000600	0.00130	0.0030
	01-Sep-2015	**0.3400**	<0.0002	0.00110	0.1230	<0.0001	<0.0005	0.009	0.0000100	0.00001	0.00020	<0.001	**0.320**	0.0002000	0.0040	0.01300	<0.000005	<0.001	<0.0005	0.000300	<0.00001	0.1150	<0.00005	<0.001	0.01110	0.000600	0.00150	0.0020

Notes:

1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1987). Exceedances are highlighted as:
   - 1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
   - 1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
   - 1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
   - 1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
   - 1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
   - 1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
   - 1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
   - 1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
   - 1i. Value (i) Concentration is less than guidelines
2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   - 4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

GENERAL		TOTAL METALS																												
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																														
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1g]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1h]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
SMW-R2	04-Jul-2006	**0.4000**	0.00080	0.00270	0.1090	<0.001	-	0.150	<0.0002	<0.0002	<0.002	0.00200	**0.333**	0.0002000	0.0100	0.03100	<0.0002	<0.005	<0.002	0.000700	<0.0004	-	<0.0001	<0.05	0.03400	0.001200	0.00300	0.0120
	17-Jul-2006	**0.4900**	0.00070	0.00170	0.0900	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.552**	0.0004000	<0.01	0.02700	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.01300	0.000800	0.00300	0.0050
	14-Aug-2006	**0.1700**	0.00070	0.00110	0.0890	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.150	0.0001000	<0.01	0.01500	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000500	0.00100	<0.004
	28-Aug-2006	**0.4200**	0.00080	0.00110	0.0990	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.276	0.0002000	<0.01	0.02400	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00900	0.000500	0.00100	<0.004
	25-Jun-2007	**0.7400**	<0.0004	0.00100	0.0850	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.660**	0.0004000	<0.01	0.02400	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.02400	0.000700	0.00300	0.0220
	09-Jul-2007	**0.9700**	0.00100	0.00120	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	**0.763**	0.0004000	<0.01	0.02500	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.02200	0.000700	0.00200	0.0070
	07-Aug-2007	**0.4600**	<0.0004	0.00110	0.0920	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	**0.459**	0.0002000	<0.01	0.01700	<0.0002	<0.005	<0.002	0.000600	<0.0004	-	<0.0001	<0.05	0.01000	0.000600	0.00100	0.0060
	20-Aug-2007	**0.1400**	<0.0004	0.00100	0.0990	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.181	0.0001000	<0.01	0.01800	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000500	<0.001	0.0120
	06-Jul-2011	**0.1760**	<0.0002	0.00260	0.0590	<0.0001	<0.0005	0.031	0.0000200	0.00002	0.00040	0.00200	0.180	0.0002000	0.0250	0.02400	<0.0001	0.00100	0.00120	0.000600	<0.00001	0.2340	<0.00005	<0.001	0.00510	0.002200	0.00190	0.0010
	20-Jul-2011	**0.7100**	<0.0002	0.00210	0.0680	<0.0001	<0.0005	0.023	0.0000200	0.00002	0.00040	0.00100	**0.600**	0.0003000	0.0120	0.03300	<0.0001	<0.001	0.00120	<0.0002	<0.00001	0.1530	<0.00005	<0.001	0.01560	0.001100	0.00300	0.0050
	10-Aug-2011	**0.1400**	<0.0002	0.00180	0.0810	<0.0001	<0.0005	0.014	0.0000200	0.00002	0.00020	<0.001	0.150	0.0001000	0.0070	0.04700	<0.0001	<0.001	0.00060	<0.0002	<0.00001	0.1230	<0.00005	<0.001	0.00320	0.000700	0.00140	0.0020
	31-Aug-2011	**0.1900**	<0.0002	0.00180	0.0850	<0.0001	<0.0005	0.014	0.0000200	0.00002	0.00020	<0.001	0.220	0.0002000	0.0070	0.02500	<0.0001	<0.001	0.01130	<0.0002	<0.00001	0.1160	<0.00005	<0.001	0.00420	0.000600	0.00140	0.0020
	06-Jun-2012	**0.5800**	<0.0002	0.00100	0.0700	<0.0001	<0.0005	0.015	0.0000200	0.00002	0.00040	0.00100	**0.710**	0.0005000	0.0080	0.04100	<0.0001	<0.001	0.00120	0.000300	<0.00001	0.1130	<0.00005	<0.001	0.01180	0.001000	0.00240	0.0040
	18-Jun-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jul-2012	**0.5600**	<0.0002	0.00170	0.0680	<0.0001	<0.0005	0.012	0.0000200	0.00002	0.00040	0.00200	**0.580**	0.0004000	0.0080	0.02900	<0.0001	<0.001	0.00110	<0.0002	0.00002	0.1010	<0.00005	<0.001	0.01280	0.000900	0.00260	0.0030
	23-Jul-2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01-Aug-2012	**0.3000**	<0.0002	0.00130	0.0740	<0.0001	<0.0005	0.011	<0.00001	<0.00001	0.00020	<0.001	0.280	0.0001000	0.0040	0.01500	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0900	<0.00005	<0.001	0.00530	<0.0005	0.00140	0.0020
	29-Aug-2012	**0.1900**	<0.0002	0.00120	0.0920	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00020	0.00100	0.210	0.0002000	0.0060	0.01600	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0970	<0.00005	<0.001	0.00540	0.000600	0.00110	0.0030
	12-Jun-2013	**0.5800**	<0.0002	0.00130	0.0700	<0.0001	<0.0005	0.009	0.0000100	0.00001	0.00030	0.00100	**0.540**	0.0003000	0.0060	0.02800	<0.0001	<0.001	0.00100	0.000300	<0.00001	0.0940	<0.00005	<0.001	0.00950	0.000700	0.00200	0.0030
	03-Jul-2013	0.0900	<0.0002	0.00160	0.0760	<0.0001	<0.0005	0.016	<0.00001	<0.00001	0.00020	0.00100	0.170	<0.0001	0.0140	0.03400	<0.0001	<0.001	0.00090	0.000400	<0.00001	0.1490	<0.00005	<0.001	0.00130	0.001800	0.00110	0.0020
	31-Jul-2013	**0.1600**	<0.0002	0.00110	0.0810	<0.0001	<0.0005	0.009	<0.00001	<0.00001	0.00010	<0.001	0.200	0.0001000	0.0050	0.01900	<0.0001	<0.001	0.00140	<0.0002	0.00001	0.0940	<0.00005	<0.001	0.00300	<0.0005	0.00080	0.0010
	28-Aug-2013	0.0800	<0.0002	0.00110	0.0930	<0.0001	<0.0005	0.009	0.0000200	0.00002	<0.0001	<0.001	0.110	<0.0001	0.0040	0.01200	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0950	<0.00005	<0.001	0.00160	<0.0005	0.00060	0.0020
	12-Jun-2014	0.0900	<0.0002	0.00170	0.0590	<0.0001	<0.0005	0.012	0.0000100	0.00001	0.00020	0.00100	0.210	0.0003000	0.0070	0.02700	**0.000107**	<0.001	<0.0005	0.000300	<0.00001	0.1140	<0.00005	<0.001	0.00210	0.000900	0.00120	0.0040
	09-Jul-2014	**0.1500**	<0.0002	0.00360	0.1500	<0.0001	<0.0005	0.026	0.0000100	0.00001	0.00040	0.00100	0.270	0.0002000	0.0150	0.06000	<0.000005	0.00100	0.00170	0.000600	<0.00001	0.2180	<0.00005	<0.001	0.00350	0.001100	0.00200	0.0060
	07-Aug-2014	**0.1400**	<0.0002	0.00160	0.1100	<0.0001	<0.0005	0.015	<0.00001	<0.00001	0.00020	0.00100	0.220	0.0001000	0.0050	0.02300	<0.000005	<0.001	0.00090	0.000200	<0.00001	0.1390	<0.00005	<0.001	0.00300	0.000500	0.00080	0.0020
	04-Sep-2014	0.0300	<0.0002	0.00340	0.0980	<0.0001	<0.0005	0.017	<0.00001	<0.00001	0.00020	<0.001	0.070	<0.0001	0.0080	0.18500	<0.000005	0.00100	0.00120	0.000400	<0.00001	0.1760	<0.00005	<0.001	0.00060	0.001000	0.00110	0.0060
	09-Jun-2015	**0.1300**	<0.0002	0.00140	0.0660	<0.0001	<0.0005	0.012	<0.00001	<0.00001	0.00020	0.00500	0.170	0.0001000	0.0060	0.02400	<0.000005	<0.001	0.00070	0.000300	<0.00001	0.0970	<0.00005	<0.001	0.00320	0.000800	0.00160	0.0010
	07-Jul-2015	**0.3400**	<0.0002	0.00090	0.0800	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00020	<0.001	**0.490**	0.0003000	0.0040	0.02200	<0.000005	<0.001	<0.0005	<0.0002	<0.00001	0.0890	<0.00005	<0.001	0.00680	0.000600	0.00140	0.0030
	28-Jul-2015	**0.1500**	<0.0002	0.00110	0.0900	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00010	<0.001	0.230	0.0001000	0.0040	0.01500	<0.000005	<0.001	0.00060	<0.0002	<0.00001	0.1060	<0.00005	<0.001	0.00380	0.000500	0.00090	0.0010
	01-Sep-2015	**0.2900**	<0.0002	0.00100	0.1160	<0.0001	<0.0005	0.011	<0.00001	<0.00001	0.00020	<0.001	**0.330**	0.0002000	0.0050	0.01900	<0.000005	<0.001	<0.0005	<0.0002	<0.00001	0.1110	<0.00005	<0.001	0.00730	0.000600	0.00110	0.0020
SMW-S1	04-Jul-2006	**0.5800**	0.00080	0.00090	0.1480	<0.001	-	0.150	<0.0002	<0.0002	<0.002	0.00200	**0.444**	0.0003000	<0.01	0.01900	<0.0002	<0.005	<0.002	0.000500	<0.0004	-	<0.0001	<0.05	0.04000	0.000900	0.00200	0.0110
	17-Jul-2006	**0.4500**	0.00050	0.00080	0.1130	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	**0.354**	0.0002000	<0.01	0.01300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00800	0.000700	0.00100	0.0160
	14-Aug-2006	**0.3800**	<0.0004	0.00090	0.1200	<0.001	-	0.060	<0.0002	<0.0002	<0.002	0.00100	0.234	0.0002000	<0.01	0.00900	<0.0002	<0.005	<0.002	**0.001300**	<0.0004	-	0.000400	<0.05	0.01100	0.000500	0.00200	<0.004
	28-Aug-2006	**0.1400**	0.00100	0.00070	0.1220	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	0.160	0.0001000	<0.01	0.00900	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000500	<0.001	<0.004
	25-Jun-2007	**0.2700**	<0.0004	0.00050	0.1180	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.200	0.0001000	<0.01	0.01300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00600	0.000500	0.00100	0.0060
	09-Jul-2007	**0.4200**	<0.0004	0.00070	0.1160	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.268	0.0002000	<0.01	0.01400	<0.0002	<0.005	<0.002	0.000800	<0.0004	-	<0.0001	<0.05	0.00900	0.000600	<0.001	0.0050
	07-Aug-2007	**0.4500**	<0.0004	0.00090	0.1150	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	0.00100	**0.355**	0.0002000	<0.01	0.01400	<0.0002	<0.005	<0.002	0.000900	<0.0004	-	<0.0001	<0.05	0.01000	0.000700	0.00100	0.0050
	20-Aug-2007	**0.1600**	<0.0004	0.00060	0.1240	<0.001	-	<0.05	<0.0002	<0.0002	<0.002	<0.001	0.171	0.0002000	<0.01	0.01300	<0.0002	<0.005	<0.002	<0.0004	<0.0004	-	<0.0001	<0.05	0.00400	0.000500	<0.001	0.0160
SMW-S2	06-Jul-2011	**0.2500**	<0.0002	0.00140	0.1020	<0.0001	<0.0005	0.024	0.0000100	0.00001	0.00020	0.00200	0.220	0.0002000	0.0140	0.02900	<0.0001	<0.001	0.00070	0.000500	<0.00001	0.2380	<0.00005	<0.001	0.00510	0.001600	0.00140	0.0060
	20-Jul-2011	**0.5800**	<0.0002	0.00110	0.1140	<0.0001	<0.0005	0.014	0.0000200	0.00002	0.00020	0.00100	**0.480**	0.0003000	0.0070	0.03700	<0.0001	<0.001	0.00050	0.000400	<0.00001	0.1480	<0.00005	<0.001	0.01270	0.000800	0.00210	0.0040
	10-Aug-2011	**0.3100**	<0.0002	0.00100	0.1060	<0.0001	<0.0005	0.010	0.0000200	0.00002	0.00010	<0.001	0.250	0.0002000	0.0040	0.02000	<0.0001	<0.001	<0.0005	<0.0002	0.00001	0.1110	<0.00005	<0.001	0.00510	0.000500	0.00120	0.0040
	31-Aug-2011	**0.1600**	<0.0002	0.00090	0.1130	<0.0001	<0.0005	0.011	0.0000200	0.00002	0.00010	<0.001	0.140	<0.0001	0.0050	0.01800	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.1010	<0.00005	<0.001	0.00290	<0.0005	0.00070	0.0020
	06-Jun-2012	**0.5000**	<0.0002	0.00060	0.1240	<0.0001	<0.0005	0.013	<0.00001	<0.00001	0.00020	0.00100	**0.560**	0.0003000	0.0060	0.02900	<0.0001	<0.001	0.00080	<0.0002	<0.00001	0.1260	<0.00005	<0.001	0.00960	0.000700	0.00160	0.0030
	04-Jul-2012	**0.5400**	<0.0002	0.00100	0.1160	<0.0001	<0.0005	0.014	0.0000200	0.00002	0.00030	0.00100	**0.510**	0.0004000	0.0070	0.03300	<0.0001	<0.001	0.00090	0.000400	<0.00001	0.1280	<0.00005	<0.001	0.01570	0.000800	0.00210	0.0040
	01-Aug-2012	**0.3600**	<0.0002	0.00080	0.1100	<0.0001	<0.0005	0.011	0.0000100	0.00001	0.00010	0.00100	0.270	0.0002000	0.0040	0.01600	<0.0001	<0.001	<0.0005	0.000200	<0.00001	0.0980	<0.00005	<0.001	0.00780	0.000500	0.00120	0.0020
	29-Aug-2012	**0.1900**	<0.0002	0.00090	0.1050	<0.0001	<0.0005	0.011	<0.00001	<0.00001	0.00010	0.00100	0.180	0.0001000	0.0050	0.01400	<0.0001	<0.001	<0.0005	0.000200	0.00001	0.0850	<0.00005	<0.001	0.00530	<0.0005	0.00090	0.0030
	12-Jun-2013	**0.3000**	<0.0002	0.00060	0.1120	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00010	<0.001	0.250	<0.0001	0.0050	0.01800	<0.0001	<0.001	0.00050	<0.0002	<0.00001	0.1190	<0.00005	<0.001	0.00310	0.000600	0.00080	0.0010
	03-Jul-2013	**0.5400**	<0.0002	0.00070	0.1170	<0.0001	<0.0005	0.011	0.0000200	0.00002	0.00020	0.00100	**0.440**	0.0003000	0.0040	0.02400	<0.0001	<0.001	0.00070	<0.0002	<0.00001	0.0920	<0.00005	<0.001	0.00840	<0.0005	0.00140	0.0040
	31-Jul-2013	0.0900	<0.0002	0.00060	0.1100	<0.0001	<0.0005	0.008	<0.00001	<0.00001	<0.0001	<0.001	0.090	<0.0001	0.0030	0.01100	<0.0001	<0.001	<0.0005	<0.0002	0.00002	0.0860	<0.00005	<0.001	0.00130	<0.0005	0.00050	<0.001
	28-Aug-2013	0.0600	<0.0002	0.00070	0.1080	<0.0001	<0.0005	0.007	<0.00001	<0.00001	<0.0001	<0.001	0.080	<0.0001	0.0020	0.00900	<0.0001	<0.001	<0.0005	<0.0002	<0.00001	0.0800	<0.00005	<0.001	0.00100	<0.0005	0.00040	<0.001
	12-Jun-2014	**0.1800**	<0.0002	0.00080	0.1360	<0.0001	<0.0005	0.008	0.0000100	0.00001	0.00020	<0.001	0.230	0.0002000	0.0040	0.02700	**0.000088**	<0.001	<0.0005	<0.0002	<0.00001	0.1210	<0.00005	<0.001	0.00410	0.000600	0.00070	0.0040
	09-Jul-2014	**0.4500**	<0.0002	0.00160	0.1110	<0.0001	<0.0005	0.020	<0.00001	<0.00001	0.00020	0.00200	**0.350**	0.0003000	0.0090	0.05600	<0.000005	<0.001	0.00120	0.000600	<0.00001	0.1870	<0.00005	<0.001	0.00600	0.001100	0.00140	0.0070
	07-Aug-2014	**0.1900**	<0.0002	0.00110	0.1180	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00010	0.00100	0.230	0.0002000	0.0040	0.01800	<0.000005	<0.001	0.00070	0.000200	0.00002	0.1260	<0.00005	<0.001	0.00570	0.000500	0.00090	0.0020
	04-Sep-2014	**0.3200**	<0.0002	0.00340	0.0930	<0.0001	<0.0005	0.023	0.0000200	0.00002	0.00050	0.00100	**0.540**	0.0003000	0.0140	0.07400	<0.000005	<0.001	0.00190	0.000400	<0.00001	0.1870	<0.00005	<0.001	0.00710	0.001100	0.00210	0.0070
	09-Jun-2015	**0.4400**	<0.0002	0.00080	0.1290	<0.0001	<0.0005	0.010	0.0000200	0.00002	0.00020	0.00500	**0.450**	0.0003000	0.0050	0.02700	<0.000005	<0.001	0.00100	0.000200	<0.00001	0.1320	<0.00005	<0.001	0.01110	0.000700	0.00160	0.0020
	07-Jul-2015	**0.2900**	<0.0002	0.00070	0.0970	<0.0001	<0.0005	0.010	<0.00001	<0.00001	0.00010	<0.001	**0.310**	0.0001000	0.0040	0.01500	<0.000005	<0.001	<0.0005	<0.0002	<0.00001	0.0970	<0.00005	<0.001	0.00690	0.000500	0.00110	0.0020
	28-Jul-2015	**0.1100**	<0.0002	0.00080	0.1250	<0.0001	<0.0005	0.007	<0.00001	<0.00001	<0.0001	<0.001	0.120	<0.0001	0.0030	0.01000	<0.000005	<0.001	<0.0005	<0.0002	<0.00001	0.1070	<0.00005	<0.001	0.00260	0.000500	0.00060	0.0010
	01-Sep-2015	0.0800	<0.0002	0.00100	0.1270	<0.0001	<0.0005	0.009	<0.00001	<0.00001	<0.0001	<0.001	0.090	<0.0001	0.0040	0.00900	<0.000005	<0.001	<0.0005	0.000300	<0.00001	0.1060	<0.00005	<0.001	0.00230	0.000500	0.00070	<0.001
AB05AG0261 (Chin Reservoir)	18-Jun-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000005	-	-	-	-	-	-	-	-	-	-	-
	06-Aug-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000005	-	-	-	-	-	-	-	-	-	-	-
	03-Sep-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000005	-	-	-	-	-	-	-	-	-	-	-
	23-Sep-2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000005	-	-	-	-	-	-	-	-	-	-	-
AB05AG0260 (Stafford Reservoir)	18-Jun-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00000043	-	-	-	-	-	-	-	-	-	-	-
	16-Jul-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00000047	-	-	-	-	-	-	-	-	-	-	-
	14-Aug-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00000034	-	-	-	-	-	-	-	-	-	-	-
	10-Sep-2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00000047	-	-	-	-	-	-	-	-	-	-	-

Notes:
1. Guidelines are based on Environmental Quality Guidelines for Alberta Surface Waters (2018) and Canadian Council of Ministers of the Environment (CCME) (1987). Exceedances are highlighted as:

1a. Value (a) AB Surface Water Quality Guidelines for Freshwater Aquatics - Chronic
1b. Value (b) AB Surface Water Quality Guidelines for Freshwater Aquatics - Acute
1c. Value (c) AB Surface Water Quality Guidelines for Irrigation
1d. Value (d) AB Surface Water Quality Guidelines for Livestock and CCME Water Quality Guidelines for the Protection of Agriculture - Livestock
1e. Value (e) AB Surface Water Quality Guidelines for Recreation and Aesthetics
1f. **Value** (f) CCME Water Quality Guidelines for the Protection of Aquatic Life - Chronic
1g. Value (g) CCME Water Quality Guidelines for the Protection of Aquatic Life - Acute
1h. Value (h) CCME Water Quality Guidelines for the Protection of Agriculture - Irrigation
1i. Value (i) Concentration is less than guidelines

GENERAL		TOTAL METALS																										
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (Trivalent)	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																												
Freshwater Aquatics - Chronic [1a]		-	-	0.005	-	-	-	1.5	Equation	0.0089	Equation	0.007	-	Equation	-	Equation	0.000005	0.073	Equation	0.002	0.0025	-	0.0008	-	-	0.015	-	0.03
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	Equation	-	-	-	-	0.000013	-	Equation	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.16	-	0.1	-	0.5	0.0082	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	0.01	0.2	0.02	-	-	-	-	-	0.01	0.1	1
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50
Recreation and Aesthetics [1e]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freshwater Aquatics - Chronic [1f]		**0.1**	-	**0.005**	-	-	-	**1.5**	**Equation**	**0.001**	-	**Equation**	**0.3**	**Equation**	-	**Equation**	**0.0000026**	**0.073**	**Equation**	**0.001**	**0.00025**	-	**0.0008**	-	-	**0.015**	-	**Equation**
Freshwater Aquatics - Acute [1b]		-	-	-	-	-	-	29	Equation	-	-	-	-	-	-	Equation	-	-	-	-	-	-	-	-	-	0.033	-	-
Irrigation [1c]		5	-	0.1	-	0.1	-	0.5	0.0051	0.0049	0.05	0.2	5	0.2	2.5	0.2	-	-	0.2	0.02	-	-	-	-	-	0.01	0.1	5
Livestock [1d]		5	-	0.025	-	0.1	-	5	0.08	-	1	0.05	-	0.1	-	-	0.003	0.5	1	0.05	-	-	-	-	-	0.2	0.1	50

2. - no guideline
3. - data not recorded or analyzed
4. Guidelines dependent on other parameters are summarized below:
   4e. Cadmium, cobalt, copper, lead and nickel are hardness dependent.

| GENERAL | | |

GENERAL		PESTICIDES
Location	Sample Date (dd-mmm-yyyy)	2,4-Dichlorophenol; 2,4-Dichlorophenoxyacetic acid; 4-(2,4-dichlorophenoxy)butyric acid; Alachlor; Aldrin; Allidochlor; alpha-Endosulfan; Aminomethylphosphonic acid; Azinphos-methyl; Atrazine; Azoxystrobin; Benalaxyl; Bentazon; Benfluralin; Benzoylprop-Ethyl; Bifenazate; Bifenthrin; Boscalid; Bromacil; Bromophos-Ethyl; Bromopropylate; Bromoxynil; Bupirimate; Butylate; Butachlor; Butralin; Captan; Carbaryl; Carbofuran; Carfentrazone-ethyl; Chlormephos; Chloroneb; Chlorothalonil; Chlorpyrifos; Chlorpyrifos-Methyl; Chlorthal-Dimethyl; Chlorthiamid; cis-Chlordane; cis-Permethrin; Clodinafop-propargyl; Clomazone; Clopyralid; Cycloate; Cyfluthrin; Cyhalothrin lambda; Cypermethrin-beta; Cypermethrin-zeta; Cyprodinil; Deltamethrin; Desmetryn; Diazinon; Dicamba; Dichlobenil; Dichlofenthion; Dichlorprop; Dichlorvos; Diclofop; Dieldrin; Difenoconazole; Dimethachlor; Dimethenamid-P; Dimethoate; Dimethomorph; Dioxathion; Diphenamid; Diuron; Endrin; EPTC_(S-ethyl_Dipropylthiocarbamate); Ethalfluralin; Ethion; Ethofumesate; Etodialzate; Etoxazole; Etrimphos; Famoxadone; Fenamidone; Fenchlorphos; Fenoxaprop; Fenthion; Flamprop-Isopropyl; Flamprop-Methyl; Fluazifop-p-butyl; Fludioxonil; Flumetralin; Flumioxazin; Fluroxypyr; Flutriafol; Folpet; Fonofos; Glufosinate; Glyphosate; Heptachlor; Hexachlorocyclohexane-alpha; Hexachlorocyclohexane-beta; Hexachlorocyclohexane-delta; Hexazinone
Units		ug/L
GUIDELINES		
Freshwater Aquatics - Chronic [1a]		0.2; 4; 25; -; -; -; -; -; -; 1.8; -; -; -; -; -; -; -; -; 5; -; 25; 5; -; -; -; -; 1.3; 0.2; 1.8; -; -; 0.18; 0.002; -; -; -; -; -; -; -; -

| GENERAL | | PESTICIDES | | |

GENERAL		PESTICIDES
Location	Sample Date (dd-mmm-yyyy)	2,4-Dichlorophenol; 2,4-Dichlorophenoxyacetic acid; 4-(2,4-dichlorophenoxy)butyric acid; Aldicarb; Aldrin; Allidochlor; alpha-Endosulfan; Aminomethylphosphonic acid; Azinphos-methyl; Atrazine; Azoxystrobin; Benalaxyl; Bentazon; Bifenthrin; Boscalid; Bromacil; Bromophos-Ethyl; Bromopropylate; Bromoxynil; Bupirimate; Butylate; Butachlor; Butralin; Captan; Carbaryl; Carbofuran; Carfentrazone-ethyl; Chlormephos; Chlorneb; Chlorothalonil; Chlorpyrifos; Chlorpyrifos-Methyl; Chlorthal-Dimethyl; Chlorthiamid; Chlordane; cis-Permethrin; Clodinafop-propargyl; Clomazone; Clopyralid; Cycloate; Cyfluthrin; Cyhalothrin lambda; Cypermethrin-beta; Cypermethrin-zeta; Cyprodinil; Deltamethrin; Desmetryn; Diazinon; Dicamba; Dichlobenil; Dichlofenthion; Dichlorprop; Dichlorvos; Diclofop; Dieldrin; Difenoconazole; Dimethachlor; Dimethenamid-P; Dimethoate; Dimethomorph; Dioxathion; Diphenamid; Diuron; Endrin; EPTC_(S-ethyl_Dipropylthiocarbamate); Ethalfluralin; Ethion; Ethofumesate; Etradiazole; Etoxysulfuron; Famoxadone; Fenamidone; Fenchlorphos; Fenoxaprop; Fenthion; Flamprop-Isopropyl; Flamprop-Methyl; Fluazifop-p-butyl; Fludioxonil; Flumetralin; Flumioxazin; Fluroxypyr; Flutriafol; Folpet; Fonofos; Glufosinate; Glyphosate; Heptachlor; Hexachlorocyclohexane-alpha; Hexachlorocyclohexane-beta; Hexachlorocyclohexane-delta; Hexazinone
Units		ug/L; ug/L; ug/L;

| GENERAL | | PESTICIDES | | |

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| GENERAL | | PESTICIDES | | |

APPENDIX 169.1

Alberta Agriculture and Forestry Water Quality Index Results

Appendix 169.1
Alberta Agriculture and Forestry Water Quality Index Results

The AAF study used five categories to define the range of WQI values for the IDWQ project (2021a), based on categories that had been previously defined by CCME for use with the indices (2007). The categories and corresponding WQI value range are defined in Table 1.

Table 1 CCME WQI Categories (AAF 2021a)

Category	WQI Value	Statement
Excellent	95.0–100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80.0–94.9	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65.0–79.9	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45.0–64.9	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor	0–44.9	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

The IDWQ project WQI results for each sampling station within the SMRID system, for each of the WQI sub-indices, are provided in Table 2 to Table 8, adapted directly from the AAF study report (2021a). Of note, N/A indicates that data was not available, usually due to the site not being sampled in that year.

The WQI categories are colour-coded as:

Excellent | Good | Fair | Marginal | Poor

Table 2 Irrigation WQI General/Pesticide Sub-index Values and Categories (AAF 2021a)

Site	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018
SMC-P1	84.3	78.1	94.3	94.7	100	93.4	86.0	86.8	100	100
SME-P1	84.5	83.5	87.4	100	94.9	93.9	90.8	95.0	100	95.0
SMW-P1	94.0	100	89.9	100	100	95.0	95.0	100	100	100
SMC-S1	91.7	91.2	100	100	100	95.0	100	69.9	100	94.6
SMC-S2	93.5	85.6	100	100	95.0	95.0	78.2	89.0	100	94.9
SMC-S3	77.9	77.5	94.3	94.9	95.0	94.6	95.0	75.1	100	100
SME-S1	94.0	83.2	100	100	100	100	100	100	100	100
SMW-S1	86.7	94.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SMW-S2	N/A	N/A	90.0	100	95.0	95.0	95.0	90.1	100	94.8
SMC-R1	78.0	84.9	95.0	91.0	95.0	95.0	93.6	87.3	87.1	94.1
SMC-R3	100	71.6	90.0	89.6	95.0	93.0	88.9	80.9	91.6	94.9
SMC-R4	77.8	68.0	89.5	91.9	89.7	87.2	87.3	85.7	89.5	91.9
SME-R1	81.5	67.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SME-R1a	N/A	N/A	94.6	100	100	94.3	94.0	78.1	100	93.5
SME-R2	N/A	N/A	77.0	89.6	89.1	60.3	80.1	88.8	89.3	81.3
SMW-R1	72.8	66.8	84.3	57.8	95.0	84.0	87.3	54.4	94.6	93.3
SMW-R2	69.4	68.1	87.0	82.2	84.8	83.3	84.2	72.7	94.0	94.2

Table 3 Irrigation WQI Metals Sub-index Values and Categories (AAF 2021a)

Site	2006	2007	2011	2012	2013	2014	2015
SMC-P1	100	100	100	100	100	100	100
SME-P1	100	100	100	100	100	100	100
SMW-P1	100	100	100	100	100	100	100
SMC-S1	100	100	100	100	100	100	100
SMC-S2	100	100	100	100	100	100	100
SMC-S3	100	100	100	100	100	100	100
SME-S1	100	97	100	100	100	100	100
SMW-S1	100	100	N/A	N/A	N/A	N/A	N/A
SMW-S2	N/A	N/A	100	100	100	100	100
SMC-R1	100	100	100	100	100	100	100
SMC-R3	100	100	100	100	100	100	100
SMC-R4	100	100	100	100	100	100	100
SME-R1	97	100	N/A	N/A	N/A	N/A	N/A
SME-R1a	N/A	N/A	100	100	100	100	100
SME-R2	N/A	N/A	97	100	97	100	100
SMW-R1	100	100	100	100	100	100	100
SMW-R2	100	100	100	100	100	100	100

Table 4 Livestock WQI General/Pesticide Sub-index Values and Categories (AAF 2021a)

Site	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018
SMC-P1	100	100	100	100	100	100	100	100	100	100
SME-P1	100	100	100	100	100	100	100	100	100	100
SMW-P1	100	100	100	100	100	100	100	100	100	100
SMC-S1	100	100	100	100	100	100	100	100	100	100
SMC-S2	100	100	100	100	100	100	100	100	100	100
SMC-S3	100	100	100	100	100	100	100	100	100	100
SME-S1	100	100	100	100	100	100	100	100	100	100
SMW-S1	100	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SMW-S2	N/A	N/A	100	100	100	100	100	100	100	100
SMC-R1	100	100	100	100	100	100	100	100	100	100
SMC-R3	100	100	100	100	100	100	100	100	100	100
SMC-R4	100	100	100	100	100	100	100	100	100	100
SME-R1	100	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SME-R1a	N/A	N/A	100	100	100	100	100	100	100	100
SME-R2	N/A	N/A	100	100	100	100	100	100	100	100
SMW-R1	100	100	100	100	100	100	100	100	100	100
SMW-R2	100	100	100	100	100	100	100	100	100	100

Table 5 Livestock WQI Metals Sub-index Values and Categories (AAF 2021a)

Site	2006	2007	2011	2012	2013	2014	2015
SMC-P1	100	100	100	100	100	100	100
SME-P1	100	100	100	100	100	100	100
SMW-P1	100	100	100	100	100	100	100
SMC-S1	100	100	100	100	100	100	100
SMC-S2	100	100	100	100	100	100	100
SMC-S3	100	100	100	100	100	100	100
SME-S1	100	100	100	100	100	100	100
SMW-S1	100	100	N/A	N/A	N/A	N/A	N/A
SMW-S2	N/A	N/A	100	100	100	100	100
SMC-R1	100	100	100	100	100	100	100
SMC-R3	100	100	100	100	100	100	100
SMC-R4	100	100	100	100	100	100	100
SME-R1	100	100	N/A	N/A	N/A	N/A	N/A
SME-R1a	N/A	N/A	100	100	100	100	100
SME-R2	N/A	N/A	100	100	100	100	100
SMW-R1	100	100	100	100	100	100	100
SMW-R2	100	100	100	100	100	100	100

Table 6 PAL WQI General Sub-index Values and Categories (AAF 2021a)

Site	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018
SMC-P1	100	100	100	100	100	100	100	100	100	100
SME-P1	100	100	100	100	80.1	100	100	100	100	100
SMW-P1	100	100	100	100	100	100	100	100	100	100
SMC-S1	100	100	100	100	100	100	100	100	100	100
SMC-S2	100	100	100	100	100	100	100	100	100	100
SMC-S3	100	100	100	89.9	100	100	100	100	100	100
SME-S1	78.3	80.1	100	79.1	100	80.1	79.3	100	100	87.1
SMW-S1	100	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SMW-S2	N/A	N/A	100	100	100	100	100	100	100	100
SMC-R1	78.5	100	100	100	100	100	100	100	100	100
SMC-R3	75.4	100	100	100	100	100	80.1	100	100	100
SMC-R4	100	100	100	100	100	100	100	100	100	100
SME-R1	78.5	80.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SME-R1a	N/A	N/A	100	80.1	100	100	80.1	100	100	88.1
SME-R2	N/A	N/A	100	100	100	100	100	100	100	100
SMW-R1	100	100	100	100	100	100	100	100	100	100
SMW-R2	100	100	80.2	80.1	79.2	79.4	80.1	100	100	100

Table 7 PAL WQI Pesticide Sub-index Values and Categories (AAF 2021a)

Site	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018
SMC-P1	100	100	100	100	100	100	100	100	100	100
SME-P1	100	100	100	100	100	100	100	100	100	100
SMW-P1	100	100	100	100	100	100	100	100	100	100
SMC-S1	100	100	100	100	100	100	100	100	100	100
SMC-S2	100	100	100	100	100	100	100	100	100	100
SMC-S3	100	100	100	100	100	100	100	100	100	100
SME-S1	100	100	100	100	100	100	100	100	100	100
SMW-S1	100	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SMW-S2	N/A	N/A	100	100	100	100	100	100	100	100
SMC-R1	91.9	100	100	100	100	100	100	100	100	100
SMC-R3	100	100	100	100	100	100	100	97.2	100	100
SMC-R4	100	100	100	100	100	100	100	100	100	100
SME-R1	100	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SME-R1a	N/A	N/A	100	100	97.3	100	100	100	100	100
SME-R2	N/A	N/A	100	100	100	100	100	100	100	100
SMW-R1	100	100	100	100	100	100	100	97.1	100	100
SMW-R2	100	100	100	100	100	100	100	100	100	100

Table 8 PAL WQI Metals Sub-index Values and Categories (AAF 2021a)

Site	2011	2012	2013	2014	2015
SMC-P1	100	100	100	100	100
SME-P1	100	100	95.5	100	100
SMW-P1	100	100	100	100	100
SMC-S1	100	100	100	100	100
SMC-S2	100	100	100	100	100
SMC-S3	100	100	100	100	100
SME-S1	95.7	95.7	100	95.7	95.7
SMW-S2	100	100	100	100	100
SMC-R1	100	100	100	100	100
SMC-R3	100	100	100	100	100
SMC-R4	100	100	100	100	100
SME-R1a	100	95.7	100	95.7	95.4
SME-R2	100	100	95.7	100	100
SMW-R1	100	100	100	100	100
SMW-R2	100	100	100	100	100