Volume 2, Section 7 Snake Lake Reservoir Expansion Project
Environmental Impact Assessment
Surface Waterbodies

Submitted to:

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Executive Summary

The Eastern Irrigation District (EID) is applying for approval under the *Environmental Protection and Enhancement Act* (Government of Alberta (GOA), 2000d) to construct the proposed Snake Lake Reservoir (SLR) Expansion Project (the Project). The Project, located between Bassano and Brooks in Alberta, involves the construction of a roughly 8 km long, up to 20 m high dam to increase the storage capacity of the reservoir system from 19.25 million m^3 to 87.4 million m^3. This Environmental Impact Assessment (EIA) section includes a baseline assessment, which contains a comprehensive description of water quality and quantity, and impacts anticipated to both, for surface waterbodies in local and regional study areas as a result of the Project. This is based on requirements provided in the Final Terms of Reference (FTOR; Volume 2, Appendix A) for the Project issued by Alberta Environment and Protected Areas (Alberta EPA), and following the Guide to Preparing Environmental Impact Assessments in Alberta (GOA, 2013). This document also contains residual impacts, but a cumulative effects assessment was not completed since the Project will result in a net gain in surface water on the landscape.

The extant reservoir including dams and water surface, covers 302 ha, with 299 ha of water surface, and stores 15,600 ac-ft (19.25 million m^3) of water at full supply level (FSL) of 781.7 m asl (above sea level). The EID proposes to expand the SLR for additional offsite water storage for irrigation users. The new reservoir, including the dams will occur over 4 sections of land, covering 827 ha, increasing storage volume by 66 million m^3. They also plan to increase the FSL to 782.0 m, storing an additional 2.1 million m^3, for a total of 87.4 million m^3 of storage. The new reservoir requires construction of 8 km of earthen banks on the north, east and south sides of the new reservoir, up to 20 m high. Project activities are expected to affect waterbody characteristics and resources including drawdown of the existing reservoir (before joining the new reservoir), creation of the new reservoir basin, loss of small surface waterbodies in the reservoir expansion area, and alteration of water quality during and after reservoir filling.

An aquatic local study area (ALSA) was defined as the area where direct and indirect effects may occur on waterbodies, focusing on the existing and expanded reservoir areas. The ALSA has a total of 418 ha of surface water features (31.9% of the ALSA). These include the existing reservoir (298.8 ha), 40.2 ha of canals and ditches, and 78.9 ha of other waterbodies, including wetlands, dugouts and other ponds. The aquatic regional study area (ARSA) includes waterbodies mainly within the Onetree Creek Watershed of the greater Red Deer River Watershed. The ARSA includes a total of 11,407.9 ha of surface water features, or 9.9% of the total area; this includes 671.7 ha of reservoirs, 928.4 ha of canals and ditches, 78.1 ha of watercourses, and 9,731.5 ha of other waterbodies.

Baseline information was supported by fieldwork including collection of water and sediment samples for laboratory analysis and quantification of lake morphology. Bathymetry of the existing reservoir was mapped based on measurements of depth in transects across the reservoir at full supply level and during drawdown within a drought year (2023). Drought year measurements were supported by additional depth measures in the reservoir during fieldwork. Depth was greatest in the basin near the East Dam. Maximum depth was 14.3 m at full supply level, and this decreased to 12.8 m in fall 2021. In September 2023, following a season of extensive drawdown, the maximum depth was 6.0 m (i.e., 8.3 m of water was drawn down).

Water quality was compared to guidelines for agricultural water use, recreational use, and for the protection of aquatic life (PAL). The SLR and dugout water quality were found to fall within all guidelines for Agricultural Water Use (GOA, 2018a); however, when compared to guidelines for PAL (GOA, 2018a) three parameters measured exceeded the guidelines. These included fluoride (spring 2021, winter 2022), total mercury (winter 2022 and fall 2023), and pH: while laboratory samples were within guidelines, in-situ measurements in winter 2022 exceeded pH 9.0. In sampled dugouts, mercury did not exceed PAL guidelines. The water quality of Bow River water, the source of the reservoir water, was also examined and compared using information obtained from the Irrigation District Water Quality Data Tool, with the change in water quality shown at three downstream sites prior to return to the Red Deer River.

SLR water chemistry was found to be alkaline in character (pH 8.1 to 9.4), with similar pH (8.1) reported for smaller waterbodies in the planned expansion area. Alkaline pH values are typical for till covered areas in southern Alberta where minerals in the surficial deposits react with water to increase alkalinity of surface water. The reservoir was not stratified during spring, fall, and winter sampling events. Stratification normally occurs in mid-summer; however, it is likely this reservoir does not stratify because the water column is influenced by wind action. Dissolved oxygen concentration measured varied between 3 and 14 mg/L across depths during spring and summer sampling visits. Reservoir water quality resembles that of its source of water, the Bow River. Irrigation drawdown of 1.5 to 2.0 m does not compromise local aquatic habitat; aquatic life is supported in the reservoir year-round. Lack of summer stratification, given the lake's fetch (length of exposed water), ensures oxygenation throughout the open water season.

Sediment sampling in the SLR was completed to determine if they held high concentrations of metals such as methylmercury and other elements. A comparison between sediment data and the Environmental Quality Guidelines for Alberta Surface Waters showed that sediment metal parameters fall within PAL guidelines. Inorganic mercury concentration in water was inconclusive: two sampling periods had concentrations within guideline, while two others were orders of magnitude larger and beyond the concentration guidelines. This could be a sampling artifact since only 2 samples were collected per location and season. Regardless, further testing is required to confirm the typical range for mercury concentration in water.

Effects of the Project on surface water include a permanent loss of shallow waterbodies and ponds within the footprint of the expanded basin. These will by offset by the doubling of littoral habitat in the expanded reservoir. In addition, change in surface water quality is anticipated to be neutral during construction and infilling of the dam. There will be drawdown of the extant basin when the expanded basin begins to fill; however, this will be temporary and deemed neutral. No further effects of the expansion are anticipated once the expansion is complete and reservoir filled.

It is recommended to monitor surface water at 1 year post construction to determine if water quality changes and stabilizes.

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Abbreviations

ac-ft	Acre-feet
ALSA	Aquatic Local Study Area
ARSA	Aquatic Regional Study Area
asl	Above Sea Level
BOD	Biological oxygen demand
BTEX	A group of the chemical compounds: Benzene, Toluene, Ethylene, Xylene
CCME	Canadian Council of Ministers of the Environment
DO	Dissolved oxygen
EIA	Environmental Impact Assessment
EID	Eastern Irrigation District
EPEA	Environmental Protection and Enhancement Act
FSL	Full Supply Level
FTOR	Final Terms of Reference
GOA	Government of Alberta
HUC	Hydrologic Unit Code
IFN	Instream Flow Need
IO	Instream objective
PAH	Polycyclic aromatic hydrocarbons
PAL	Protection of Aquatic Life
PCB	Polychlorinated biphenyl
SLR	Snake Lake Reservoir
SSRP	South Saskatchewan Regional Plan
TDS	Total dissolved solids
TKN	Total Kjeldahl Nitrogen

7.1 INTRODUCTION

7.1.1 Background

In the early 1900s, the Eastern Irrigation District (EID) built a system of canals and reservoirs filled with water diverted from the Bow River to meet demands of Alberta's agricultural industry (GOA, 2020). Reservoirs store water in times of high-flow and release it by canal and pipeline infrastructure through summer and early fall to meet agricultural demand. Irrigation reservoirs may be on- or off-stream; on-stream reservoirs are constructed by impounding a watercourse and using the natural valley walls or low terrain to hold-back flowing water. Off-stream reservoirs store water obtained from offsite in any low elevation feature such as a dammed coulee, lake, or an excavated and/or raised pond.

Snake Lake Reservoir (SLR) is an off-stream reservoir located 23 km northwest from the City of Brooks, AB. It was constructed from 1995 to 1997 in a natural coulee with a downstream (east) and upstream (west) dam (Eastern Irrigation District and Government of Alberta, 1995). It is owned and operated by the EID under *Alberta's Irrigation Districts Act* (GOA, 2000a). The EID is authorized to withdraw annually 938 million m^3 of water from the Bow River (*Water Act* Licence No. 00071066-00-00). Use to date (10-year average) has been 549 million m^3 per year (ranging from 363 million m^3 to 663 million m^3). As such, an average of 389 million m^3 of water available for offsite storage is not used in a typical year (Eastern Irrigation District, 2020). Recent data for 2023, a drought year, showed EID water withdrawal was 676 million m^3, which was still well below the licenced allocation. Although demand was higher in mid-summer to early fall 2023, greater use of water could not occur as the EID ensured the minimum instream objective (IO) was maintained throughout the year. If larger reservoirs were present, additional water could have been stored from periods of high river flow, for use when needed.

The SLR currently stores up to 15,600 acre-feet (ac-ft; 19.25 million m^3) of water at Full Supply Level (FSL) at an elevation of 781.7 m above sea level (asl). Bow River water is diverted at Bassano Dam and the EID's East Branch Canal carries it 20 km to the reservoir. Water enters the reservoir on the west side via a gated inlet controlled by an online check structure. Outflow from the reservoir is through a low-level outlet structure located near the north end of the East Dam.

The EID proposes to expand the SLR by constructing up to 20 m high berms around the perimeter and inundating an additional 764 ha within four sections of land east of the present reservoir (Appendix E1, Figure E1-1). The base will be excavated for aggregate materials to construct the berms, so the new reservoir will hold water both below and above the natural soil surface elevation. Reservoir expansion will provide additional water security during drought conditions when direct withdrawal from the river cannot be maintained (i.e., when river water level is low in late summer and early fall and when most or all river water is needed to meet the Bow River IO below Bassano Dam, for the protection of aquatic life).

Once expanded, the reservoir is estimated to hold an additional 66 million m^3 (53,500 ac-ft) in 2 basins (the original and new basin) at FSL. Additional increase of 0.3 m to the FSL will store an additional 2.1 million m^3 (1,700 ac-ft), for total storage of 87.4 million m^3 (70,900 ac-ft) of water This water will would be fully able to supply needed water for a full year to the 20,000 ha (50,000 acres) of irrigated agricultural lands below SLR along the Spring Hill Canal. This water will not be used to support new irrigated agricultural lands. However, as efficiencies in water use continue to improve, as aided by reservoirs, pipes replacing canals and on-farm improvements, additional irrigable lands will be increased in the EID on the same allocated water, as has been occurring for many decades.

The EID's Water Licence allows it to extract water, subject to:

- Ensure discharge in the Bow River meets or exceeds the minimum IO required to protect aquatic resources downstream from Bassano Dam (400 ft^3/s = 11.3 m^3/s);
- Ensure water extracted does not compromise Alberta's ability to meet apportionment requirements with Saskatchewan; and
- Additional provisions for water restrictions be met when the Alberta Drought Response Plan (GOA, 2024e) is in enacted.

In the first year(s) of operation and in any subsequent year after drought-related drawdown, the reservoir will require up to 87.4 million m^3 of water to fill, in addition to the 80 to 90 million m^3 which downstream irrigators would use in the same year. While this seems like a large amount of water to add to the EID's overall use, there is ample unused water within EID's Water Licence (typically between 300 and 500 million m^3/year). Thus, water is available for filling the reservoir and requirements for water extraction will continue to be met, as they have in past years. Should discharge be lower than average when scheduled to be filled, the EID will extend the filling period across multiple seasons or years to ensure diversion does not compromise water available for irrigators or the minimum IO in the river downstream from Bassano.

Reservoir expansion is not being designed as a flood protection measure; flood protection on the Bow River is one of the objectives for the existing Bassano Dam. The Project will be fully accommodated by existing water allocation under the EID's Water Licence. Additionally, the Project is not being developed to increase the irrigated land base, thus the amount of field runoff will not change. Consequently, while the Final Terms of Reference (FTOR) requires the proponent to address effects of increased water withdrawal at Bow River, increased water return flow to the Red Deer River, discharge, volume, and water quality of the Bow River, and effects on riparian lands, these are not applicable and will not be addressed. Thus, no change is expected on return flow volume, and the quality of return flow water will not be affected by the Project as the total area and volume of water irrigated will be the same in the areas receiving water from the expanded SLR. Quality of return flow volumes is also addressed with many years of measurements by the EID throughout the district's canals.

Since the Project will not have any new incoming sources of nutrients or organic carbon, a management plan for these parameters is unnecessary. Water chemistry and aquatic vegetation will remain unchanged. Therefore, the following FTOR requests are not applicable to this impact assessment and not discussed further:

- 3.3.2 2. b) Assess potential changes to channel regime for Bow River (during minimum, average, and peak flows);
- 3.3.2 2. c) Assess changes to water levels in water courses;
- 3.3.2 2. e) Assess potential changes to sediment transport and yield;
- 3.3.2 3. c) Assess the extent of hydrological changes including changes in runoff rates and volumes before, during, and after construction of the Project;
- 3.3.2 3. d) Assess changes in erosion and sedimentation in watercourses resulting from the Project;

- 3.3.2 5. Describe how water conservation objectives and instream objectives may be adversely affected with the development of the Project;
- 3.3.2 6. and 8. d) Describe the impacts on other surface water users (specific to the Bow River) and any potential water use conflicts;
- 3.3.2 8. a) and b) and 3.4.2 7 a) and b) Describe mitigation measures to address surface quantity and quality impacts during all stages of the Project, including alteration in flow regimes and potential flood events;
- 3.3.2 8. c) (in part) Describe mitigation measures to address surface quantity impacts (on Bow River) during all stages of the Project, including potential drought events;
- 3.3.2 10. Discuss the impact of low-flow conditions on water conservation objectives, instream objectives, and water and wastewater management strategies;
- 3.4.1 1. (in part) Describe baseline water quality of water courses including water quality for high-flow events (1 in 20-year and 1 in 100-year and 1 in 300-year) under current conditions.
- 3.4.2 2. b) vi) and x) (in part) Describe and predict the potential impacts of the Project on surface water quality on downstream bodies of water including changes in concentrations, loading amounts, and timing of key water quality parameters including routine parameters, including: vi) implications to the health and extent of riparian lands and x) impact on creek banks during flood events;
- 3.4.2 8. Discuss the impact of the return flow loadings to the receiving water body and water and wastewater management strategies; and
- 3.4.2 10. a) and b) Describe the potential and implications for organic carbon and nutrient management in the Project, based on the proposed operating regime, to impact treatment of water and downstream bodies of water for drinking water purposes (e.g., disinfection by-products) and to impact productivity of aquatic vegetation (e.g., macrophyte, algae).

Construction of the new reservoir requires 8 km of earthen berms and an estimated 7 million m^3 of material. Most of this material will be excavated within the Project footprint, in areas that will form the reservoir basin. The expanded reservoir will be steep walled, up to 18 m deep at the lowest elevation (east) side and will connect to the existing SLR via a notch to be removed from the extant East Dam (Appendix E1, Figure E1-1). Before connecting the reservoir basins, and filling the new dam area, most of the SLR will need to be drawn down. Water will then be allowed to fill the reservoir forming a single functioning basin.

This Environmental Impact Assessment (EIA) section includes a baseline assessment, which contains a comprehensive description of water quality and quantity, and impacts anticipated to both, for surface waterbodies in local and regional study areas as a result of the Project.

7.1.2 Purpose

What follows is a description of baseline state, Project effects, mitigation measures, residual impacts, and a monitoring plan for surface waterbodies. The baseline sets the standard of water in natural and man-made waterbodies before expansion from which Project-related changes were predicted or quantified. These results will be used to describe environmental effects on surface water based on a review of selected indicators. This section mentions wetlands as surface waterbodies but does not discuss their habitat or qualify specific effects of the expansion on wetland habitat. Instead, wetlands are discussed within the Vegetation and Wetland section (Volume 2, Section 10).

7.1.3 Project Setting

The Project occurs within the Dry Mixedgrass Natural Subregion of the Grassland Natural Region in the province of Alberta (GOA, 2006b). The Dry Mixedgrass, the largest subregion within the Grassland Region, is situated in the southeast portion of the province. Terrain is characteristically low relief and level to undulating such as rolling hills, reworked aeolian features (dunes), and glaciofluvial or fluvial deposits laid down in depressional (valley) areas. The climate of this subregion is warm and dry with a mean annual temperature of 4.2°C. In summer, the mean temperature is 18.5°C, and in winter the mean temperature is -10.2°C. Mean annual precipitation is 333 mm, the lowest of any natural subregion in Alberta (GOA, 2006b). Droughts occur every few years and are defined by a prolonged reduction in precipitation and/or sustained water deficits - when net evapotranspiration exceeds precipitation. Surface conditions in low lying areas are often extremely saline with salt crusts occurring in wetland and waterbody areas and hardpans (alkaline soils) in low lying areas.

Open waterbodies are common throughout the subregion. Most are small, temporarily or seasonally flooded wetlands. Permanently flooded waterbodies are rare historically; however, irrigation infrastructure and dugouts are now common. This portion of the EID area is dominated by the existing SLR and canals conveying water diverted from the Bow River toward agricultural lands to the southeast and northeast. A few notable large lakes and reservoirs occur in the region surrounding the Project, all of which are filled with water conveyed by the EID. These include:

- Kitsim Reservoir, Lake Newell, and San Francisco Lakes to the southeast;
- Crawling Valley Reservoir to the north;
- Rock Lake Reservoir to the northeast; and
- Cowoki and Tilley A and Tilly B reservoirs to the east.

Wetlands and dugouts support open water and riparian areas. They provide cover, breeding, rearing and foraging habitat, and migration corridors for aquatic species, wildlife, and upland plants. Permanent watercourses are rare in the Project area; the Bow and Red Deer rivers are most prominent, as well as several tributaries. Natural water flow in this region has been augmented for decades with irrigation canal flow.

7.1.4 Regulatory Context

Parameters were identified to establish surface water quantity and quality in accordance with the FTOR for the Project (Table 7-1). The FTOR has been guided by provincial and federal legislative requirements for the management and protection of water quality and aquatic ecosystems. Environmental Quality Guidelines "*are science-based recommendations that form a cornerstone of water quality and aquatic ecosystem management"* (GOA, 2018a).

Alberta legislation and guidelines include the *Water Act*, which regulates all activities that could affect waterbodies and aquatic resources in Alberta (GOA, 2000c). The *Act* uses approval tools such as Licences, Approvals, and Codes of Practice to ensure water quality, discharge and water volume are protected during and post-development. These policy tools guide projects including water crossings, disturbances to the bed and shore of waterbodies, water diversion, reservoir development, excavation of dugouts or other man-made water features, plus the protection of springs, aquifers, lakes, wetlands, watercourses, and swales (ephemeral draws).

Irrigation works and canals are governed by the *Irrigation Districts Act* (GOA, 2000a). Besides irrigation water, canals provide fish habitat, but only when flowing. Once water stops flowing each fall, canals cease to be aquatic habitat. Also, once irrigation works are approved under a Water Licence, new *Water Act* approvals are not required for activities on the same land(s).

Water quality is also protected under the *Water Act*. It ensures water currently suitable for aquatic life does not become unsuitable because of human activities (i.e., exceed acute or chronic toxicity of parameters or fails to meet the quality needed for protection of aquatic life). Water quality concentration limits for the protection of aquatic life, agricultural water uses, recreational use, and sediment quality are established by the Environmental Quality Guidelines for Alberta Surface Waters (GOA, 2018a) (Table 7-1). The Project is also guided by the South Saskatchewan Regional Plan (SSRP) and is in the Red Deer River Watershed (Red Deer Watershed Alliance, 2009). The SSRP provides strategies and best management practices to protect and manage water and waterbodies, minimizing disturbances and reducing sedimentation. The SSRP encourages the development of source water protection plans. It encourages riparian and wetland mapping and inventories to maintain recharge capabilities of headwater areas, supporting flood management, and supporting water quality, quantity, and aquatic ecosystems regionally.

Table 7-1: Regulations and guidelines for assessment of surface water quantity and quality in Alberta

Regulation or Guideline	Context
Alberta Water Act	Supports and promotes the conservation and management of water, through the use and allocation of water in Alberta. It requires the establishment of water management licences, approvals and codes and sets out requirements for the preparation of water management plans. Any impacts to waterbodies must first be approved under this *Act.*
Canadian Council of Ministers of the Environment (CCME); Water Quality Guidelines: Protection of Aquatic Life	Guidelines developed to protect all forms of aquatic life and all aspects of aquatic life cycles.
CCME; Water Quality Guidelines for the Protection of Agricultural Water Uses	Guidelines developed for agricultural applications relating to irrigation to protect sensitive species and life stages of agricultural crops.
CCME; Sediment Quality Guidelines for the Protection of Aquatic Life	Concentration guidelines intended to protect all forms of freshwater aquatic life during their aquatic life cycles for an indefinite period of exposure to substances associated with bed sediments.
Guidelines for Canadian Recreational Water Quality	Guidelines developed by Health Canada that consider the various factors that could interfere with the safety of recreational waters from a human health perspective. This document includes information on the physical, aesthetic, and chemical characteristics of recreational areas.
Canadian Navigable Waters Act	An *Act* created to address whether in-stream works are likely to substantially interfere with navigation. If these major works interfere with navigation, they require approval from Transport Canada (GOC, 1985). This is not applicable to irrigation reservoirs, and there is no in-stream work in the Bow or Red Deer rivers for the Project.
Environmental Quality Guidelines for Alberta Surface Waters	Guidelines for surface water quality (to protect aquatic life, agricultural, and recreational uses), sediment quality, and tissue residue (to protect wildlife consumers and fish from direct toxicity).
South Saskatchewan Regional Plan	Provincial policy for the preservation and management of water and waterbodies, including minimizing land disturbances, reducing sedimentation, and ensuing water quality meets the South Saskatchewan Region Surface Water Quality Management Framework (GOA, 2018b).
Public Lands Act	Provincial legislation addressing all permanent and naturally occurring Crown owned waterbodies (GOA, 2000b).

7.2 STUDY AREAS

Baseline state and potential Project effects were investigated at both a local (Project-specific) and a regional (cumulative effects) scale. Resources or indicators were identified within each study area. The study areas for waterbodies and their characteristics were defined as:

- Aquatic Local Study Area (ALSA; Appendix E1, Figure E1-1).
- Aquatic Regional Study Area (ARSA; Appendix E1, Figure E1-2).

The ALSA has been used in the assessment of Project effects on surface water resources. It includes the existing SLR, its inlet canal from EID's East Branch Canal, and the reservoir expansion area (i.e., all areas east of the East Branch Canal and SLR within Sections 29, 30, 31, and 32-21-16 W4M). This area includes all lands that will interact directly with Project construction and is where direct and indirect effects on water resources will occur.

The ARSA was selected to cover all land from the water source at Bassano Dam on the Bow River, to the Main Canal, then to the East Branch Canal, and into SLR. It includes all terrain where water will flow in canals downstream of the SLR to their confluence with the Red Deer River to the northeast. The ARSA was developed as a land base for the cumulative effects assessment and would address how Project effects may interact with past, present, and future activities. The ARSA included the Onetree Creek Watershed boundary that was an appropriate size to examine all waters that could flow from the source canal at the Bow River to the ultimate return of water to the Bow and Red Deer rivers. The Onetree Creek watershed boundary was modified to provide a larger area north of the footprint to account for other canals that interact with the Project and to include the source of water at Bassano Dam.

7.3 ISSUE SCOPING

Issue scoping for this discipline identified resources and indicators for the surface waterbodies discipline, potential effects between the Project activities and surface waterbodies, and determined the likelihood of them occurring (screening out effects that are likely to be negligible). These are tabulated below (Table 7-2 below):

- project activities that may alter or remove surface waterbodies;
- resources for surface waterbodies;
- potential issues, risks or concerns regarding Project impacts;
- indicators or measures used to assess potential impacts on surface waterbodies;
- screening on whether high effects are likely or are likely to be negligible; and
- the spatial scale that the potential issue is applicable for (local and/or regional).

This Project is not planned to be decommissioned (See Volume 1, Section 2). This is similar to the other reservoirs in the EID. In fact, the Bassano Dam was the first constructed as part of the EID infrastructure and has been in operation since 1914 (110 years). Consequently, potential effects from decommissioning of surface waterbodies required by the FTOR will not be addressed. Potential effects on surface waterbodies for drinking purposes are also not addressed since the reservoir is not a direct source of potable water.

Table 7-2: Issue scoping for surface water resources

<table>
<tr><th>Project Activities and Risks</th><th>Resources</th><th>Potential Issues</th><th>Indicators or Measures</th><th>Screening[1]</th><th>Applicability</th></tr>
<tr><td rowspan="8">• Removal of surface waterbodies in expansion area
• Altered water drainage patterns
• Increased seepage due to hydraulic head of reservoir water pressurizing aquifers
• Altered water quality during initial reservoir filling
• Creation of new reservoir boundaries (land footprint)
• Reservoir drawdown prior to new reservoir filling
• Reservoir drawdown during drought conditions</td><td rowspan="8">Natural and Man-made Waterbodies</td><td>• Changes to drainages and drainage patterns</td><td>• Drainage Pattern</td><td>• Effects likely – existing areas with seasonal flow will be permanently removed affecting where waters flow, while other new drainages may form surrounding the reservoir footprint</td><td>Local</td></tr>
<tr><td>• Increased water flow due to seepage</td><td>• Water flow in drainages and level in surface water bodies</td><td>• Effects likely – increased water storage capacity may increase subsurface water pressure, leading to greater seepage (recharge) into surrounding lands</td><td>Local and Regional</td></tr>
<tr><td>• Loss of wetlands and open waterbodies</td><td>• Surface area of waterbodies (ha)</td><td>• Effects likely – expansion of the new reservoir footprint will remove existing wetlands, ponds, dugouts and draws, and their associated aquatic habitats.</td><td>Local Only</td></tr>
<tr><td>• Increased reservoir area and volume</td><td>• Total water volume</td><td>• Effects likely – the new reservoir will cover a larger area</td><td>Local Only</td></tr>
<tr><td>• Altered reservoir drawdown cycle</td><td>• Reservoir drawdown cycle</td><td>• Effects likely – greater water volume in the expanded reservoir will attenuate drawdown of shallow littoral zone(s)</td><td>Local</td></tr>
<tr><td>• Reduced water quality during reservoir construction</td><td rowspan="3">• Water Quality
• Sediment Quality</td><td>• Effects likely – changes in water quality and quantity in site water features may be affected by erosion and sediment runoff</td><td>Local Only</td></tr>
<tr><td>• Reduced water quality during initial reservoir filling</td><td>• Effects likely – changes in water quality and quantity may be affected by intermixing with saline and mineral laden substrates (soils)</td><td>Local Only</td></tr>
<tr><td>• Reduced water quality during reservoir operations</td><td>• Effects possible – despite frequent turnover of water, some minerals and nutrients may be deposited into sediments and released annually if the new reservoir stratifies and mixes seasonally (e.g., nutrients)</td><td>Local Only</td></tr>
</table>

[1] Determine if the issue is unlikely to occur, or if relevant data is not sufficient for assessment.

Based on the screening, the following indicators were selected for the assessment of surface waterbodies:

- drainages and drainage patterns;
- water flow in surrounding drainages and wetlands with change in seepage;
- surface waterbodies area (ha);
- reservoir area (ha);
- reservoir volume (m^3);
- reservoir drawdown cycle;
- water quality (various metrics); and
- sediment quality (various metrics).

As required in the FTOR, effects of temporary roads on waterbodies have been qualified. Temporary waterbody crossings have been required throughout the initial planning stages for this development. These will be required to facilitate transport of supplies and movement of equipment prior to receiving *Water Act* approval. Until this occurs, all temporary crossings have been and will be subject to notification and standard mitigation measures under the Code of Practice for Watercourse Crossings.

7.4 BASELINE

This section describes the existing conditions before initiation of the Project or the conditions that would exist if the Project were not developed.

7.4.1 Baseline Methods

7.4.1.1 Waterbodies

All surface hydrological features in the Project area were identified, classified, and delineated, including wetlands, drainages, watercourses, and man-made waterbodies. Wetlands were classified per the Alberta Wetland Classification System (GOA, 2015). Watercourses, ephemeral drainages, and draws were classified based on the Alberta Public Lands Glossary of Terms and the Alberta Timber Harvest Planning Operating Ground Rules Framework (Bow River Basin Council, 2012; GOA, 2024a; GOA, 2023). Man-made waterbodies, including dugouts, reservoirs, ditches, and industrial/stormwater ponds, were classified based on aerial imagery. Any change in linear edges over the historical record were noted then confirmed by a wetland authenticator. For the ALSA and ARSA, wetlands and waterbodies were compiled from existing inventories, including the Alberta Merged Wetland Inventory (GOA, 2021) and hydrological mapping (e.g., Fisheries and Wildlife Information System and Base Features Mapping (GOA, 2024b; AltaLIS, 2024).

7.4.1.2 Bathymetry

Reservoir bathymetry was mapped along 7 transects: 6 equidistant across the short axis, and one along the longitudinal axis of the lake spanning the main basin’s length (Appendix E1, Figure E1-3). A boat mounted Hummingbird® side scan sonar transducer and receiver was used to measure depth every 100 m for the longitudinal transect and every 10 m along each of the 6 lateral transects. Depth was recorded continuously along each and individual soundings were georeferenced and saved in the unit's receiver. Data were downloaded from the receiver into an ArcGIS software compatible spreadsheet.

Reservoir bathymetry was mapped at 1 m depth intervals and plotted in 2 m isopleths. The 3 m depth contour was also determined, allowing pelagic (>3 m depth) and littoral (0-3 m depth) zones to be mapped and quantified. Both were also quantified during a typical fall drawdown (1.5 m in 2021 and 2022), and a drought year (8.3 m drawdown in 2023). Maps were used to compare changes in habitat availability between the existing and expanded reservoir basin.

7.4.1.3 Water and Sediment Quality

Water quality and sediment baseline samples were collected from the ALSA from 2021-2023. To determine seasonal variation in water chemistry, sampling events coincided with high, mid-season, and low water levels over the year. Water samples were collected from two locations within the reservoir: West SLR and East SLR (Appendix E3: Plate E3-1 and Plate E3-2; Appendix E1, Figure E1-3). Limnologists lowered a Van Dorn sampler to a depth between 0.5 and 1 m above the reservoir bottom to collect water samples.

Reservoir sediment and water was sampled in September 2023 when water level had receded 8+ m following a prolonged, dry summer. Sediment grab samples were obtained to quantify background levels of salts and metals in reservoir substrate. Additionally, two open waterbodies on the planned expansion footprint were sampled for water in the fall of 2023 to characterize non-reservoir conditions (Appendix E3: Plate E3-3 and Plate E3-4). Only two were sampled as all other waterbodies were dry. Bow River water quality data was obtained from the Alberta Irrigation District Water Data Tool (Alberta Irrigation Districts Association, 2024) (Appendix E2: Table E2-4). This water quality was used to compare with that diverted to the canal upstream from the reservoir (source water).

Water quality parameters were measured at 0.5 m depth intervals from surface to bottom of the reservoir at 2 vertical stations. A calibrated, YSI Professional Plus Quatro™ multiparameter meter on a cable was lowered to each depth to measure parameters. These included temperature, dissolved oxygen (DO), pH, and specific conductivity. Temperature and DO were measured from surface to the reservoir bottom by lowering the sensor probe at 1 m intervals. Once readings stabilized on the digital display, the data were recorded.

In spring and fall, Secchi depth was recorded at both water quality locations. Secchi depth is a measure of how transparent the water column is and indicative of the trophic state of a waterbody. It was recorded by lowering the disk into the water column, avoiding shadow cast by the boat. Transparency was recorded when the disk was just out of sight. Turbidity was also measured at the surface in the fall and winter field trips using a LaMotte 2020we Turbidity Meter (Table 7-3).

Collection and processing of samples was completed with single-use nitrile gloves, and laboratory-supplied sample bottles and preservatives. Samples were stored and kept cool with ice in a cooler to maintain a temperature below 10°C. Once collected samples were submitted to either ALS Environmental Laboratory or AGAT Laboratories, both in Calgary, Alberta. Hold times were as specified in the Canadian Council of Ministers of the Environment (CCME) guidance documents (GOC, 2011).

Table 7-3: Water chemistry sampling event dates at SLR, 2021-2023

Site ID	Waterbody ID	Date Sampled	Parameters Measured
Spring West SLR	SLR	9-Jun-21	In Situ, Lab parameters
Spring East SLR	SLR	9-Jun-21	In Situ, Lab parameters
Fall West SLR	SLR	5-Oct-21	In Situ, Lab parameters
Fall East SLR	SLR	5-Oct-21	In Situ, Lab parameters
Winter West SLR	SLR	19-Jan-22	In Situ, Lab parameters
Winter East SLR	SLR	19-Jan-22	In Situ, Lab parameters
Fall West SLR (sediment and water)	SLR	28-Sept-23	Lab parameters
Fall East SLR (sediment and water)	SLR	28-Sept-23	Lab parameters
Fall Dugout 1	Dugout #1	28-Sept-23	Lab parameters
Fall Dugout 3	Dugout #3	28-Sept-23	Lab parameters

One grab sample was taken per site and visit then analyzed for general chemistry, metals, nutrients, and hydrocarbons. Once analyzed, individual quality parameters were compared to appropriate water quality guidelines. The list of parameters analyzed included:

- Alkalinity, Total (as calcium carbonate [$CaCO_3$])
- pH (Calcium Chloride [$CaCl_2$] extraction)
- Conductivity, electrical (EC, saturated paste)
- Hardness (as $CaCO_3$)
- Total Dissolved Solids (calculated)
- Carbonate (CO_3)
- Chloride (Cl, soluble)
- Fluoride (F)
- Nitrogen species (Ammonia, Nitrate, Nitrite, Total Kjeldahl [TKN])
- Phosphorus (P, total)
- Sulfate (SO_4, soluble).
- Coliform bacteria
- Total and Dissolved Metals and Trace Elements
- Biological Oxygen Demand (BOD)
- Organochlorine Pesticides
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Polychlorinated Biphenyls (PCBs)

Sediment samples were collected in September 2023 from East SLR and West SLR. Sampling methods followed the Protocols Manual for Water Quality Sampling in Canada and Aquatic Ecosystems Field Sampling Protocols (GOC, 2011; GOA, 2006a). Sediment grab samples were submitted to AGAT Laboratories in Calgary, AB for analysis. Those collected in September 2023 were analyzed for:

- water saturation;
- resistivity;
- sodium;
- potassium;
- calcium;
- methylmercury;
- magnesium;
- sulfur (as sulfate); and
- chloride.

Once analyzed, water quality and sediment data were transcribed to an electronic spreadsheet to be compared with published standards. Sediment samples were compared to the Environmental Guidelines for Alberta Surface Waters for the Protection of Aquatic Life, Recreation Use, and Agricultural Water Use (GOA, 2018a).

7.4.2 Baseline Results

The SLR operates as a continuous input and release reservoir to serve agricultural demand. It fills to capacity in spring and releases more water through summer and fall months when demand exceeds supply. Water quality for the existing SLR was analyzed to identify background, seasonal, and spatial patterns.

7.4.2.1 Waterbodies in the Local and Regional Study Areas

Aquatic Local Study Area

The ALSA (Appendix E1, Figure E1-1) includes the SLR and its inlet canal from EID's East Branch Canal, the reservoir expansion area (i.e., areas within sections 29, 30, 31, and 32-21-16 W4M), and the outlet from the SLR expansion into the Snake Lake Canal (Table 7-4). These lands and irrigation infrastructures are fully owned and operated by the EID.

Table 7-4: Components of the Aquatic Local Study Area by area in hectares

Aquatic Local Study Area	Baseline Areas	Area (ha)	% of ALSA
Existing SLR Area	Reservoir (Water Surface)	298.8	22.8
	Canals and Ditches	27.8	2.1
	Other Waterbodies	12.8	1.0
	Vegetated Areas	86.0	6.6
	Disturbances	4.7	0.4
	Subtotal	*430.1*	*32.8*
Expansion Area	Canals and Ditches	12.4	1.0
	Other Waterbodies	66.2	5.1
	Vegetated Areas	788.1	60.2
	Disturbances	12.5	1.0
	Subtotal	*879.2*	*67.2*
Total	Reservoir (Water Surface)	298.8	22.8
	Canals and Ditches	40.3	3.1
	Other Waterbodies	78.9	6.0
	Vegetated Areas	874.1	66.8
	Disturbances	17.2	1.3
	Total	**1,309.2**	**100.0**

Aquatic Regional Study Area

The ARSA represents a mix of natural landscapes (i.e., regional water bodies and canals) and modified lands for agriculture, transportation, oil and gas, utilities, and other industrial and municipal land uses.

The watershed selected is the Hydrologic Unit Code (HUC) Level 8 watershed (GOA, 2024c) named the Onetree Creek Subbasin, a subset of the larger HUC 6 Matzhiwin Creek Basin (Red Deer Watershed Alliance, 2009). The HUC watersheds of Alberta define hydrologic units that are standardized throughout the province. Successively smaller hydrologic units are nested within larger ones to create hierarchal watershed boundaries based on flow direction determined through detailed surface elevation mapping. Because the Onetree Creek watershed did not include the source of reservoir water at Bassano Dam, and because the northern boundary was within 1 km of the ALSA, additional lands were added to the ARSA north of the Project from the Trans-Canada Highway to the western edge of the Matzhiwin watershed. The boundary then followed the natural contours of high land south to the Bow River.

The ARSA covers 22 townships in southeast Alberta surrounding the Town of Bassano and City of Brooks, and near Duchess and Patricia, to the east. Notable aquatic features within the study area include Bassano Dam on the Bow River in the northwest, San Francisco Lakes southeast of the existing SLR, most of the Rock Lake Reservoir (near Duchess), and numerous smaller reservoirs and canals. Natural, shallow, saline lakes and wetlands are also common throughout the ARSA, as are several ephemeral draws and intermittent watercourses fed by the canal system, local runoff, and some groundwater input. The ARSA covers 115,712.5 ha (Table 7-5).

Table 7-5: Components of the Aquatic Regional Study Area

Feature	Area (ha)	% of ARSA
Reservoir (Water Surface)	671.1	0.6
Canals and Ditches	928.4	0.8
Watercourses	78.1	0.1
Other Waterbodies	9,731.5	8.4
Vegetated Areas	95,148.0	82.2
Disturbances	9,155.5	7.9
Subtotal	**115,712.5**	**100.0**

7.4.2.2 Water Quantity

Aquatic Local Study Area

The EID proposes to expand the SLR to provide additional offsite water storage for irrigation users. This will occur over four sections of land, covering 827 ha (reservoir surface plus embankments), and increase the current 19.25 million m^3 storage by 68.15 million m^3 to a total of 87.4 million m^3. This includes the increase of 2.1 million m^3 due to increasing the FSL by 0.3 m to 782 m asl. All surface hydrological features on the Project site have been identified, classified, and mapped, including wetlands, watercourses, and anthropogenic water bodies (Table 7-6; Appendix E1, Figure E1-4). Additional detail on wetland and waterbody classification is presented in Volume 2, Section 10. Once constructed, the expanded SLR surface water area at FSL will increase from 299 ha to 1,069 ha.

Table 7-6: Water features in the Aquatic Local Study Area

Surface Water Type	Area (ha)	% of Water	% of ALSA
Reservoir	298.8	71.5	22.8
Canals	40.2	9.6	3.1
Ditches	<0.1	<0.1	<0.1
Dugouts	2.1	0.5	0.2
Marshes	51.4	12.3	3.9
Open Water	25.4	6.1	1.9

Surface Water Type	Area (ha)	% of Water	% of ALSA
Subtotal	*418.0*	*100.0*	*31.9*
Vegetated Areas	874.3	N/A	66.8
Disturbances	17.2		1.3
Total ALSA	**1,309.2**		**100.0**

7.4.2.3 SLR Bathymetry at FSL and During Drawdown

The SLR's deepest basin (>12 m depth) occurs near the northeast end. At FSL, shallow waters with a depth of 0 to 2 m occur in the northwest; this area is composed a former inlet to the coulee and an extensive flat area with several depressions that may have been borrow pits, dugouts, or wetlands, ranging in size from 0.02 ha to 3.8 ha; additionally, a chain of raised mounds occur from the western dam leading to the southeast. At high water levels, a raised peninsula and 3 to 4 islands are present; however, during drawdown, these features form a single connected peninsula. Water depths from the inner (south side) of the peninsula and from all other shores and dams increase quickly within a 100 m to 200 m distance from the shoreline to a depth of >8 m. During drawdown, an extensive area of mudflats develops with up to six shallow-to-deep ponds of various sizes. Deeper drawdown results in mudflats around the perimeter of the reservoir. Bathymetry at FSL in SLR is shown in Figure E1-5**.**

Maximum depth in SLR was 14.3 m at FSL during spring of 2021 (Table 7-7). This decreased to 12.8 m in the fall of 2021: a 1.5 m drawdown. Data collected from the water gauge at the SLR dam showed drawdown began in early August (Appendix E1, Figure E1-6). During the winter of 2022, water was released slowly from the reservoir to a depth of 2 m below FSL. Drawdown in 2023 started in July and resulted in drawdown of 8.3 m resulting in 6 m maximum depth (per field measurement) by late September. However, water level increased to near FSL as the reservoir was filled in October 2023, before diversion from the river was shuttered for the season.

Table 7-7: SLR water depth and volume in a typical year and drought year

Scenario	Surface Area (ha)	Littoral Zone (0-3 m; ha)	Pelagic Zone (>3 m; ha)	Maximum Depth (m)	Mean Depth (m)	Water Volume (million m^3)
Typical Year (FSL)	298.8	105.1	193.7	14.3	5.6	16.6
Typical Fall Drawdown (1.5 m)	297.1	105.1	192.0	12.8	4.1	12.0
Drought Year Drawdown (8.3 m)	97.0	85.2	11.8	6.0	1.5	1.7

*Water volumes were estimated based on surface area and mean depth and are considered an underestimate compared to actual volumes based on measured storage capacity.

Spring freshet for the Bow River at Bassano Dam is experienced typically between June 1 and July 15 (Appendix E1, Figure E1-7). Depth varies from 1.7 to 2.1 m at the canal inlet, and discharge from 150 to 300 m^3/s. Before freshet, and through most of the spring, fall, and winter, 1.2 to 1.5 m depths and discharge from 60 to 100 m^3/s is typical at the headworks of the canal. Water is diverted only when the minimum instream flow objective (400 ft^3/s; 11.3 m^3/s) for the Bow River downstream from Bassano Dam can be met (Figure E1-8).

In 2021, freshet occurred from June 1 through July 15 at higher than average depth (1.7 to 2.3 m) but finished lower than average at 1.0 to 1.4 m for the remainder of the summer and through fall. In 2022, freshet was delayed until June 12, followed by a rapid peak of >3 m depth at the headworks and remained near 2 m until early August. In 2023, a drought year, the freshet occurred earlier, from May 13 to June 5, with lower water levels (peaking at 1.8 m) and base flow remaining near 1 m from June 6 through summer and fall. Less than 30 m^3/s of flow occurred through August and September, rising again in September to >50 m^3/s. Regardless, minimum instream flow was maintained in the Bow River all year.

Existing waterbodies and wetlands in the planned reservoir expansion area also store water, which varies with time of year and amount of precipitation received. A simple estimate of water storage in this area was determined based on the area of wetlands/waterbodies and their depths (m) for various classes in the expansion area. For this assessment, wetlands were classified further based on information in Volume 2, Section 10 (Vegetation and Wetlands) into classes with average depths. This allowed the depth multiplied by the area to be summed for each feature. The volume of water was calculated for 3 periods:

- Full (spring) - full wetlands following snowmelt and/or rainstorms;
- Low Depth (late summer) - when most shallow wetlands have dried; and
- Winter, when only dugouts and a small base flow in canals remains (Table 7-8).

Table 7-8: Estimated volume of surface waterbodies ranging from flooded (typical spring) to drawn down (typical winter) conditions in the ALSA

Feature Type	Estimated Water Volume (m^3) Under Variable Conditions		
	Full Depth[1]	Low Depth[2]	Winter[3]
Marshes	496,000	35,000	0
Open Water	254,000	0	0
Dugouts	62,000	35,000	35,000
Canals	1,300,000	1,300,000	26,000
Ditches	42,000	42,000	0
Total	**2,154,000**	**1,412,000**	**61,000**

1. Typical spring conditions after large rainfall event.
2. Typical mid-summer to fall conditions when temporary wetlands have dried, and seasonal wetlands are drawn down.
3. Typical winter conditions when wetlands and ditches are dry, canals are drained, and deeper waterbodies are drawn down.

These features were estimated to hold (at maximum), up to 2.1 million m^3 of water. However, in mid to late summer when most of these features are dry, water will only be present in dugouts, canals and a few of the deeper wetlands. At these times the estimated volume of water is 1.41 million m^3. In winter it is assumed canal depths are reduced to 20 cm and sustained by base flow. Only dugouts continue to retain water. During this time, water volume within the expansion area is reduced to 0.061 million m^3. At maximum, the volume of water within these features represents 13% of that stored in the reservoir.

Aquatic Regional Study Area

All surface hydrological features on the Project site were identified, classified and mapped. These include wetlands, watercourses, and man-made waterbodies. Marshes and open water dominate the local study area (Table 7-9 and Appendix E1, Figure E1-9).

Table 7-9: Water features present in the Aquatic Regional Study Area

Baseline Areas	Area (ha)	% of Water	% of ARSA
Reservoir	671.1	5.9	0.6
Canals	810.1	7.1	0.7
Ditches	118.3	1.0	0.1
Dugouts	290.3	2.5	0.3
Marshes	5,378.6	47.1	4.6
Open Water	4,062.6	35.6	3.5
Watercourse	78.1	0.7	0.1
Subtotal	*11,409.1*	*100*	*9.9*
Vegetated Areas	95,148.1	N/A	82.2
Disturbances	9,155.5		7.9
Total ALSA	**115,712.5**		**100.0**

7.4.2.4 Water Quality

Water quality is defined through the measurement of physical, chemical, and biological parameters. Routine parameters measured to describe water quality include temperature, dissolved oxygen (DO), pH, conductivity, salinity, and total suspended solids (TSS), or turbidity. Metals and trace elements are also measured as total or dissolved concentrations. Note that "total" concentrations are derived from unfiltered water samples and will be influenced by suspended particles when preserved in the field.

SLR Laboratory Sampling Results

Comparison between SLR water chemistry data and Environmental Quality Guidelines for Alberta Surface Waters (Agricultural, Irrigation and Livestock) Water Use (Appendix E2: Table E2-2) yielded water quality parameters that fall within the current guidelines (GOA, 2018a), with the exception of the parameters listed below. Comparison between SLR water chemistry data and CCME Aquatic Life Guidelines and the Environmental Quality Guidelines for Alberta Surface Waters for the PAL (Appendix E2: Table E2-2) found that most water quality parameters fall within the guidelines noted (GOA, 2018a; Canadian Council of Ministers of the Environment, 2007). Comparisons were also made to Environmental Quality Guidelines for Alberta Surface Waters for recreational use.

The following exceedances for protection of aquatic life were identified, for either the Environmental Quality Guidelines for Alberta Surface Waters (GOA, 2018a) or the CCME Aquatic Life Guideline (Canadian Council of Ministers of the Environment, 2007):

- pH: *in-situ* (winter 2022);
- fluoride (spring 2021, winter 2022, fall 2023 in dugouts), and

- total mercury (winter 2022 and fall 2023).

Temperature is a primary physical quality of water as it affects the rate of chemical reactions, decomposition, and growth, and strongly influences DO concentrations. Most Alberta lakes range from 0°C to 26°C throughout the year (Mitchell & Prepas, 1990). Because cold water is denser than warm water, in summer, a warm upper layer tends to occur over a colder lower layer separated by a thin layer that changes abruptly (thermocline); this is stratification. In winter, ice that is less dense than water forms on the surface, protecting the water from extreme cold, but also reduces oxygenation through air contact. Below 4°C, water becomes less dense, which can result in reverse stratification at lake bottom. Maximum ice thickness in mid-winter typically ranges from 0.4 to 1.0+ m and, in Alberta, ice cover lasts from 4 to 6 months but varies with the region.

All aquatic organisms in a waterbody use DO to survive. Concentration of DO is a function of water temperature, oxygen content of incoming water, input of oxygen at the water/air interface, and presence of algae and aquatic plants, which respire oxygen during photosynthesis. As photosynthesis only occurs during daylight, DO tends to cycle daily, especially near the surface of waterbodies where most phytoplankton occur (the euphotic zone). The ability of a waterbody to support fishes depends on relatively high DO concentration (8-10 mg/L).

Decomposition of plant and animal matter (respiration) removes DO from water that overlies substrate creating biological oxygen demand (BOD). Respiration is greatest at warmer temperature and accelerates as oxygen concentration drops. Typically, DO varies between 0 (anoxic) and 10-15 mg/L (saturated) in lakes with higher concentration near the surface and less to none at the bottom because of respiration (Mitchell & Prepas, 1990).

The SLR does not stratify in summer; its temperature is near uniform regardless of depth. Dissolved oxygen showed a similar pattern with depth during all sampling events. This may have occurred because sampling took place after spring and fall turnover (Mitchell & Prepas, 1990). Regardless, given the reservoir is up to 15 m deep and its fetch (length of exposed water) is oriented parallel to the prevailing wind, it is likely that the reservoir turns over frequently. Its narrow width and long axis aligned with the prevailing wind encourages the lake to mix through wind and wave action. Additionally, the residency time of water is short, so the reservoir lacks time to stratify. Most likely, lack of thermal stratification is a function of both short residency time and fetch of the main basin (Mitchell & Prepas, 1990).

Typically, water contains minute amounts of salts. When dissolved in water, salts separate into positively charged cations and negatively charged anions. Common cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}), while common anions include bicarbonate (HCO_3^{-}), carbonate (CO_3^{2-}), sulphate ($S0_4^{2-}$) and chloride (Cl^{-}). Major ions present in water are vital to the health of plants and animals. Specific conductivity measures the ability of an electric current to flow in water, which increases with ionization; “specific” means it is standardized to 25°C as temperature also affects ionization, and therefore the ability to conduct an electrical current. Water can range from fresh (conductivity less than 500 µS/cm) to highly saline (>32,000 µS/cm). Reservoir water derived from Alberta mountain rivers tends to have low electrical conductivity, while groundwater measured at spring outlets or low-lying wetlands tend to have high electrical conductivity. Salinity affects the types of plants that can grow in a waterbody. When saline lakes and wetlands dry, a white crust (evaporated salts) can form along the water's edge.

Whether water is acidic or basic is defined by its pH. The term pH refers to the concentration of hydrogen ions (H^+) on a negative logarithmic scale extending from 1 (highly acidic) to 14 (highly basic). Basic solutions have a high concentration of hydroxide ions (OH^-). A decrease of one unit in pH corresponds to a 10-fold increase in the concentration of hydrogen ions (or a 10-fold decrease of hydroxide ions). When the pH is <7 the solution is considered acidic, at pH 7 it is neutral, and above this it is considered basic.

While rainwater is slightly acidic (pH 5.5 to 6.5), in most Alberta lakes the pH is between 7 and 10 and is basic. This results from water that has dissolved alkaline hydroxides that can neutralize hydrogen ions. High (>9.0) or low (<4.5) pH is detrimental to many organisms. When a basic solution contains dissolved hydroxides of alkali or alkaline earth elements, such as potassium (KOH), sodium (NaOH), calcium [$Ca(OH)_2$], or magnesium [$Mg(OH)_2$], the solution is termed alkaline. These differ from saline solutions as the negative ion is a non-basic ion such as chloride (Cl^-) or carbonate (CO_3^{2-}), instead of hydroxide (OH^-), and does not directly affect pH.

SLR *In-Situ* Sampling Results

While pH did not exceed 9 in laboratory water samples, *in-situ* samples were at or above 9 in the fall and winter seasons in at least 1 of the 2 sample locations within SLR (Appendix E1, Figure E1-10). The guidelines for aquatic health suggest a pH between 6.5 and 9 (GOA, 1987). Field and laboratory pH measurements often vary because of instrument sensitivity and accuracy. Even though water in SLR is slightly more basic than suggested for optimal aquatic resource health, the reservoir supports aquatic life. Alkalinity is an indicator of acid-neutralizing capacity and concentrations of this parameter indicate that water in the reservoir is well-buffered.

The water column did not stratify during spring, fall, and winter 2021-2022 sampling events. Water temperature was almost identical across vertical stations and depth intervals during all 3 sample periods. Dissolved oxygen concentration declined in spring with reduced DO in the lower 2 m of the deepest basin (Appendix E1, Figure E1-10). Recorded DO varied between 3 and 14 mg/L across depths during spring and summer field visits; while data from winter 2022 showed values between 14 and 16 in one sample (West) and between 21 and 23 mg/L in the other sample (East), these data are clearly erroneous and are likely attributed to a faulty sensor. DO should not typically exceed concentration over 13 mg/L in cold water, however, if water is supersaturated, due to high winds, as experienced in SLR, values up to 14 are plausible (Canadian Council of Ministers of the Environment, 1999) . These concentrations are suitable to support aquatic life in the reservoir year-round (Barton & Taylor, 1996).

DO remained high in all *in-situ* samples. It decreased slightly from the surface (9 to 11 mg/L) to lake bottom (3 to 5 mg/L) in spring but was similar across all depths in fall and winter when concentration varied from 7 to 13 mg/L. Conductivity changed little over the year (slightly above 500 µS/cm in spring, summer and fall) and below 500 µS/cm in winter. Water chemistry was related to the input of low conductivity river and rainwater in summer and fall with little time for mineral contact and reaction.

Phosphorus and nitrogen are the two principal nutrients for plant growth as well as potassium, carbon, sulphate, and micronutrients (chemicals needed in much smaller amounts) (Mitchell &

Prepas, 1990). A small amount of phosphorus is continuously being transferred into lakes through precipitation and runoff, but most phosphorus is recycled from the bottom sediments. In summer, a small amount will dissolve near the lake bottom. Once this mixes into the euphotic zone (upper 3 m of the water column), it will lead to rapid growth of algae, especially under warmer conditions. More phosphorus is mobilized in warm shallow lakes than deep stratified lakes. Both phosphorus and nitrogen influence water chemistry and can be loaded externally to waterbodies dissolved in runoff. Nitrogen is also an essential nutrient for primary producers. Nitrogen is usually present in much higher concentrations than phosphorus and exceeds the needs of aquatic plants. Nitrogen is expressed as a concentration (mg/L) and as the ratio of inorganic carbon to total nitrogen (C:N Ratio). Nitrogen needs to be in ionic form for uptake by plants and animals, including nitrite (NO_2^-), nitrate (NO_3^-) or ammonium (NH_4^+).

Inorganic nitrogen concentration in SLR was below detection limit, and TKN values were generally low (average of 0.89 mg/L). Phosphorus concentration was also low with a mean of 0.011 mg/L. Most anions and nutrients analyzed exhibited concentrations below respective method detection limits except for total mercury and fluoride. Fluoride in the reservoir was 0.160 mg/L in the spring of 2021, 0.157 mg/L in the winter of 2022 and 0.12 mg/L in fall 2023. Floride in dugouts downstream of the reservoir was recorded as 0.29 mg/L in the fall of 2023.

Water quality parameters measured from SLR samples were compared to surface water quality guidelines for the protection of aquatic life, for agricultural (irrigation and livestock) use and for recreational use; in addition, CCME Guidelines for Protection of Aquatic Life were also compared. Many metals and trace elements are present in surface water, and concentrations will vary depending on season. Metals and trace elements may originate from both natural and anthropogenic sources (i.e., atmospheric deposition, overland runoff, and groundwater discharge). In SLR, total metals and trace elements were generally below surface water quality guidelines, apart from total mercury. Mercury exceeded the guideline for the PAL of 0.026 µg/L in the winter of 2022 and during the fall of 2023 with concentrations of 0.36 µg/L and 0.34 µg/L, after readings of 0.00033 µg/L and 0.00024 µg/L in the first two samples (Appendix E2, Table E2-2). It is unknown why mercury was approximately 1,000 times higher in the latter two samples compared to the first two samples as similar increases were not observed in other metals; additional monitoring is recommended to examine this and see if elevated mercury concentration remain.

Total suspended solids (TSS) concentrations are generally highest in the spring and summer caused by short term precipitation events and resultant effect on surface erosion and deposition. This effect is diminished significantly during winter. The dissolved concentrations for metals and trace elements in the reservoir were generally low indicating most are present in particulate form (i.e., suspended, not dissolved), and are not available to aquatic life.

Hydrocarbons were all below respective method detection limits including the F1-F4 fractions, BTEX (a group of the chemical compounds: Benzene, Toluene, Ethylbenzene, and Xylenes), PAHs (polycyclic aromatic hydrocarbons), and PCBs (polychlorinated biphenyls).

Comparison to Alberta Irrigation Districts Water Quality Data Tool

Comparison between SLR water chemistry data and Environmental Quality Guidelines for Alberta Surface Waters for Agricultural and Recreational Use (GOA, 2018a) showed water quality parameters are within guidelines. This was expected since the source of water is the Bow River and the water travels approximately 20 km to the reservoir through large canals. Additional data on water quality upstream and downstream of the reservoir were obtained through the Alberta Irrigation Districts Water Quality Data Tool (Alberta Irrigation Districts Association, 2024). The data was analysed and shows there are a few exceedances vs. guideline levels (Appendix E2: Table E2-4 to Table E2-7, Appendix E1: Figure 1-13). These data, spanning years 2006 through 2024 included between 2 and 8 measurements per year per location examined, and have been analysed by determining the maximum concentration of each assessed parameter by year. This allowed a conservative examination of how water quality changed over time and space. The four monitoring sites examined were:

- E-P1: This site is below Bassano Dam on Main Canal at Little Dam Reservoir. This is essentially raw Bow River Water, having travelled only 5 km in a large canal (Appendix E2: Table E2-4);
- E-S2: This site is on Spring Hill Canal at confluence with Snake Lake Canal. This measures water after it has passed through SLR, representing quality of water available for irrigation use downstream (Appendix E2: Table E2-5);
- E-R2: this site is on the terminus of the canal system before draining excess water into Red Deer River; this site has occurred only within canals and therefore does not pick up substantial return runoff from fields, nor effects of bank erosion (Appendix E2: Table E2-6);
- E-R2A: This site is on a second return flow site to Red Deer River, in this case, it occurs within a natural watercourse (Matzhiwin Creek), which will have picked up any field runoff, and would experience natural sedimentation as banks erode (Appendix E2: Table E2-7).

Note that some guidelines use a narrative approach or determining if a concertation has been exceeded. In absence of starting values for these comparisons, estimated narrative values were estimated by comparison to the median of the maximum values among years to identify possible exceedances for the following parameters:

- Temperature: estimated as the median plus 5°C;
- TSS: estimated as the median plus 25 mg/L or plus 10% if the median was >250 mg/L;
- Total Nitrogen: Median multiplied by 2 in mg/L; and
- Total Phosphorus: Median multiplied by 2 in mg/L.

The assessment of exceedances for the above parameters identifies potential exceedances only. Note that the same parameters were not measured in each year, such that some parameters are based on 16 years of measurement while others are only from a subset of those years.

This summarized information shows that the incoming Bow River water (Site E-P1) had exceedances of TSS and phosphorus (3 of 16 years), E-coli (6 of 16 years), cadmium and cobalt (1 of 8 years), and zinc (5 of 8 years). Finally, the only other value that exceeded guideline value in the incoming water was Dicamba, a broadleaf herbicide (4 of 16 years). Note that these do not identify the surface water quality through the year, only that occasionally exceedances occur in the incoming water.

The water below SLR at E-S2, had assessed exceedances of TSS and total phosphorus (3 of 16 years), E-Coli in (2 of 16 years), thallium (1 of 8 years), Chlorpyrifos (an insecticide; 1 of 16 years) and Mirex (an insecticide; 1 of 14 years). Additionally, methyl chlorophenoxy propionic acid (MCPA; a broadleaf herbicide) also exceeded guidelines (3 of 15 years).

At the first return flow Site E-R2, there were exceedances for water temperature (1 of 16 years), TSS (1 of 16 years), sulphate (4 of 16 years), TDS (1 of 16 years), total phosphorus (1 of 16 years), E-Coli (15 of 16 years), manganese (1 of 8 years), Dicamba (14 of 16 years), MCPA (1 of 16 years), cis-Permethrin, a livestock pesticide for lice (1 of 16 years), and Simazine, a grass herbicide (1 of 16 years).

At the second return site (ER2A), near the terminus of Matzhiwin Creek, there were exceedances for TSS (5 of 14 years), sulphate (14 of 14 years), phosphorus (1 of 14 years), E-Coli (14 of 14 years), cadmium (2 of 6 years), Dicamba (9 of 14 years), and MCPA (6 of 14 years).

These data indicate the following general trends:

- exceedances have occurred among all sites at baseline, even in incoming water from the Bow River;
- a few common pesticides and herbicides are identified, with more occurrences and exceedances further downstream; and
- TSS and sulphate are more common near the return flow sites.

Thus, water quality is not likely to be affected by additional stored water in the expanded reservoir. The parameters that exceed guideline values in return water will also be highly diluted when water mixes into the Red Deer River, such that effects on the river downstream of SLR are not likely. As water is already exceeding guidelines at baseline, it is unlikely that stored water from a larger reservoir will result in any new exceedances. However, as we cannot quantitatively predict future exceedances, monitoring of water at the four sites will need to continue post construction.

7.4.2.5 Sediment Quality

Water quality is associated closely with sediment quality in waterbodies. Comparisons between concentrations of constituents in the sediment, including parameters such as nutrients and metals, can provide insight into water quality changes over time. Substrate in SLR is composed mostly of organic detritus and fine soil minerals. Sediments are made up of organic material produced in the lake, supplemented with suspended minerals present in the incoming water. Silicon skeletons of diatoms and broken shells of invertebrates are often present. Over time, there tends to be a greater accumulation of bottom sediments in deep water sections compared to shallow nearshore areas.

Local sites susceptible to erosion and sedimentation are the upper areas of the extant reservoir and the north side of the extant reservoir. Sediment deposition in the reservoir has been limited to date. The reservoir is over 25 years old, and the bottom sediments were observed by field crews to be a thin layer. This will not change once the expanded basin is filled, since most sediment is captured at Bassano Dam before water is diverted to the canal. Fines suspended during freshet will settle out in the canal over 20 km with small amounts deposited in the reservoir when turbidity is high. Erosion is not anticipated from the rock walls of the reservoir given their composition. Sediment has historically been low because bathymetry is unchanged and because reservoir surface only has a small layer of sediment after over 25 years of operation.

A common challenge associated with reservoir development is the metabolism of mercury at the soil and water interface, and its potential accumulation through the food web during the years immediately post-inundation. Mercury is a naturally occurring element present in water, mostly bound to suspended particles or sediments (Ullrich, Tanton, & Abdrashitova, 2001). It occurs in various chemical forms, primarily as mercury sulfide (HgS; Cinnabar), but also as mercury oxide (MgO), mercury chloride ($HgCl_2$), or as elemental mercury (Hg). Mercury occurs naturally in low concentrations in rocks, soils, water, organic materials, and in atmospheric particulate matter. It is released to the environment by volcanoes, forest fires, or burning of fossil fuels – particularly coal. In aquatic environments, mercury is released through the breakdown of minerals in rocks and soils, by deposition of particulate matter and by transport of silt and dust into low-lying water bodies associated with runoff. Most forms of mercury have relatively low toxicity, except when present in high concentrations. In saturated areas, such as in wetlands, lakes, or reservoirs, the inorganic form of mercury can be reduced to an organic form, known as methylmercury (CH_3Hg^+).

Newly impounded reservoirs are especially susceptible to mercury methylation since inundated organic matter and fluctuating to low DO concentrations at depth can drive sediment uptake of mercury, or conversely, its metabolism (Ullrich, Tanton, & Abdrashitova, 2001). Newly impounded reservoirs often lead to elevated concentration of mercury in fish tissue 2 to 5 years following inundation (Feng, Hiltz, & Wharmby, 2011). This phenomenon results from the methylation of mercury when DO concentration declines at the sediment/water interface once the original land is flooded. Elevated methylmercury in biota is generally followed by a slow decline back to background concentration. This metabolism can take up to 30 years based on the reaction half-life and associated water temperatures (Bodaly, et al., 2007; Feng, Hiltz, & Wharmby, 2011). Further details can be found in the Aquatic Resources section of the EIA (Volume 2, Section 8).

The FTOR requires discussion of other metals that may be susceptible to methylation and could become water quality issues if they can enter the aquatic food chain. Other elements of interest include lead, arsenic, cadmium, and selenium. These were not selected as applicable to the Project since they do not occur above guidelines for PAL or for use in agriculture. Additional, mercury methylation is the main concern for reservoirs in Alberta while the other potentially methylated elements are more specific to mining projects where ore, mine tailings, or overburden associated with mining tend to release these elements (e.g., selenium release is related to coal mining in Alberta).

Comparison between sediment data and Environmental Quality Guidelines for Alberta Surface Waters (GOA, 2018a) (Table 7-10) indicate most sediment quality parameters fall within guidelines except the following:

- Under the sediment quality guidelines for the PAL, arsenic levels exceed the “Interim Sediment Quality Guideline” but are still below the “Probable Effects Level”.
- Conductivity falls within the “Possibly Safe” range for the Guideline for the Protection of Agricultural Water Uses.
- Nickel exceeds the “Lowest Effects Level” guideline for the PAL.

Table 7-10: Sediment chemistry from the existing SLR (2023) compared to sediment quality guidelines

Parameter	Units	Detection Limit	Environmental Quality Guidelines for Alberta Surface Water			West SLR Fall 2023	East SLR Fall 2023
			Interim Sediment Quality Guideline	Probable Effects Level[1]	Other (see footnotes)		
pH ($CaCl_2$ Extraction)	pH Units	N/A				7.32	7.20
Conductivity (EC; Saturated paste)	dS/m	0.05			≤ 1[2]	1.20	1.21
Sodium Adsorption Ratio	N/A	N/A			≤ 5[2]	0.98	1.09
Saturation Percentage	%	1				90	73
Sodium (soluble)	mg/L	6				58	61
Calcium (soluble)	mg/L	1				173	160
Magnesium (soluble)	mg/L	1				56	48
Potassium (soluble)	mg/L	2				28	25
Chloride (soluble)	mg/L	5				137	181
Sulfur (as sulfate – soluble)	mg/L	2				445	610
Theoretical Gypsum Requirement	tonnes/ha	0.01				<0.01	<0.01
Chloride (soluble)	meq/L	0.14				3.86	5.11
Magnesium (soluble)	mg/kg	1				50	35
Magnesium (soluble)	meq/L	0.08				4.61	3.95
Resistivity in sat. paste	ohm*cm					833	826
Sulfur (soluble)	mg/kg	2				401	445
Potassium (soluble)	mg/kg	2				25	18
Calcium (soluble)	meq/L	0.05				8.63	7.98
Sulfur (soluble)	meq/L	0.04				9.27	12.7
Potassium (soluble)	meq/L	0.05				0.72	0.64
Sodium (soluble)	meq/L	0.09				2.52	2.65
Calcium (soluble)	mg/kg	1				156	117
Sodium (soluble)	mg/kg	2				52	45
Chloride (soluble)	mg/kg	2				123	132
Antimony (Sb)-Total	mg/kg	0.5				<0.5	<0.5
Arsenic (As)	µg/kg	1000	5900	17,000		7,000	9,000
Barium (Ba)	mg/kg	0.5				273	306
Beryllium (Be)	mg/kg	0.5				0.7	0.7
Cadmium (Cd)	mg/kg	0.5				<0.5	<0.5
Chromium (Cr)	µg/kg	500	37,300	90,000		21,600	24,400
Cobalt (Co)	mg/kg	0.5				11.5	11.0
Copper (Cu)	µg/kg	500	35700	197000		27800	24800
Lead (Pb)	mg/kg	0.5	35	91.3		14.5	13.5
Methylmercury	ng/g	0.4				<0.4	<0.4
Molybdenum (Mo)	mg/kg	0.5				<0.5	0.7
Nickel (Ni)	mg/kg	0.5			16[3]	28.5	26.4
Selenium (Se)	µg/kg	500	2000			1400	900
Silver (Ag)	mg/kg	0.5				<0.5	<0.5
Thallium (Tl)	mg/kg	0.5				<0.5	<0.5
Tin (Sn)	mg/kg	0.5				0.7	0.7
Uranium (U)	mg/kg	1				1	1
Vanadium (V)	mg/kg	103				35.2	44.7
Zinc (Zn)	mg/kg	1	123	315		103	97

1. Probable Effects Level: Defines the level above which adverse effects are expected to occur frequently.
2. Guideline for the Protection of Agricultural Water Uses. Conductivity: ≤ 1 Safe; > 1.0 to < 2.0 Possibly Safe, ≥ 10 Hazardous. Sodium Adsorption Ratio: ≤ 5 Safe; > 5 to < 10 Possibly Safe, ≥ 10 Hazardous.
3. Lowest Effects Level; indicates a level of contamination that can be tolerated by most sediment-dwelling organisms.

Note: Red shading indicate value exceeds guideline.

7.5 IMPACT ASSESSMENT

Refer to the Project Description (Volume 1) for water management and use analysis as it pertains to surface water in the ALSA and ARSA. The approach taken to address the consequences of the expansion on surface water is based on data collected in the field to define its quality for aquatic fauna and agricultural use in anticipation of quadrupling the volume and area of off-stream storage that will result from the reservoir expansion.

7.5.1 Assessment Methods

For a full description of the Environmental Impact Assessment Approach including the assessment methods and EIA criteria see Volume 2, Section 2. Anticipated effects on surface waterbodies were assessed through measured changes to baseline waterbodies, increased area of the new reservoir, updated areas of littoral and pelagic habitats, and predicted bathymetry of the new reservoir area. Effects on water quality were qualified based on professional knowledge and an understanding of how reservoir water quality is likely to change during filling and operation. As water quality was not predicted for the Project case, post-construction and monitoring during operation will be needed to confirm water quality predictions. Mitigation measures will help to offset any adverse effects associated with the construction, filling and operation stages.

7.5.2 Measures to Mitigate Adverse Effects

There are few risks to water quality associated with the Project. Alteration of flow regimen is not anticipated given operation is canal fed and will be consistent year-to-year and no different than it has been in the past. In the event of a flood, more water could be diverted opportunistically to meet operational demand (filling of the reservoir). In the event of a prolonged drought in the EID, reservoirs would be drawn down to meet irrigation demand. If the minimum IO in the Bow River is at risk, then no water can be diverted into SLR and it will be drawn down as required. By storing extra water in periods of high flow, water can continue to be used to meet irrigation needs during periods of low flow, as water is then drawn out of the reservoirs. Currently, in periods of low flow, irrigators need to restrict watering and may need to cut crops early for feed or accept lower yields during harvest. Water use conflicts are not anticipated as the point of building the expansion is to mitigate conflicts for water. The South Saskatchewan Water Quality Management Plan will be respected and aquatic resources in the rivers downstream will not be compromised by diversion driven by the EID operations; the status quo will persist. If warmer and dryer irrigation seasons are the “new normal”, then runoff from irrigated agriculture could increase in salinity (and other components such as nutrients) from within the EID lands. However, with more sophisticated modern irrigation systems and operators within the EID embracing the technology, the goal is to reduce run off. These may include use of precision irrigation “smart heads” that incorporate global positioning technology and humidity sensors to maximize irrigation efficiency and minimize waste and runoff. Consequently, little if any change is anticipated in water chemistry in return water to the Bow and Red Deer rivers given newer precision and timed irrigation systems. In addition, the analysed water data from sites within the EID does show an increase in salinity (e.g., sodium ion concentration), but not to the level that exceedances occur; as the flow of return water with elevated salinity in the EID is already occurring at baseline, it is unlikely that this will change with the Project. However, the continuing measurement of the existing monitoring sites will allow this to be analysed for trends over time to see if this does occur.

With construction best management practices followed, surface water will not be adversely affected. Nevertheless, risk to surface water quality will arise when the dam is breached to begin infilling the new basin. The EID intends to employ several standard mitigation measures to ensure the period of breaching of the east dam and infilling of the new basin is controlled and does not trigger sedimentation downstream. The following are a few:

- The proponent will notch the dam in a way that will allow for gradual draining of the SLR to minimize scour downstream as the basin fills. This is needed to prevent the clay surface from eroding during infilling of the new basin, and to reduce the increase in turbidity that would occur.
- The SLR will be isolated from active workspace whenever construction requires excavation or placement of material within the wetted perimeter of the reservoir. Placement of a silt curtain weighted with a chain will help contain sediment mobilized within the workspace, especially during breaching of the east dam and removal then replacement of rock armour on its face.
- Equipment breaching the dam or within the reservoir basin will operate with vegetable based hydraulic fluid to prevent deleterious effects if a spill occurs.
- Equipment is not to be refuelled within 100 m of the reservoir.
- All motorized equipment must be placed in a spill tray or have ready access to a spill kit. All spills need to be reported to Alberta Environment and Protected Areas (Alberta EPA), then cleaned. With any contaminated soil removed and disposed at an appropriate facility.
- Continued management will address water use and operation conflicts; these include management of water extraction at Bassano Dam so that the downstream discharge is maintained at a high enough level to meet the IO, apportionment requirements, and any further needs agreed to by EID when the provincial drought plan is in effect; and
- Mitigation to reduce effects on water quality parameters of concern include isolating working areas within the reservoir during any instream work, monitoring downstream flow during the initial filling to ensure water meets guideline levels for turbidity, and stopping releases if these are too high should be adhered to.

7.5.3 Assessment Results

This section describes the predicted effects of SLR expansion for the Application case, which includes the Project including mitigation plus the baseline and compares it to the Baseline Case (baseline only). These are described in the sections that follow and summarized in Table 7-14.

7.5.3.1 Potential Hydrological Changes

Influence of Construction on Surface Water

The EID intends to operate the extant SLR in the same manner it always has. Water will continue to flow through the SLR and into Snake Lake Canal throughout the construction process. The new low level east outlet to the canal will be constructed first, so that this canal outflow can be maintained throughout the construction process. Measures will be employed to manage dust as to minimize increased sediment loads resulting from traffic and excavation. Runoff during construction will be managed through natural drainage or be pumped off through vegetated areas away from the canal to the north and east.

Once constructed, the expanded reservoir will fill passively from the extant basin until water level equilibrates.

Surface Water Changes

The expanded basin will inundate 763.6 ha of a natural land area currently composed of native grasslands, wetlands, canals, dugouts and other water classes, and existing disturbances. An additional 63.5 ha will be developed including the above water portion of the reservoir berms for a total permanent disturbance of 827.1 ha (Appendix E1, Figure E1-11). A temporary workspace area will also be developed and then reclaimed; this area, totalling 52.3 ha, results in a total disturbed area of 879.4 ha. There will be permanent loss of all natural waterbodies within this footprint area during Project construction (Table 7-11). However, this will be more than replaced by construction of the new reservoir area. As discussed in the Vegetation and Wetland section (Volume 2, Section 10, Figure H1-13), there will also be replacement, through *Water Act* approval, of up to 93 ha of wetland areas within the reservoir shallow areas, resulting in greater area of natural open water classes than at Baseline, negating the loss of natural wetland areas.

Table 7-11: The effect on surface water features in the ALSA

Surface Water Type	Baseline Area (ha)	Project Construction Case (ha)	% Change	Operations Case (ha)	% Change
Reservoir	298.8	305.3	2.2	1,068.9	+257.7
Canals	40.2	27.8	-30.8	27.8	-30.8
Ditches	0	0	0.0	0	0.0
Dugouts	2.1	0	-100.0	0	-100.0
Marshes	51.4	2.1	-95.9	2.1*	-95.9
Open Water	25.4	14.3	-43.7	14.3	-43.7
Subtotal	**418.0**	**349.5**	**-16.4**	**1,113.1**	**+166.3**
Vegetated Areas	874.28	75.8	-91.3	181.1	-79.3
Disturbances	17.2	884.1	5,040.1	15.2	-11.6
Total ALSA	**1,309.2**	**1,309.2**	**0.0**	**1,309.2**	**0.0**

* Will increase to 95.5 ha per Wetland Replacement discussed in Volume 2, Section 10

As described in Volume 1, Section 6 (Dam Safety): 6.2.1.1, an additional change to surface water will occur as the FSL will be increased by 0.3 m to 782.0 m asl. This will alter the amount of littoral (<3 m depth) and pelagic (>3 m depth) habitat areas. These have been examined at the new FSL, at a typical drawdown level of 1.5 m, and at an expected drought drawdown level of 12.5 m (leaving 5 m depth) at the deepest point of the expanded reservoir. Once filled to the new FSL of 782.0 m asl, the expanded reservoir will be up to 17.5 m deep on the east side (based on current surface elevation), or deeper if borrow pits extract materials below this depth. On the west side depths of 2 to 6 m will be common, and average depth will be approximately 10 to 12 m. Waterbody area, depth, and area of pelagic and littoral zones will vary in most years as the reservoir is filled and water is drawn out (Table 7-12, Table 7-13). Waterbody depths, volumes, and depth zones are shown for FSL (Appendix E1, Figure E1-12), typical yearly drawdown of 1.5 m and deep drawdown of 12.5 m as could occur during a prolonged drought. This estimates the potential range in water depth and volume expected within and among years as needed to address requirements of the FTOR. It is assumed following connection to the new reservoir area, the extant reservoir area will maintain the same deep basins, such that during drawdown, residual littoral and pelagic habitat will be maintained as assessed for the Baseline Case.

Table 7-12: Estimated change to littoral and pelagic habitat areas anticipated at the SLR at Full Supply Level

Measure	Full Supply Level				
	Baseline FSL	Extant Reservoir (New FSL)	% Change	Expanded Reservoir (New FSL)	% Change
Surface Area (ha)	298.8	305.3	+2.2	1,072.9	+259.1
Littoral Zone (0-3 m) (ha)	105.1	85.3	-18.8	166.9	+58.8
Pelagic Zone (>3 m) (ha)	193.7	220.0	+13.6	906.0	+367.8
Maximum Depth (m)	14.3	14.3	0.0	17.5	+22.4
Mean Depth (m)	5.6	5.7	+1.8	9.0	+60.7
Water Volume (million m^3)*	16.5	17.4	+5.5	96.5	+484.8

*Water volumes were estimated based on surface area and mean depth and are considered an underestimate compared to actual volumes based on measured storage capacity.

Table 7-13: Estimated change to littoral and pelagic habitat areas anticipated at the SLR during Drawdown Conditions

Measure	Estimated Drawdown Conditions		
	Expanded Reservoir	Typical Drawdown (1.5 m)	Deep Drawdown (12.5 m)
Surface Area (ha)	1072.9	1025	240
Littoral Zone (0-3 m) (ha)	166.9	146	203
Pelagic Zone (>3 m) (ha)	906.0	879	37
Maximum Depth (m)	17.5	16.0	5
Mean Depth (m)	9.0	7.5	2
Water Volume (million m^3)*	96.5	69	4

*Water volumes were estimated based on surface area and mean depth and are considered an underestimate compared to actual volumes based on measured storage capacity.

Surface Water Movement

There will be no change in surface water movement through the canal system; the canal system already established will convey the same volume of water over time dictated by agricultural demand as has been the case with extant SLR operation. Runoff from the berms and seepage from under their footprint will be passively collected in a gravel drainage layer built into the berms.

This will be directed to a low area on the east side of the new reservoir and east towards San Francisco Lake.

The EID does not plan to take additional water from the Bow River to fill the reservoir. As discussed In the Project Description, the EID has several million cubic metres of unused allocated water in most years. On its own, this will be sufficient to fill the reservoir in the first year of operation, if minimum flow requirements below Bassano Dam can be maintained and contribution to the required flow into Saskatchewan is achieved. If water supply during the first year of filling is low because of drought, there is the option to fill the reservoir over multiple years, to ensure environmental effects on water supply in the Bow River are not realized. Past this filling event, the expanded SLR will continue operation as it has for the past 20+ years under the EID's diversion licence. When water is abundant in the Bow River and irrigation demand is lower, the expanded reservoir will fill at the same rate as in the past. If there is insufficient water in the Bow River to maintain IO (11.3 m^3/s), no water will be diverted to SLR and water stored in the reservoir will be drawn out to meet agricultural demand. For example, during summer and fall 2023, the IO was maintained throughout summer and fall despite the drier than average condition (Appendix E1, Figure E1-6).

By nearly quadrupling the surface area of the reservoir once filled to FSL, increased evaporation will occur, estimated as an increase of 6 million m^3. However, this will be more than offset by the increased efficiency in water use throughout the EID per the Project Description (Volume 1, Section 2.11) including reduced seepage from canal to pipeline improvements (12.5 million m^3), improved water management (12.4 million m^3) and improved on-farm watering methods (9.3 million m^3) which total up to 34.2 million m^3/year. See Volume 1 Project Description for further discussion on efficiencies in water use.

Conflict with Other Water Users

There will be no conflict with water conservation objectives stated in the South Saskatchewan River Watershed Plan and specifically Bow River. Operation of an expanded SLR will not conflict with minimum IFN in the river: the EID will operate the reservoir no differently than it is now. There will be no conflict with surface water users; more water available will enhance water security to meet downstream agricultural demand. Return water will be similar in quality as it has been to date after expansion of SLR.

Water level in the expanded reservoir will decrease over summer and early fall to meet irrigation demand most years. Summer 2023 was a dry year, and the EID drew SLR down by 8 m to a residual maximum depth of 6 m by late August after the canal operation ceased. That drawdown had recovered to within 1 m of FSL by the end of the first week in September 2023 (Appendix E1, Figure E1-6). The EID will operate the reservoir to maintain water level during May when littoral habitat could dewater and compromise habitat for Northern Pike that may spawn in this habitat in early spring with eggs hatching by early June (see Volume 2, Section 8, Aquatic Resources for rationale).

7.5.3.2 Change in Reservoir Water Chemistry

Water in SLR is neutral to slightly alkaline in pH and relatively hard given its moderate conductivity (TDS). Water within the shallow littoral zone becomes more alkaline as summer progresses and the level drops. This is typical for all waterbodies within the region which is dominated by shallow alkaline lakes and ponds that overly alkaline soils. Runoff from adjacent land will be confined to what enters the reservoir from the berms. Adjacent land is used for livestock grazing. Phosphorus and nitrogen loading from surface runoff is not considered to pose a risk to water chemistry – residency time is short and input dilute relative to other basins with off stream storage.

Once built and filled, no change is anticipated in water chemistry in the expanded reservoir from that which is present in the extant basin. The expanded basin is twice as deep and should stratify more than the existing reservoir. However, the expanded reservoir will be connected to the extant basin through the footprint of the extant east dam. This will permit wind driven water to move freely between basins. The long fetch will persist relative to the prevailing wind and drive turnover regularly. Although almost twice as deep, the new basin is anticipated to mix similarly to that experienced in the extant basin the result of wind driven wave action.

Little if any change in water quality parameters are anticipated; simply more of it will be stored in the expanded basin. Volume will increase 5 times over Baseline, but composition will be the same. The only metal of concern is mercury. The concentration of mercury (and other metals) will be monitored to track both dissolved and sediment mercury concentration after the reservoir is filled.

No hydrocarbon contamination of surface water is anticipated in the expanded reservoir. Old wells and pipelines within the Project footprint will be removed fully and remediated before the start of construction. Additionally, if any contamination is observed during construction, or if there are any spills, they will be immediately cleaned per the spill management plan.

No cyanobacteria were observed in shallow water during the late August 2023, post-drought field trip. This would have been the time when they would be prevalent as surface water temperature was high and the reservoir had been drawn down 8 m. Their absence is not surprising since drawdown is relatively rapid (8 m over 2 months), turnover and frequent mixing reduces the opportunity for these bacteria to bloom. Furthermore, shallow warm water is scarce by summer as drawdown reduces littoral zone habitat appreciably to that with a few pockets of standing water remaining within it by late summer. These pockets are spatially segregated from the extant SLR basin by late summer given drawdown.

Overall, frequent turnover maintains clarity and temperature, water is cold-cool and clear over the irrigation season and nutrient concentration low to moderate. SLR is not attractive as habitat for this bacterium (and other toxins such as “swimmers itch”) to bloom. Currently, recreation is limited to some boating, swimming, and sport fishing. With expansion, this reservoir will attract more recreation. It is unlikely that either bacterium will limit recreational opportunities at the expanded SLR.

There will be no change in return flow loadings, since water use for irrigation will persist according to individual licenced users needs (~40.6 cm of moisture) supported by the EID. Ideally, no runoff from property will occur under “smart” irrigation infrastructure. Undoubtedly some concentration of minerals and nutrients will be experienced in return water. To date, few guideline values have been exceeded, although baseline exceedances do occur more commonly near the return flow sites. Water in SLR is not for potable use. Consequently, there will be no water treatment facility or management.

No evidence of eutrophication has happened since SLR was built. It is drawn down partially to fully (to meet irrigation demand and maintenance, respectively, depending on the year) and water turns over regularly. Berms surrounding the expansion will prevent runoff from the landscape and should also impede the accumulation of nutrients that cause algal blooms. Input from agriculture (e.g., pesticides, herbicides, fertilizers) will not occur since the surrounding upland is grazed, but not continuously. Livestock move through the area over the season – use is transitional.

The extant reservoir is isothermal for much of the year. The reservoir's long fetch relative to the prevailing wind encourages wind driven mixing. This combined with a relatively short residency time of water as the reservoir fills and empties results in water chemistry that remains static and suitable for all fauna in and vegetation around it. No change in trophic status and pH will result once the expanded basin is filled.

Given high turnover, water quality in the reservoir depends on the quality of that diverted to the reservoir through the East Branch Canal. Baseline water chemistry data collected from the canals above and below the reservoir were compared. The range in values of the parameters recorded at these sites provides a record of the worst case incoming and outgoing water quality. The few exceedances reported for TDS, TSS, and various metals could be the result for flood events in the Bow River. This is because during floods, incoming water contains higher than normal TDS and TSS, which can contain higher than normal dissolved and total metals, routine ions, and other chemicals.

Unlike baseline conditions, the expanded reservoir will hold nearly 5-times the volume of water, such that water inputs during flood events will mix into the relatively clean water in the reservoir diluting incoming water chemistry. Additionally, the new reservoir area and depth will allow particulates to settle and dissolved components longer time to precipitate and sink to the bottom. Further, as high-water events occur during periods of high rainfall, it is likely the demand for water in the reservoir will be reduced regionally and less input of poor-quality water will be diverted during these times.

When water is highly turbid, EID has the option to reduce or stop withdrawal of water at Bassano Dam, relying on water in off stream reservoirs to meet the needs of irrigators in these periods. It is in the interest of EID to ensure water that reaches farms is not high in TSS, as this can damage pump infrastructure (e.g., impellers). Therefore, by managing timing of diversion and avoiding peak floods, water chemistry will be consistent between incoming or outgoing water from SLR, especially after expansion. TDS and TSS will settle in the expansion of SLR. Infilling from settling of sediment is not anticipated in the expansion of SLR.

Groundwater – Surface Water Interactions

Since the new reservoir will be lined with (or naturally contain) clay till materials, and the basin has been characterized as an aquitard (see Volume 2, Section 6), interaction between surface and groundwater is not anticipated. Most surface water is alkaline within the footprint given higher salinity in the surrounding soils. No potential for heated ground water to influence habitat viability in the reservoir (thermal plumes) given the footprint does not overly thermal vents or heated groundwater. The area is geologically inert.

7.5.4 Residual Impact Characterization

Table 7-14 summarizes the residual effects (those that remain between the Application (including mitigation and Baseline cases) on water quantity and quality during the three Project phases of construction, filling, and operation. These are expected to occur during all three phases and include low to high negative effects during construction, and both high positive and neutral residual effects during the filling and operation phases. All residual effects are restricted to the Project footprint. The Project footprint will experience a net positive gain in surface water and natural water bodies. The increased reservoir area will promote additional opportunities for recreation. Water security will be improved should drier summers persist into the future.

Table 7-14: Project residual impacts on surface waterbodies during the Project phases

Impact Description	Direction	Key Criteria			Modifiers		Residual Impact Rating
		Magnitude	Geographical Extent	Duration	Confidence	Ecological and Social Context	
Construction							
Influence of construction on surface water	Neutral						Neutral
Filling							
Permanent loss of shallow or seasonal waterbodies within footprint	Positive	High	Footprint	Long-term	High	N/A	High Positive
Operations							
Change in surface water movement	Neutral						Neutral
Conflict with other water users	Neutral						Neutral
Change in water and sediment chemistry	Neutral						Neutral
Groundwater - Surface Water Interaction	Neutral						Neutral

7.6 CUMULATIVE EFFECTS ASSESSMENT

The section assesses how the Project may interact with other past, present or future projects and activities, and their combined effect on Surface Waterbodies. For a full description of the Cumulative Effects Assessment Approach see Volume 2, Section 2. Only resources in which the Project was expected to result in high negative or medium negative residual impacts (Table 7-14) are discussed in the cumulative effects assessment.

The SLR expansion will contribute to a net positive increase in surface water within the region. Given the net positive gain, there are no adverse cumulative effects, hence no further analysis is necessary. Specifically:

- The Project is not expected to affect water quality within the Bow and Red Deer rivers. Water quality parameters will be monitored by the EID through filling and operations phases, including monitoring at several existing monitoring sites up to 4 times per year to trace the chemistry of water from near Bassano dam, through reservoirs and back to the Bow or Red Deer rivers.
- The Project results in a net increase in surface water. The timing, volume, peak and minimum flow rates of water courses or waterbody level will remain consistent. There are no effects as the water requirement is within the existing EID allocation and timing of withdrawal will occur to ensure minimum water flows are maintained. Conflict with regional surface water users is not anticipated at any point since the proponent will operate within the regional water quality management framework.

7.7 MONITORING

Surface water quality monitoring is recommended for the expanded reservoir in midsummer to early fall, one year after the reservoir is filled and operating. This would require sampling at three sites: the expansion outlet, and one sample in each of existing and expansion SLR basin. A full set of parameters would be subject to laboratory analysis to assess water quality for agricultural use and PAL (see Appendix E2, Table E2-1). These parameters would include routine measures, dissolved and total metals, nutrients (P, N), and bacteria (coliforms). Sampling for one year is justified since the EID already measures water quality annually at sites upstream and downstream of SLR (Alberta Irrigation Districts Association, 2024) and any future changes in quality upstream and downstream of SLR would be detected in that program. In-situ parameters (DO profile, temperature profile, specific conductivity and pH, would also be measured, one sample in each basin, and in the outlet water in early summer to fall.

Mercury is one of the key elements measured to assess water for PAL. Mercury testing in water and sediments is recommended to determine how mercury concentrations in water and sediments change after filling. Mercury is not currently examined in the existing EID water monitoring program, and evidence obtained from the baseline for this EIA showed mercury concentrations above PAL guideline levels in two out of four samples obtained. Water and sediment samples would be collected from the deep basins of the existing and expanded reservoir areas and analyzed for inorganic mercury and methylmercury (in sediment). This monitoring is recommended for year 1 after filling to assess if mercury is increasing in water and sediments that could enter the food chain.

Therefore, the recommended samples and timing include:

- Water: full parameter set for PAL and Agricultural Use – three sites, 1 year after filling
- Water: In-situ parameters – three sites, 1 year after filling
- Water inorganic mercury – two sites, 1 year after filling
- Sediment inorganic and methylmercury – two sites, 1 year after filling

Note that FTOR clause 3.4.2 12. requires the proponent to "identify the surface water quality monitoring program that will be implemented to assess the future impacts of construction and operation (including maintenance) of the reservoir project on the Bow." This monitoring is not applicable, as the Project will not require additional withdrawals or result in additional returns of water to the Bow River. Additionally, water throughout the EID, from source to return, is already sampled annually in the EID's existing water quality monitoring program (Alberta Irrigation Districts Association, 2024; GOA, 2024d) at upstream and downstream sites, including sites where water flowing through SLR is returned to Red Deer River.

7.8 CONCLUSION

The new reservoir will be up to 6 m deeper than the existing SLR and 4 times larger in area. It will store more than quadruple the volume of water for release into the EID canal. Retention time is anticipated to be short, and conditions experienced currently are anticipated to be similar for the expansion. Most water quality parameters sampled fell within published guidelines for the protection of aquatic life. Exceedances of the guidelines for protection of aquatic life were identified for fluoride (spring 2021, winter 2022) and total mercury (winter 2022 and fall 2023). The water in the reservoir is alkaline, with a pH range from 8.1 to 9.4. The existing SLR remains well oxygenated during the spring summer and fall seasons, and specific conductivity and TDS values are typical for freshwater lakes with little variation between seasons.

Residual effects from the reservoir expansion will include permanent removal of all existing waterbodies within the Project footprint. All existing waterbody features will be removed and replaced with the new expansion reservoir, some of which will develop into natural wetlands, offsetting these losses. The filling of the reservoir will create additional open water habitat.

Employment of best management practices during construction and operation of this reservoir expansion should protect existing and any newly formed aquatic ecosystems. These include, but are not limited to:

- use of temporary and permanent erosion control structures (i.e., silt fencing, riprap placement, etc.);
- completing any activities within the existing SLR when the reservoir is drawn down; and
- raising water levels slowly in the newly formed reservoir basin to minimize mobilization of sediment into the canal system downstream.

7.9 REFERENCES

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Appendix E

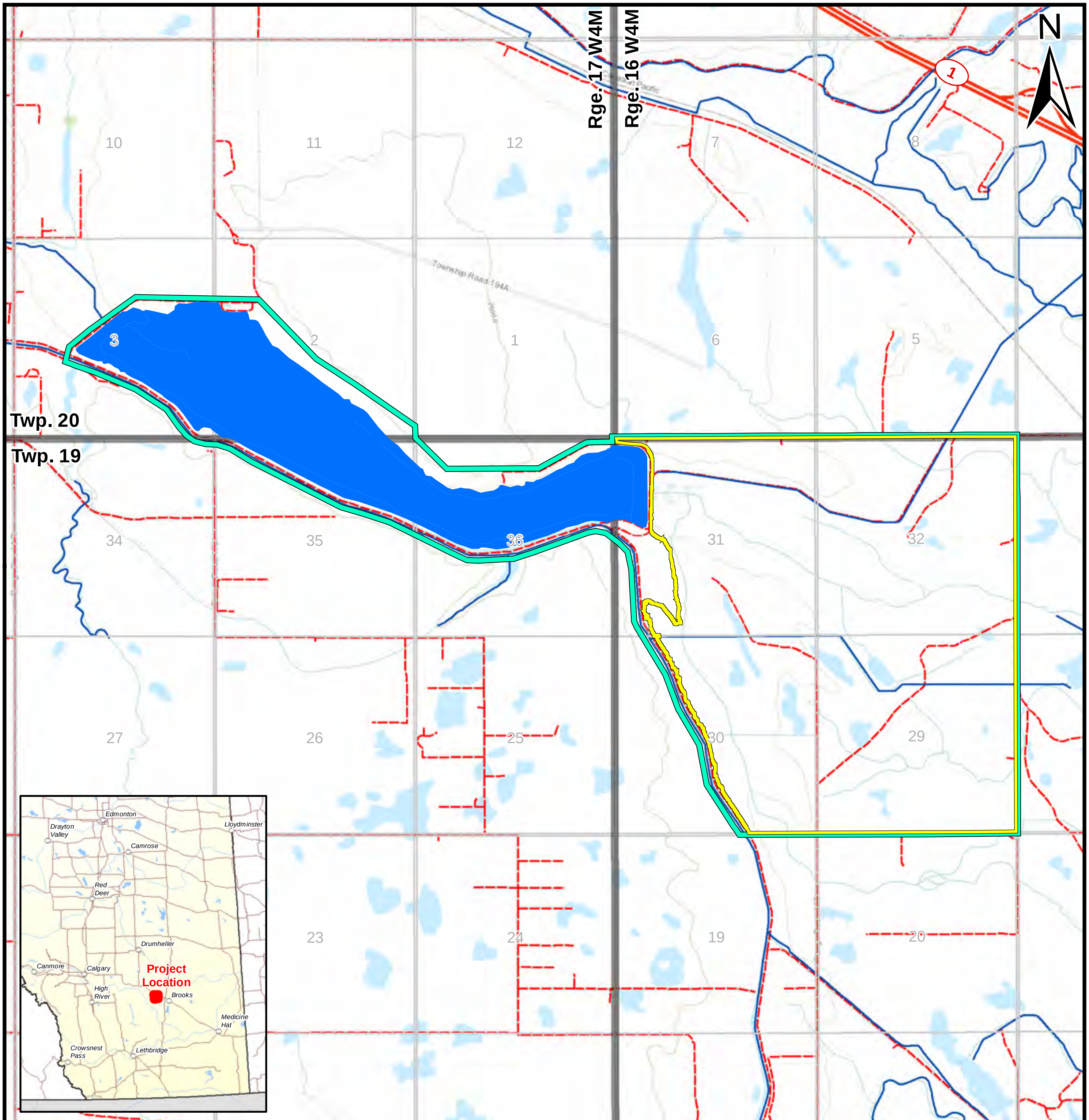
Appendices

Figures

Tables

Field Photographs

Appendix E1: Figures



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Approved:	TB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Local Study Area
- Snake Lake Reservoir Expansion Project Area
- Reservoir at Full Supply
- Unpaved Road
- Canal/Watercourse

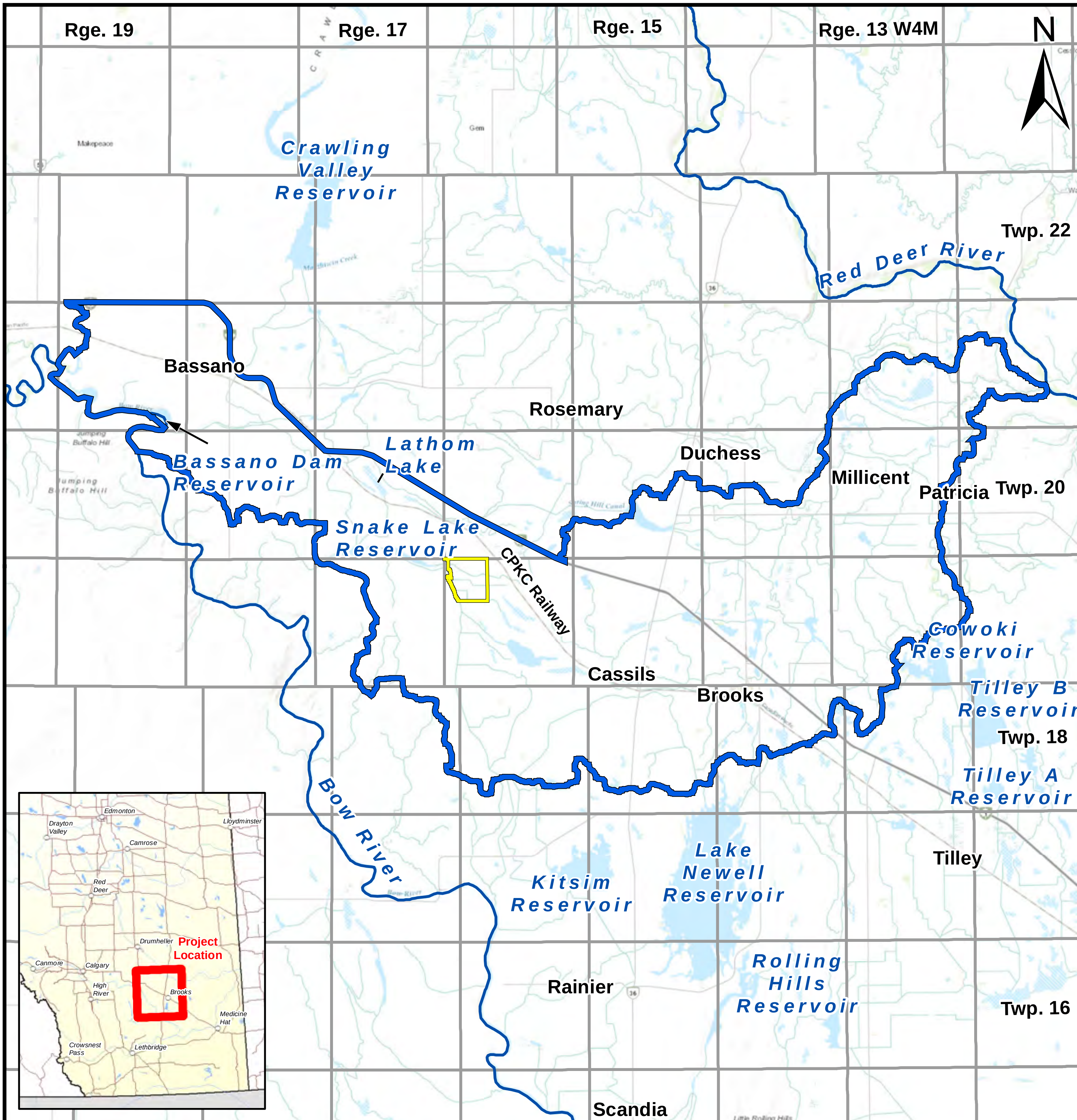
EID

Aquatic Local Study Area for the Proposed Snake Lake Reservoir Expansion

March 2025

REF.: AARES21-127
(Water Quantity)

Figure E1-1



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Approved:	WB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR
Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

Aquatic Regional Study Area (ARSA)

Snake Lake Reservoir Expansion Project Area

River

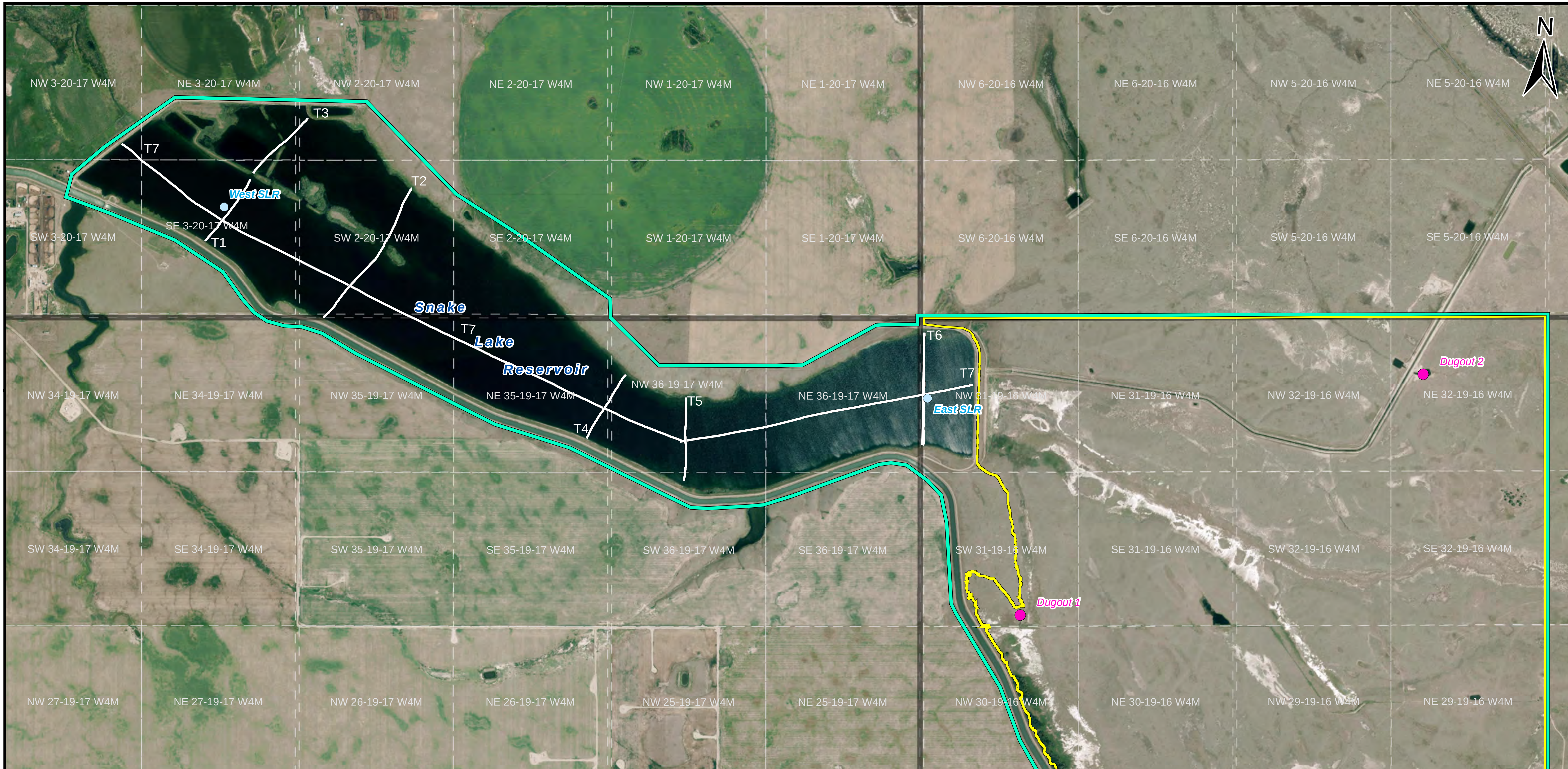
EID

Aquatic Regional Study Area for the Proposed Snake Lake Reservoir Expansion

March 2025

REF.: AARES21-127 (Water Quantity)

Figure E1-2



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Drafted:	JNB	Date:	Mar 17, 2025
Approved:	WB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
Imagery Reference: ESRI 2019/08/05
ATS Grid: AltaLIS 2007.

Approximate location based on field survey.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2019 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

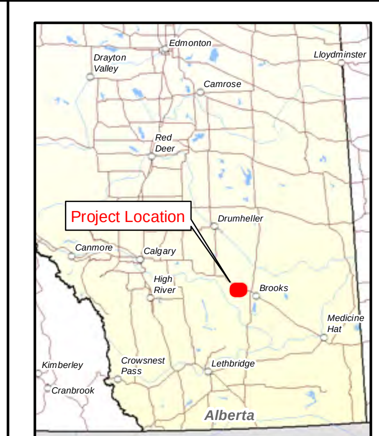
Legend

Routing:

- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area

Fisheries Survey Data*:

- Depth Transect
- Dugout Water Quality Sample Sites
- Water Quality Locations



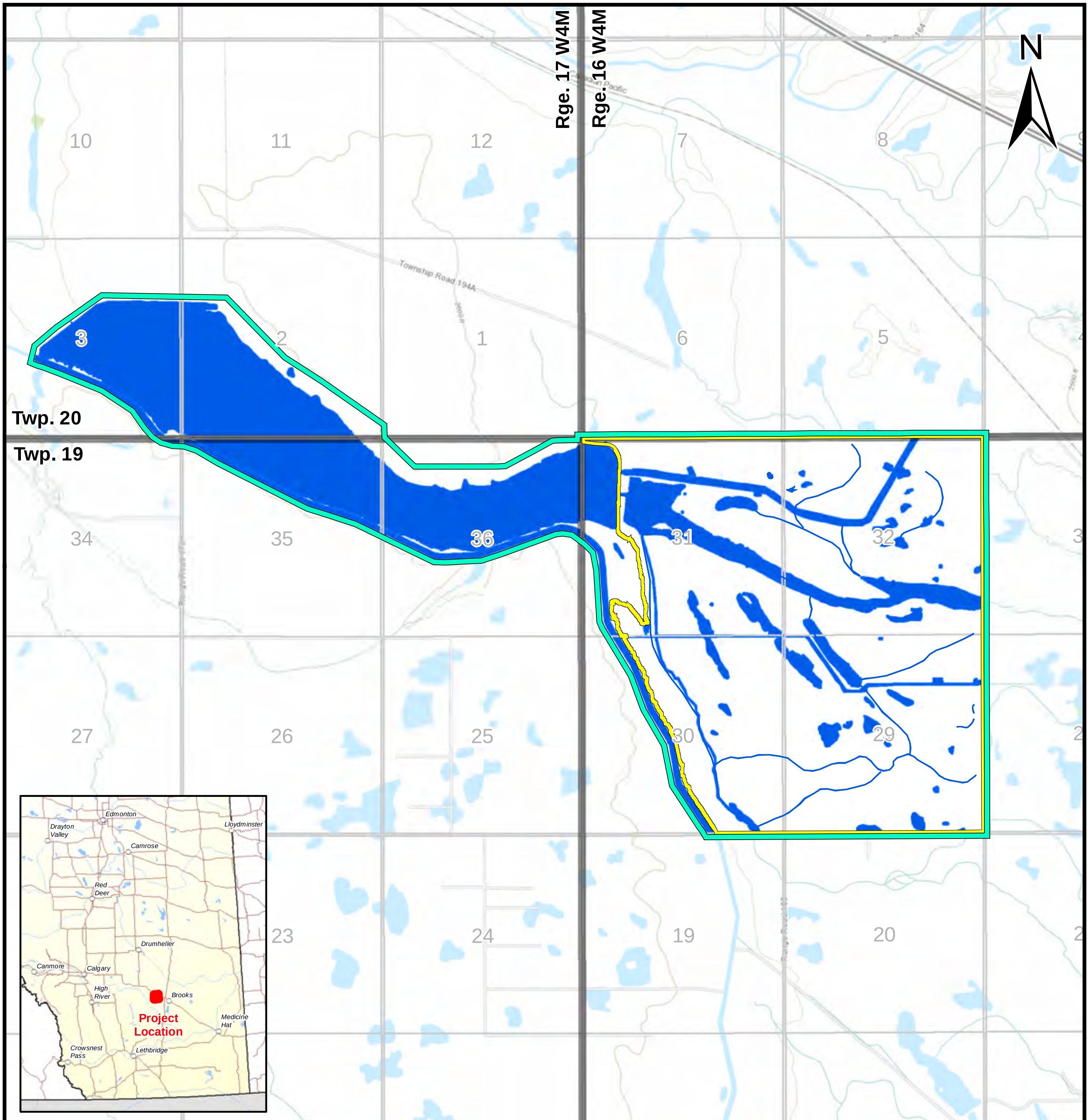
EID

Sampling Locations for Water Chemistry and Bathymetry

March 2025

REF.: AARES 21-127 (Water Quantity)

Figure E1-3



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Approved:	WB	Revision:	0
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CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.
Waterbody Basedata: Alberta Merged Wetland Inventory; AltaLIS 2007.

AAR
Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area
- Confirmed Waterbodies
- Waterbodies Outside ALSA

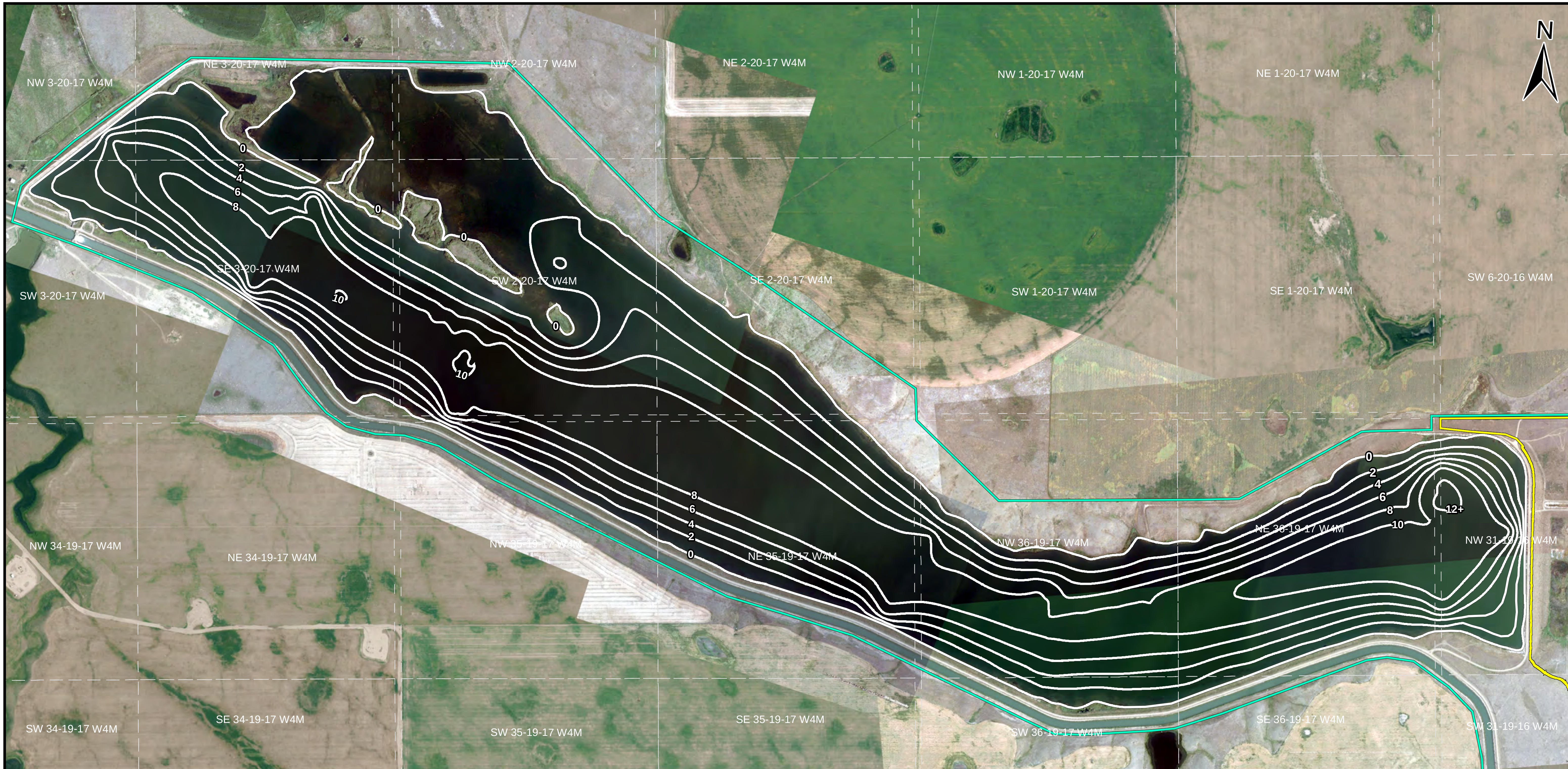
EID

Surface Waterbodies in the Aquatic Local Study Area

January 2025

REF.: AARES21-127 (Water Quantity)

Figure E1-4



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Approved:	WB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
Imagery Reference: ESRI 2018/08/15
ATS Grid: AltaLIS 2007.

*Approximate location based on field survey.

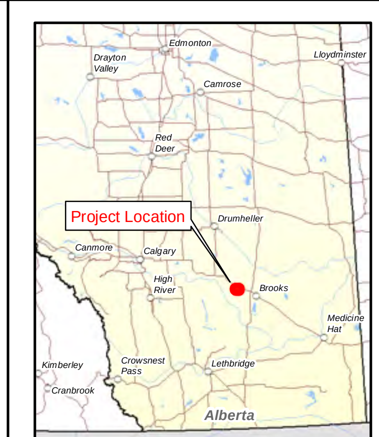
AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2018 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

Legend

- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area
- Bathymetry Contour (m)*



EID

Bathymetry of the Snake Lake Reservoir at Full Supply Level (781.7m)

March 2025

REF.: AARES 21-127 (Water Quantity)

Figure E1-5

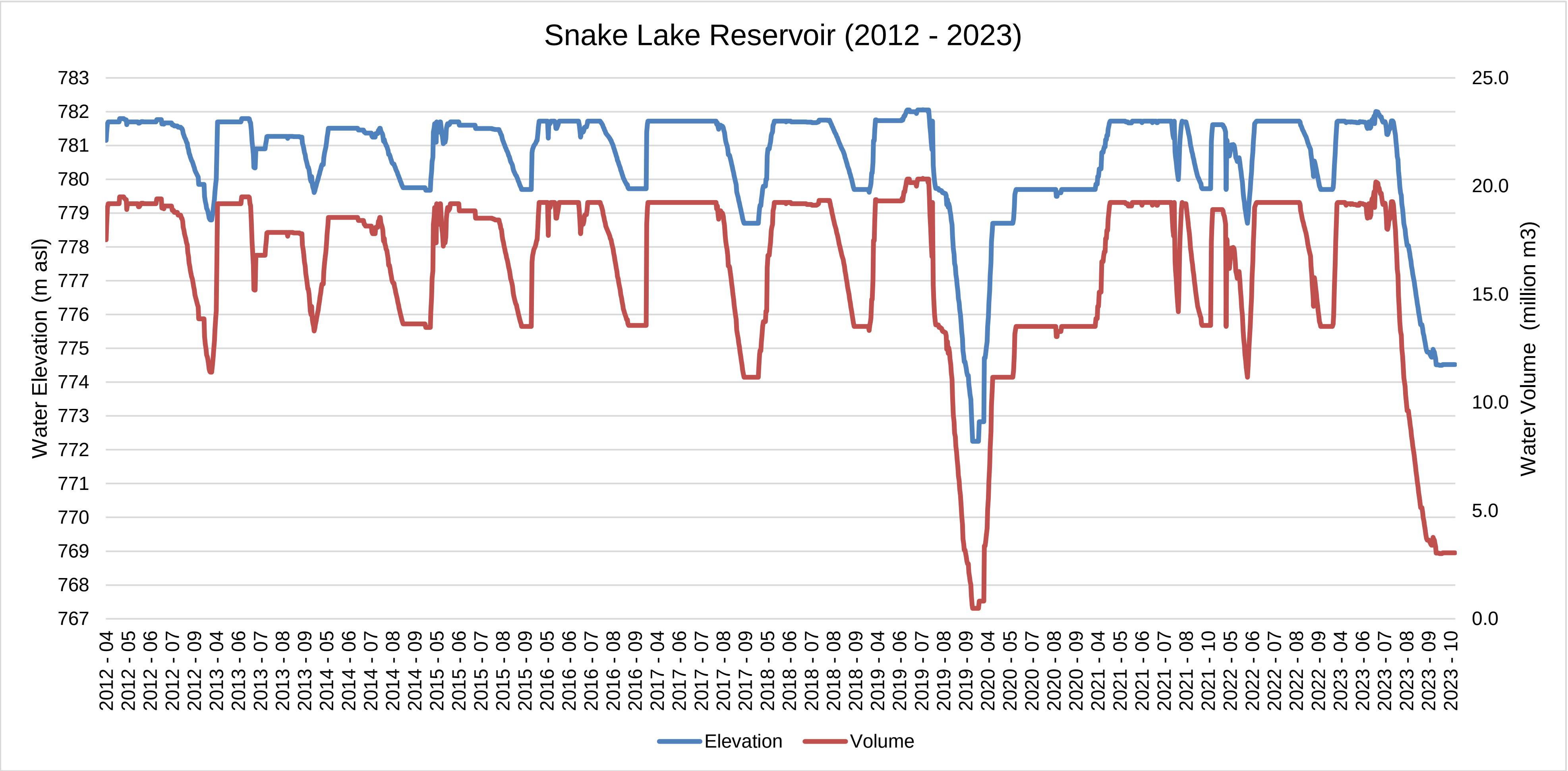


Figure E1-6: Snake Lake Reservoir Surface Water Elevation and Volume (2012-2023)

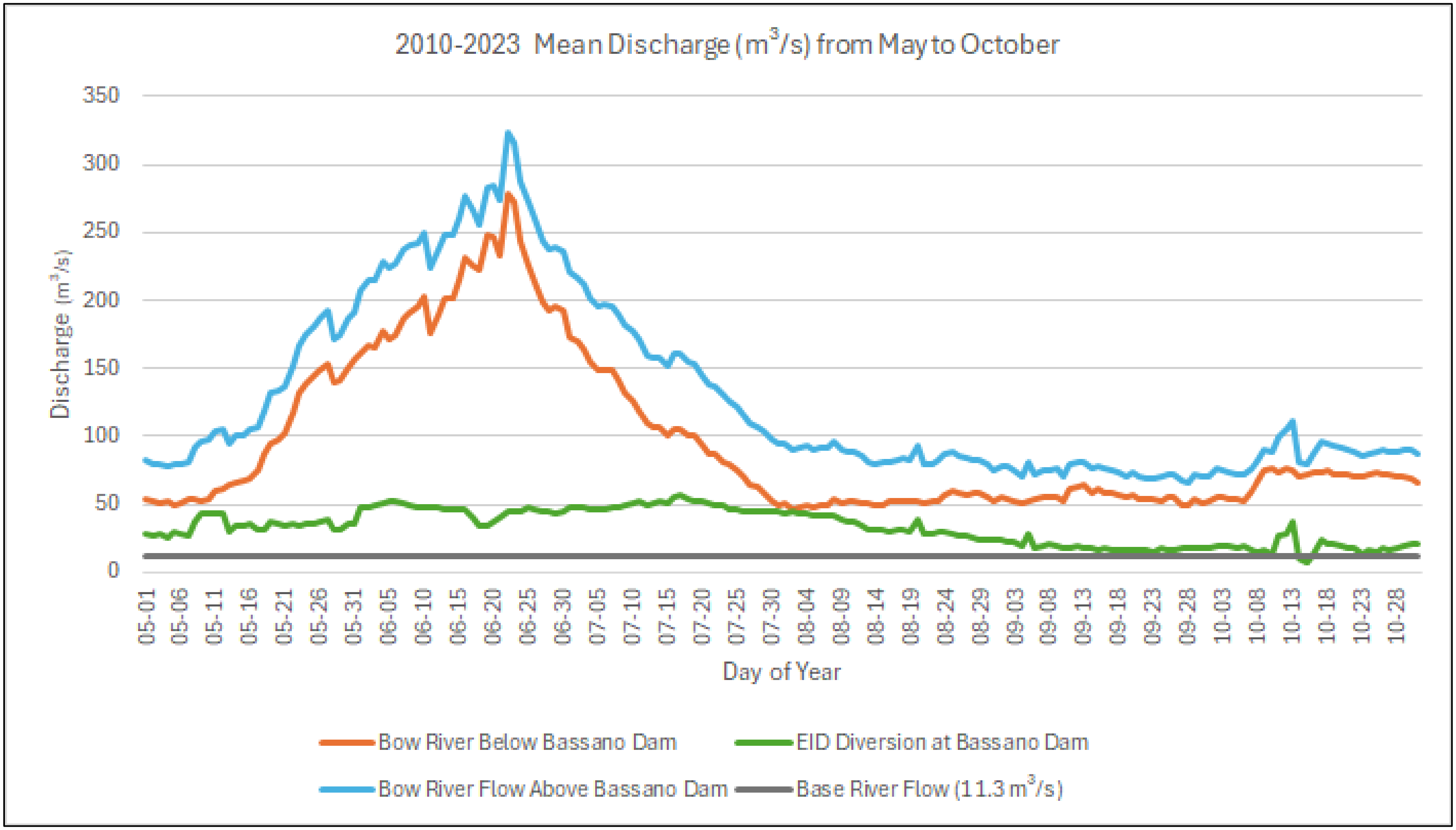


Figure E1-7: Bow River and EID Discharge at Bassano Dam (Mean 2010 to 2023)

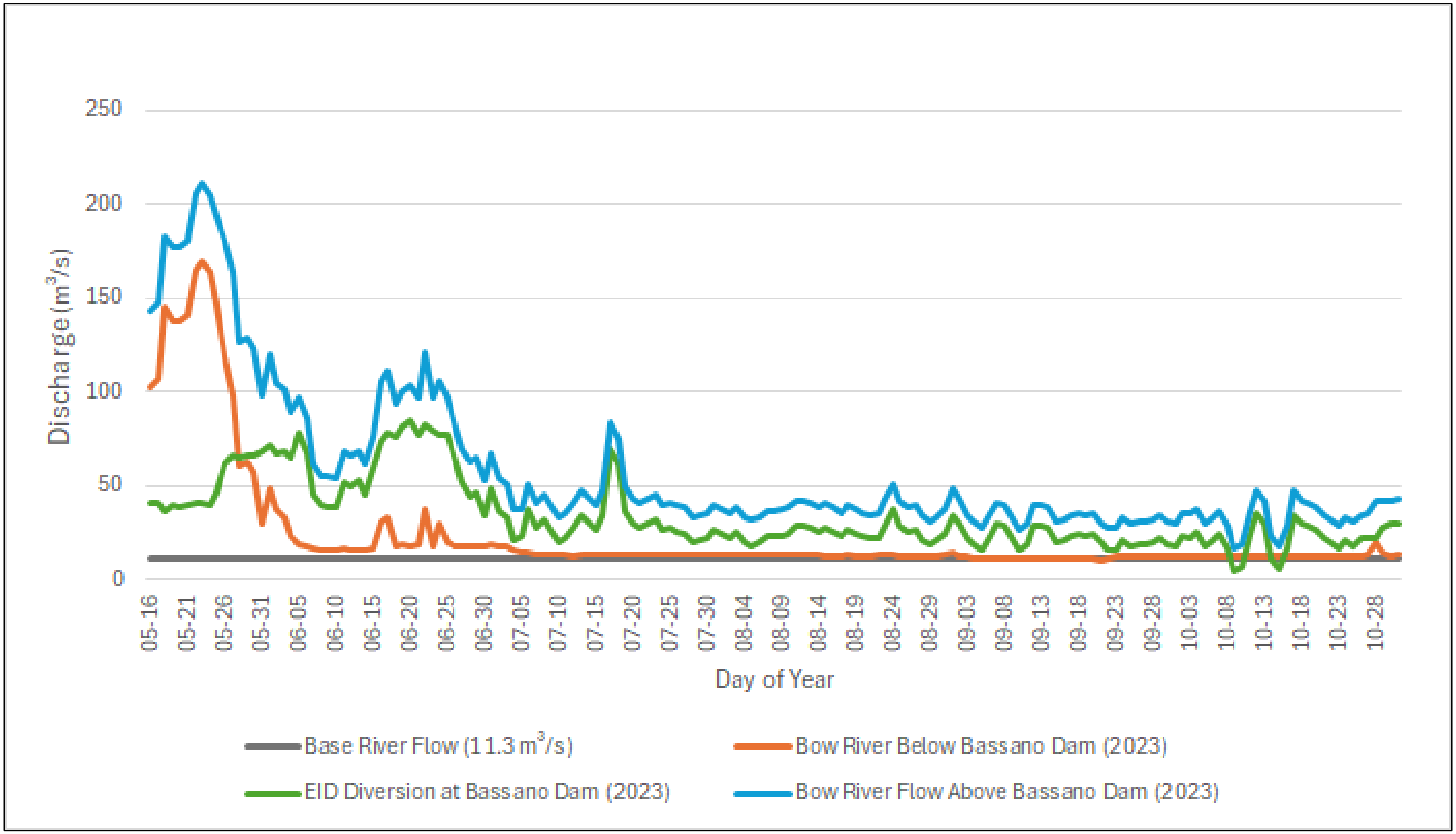
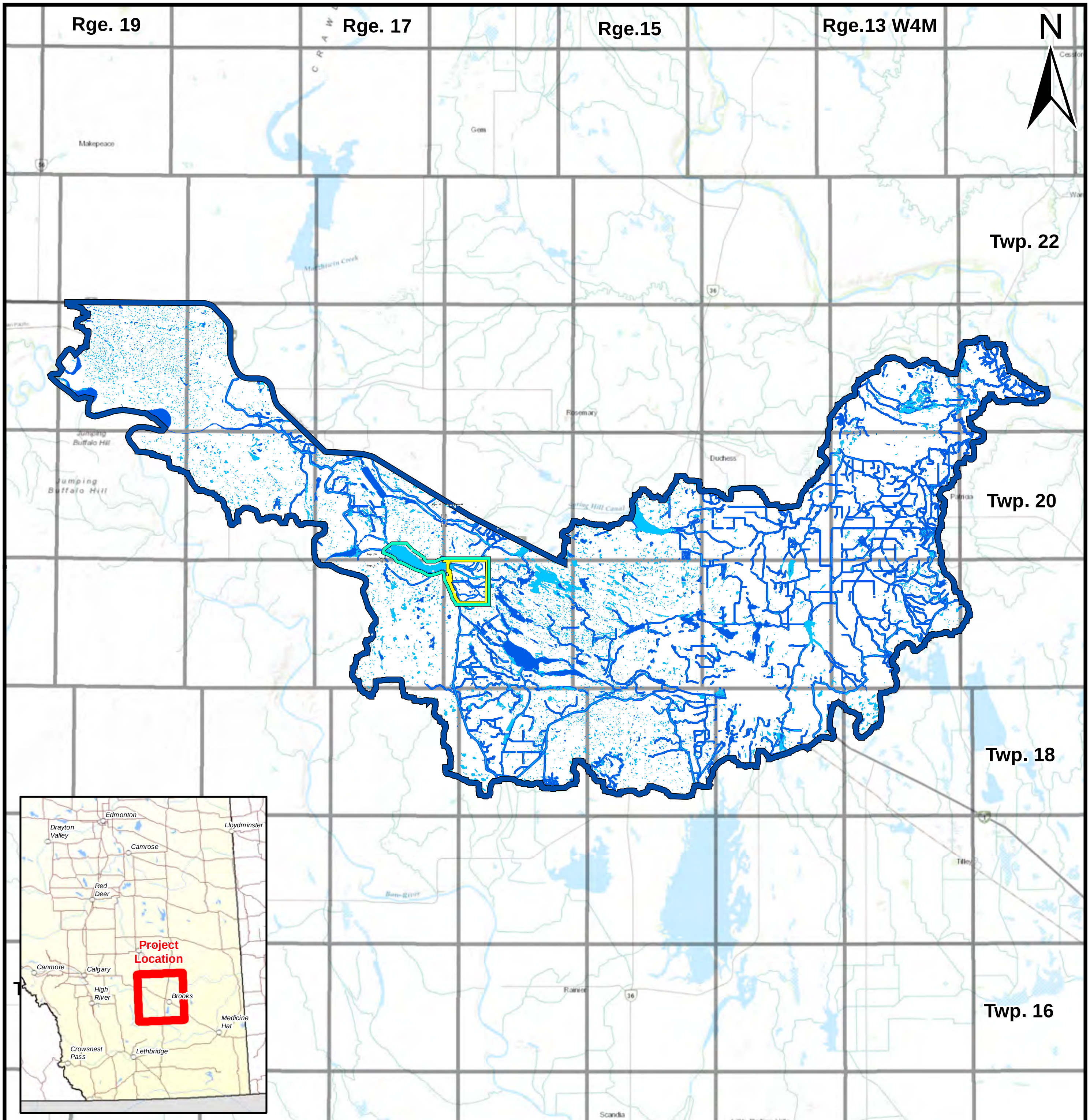


Figure E1-8: Bow River and EID Discharge at Bassano Dam (2023)



SCALE: 1:420,000

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Drafted:	NM	*Date:*	Jan 14, 2025
Approved:	WB	*Revision:*	0
Route Source:		*Date:*	Feb 18, 2022
CAD Survey		*Revision:*	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.
Waterbody Basedata: Alberta Merged Wetland Inventory; AltaLIS 2007.

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Regional Study Area (ARSA)
- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area
- Confirmed Waterbodies
- Wetlands, Canals, Watercourses, Reservoirs
- Waterbodies Outside ARSA

Waterbodies in the Aquatic Regional Study Area

January 2025

REF.: AARES21-127 (Water Quantity)

Figure E1-9

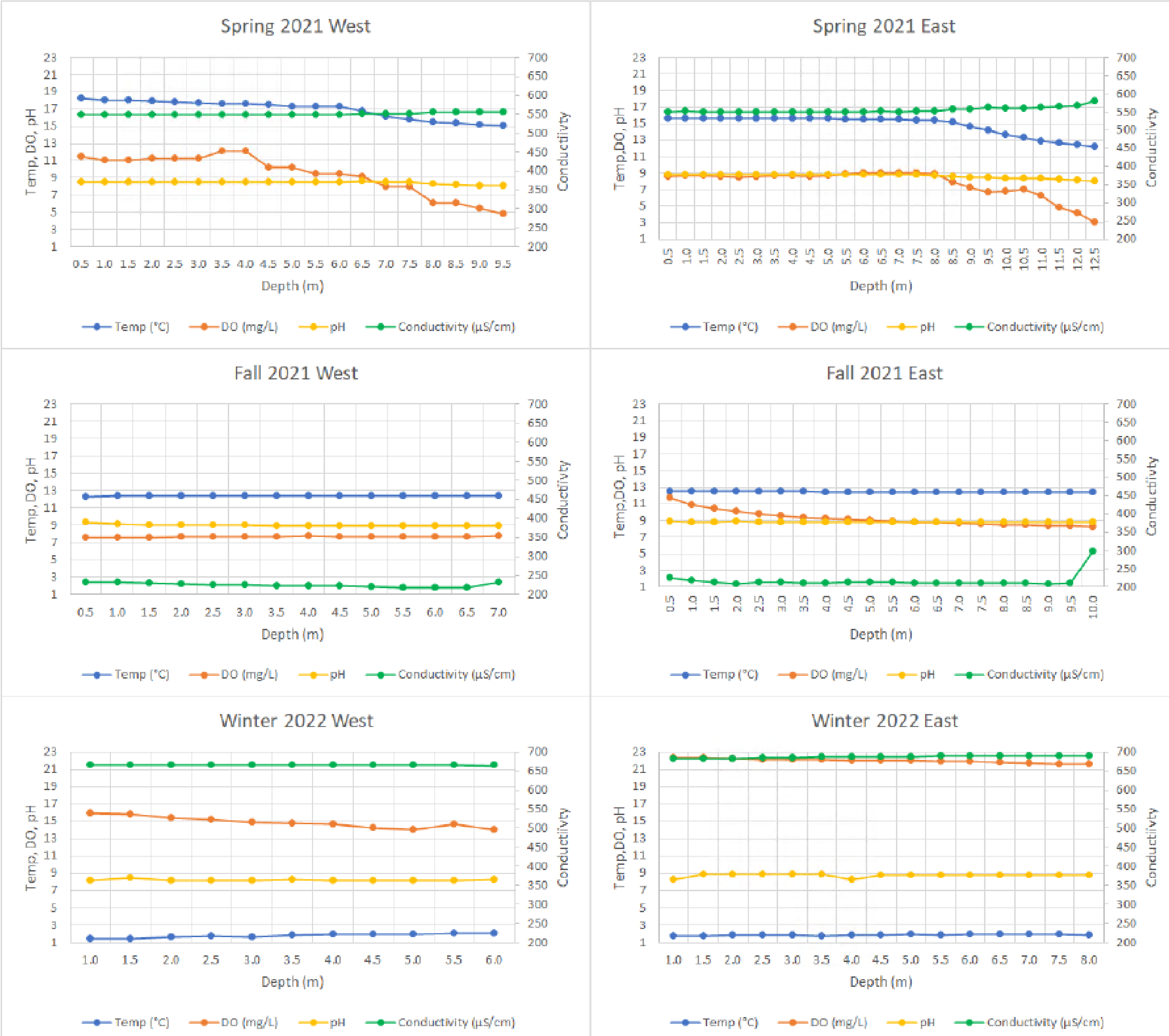
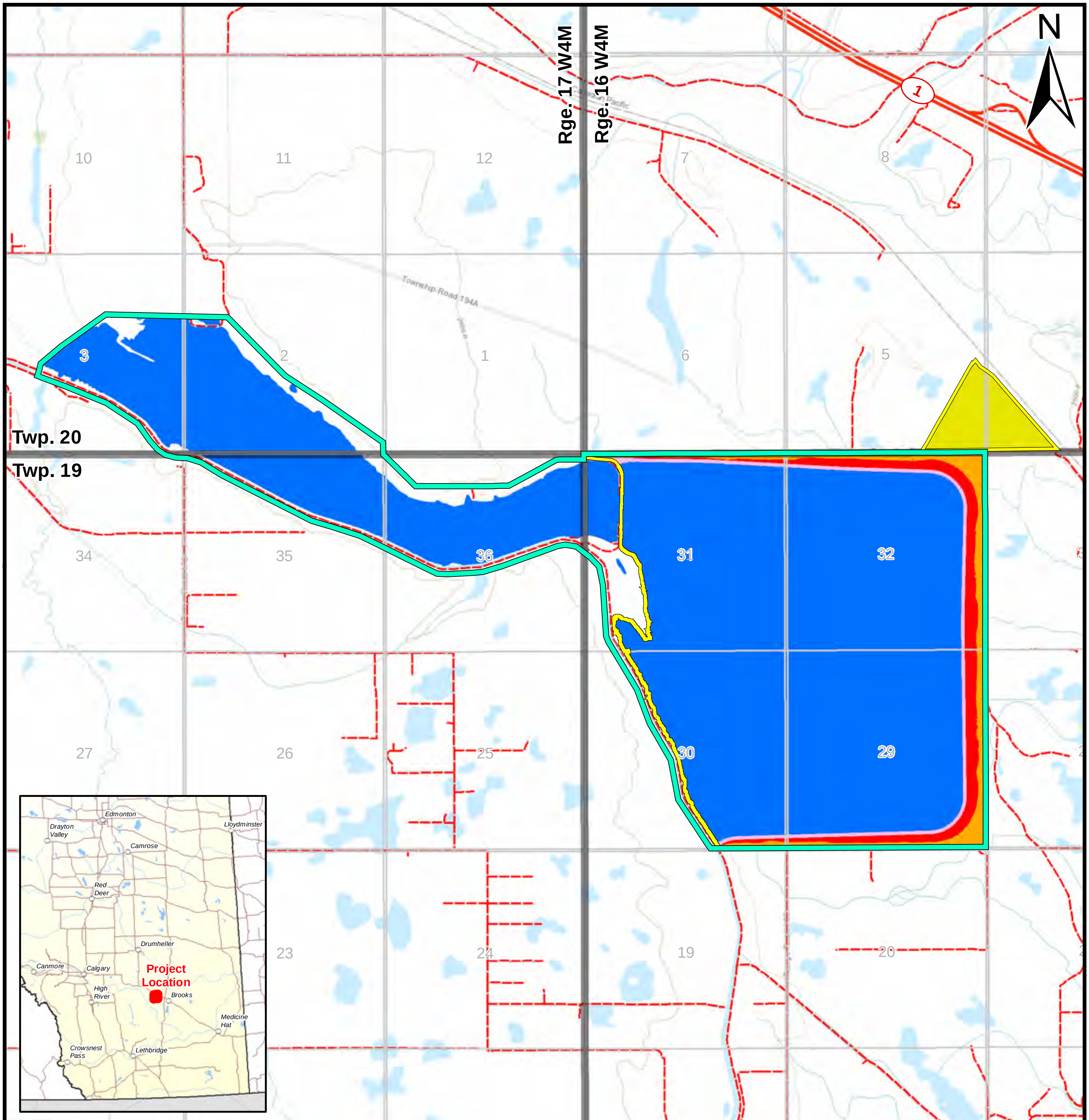


Figure E1-10: Water Quality Parameters Sampled at Snake Lake Reservoir (2021-2022)



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Drafted:	JNB	Date:	Jan 10,2025
Approved:	TB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR
Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Local Study Area
- Snake Lake Reservoir Expansion Project Area
- Reservoir at Full Supply
- Berm Road
- Reclaimed Berm
- Reclaimed Berm to Section
- Reclaimed Soil Storage Area
- Highway
- Unpaved Road

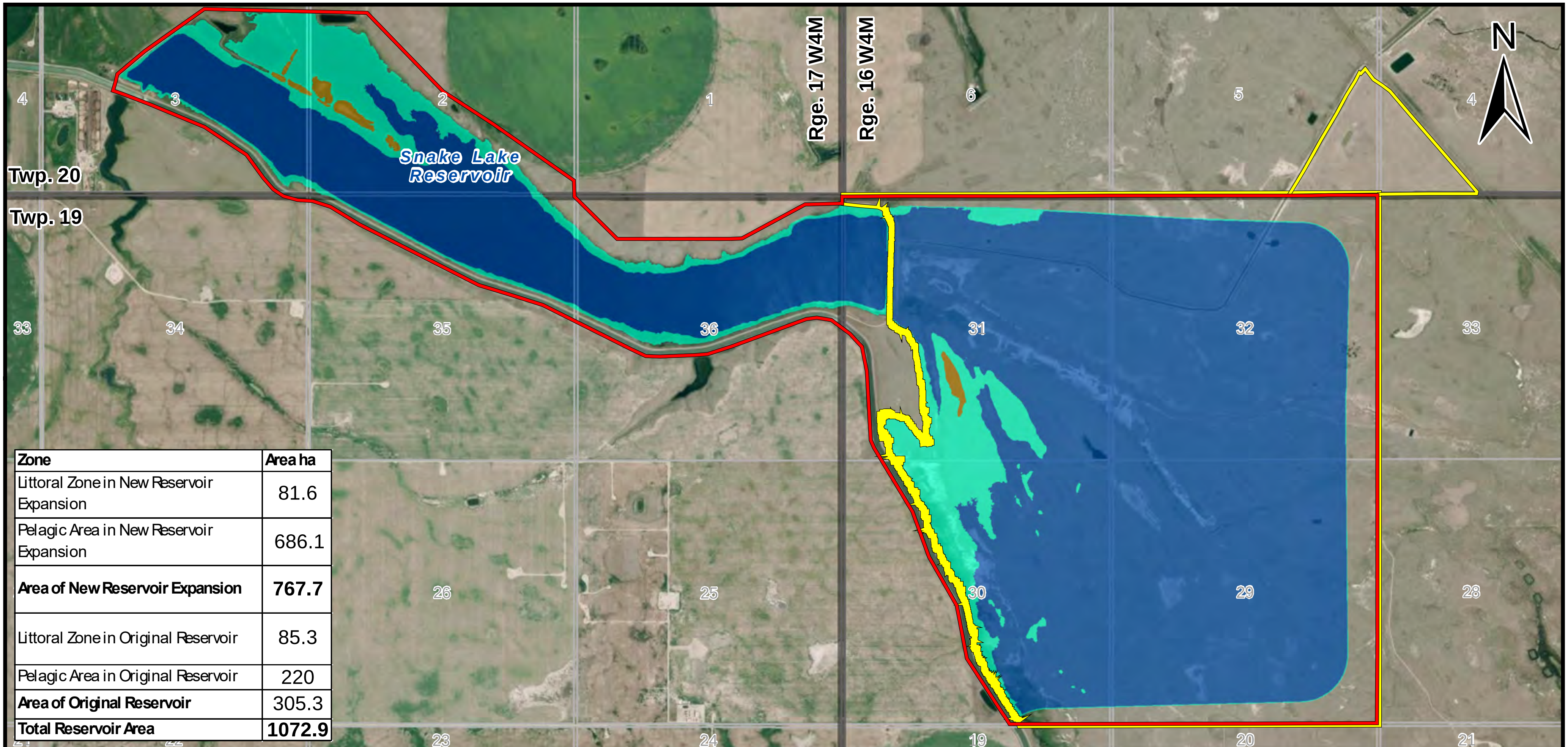
EID

Aquatic Local Study Area with Project Components

January 2025

REF.: AARES21-127 (Aquatics)

Figure E1-11



Zone	Area ha
Littoral Zone in New Reservoir Expansion	81.6
Pelagic Area in New Reservoir Expansion	686.1
Area of New Reservoir Expansion	**767.7**
Littoral Zone in Original Reservoir	85.3
Pelagic Area in Original Reservoir	220
Area of Original Reservoir	305.3
Total Reservoir Area	**1072.9**

SCALE: 1:35,000

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Drafted:	JNB	*Date:* Jan 10, 2025	
Approved:	WB	*Revision:*	0
Route Source:	SHP	*Date:* Feb 09, 2024	
		Revision:	0

Legend

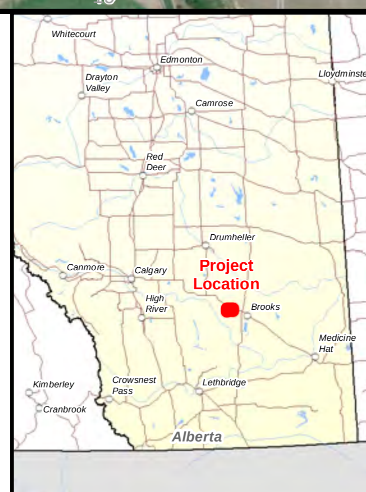
- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area
- Pelagic Habitat (Depth >3 m)
- Littoral Habitat (Depth 0-3 m)
- Area Above Water at FSL

Data Sources:
Imagery: ESRI. Date 7/10/2021.
ATS Grid: AltaLIS 2007.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2021 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.



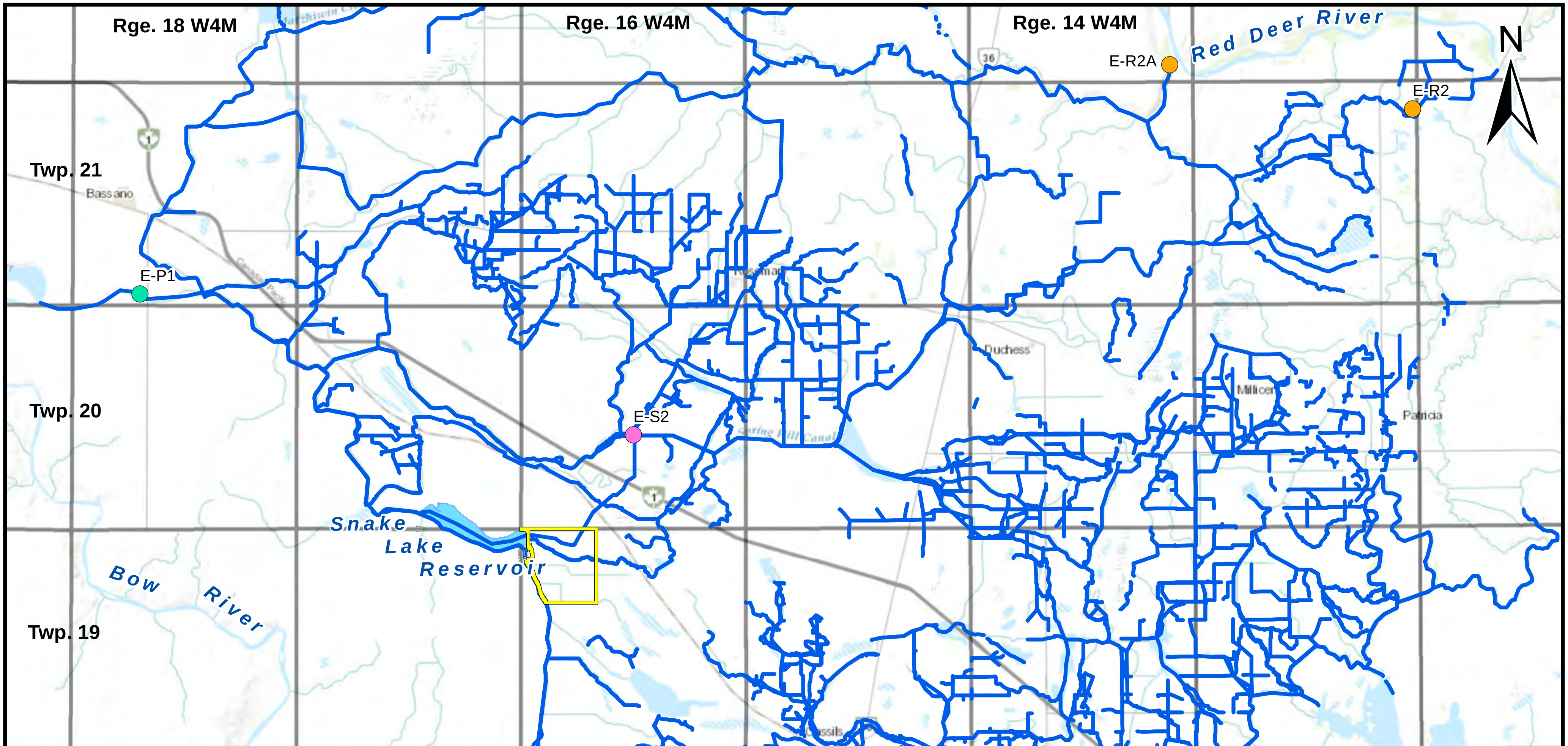
EID

Predicted Littoral and Pelagic Zones within the Snake Lake Reservoir Expansion at New Full Supply Level (782.0 m)

January 2025

REF.: AARES 21-127 (Aquatics)

Figure E1-12



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Approved:	EM	Revision: 0
Route Source:		Date: Feb 14, 2022
KML		Revision: 0

Data Sources:
Imagery: ESRI. Date 1/15/2018
ATS Grid: AltaLIS 2007.
Sampling Locations: http://www.idwq.ca/

AAR Environmental Services

Please contact AARES
for all other sources.

Please note that the imagery is from 2018 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

Legend

- Snake Lake Reservoir Expansion Area Project
- Existing Snake Lake Reservoir
- Irrigation District Canal
- Primary Sampling Site - Active
- Secondary Sampling Site - Active
- Return Sampling Site - Active

EID

Alberta Irrigation District Water Quality Sampling Sites for Water Chemistry Parameters

February 2025

REF.: AARES 21-127
(Water Quantity)

Figure E1-13

Appendix E2: Tables

Irrigation water upstream and downstream of Snake Lake Reservoir

Water Quality Data from the Irrigation District Water Quality Data Portal (http://www.idwq.ca) was assessed at EID locations upstream (E-P1) and downstream (E-S2) of the SLR see Figure E1-13. Data from these sites between 2021-2023 was extracted from the database and compared with published standards. Specifically, the Alberta Surface Water Quality Guidelines for the Protection of Aquatic Life, Agricultural Water Use and Recreation (Government of Alberta, 2018) and the CCME Aquatic Life Guidelines (Canadian Council of Ministers of the Environment, 2007).This period was selected to align with field sampling from the SLR. All parameters in the database were included in the comparison.

Table E2-1: Guideline values for irrigation, livestock, recreation, and protection of aquatic life based on Environmental Quality Guidelines for Alberta Surface Waters and CCME Aquatic Life Guidelines

Parameter	Unit	Environmental Quality Guidelines[9]				CCME Aq Life
		Irrigation	Livestock	Recreation	PAL[7]	
Water Temperature	°C				Narrative[8]	
Total Suspended Solids	mg/L				Narrative[8]	
pH				5.0 to 9.0	6 to 9	
Electric conductivity	dS/m	≤ 1.0[1]				
Dissolved Calcium	mg/L		1,000			
Sodium adsorption ratio		≤ 5[1]				
Dissolved Iron	mg/L				0.3	0.3
Chloride	mg/L	100 to 700[3]			120	120
Sulphate	mg/L		1,000		128[6]	
Total Alkalinity as $CaCO_3$	mg/L				20 (min)	
Total dissolved solids	mg/L	500 to 3,500[3]	3,000			
Nitrate as N	mg/L				3	
Nitrite as N	mg/L		10		0.06[5]	
Nitrate as N + Nitrite as N	mg/L		100			
Total phosphorus	mg/L				Narrative[8]	
Escherichia coli	cfu/100mL	100		≤ 100		
Aluminium total	mg/L	5[2]	5		5	
Arsenic total	mg/L	0.16	0.025		0.005	0.005
Beryllium total	mg/L	0.1	0.1			
Boron total	mg/L	0.5 to 6[3]	5		1.5	1.5
Cadmium total	mg/L	0.0082	0.08		equation[4,6]	0.00009
Chromium (hexavalent) total	mg/L	0.008	0.05		0.0089	0.001
Chromium (trivalent) total	mg/L	0.0049	0.05			0.0089
Cobalt total	mg/L	0.05[2]	1		equation[4,6]	
Copper total	mg/L	0.2	0.5		0.007[4]	equation[4]
Iron total	mg/L	5				
Lead total	mg/L	0.2	0.1		equation[4,6]	equation[4]
Lithium total	mg/L	2.5				
Manganese total	mg/L	0.2[2]				0.43[10]
Mercury total	mg/L		0.003		0.005	0.000026
Molybdenum total	mg/L	0.01	0.5[C]		0.073	0.073
Nickel total	mg/L	0.2[2]	1[2]		equation[4,6]	
Selenium total	mg/L	0.02 or 0.05[12]	0.05			
Silver total	mg/L				0.00025	0.00025
Thallium total	mg/L				0.0008	0.0008
Uranium total	mg/L	0.01	0.2		0.015	0.015
Vanadium total	mg/L	0.1	0.1			
Zinc total	mg/L	1 or 5[11]			0.03	0.007
Glyphosate	ug/L		280			800
2,4-Dichlorophenoxyacetic acid	ug/L				4	
4-(2,4-dichlorophenoxy)butyric acid	ug/L				25	
2,4-Dichlorophenol	ug/L				0.2	
Atrazine	ug/L	10	5		1.8	1.8
Azinphos-methyl	ug/L				0.01	
Bromacil	ug/L	0.2	1,100		5	5.0
Bromoxynil	ug/L	0.44	11		5	5.0
Captan	ug/L		13		1.3	1.3
Carbaryl	ug/L		1,100		0.2	0.2
Carbofuran	ug/L		45			
Chlorpyrifos	ug/L		24		0.002	0.002
Deltamethrin	ug/L		2.5		0.0004	
Diazinon	ug/L				0.17	
Dicamba	ug/L	0.008	122		10	10

Parameter	Unit	Environmental Quality Guidelines[9]				CCME Aq Life
		Irrigation	Livestock	Recreation	PAL[7]	
Dimethoate	ug/L		3		6.2	
Fluoride	mg/L	1[2]	1[2]			
Hexachlorocyclohexane-alpha	ug/L					
Hexachlorocyclohexane-delta	ug/L					
Lindane (Hexachlorocyclohexane)	ug/L		4		0.01	0.01
Linuron	ug/L	0.11			7	
Malathion	ug/L				0.1	
MCPA (4-chloro-2methyl phenoxy acetic acid)	ug/L	0.04	25			
Mecoprop	ug/L		100		13	
Metolachlor	ug/L	28	50		7.8	7.8
Methoprene	ug/L				0.9	0.09
Methoxychlor	ug/L				0.03	
Mirex	ug/L				0.001	
cis-Permethrin	ug/L				0.004	0.004
trans-Permethrin	ug/L				0.004	0.004
Picloram	ug/L		190		29	29
Quinclorac	ug/L		100			
Simazine	ug/L	0.5	10		10	10
Triallate	ug/L		230		0.24	0.24

1. For irrigation suitability, the "safe" value was listed for conductivity.
2. Irrigation guidelines were derived for all soils, but higher concentrations may be safe for neutral or alkaline soils. However, the substance should not be allowed to accumulate in soils.
3. The irrigation guideline for is crop-specific.
4. Varies with hardness.
5. Varies with chloride.
6. Equations available in corresponding Guidelines documents.
7. Protection of Freshwater Aquatic Life.
8. Narrative the guideline is based on maintaining the value within a certain range of the baseline concentration. For this assessment, baseline assumed to be the median among years. Narrative values assessed as: Temperature: Median + 5 ºC. Total Suspended Solids: Median + 25 mg/L or +10 mg/L for median > 250. Total Nitrogen and Total Phosphorus: Median x 2
9. For guidelines with both short-term (acute) and long-term (chronic) values, the concentration for long-term was selected. For values with a range, the more stringent value was selected.
10. Lifetime guideline.
11. Irrigation guideline is 1 mg/L when soil pH is <6.5 and 5 mg/L when soil pH is > 6.5.
12. Depending on continuous or intermittent use.

Parameters with no Guidelines:

Acetamiprid , Alachlor, Aldrin, Allidochlor, alpha-Endosulfan, Ametoctradin , Aminomethyl phosphonic acid, Ammonia as N, Antimony total, Azoxystrobin, Barium total, Benalaxyl, Benfluralin, Bentazon, Benzoylprop-Ethyl, Bicarbonate as CaCO3, Bifenazate, Bifenthrin, Bismuth total, Bixafen, Boscalid, Broflanilide, Bromophos-Ethyl, Bromopropylate, Bupirimate, Butachlor, Butralin, Butylate, Carbofuran, Carbonate as CaCO3, Carfentrazone-ethyl, Chlorantraniliprole, Chlorimuron ethyl, Chlormephos, Chloroneb, Chlorophyll-a, Chlorothalonil, Chlorpyrifos-Methyl, Chlorthal-Dimethyl, Chlorthiamid, cis-Chlordane, Clethodim, Clodinafop-propargyl, Clomazone, Clopyralid, Cloransulam methyl, Clothianidin, Cyantraniliprole, Cycloate, Cyfluthrin, Cyhalothrin lambda, Cypermethrin-beta, Cypermethrin-zeta, Cyprodinil, Desmetryn, Dichlobenil, Dichlofenthion, Dichlorprop, Dichlorvos, Diclofop, Dieldrin, Difenoconazole, Dimethachlor, Dimethenamid-P, Dimethomorph, Dinotefuran, Dioxathion, Diphenamid, Diuron, Endrin, EPTC_(S-ethyl_dipropylthiocarbamate), Ethalfluralin, Ethion, Ethofumesate, Etradiazole, Etrimphos, Famoxadone, Fenamidone, Fenchlorphos, Fenhexamid, Fenoxaprop, Fenthion, Flamoxadone, Flamprop-Isopropyl, Flamprop-Methyl, Flonicamid, Fluazifop-p-butyl, Fludioxonil, Flumetralin, Flumioxazin, Flupyradifurone, Fluroxypyr, Flutriafol, Fluxapyroxad, Folpet, Fonofos, Glufosinate, Halosulfuron-methyl, Hardness as CaCO3, Heptachlor, Hexachlorocyclohexane-beta, Hexazinone, Hydroxide as CaCO3, Imazamethabenz, Imazethapyr, Imidacloprid, Ion Balance, Ipconazole, Iprodione, Isofenphos, Kjeldahl nitrogen Total, Kresoxim, Magnesium Dissolved, Magnesium total, Manganese Dissolved, MCPA-EHE, MCPB-methyl, Metalaxyl, Metconazole, Metrafenone, Metribuzin, Monolinuron, Myclobutanil, Naled, Napropamide, Nicotine, Nitenpyram, Nitrapyrin, Nitrogen Total, o,p-Dichlorodiphenyl-dichloroethane, o,p-Dichlorodiphenyl-dichloroethylene, o,p-Dichlorodiphenyl-trichloroethane, Oxycarboxin, Oxyfluorfen, p,p-Dichlorodiphenyl-dichloroethane, p,p-Dichlorodiphenyl-dichloroethylene, p,p-Dichlorodiphenyl-trichloroethane, Pendimethalin, Phorate, Phosmet, Phosphorus Dissolved reactive, Phosphorus Total dissolved, Picoxystrobin, Piperonyl butoxide, Pirimicarb, Pirimiphos-Ethyl, Pirimiphos-Methyl, Potassium Dissolved, Potassium total, Procymidone, Prometon, Prometryn, Propetamphos, Propham, Propiconazole, Propoxur, Propoxycarbazone sodium salt, Propyzamide, Prothioconazole-Desthio, Pymetrozine, Pyraclostrobin, Pyrasulfotole, Pyridaben, Pyrimethanil, Pyroxasulfone, Quinoxyfen, Quintozene, Quizalofop-ethyl, Saflufenacil, Sedaxane, Silicon total, Sodium Dissolved, Sodium total, Spirodiclofen, Spiromesifen, Spiroxamine, Strontium total, Sulfentrazone, Sulfotep, Sulfoxaflor, Sulfur total, Sulprophos, t-Chlordane, Tebuconazole, Tembotrione, Terbacil, Terbufos, Terbutryn, Tetraconazole, Tetradifon, Tetramethrin I, Tetrasul, Thiacloprid, Thiamethoxam, Thifensulfuron-methyl, Thiophanate-methyl, Tin total, Titanium total, trans-Heptachlor Epoxide, Triclopyr, Trifloxystrobin, Trifluralin, Triticonazole, Vinclozolin, Zoxamid

Table E2-2: Snake Lake Reservoir water chemistry parameters (2021 to 2023) versus water quality guidelines

Parameter	Unit	Spring 2021[1]	Fall 2021[1]	Winter 2022[1]	Fall 2023[1]	Fall 2023 (Dugouts)[1]
TSS	mg/L	<3.0	-	<3.0	-	-
Turbidity	NTU	0.80	-	2.23	-	-
TDS (Calculated)	mg/L	341	-	329.5	240.0	307.5
Alkalinity, Total (as $CaCO_3$)	mg/L	162	-	163	118	84
Bicarbonate (HCO_3)	mg/L	197	-	193.5	148	104.5
Carbonate (CO_3)	mg/L	<5.03[3]	-	1.3	<5	<5
Chloride (Cl) (Soluble)	mg/L	16.9	-	17.1	15	17.1
Conductivity (EC)	µS/cm	544	-	536	422	517
Fluoride (F)	mg/L	0.160	-	0.157	0.12	0.25
Hardness (as $CaCO_3$)	mg/L	213	-	159.5	179	170.5
Hydroxide (OH^-)	mg/L	<5.0	-	<1.0	<5	<5
Nitrate (as N)	mg/L	<0.020	<0.020	<0.020	<0.02	<0.02
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.01	<0.01
TKN	mg/L	0.35	0.37	0.330	-	1.95
Total Nitrogen	mg/L	0.35	0.37	0.330	-	3.6
pH ($CaCl_2$ Extraction)	pH	7.79	-	8.32	7.92	8.08
Phosphorus (P)-Total	mg/L	0.0126	0.0170	2	-	-
Sulfate (SO_4; Soluble)	mg/L	120	-	107	15	17.1
Coliform Bacteria	CFU/100mL	<1	<1	<1	-	-
MPN - Total Coliforms	MPN/100mL	7	-	<1	-	-
BOD	mg/L	<2.0	<2.0	<2.0	-	-
Aluminum (Al)-Total	mg/L	0.0256	0.0256	0.0091	0.031	0.029
Antimony (Sb)-Total	mg/L	<0.00010	<0.00010	0.00011	<0.001	<0.001
Arsenic (As)-Total	mg/L	0.00054	0.00097	0.00068	0.005	0.005
Barium (Ba)-Total	mg/L	0.0608	0.0571	0.0709	0.06	0.10
Beryllium (Be)-Total	mg/L	<0.00010[2]	<0.00010	<0.000020	<0.0005	<0.0005
Bismuth (Bi)-Total	mg/L	<0.000050	<0.000050	<0.000050	-	-
Boron (B)-Total	mg/L	0.028	0.023	0.030	0.03	0.06
Cadmium (Cd)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.000016	<0.000016
Calcium (Ca)-Total	mg/L	55.7	45.3	54.35	-	-
Cesium (Cs)-Total	mg/L	<0.000010	<0.000010	<0.000010	-	-
Chromium (Cr)-Total	mg/L	<0.00010	<0.00010	<0.00050	<0.0005	<0.0005
Cobalt (Co)-Total	mg/L	0.00016	0.00015	0.00014	0.00022	0.00061
Copper (Cu)-Total	mg/L	0.00075	0.00052	0.00071	0.0012	0.0013
Iron (Fe)-Total	mg/L	0.024	0.052	0.014	1.1	1.1
Lead (Pb)-Total	mg/L	<0.000050	<0.000050	0.000121	0.0002	0.0007
Lithium (Li)-Total	mg/L	0.0144	0.0106	0.0141	-	-
Magnesium (Mg)-Total	mg/L	20.9	18.6	22.5	-	-
Manganese (Mn)-Total	mg/L	0.00630	0.00929	0.00530	0.023	0.084
Mercury (Hg)-Total	µg/L	0.00033	0.00024	0.360	0.3375	<0.025
Molybdenum (Mo)-Total	mg/L	0.00162	0.00145	0.00642	0.001	0.002
Nickel (Ni)-Total	mg/L	0.00122	0.00114	0.00135	0.003	0.003
Phosphorus (P)-Total	mg/L	<0.050	0.017	<0.050	-	-
Potassium (K)-Total	mg/L	3.33	2.51	3.09	2.4	5.8
Rubidium (Rb)-Total	mg/L	0.00082	0.00081	0.00076	-	-
Selenium (Se)-Total	mg/L	0.000228	0.000237	0.000227	<0.0005	<0.0005
Silicon (Si)-Total	mg/L	0.772	0.672	0.20	-	-
Silver (Ag)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.00005	<0.00005
Sodium (Na)-Total	mg/L	30.6	24.2	28.6	19	43.3
Strontium (Sr)-Total	mg/L	0.315	0.277	0.331	-	-
Sulfur (S)-Total	mg/L	40.45	29.7	41.7	-	-
Tellurium (Te)-Total	mg/L	<0.00020	<0.00020	<0.00020	-	-

Parameter	Unit	Spring 2021[1]	Fall 2021[1]	Winter 2022[1]	Fall 2023[1]	Fall 2023 (Dugouts)[1]
Thallium (Tl)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.0001	<0.0001
Thorium (Th)-Total	mg/L	<0.00010	<0.00010	<0.00010	-	-
Tin (Sn)-Total	mg/L	<0.00010	<0.00010	<0.00010	-	-
Titanium (Ti)-Total	mg/L	<0.00030	0.0004	<0.00030	0.002	<0.001
Tungsten (W)-Total	mg/L	<0.00010	<0.00010	<0.00010	-	-
Uranium (U)-Total	mg/L	0.00121	0.000734	0.00105	<0.001	<0.001
Vanadium (V)-Total	mg/L	<0.00050	0.00062	0.00052	-	-
Zinc (Zn)-Total	mg/L	<0.0030	<0.0030	<0.0030	0.006	<0.004
Zirconium (Zr)-Total	mg/L	<0.00020	<0.00020	<0.00020	-	-
Acenaphthene	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00001
Acridine	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00005
Anthracene	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00001
Benzo(a)anthracene	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00001
Benzo(a)pyrene	mg/L	<0.000005	<0.000005	<0.000005	-	<0.000007
Fluoranthene	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00001
Fluorene	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00001
Naphthalene	mg/L	<0.00002	<0.00002	<0.00005	-	<0.00001
Phenanthrene	mg/L	<0.00002	<0.00002	<0.00002	-	<0.00001
Pyrene	mg/L	<0.00001	<0.00001	<0.00001	-	<0.00001
Quinoline	mg/L	<0.00005	<0.00005	<0.00005	-	<0.00004
Total PCBs	µg/L	<0.030	<0.030	<0.060	-	<0.050

1. Mean of East and West Sites for the SLR, or of two dugout sites in the expansion area.
2. Narrative: the guideline is based on maintaining the value within a certain range of the baseline concentration.
3. Chronic effects guideline.

Note: Red shading indicates an exceedance of guideline levels for protection of aquatic life; (-) = not measured.

Table E2-3: Calculated guideline values for water quality parameters from SLR (2021 to 2023) based on Environmental Quality Guidelines for Alberta Surface Waters

Parameter	Unit	Method	Spring 2021	Winter 2022	Fall 2023	Fall 2023 (Dugouts)
Cadmium Chronic Guideline	µg/L	Varies with hardness[1]	0.000030	0.00023	0.00026	0.00025
Cadmium Acute Guideline	µg/L	Varies with hardness[1]	0.0046	0.0034	0.0038	0.0036
Cobalt Chronic Guideline	µg/L	Varies with hardness[1]	0.0014	0.0012	0.0013	0.0013
Copper Acute Guideline	µg/L	Varies with hardness[1]	0.034	0.025	0.028	0.027
Lead Chronic Guideline	µg/L	Varies with hardness[1]	0.007	0.0058	0.0067	0.0063
Nickel Chronic Guideline	µg/L	Varies with hardness[1]	0.10	0.078	0.078	0.082
Nickel Acute Guideline	µg/L	Varies with hardness[1]	0.900	0.700	0.700	0.740
Nitrite-N 30 Day Average Guideline	mg/L	Varies with chloride[2]	0.429	0.309	0.309	0.309
Nitrite-N Maximum Guideline	mg/L	Varies with chloride[2]	0.0002	0.0002	0.0002	0.0002
Sulfate (SO_4^2) (Soluble)	mg/L	Varies with hardness[1]	429	309	309	309

Note: Fall 2021 values were not collected. Values presented in this table are calculated based on Table 1.3 and Table 1.4 in Environmental Quality Guidelines for Alberta Surface Waters (Government of Alberta, 2018).

[1]Refer to measured **Hardness (as $CaCO_3$)** values for each specified timeframe, presented in Table E2-2.

[2]Refer to measured **Chloride (Cl) (Soluble)** values for each specified timeframe, presented in Table E2-2.

Table E2-4: Water chemistry parameters (maximum annual values, 2006 to 2024) from Site EP1 upstream of the SLR versus water quality guidelines

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Water Temperature[1]	degrees C	22.70	21.80	19.80	18.40	19.70	24.20	22.40	21.50	20.50	19.80	20.10	23.50	23	20.30	22.70	20.20
Total Suspended Solids[1]	mg/L	11	7	25	34	144	20	12	13	49	48	156	90	25	37	10	14
pH		8.60	8.60	8.33	8.40	8.39	8.47	8.58	8.52	8.27	8.24	8.29	8.37	8.43	8.52	8.68	8.18
Electric conductivity	dS/m	0.36	0.36	0.35	0.35	0.37	0.38	0.36	0.41	0.40	0.36	0.37	0.40	0.37	0.38	0.36	0.38
Dissolved Calcium	mg/L	41.10	42.80	41.50	43.80	48.80	48.40	44	43.40	47.70	43.80	46.40	50	46.40	43.60	40.80	45.60
Dissolved Magnesium	mg/L	14.50	15.40	14.30	15.60	15.10	15.10	15	15.80	17	14.60	14.90	15	15.40	16.30	15	15.90
Dissolved Sodium	mg/L	13	14	9.70	11.70	12	11.90	13.30	20	16.20	12.50	12.40	14.80	12.20	11.70	13.70	12.70
Dissolved Potassium	mg/L	1.80	1.90	1.10	1.60	1.40	1.70	1.70	2.30	2.10	1.80	1.80	2	1.60	12.90	10.20	1.90
Sodium adsorption ratio		0.45	0.49	0.35	0.40	0.40	0.40	0.40	0.70	0.50	0.40	0.40	0.50	0.40	0.40	0.50	0.40
Dissolved Iron	mg/L	-	-	-	0	0	0	0	0	0	0	0	0.02	0	0.01	0.01	-
Chloride	mg/L	8.90	9.30	8.40	8.70	8.80	10.60	11.10	13	11.80	10.60	13.30	11.70	12.30	12.80	14.80	12.90
Sulphate	mg/L	50.70	51	44.70	45.40	45	44.90	50.70	61.40	60.50	50.90	49.60	45	46.90	55.90	50.10	53.80
Bicarbonate as $CaCO_3$	mg/L	149	203	173	168	189	180	163	168	165	161	170	177	182	160	148	157
Carbonate as $CaCO_3$	mg/L	8	6	0	0	0	7	6	0	0	0	0	0	0	9	7	6
Total Alkalinity as $CaCO_3$	mg/L	136	167	142	138	155	159	134	138	135	132	140	145	150	131	122	130
Hardness as $CaCO_3$	mg/L	162	165	162	163	184	183	172	173	180	164	176	184	173	171	161	177
Ion Balance	%	101	102	98	102	100	99	100	101	105	99	103	105	104	103	105	104
Total dissolved solids	mg/L	208	221	226	199	219	226	215	236	229	202	218	225	212	213	199	214
Total nitrogen[1]	mg/L	-	-	0.47	0.66	0.63	0.67	0.61	0.61	0.91	0.92	0.91	0.58	0.61	0.61	0.59	0.59
Total kjeldahl nitrogen	mg/L	0.5	2.5	0	0	0	0	0	0	-	-	-	-	-	-	-	-
Nitrate as N	mg/L	0.56	0.49	0.51	0.45	0.47	0.51	0.52	0.42	0.57	0.43	0.46	0.39	0.44	0.36	0.31	1
Nitrite as N	mg/L	0	0	0.007	0	0.006	0.008	0	0.012	0.007	0.008	0.034	0.007	0	0.006	0.007	0
Nitrate as N + Nitrite as N	mg/L	0.56	0.49	0.51	0.45	0.48	0.52	0.52	0.42	0.57	0.44	0.50	0.39	0.44	0.36	0.31	-
Ammonia as N	mg/L	0	0.09	0	0	0.08	0	0	0	0	-	-	-	-	-	-	-
Total phosphorus[1]	mg/L	0.02	0.1	0	0.05	0.13	0.03	0.02	0.03	0.02	0.05	0.18	0.05	0.03	0.02	0.01	0.03
Total dissolved phosphorus	mg/L	-	-	0	0.005	0.009	0.007	0.008	0.008	0.006	-	-	-	-	-	-	-
Dissolved reactive phosphorus	mg/L	0.01	0	0	0.007	0.01	0.008	0	0	-	-	-	-	-	-	-	-
Chlorophyll-a	mg/L	-	-	3	1.80	0	0	0	0	-	-	-	-	-	-	-	-
Escherichia coli	cfu/100mL	40	196	61	150	300	150	53	50	20	110	130	90	35	39	28	34
Aluminium total	mg/L	0.66	2.71	0.57	1.19	3.11	0.44	0.3	0.14	-	-	-	-	-	-	-	-
Antimony total	mg/L	0.0009	0.001	0	0	0	0	0	0	-	-	-	-	-	-	-	-
Arsenic total	mg/L	0.0008	0.0013	0.0006	0.0008	0.0015	0.0006	0.0008	0.0006	-	-	-	-	-	-	-	-
Barium total	mg/L	0.10	0.09	0.06	0.07	0.11	0.07	0.06	0.06	-	-	-	-	-	-	-	-
Boron total	mg/L	0.15	0	0.02	0.02	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-
Cadmium total[2]	mg/L	0	0	0.00002	0.00003	0.00018	0.00002	0.00001	0.00001	-	-	-	-	-	-	-	-
Chromium total	mg/L	0	0	0.0009	0.0024	0.003	0.0006	0	0	-	-	-	-	-	-	-	-
Cobalt total[2]	mg/L	0	0	0.0002	0.0006	0.0013	0.0003	0.0002	0.0002	-	-	-	-	-	-	-	-
Copper total[2]	mg/L	0.006	0.003	0.001	0.002	0.004	0.001	0.001	0	-	-	-	-	-	-	-	-
Iron total	mg/L	0.49	2.22	0.48	0.94	3.07	0.49	0.28	0.15	-	-	-	-	-	-	-	-
Lead total[2]	mg/L	0.0005	0.0014	0.0003	0.0008	0.0019	0.0004	0.0003	0.0002	-	-	-	-	-	-	-	-
Lithium total	mg/L	0	0	0.005	0.006	0.007	0.005	0.005	0.006	-	-	-	-	-	-	-	-
Magnesium total	mg/L	14	14.30	14	0	0	0	0	0	-	-	-	-	-	-	-	-
Manganese total	mg/L	0.02	0.05	0.02	0.04	0.07	0.02	0.02	0.02	-	-	-	-	-	-	-	-
Molybdenum total	mg/L	0	0	0	0.001	0.001	0.001	0.001	0.001	-	-	-	-	-	-	-	-
Nickel total[2]	mg/L	0	0.004	0	0.0017	0.0044	0.0013	0.001	0.0008	-	-	-	-	-	-	-	-
Potassium total	mg/L	1.8	2.3	1.5	0	0	0	0	0	-	-	-	-	-	-	-	-
Selenium total	mg/L	0.0008	0.0012	0.0009	0.0007	0.0009	0.0005	0.0005	0.0004	-	-	-	-	-	-	-	-
Silicon total	mg/L	-	-	2	5.16	9.24	2.74	1.82	0.49	-	-	-	-	-	-	-	-
Silver total	mg/L	0	0	0.00001	0.00001	0.00003	0.00005	0	0	-	-	-	-	-	-	-	-
Sodium total	mg/L	13	13	10	0	0	0	0	0	-	-	-	-	-	-	-	-
Strontium total	mg/L	-	-	0.21	0.22	0.24	0.24	0.23	0.26	-	-	-	-	-	-	-	-
Sulfur total	mg/L	-	-	12.8	15.1	14.2	14.8	17.1	20.9	-	-	-	-	-	-	-	-
Thallium total	mg/L	0.0002	0.0006	0.0002	0	0.00006	0	0	0	-	-	-	-	-	-	-	-
Titanium total	mg/L	0.04	0.03	0.01	0.04	0.04	0.007	0.007	0.004	-	-	-	-	-	-	-	-
Uranium total	mg/L	0.0008	0.0009	0.0007	0.0008	0.0009	0.0007	0.0007	0.0008	-	-	-	-	-	-	-	-
Vanadium total	mg/L	0.002	0.007	0.0017	0.005	0.0063	0.0012	0.0011	0.0007	-	-	-	-	-	-	-	-
Zinc total	mg/L	0.031	0.028	0.021	0.007	0.020	0.006	0.005	0.002	-	-	-	-	-	-	-	-
2,4-Dichlorophenoxyacetic acid	ug/L	0.20	0.08	0.05	0.08	0.09	0.18	0.09	0.18	0.08	0.06	0.05	0.03	0	0	0	-
4-(2,4-dichlorophenoxy)butyric acid	ug/L	0	0	0	0	0	0	0	0	0	0	0	0.07	0	0	0	-
Atrazine	ug/L	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0.01	0

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Bentazon	ug/L	-	-	-	0	0	0	0	0.04	0	0	0	0	-	-	-	-
Broflanilide	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0.02	0
Cloransulam methyl	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0.03	0
Dicamba	ug/L	0.02	0.32	0	0	0	0	0	0	0	0.03	0	0	0	0.03	0	-
Diphenamid	ug/L	-	-	0	0	0	0	0	0	0	0	0	0.02	-	-	0	0
Ethion	ug/L	-	-	0	0	0	0	0	0	0	0	0	-	0	0.23	0	-
Hexazinone	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.39	0	0	0	0
Imazamethabenz	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0	0.06	0
MCPA_(2-methyl-4-chlorophenoxyacetic_acid)	ug/L	0	0	0	0	0	0	0.03	0.04	0	0	0	0	0	0	0	-
Mecoprop_(methylchlorophenoxypropionic_acid)	ug/L	0.07	0.05	0	0	0	0.04	0	0.07	0	0	0	0	0.08	0	0	-
Procymidone	ug/L	-	-	0	0	0	0	0	0	0	0	0	-	0.05	0	0	-
Prothioconazole-Desthio	ug/L	-	-	-	0	0	0	0.03	0	0	0	0	-	-	-	-	-
Quinoxyfen	ug/L	-	-	-	0	0	0	0	0	-	-	0	-	0	0	0.04	0
Spiroxamine	ug/L	-	-	-	0	0	0	0	0	-	-	0	-	0	0.13	0	0
Thifensulfuron-methyl	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0	1.10
Zoxamide	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0.09	0

1. Narratives:
   Temperature:: Median + 5 ºC = 26.5 ºC
   Total Suspended Solids: Median + 25 mg/L or +10 % for median > 250 = 50 mg/L
   Total Nitrogen: Median x 2 = 1.22 mg/L
   Total Phosphorus: Median x 2 = 0.064
2. Equation Values based on Minimum Hardness ($CaCO_3$) = 161 mg/L
   Cadmium total: 0.00023 mg/L
   Cobalt total: 0.00012 mg/L
   Copper total: 0.025 mg/L
   Lead total: 0.0058 mg/L
   Nickel total: 0.078 mg/L

Note: 0 = Below detection limit; (-) = not measured

Parameter not measured or not detected in all samples:

2,4-Dichlorophenol, Acetamiprid, Alachlor, Aldrin, Allidochlor, alpha-Endosulfan, Ametoctradin , Aminomethyl phosphonic acid, Azinphos-methyl, Azoxystrobin, Benalaxyl, Benfluralin, Benzoylprop-Ethyl, Beryllium total, Bifenazate, Bifenthrin, Bismuth total, Bixafen , Boscalid, Bromacil, Bromophos-Ethyl, Bromopropylate, Bromoxynil, Bupirimate, Butachlor, Butralin, Butylate, Captan, Carbaryl, Carbofuran, Carboxin , Carfentrazone-ethyl, Chlorantraniliprole , Chlorimuron ethyl , Chlormephos, Chloroneb, Chlorothalonil, Chlorpyrifos, Chlorpyrifos-Methyl, Chlorthal-Dimethyl, Chlorthiamid, cis-Chlordane, cis-Permethrin, Clethodim , Clodinafop-propargyl, Clomazone, Clopyralid, Clothianidin , Cyantraniliprole , Cycloate, Cyfluthrin, Cyhalothrin lambda, Cypermethrin-beta, Cypermethrin-zeta, Cyprodinil, Deltamethrin, Desmetryn, Diazinon, Dichlobenil, Dichlofenthion, Dichlorprop, Dichlorvos, Diclofop, Dieldrin, Difenoconazole, Dimethachlor, Dimethenamid-P, Dimethoate, Dimethomorph, Dinotefuran , Dioxathion, Dissolved Manganese, Diuron, Endrin, EPTC_(S-ethyl_dipropylthiocarbamate), Ethalfluralin, Ethofumesate, Etradiazole, Etrimphos, Famoxadone, Fenamidone, Fenchlorphos, Fenhexamid , Fenoxaprop, Fenthion, Flamoxadone , Flamprop-Isopropyl, Flamprop-Methyl, Flonicamid , Fluazifop-p-butyl, Fludioxonil, Flumetralin, Flumioxazin, Flupyradifurone , Fluroxypyr, Flutriafol, Fluxapyroxad , Folpet, Fonofos, Glufosinate, Glyphosate, Halosulfuron-methyl , Heptachlor, Hexachlorocyclohexane-alpha, Hexachlorocyclohexane-beta, Hexachlorocyclohexane-delta, Hydroxide as $CaCO_3$, Imazethapyr, Imidacloprid , Ipconazole, Iprodione, Isofenphos, Kresoxim, Lindane_(Hexachlorocyclohexane-gamma), Linuron , Malathion, MCPA-EHE, MCPB-methyl, Mercury total, Metalaxyl, Metconazole, Methoprene, Methoxychlor, Metolachlor, Metrafenone, Metribuzin, Mirex, Monolinuron, Myclobutanil, Naled, Napropamide, Nicotine, Nitenpyram , Nitrapyrin, o,p-Dichlorodiphenyldichloroethane, o,p-Dichlorodiphenyldichloroethylene, o,p-Dichlorodiphenyltrichloroethane, Oxycarboxin, Oxyfluorfen, p,p-Dichlorodiphenyldichloroethane, p,p-Dichlorodiphenyldichloroethylene, p,p-Dichlorodiphenyltrichloroethane, Pendimethalin, Phorate, Phosmet, Picloram, Picoxystrobin, Piperonyl butoxide, Pirimicarb, Pirimiphos-Ethyl, Pirimiphos-Methyl, Prometon, Prometryn, Propetamphos, Propham, Propiconazole, Propoxur, Propoxycarbazone sodium salt , Propyzamide, Pymetrozine, Pyraclostrobin, Pyrasulfotole , Pyridaben, Pyrimethanil, Pyroxasulfone , Quinclorac, Quintozene, Quizalofop-ethyl, Saflufenacil , Sedaxane , Simazine, Spirodiclofen, Spiromesifen, Sulfentrazone, Sulfotep, Sulfoxaflor , Sulprophos, t-Chlordane, Tebuconazole, Tembotrione , Terbacil, Terbufos, Terbutryn, Tetraconazole , Tetradifon, Tetramethrin I, Tetrasul, Thiacloprid , Thiamethoxam , Thiophanate-methyl , Tin total, trans-Heptachlor Epoxide, trans-Permethrin , Triallate, Triclopyr, Trifloxystrobin, Trifluralin, Triticonazole, and Vinclozolin

Table E2-5: Water chemistry parameters (maximum annual values, 2006 to 2024) from Site ES2 downstream of the SLR (2021 to 2023) versus water quality guidelines

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Water Temperature[1]	degrees C	22.70	21.40	20.10	18.90	20.10	23.30	21.20	21	19.10	19.70	20.50	22.50	23	21.30	22.60	20.60
Total Suspended Solids[1]	mg/L	12	6	32	18	90	251	29	8	30	18	151	26	26	21	10	7
pH		8.60	8.70	8.31	8.37	8.34	8.49	8.44	8.43	8.24	8.25	8.32	8.51	8.37	8.42	8.46	8.16
Electric conductivity	dS/m	0.35	0.36	0.35	0.35	0.37	0.37	0.35	0.43	0.42	0.38	0.41	0.39	0.37	0.38	0.35	0.40
Dissolved Calcium	mg/L	40.50	38.80	42.10	43.10	47.50	47.90	43	42.70	49.70	42.50	50.10	46.20	46.30	43.10	40.80	48.30
Dissolved Magnesium	mg/L	14.60	15.80	16.50	15.20	14.80	15.10	15	17.20	18.50	15.70	16.50	15.70	15.30	16.50	15.30	16.20
Dissolved Sodium	mg/L	13	14	11.10	12	16.20	11.80	13.60	23.70	21.80	17.30	13.40	15.70	13	14.90	13.80	14.50
Dissolved Potassium	mg/L	1.70	1.80	1.37	1.50	1.50	1.60	1.70	2.20	2.10	2	1.80	1.80	1.70	13.80	11.70	1.90
Sodium adsorption ratio		0.46	0.49	0.37	0.42	0.53	0.40	0.50	0.80	0.70	0.60	0.40	0.50	0.40	0.50	0.50	0.50
Dissolved Iron	mg/L	-	-	-	-	-	-	-	-	0	0	0.01	0	0	0.01	0	-
Chloride	mg/L	8.30	9.20	7.90	9.20	9.40	9	10.40	12.90	13.20	11.20	15.10	11.40	12.60	17.50	13.40	14.50
Sulphate	mg/L	50.70	53.10	46.50	47.20	52.60	45.70	52.10	77.90	77.60	62.10	53.70	59	51.30	57.50	52.60	55.50
Bicarbonate as $CaCO_3$	mg/L	152	162	179	179	189	171	180	167	173	154	196	171	173	160	146	166
Carbonate as $CaCO_3$	mg/L	6	6	0	0	0	6	6	0	0	0	0	0	0	0	0	0
Total Alkalinity as $CaCO_3$	mg/L	135	133	147	147	155	149	147	137	142	126	161	140	142	131	119	136
Hardness as $CaCO_3$	mg/L	161	157	165	167	177	182	169	175	184	158	193	175	172	176	160	184
Ion Balance	%	98.90	99.80	100	97	102	100	100	100	103	103	102	103	103	103	105	105
Total dissolved solids	mg/L	208	222	227	212	224	220	219	250	250	216	247	230	221	221	200	220
Total nitrogen[1]	mg/L	-	-	0.40	0.55	0.64	0.67	0.49	1.11	0.58	0.61	0.83	0.54	0.98	0.81	0.43	0.49
Total Kjeldahl Nitrogen	mg/L	0.3	0.2	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate as N	mg/L	0.52	0.43	0.43	0.36	0.45	0.48	0.32	0.36	0.35	0.31	0.38	0.31	0.45	0.38	0.3	0
Nitrite as N	mg/L	0	0	0.007	0	0.009	0.007	0	0.007	0.009	0.007	0.012	0	0	0.007	0	0
Nitrate as N + Nitrite as N	mg/L	0.52	0.43	0.43	0.36	0.45	0.48	0.32	0.36	0.359	0.31	0.39	0.31	0.45	0.39	0.3	-
Ammonia as N	mg/L	0	0.06	0	0	0.08	0	0	0	0	-	-	-	-	-	-	-
Total phosphorus[1]	mg/L	0	0	0.06	0.05	0.10	0.03	0.04	0.01	0.02	0.02	0.18	0.13	0.04	0.02	0.01	0.03
Total dissolved phosphorus	mg/L	-	-	0	0	0.009	0.009	0.007	0.014	0	-	-	-	-	-	-	-
Dissolved reactive phosphorus	mg/L	0.01	0	0	0	0.01	0.01	0	0	-	-	-	-	-	-	-	-
Chlorophyll-a	mg/L	-	-	4.20	1.80	-	-	-	-	-	-	-	-	-	-	-	-
Escherichia coli	cfu/100mL	78	60	22	56	140	20	69	80	38	50	250	41	31	90	45	80
Aluminium total	mg/L	0.32	0.24	0.51	1.19	1.52	0.32	0.63	0.06	-	-	-	-	-	-	-	-
Antimony total	mg/L	0.0011	0.0011	0	0	0	0.0003	0	0	-	-	-	-	-	-	-	-
Arsenic total	mg/L	0.0008	0.0006	0.0007	0.0008	0.0011	0.0006	0.0008	0.0007	-	-	-	-	-	-	-	-
Barium total	mg/L	0.092	0.053	0.064	0.071	0.086	0.066	0.062	0.06	-	-	-	-	-	-	-	-
Boron total	mg/L	0.15	0	0.016	0.016	0.015	0.016	0.017	0.021	-	-	-	-	-	-	-	-
Cadmium total[2]	mg/L	0	0	0.00002	0.00002	0.00005	0.00002	0.00002	0.00001	-	-	-	-	-	-	-	-
Chromium total	mg/L	0	0	0.0009	0.0018	0.0016	0	0.0008	0	-	-	-	-	-	-	-	-
Cobalt total[2]	mg/L	0	0	0.0003	0.0004	0.0007	0.0003	0.0004	0.0002	-	-	-	-	-	-	-	-
Copper total[2]	mg/L	0.001	0	0.001	0.003	0.002	0.001	0.002	0	-	-	-	-	-	-	-	-
Iron total	mg/L	0.26	0.18	0.47	0.74	1.36	0.4	0.61	0.08	-	-	-	-	-	-	-	-
Lead total[2]	mg/L	0.0003	0.0002	0.0004	0.0005	0.0011	0.0003	0.0005	0	-	-	-	-	-	-	-	-
Lithium total	mg/L	0	0	0.006	0.006	0.005	0.005	0.005	0.008	-	-	-	-	-	-	-	-
Magnesium total	mg/L	13.70	14.40	14.10	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese total	mg/L	0.02	0.01	0.04	0.03	0.05	0.02	0.03	0.01	-	-	-	-	-	-	-	-
Mercury total	mg/L	0	0	0	0	0	0.000021	0	0	-	-	-	-	-	-	-	-
Molybdenum total	mg/L	0	0	0	0.001	0.001	0.001	0.001	0.001	-	-	-	-	-	-	-	-
Nickel total[2]	mg/L	0	0	0	0.0017	0.0025	0.0011	0.0014	0.0013	-	-	-	-	-	-	-	-
Potassium total	mg/L	1.7	1.7	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium total	mg/L	0.0007	0.0012	0.0007	0.0005	0.0007	0.0005	0.0005	0.0005	-	-	-	-	-	-	-	-
Silicon total	mg/L	-	-	2.04	5.82	5.80	2.53	2.77	0.37	-	-	-	-	-	-	-	-
Silver total	mg/L	0	0	0	0.00001	0.00002	0.00003	0	0	-	-	-	-	-	-	-	-
Sodium total	mg/L	13	14	11	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium total	mg/L	-	-	0.22	0.22	0.23	0.23	0.23	0.27	-	-	-	-	-	-	-	-
Sulfur total	mg/L	-	-	13.30	15.30	16.20	14.90	17.20	23.70	-	-	-	-	-	-	-	-
Thallium total	mg/L	0.0001	0	0.0021	0	0	0	0	0	-	-	-	-	-	-	-	-
Titanium total	mg/L	0.03	0.01	0.01	0.03	0.02	0.01	0.02	0.001	-	-	-	-	-	-	-	-
Uranium total	mg/L	0.0008	0.0007	0.0008	0.0008	0.0008	0.0007	0.0007	0.0009	-	-	-	-	-	-	-	-
Vanadium total	mg/L	0.001	0	0.0018	0.0039	0.0033	0.001	0.0019	0.0005	-	-	-	-	-	-	-	-
Zinc total	mg/L	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.002	-	-	-	-	-	-	-	-
2,4-Dichlorophenoxyacetic acid	ug/L	0.37	0.10	0.04	0.07	0.06	0.15	0.07	0.11	0	0.09	0	0.12	0	0.33	0	-
4-(2,4-dichlorophenoxy)butyric acid	ug/L	0	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	-

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Atrazine	ug/L	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0.02	0
Azoxystrobin	ug/L	-	-	-	-	-	-	0	1.01	0	0	0	-	-	-	0	0
Bentazon	ug/L	-	-	-	-	0	0	0	8.18	0	0	0	0	-	-	-	-
Benzoylprop-Ethyl	ug/L	-	-	0	0	0	0	0	0	0	0	0	-	0	0.02	0	0
Broflanilide	ug/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0
Bromoxynil	ug/L	0	0	0	0	0	0	0.13	0	0	0	0	0	0	0	0	-
Boscalid	ug/L	-	-	-	-	-	-	0.05	0	0	0	0	0.03	-	-	0	0
Chlorpyrifos	ug/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0
Clopyralid	ug/L	0.01	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
Cloransulam methyl	ug/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0
Dicamba	ug/L	0.13	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	-
Diphenamid	ug/L	-	-	0	0	0	0	0	0	0	0	0	0.10	-	-	0	-
Ethofumesate	ug/L	-	-	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
Flutriafol	ug/L	-	-	-	-	-	-	-	-	-	-	0	0.17	0	0	0	0
Hexazinone	ug/L	-	-	-	-	-	-	0	0	0	0	0	0.08	0	0	0	0
Imazamethabenz	ug/L	-	-	-	-	-	-	0	0	0	0	0	-	0	0	0.05	0
Imazethapyr	ug/L	0	0	0	0	0	0	0	0.58	0	0	0	-	-	-	0	0
MCPA_(2-methyl-4-chlorophenoxyacetic_acid)	ug/L	0.04	0.02	0	0	0	0	0.12	0.20	0.08	0.03	0	0	0	0	0	-
Mecoprop_(methylchlorophenoxypropionic_acid)	ug/L	0.11	0.07	0	0	0	0.03	0.05	0	0	0.03	0	0	0	0.11	0	-
Metalaxyl	ug/L	-	-	-	-	-	-	0	0.14	0	0	0	0	0	0	0	0
Mirex	ug/L	-	-	0	0	0	0	0	0	0	0	0	-	0	0.04	0	-
Myclobutanil	ug/L	-	-	-	-	-	-	-	0	0	0	0	0	0	0.05	0	0
Picoxystrobin	ug/L	-	-	-	-	-	-	-	0.07	0	0	0	0	0	0	0	0
Procymidone	ug/L	-	-	0	0	0	0	0	0	0	0	0	-	0	0	0.04	-
Pyraclostrobin	ug/L	-	-	-	-	-	-	0	0	0	0	0	0	0.97	0	0	0
Quinoxyfen	ug/L	-	-	-	-	-	-	-	-	-	-	0	-	0	0	0.04	0
Spirodiclofen	ug/L	-	-	-	-	-	-	-	-	-	-	0	0	2.62	0	0	-
Spiroxamine	ug/L	-	-	-	-	-	-	-	-	-	-	0	-	0	0.32	0	0
Tebuconazole	ug/L	-	-	-	-	-	-	0.08	0	0	0	0	-	-	-	0	0
Zoxamide	ug/L	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0.08	0

1. Narratives:
   Temperature: Median + 5 ºC = 26.2 ºC
   Total Suspended Solids: Median + 25 mg/L or +10% for median > 250 = 51 mg/L
   Total Nitrogen: Median x 2 = 1.22 mg/L
   Total Phosphorus: Median x 2 = 0.074
2. Equation Values based on Minimum Hardness ($CaCO_3$) = 161 mg/L
   Cadmium total: 0.00023 mg/L
   Cobalt total: 0.00012 mg/L
   Copper total: 0.025 mg/L
   Lead total: 0.0056 mg/L
   Nickel total: 0.076 mg/L

Note: 0 = Below detection limit; (-) = not measured

Parameter not measured or not detected in all samples:

2,4-Dichlorophenol, Acetamiprid , Alachlor, Aldrin, Allidochlor, alpha-Endosulfan, Ametoctradin , Aminomethyl phosphonic acid, Azinphos-methyl, Benalaxyl, Benfluralin, Beryllium total, Bifenazate, Bifenthrin, Bismuth total, Bixafen , Bromacil, Bromophos-Ethyl, Bromopropylate, Bupirimate, Butachlor, Butralin, Butylate, Captan, Carbaryl, Carbofuran, Carboxin , Carfentrazone-ethyl, Chlorantraniliprole , Chlorimuron ethyl , Chlormephos, Chloroneb, Chlorothalonil, Chlorpyrifos-Methyl, Chlorthal-Dimethyl, Chlorthiamid, cis-Chlordane, cis-Permethrin, Clethodim , Clodinafop-propargyl, Clomazone, Clothianidin , Cyantraniliprole , Cycloate, Cyfluthrin, Cyhalothrin lambda, Cypermethrin-beta, Cypermethrin-zeta, Cyprodinil, Deltamethrin, Desmetryn, Diazinon, Dichlobenil, Dichlofenthion, Dichlorprop, Dichlorvos, Diclofop, Dieldrin, Difenoconazole, Dimethachlor, Dimethenamid-P, Dimethoate, Dimethomorph, Dinotefuran , Dioxathion, Dissolved Manganese, Diuron, Endrin, EPTC_(S-ethyl_dipropylthiocarbamate), Ethalfluralin, Ethion, Etradiazole, Etrimphos, Famoxadone, Fenamidone, Fenchlorphos, Fenhexamid , Fenoxaprop, Fenthion, Flamoxadone , Flamprop-Isopropyl, Flamprop-Methyl, Flonicamid , Fluazifop-p-butyl, Fludioxonil, Flumetralin, Flumioxazin, Flupyradifurone , Fluroxypyr, Fluxapyroxad , Folpet, Fonofos, Glufosinate, Glyphosate, Halosulfuron-methyl , Heptachlor, Hexachlorocyclohexane-alpha, Hexachlorocyclohexane-beta, Hexachlorocyclohexane-delta, Hydroxide as CaCO3, Imidacloprid , Ipconazole, Iprodione, Isofenphos, Kresoxim, Lindane_(Hexachlorocyclohexane-gamma), Linuron , Malathion, MCPA-EHE, MCPB-methyl, Metconazole, Methoprene, Methoxychlor, Metolachlor, Metrafenone, Metribuzin, Monolinuron, Naled, Napropamide, Nicotine, Nitenpyram , Nitrapyrin, o,p-Dichlorodiphenyldichloroethane, o,p-Dichlorodiphenyldichloroethylene, o,p-Dichlorodiphenyltrichloroethane, Oxycarboxin, Oxyfluorfen, p,p-Dichlorodiphenyldichloroethane, p,p-Dichlorodiphenyldichloroethylene, p,p-Dichlorodiphenyltrichloroethane, Pendimethalin, Phorate, Phosmet, Picloram, Piperonyl butoxide, Pirimicarb, Pirimiphos-Ethyl, Pirimiphos-Methyl, Prometon, Prometryn, Propetamphos, Propham, Propiconazole, Propoxur, Propoxycarbazone sodium salt , Propyzamide, Prothioconazole-Desthio, Pymetrozine, Pyrasulfotole , Pyridaben, Pyrimethanil, Pyroxasulfone , Quinclorac, Quintozene, Quizalofop-ethyl, Saflufenacil , Sedaxane , Simazine, Spiromesifen, Sulfentrazone, Sulfotep, Sulfoxaflor , Sulprophos, t-Chlordane, Tembotrione , Terbacil, Terbufos, Terbutryn, Tetraconazole , Tetradifon, Tetramethrin I, Tetrasul, Thiacloprid , Thiamethoxam , Thifensulfuron-methyl , Thiophanate-methyl , Tin total, trans-Heptachlor Epoxide, trans-Permethrin , Triallate, Triclopyr, Trifloxystrobin, Trifluralin, Triticonazole, and Vinclozolin

Table E2-6: Water chemistry parameters (maximum annual values, 2006 to 2024) from Site ER2 downstream of the SLR versus water quality guidelines

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Water Temperature[1]	degrees C	23.10	20.20	15.50	28	23.20	21.90	22	22	19.50	20.70	19.30	20.80	22.50	20.60	20.20	23.20
Total Suspended Solids[1]	mg/L	11	11	0	10	13	7	40	7	14	8	22	7	14	10	11	18
pH		8.60	8.40	7.40	8.56	8.36	8.30	8.27	8.91	8.23	8.13	8.10	8.55	8.29	8.27	8.30	8.16
Electric conductivity	dS/m	0.49	0.45	0.45	0.57	0.57	0.45	0.47	0.71	0.53	0.46	0.45	0.77	0.48	0.48	0.44	0.48
Dissolved Calcium	mg/L	42.40	44.70	46.10	47	51.60	49.10	45.10	56	46.30	45.80	53.60	62.40	50.50	51.20	44.70	49.80
Dissolved Magnesium	mg/L	20	18.90	19.80	22.60	21.30	17.50	19.40	24.10	22.10	18.30	17.90	28	18.40	18.20	17.40	18.60
Dissolved Sodium	mg/L	35	31	21.30	49.40	41.30	21.10	31.20	53.30	36.90	25.80	18.30	61.60	22.40	20.50	20	24.50
Dissolved Potassium	mg/L	2.90	2.80	2.42	2.90	3.20	2.80	2.90	4.30	3.40	2.50	2.50	7.30	2.20	23.20	22.70	2.40
Sodium adsorption ratio		1.13	1.03	0.66	1.48	1.22	0.70	1	1.50	1.10	0.80	0.60	1.60	0.70	0.70	0.70	0.80
Dissolved Iron	mg/L	-	-	-	0	0	0	0	0	0	0.02	0	0.02	0	0.01	0.02	-
Dissolved Manganese	mg/L	-	-	-	0	0	0	0	0	0.01	0	0.01	0.01	0	0	0	-
Chloride	mg/L	8.70	10.50	9.20	9.60	13.30	11.30	12.10	15.70	13.40	11.90	16.10	17.50	11.70	14.80	14.80	20.40
Sulphate	mg/L	114	97.90	79.60	164	136	70.60	96.30	181	122	85.70	71.80	235	89.30	85.30	76.10	85.60
Bicarbonate as $CaCO_3$	mg/L	165	175	202	182	197	191	177	189	173	169	186	185	168	184	173	181
Carbonate as $CaCO_3$	mg/L	7	0	0	0	0	6	6	17	0	0	0	7	0	0	0	0
Total Alkalinity as $CaCO_3$	mg/L	140	144	166	149	161	156	145	176	142	139	152	164	138	151	142	149
Hardness as $CaCO_3$	mg/L	182	189	162	210	216	195	192	239	206	185	207	271	202	203	183	192
Ion Balance	%	101	106	-	99	101	101	101	100	103	105	101	101	106	104	101	101
Total dissolved solids	mg/L	301	283	293	379	354	262	294	440	327	271	270	510	272	286	260	270
Total nitrogen[1]	mg/L	-	-	-	0.56	0.49	0.4	0.49	0.97	0.51	0.60	0.53	1.02	0.41	0.34	0.33	0.64
Total kjeldahl nitrogen	mg/L	0.70	0.40	0.40	0	0	0	0	0	-	-	-	-	-	-	-	-
Nitrate as N	mg/L	0	0	0	0	0	0.16	0.10	0.04	0.02	0.05	0.11	0.03	0.2	0.05	0	0
Nitrite as N	mg/L	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0
Nitrate as N + Nitrite as N	mg/L	0	0	0	0	0	0.17	0.10	0.04	0.02	0.05	0.11	0.03	0.2	0.05	0	-
Ammonia as N	mg/L	0	0	0	0	0	0	0	0.075	0	-	-	-	-	-	-	-
Total phosphorus[1]	mg/L	0.11	0.06	0.03	0.09	0.07	0.04	0.07	0.05	0.02	0.05	0.04	0.03	0.04	0.03	0.02	0.05
Total dissolved phosphorus	mg/L	-	-	-	0.06	0.03	0.03	0.03	0.03	0.01	-	-	-	-	-	-	-
Dissolved reactive phosphorus	mg/L	0.03	0.03	0.01	0.05	0.03	0.02	0.02	0	-	-	-	-	-	-	-	-
Chlorophyll-a	mg/L	-	-	-	0	0	0	0	0	3	3	-	-	-	-	-	-
Escherichia coli	cfu/100mL	691	2420	66	930	1200	900	300	490	700	430	268	190	410	240	440	3500
Aluminium total	mg/L	0.53	0.74	0.23	0.25	0.32	0.14	0.38	0.08	-	-	-	-	-	-	-	-
Antimony total	mg/L	0.001	0.0012	0.0008	0	0.0002	0	0	0	-	-	-	-	-	-	-	-
Arsenic total	mg/L	0.0026	0.0016	0.0011	0.002	0.0018	0.0015	0.0016	0.0013	-	-	-	-	-	-	-	-
Barium total	mg/L	0.07	0.07	0.06	0.07	0.08	0.08	0.08	0.07	-	-	-	-	-	-	-	-
Boron total	mg/L	0.14	0	0	0.05	0.04	0.03	0.03	0.04	-	-	-	-	-	-	-	-
Cadmium total[2]	mg/L	0	0	0	0.00001	0.00001	0.00001	0.00002	0.00001	-	-	-	-	-	-	-	-
Cobalt total[2]	mg/L	0	0	0	0.0006	0.0006	0.0004	0.0005	0.0003	-	-	-	-	-	-	-	-
Copper total[2]	mg/L	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0	-	-	-	-	-	-	-	-
Iron total	mg/L	0.54	0.71	0.24	0.31	0.51	0.21	0.59	0.19	-	-	-	-	-	-	-	-
Lead total[2]	mg/L	0.0004	0.0004	0.0002	0.0002	0.0002	0.0002	0.0004	0.0001	-	-	-	-	-	-	-	-
Lithium total	mg/L	0.03	0.02	0.01	0.04	0.02	0.01	0.02	0.02	-	-	-	-	-	-	-	-
Magnesium total	mg/L	18.90	18	17	0	0	0	0	0	-	-	-	-	-	-	-	-
Manganese total	mg/L	0.07	0.05	0.03	0.12	0.22	0.06	0.08	0.03	-	-	-	-	-	-	-	-
Mercury total	mg/L	0	0.0002	0	0	0	0	0.000005	0	-	-	-	-	-	-	-	-
Molybdenum total	mg/L	0	0	0	0.001	0.002	0.001	0.002	0.001	-	-	-	-	-	-	-	-
Nickel total[2]	mg/L	0.003	0.004	0.003	0.0042	0.0044	0.0023	0.0027	0.003	-	-	-	-	-	-	-	-
Potassium total	mg/L	2.7	2.9	2.8	0	0	0	0	0	-	-	-	-	-	-	-	-
Selenium total	mg/L	0.0008	0.0012	0	0.0004	0.0005	0.0005	0.0005	0.0004	-	-	-	-	-	-	-	-
Silicon total	mg/L	-	-	-	1.21	2.76	2.38	2.84	0.65	-	-	-	-	-	-	-	-
Silver total	mg/L	0	0	0	0	0.00007	0.00002	0	0	-	-	-	-	-	-	-	-
Sodium total	mg/L	33	30	21	0	0	0	0	0	-	-	-	-	-	-	-	-
Strontium total	mg/L	-	-	-	0.31	0.34	0.30	0.26	0.32	-	-	-	-	-	-	-	-
Sulfur total	mg/L	-	-	-	54.80	43.60	26.50	32.60	42	-	-	-	-	-	-	-	-
Thallium total	mg/L	0	0	0.0003	0	0	0	0	0	-	-	-	-	-	-	-	-
Titanium total	mg/L	0.028	0.02	0.004	0.0078	0.003	0.0036	0.0097	0.0029	-	-	-	-	-	-	-	-
Uranium total	mg/L	0.0013	0.0014	0.0011	0.002	0.0017	0.0012	0.0013	0.0017	-	-	-	-	-	-	-	-
Vanadium total	mg/L	0.002	0.002	0	0.0015	0.0011	0.0011	0.0017	0.0009	-	-	-	-	-	-	-	-
Zinc total	mg/L	0.04	0.02	0.02	0.004	0.02	0.01	0.01	0.003	-	-	-	-	-	-	-	-
Aminomethyl phosphonic acid	ug/L	-	-	-	0	0.35	0	0.40	0	-	-	-	-	-	-	-	-
Glyphosate	ug/L	-	-	-	0	0.88	0	2.50	0.20	-	-	-	-	-	-	-	-

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
2,4-Dichlorophenoxyacetic acid	ug/L	0.14	0.08	0.09	0.11	0.09	0	0.06	0.18	0	0	0	0.31	0.03	0	0	-
4-(2,4-dichlorophenoxy)butyric acid	ug/L	0	0	0	0	0	0	0	0	0	0	0	0.15	0.04	0	0	-
Atrazine	ug/L	0	0	0	0	0	0	0	0	0.03	0.03	0	0.23	0	-	0.02	0
Azoxystrobin	ug/L	-	-	-	0	0	0	0.14	0	0	0	0	-	-	-	0	0
Benzoylprop-Ethyl	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0	0.01	0
Bromoxynil	ug/L	0	0	0	0	0	0	0	0.07	0	0	0	0	0	0	0	-
Boscalid	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0.25	-	0	0
Bupirimate	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0	0.02	0
Chloroneb	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0.04	0.02	0	-
Clothianidin	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0.01	0.02
Dicamba	ug/L	0.62	0.15	0.38	0.08	14.51	0.10	0.14	3.59	0.25	0.03	0.04	0.04	0.06	0.06	0	-
Dichlorprop	ug/L	0.02	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-
Dimethoate	ug/L	0	0	0	0	0	0	0	0	0	0	0	1.25	1.24	0	0	0
Diphenamid	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.12	0.30	-	0	0
Ethofumesate	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.04	0	0	0	0
Flutriafol	ug/L	-	-	-	0	0	0	0	0	-	-	0	0.15	0	0	0	0
Hexazinone	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.11	0.27	0	0	0
Imazamethabenz	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0	0.10	0
MCPA_(2-methyl-4-chlorophenoxyacetic_acid)	ug/L	0	0.03	0	0	0	0	0	0.11	0	0	0	0.03	0	0	0	-
Mecoprop_(methylchlorophenoxypropionic_acid)	ug/L	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	-
Metrafenone	ug/L	-	-	-	0	0	0	0	0	-	-	0	-	0	0	0.03	0
Nitrapyrin	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.04	0	0	0	-
cis-Permethrin	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0.04	0	-
Procymidone	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0.05	0	-
Prometon	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0.07	0	0	-
Pyraclostrobin	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0.06	0
Quinoxyfen	ug/L	-	-	-	0	0	0	0	0	-	-	0	-	0	0	0.08	0
Simazine	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.57	0	0	0.02	0
Spirodiclofen	ug/L	-	-	-	0	0	0	0	0	-	-	0	0	0.46	0	0	-
Tetramethrin I	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0.72	0	-
Trifloxystrobin	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.05	0	0	0	0
Triticonazole	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	1.36	0	0	0
Zoxamide	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0.11	0

1. Narratives:
   Temperature:: Median + 5 ºC = 26.9 ºC
   Total Suspended Solids: Median + 25 mg/L or +10% for median > 250 = 36 mg/L
   Total Nitrogen: Median x 2 = 1.04 mg/L
   Total Phosphorus: Median x 2 = 0.090
2. Equation Values based on Minimum Hardness ($CaCO_3$) = 162 mg/L
   Cadmium total: 0.00023 mg/L
   Cobalt total: 0.00012 mg/L
   Copper total: 0.025 mg/L
   Lead total: 0.0058 mg/L
   Nickel total: 0.078 mg/L

Note: 0 = Below detection limit; (-) = not measured

Parameter not measured or not detected in all samples:

2,4-Dichlorophenol, Acetamiprid , Alachlor, Aldrin, Allidochlor, alpha-Endosulfan, Ametoctradin , Azinphos-methyl, Benalaxyl, Benfluralin, Bentazon, Beryllium total, Bifenazate, Bifenthrin, Bismuth total, Bixafen , Broflanilide , Bromacil, Bromophos-Ethyl, Bromopropylate, Butachlor, Butralin, Butylate, Captan, Carbaryl, Carbofuran, Carboxin , Carfentrazone-ethyl, Chlorantraniliprole , Chlorimuron ethyl , Chlormephos, Chlorothalonil, Chlorpyrifos, Chlorpyrifos-Methyl, Chlorthal-Dimethyl, Chlorthiamid, Chromium total, cis-Chlordane, Clethodim , Clodinafop-propargyl, Clomazone, Clopyralid, Cloransulam methyl , Cyantraniliprole , Cycloate, Cyfluthrin, Cyhalothrin lambda, Cypermethrin-beta, Cypermethrin-zeta, Cyprodinil, Deltamethrin, Desmetryn, Diazinon, Dichlobenil, Dichlofenthion, Dichlorvos, Diclofop, Dieldrin, Difenoconazole, Dimethachlor, Dimethenamid-P, Dimethomorph, Dinotefuran , Dioxathion, Diuron, Endrin, EPTC_(S-ethyl_dipropylthiocarbamate), Ethalfluralin, Ethion, Etradiazole, Etrimphos, Famoxadone, Fenamidone, Fenchlorphos, Fenhexamid , Fenoxaprop, Fenthion, Flamoxadone , Flamprop-Isopropyl, Flamprop-Methyl, Flonicamid , Fluazifop-p-butyl, Fludioxonil, Flumetralin, Flumioxazin, Flupyradifurone , Fluroxypyr, Fluxapyroxad , Folpet, Fonofos, Glufosinate, Halosulfuron-methyl , Heptachlor, Hexachlorocyclohexane-alpha, Hexachlorocyclohexane-beta, Hexachlorocyclohexane-delta, Hydroxide as $CaCO_3$, Imazethapyr, Imidacloprid , Ipconazole, Iprodione, Isofenphos, Kresoxim, Lindane_(Hexachlorocyclohexane-gamma), Linuron , Malathion, MCPA-EHE, MCPB-methyl, Metalaxyl, Metconazole, Methoprene, Methoxychlor, Metolachlor, Metribuzin, Mirex, Monolinuron, Myclobutanil, Naled, Napropamide, Nicotine, Nitenpyram , o,p-Dichlorodiphenyldichloroethane, o,p-Dichlorodiphenyldichloroethylene, o,p-Dichlorodiphenyltrichloroethane, Oxycarboxin, Oxyfluorfen, p,p-Dichlorodiphenyldichloroethane, p,p-Dichlorodiphenyldichloroethylene, p,p-Dichlorodiphenyltrichloroethane, Pendimethalin, Phorate, Phosmet, Picloram, Picoxystrobin, Piperonyl butoxide, Pirimicarb, Pirimiphos-Ethyl, Pirimiphos-Methyl, Prometryn, Propetamphos, Propham, Propiconazole, Propoxur, Propoxycarbazone sodium salt , Propyzamide, Prothioconazole-Desthio, Pymetrozine, Pyrasulfotole , Pyridaben, Pyrimethanil, Pyroxasulfone , Quinclorac, Quintozene, Quizalofop-ethyl, Saflufenacil , Sedaxane , Spiromesifen, Spiroxamine, Sulfentrazone, Sulfotep, Sulfoxaflor , Sulprophos, t-Chlordane, Tebuconazole, Tembotrione , Terbacil, Terbufos, Terbutryn, Tetraconazole , Tetradifon, Tetrasul, Thiacloprid , Thiamethoxam , Thifensulfuron-methyl , Thiophanate-methyl , Tin total, trans-Heptachlor Epoxide, trans-Permethrin , Triallate, Triclopyr, Trifluralin, and Vinclozolin.

Table E2-7: Water chemistry parameters (Maximum annual values, 2006 to 2024) from return flow Site ER2A versus water quality guidelines

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Water Temperature[1]	degrees C	-	-	22.70	20.80	19.40	22.20	22.80	23.40	21.10	21.60	17.80	19.90	21.60	17.20	20.10	19.50
Total Suspended Solids[1]	mg/L	-	-	255	314	161	242	300	333	132	403	233	290	181	244	128	131
pH		-	-	8.37	8.55	8.38	8.5	8.38	8.57	8.32	8.22	8.34	8.36	8.45	8.32	8.42	8.13
Electric conductivity	dS/m	-	-	0.69	0.95	0.98	0.57	0.65	0.96	0.76	0.74	0.72	1.30	0.97	0.79	0.82	0.95
Dissolved Calcium	mg/L	-	-	45.90	51.70	59.50	48.40	47	58.40	58.50	56.50	62.60	76.70	64.20	57.20	55.10	66.70
Dissolved Magnesium	mg/L	-	-	24.20	34.60	35	21.50	25.10	31.10	26.60	26.10	26.80	46.40	36.40	27.20	26.80	34.70
Dissolved Sodium	mg/L	-	-	76	124	110	45.8	65.4	106	72	73.5	60.8	160	99.9	35.3	90.6	99.2
Dissolved Potassium	mg/L	-	-	4.70	5.20	5.20	3.60	4.90	6.30	4.50	5.60	4.50	10.80	6.40	77.40	35.10	5.60
Sodium adsorption ratio		-	-	2.37	3.27	2.80	1.40	1.90	2.80	2	2	1.70	3.50	2.50	2.10	2.50	2.40
Dissolved Iron	mg/L	-	-	-	0	0	0	0	0	0	0	0	0.03	0	0.01	0	-
Chloride	mg/L	-	-	11.80	12.20	16.80	11.70	15.80	17.30	15.10	14.30	20	24.10	19.70	16.80	18.20	22.60
Sulphate	mg/L	-	-	185	319	318	125	160	326	195	194	176	451	277	216	210	252
Bicarbonate as $CaCO_3$	mg/L	-	-	210	214	239	199	236	203	231	237	265	237	276	227	246	264
Carbonate as $CaCO_3$	mg/L	-	-	0	7	0	7	6	7	0	0	0	15	0	0	0	0
Total Alkalinity as $CaCO_3$	mg/L	-	-	172	187	196	172	193	166	189	194	218	220	227	186	202	217
Hardness as $CaCO_3$	mg/L	-	-	209	272	293	209	221	274	253	248	267	382	310	255	245	310
Ion Balance	%	-	-	99	102	98	102	102	100	102	101	103	103	102	103	103	104
Total dissolved solids	mg/L	-	-	441	658	662	352	434	634	483	487	479	901	640	507	527	611
Total nitrogen[1]	mg/L	-	-	0.48	1	0.79	0.66	0.49	0.86	0.62	0.63	0.52	0.73	0.53	0.47	0.52	0.44
Nitrate as N	mg/L	-	-	0.07	0.06	0.04	0.09	0.1	0.02	0.1	0.19	0.07	0.07	0.13	0.15	0.04	0
Nitrite as N	mg/L	-	-	0	0	0	0	0.007	0	0.01	0	0	0	0	0	0	0
Nitrate as N + Nitrite as N	mg/L	-	-	0.07	0.06	0.04	0.09	0.1	0.02	0.11	0.19	0.07	0.07	0.13	0.15	0.04	-
Ammonia as N	mg/L	-	-	0	0	0	0	0	0.031	0	-	-	-	-	-	-	-
Total phosphorus[1]	mg/L	-	-	0.17	0.16	0.14	0.14	0.21	0.18	0.11	0.18	0.12	0.29	0.16	0.36	0.14	0.11
Total dissolved phosphorus	mg/L	-	-	0	0.06	0.029	0.051	0.032	0.052	0.024	-	-	-	-	-	-	-
Dissolved reactive phosphorus	mg/L	-	-	0.04	0.05	0.04	0.03	0.03	0.01	-	-	-	-	-	-	-	-
Chlorophyll-a	mg/L	-	-	7	3.3	0	0	0	0	4	3	-	-	-	-	-	-
Escherichia coli	cfu/100mL	-	-	261	500	400	310	500	600	600	410	440	300	250	430	290	380
Aluminium total	mg/L	-	-	4.40	3.09	1.56	2.60	5.40	0.540	-	-	-	-	-	-	-	-
Antimony total	mg/L	-	-	0.0002	0	0.0002	0.0002	0.0002	0	-	-	-	-	-	-	-	-
Arsenic total	mg/L	-	-	0.0042	0.0037	0.003	0.0037	0.0041	0.002	-	-	-	-	-	-	-	-
Barium total	mg/L	-	-	0.12	0.09	0.09	0.13	0.15	0.07	-	-	-	-	-	-	-	-
Beryllium total	mg/L	-	-	0.0004	0.0002	0.0002	0.0002	0.0002	0	-	-	-	-	-	-	-	-
Boron total	mg/L	-	-	0.07	0.11	0.07	0.04	0.05	0.04	-	-	-	-	-	-	-	-
Cadmium total[2]	mg/L	-	-	0.0001	0.00008	0.00006	0.00009	0.00012	0.00003	-	-	-	-	-	-	-	-
Chromium total	mg/L	-	-	0.0058	0.0034	0.0022	0.003	0.0061	0.001	-	-	-	-	-	-	-	-
Cobalt total[2]	mg/L	-	-	0.003	0.002	0.0014	0.0024	0.0029	0.0007	-	-	-	-	-	-	-	-
Copper total[2]	mg/L	-	-	0.008	0.006	0.004	0.007	0.008	0.002	-	-	-	-	-	-	-	-
Iron total	mg/L	-	-	3.99	2.79	1.65	3.28	4.75	0.69	-	-	-	-	-	-	-	-
Lead total[2]	mg/L	-	-	0.0033	0.0024	0.002	0.0029	0.0037	0.0007	-	-	-	-	-	-	-	-
Lithium total	mg/L	-	-	0.05	0.08	0.06	0.03	0.03	0.03	-	-	-	-	-	-	-	-
Manganese total	mg/L	-	-	0.16	0.19	0.09	0.13	0.14	0.04	-	-	-	-	-	-	-	-
Mercury total	mg/L	-	-	0	0	0	0.000009	0.000019	0	-	-	-	-	-	-	-	-
Molybdenum total	mg/L	-	-	0.002	0.002	0.002	0.001	0.002	0.002	-	-	-	-	-	-	-	-
Nickel total[2]	mg/L	-	-	0.0082	0.0076	0.0058	0.0074	0.0087	0.0038	-	-	-	-	-	-	-	-
Selenium total	mg/L	-	-	0.0003	0.0004	0.0007	0.001	0.0005	0.0003	-	-	-	-	-	-	-	-
Silicon total	mg/L	-	-	7.50	9.73	4.24	6.79	6.78	1.63	-	-	-	-	-	-	-	-
Silver total	mg/L	-	-	0.00005	0.00004	0.00007	0.00004	0.00003	0	-	-	-	-	-	-	-	-
Strontium total	mg/L	-	-	0.35	0.43	0.51	0.35	0.38	0.37	-	-	-	-	-	-	-	-
Sulfur total	mg/L	-	-	58.70	108	102	41.70	53.80	59.30	-	-	-	-	-	-	-	-
Thallium total	mg/L	-	-	0.00009	0.00008	0.00005	0.00007	0.0001	0	-	-	-	-	-	-	-	-
Tin total	mg/L	-	-	0.002	0	0	0	0	0	-	-	-	-	-	-	-	-
Titanium total	mg/L	-	-	0.09	0.07	0.04	0.05	0.08	0.0	-	-	-	-	-	-	-	-
Uranium total	mg/L	-	-	0.0021	0.0032	0.0025	0.002	0.0021	0.0019	-	-	-	-	-	-	-	-
Vanadium total	mg/L	-	-	0.0118	0.0093	0.0046	0.0073	0.0116	0.0026	-	-	-	-	-	-	-	-
Zinc total	mg/L	-	-	0.03	0.02	0.01	0.02	0.03	0.01	-	-	-	-	-	-	-	-
Aminomethyl phosphonic acid	ug/L	-	-	-	0	0	0	0	0	0.6	-	-	-	-	-	-	-
Glyphosate	ug/L	-	-	-	0	0.11	0	0.3	0	0.4	-	-	-	-	-	-	-
2,4-Dichlorophenoxyacetic acid	ug/L	-	-	0.08	0.17	0.11	0.15	0.10	0.45	0.03	0.22	0	0.06	0.32	0	0	-
4-(2,4-dichlorophenoxy)butyric acid	ug/L	-	-	0	0	0	0	0	0.04	0	0	0	0.08	0	0	0	-

Measured Parameter	Units	2006	2007	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Ametoctradin	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0.01	0
Atrazine	ug/L	-	-	0	0	0	0	0	0	0	0	0	0	0	-	0.01	0
Bentazon	ug/L	-	-	-	0	0	0	0	0.06	0	0	0	0	0	-	-	-
Bifenthrin	ug/L	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0.12	-
Broflanilide	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0.02	0
Bromoxynil	ug/L	-	-	0	0	0	0.06	0	0	0	0	0.21	0	0	0	0	-
Boscalid	ug/L	-	-	-	0	0	0	0	0	0	0	0	0.27	0.05	-	0	0
Clopyralid	ug/L	-	-	0.05	0	0	0	0	0	0	0	0	0.03	0	-	-	-
Cloransulam methyl	ug/L	-	-	-	0	0	0	0	0	-	-	-	-	-	-	0.03	0
Dicamba	ug/L	-	-	1.62	0.22	0	4.69	0.15	4.28	0.32	0	0	0.09	0.07	0.14	0	-
Dimethoate	ug/L	-	-	0	0	0	0	0	0	0	0	0	1.25	0	0	0	0
Diphenamid	ug/L	-	-	0	0	0	0	0	0	0	0	0	0.06	0.08	-	0	0
Fluroxypyr	ug/L	-	-	-	0	0	0.04	0	0.07	0	0	0	-	-	-	0	0
Flutriafol	ug/L	-	-	-	0	0	0	0	0	-	-	0	0.14	0	0	0	0
Hexazinone	ug/L	-	-	-	0	0	0	0.03	0	0	0	0	0.42	0	0.14	0	0
Imazamethabenz	ug/L	-	-	-	0	0	0	0	0	0	0	0	-	0	0	0.06	0
MCPA_(2-methyl-4-chlorophenoxyacetic_acid)	ug/L	-	-	0.10	0	0.03	0.09	0.05	0.15	0	0	3.34	0.04	0	0	0	-
Picoxystrobin	ug/L	-	-	-	0	0	0	0	0.04	0	0	0	0	0	0	0	0
Prometon	ug/L	-	-	0	0	0	0	0	0	0	0	0	-	0.07	0	0	-
Propham	ug/L	-	-	0	0	0	0	0	0	0	0	0	0	0.04	0	0	-
Pyraclostrobin	ug/L	-	-	-	0	0	0	0	0	0	0	0	2.83	0	0	0	0
Quinoxyfen	ug/L	-	-	-	0	0	0	0	0	-	-	0	-	0	0	0.04	0
Tebuconazole	ug/L	-	-	-	0	0	0	0.03	0	0	0	0	-	-	-	0	0
Triticonazole	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	1.08	0	0	0
Zoxamide	ug/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0.09	0

1. Narratives:
   Temperature:: Median + 5 ºC = 26.1 ºC
   Total Suspended Solids: Median + 25 mg/L or +10% for median > 250 = 261 mg/L
   Total Nitrogen: Median x 2 = 1.24 mg/L
   Total Phosphorus: Median x 2 = 0.318
2. Equation Values based on Minimum Hardness (CaCO3) = 209 mg/L
   Cadmium total: 0.00029 mg/L
   Cobalt total: 0.00014 mg/L
   Copper total: 0.032 mg/L
   Lead total: 0.0007 mg/L
   Nickel total: 0.096 mg/L

Note: 0 = Below detection limit; (-) = not measured

Parameters not measured or not detected in all samples:

2,4-Dichlorophenol, Acetamiprid , Alachlor, Aldrin, Allidochlor, alpha-Endosulfan, Azinphos-methyl, Azoxystrobin, Benalaxyl, Benfluralin, Benzoylprop-Ethyl, Bifenazate, Bismuth total, Bixafen , Bromacil, Bromophos-Ethyl, Bromopropylate, Bupirimate, Butachlor, Butralin, Butylate, Captan, Carbaryl, Carbofuran, Carboxin , Carfentrazone-ethyl, Chlorantraniliprole , Chlorimuron ethyl , Chlormephos, Chloroneb, Chlorothalonil, Chlorpyrifos, Chlorpyrifos-Methyl, Chlorthal-Dimethyl, Chlorthiamid, cis-Chlordane, cis-Permethrin, Clethodim , Clodinafop-propargyl, Clomazone, Clothianidin , Cyantraniliprole , Cycloate, Cyfluthrin, Cyhalothrin lambda, Cypermethrin-beta, Cypermethrin-zeta, Cyprodinil, Deltamethrin, Desmetryn, Diazinon, Dichlobenil, Dichlofenthion, Dichlorprop, Dichlorvos, Diclofop, Dieldrin, Difenoconazole, Dimethachlor, Dimethenamid-P, Dimethomorph, Dinotefuran , Dioxathion, Dissolved Manganese, Diuron, Endrin, EPTC_(S-ethyl_dipropylthiocarbamate), Ethalfluralin, Ethion, Ethofumesate, Etradiazole, Etrimphos, Famoxadone, Fenamidone, Fenchlorphos, Fenhexamid , Fenoxaprop, Fenthion, Flamoxadone , Flamprop-Isopropyl, Flamprop-Methyl, Flonicamid , Fluazifop-p-butyl, Fludioxonil, Flumetralin, Flumioxazin, Flupyradifurone , Fluxapyroxad , Folpet, Fonofos, Glufosinate, Halosulfuron-methyl , Heptachlor, Hexachlorocyclohexane-alpha, Hexachlorocyclohexane-beta, Hexachlorocyclohexane-delta, Hydroxide as CaCO3, Imazethapyr, Imidacloprid , Ipconazole, Iprodione, Isofenphos, Kresoxim, Lindane_(Hexachlorocyclohexane-gamma), Linuron , Magnesium total, Malathion, MCPA-EHE, MCPB-methyl, Mecoprop_(methylchlorophenoxypropionic_acid), Metalaxyl, Metconazole, Methoprene, Methoxychlor, Metolachlor, Metrafenone, Metribuzin, Mirex, Monolinuron, Myclobutanil, Naled, Napropamide, Nicotine, Nitenpyram , Nitrapyrin, o,p-Dichlorodiphenyldichloroethane, o,p-Dichlorodiphenyldichloroethylene, o,p-Dichlorodiphenyltrichloroethane, Oxycarboxin, Oxyfluorfen, p,p-Dichlorodiphenyldichloroethane, p,p-Dichlorodiphenyldichloroethylene, p,p-Dichlorodiphenyltrichloroethane, Pendimethalin, Phorate, Phosmet, Picloram, Piperonyl butoxide, Pirimicarb, Pirimiphos-Ethyl, Pirimiphos-Methyl, Potassium total, Procymidone, Prometryn, Propetamphos, Propiconazole, Propoxur, Propoxycarbazone sodium salt , Propyzamide, Prothioconazole-Desthio, Pymetrozine, Pyrasulfotole , Pyridaben, Pyrimethanil, Pyroxasulfone , Quinclorac, Quintozene, Quizalofop-ethyl, Saflufenacil , Sedaxane , Simazine, Sodium total, Spirodiclofen, Spiromesifen, Spiroxamine, Sulfentrazone, Sulfotep, Sulfoxaflor , Sulprophos, t-Chlordane, Tembotrione , Terbacil, Terbufos, Terbutryn, Tetraconazole , Tetradifon, Tetramethrin I, Tetrasul, Thiacloprid , Thiamethoxam , Thifensulfuron-methyl , Thiophanate-methyl , Total kjeldahl nitrogen, trans-Heptachlor Epoxide, trans-Permethrin , Triallate, Triclopyr, Trifloxystrobin, Trifluralin, and Vinclozolin.

REFERENCES

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Government of Alberta. (2018). *Environmental Quality Guidelines for Alberta Surface Waters.* Edmonton: Alberta Environment and Protected Areas. Water Policy Branch.

Appendix E3: Field Photographs

Plate E3-1: West SLR water quality sampling location facing southeast (September 28, 2023; 12U 410064 5613285; 3-20-17 W4M)

Plate E3-2: East SLR water quality sampling location facing southwest (September 29, 2023; 12U 413986 5612531; 13-31-19-16 W4M)

Plate E3-3: Dugout #1 water quality sampling location facing north (September 28, 2024; 12U 414219 5611053; 3-31-19-16 W4M)

Plate E3-4: Dugout #3 water quality sampling location facing southeast (September 28, 2024; 12U 416319 5612330; 15-32-19-16 W4M)