Volume 2, Section 9 Snake Lake Reservoir Expansion
Environmental Impact Assessment
Soil and Terrain

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Executive Summary

The Eastern Irrigation District (EID) is applying for approval under the *Environmental Protection and Enhancement Act* (EPEA) 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 details on soil and terrain resources in local and regional study areas, 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 (Government of Alberta [GOA], 2013). This document also contains residual impacts and cumulative effects assessments.

Field data were collected within the soil and terrain local study area (STLSA), which includes the reservoir expansion Project footprint, to describe and map soil and terrain resources. Regional data and information were also gathered from published sources to describe and map a terrestrial regional study area (TRSA) based on the planned expansion plus a 15 km buffer. A scoping exercise was completed to determine soil and terrain resources and indicators for detailed assessment, including assessing soil in the STLSA for quality and reclamation suitability. As construction will include the partial removal of topsoil and subsoil within the Project footprint, soils in the STLSA were assessed against criteria to determine their suitability for reclamation, and topsoil and subsoil deemed suitable for reclamation uses will be salvaged and used in construction of the reservoir berms. Salvaged subsoil and topsoil will be stored onsite for use in construction and reclamation, respectively. While soil is being stored, mitigation measures will be implemented to maintain the quality of the salvaged soil and protect the soil from erosion.

The final residual loss of soils is 661.6 ha, or 84% of the STLSA; the residual impact was rated High-Negative. A Cumulative Effects Assessment (CEA), which assesses how the Project may interact with past, present, or reasonably foreseeable future projects, was completed for indicators or resources where a negative Project-related change was determined. For soil and terrain, the assessed resource was the loss of area of soil orders. The loss of soil orders from past projects totals approximately 2,900 ha, representing a 3.2% change. The Project is anticipated to contribute an additional 760 ha, or less than 1%. Future projects are anticipated to contribute 8%. The overall cumulative change in the TRSA is approximately 11.7%. As the key mitigation to reduce these soil losses is reclamation of 105.3 ha using the salvaged soil, it is important to ensure preservation of the physical soil and to monitor the berms to ensure that reclaimed soils develop as a functional soil unit over time. Excess soil that is stored off site will be available for future use as required.

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Abbreviations

asl	Above Sea Level
AGRASID	Agricultural Region of Alberta Soil Inventory Database
AGS	Alberta Geological Survey
CEA	Cumulative Effects Assessment
CSSC	Canadian System of Soil Classification
DMNS	Dry Mixedgrass Natural Subregion
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EID	Eastern Irrigation District
EPEA	*Environmental Protection and Enhancement Act*
F-G	Fair to Good
F-P	Fair to Poor
GOA	Government of Alberta
GOC	Government of Canada
LiDAR	Light Detection and Ranging
SAR	Sodium Adsorption Ratio
Sat%	Saturation Percentage
SLR	Snake Lake Reservoir
STLSA	Soils and Terrain Local Study Area
SIL 2	Survey Intensity Level 2
TRSA	Terrestrial Regional Study Area

Glossary

AB	Transitional horizon between A & B
Ae	‘A’ horizon with eluviation of clay, iron, aluminum, or organic matter alone or in combination.
Ah	‘A’ horizon enriched with organic matter
Ahsakg	‘A’ horizon; h: enriched with organic matter, sa: saline, k: carbonate enriched such that sample effervesces in dilute hydrochloric acid, g: mottled or gleyed due to saturated (reducing) conditions
Bm	‘B’ horizon slightly altered by hydrolysis, oxidation, or solution, or all three to give a change in color and/or structure
Bnt	‘B’ horizon with n: a ratio of exchangeable calcium to sodium of 10 or less, and t: enriched with silicate clay
Bsg	‘B’ horizon with s: salt crystals, veins, or surface crust and g: mottled or gleyed due to saturated (reducing) conditions
Btnj	‘B’ horizon with t: illuvial layer lattice clay, nj: a ratio of exchangeable calcium to sodium that is not quite 10 or less
Cca	‘C’ horizon with carbonate enrichment greater than that in the parent materials
Cg	‘C’ horizon mottled or gleyed due to saturated (reducing) conditions
Ck	‘C’ horizon carbonate enriched such that sample effervesces in dilute hydrochloric acid
Csk	‘C’ horizon with s: salt crystals, veins, or surface crust and k: carbonate enriched such that sample effervesces in dilute hydrochloric acid
Cskg	‘C’ horizon with s: salt crystals, veins, or surface crust, k: carbonate enriched such that sample effervesces in dilute hydrochloric acid, and mottled or gleyed due to saturated (reducing) conditions
Om	Organic horizon developed mainly from mosses, rushes, and woody materials, at a middle stage of decomposition between fibric and humic
II	Buried Soil Horizon starts with Roman Numeral 2, (e.g., IICk)
1, 2	Two differently coloured or textured layers of the same horizon are designated with Arabic Numerals after the Horizon (e.g., Cg1, Cg2)

9.1 INTRODUCTION

9.1.1 Background

The Eastern Irrigation District (EID) is applying for approval under the *Environmental Protection and Enhancement Act* (EPEA) 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. The proposed expansion will permanently alter soils on 827.1 ha of land east of the existing SLR; an additional 52.3 ha of temporary workspace will be temporarily altered, for a total affected area of 879.4 ha. (Appendix G1, Figure G1-1). An additional 41.3 ha soil storage area will occur on EID land northeast of the Project. The soil storage area will not be stripped and was not assessed for baseline soil conditions.

9.1.2 Purpose

The purpose of this section is to describe baseline conditions, assess mitigation measures to reduce effects on soils, assess residual impacts, and assess cumulative effects for soil and terrain resources.

The objectives of the soil and terrain investigations are to map soil and terrain resources and to evaluate soil quality in the local and regional study areas. A soil and terrain local study area (STLSA) focused on the reservoir expansion site was assessed for detailed soil and terrain information (Appendix G1, Figure G1-2). Soil resources include soil types and distribution, soil profiles, and assessment of agricultural land capability, soil capability for reclamation, erosion sensitive and saline-sodic soils, and soils affected by erosion or human use. Terrain resources include bedrock and surficial geology, topography, and slope. Locally collected soils data will allow determination of topsoil and subsoil stripping plans which will assist with reclamation and mitigation planning.

9.1.3 Project Setting

The STLSA occurs within the Dry Mixedgrass Natural Subregion (DMNS) of the Grassland Natural Region (GOA, 2006). The DMNS is the largest subregion within the Grassland Region of Alberta and occurs in the southeast portion of the province. The climate of this subregion is warm and dry, with a mean annual temperature of 4.2°C. In summer, 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. Gently undulating glaciated plains with inclusions of hummocky and dissected uplands are typical. Surficial materials are dominated by medium textured, moderately calcareous glacial till deposits ranging from <2 m thick on undulating plains to over 10 m in hummocky landscapes (GOA, 2006). The Project site is underlain by the Bearpaw Formation, which consists of dark grey shale, dark grey sandstone, concretionary ironstone, and bentonite beds (Alberta Geological Survey, 2020b). The general area has numerous crevasse fills and a region of esker (Alberta Geological Survey, 2020c). There are fluvial deposits of sand and gravel at the surface in the northeast region of site, and glaciolacustrine deposits of sand, silt, clay, and minor gravel resources at the surface in the south and west areas of site (Fenton, et al., 2013). A minor meltwater channel runs west to east (Alberta Geological Survey, 2020c).

Topography in the Project area is typically gently undulating to undulating with slopes less than 5%. Overall, there is a gradual slope to the East (<1% mean gradient) and 18 m of relief, with a high point of 783 m and a low point of 765 m, based on light detection and ranging (LiDAR) data. The greatest slopes occur on the west side adjacent to the existing East Branch Canal and SLR, and along the edges of a meltwater channel in the north half of Project site. Most of the area is underlain by till or glaciofluvial sands and gravels. These materials are saline to sodic in low lying areas. Depressions with wetlands and soil blowouts are also common.

The Project occurs in the Brown Soil Zone, an area with relatively thin, brown coloured topsoil horizons developed under short-grass prairie. As per the Agricultural Region of Alberta Soil Inventory Database (AGRASID) (GOA, 2016a), the dominant soils, making up >85% of the Project area include Brown Solodized Solonetz soils (38%), Brown Solonetzic Solods (2%), and Brown Solods (18%). The Chernozems are further divided into Orthic Brown Chernozems (28%) and Solonetzic Brown Chernozems (7%). Lesser soils include saline Rego Gleysols (5%) and peaty Rego Gleysols (1%) which are typical wetland soils. The well to moderately well drained Brown Solodized Solonetz soils have 3 to 6 cm of topsoil and occur over stony, hard loams and clay loams that are strongly saline and sodic. Orthic Brown Chernozem soils include moderately-well to rapidly drained soils with 4 to 10 cm of topsoil over stony loam to clay loam till, or on stone-free to slightly stony, sandy loam, with a small amount on glaciofluvial gravel. The Brown Solodized soil is well to moderately-well drained and has 4 to 10 cm of topsoil over stony loam to clay loam textured till and occurs in upper landscape positions; their subsoils are friable and not as firm as the Solonetzic soils but still have strongly saline and sodic components. Solonetzic Brown Chernozems have 4 to 8 cm of topsoil and occur over stony loam to clay loam textured till on gently undulating to undulating terrain. These soils are usually non-saline to weakly saline and moderately to strongly sodic. Finally, poorly drained depressional and level areas consist of saline Rego Gleysols or peaty Gleysols with 0 to 10 cm topsoil developed on stone-free glaciolacustrine clays or slightly to very stony, loam to clay loam till.

Native grasslands in the DMNS have been subject to land use change for agricultural use including conversion to tame pasturelands, croplands, and irrigated croplands. Other land uses and disturbances are less common but include industrial activities, intensive farming operations, transportation infrastructure, and residential uses. Natural water systems have also been supplemented by a system of reservoirs and canals.

9.1.4 Regulatory Context

The *Soil Conservation Act* provides a framework for encouraging soil conservation practices to preserve Alberta's agricultural land base and to ensure the long-term productivity of the farming sector (GOA, 2000a). The *Soil Conservation Act* describes the requirement for landholders to prevent soil loss or deterioration from taking place or to stop loss or deterioration from continuing, and delegates authority to local municipalities and outlines the powers and duties of the designated officers (GOA, 2000a).

The *Conservation and Reclamation Regulation* under the *Environmental Protection and Enhancement Act* (GOA, 2000b) provides guidance for conserving and reclaiming disturbed land and restoring it to equivalent land capability. The regulation addresses requirements to achieve a reclamation certification and provides guidance on the approvals, operating procedures, reclamation techniques and targets (GOA, 1993).

Rangeland Health Assessment for Grassland, Forest & Tame Pasture provides guidance for the field measurements of soils and vegetation to classify and characterize native and non-native grasslands and provides information required for reclamation (GOA, 2016b).

9.2 STUDY AREAS

Baseline conditions and potential Project effects were assessed at both a local (Project impacts) scale and a regional (cumulative effects) scale by examining resources or indicators in the Local and Regional Study Areas. The study areas for soils and terrain were defined as:

- Soil and Terrain Local Study Area (STLSA) – reservoir expansion boundary (Appendix G1, Figure G1-2).
- Terrestrial Regional Study Area (TRSA) – reservoir expansion boundary + 15 km buffer (Appendix G1, Figure G1-3).

The STLSA was defined as the Reservoir Expansion area boundary plus all lands up to the East Branch Canal or extant reservoir on the west side of the Project; all direct effects on soils and terrain will occur in this area. This total area, 899 ha, is the area where field assessment of soils was completed. A small area (19.5 ha) to the west of the Project area falls outside what will be developed for the Project.

The topsoil storage area (Volume 1, Attachment 2, Figure 2A-6) to the northeast of the expansion area was not included since disturbance there will be temporary; this area will be assessed within the TRSA. Some of the important local features found within the STLSA include the SLR East Dam, Snake Lake Canal, native prairie soils, soils disturbed by past industrial or transportation uses, and private pasture lands.

The TRSA, which is the same study area used by Wildlife (Volume 2, Section 11), Vegetation and Wetlands (Volume 2, Section 10), and Land Use (Volume 2, Section 13) disciplines, occurs in the DMNS and represents a mix of natural landscapes and lands modified for agriculture, transportation, oil and gas, utilities, and other industrial and municipal land uses. The TRSA was used for the Cumulative Effects Assessment (CEA) to address how Project effects interact with past, present, and future activities on regional resources or indicators. The TRSA was defined as a 15 km radius surrounding the reservoir expansion footprint. These study areas have been parametrized with existing disturbances and land uses. The TRSA was also used in the assessment of indirect Project effects on soil and terrain resources for the EIA.

9.3 ISSUE SCOPING

Scoping for this discipline includes:

- identifying the Project activities that may alter or remove the resources or indicators;
- developing a list of resources or indicators for each discipline;
- identifying the risks, issues, or concerns regarding these effects;
- determining what assessments to include (ones where high effects are likely), and which to exclude (effects are likely to be negligible or trivial); and
- identifying the quality of available information and data to assess whether the issue can be addressed locally and/or regionally.

Soil and terrain resources with the potential to be affected by the Project have been summarized (Table 9-1).

Table 9-1: Issue scoping for soil and terrain resources

Project Activities and Risks	Resources	Indicators or Measures	Potential Issues	Screening
• Stripping of topsoil and subsoil in the reservoir expansion area • Reclamation of soils in outer berm areas • Soil erosion • Loss of soil productivity • Mulching and storing woody debris	Soil Orders	• Area (ha) of soil orders in the TRSA • Area (ha) of natural, cultivated, reclaimed, and disturbed soils	• Permanent removal or flooding of soils • Alteration of soils by human land uses	• Likely – Excavation of the reservoir will require removal of topsoil to reach the surficial materials needed for berm construction and to develop a suitable base for temporary workspace and berm construction • Likely – Topsoil overlying unsuitable surficial materials will be left in place and flooded
		• Area (ha) of soils suitable for reclamation	• Loss of area (ha) of soils	• Likely – Suitable topsoil and subsoil will be used for berm reclamation or removed from site
	Soil Quality	• Area (ha) of soils by Agricultural Land Suitability Classes	• Loss of soil productivity or quality for agricultural use	• Unlikely – Soils will no longer be used for agriculture; changes not assessed from baseline
		• Area (ha) of soils by risk classes for wind and water erosion	• Loss of soil productivity or quality due to erosion, acidification	• Unlikely – Appropriate erosion prevention will be implemented; changes not assessed from baseline
		• Effects on soils due to spills	• Loss of soil productivity or quality due to spills	• Unlikely – Appropriate spill prevention and response procedures will be implemented; changes not assessed from baseline
		• Effects on soils due to clubroot/disease	• Loss of soil productivity or quality due to clubroot or disease	• Unlikely – Project soils are not being used for agriculture and are not directly adjacent to any cultivated soils so potential for clubroot/diseases is low; not assessed
		• Effects on soils due to mulching and storing woody debris	• Vulnerability to fire, degradation of soil quality and increased footprint	• Unlikely – as there is minimal woody vegetation onsite (<1% TLSA area; Volume 2, Section 10) potential soil and terrain impacts from mulching and storing woody debris were not assessed

.

9.4 BASELINE

This section describes the existing conditions in the STLSA and TRSA before initiation of the Project, or the conditions that would exist if the Project were not developed. Conditions assessed at Baseline are guided by the Project's FTOR requirements and the Guide to Preparing Environmental Impact Assessments in Alberta (the Guide) (Government of Alberta [GOA], 2013).

9.4.1 Baseline Methods

Baseline conditions of the study area were examined using the methodology described in this section. Field work and a follow-up report was completed by Mentiga Pedology Consultants Ltd. (Mentiga Pedology Consultants, 2022).

9.4.1.1 Field Studies

Soil surveys were completed in the STLSA to identify and delineate soils, terrain features, and surficial materials to be used for reclamation planning and impact assessment. Soil mapping is based on the philosophy of pedology – that soils are natural bodies that reflect the influence of their environment. Point observations of soils were extrapolated to areas by using principles of geomorphology and surficial geology, combined with vegetation pattern indicators. Since soil is a continuum, and adjacent soils seldom have sharp boundaries, a Soil Unit is defined as a generally homogenous soil area exhibiting a range of properties but formed from similar surficial materials, on a similar landform, with a similar profile, and exhibiting similar soil moisture conditions. In practice, Soil Units are described as Soil Series (GOA, 2016c) or other previously undescribed classes which can be mapped as a single polygon or amalgamated into larger map units.

As per the Guide (Government of Alberta [GOA], 2013), soils must be surveyed to at least Survey Intensity Level 2 (SIL 2) in the Project area. SIL 2 requires an index value of 0.04 to 0.39 and represents soils surveyed with at least one inspection for 80% of delineations (GOC, 1981). The Survey Index formula is: **study area (ha) / number of survey inspection sites / percent of polygons inspected**. There were 49 soil inspection sites in a surveyed area of 899 ha with 77% of polygons inspected, resulting in an index of 0.24, showing the survey met the SIL 2 standard.

Soil Unit properties measured during field investigations included depth and thickness of horizons, colour, texture, structure, consistence, and any other relevant details. Site characteristics such as surficial materials, landform, topography, drainage, and surface stoniness were also described. Soil Series names and Map Units were then assigned to each polygon. Soil mapping was conducted on photomosaics at a scale of 1:12,000.

The Project area soil survey occurred during non-frozen conditions on August 8-10, 2022, by Mentiga Pedology Consultants Ltd. Soils were inspected at 49 preselected sample sites (Appendix G1, Figure G1-4). The usual procedure was to hand auger to the bottom of the B horizon and into the C material to a maximum depth of 1.2 m and describe the morphological characteristics of the soil. Landscape features and land use were also described at each inspection site.

Soils were sampled for laboratory analyses at 15 sites (see Appendix G1, Figure G1-4) to provide detailed chemistry on various Soil Units. The upper and lower subsoils of the soil pedon (a three-dimensional sample of a body of soil) were sampled separately; topsoil was also sampled at two of the sites. Analyses were carried out by IEH Services Canada Laboratories in Brooks, Alberta using standard methods (McKeague, 1978) (see Table 9-2).

Table 9-2: Laboratory analysis methods of soil samples

Analysis	Extraction	Determination
pH (water)	Saturated Paste	Electrodes
Electrical Conductivity	Saturated Extract	Conductivity Bridge
Soluble Salts and Sodium Adsorption Ratio (SAR) (Ca, Mg, Na)	Saturated Extract	Atoms. Ab. – Tech. II
%Saturation	Saturated Paste	%H_2O added
Organic Matter	Dry Combustion	LECO Furnace

Electrical conductivity (EC), saturation percentage (Sat%), and soil reaction (pH) were determined on all samples collected. Organic matter content was analyzed on topsoil samples. Soluble cations and sodium adsorption ration (SAR) were determined on subsoil samples. Plant available nutrients (N, P, K, SO_4) were analyzed on topsoil samples collected from selected native prairie lands.

Mapping of the STLSA was conducted on photomosaics at a scale of 1:12,000. Prior to soil survey, photomosaics were delineated into potential soil polygons based on observed changes in elevation, slope, vegetation, and other observed surface features. AGRASID mapping was consulted during this process to ensure previously delineated boundaries were included where relevant. Wetland polygons, completed as part of the Vegetation and Wetlands Assessment (Volume 2, Section 10), were also used. Sites for soil inventory were then selected to sample and characterize each soil polygon. Following field survey, soil polygons were revised based on survey results. For example, two neighbouring polygons with the same characteristics would be merged, and more complex sites might be further divided. These final polygons were digitized to create soil Map Units. Each Map Unit was attributed with soil characteristics, as described above. These characteristics were used to determine soil suitability, erosion, and reclamation ratings.

On the soils maps developed for the Project, the label of a Map Unit Delineation identifies a Soil Unit (i.e., soil series or newly defined soil) in the numerator and the Topographic Class in the denominator. Also indicated in the numerator (in parenthesis) is the average depth or range in depth of the topsoil, in cm. For example:

$$\frac{\text{MAB(15)}}{3}$$

identifies Maleb soil on Topographic Class 3 (2-5% slopes). The average depth of topsoil in the Map Unit is 15 cm.

Mapping phases are sometimes used to indicate important soil characteristics affecting agricultural ratings or reclamation suitability ratings. For example:

$$\frac{\text{saHUK(10)}}{2}$$

identifies saline Hemaruka soils on Topographic Class 2 (0.5-2% slopes). The average depth of topsoil in the Map Unit is 10 cm. Both the upper and lower subsoils in these soils are moderately to strongly saline. The topsoil may also be saline.

The mapping phases used in this study include:

- Peaty Phase – indicated by the notation "pt" preceding the Soil Unit abbreviation. It indicates areas of Ventre soils that have 20-50 cm of peat at the surface (ptVET).
- Saline Phase – indicated by the notation "sa" preceding the Soil Unit abbreviation. It indicates areas of Hemaruka or Halliday soils that are moderately to strongly saline at or near the surface (saHUK or saHDY). The topsoil horizon may also be saline.

9.4.1.2 Mapping and Description of Terrain and Soils

Bedrock Geology

Desktop review of the Bedrock Geology of Alberta spatial dataset was used to examine bedrock geology for the STLSA and TRSA (Alberta Geological Survey, 2020a). The dataset is a compilation of existing geological maps and original geological mapping by the Alberta Geological Survey (AGS). The mapping includes field observations and three-dimensional models of subsurface stratigraphy based on the interpretation of geophysical logs from oil and gas wells at a 1:1,000,000 scale. This information was mapped for the STLSA and TRSA to show the dominant geological layers in the Project and surrounding area.

Surficial Materials

Surficial materials (parent materials) are the initial mineral components (e.g., clay, silt, sand, gravel, cobbles, bedrock, etc.) from which soils develop. Excluding bedrock, these materials are deposited through geomorphological processes (e.g., eolian, glaciofluvial, etc.), and combinations of these processes. Each process results in a characteristic set of mineral types and sizes with typical chemical or physical properties. Over long periods, surficial materials, in combination with topography and climate, affect (and are affected by) drainage and moisture holding properties and exposure, which influence biological, chemical, and physical processes, resulting in the development of specific soil characteristics (GOC, 2021; Alijani & Sarmandian, 2015). The dominant material classes in the Project area included Stagnant Ice Moraine, Glaciolacustrine, Fluvial/Glaciofluvial, Ice-thrust Moraine, Colluvial, and Eolian material, which are classified by the processes that led to the types and sizes of mineral materials present.

Stagnant Ice Moraine forms during periods of glacial retreat. As the glacial movement stagnates, debris (till) carried by the ice is deposited at the glacier's edge due to decreased ice velocity and melting. This accumulation of sediment and debris creates a ridge-like landform known as a moraine. Stagnant Ice Moraine till is composed of a mixture of unsorted sediment, ranging from fine silt to large boulders, as well as rock fragments and debris entrained within the glacial ice. The composition of the moraine reflects the geological materials encountered and transported by the glacier during its advance. These moraines are often characterized by their ridge-like or mound-like appearance. The deposited till is irregular and heterogeneous, with variations in sediment size, sorting, and orientation. The moraine may exhibit a hummocky (mounded) or ridged surface morphology, reflecting the deposition of material in irregular mounds and ridges as the glacier margin stagnates and retreats (Alberta Geological Survey, 2020c).

Glaciolacustrine surface material forms extensive flat or gently sloping plains (Soil Classification Working Group, 1998). Glaciolacustrine surface materials are sedimentary deposits of glacial origin that have been modified by lacustrine (lake) processes. These deposits are commonly found in areas that were once covered by glaciers and later became occupied by glacial lakes (lakes formed of glacial meltwater at the foot of a glacier) or proglacial lakes (lakes formed when a glacier dams flowing water). When sediment eroded by glacial meltwater is deposited in the lake basin, the sediments settle in layers. Heavier rocks and sands are deposited first near the edge of the lake, while silts and then clays settle out near the centre of the lake. Common features include laminations (fine layers), graded bedding, and ripple marks. Glaciolacustrine surface material typically consists of fine-grained sediment such as silt and clay, as well as areas with sand, gravel, and organic material. The composition of the sediment reflects the variety of materials transported and deposited by glacial ice, as well as the subsequent sorting and settling processes within the lacustrine environment.

Fluvial (or Glaciofluvial) surface material refers to sedimentary deposits formed through the erosional and depositional action of flowing water in rivers and streams. This material, characterized by worn and rounded sand grains and rocks, is transported in fast flowing waters and deposited in slow flowing waters. The process begins with the erosion of sediment from the riverbed and banks, which is then transported downstream. As the velocity of the water decreases, sediment is deposited along the riverbed and floodplain, forming fluvial deposits. The deposits are typically composed of a mixture of sedimentary particles, including sand, silt, clay, gravel, and organic matter; these materials exhibit a gradation of grain sizes, ranging from coarse gravel and sand near the channel bed to fine silt and clay on the floodplain. Fluvial surface material may exhibit distinct sedimentary structures, such as crossbedding, ripple marks, and mud cracks (Soil Classification Working Group, 1998).

Ice-thrust moraines form when advancing glacial ice pushes and displaces sediment and debris along its path. As a glacier advances, it accumulates sediment and debris at its leading edge, creating a ridge-like landform. This accumulation occurs due to the pressure exerted by the moving ice, which compresses and deforms the sediment and debris, forming a distinct moraine ridge. The ridge-like or mound-like structure, extends perpendicular to the direction of glacial advance. The structure of the moraine may be irregular and heterogeneous, with variations in sediment size, sorting, and orientation. The ridge often shows evidence of deformation and displacement caused by thrusting of the advancing ice (Alberta Geological Survey, 2020c).

Colluvial surficial material refers to sedimentary deposits that accumulate at the base of slopes or hillsides due to gravitational processes. These deposits are composed of a mixture of weathered rock fragments, soil, and other debris derived from the erosion and weathering of the underlying bedrock and regolith, that have been transported downslope by gravity and deposited at the base of the slope. Depending on steepness, different sizes of rock materials accumulate or are eroded away (e.g. rocky scree remains on steep slopes while sands and silts are eroded by wind and water). Colluvial surficial material may exhibit various sedimentary structures, including horizontal bedding, grading, and sorting (Soil Classification Working Group, 1998).

Eolian surficial material refers to sedimentary deposits that are transported and deposited by wind. These deposits form where wind is the dominant erosional and depositional agent. The process begins with the detachment of sediment particles from the ground surface, typically through abrasion and deflation. These particles are then transported by wind action, which can involve saltation (bouncing), suspension (suspended in air), and creep (rolling along the surface). Finally, the sediment is deposited when wind speed decreases, often resulting in the formation of distinctive landforms such as dunes, sand sheets, and loess (silt sized grains loosely cemented by calcium carbonate) deposits. Eolian surficial material is primarily composed of fine-grained sediment particles, including sand, silt, and clay. Sand-sized particles are transported and deposited in short distances by wind, giving rise to dunes and sand sheets, while finer particles such as silt and clay are transported longer distances forming loess deposits (GOC, 2023).

Data from field inspections and soil laboratory samples were used to map surficial materials in the STLSA. Surficial materials in the TRSA were mapped based on the Surficial Geology of Alberta spatial dataset (Fenton, et al., 2013). This dataset is a compilation of existing geological maps at a 1:1,000,000 scale.

Landform and Topography (Slope, Elevation, and Relief)

The Government of Canada (GOC) defines landforms as the shape of the land surface due to natural and anthropogenic processes such as soil deposition, erosion, sedimentation, and earth crust movements (GOC, 2021). These processes create the elevation, slope, aspect, and other surface features that make up landforms (Papiernik, Koskinen, & Yates, 2009).

For the STLSA, landforms and topography were mapped using a combination of soil sampling data and high-level spatial mapping (i.e., digital elevation model derived from LiDAR, and topographic mapping). This mapping was used to show elevation, slope, aspect, and relief. The TRSA was mapped based on slope classes and topographic mapping, for soil polygons within the AGRASID database (GOA, 2016a). This allowed identification of prominent landform features such as coulees.

Soil Classification

Soils have been classified and described according to the Canadian System of Soil Classification (CSSC) (Soil Classification Working Group, 1998). This system classifies soils in their natural state and indicates relationships between soils and their environment.

For the STLSA, field measured soil properties including depth and thickness of horizons, colour, texture, structure, consistence, and any other pertinent details, as well as site characteristics such as surficial materials, landform, topography, drainage, and surface stoniness, were also used to determine Alberta Soil Series as per Alberta Soils Names file, Generation 4 (GOA, 2016c), and Soil Orders and Great Groups as per the CSSC. In the TRSA, previously mapped Soil Series were obtained from AGRASID (GOA, 2016a). Soils were then mapped to Soil Orders and Great Groups as per the CSSC.

Land Use and Soil Disturbance

Soils classes were overlaid onto land use mapping to determine the areas of soils by disturbance and reclamation cases in the STLSA and TRSA. Soils in native grassland and wetland areas were considered natural soils. Areas of pipelines, old wellsites, existing reservoir berms, and other former industrial sites were classified as reclaimed soils. Finally, all other disturbances, including roads, trails, railroads, active commercial/industrial and intensive agricultural and residential sites were classified as disturbed soils.

Soil Quality for Agriculture and Reclamation

The criteria used to rate soil quality were those proposed by the Soil Quality Criteria Subcommittee of the Alberta Soils Advisory Committee (GOA, 1987). These guidelines provide a subjective evaluation (Good, Fair, Poor, Unsuitable) of soil quality based on interpretation of physical and chemical properties of the soils. Soil quality was determined through field observation and laboratory analysis of on-site soil sampling. Soil quality of the STLSA was used as a measure of agricultural land capability and suitability for reclamation. The ratings were based on general predictions of soil performance and do not consider varying requirements of individual plant species or special management input. Ratings were assigned to the soils using their physical characteristics and results from laboratory analyses for those soils sampled. For soils that were not sampled for laboratory analysis, ratings are based on field observations.

Quality ratings were further categorized to simplify criteria for topsoil salvage. Topsoils rated Fair to Good were classified as Suitable Topsoil, while those rated Fair to Poor or Unsuitable were classified as Unsuitable Topsoil. Similarly, subsoils rated Fair to Good were classified as Suitable Subsoil, while subsoils rated Fair to Poor or Unsuitable were classified as Unsuitable Subsoil.

Soil Erosion Risk

Soil erosion hazard addresses the expected volume and rate of soil loss, by water and/or wind, that may be expected in an area following removal of the protective vegetation cover and failure to implement the proper erosion control measures. The rate of erosion depends on several factors: the amount, intensity, and seasonal distribution of rainfall; the steepness and length of slopes; the absence or presence of channels of concentration; the type of vegetation cover; and the nature of the soil. Infiltration capacity and structural stability are two soil characteristics influencing water erosion while particle size, durability of surface cloddiness (containing compact masses of soil), rock fragments, and organic matter are important soil characteristics influencing wind erosion. Erosion risk is reported based on soil characteristics observed for the soil series. Once soils are stripped and stockpiled for storage, erosion risk cannot be quantified and compared to Baseline as the soils are mixed together and no longer belong to the soil's series.

Spills

Potential for spills of hazardous materials and contamination of soils was assessed. If a spill occurs, soil may become contaminated and unusable for reclamation. Contamination can lead to adverse affects to the environment and/or human health. Contamination factors related to soils include depth to ground water, drainage class of the soils, landscape characteristics (e.g., slope), chemical make up of the pollutant, exposure time, surficial material type and texture, and soil chemistry (e.g., buffering capacity).

9.4.2 Baseline Results

9.4.2.1 Local Baseline Results

Local soils and terrain resources are described in terms of landform, surficial materials, slope, texture, surface stoniness, topsoil thickness, drainage conditions, profile morphology and soil chemistry. Results are presented in tables and maps.

Bedrock Geology

Bedrock geology describes the morphology and origin of the solid layer of rock below soil and glacial deposits. In Western Canada, most bedrock is composed of sedimentary rock layers that formed as mineral deposits, which have been lithified (turned to stone) and uplifted through geological processes over time (University of Wisconsin-Madison, 2024). Bedrock geology has a minor influence on soils and terrain except where bedrock is shallow (close to surface) or where outcrops occur. Outcrops may occur in higher terrain or on coulee slopes as bedrock is more resistant to erosion.

The STLSA is underlain by the Bearpaw Formation (Appendix G1, Figure G1-5) (Hamilton, Price, & Langenberg, 1999). The Bearpaw Formation is characterized by dark grey blocky shale and silty shale, greenish glauconitic and grey clayey sandstone, and thin concretionary ironstone and bentonitic beds. The Bearpaw Formation is of marine origin. Bedrock was not encountered within 1.2 m of the surface at any of the sites investigated.

Field Assessment and Soil Mapping

Soils investigations and mapping were conducted on August 8-10, 2022, on field photomosaics at a scale of 1:12,000. The distribution and extent of the soil Map Units (soil boundaries) are shown in Appendix G1, Figure G1-6). Average depth of topsoil and topography are also indicated on the Soil Maps. Field photographs of example soil classes are shown in Appendix G2. The topsoil and subsoil characteristics of each sample site are summarized in Table 9-3. Table 9-4 provides legend details for Table 9-3. Detailed summaries of field assessed Soil Units are provided in Appendix G3. See Appendix G2, Photo Plates 9-1 to 9-8 that illustrate a range of the most common soil classes in the Project area.

Table 9-3: Soil and Terrain site inspection summary (see Table 9-4 for legend)

Site	Soil Unit	Class	Parent Material	Topsoil Depth (cm)	Dominant Texture Top/Subsoil	Slope Class	Drainage Class	Surface Stoniness Class	Comments
1	BVL	O.BC	GF	9	SL/SL-L	2-3	W	S1	
2	BVL	O.BC	GF	8	SL/(SL/L/SL)	2-3	W	S0	
3	BVL	O.BC	GF	6	SL/SL	2-3	W	S0	
4	BVL	O.BC	GF	6	SL/(L/SL)	2-3	W	S0	
5	DHP	saO.HG	T	10	L/CL-C	1	P	S1	
6	PUN	O.BC	GF	8	SL/(gvSL/SL)	3	W-R	S1-2	
7	BVL	O.BC	GF	8	SL/(L/SL)	2-3	W	S0	
8	GPH	B.SS	GF/T	8	SL/(SL/CL)	2-3	W-MW	S1	till at 48 cm
9	GPH	B.SS	GF/T	5	SL/(SL/CL)	2-3	MW	S1-2	till at 15 cm
10	ROL	SZ.BC	T	6	SL/(L-CL)	2-3	MW	S1-2	
11	ROL	SZ.BC	T	8	SL/(L-CL/L)	2-3	MW	S1-2	
12	DPH	saO.HG	T	10	L/C	1	P	S0-1	white salt crust on surface
13	PUN	O.BC	GF	10	SL/gvSL	2-3	W-R	S1-2	
14	HDY	B.SO	T	10	L/(SL/L-CL)	2-3	MW	S1-2	salts at 50 cm; Bnt not tough
15	BVL	O.BC	GF	8	SL/(SL-L/SL)	2	W	S0	
16	HUK	B.SS	T	4	L/CL-C	2-3	MW	S2	salts at 28 cm
17	HUK	B.SS	T	5	L/CL-C	2	MW	S2	salts at 28 cm
18	HUK	B.SS	T	3	L/CL-C	2	MW	S1	salts at 20 cm
19	HDY	B.SO	T	4	L/L-CL	2	MW	S1	salts at 40 cm
20	HDY	B.SO	T	4	L/L-CL	2-3	MW	S1	salts at 30 cm; no Ae
21	DPH	saR.G	GL	0	-/SiCL	1	P	S0	very strongly saline and sodic
22	MAB	O.BC	T	4	SL/L	3	W	S3	very stony till at 20 cm
23	HDY	B.SO	T	6	L/(L-SL/L-CL)	3	MW	S1-2	Bnt not tough
24	HUK	B.SS	T	4	L/(L-CL/L)	2-3	MW	S1-2	salts at 26 cm
25	MAB	O.BC	T	4	L/(L/L-CL)	3	MW	S2-3	no salts observed
26	HUK	B.SS	T	6	SiL/CL	2	MW	S1	salts at 15 cm
27	HDY	B.SO	T	4	L/(L/CL/L)	2-3	MW	S1-2	salts at 28 cm
28	HUK	B.SS	T	4	L/CL-C	2	MW	S1	salts at 30 cm
29	saHUK	saB.SS	T	3	L/CL	2	MW	S1-2	salts at surface
30	DHP	saR.G	T	0	-/SiCL	1	P	S0	very strongly saline and sodic
31	DHP	saR.G	T	0	-/L	1	P	S2-3	very strongly saline and sodic
32	HUK	B.SS	T	4	L/CL	3	MW	S1-2	salts at 25 cm
33	HUK	B.SS	T	4	L/CL	2-3	MW	S1-2	salts at 25 cm
34	ROL	SZ.BC	T	4	L/(CL/L)	2-3	MW	S1-2	
35	saHDY	saB.SO	T	10	L/(L/CL/L)	2-3	MW	S1	salts >10 cm/ canal seepage?
36	HUK	B.SS	T	6	L/CL	2-3	MW	S1-2	salts at 36 cm
37	MAB	O.BC	T	4	L/(L/CL/L)	2-3	W-MW	S1-2	no salts observed
38	HDY	B.SO	T	4	L/(L/CL/L)	2-3	MW	S1	salts at 35 cm
39	DHP	saR.G	T	4	L/SiCL	1	P	S0-1	salts at surface
40	ptVET	ptR.G	T	4	O/SiCL	1	P	S0-1	22 cm of peat; low pH
41	GPH	B.SS	GF/T	4	SL/(SL/L)	2-3	W	S0-1	till at 40 cm
42	HDY	B.SO	T	5	L/(L/CL)	3	MW	S1	salts at 38 cm
43	DHP	saR.G	T	0	O/SiC-C	1	P	S0	salts at surface; 9 cm peat
44	HUK	B.SS	T	4	L/(L-CL/CL)	2	MW	S1	salts at 28 cm
45	MAB	O.BC	T	10	L/L	3	W-MW	S1	no salts observed
46	HDY	B.SO	T	5	L/(CL/L)	3	MW	S1	not a tough Bnt
47	DHP	saR.G	GL	0	-/SiCL	1	P	S0	salts at surface
48	DHP	saR.G	GL	10	0/SiCL-C	1	P	S0	10 cm of peat at surface
49	MAB	O.BC	T	8	SL/(SL/L)	2-3	W	S1	no salts observed

Note: a dash (-) in the “Dominant Texture” column indicates absence of topsoil or the topsoil could not be textured.

Table 9-4: Soil and Terrain site inspection legend

Variable	Code	Name
Soil Series	BVL	Bingville
	DHP	Dishpan
	GPH	Gopher
	HDY	Halliday
	HUK	Hemaruka
	MAB	Maleb
	PUN	Pemukan
	ROL	Ronalaine
	ptVET	peaty Ventre
Miscellaneous Land Units	B	Berm
	C	Canal
	DL	Disturbed Land
Soil Phases	pt	peaty
	sa	saline
Soil Classification into Orders	B.SO	Brown Solod
	B.SS	Brown Solodized Solonetz
	O.BC	Orthic Brown Chernozem
	O.HG	Orthic Humic Gleysol
	R.G	Rego Gleysol
	SZ.BC	Solonetzic Brown Chernozem
	ptR.G	peaty Rego Gleysol
	saB.SO	saline Brown Solod
	saB.SS	saline Brown Solodized Solonetz
	saO.HG	saline Orthic Humic Gleysol
	saR.G	saline Rego Gleysol
Surficial Materials	GF	glaciofluvial
	GL	glaciolacustrine
	T	till
Texture Classes	C	clay
	CL	clay loam
	gvSL	gravelly sandy loam
	L	loam
	O	organic
	S	sand
	SiCL	silty clay loam
	SL	sandy loam
Drainage Classes	R	rapidly
	W	well
	MW	moderately well
	I	imperfectly
	P	poorly
Slope Classes	1	0 – 0.5%
	2	0.5 – 2%
	3	2 – 5%
	4	5 – 10%
	5	10 – 15%
	6	15 – 30%
Surface Stoniness	S0	non-stony (stones >25 m apart)
	S1	slightly stony (stones 8-25 m apart)
	S2	moderately stony (stones 1-8 m apart)
	S3	very stony (stones 0.5-1 m apart)
	S4	exceedingly stony (stones 0.1-0.5 m apart)

Surficial Materials

Surficial materials in the STLSA are slightly to very stony in most areas. Loam to clay loam textured till is the dominant surficial material occupying 85% of the study area. Most of the till is moderately to strongly saline and sodic especially in low lying areas. The remaining 15% consists of glaciofluvial sands and gravels as well as glaciofluvial sands overlying loam to clay loam textured till (Table 9-5). The glaciofluvial sands and gravels are non-saline and non-sodic while the underlying till was moderately to strongly saline and sodic.

Table 9-5: Surficial materials of the STLSA

Surficial Material	Area (ha)	Area (%)
Disturbed[1]	3.4	0.4
Glaciofluvial	125.1	13.9
Glaciofluvial Veneer overlying Till	31.7	3.5
Glaciolacustrine or Till	99.4	11.1
Glacial Moraine (Till)	639.4	71.1
Total	**899.0**	**100.0**

1. Disturbed surficial materials only apply to existing berms for the SLR where subsurface materials are substantially altered as shown on Figure G1-6.

Most of the west and central areas of the STLSA are composed of till, including slopes associated with the meltwater channel and undulating areas to the north and south of this feature (Appendix G1, Figure G1-7). The till on the steeper slopes is moderately to very stony. Glaciofluvial sands and gravels are generally confined to the first 200 to 400 m along the eastern side of the study area where slopes are gentle. In the northeast corner of the STLSA, till is overlain by a thin glaciofluvial veneer; another small area of this class occurs near the west side of the STLSA. Most of the low-lying areas in the meltwater channel and other lower depressions – where wetlands occur – are underlain by glaciolacustrine materials or till. These areas support Gleysolic soils and are strongly saline and sodic.

Landform and Topography

Topography in the STLSA is predominantly gently undulating to undulating with slopes less than 5% (Appendix G1, Figure G1-8). Undulating topography means there are gently sloped wave-like mounds and troughs of 2-10 m relief over a slope-length typically less than 800 m (Soil Classification Working Group, 1998). Gently to moderately rolling ridges with slopes up to 15% occur adjacent to the central drainage feature with the most prominent slopes in central areas of the STLSA. Rolling topography includes gently to moderately sloped depressions and mounds, with 10-100 m of relief over a slope length of 1,600 m or more (Soil Classification Working Group, 1998). In addition, poorly drained, level to depressional areas, with wetlands, are scattered throughout the study area, with prominent features in the old glacial meltwater channel and in areas near the west side of the Project area below the East Branch Canal.

Slopes in the STLSA range from 0-15%, with some moderately rolling hills encouraging water runoff toward lower depressional areas (Table 9-6). Most of the STLSA is level (<0.5%) to gently sloping (5-10%). Landforms in these areas include low-relief wavelike hills and depressions characteristic of undulating topography. In contrast, the centre of the STLSA consists of moderate slopes (10-15%) and rolling topography. The east side of the STLSA, where the surficial materials are glacifluvial or glaciofluvial over till, is characterized by nearly level to gentle slopes.

The STLSA ranges in elevation from 765 m to 783 m above sea level, based on detailed LiDAR mapping (Appendix G1, Figure G1-8). The highest elevations occur in the north and west of the study area and the lowest elevations are to the east side in depression or at the east end of the meltwater channel. The steepest slopes in the STLSA occur parallel on the north and south sides of this channel. Most of the area (45%) is classified as Nearly Level to Very Gentle. The remainder of the area is Very Gentle (27%), Nearly Level is (7%) and Level (13%). With lesser percentages of Very Gentle Slopes to Nearly Level and Nearly Level to Very Gentle slopes in the north. The canal bordering the west side of the proposed Project footprint is on the most elevated part of the STLSA; the canal borders slopes classed as Nearly Level, Level, and Nearly Level to Very Gentle.

Table 9-6: Topographical (slope) classes of the STLSA

Slope	Area (ha)	Area (%)
Disturbed[1]	15.9	1.8
1 (Level: <0.5%)	120.1	13.4
2 (Nearly Level: 0.5 to 2%)	64.3	7.1
2-3 (Nearly Level to Very Gentle: 0.5 to 5%)	401.8	44.7
3 (Very Gentle: 2 to 5%)	246.1	27.4
3-4 (Very Gentle to Gentle: 2 to 10%)	24.3	2.7
4-5 (Gentle to Moderate: 5 to 15%)	26.6	3.0
Total	**899.0**	**100.0**

1. Disturbed classes include areas where slopes have been altered, includes all areas as shown on Figure G1-8 (Appendix G1).

Soil Types and Distribution

The STLSA occurs in the Brown Soil Zone, an area where soils with relatively thin, brown-coloured topsoil horizons have developed under predominantly short-grass prairie. Soils are mapped at the soil order level as it provided more clarity of the landforms as seen in Appendix G1, Figure G1-9. Soil Orders found in the STLSA that are in the Brown Soil Zone include Chernozemic, Gleysolic, and Solonetzic soils. Soil Great Group and Subgroup classifications found in the STLSA are Brown Solodized Solonetz, Brown Solods, Solonetzic Brown Chernozems, Orthic Brown Chernozems, and Rego Gleysols (Table 9-7). Detailed soil descriptions are provided in Appendix G3. To determine the total soils area, disturbances (35.5 ha) and water (77.1 ha) was subtracted from the STLSA area of 899 ha, for a total soils area of 786.4 (Table 9-7).

Excluding disturbances (3.9%) and open water classes (8.6%), soils cover 87.5% of the STLSA. Among the soil orders, Chernozemic soils cover 30.9%, Gleysolic Soils cover 5.2% and Solonetzic 51.4% of the STLSA.

Moderately well drained Brown Solodized Solonetz (Hemaruka Soils Series) with 3-6 cm of topsoil and developed on slightly to moderately stony, loam to clay loam textured till occupy 28.5% of the study area. Topsoils are not easily distinguished from subsoils by colour. Sometimes the topsoil consists only of an Ae horizon. These soils have a strong columnar structured Bnt horizon at shallow depths that is very firm in consistency and strongly sodic. The Csk horizon occurs at 15-36 cm below the surface and usually is strongly saline and sodic. In addition, well to moderately well drained Brown Solodized Solonetz (Gopher Soil Series) developed on sandy loam textured glaciofluvial veneers overlying loam to clay loam textured till cover 3.5% of the STLSA; overall, Brown Solodized Solonetzic soils cover 32.0% of the STLSA. Finally, saline Brown Solodized

Solonetz soils (2% of the STLSA) occur adjacent to the north side of the drainage that traverses from west to east. These soils are strongly saline at the surface.

Table 9-7: Soil class distribution of the STLSA

Order	Great Group	Soil Series	Soil Drainage	Area (ha)[1]	Area (%)[2]
Chernozemic	Solonetzic Brown Chernozem	ROL (Ronalaine)	Well to Mod. Well	56.9	6.3
	Orthic Brown Chernozem	BVL (Bingville)	Well	70.3	7.8
		MAB (Maleb)	Well to Mod. Well	101.3	11.3
		PUN (Pemukan)	Rapid	49.2	5.5
			Subtotal Orthic Brown Chernozem	*220.9*	*30.9*
			Subtotal Chernozemic	*277.8*	*30.9*
Gleysolic	Saline Rego Gleysol	DHP (Dishpan)	Poor	36.9	4.1
	Peaty Rego Gleysol	ptVET (peaty Venture)	Poor	9.9	1.1
			Subtotal Gleysolic	*46.8*	*5.2*
Solonetzic	Brown Solodized Solonetz	GPH (Gopher)	Well to Mod. Well	31.3	3.5
		HUK (Hemaruka)	Mod. Well	256.2	28.5
			Subtotal Brown Solodized Solonetz	*287.4*	*32.0*
	Saline Brown Solodized Solonetz	saHUK (saline Hemaruka)	Mod. Well	18.3	2.0
	Brown Solod	HDY (Halliday)	Well to Mod. Well	141.2	15.7
	saline Brown Solod	saHDY (saline Halliday)	Well to Mod. Well	14.8	1.6
			Subtotal Solonetzic	*443.6*	51.4
			Total Soils	***786.4***	***87.5***

1. Total STLSA is: 899.0 ha (100%) – (Disturbances 35.5 ha (3.9%) + Water 77.1 ha (8.6%)) = 786.4 ha
2. Percent area calculated on total area of STLSA (899.0 ha)

Well to moderately well drained Brown Solods (Halliday Soil Series) with 4-10 cm of topsoil and developed on slightly to very stony, loam to clay loam textured till, occur in upper landscape positions covering 15.7% of the STLSA. Topsoils are not easily distinguished from subsoils by colour. These soils have a friable AB horizon below the topsoil (A) horizon and the Bnt horizon is not as strongly structured or as firm as what occurs in the Brown Solodized Solonetzic soils. The Csk horizon occurs at 28-50 cm below surface and is strongly saline and sodic. An area of saline Brown Solods (saline Halliday; 1.6% of the STLSA) occur near the canal in the southwest corner. These soils are strongly saline and sodic, which may be due to canal seepage.

Well to moderately well drained Solonetzic Brown Chernozems (Ronalaine Soil Series) with 4-8 cm of topsoil and developed on slightly to moderately stony, loam to clay loam textured till occur in the northwest and southeast portions of the STLSA, on gently undulating to undulating terrain. These occupy 6.3% of the study area. Colour differentiation of topsoils from subsoils is Fair to Poor in these soils. Colour differentiation refers to a qualitative assessment of the colour change between the A and B horizons in a location, and not the colour change between sites. The Btnj horizon is weakly developed and a Ck or Csk horizon occurs at 35-40 cm below the surface. These soils are usually non-saline to weakly saline and moderately to strongly sodic.

Well to moderately well drained Orthic Brown Chernozems (Maleb Soil Series) with 4-10 cm of topsoil and developed on slightly to very stony, loam to clay loam textured till occur in upland landscape positions and occupy 11.3% of the study area. Colour differentiation between topsoils and upper subsoils is Fair. These soils have a friable to firm Bm horizon that is yellowish brown in colour and subangular blocky structure. The Ck horizon occurs at 30-45 cm below the surface and is non-saline and non-sodic.

Well drained Orthic Brown Chernozems (Bingville Soil Series) with 6-9 cm of topsoil and developed on stone-free to slightly stony, sandy loam textured glaciofluvial material are generally confined to the southwestern portion and occupies 7.8% of the study area. Topsoils are easily distinguished from subsoils by colour. These soils have a friable Bm horizon and the Ck or Cca horizon occurs at 55-65 cm below the surface. These soils are sandy loam to loam textured, non-saline and non-sodic.

Rapidly drained Orthic Brown Chernozems (Pemukan Soil Series) developed on glaciofluvial gravels occur in the northwestern and western portions and occupy 5.5% of the study area. Topsoil varies from 5-10 cm and colour differentiation between topsoils and upper subsoils is Fair to Poor. These soils are non-saline and non-sodic. The gravel consists mainly of pea-gravel size. In total, Orthic Brown Chernozems cover 24.6% of the STLSA.

Poorly drained depressional and level areas consist of saline Rego Gleysols (Dishpan Soil Series) developed on stone-free glaciolacustrine clays or slightly to very stony, loam to clay loam textured till. Topsoils vary from 0 to 10 cm. Colour differentiation between the topsoil, when it occurs, and the upper subsoil is Fair to Poor. These soils are often very strongly saline and sodic at or near the surface and occupy 4.1% of the STLSA. In addition, peaty Rego Gleysols (peaty Venture Soil Series) on stone-free to slightly stony silty clay to clay tills covers 1.1% of the STLSA).

The Soil Units identified in the study area are described in Appendix G-3. A key to the soils is presented in Appendix G-3, Table G3-2. The extent of the soils by order and Great Group is shown in Table 9-7 (above). Laboratory analyses of sampled soils are provided in Table 9-8 (below).

Table 9-8 Soil Characteristics of Sampled Soils

Site	Soil Unit	Horizon	Depth (cm)	pH (H_2O)	EC (dS/m)	Sat (%)	SAR	Organic C (%)	Field Texture	Ratings and Limitations*
3	Bingville	Ah Bm Cca	0-6 6-65 65-100	6.6 7.2 8.2	1.1 0.8 1.9	56 35 34	- 1.1 6.7	2.8 - -	SL SL SL	G G F(1,3)
5	Dishpan	Bsg Cskg	10-35 35-80	6.5 7.7	9.5 13.5	70 79	13.8 23.1	- -	CL-C C	U(3) U(2,3)
12	Dishpan	Bsg Cskg	10-50 50-80	7.5 7.7	10.7 14.0	71 87	17.7 24.6	- -	C C	U(2,3) U(2,3)
21	Dishpan	Cskg	0-20	8.2	34.5	70	61.7	-	SiCL	U(2,3)
31	Dishpan	Cskg	0-10	7.7	66.1	81	103	-	L	U(2,3)
14	Halliday	Bnt Csk	16-50 50-100	7.3 7.8	18.0 22.3	60 66	26.3 33.1	- -	L-CL L-CL	U(2,3) U(2,3)
16	Hemaruka	Bnt Csk	10-28 28-70	6.7 7.1	5.9 7.1	81 94	13.4 14.6	- -	CL-C CL-C	U(3) U(3)
28	Hemaruka	Bnt Csk	8-30 30-60	7.4 8.3	1.2 3.1	73 112	9.5 21.1	- -	CL-C CL	F(3,7) U(3)
25	Maleb	Bm Ck	12-32 32-80	6.4 7.5	0.4 0.8	50 54	0.2 0.6	- -	L-CL L	F(1,6) G
37	Maleb	Bm Ck	10-32 32-70	6.4 7.4	0.5 0.7	55 58	0.3 0.5	- -	L-CL L	F(1,6) G
45	Maleb	Ah Bm Ck	0-10 23-43 43-70	6.0 6.6 7.8	0.8 0.6 0.7	86 57 52	- 0.6 1.2	5.3 - -	L L L	F(1,4) G F(1)
49	Maleb	Bm Ck	12-40 40-66	6.8 7.7	0.6 0.5	41 35	0.2 0.9	- -	L SL-L	G F(1)
11	Ronalaine	Btnj Csk	22-40 40-100	7.9 8.3	1.5 3.0	67 60	11.5 12.6	- -	L-CL L	P(3) U(3)
34	Ronalaine	Btnj Ck	15-36 36-80	6.7 8.2	0.5 1.1	43 51	0.6 7.1	- -	L-CL L	F(6) F(1,3)
40	peaty Ventre	Cg Cg	0-35 35-80	4.8 5.2	2.2 1.5	57 57	7.1 5.9	- -	SiCL SiCL	P(1) P(1)

* Limitations		Reclamation Suitability Ratings (After (GOA, 1987))
1 – pH	5 – Stoniness	G – Good
2 – EC	6 – Texture	F – Fair
3 – SAR	7 – Consistence	P – Poor
4 – Sat%	8 – Organic Carbon	U – Unsuitable

Soil Disturbance and Waterbodies

Soils in the Project area have been affected by disturbances such as oil and gas surface wells and pipelines, roads and trails, canals and irrigation infrastructure, and gravel pit extraction. Of the 899.0 ha STLSA, disturbed soils (total anthropogenic features) cover 35.5 ha (3.9%; Table 9-9). Natural water features, including wetlands and other waterbodies cover 77.1 ha (8.6%).

Table 9-9: Soil disturbance and water features of the STLSA

Disturbance Type	Disturbance	Area (ha)	Area (%)[1]
Anthropogenic Land Features	Berm	3.1	0.3
	Disturbed Land	0.5	0.1
	Gravel Pit, naturalized	2.3	0.3
	Reclaimed Wellsite	0.1	0.1
	Road	0.7	0.1
	Trail	1.5	0.2
	Wellsite	0.1	0.1
	Subtotal	*8.3*	*0.9*
Anthropogenic Water Features	Canal	21.6	2.4
	Ditch	3.1	0.3
	Dugout	2.6	0.3
	Subtotal	*27.3*	*3.0*
Natural Water Features	Ephemeral Waterbody	5.1	0.6
	Intermittent Shallow Open Water	11.8	1.3
	Seasonal Marsh	32.1	3.6
	Temporary Marsh	20.3	2.3
	Other Waterbodies	7.6	0.8
	Subtotal	*76.9*	*8.6*
All Anthropogenic Features		35.6	4.0
All Water Features (Anthropogenic and Natural)		104.5	11.6
	Total Anthropogenic and Water	*112.5*	*12.5*

1. Percent area calculated on total area of STLSA (899.0 ha).

Soil Quality for Agriculture and Reclamation

Soil quality ratings (GOA, 1987) were adapted to identify topsoil and subsoil classes suitable for reclamation and are presented in Appendix G1, Figure G1-10. Topsoil and subsoil are rated separately as suitable topsoil may overlay unsuitable subsoil (Table 9-10).

Reclamation suitability also considers compaction. All soils are somewhat susceptible to soil compaction and rutting if unfavourable moisture conditions prevail at the time of construction. However, since most soils in the STLSA have sandy loam to clay loam textures and are rapidly to moderately well drained, they are not highly susceptible to compaction and rutting. Only poorly drained Dishpan and peaty Ventre soils are highly susceptible to soil compaction and rutting.

The STLSA is characterized by soils that have rather thin topsoil depths (generally less than 10 cm thick) and are frequently strongly saline and sodic at shallow depths. As topsoil is a better growth medium than the underlying subsoil, the total depth of topsoil (Ah, Ae and AB horizons) should be salvaged and stored for reclamation of the outer edge of the perimeter embankment. Separation of topsoil from subsoil cannot be easily made by colour, so measured depth and judgement of an environmental inspector should be used at the time of salvage. Average topsoil depths are shown in Appendix G1, Figure G1-6 and can be used as a guide for topsoil salvage.

Most soils in the STLSA were rated as Fair to Good (F-G) quality. Topsoils of Bingville, Gopher, Halliday, Maleb, and Ronalaine have favourable texture and chemical properties and are rated as F-G. Topsoils of Pemukan soils are rated as Fair to Poor (F-P) due to coarse texture and shallow A horizon, while Hemaruka topsoil was rated F-P due to shallow A horizon. Topsoils of saline Halliday, saline Hemaruka and Dishpan soils are strongly saline and sodic and considered Poor to Unsuitable (P-U) quality depending on the severity of the salinity or sodicity limitations. Peaty Ventre soils do not generally have a topsoil horizon but instead there is an organic surface horizon that is about 22 cm thick and is rated as F-P.

Considerable variation in quality occurs in the B and C horizons of the soils in the STLSA. Subsoils of Bingville and Maleb were rated F-G due to texture and chemical characteristics; however, sometimes the soil reaction (pH) was higher than desirable. Subsoils of Pemukan soils were rated Poor (P) due to coarse texture while subsoils of peaty Ventre soils are rated P due to fine texture and low pH. Subsoils of Dishpan, Hemaruka, saline Hemaruka, and saline Halliday soils are P-U depending on saline and/or sodic content. Upper subsoils of Halliday soils are rated F-P while the lower subsoil (below 28 cm) is strongly saline and/or sodic and is rated as P-U. The upper subsoil of Gopher soils is sandy loam textured glaciofluvial material and rated F-G. The lower subsoil (>15 cm deep) occurs in till, is generally moderately saline and strongly sodic, and is rated P-U. Subsoils of Ronalaine are F-P depending on sodicity.

Table 9-10: Soil quality ratings in the STLSA

Soil Symbol	Soil Name	Soil Classification	Surficial Material	Quality Ratings	
				Topsoil*	Subsoil
BVL	Bingville	Orthic Brown Chernozem	glaciofluvial	F-G(6-9)	F-G
DHP	Dishpan	saline Rego Gleysol	till or glaciolacustrine	P-U(0-10)	U
GPH	Gopher	Brown Solodized Solonetz	glaciofluvial veneer overlying till	F-G(4-8)	F-G/P-U
HDY	Halliday	Brown Solod	till	F-G(4-10)	F-P/P-U
saHDY	saline Halliday	saline Brown Solod	till	P(10)	U
HUK	Hemaruka	Brown Solodized Solonetz	till	F-P(3-6)	P-U
saHUK	saline Hemaruka	saline Brown Solodized Solonetz	till	P-U(5)	U
MAB	Maleb	Orthic Brown Chernozem	till	F-G(4-10)	F-G
PUN	Pemukan	Orthic Brown Chernozem	glaciofluvial gravels	F-P(5-10)	P
ROL	Ronalaine	Solonetzic Brown Chernozem	till	F-G(4-8)	F-P
ptVET	peaty Ventre	peaty Rego Gleysol	till	F-P(20)	P
* Range in depth of topsoil in parentheses (cm)					
Quality Ratings:	G - Good F - Fair P - Poor U - Unsuitable				

Soil Erosion Risk

Soil erosion hazard is the expected rapidity and amount of soil loss by water and/or wind that may be expected in an area following removal of the protective vegetation cover and failure to implement the proper erosion control measures. Wind is not considered a major erosion risk in the study area (Coote & Pettapiece, 1989). Water (snowmelt and rainfall intensities and duration) is also not considered a major erosive agent in the STLSA because of the relatively flat terrain and low annual rainfall. Soils in the study area were rated for wind and water soil erosion risk (Table 9-11) based on information in Table 9-12. Sandy loam soils are rated High for wind erosion risk when the vegetation is disturbed. Bingville, Gopher, and Pemukan soils are rated High. All other soils are rated Moderate except poorly drained Dishpan and peaty Ventre soils which are rated Slight. All soils on slopes less than 9% are rated Slight for water erosion risk. Since most of the STLSA occurs on slopes below 9% (Table 9-11), water erosion is typically low risk. Steeper slopes with Maleb and Halliday soils are rated Moderate. These areas occupy <4% of the study area.

Table 9-11: Wind and water soil erosion hazard ratings of soil map units in the STLSA

Map Unit	Wind Erosion Hazard	Water Erosion Hazard*
BVL(5-10)/2-3	High	Slight
BVL(5-10)/3	High	Slight
DHP(0)/1	Slight	Slight
DHP(0-5)/1	Slight	Slight
DHP(5)/1	Slight	Slight
DHP(5-10)/1	Slight	Slight
GPH(5)/2-3	High	Slight
GPH(5-10)/2-3	High	Slight
HDY(5)/2-3	Moderate	Slight
HDY(5-10)/2-3	Moderate	Slight
HDY(5)/3	Moderate	Slight
HDY(5-10)/3	Moderate	Slight
HDY(5-10)/3-4	Moderate	Slight
HDY(5)/4-5	Moderate	Moderate
saHDY(10)/2-3	Moderate	Slight
HUK(5)/1	Moderate	Slight
HUK(5)/2	Moderate	Slight
HUK(5)/2-3	Moderate	Slight
HUK(5-10)/3	Moderate	Slight
saHUK(5)/2	Moderate	Slight
MAB(5)/2-3	Moderate	Slight
MAB(5-10)/2-3	Moderate	Slight
MAB(5-10)/3	Moderate	Slight
MAB(5)/4-5	Moderate	Moderate
PUN(5-10)/3	High	Slight
ROL(5)/2-3	Moderate	Slight
ROL(5-10)/2-3	Moderate	Slight
ptVET(5)/1	Slight	Slight
Miscellaneous Land Units:		
B[1]	-	-
C[1]	-	-
DL	High	Slight

1 – these were not used in the field assessment.

Table 9-12: Soil characteristics in the STLSA

Soil Series	Soil Name	Soil Class[1]	Surficial Material[2]	Texture Class[3]	Drainage Class[4]	Topsoil Depth (cm)	Topsoil to Subsoil Colour Differentiation	Erosion Hazards[5]		Compaction and Rutting Susceptibility	Surface Stoniness [6]	Comments or Other Concerns
								Wind	Water			
BVL	Bingville	O.BC	GF	SL	W	6-9	Good	H	S	-	S0-1	these soils are non-saline and non-sodic
DHP	Dishpan	saO.HG saR.G	T or GL	L-C	P	0-10	Fair-Poor	M	S	Yes	S0-S3	strongly saine and sodic at the surface
GPH	Gopher	B.SS	GF/T	SL/L-CL	W-MW	4-8	Fair-Poor	H	S	-	-	finer textured material at 15-48 cm below surface
HDY	Halliday	B.SO	T	L-CL	W-MW	4-10	Poor	M	S-M	-	S1-S3	lower subsoil is strongly saline and sodic
saHDY	saline Halliday	saB.SO	T	L-CL	MW	10	Poor	M	S	-	S1	strongly saline and sodic at the surface
HUK	Hemaruka	B.SS	T	L-CL	MW	3-6	Poor	M	S	-	S1-S2	tough upper subsoil blow out pits only have a thin Ae horizon at the surface
saHUK	saline Hemaruka	saB.SS	T	L-CL	MW	5	Poor	M	S	-	S1-S2	strongly saline and sodic at the surface
MAB	Maleb	O.BC	T	L-CL	W-MW	4-10	Fair	M	S-M	-	S1-S3	these soils are non-saline and non-sodic
PUN	Pemukan	O.BC	GF	gvSL	R	5-10	Fair-Poor	H	S	-	S1-S3	gravels usually occur within 20 cm of surface
ROL	Ronalaine	SZ.BC	T	L-CL	W-MW	4-8	Fair-Poor	M	S	-	S1-S2	solonetzic B horizon has weak structure
ptVET	peaty Ventre	ptR.G	T	SiCL	P	0	-	S	S	Yes	S0-S1	very strongly acidic has 22 cm of surface peat

1. Soil Classification according to (Soil Classification Working Group, 1998)

2. Surficial Material
GF - glaciofluvial
GL - glaciolacustrine
T - till

3. Texture Classes
C - clay
CL - clay loam
L - loam
SiL - silt loam
SiCL - silty clay loam
SiC - silty clay
SL - sandy loam
gv - gravelly

4. Drainage Classes
R - rapidly
W - well
MW - moderately well
I - imperfectly
P - poorly

5. Erosion Hazards
S - slight
M - moderate
H - high

6. Surface Stoniness Classes
S0 - stone-free
S1 - slightly stony
S2 - moderately stony
S3 - very stony

9.4.2.2 Regional Baseline Results

Soils at the regional level were mapped based on the AGRASID inventory. AGRASID soil polygons in the TRSA were classified into Soil Order and Topographic Classes.

Bedrock Geology

Most of the TRSA is underlain by the Bearpaw Formation (99.7%); the Horseshoe Canyon Formation covers 0.3%. The Bearpaw Formation is of marine origin and is composed of dark grey and silty shales, dark grey claystones, siltstones, silty claystones, subordinate silty sandstones, and thin beds of bentonite with bedded and nodular, calcareous and ironstone, concretions. Together, these form the principal rock of the Bearpaw Formation (Hamilton, Price, & Langenberg, 1999). The Horseshoe Canyon Formation is a small component of the TRSA that can be seen in Appendix G1, Figure G1-11, in the southwest corner. The Horsehoe Canyon Formation is composed of mudstone, sandstone, carbonaceous shales, and coal seams. The Dinosaur Park Formation, SE of the TRSA formed in fluvial channel environments and is primarily fine to medium-grained, cross-bedded sandstones.

Surficial Material Classes

Surficial materials in the TRSA were primarily composed of stagnant ice moraine and glaciolacustrine deposits (52% and 39% respectively; Appendix G1, Figure G1-12; Table 9-13). The areas of water shown on Figure G1-12 also contain surficial materials not labelled. Stagnant Ice Moraine till is generally associated with elevations between 790 to 820 m above sea level (asl) while glaciolacustrine deposits are associated with elevations between 760 and 790 m asl. Ice-thrust moraine is the third most common surficial material (3%), followed by fluvial and colluvial deposits (2% each). A small percentage of the area (1%) is eolian. The glaciolacustrine deposits are in the northern and eastern portions of the TRSA, with the stagnant ice moraine mostly in the southwestern area, though it also appears sporadically in the east and north. Ice-thrust moraine deposits occur in two areas: one in the southwest, and one in the north. Glaciofluvial and fluvial deposits occur along the Bow River. One patch of eolian deposits occur in northwest areas of the TRSA.

Table 9-13: Surficial materials of the TRSA

Surficial Material[1]	Area (ha)	Area (%)
Colluvial Deposits	1,677.6	1.9
Eolian Deposits	969.3	1.1
Fluvial Deposits	1,734.0	1.9
Glaciolacustrine Deposits	34,798.3	39.4
Ice-thrust moraine	2,998.8	3.4
Stagnant Ice Moraine	46,226.9	52.3
Total	**88,404.9**	**100.0**

1. Water and disturbances are included in the surficial deposit totals.

Landform and Topography

Landforms in the TRSA are divided into disturbances, water features, and slope classifications (Appendix G1, Figure G1-13). Disturbance covers nearly 5% of the area, while water features cover about 9%. Most of the area is classified as Nearly Level to Very Gentle slopes at 53% (Table 9-14). 26.9% is classified as Very Gentle to Gentle Slopes. The remaining slope classes in the TRSA are Nearly Level at nearly 14.7%. Gentle to Moderate Slopes, Level to Nearly Level, and Level to Gentle Slopes are the remaining areas at 3.3%, 0.7% and 0.2% respectively. The elevation of the TRSA ranges from 740 m in the northeast to 840 m along the Bow River in the southwest. Much of the area is between 780 m and 800 m elevation. Some of the steepest slopes or most drastic aspects are found along water features such as the SLR and the Bow River.

Table 9-14: Topographical Classes of the TRSA

Topographic Code	Classification	Area (ha)	Area (%)
1-2	Level to Nearly Level (0-2%)	588.4	0.7
1-4	Level to Gentle Slopes (0-10%)	156.9	0.2
2	Nearly Level (0.5-2%)	11,198.3	12.7
2-3	Nearly Level to Very Gentle Slopes (0.5-5%)	40,337.7	45.6
3-4	Very Gentle to Gentle Slopes (2-10%)	20,492.9	23.2
4-5	Gentle to Moderate Slopes (5-15%)	2,538.4	2.9
5-6+	Moderate to Strong Slopes (10-30%)	518.7	0.6
N/A	Disturbance (water)	237.2	0.3
Sub-total Slope Classes		*76,068.5*	*86.1*
Disturbance[1]		*4,091.1*	*4.6*
Water Features[1]		*8,245.4*	*9.3*
Total Area[2]		**88,404.9**	**100.0**

1. See Table 9-16 for water and disturbance classes
2. Numbers don't add up exactly due to rounding errors

Soil Classification

Soil classification at the regional level was mapped at the Order level, based on AGRASID mapping (Appendix G1, Figure G1-14). Eight soil orders, plus open water areas, were mapped for the TRSA. These soil orders are listed in Table 9-15.

Solonetzic soils dominate the TRSA. They are characterized by a B horizon that contains a large amount of sodium. Brown Chernozemic soils are next most common. Chernozemic soils are defined by well to imperfectly drained soils in grassland vegetative communities. They can be characterized by a dark A horizon about 10-15 cm thick. Regosolic soils are the third most common soil in the TRSA. They are characterized by a lack of a B horizon, or a shallow A horizon. Gleysols are soils formed under saturated conditions in wetlands and other depressions. They make up <1% of the TRSA. Chernozems account for approximately 36% of the TRSA, Solonetz are approximately 57%, and Regosols are approximately 2%. The remaining soil orders are combinations of Chernozems, Solonetz, and Gleysols that account for approximately 3% of the area. Solonetzic soils dominate the TRSA's southwest, though are present throughout the area's extent. Chernozemic soils are found sporadically through the northwest and eastern area. Regosols are primarily found along the Bow River and its flood plain.

Table 9-15: Soil classification and characteristics of the TRSA

Soil Orders	Soil Characteristics	Area (ha)	Area (%)
Chernozemic	Imperfectly drained Dark A horizon (10-15 cm deep)	27,748.5	31.3
Chernozemic-Gleysolic[1]		268.2	0.3
Chernozemic-Solonetzic[1]		892.9	1.0
Gleysolic	Gleyed or mottled B or C horizons due to prolonged saturation	491.7	0.6
Regosolic	Shallow A horizon, no B horizon	1,646.3	1.9
Solonetzic	B horizon with large amounts of sodium	43,773.7	49.3
Solonetzic-Chernozemic[1]		935.7	1.1
Solonetzic-Gleysolic[1]		74.2	0.1
Non-soil Classification[2]	Non-soil as classified by AGRASID	237.2	0.3
Subtotal Soils		*76,068.4*	*85.8*
Water[3]		*8,245.3*	*9.6*
Disturbance[3]		*4,091.3*	*4.6*
Total		**88,404.9**	**100.0**

1. Map areas containing two orders intermixed
2. Non-soil as classified by AGRASID (GOA, 2016a)
3. See Table 9-16 for water and disturbance classes

Soil Disturbance and Water Features

4.6% of the TRSA is disturbed. Disturbances include activities that have removed or altered soils; but excludes cultivated areas that have intact soils. Among disturbances, roads (24%), residential (21%), existing canals (16%) and industrial activities (15%) are most common. Other disturbances (23%) include wellsites, railways, ditches, dugouts, and gravel pits (Table 9-16). Water covers 9% of the TRSA. These features include ephemeral and intermittent shallow open water, marshes, swamps, watercourses, and reservoirs.

Table 9-16: Soil disturbance and water features of the TRSA

Disturbance Type	Area (ha)	% of Disturbances	% of Water	% of TRSA
Abandoned Railway	83.6	2.0	N/A	0.1
Canal	655.7	16.0		0.7
Ditch	76.7	1.9		0.1
Dugout	201.4	4.9		0.2
Gravel Pit, naturalized	2.4	0.1		0.0
Industrial	604.9	14.8		0.7
Railway	174.8	4.3		0.2
Reclaimed Wellsite	140.9	3.4		0.2
Residential	878.9	21.5		1.0
Road	1,008.0	24.6		1.1
Trail	114.1	2.8		0.1
Wellsite	149.8	3.7		0.2
Subtotal Disturbances	*4,091.3*	*100.0*		*4.6*
Ephemeral Waterbody	10.1	N/A	0.1	0.0
Intermittent Shallow Open Water	12.5		0.2	0.0
Marsh	4,435.3		54.2	5.0
Open Water	142.5		1.7	0.2
Reservoir	624.2		7.6	0.7
Seasonal Marsh	33.2		0.4	0.0
Swamp	3.3		0.04	0.0
Temporary Marsh	29.1		0.4	0.0
Waterbody	2,897.8		35.4	3.3
Watercourse	57.2		0.7	0.1
Subtotal Water Features	*8,245.3*		*100.0*	*9.3*
Soils	*76,068.4*		N/A	*86.1*
Total	**88,404.9**			**100.0**

9.5 IMPACT ASSESSMENT

This section describes the predicted impacts and mitigation measures to be applied for the Project. Some soils will be left in place and flooded, some will be stripped and removed from the Project footprint, and some will be stripped and removed from the berm construction area. How soils are managed is based on their suitability rating presented in the Baseline. Regardless of how the soils are managed, the change to soil orders is permanent, as once the soils are disturbed from their natural pedon they are no longer classified into their previous orders. Project activities could potentially have an impact on soil quality, but appropriate soil handling and mitigation measures will be in place to minimize that risk.

9.5.1 Assessment Methods

For a full description of the EIA Approach including the assessment methods and EIA criteria see Volume 2, Section 2. The following section discusses how the Application Case for soil and terrain resources were assessed.

9.5.2 Measures to Mitigate Adverse Effects

Common risks to soil and terrain resources includes topsoil loss and degradation in quality, either by erosion or by admixing with the subsoil. The EID intends to employ standard mitigation measures and best management practices to ensure topsoil preservation during construction and reclamation. Mitigation Measures, Management Practices, and Monitoring Plans (Volume 1, Section 11) provide detailed steps for soil handling and management. Several key mitigation measures for managing Project effects on soils include:

- Stripping and salvaging total depth of good quality topsoil (A horizon) for reclamation of the outer edge of the reservoir berm.
- Seeding and stabilization of temporary topsoil storage piles to avoid loss by wind or water influenced erosion.
- Permanent placement and revegetation of salvaged topsoil on Project areas to be reclaimed, such as the outer edges of the new SLR embankment.
- The total area of reclaimed soils, as described in the Conceptual Conservation and Reclamation Plan (Volume 1, Section 10), is expected to be 105 ha. This will mitigate some of the lost soil area (14%), allowing some areas of native grassland to be restored. However, the reclaimed soil area cannot be classified to an existing soil series or order.

9.5.3 Assessment Results

The predicted effects of the SLR expansion for the Application Case, which includes the Project activities for SLR plus the Baseline, are described in the sections that follow and summarized in tables.

9.5.3.1 Loss of Soil and Soil Orders

Established in the Baseline, and identified in Figure G1-10, a large portion of both the topsoil and subsoil within the Project footprint is considered <u>suitable</u> for reclamation and will be stripped and salvaged for use in berm reclamation. As topsoil is a good growing medium, it would only be removed from site if there is a surplus, and, in the case of a surplus, good quality topsoil would likely be used elsewhere for reclamation/soil improvement purposes. Poor quality topsoil and subsoil (i.e., unsuitable for use in construction or reclamation) will be left in place within the Project footprint and will be flooded, with the exception of 33.5 ha on edges of the Project footprint, where the berm will be constructed including temporary workspace (Figure G1-15). The topsoil and subsoil in this 33.5 ha area will be stripped and removed, rather than flooded. There is also a 19.5 ha area to the west of the Project that was included in the Baseline assessment but is on the outside of the Project boundary. These soils will not be disturbed.

Table 9-17 and 9-18 below show the total area of suitable and unsuitable topsoil and subsoil, respectively, that will be affected by Project activities. As mentioned in previous sections, the total soils area of 786.4 ha is less than the total study area as disturbance and water are not included.

Table 9-17: Area of suitable and unsuitable topsoil in the STLSA affected by Project activities

Resource	Baseline Soils Area (ha)	Undisturbed (ha)	Area Affected by Project Activities (ha)	Material Salvaged, Utilized in Reclamation (ha)	Materials Removed, Not Utilized in Reclamation (ha)[1]	Materials Left in Place to be Flooded (ha)
Suitable Topsoil	657.3	17.3	640.0	640.0	0.0	0.0
Unsuitable Topsoil	129.1	2.2	126.9	0.0	33.5	93.4
Total	*786.4*	*19.5*	*766.9*	*640.0*	*33.5*	*93.4*

1 – This represents the 33.5 ha that the berm will overlay

Table 9-17 shows the total area of suitable and unsuitable topsoil. The total area of soils affected by the Project is 766.9 ha, after the 19.5 ha undisturbed area on the outside of the Project boundary is subtracted. The next column represents the area of suitable topsoil that will be stripped and salvaged (640 ha), followed by the column representing the unsuitable materials that will be removed rather than flooded (33.5 ha), as they form the footprint of the berm and must be stripped. A total of 93.4 ha of unsuitable topsoil will be left in place in the Project footprint and become flooded.

Table 9-18: Area of suitable and unsuitable subsoil in the STLSA affected by Project activities

Resource	Baseline Conditions (ha)	Undisturbed (ha)	Area Affected by Project Activities (ha)	Material Salvaged and Utilized in Reclamation (ha)	Materials Removed, Not Utilized in Reclamation (ha)[1]	Materials Left in Place to be Flooded (ha)
Suitable Subsoil	259.9	0.0	259.9	259.9	0.0	0.0
Unsuitable Subsoil	526.5	19.5	507.0	0.0	33.5	473.5
Total	*786.4*	*19.5*	*766.9*	*259.9*	*33.5*	*473.5*

1 – this represents the 33.5 ha that the berm will overlay

Table 9-18 shows the total area of suitable and unsuitable subsoil. The total area of soils affected by the Project is 766.9 ha, after the 19.5 ha undisturbed area on the outside of the Project boundary is removed. The next column represents the area of suitable subsoil that will be stripped and salvaged (259.9 ha), followed by the column representing the unsuitable materials that will be removed rather than flooded (33.5 ha), as they form the footprint of the berm and must be stripped. A total of 473.5 ha of unsuitable subsoil will be left in place in the Project footprint and become flooded.

Soil orders will also be affected by Project activities. Table 9-19 below shows the area breakdown per soil order and series for the STLSA, showing the total and percent soil order loss. The Project will cause a loss of approximately 766.8 ha of soil orders, i.e., the entire Project footprint excluding the undisturbed area of 19.5 ha. After reclamation, a reclaimed soil class will be developed on the outer berms and temporary workspace area, totalling 105.3 ha. This cannot be ascribed to a specific soil order or series; thus, the total loss of these classes does not change. However, the residual loss of soils is reduced to 661.6 ha for a residual loss of 84.1%

Table 9-19: Area of soil orders and series lost in the STLSA during Project activities

Soil Order	Soil Series	Baseline Area (ha)	Undisturbed (ha)	Total Soil Order Loss (ha)	% Soil Order Loss
Chernozemic	ROL (Ronalaine)	56.9	0.0	56.9	100.0
	BVL (Bingville)	70.3	0.0	70.3	100.0
	MAB (Maleb)	101.3	0.0	101.3	100.0
	PUN (Pemukan)	49.2	0.0	49.2	100.0
	Subtotal Chernozemic	*277.7*	0.0	*277.7*	*100.0*
Gleysolic	DHP (Dishpan)	36.9	0.2	36.7	99.5
	ptVET (peaty Venture)	9.9	1.2	8.7	87.9
	Subtotal Gleysolic	*46.8*	*1.4*	*46.8*	*100.0*
Solonetzic	GPH (Gopher)	31.3	0.0	31.3	100.0
	HUK (Hemaruka)	256.2	17.2	239.0	93.3
	saHUK (saline Hemaruka)	18.3	0.0	18.3	100.0
	HDY (Halliday)	141.2	0.0	141.2	100.0
	saHDY (saline Halliday)	14.8	0.9	13.9	93.9
	Subtotal Solonetzic	*461.8*	*18.1*	*461.8*	*100.0*
Total Soils		*786.4*	*19.5*	*766.9*	*97.5*
Total Soils after Reclamation[1]		*786.4*	*19.5*	*661.6*	*84.1*

1. 105.3 ha will be reclaimed: 53.0 ha of outer berms and 52.3 ha of temporary workspace.

Table 9-20: Area of soil orders lost in the TRSA during Project activities

Soil Order	Baseline Area (ha)	Area After Project Activities (ha)	Soil Orders Lost (ha)	% Soil Order Loss
Chernozemic	27,748.5	27,523.3	225.1	0.3
Chernozemic-Gleysolic	268.2	268.2	0.00	0.0
Chernozemic-Solonetzic	892.9	890.6	2.3	0.0
Gleysolic	491.7	381.9	109.8	0.1
Regosolic	1,646.3	1,646.3	0.00	0.0
Solonetzic	43,773.7	43,339.7	429.5	0.5
Solonetzic-Chernozemic	935.7	935.6	0.10	0.0
Solonetzic-Gleysolic	74.2	74.2	0.00	0.0
Non-soil Classification	237.2	237.2	0.01	0.0
Total Soils	*76,068.4*	*75,297.0*	*766.9*	*0.87*

Table 9-20 above shows the area of soil orders lost in the TRSA in and the percent loss. The Project will cause a 0.87% loss to soil orders in the TRSA.

9.5.3.2 Soil Quality

Potential degradation of soil productivity or quality and physical loss of soil by erosion were also identified as an issue for the Project. As discussed in the Issue Scoping (Section 9.3) after Project development soils will no longer be used for agriculture, so assessment of soils based on the Agricultural Land Suitability Classes rating system was not completed. Soils in the STLSA were assessed for wind and water erosion risk in the Baseline and it was concluded that based on terrain, slope, and annual cumulative rainfall, soils in the area generally have low susceptibility to wind or water erosion. Salvaged soils may be at risk for erosion during Project activities, especially during storage or prior to revegetation, but proper control measures will be put in place to minimize these impacts. Additional erosion measures are explained in Volume 1, Section 10 (Conceptual Conservation and Reclamation Plan) and Volume 1, Section 11 (Mitigation Measures, Management Practices, and Monitoring Plans).

Other factors affecting soil quality include the possibility of contamination via spills from mechanical equipment or fuel storage. Proper best management practices to reduce potential for spills will be employed, which are described in further detail in Volume 1, Section 10 (Conceptual Conservation and Reclamation Plan). A spill management plan will be developed in accordance with provincial and federal regulations to mitigate and address spill occurrences and associated contamination risks. Refer to Volume 1, Section 9 (Waste Management) and Section 11 (Mitigation Measures, Management Practices, and Monitoring Plans) for a more detailed breakdown of spill management and response.

9.5.4 Residual Impact

Using the criteria of direction, magnitude, geographical extent, duration, confidence, and ecological/social context, Table 9-21 (below) characterizes the residual environmental effects on soil resources, both physical loss of soil and loss in area (ha) of soil orders. All residual effects are restricted to the Project footprint. These impacts are expected to be low or medium negative, except for the loss of soil orders in the STLSA, which is rated as a high negative. For most of the

Project, the naturally occurring soil pedon (soil profile) is being removed along with the native vegetation, but the physical topsoil and subsoil is being salvaged and used in reclamation. This is an important consideration when assessing the residual impacts.

The Project will require stripping or flooding of topsoil and subsoil resources as discussed in the sections above and presented in Tables 9-15 to 9-20, above. Physical loss of both suitable and unsuitable soil was identified as an impact. Loss of suitable soil will only be medium-term and mitigated by the salvage and use in reclamation, resulting in a low negative rating. Physical loss of unsuitable soil will be long-term, as the soils will remain in place and be flooded, resulting in a medium-negative rating.

The final residual loss of soil orders is 661.6 ha, or 84% of the STLSA. This was rated as a high magnitude. The total loss is long-term and is confined to the Project footprint. Confidence in this assessment is high, as it is based on the overlaying of the planned footprint on the field assessed soil areas showing where soils will be removed and reclaimed. The ecological context was not considered high, as soil is not a highly disturbed resource in this part of the province and remains present in natural grassland and cultivated land areas. Additionally, the soil series and orders in the STLSA are not considered rare soils nor part of a rare ecological community. Overall, the residual impact was rated high-negative. As the key mitigation to reduce these losses is reclamation, it is important to ensure that reclaimed soils develop as a functional soil unit over time. This will require monitoring of the reclaimed soil areas as described in the Conceptual Conservation and Reclamation Plan (Volume 1, Section 10) and the Grassland Restoration Proposal (Volume 2, Section 10, Appendix H9).

Additional changes to the resource could occur due to compaction, spills, or erosion in small, isolated areas; these effects would be immediately addressed, and would not alter this assessment. Climate change may result in a long-term risk on this resource, as it could increase occurrence of drought, leading to increased risk of topsoil loss from wind or water erosion. Thus, it will be important to monitor reclaimed areas and complete remedial reclamation activities if areas struggle to revegetate. Overall, the residual impact assessment for loss of soil orders in the STLSA was high negative, however it was rated medium in the regional area, due to the effect being negative and long term (permanent).

Table 9-21: Residual impacts on soil resources during the Project phases

#	Impact description	Direction	Key Criteria			Modifiers		Residual Impact Rating
			Magnitude	Geographical Extent	Duration	Confidence	Ecological and Social Context	
Construction								
1	Physical loss of suitable soil	Negative	Low	Footprint	Medium-term	High	N/A	Low Negative
2	Physical loss of unsuitable soil	Negative	Low	Footprint	Long-term	High	N/A	Medium Negative
3	Loss of soil orders area in the TRSA	Negative	Low	Footprint	Long-term	High	N/A	Medium Negative
4	Loss of soil orders area in the STLSA	Negative	High	Footprint	Long-term	High	N/A	High Negative
Operation								
No resources were assessed at this stage.								

9.6 CUMULATIVE EFFECTS ASSESSMENT

The section assesses how the Project may interact with other past, present, or reasonably foreseeable future projects and activities, and their combined impact on soil resources. For a full description of the cumulative effects assessment (CEA) Approach see Volume 2, Section 2.

Per this Approach, resources that were assessed to have high negative or medium negative residual impacts need to be assessed in the CEA. For soil and terrain, the assessed resource is the loss of area (in hectares) of soil orders, and also covers physical loss of unsuitable soil.

9.6.1 Effects on Each Resource from Project or Activity Types

Proponents of construction and development activities that involve soil stripping and excavation are required to conserve the physical soil materials, but once the site is disturbed and soil is removed, the soil no longer exists in its naturally occurring pedon with the characteristics that are used to classify it into groups. As regulations enforce the conservation of the physical soil, the loss of soil discussed in this effects assessment is the alteration of the soil orders.

9.6.2 Project Development Case

The Project Development Case for soil and terrain was assessed through land use changes from 1950 to present day (historic), due to the proposed SLR Expansion (application), and reasonably foreseeable future projects (to 2050). Development that typically involves stripping and excavation of soils within the TRSA has already resulted in an alteration of approximately 2,900 ha of soil groups. Increases in industrial and residential development, anthropogenic waterbodies and roads also contribute to the alteration of soil orders. It is important to note that areas under cultivation were not considered as impacted area because although the soils are modified, they are still intact. Thus, the assessment of cumulative effects on soils will not have the same area as the other discipline resources, such as vegetation or wildlife, which use the same TRSA.

9.6.3 Cumulative Effects

Estimated cumulative effects on the soil and terrain resources with negative impacts are based on the assessment made from Table 9-22. Cumulative effects calculations focused on loss of soil orders via activities that would involve topsoil stripping or excavation from past projects (1950 to 2024), the proposed SLR expansion, and future projects to 2050.

Table 9-22: Potential effects on soil order loss from project types in the TRSA

Activities or Land Uses		Change in Area (ha)		Resources
		TRSA[1]	ARSA[2]	Soil Order Loss
Past Projects (1950 to 2024)				
Activities	Anthropogenic Waterbodies (Reservoirs, Dugouts)	436.0	96.6	436.0
	Canals	216.9	201.4	216.9
	Cultivation (Agri)	19,869.5	24,093.1	---
	Ditch	76.7	118.3	76.7
	Industrial	607.2	2,042.2	607.2
	Industrial – Agriculture	---	---	---
	Industrial – Solar	---	---	---

Activities or Land Uses		Change in Area (ha) TRSA[1]	ARSA[2]	Resources Soil Order Loss
	Railway (active)	-246.7	-250.4	---
	Residential / Urban	673.9	2,288.3	673.9
	Road	696.6	1,121.4	696.6
	Temp. Linear Features	1,090.0	1,494.7	---
	Trail	114.1	143.1	---
	Wellsite	149.8	173.4	149.8
Land Uses	Grassland / Pasture	-23,408.6	-31,388.9	---
Land Uses	Treed	57.6	51.5	---
Land Uses	Waterbody (natural)	-391.1	-262.2	---
Land Uses	Watercourse	57.2	78.1	---
Activities Sum (A)				*2,857.1*
Percent Change				*3.2*
Project – Snake Lake Reservoir Expansion				
Activities	Anthropogenic Waterbodies (Reservoirs, Dugouts)	761.5	761	761.5
Activities	Canals	-12.5	-21.2	---
Activities	Cultivation (Agri)	-13.2	-11.5	---
Activities	Ditch	-3.1	-3.1	---
Activities	Industrial	-2.4	-2.4	---
Activities	Industrial – Agriculture	---	---	---
Activities	Industrial – Solar	---	---	---
Activities	Railway (active)	---	---	---
Activities	Residential / Urban	---	---	---
Activities	Road	6.3	5.3	6.3
Activities	Temp. Linear Features	45.3	45.9	---
Activities	Trail	-1.5	-1.5	---
Activities	Wellsite	0	0	---
Land Uses	Grassland / Pasture	-703.4	-676	---
Land Uses	Treed	-10.6	-10.5	---
Land Uses	Waterbody (natural)	-66.6	-86.2	---
Land Uses	Watercourse	0	---	---
Activities Sum (B)				*767.8*
Percent Change				*0.9*
Future Projects (2025 – 2050)				
Activities	Anthropogenic Waterbodies (Reservoirs, Dugouts)	-14.1	-15	---
Activities	Canals	-6.5	-12.7	---
Activities	Cultivation (Agri)	-4,220.1	-5,208.5	---
Activities	Ditch	-0.6	-4	---

Activities or Land Uses		Change in Area (ha)		Resources
		TRSA[1]	ARSA[2]	Soil Order Loss
	Industrial	-105.3	-360.6	---
	Industrial – Agriculture	1,968.7	3,306.5	---
	Industrial – Solar	4,717.6	4,723.5	4,717.6
	Railway (active)	-14.7	-18.1	---
	Residential / Urban	-49.2	71.9	---
	Road	-104.1	-156.3	---
	Temp. Linear Features	-76.1	-92.2	---
	Trail	-5.4	-7	---
	Wellsite	-16	-16.6	---
Land Uses	Grassland / Pasture	-1,724.1	-1,652.5	---
	Treed	---	---	---
	Waterbody (natural)	-349	-557	---
	Watercourse	-1	-1.4	---
Activities Sum (C)				**6,686.3**
Percent Change				**7.6**

Table 9-23: Cumulative effects rating for terrain and soils resource(s)

Project Type	Effect of Projects on Terrain and Soils Resources
	Loss of Soil Orders
Past Projects and Activities	Low (3.2% loss)
Snake Lake Reservoir	Negligible (0.9% loss)
Future Projects and Activities	Low (7.6% loss)
Overall Cumulative Effect	**Moderate (11.7%)**
Relative Project Contribution	**Medium (7%)**

The loss of soil orders from past projects totals approximately 2,900 ha, representing a change of 3.2%. The Project is anticipated to contribute an additional 760 ha, or less than 1%. Future projects are anticipated to contribute 8%. The overall cumulative change in the TRSA is 11.7% (Table 9-23).

9.6.4 Relative Project Contribution

The relative contribution of the Project to the total cumulative effects on soil orders was assessed as medium or 7%. A moderate cumulative effect and medium relative contribution indicates that there should be some consideration made to mitigation measures and management actions, such regional cooperative initiatives.

9.6.5 Mitigations and Management Actions

As the cumulative effects and Project contribution are considered in the TRSA, any meaningful mitigations and management actions require coordination between various developers and landowners across the TRSA. Loss of soils will continue to occur within the TRSA as a result of industrial, residential, and commercial development.

To off-set the loss of soil resources as measured by soil order loss, the Project design has incorporated salvage of suitable quality topsoil and subsoil. The salvaged soil materials will be used in the reclamation of the outer surfaces of the berm, as well as in other disturbed areas to be reclaimed on completion of the construction Project. The soil orders will be unavoidably lost, since the area will eventually be flooded, but the most valuable components, the soil suitable for reclamation, will be preserved. Therefore, the primary mitigation measure for this effect is to conserve the physical soil. Recommended mitigation and management actions for soil conservation and handling are detailed in Volume 1, Section 11.

Additionally, based on the CEA, it is recommended that regional cooperative actions be invested in. For example, if suitable topsoil remains after the berm has been reclaimed, the topsoil could be utilized offsite to support reclamation activities for other EID projects. It is recommended that work continues with the EID's Partners in Habitat Development program to ensure protection of habitat including intact soils.

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Appendix G

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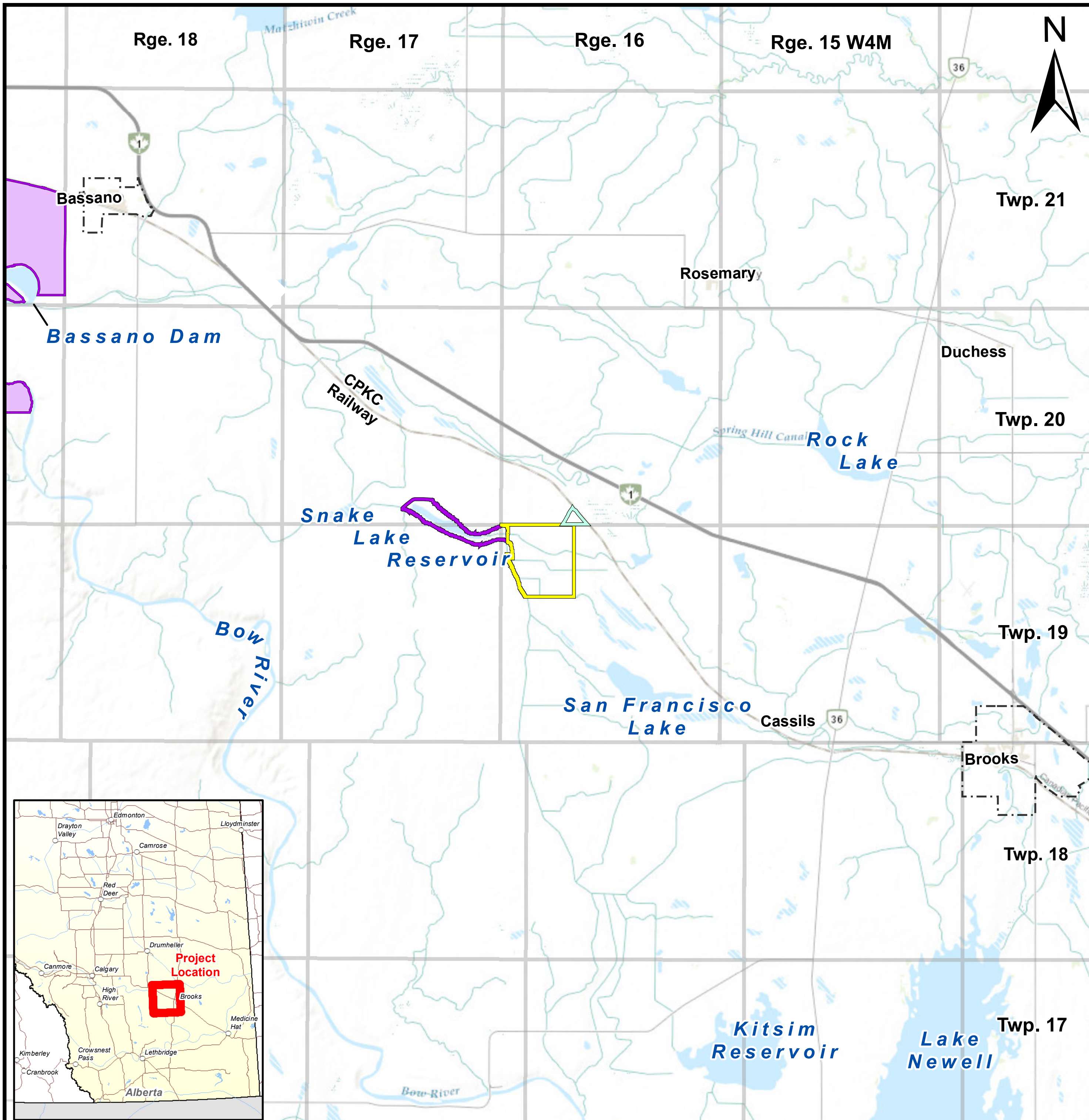

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Approved:	WB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	1

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 of that discrepancies may be present.

Legend

- Snake Lake Reservoir Expansion Project Area
- Proposed Soil Storage Area
- Extant Reservoir
- First Nation Reserve Siksika #146
- Corporate Limits

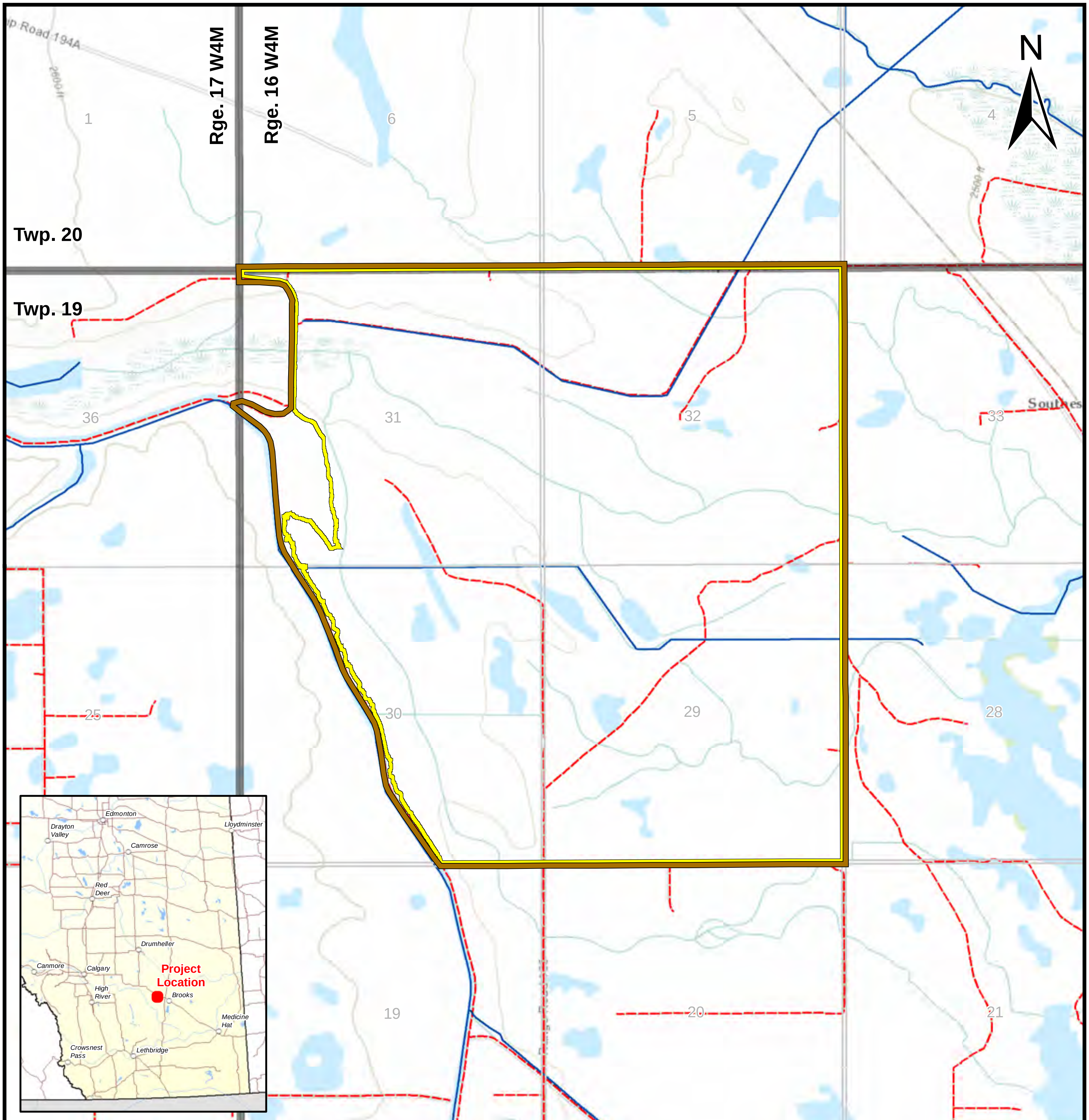
EID

Regional Location for the Proposed Snake Lake Reservoir Expansion

March 2025

REF.: AARES21-127 (Soils)

Figure G1-1



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Approved:	WB	Revision:	0
Route Source:		Date:	Feb 21, 2024
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

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area
- Unpaved Road
- Canal/Watercourse

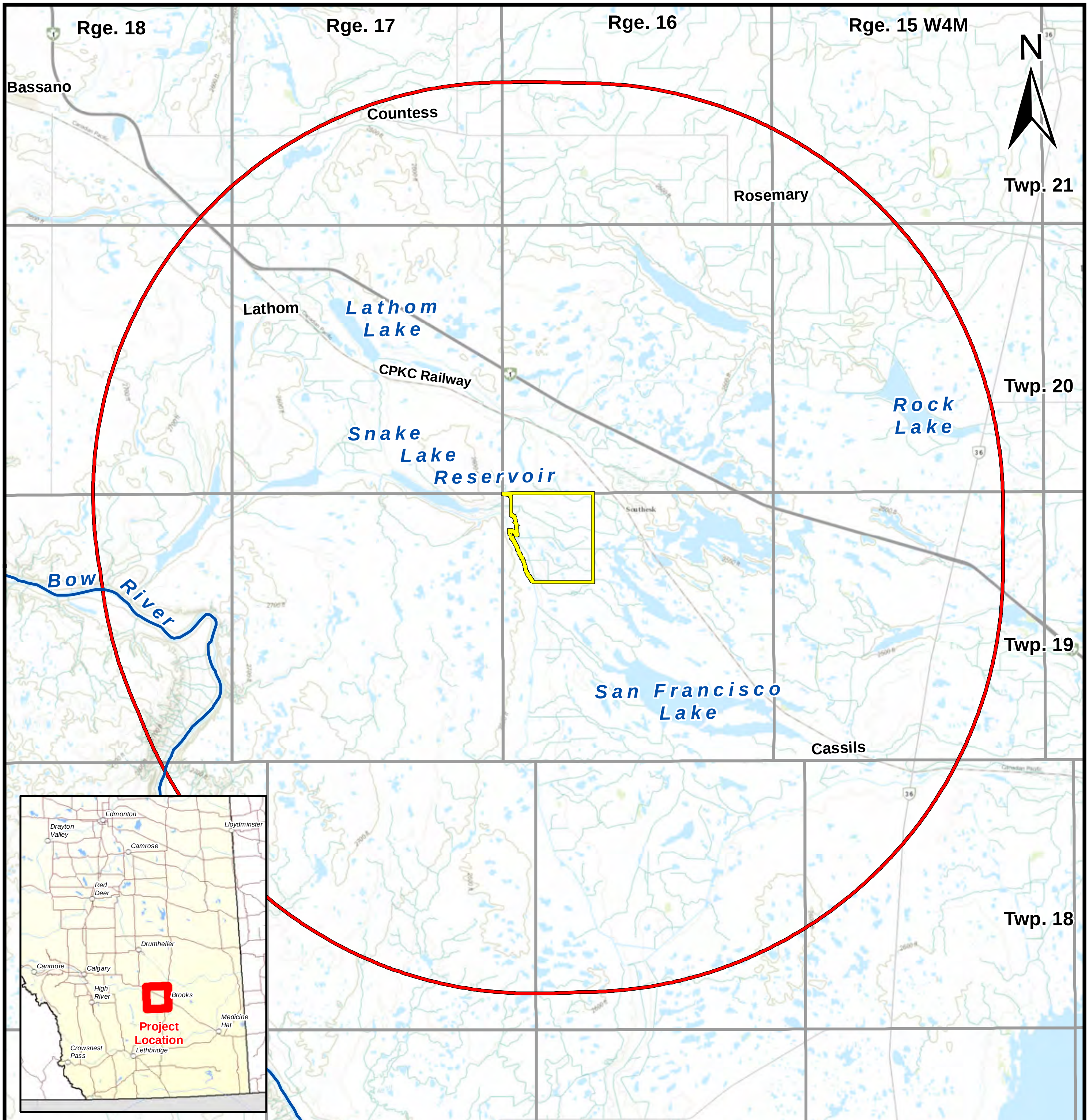
EID

Soil and Terrain Local Study Area

January 2025

REF.: AARES21-127 (Soils)

Figure G1-2



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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

- Terrestrial Regional Study Area
- Snake Lake Reservoir Expansion Project Area
- Canal/Watercourse

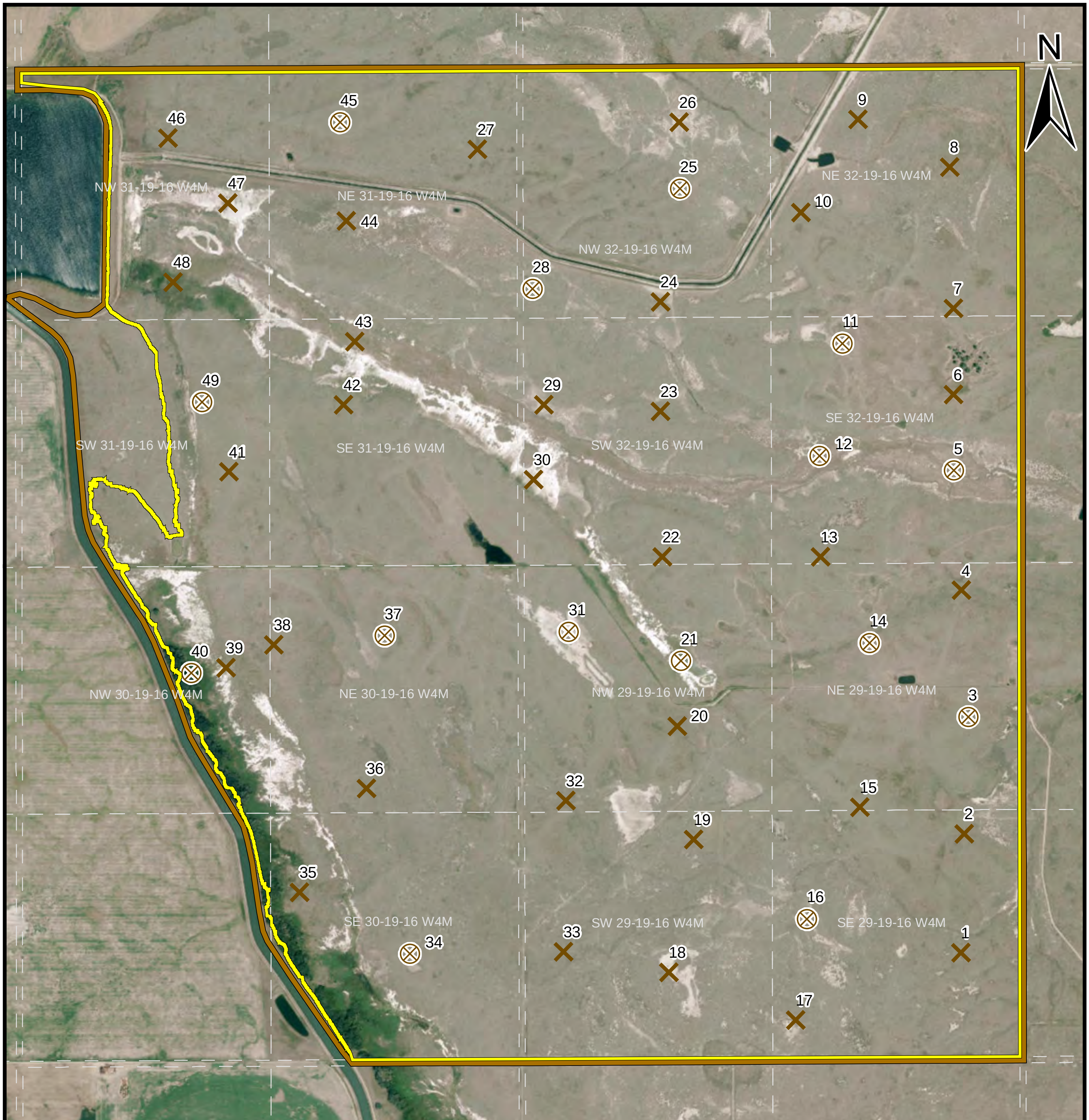
EID

Terrestrial Regional Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-3



SCALE: 1:18,000

125 0 125 250 m

Drafted:	DJS	Date:	Mar 17, 2025
Approved:	WB	Revision:	0
Route Source:		Date:	Jan 14, 2021
CAD Survey		Revision:	0

Data Sources:
Imagery Source: ESRI. Date: 2018/11/15
ATS Grid: AltaLIS 2007.

*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 discrepancies may be present.

Legend

Soil and Terrain Local Study Area

Snake Lake Reservoir Expansion Project Area

Soil Inspection Site*

Soil Inspection and Laboratory Sample Site*

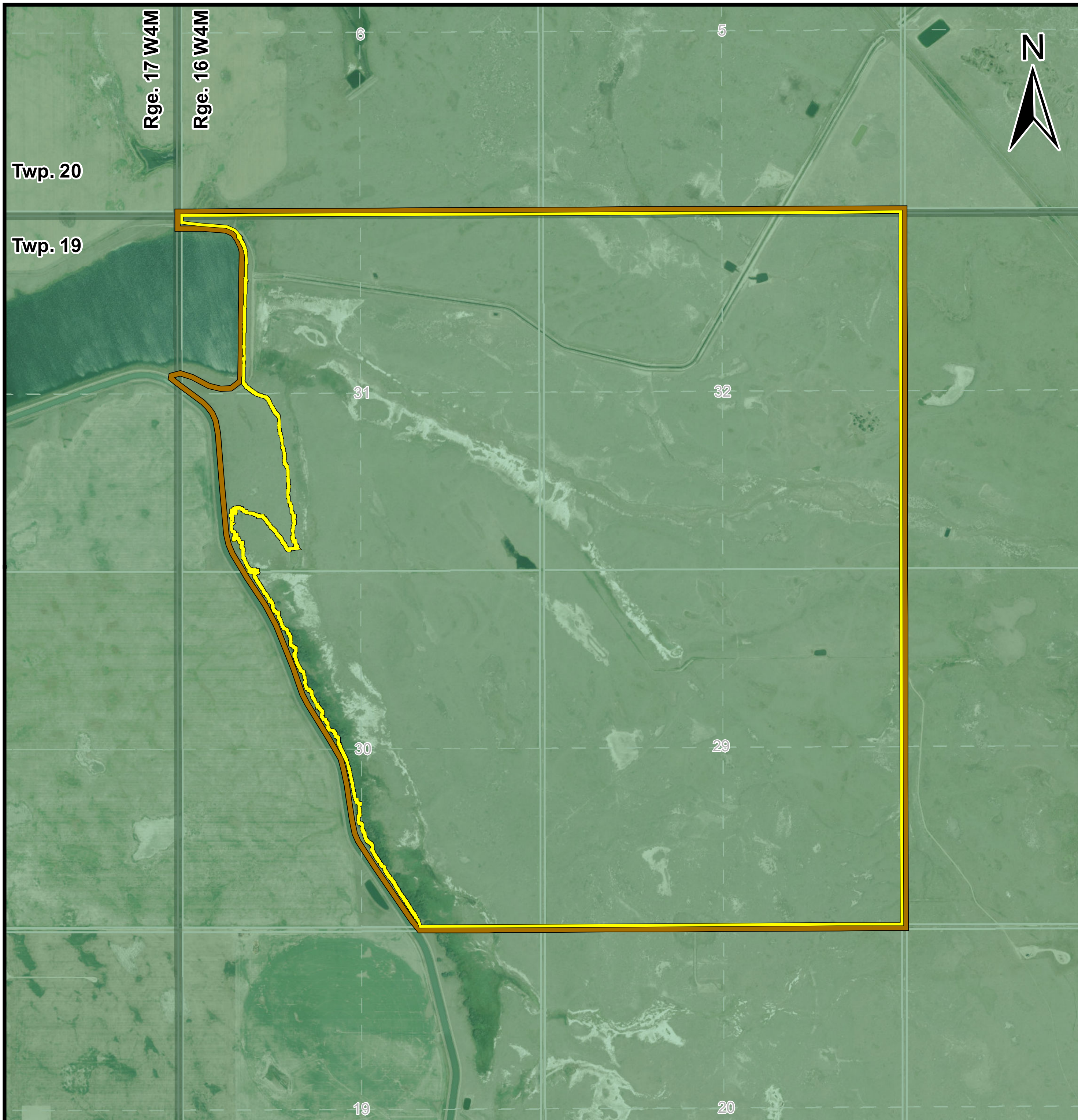
EID

Soil Sampling Locations for the Soil and Terrain Local Study Area

March 2025

REF.: AARES 21-127 (Soils)

Figure G1-4



SCALE: 1:25,000

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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: ESRI. Date: 2021/07/10
Alberta Geological Survey.
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 of that discrepancies may be present.

Legend

Routing:

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area

Bedrock Geology:

- Bearpaw Formation

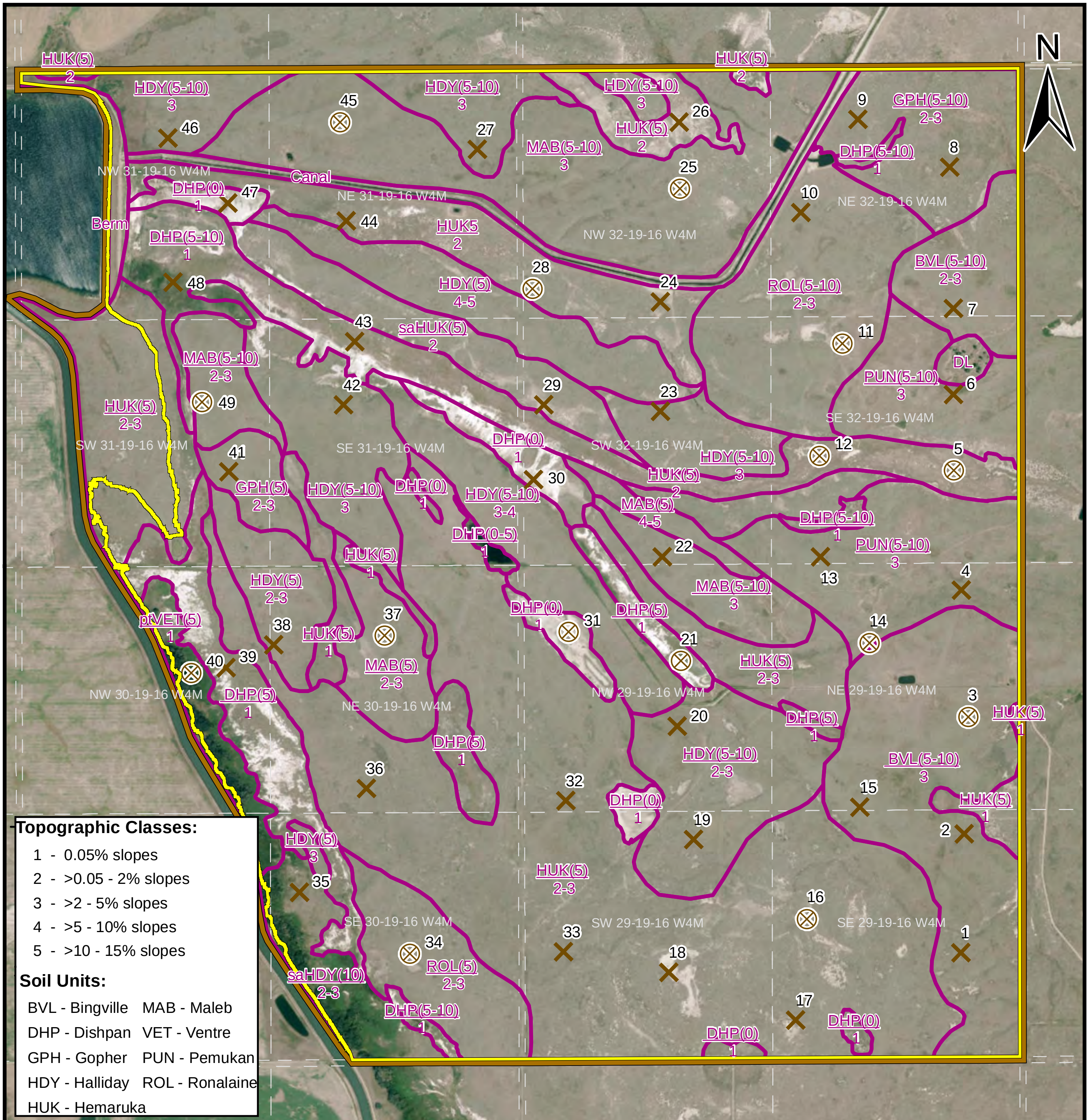
EID

Bedrock Geology of the Soil and Terrain Local Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-5



Topographic Classes:

1 - 0.05% slopes
2 - >0.05 - 2% slopes
3 - >2 - 5% slopes
4 - >5 - 10% slopes
5 - >10 - 15% slopes

Soil Units:

BVL - Bingville	MAB - Maleb
DHP - Dishpan	VET - Ventre
GPH - Gopher	PUN - Pemukan
HDY - Halliday	ROL - Ronalaine
HUK - Hemaruka	

SCALE: 1:18,000

125 0 125 250 m

Drafted:	DJS	Date:	Mar 17, 2025
Approved:	WB	Revision:	0
Route Source:		Date:	Jan 14, 2021
CAD Survey		Revision:	0

Data Sources:
Imagery Source: ESRI. Date: 2018/11/15
ATS Grid: AltaLIS 2007.

*Polygons developed from handdrawn notes
** 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 discrepancies may be present.

Legend

Routing:

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area
- Soil Boundary*
- Soil Inspection and Laboratory Sample Site**
- Soil Inspection Site**

SOIL NOTATIONS

saHUK(5-10) / **2-3**
- Soil Phase
- Soil Unit
- Depth of Topsoil (cm)
- Topographic Class

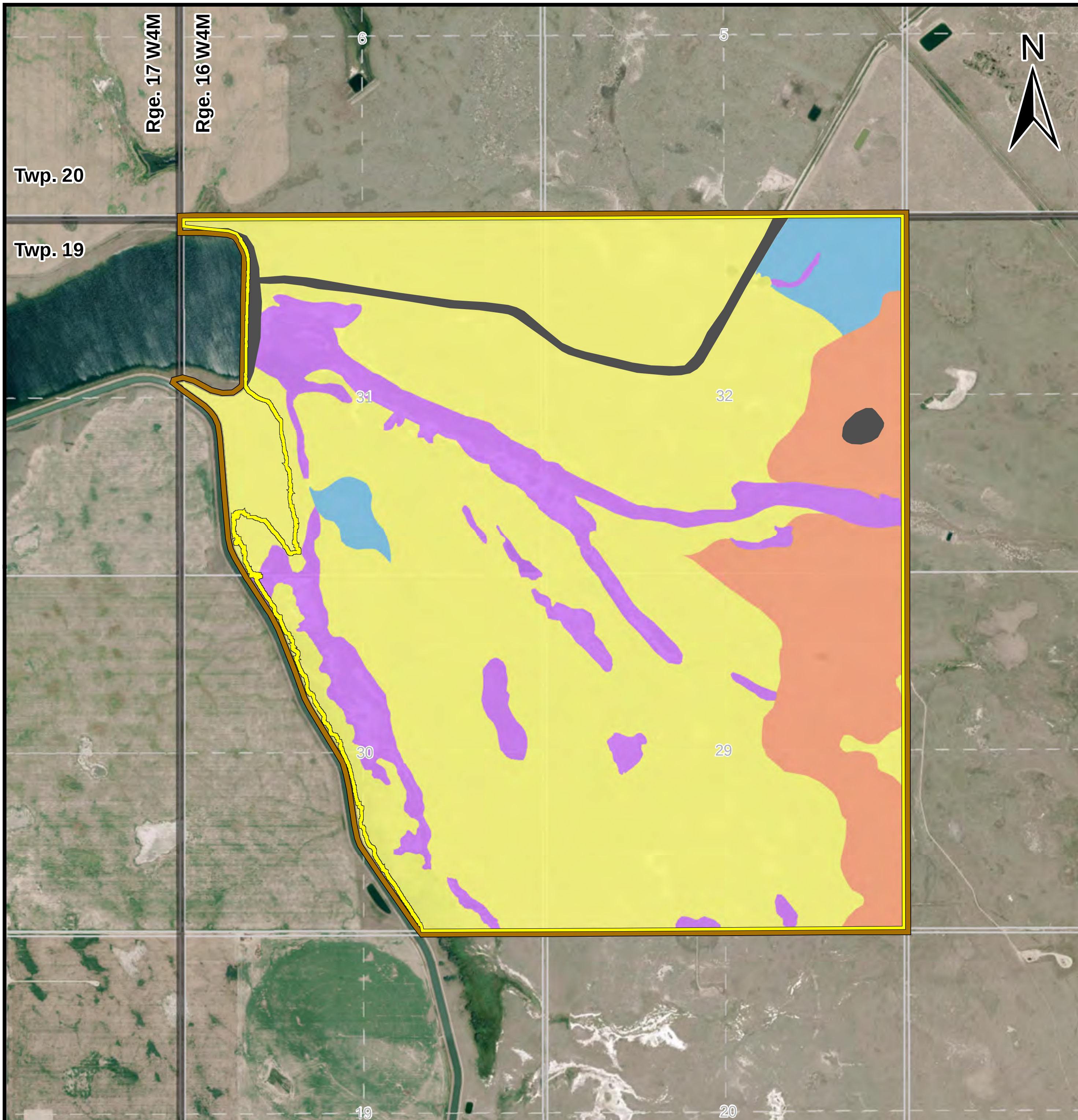
EID

Soil and Terrain Map Units in the Soil and Terrain Local Study Area

March 2025

REF.: AARES 21-127 (Soils)

Figure G1-6



SCALE: 1:25,000

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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: ESRI. Date: 2021/07/10.
Alberta Geological Survey.
ATS Grid: AltaLIS 2007.

AAR Environmental Services

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

Legend

Routing:

- Soils and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area

Surficial Geology:

- Glaciofluvial
- Glaciofluvial veneer overlying Till
- Glaciolacustrine or Till
- Till
- Disturbed Area

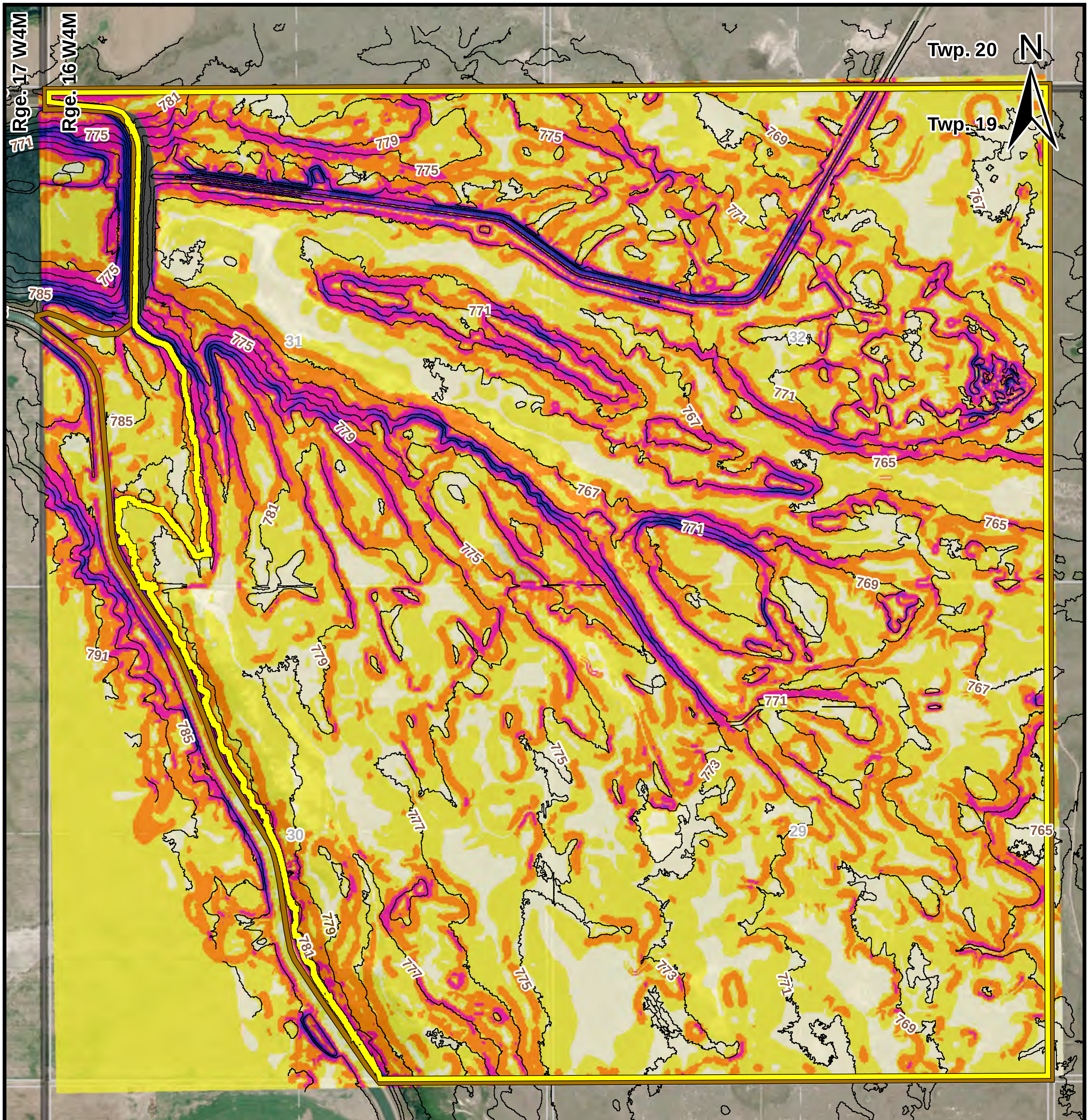
EID

Surficial Materials of the Soil and Terrain Local Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-7



SCALE: 1:18,000

125 0 125 250 m

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

Data Sources:
Imagery: ESRI. Date: 2021/07/10
ATS Grid: AltaLIS 2007.
LiDAR: MPE UAV

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 of that discrepancies may be present.

Legend

Routing:

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area

Slope Class:

- 0-0.5% Level
- >0.5-2%: Nearly Level
- >2-5% Very Gentle Slopes
- >5-10% Gentle Slopes
- >10-15% Moderate Slopes
- >15-39%: Strong Slopes
- Berm
- Contour (2m)

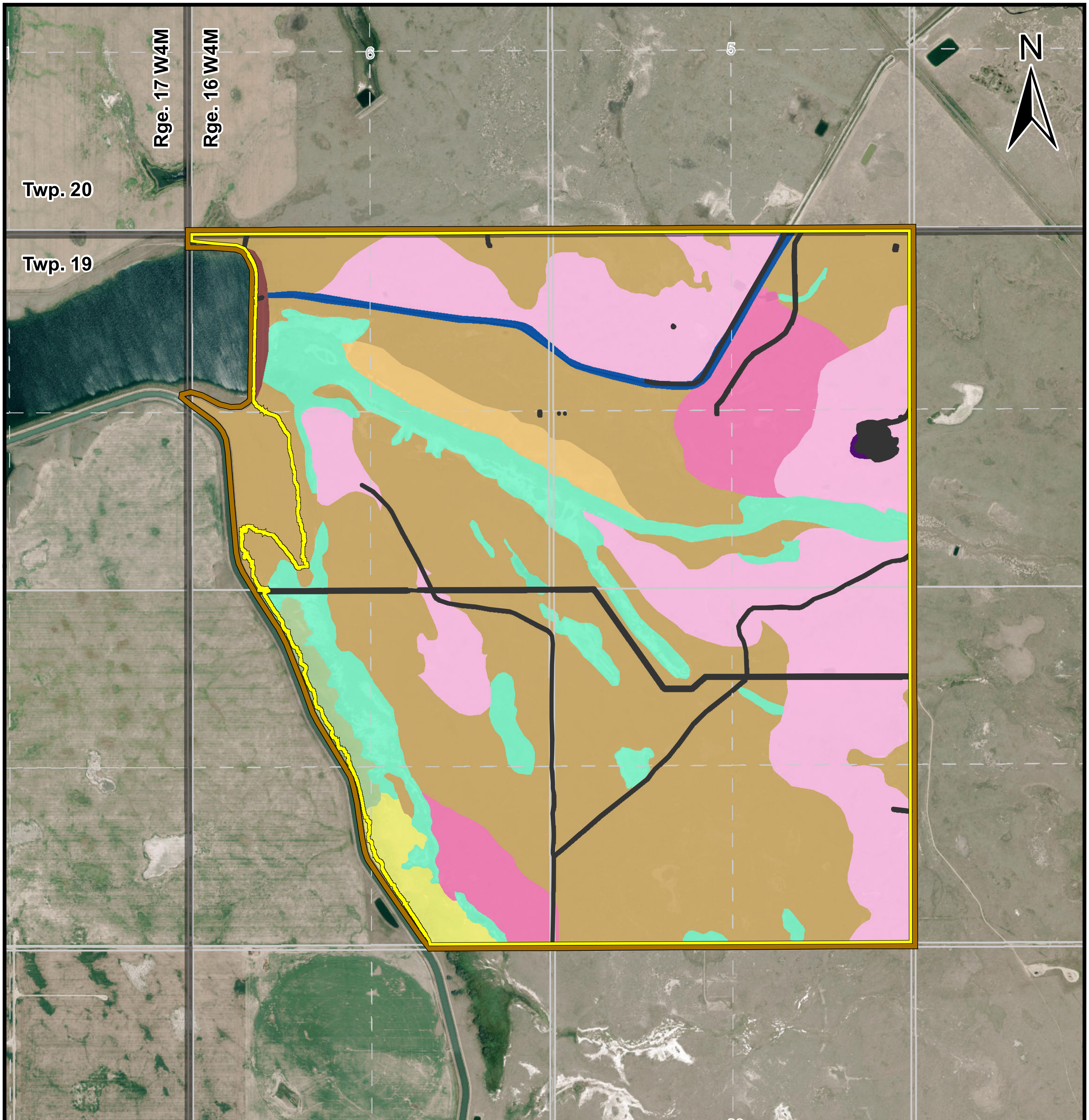
EID

Landforms and Topography of the Soil and Terrain Local Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-8



SCALE: 1:25,000
150 0 150 300 m

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

Data Sources:
Imagery: ESRI. Date: 2021/07/10
ATS Grid: AltaLIS 2007.

AAR
Environmental Services

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Legend

Routing:

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area

Soil Orders:

- Orthic Brown Chernozem
- Solonetzic Brown Chernozem
- Brown Solodized Solonetz
- saline Brown Solodized Solonetz
- saline Brown Solonetz
- saline Rego Gleysol
- peaty Rego Gleysol
- Canal
- Disturbance
- Berm

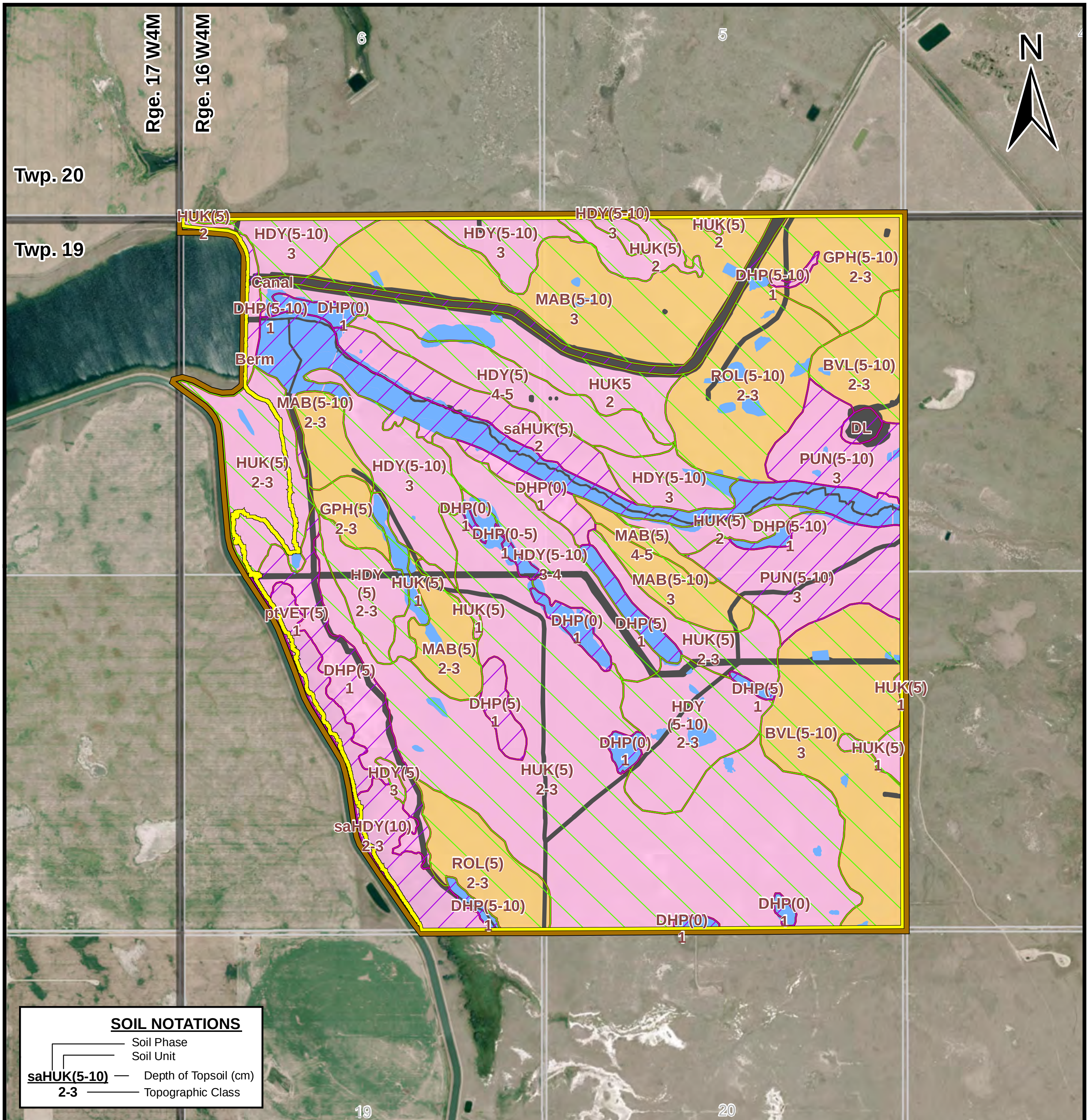
EID

Soil Orders in the Soil and Terrain Local Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-9



SCALE: 1:25,000

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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: ESRI. Date: 2021/07/10
ATS Grid: AltaLIS 2007.

AAR Environmental Services

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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 of that discrepancies may be present.

Legend

Routing:

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area

Topsoil and Subsoil Groups:

- Group 1 - Suitable Topsoil
- Group 2 - Unsuitable Topsoil
- Group 3 - Suitable Subsoil
- Group 4 - Unsuitable Subsoil
- Water Feature
- Disturbance

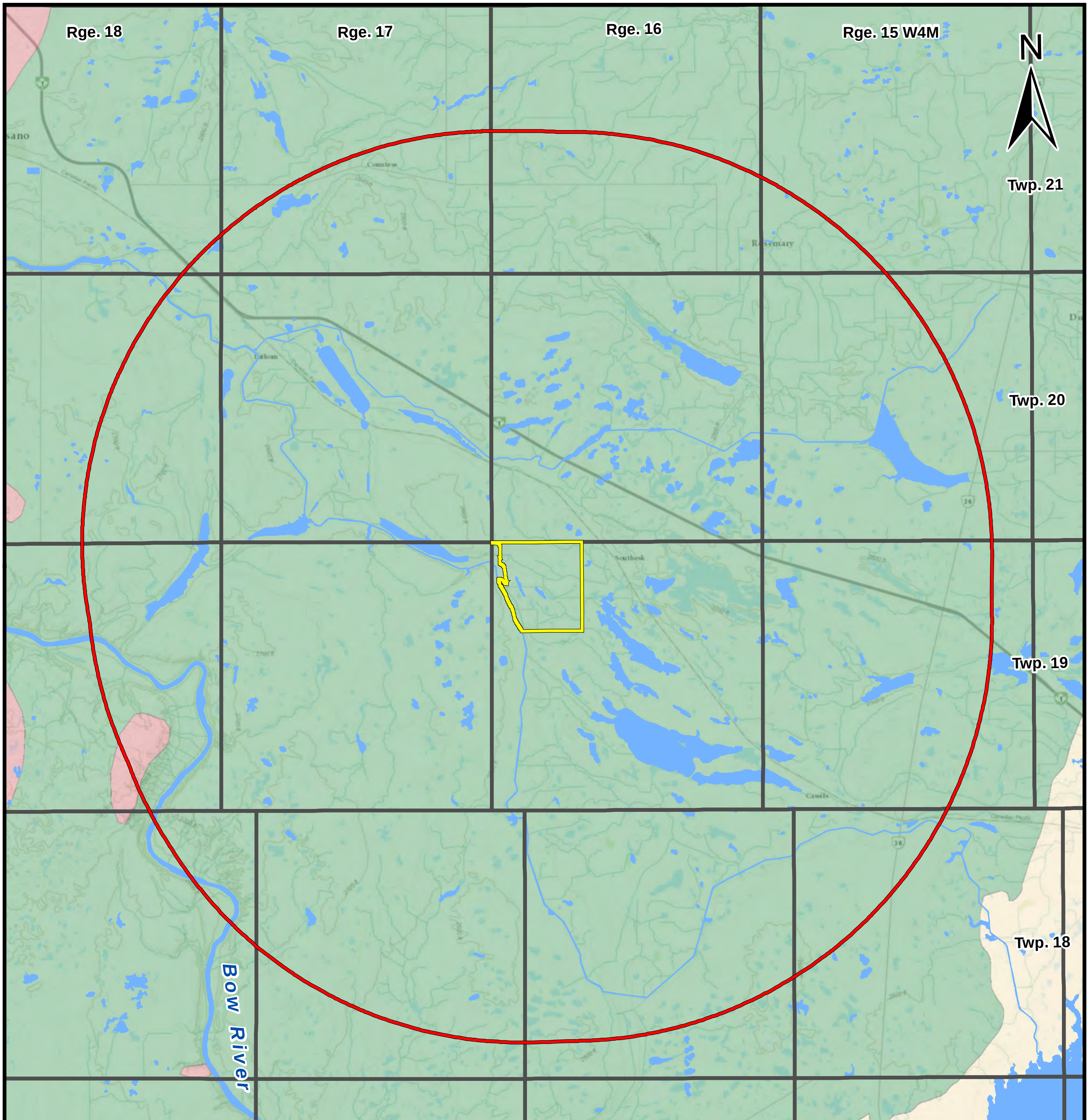
EID

Soil Series and Suitability of Topsoil and Subsoil Resources for Reclamation in the Soil and Terrain Local Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-10



SCALE: 1:200,000

1.5 0 1.5 3 Km

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

Data Sources:
ESRI World Topographic Map
Alberta Geological Survey.
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

Routing:

Terrestrial Regional Study area

Snake Lake Reservoir Expansion Project Area

Bedrock Geology:

Bearspaw Formation

Dinosaur Park Formation

Horseshoe Canyon Formation

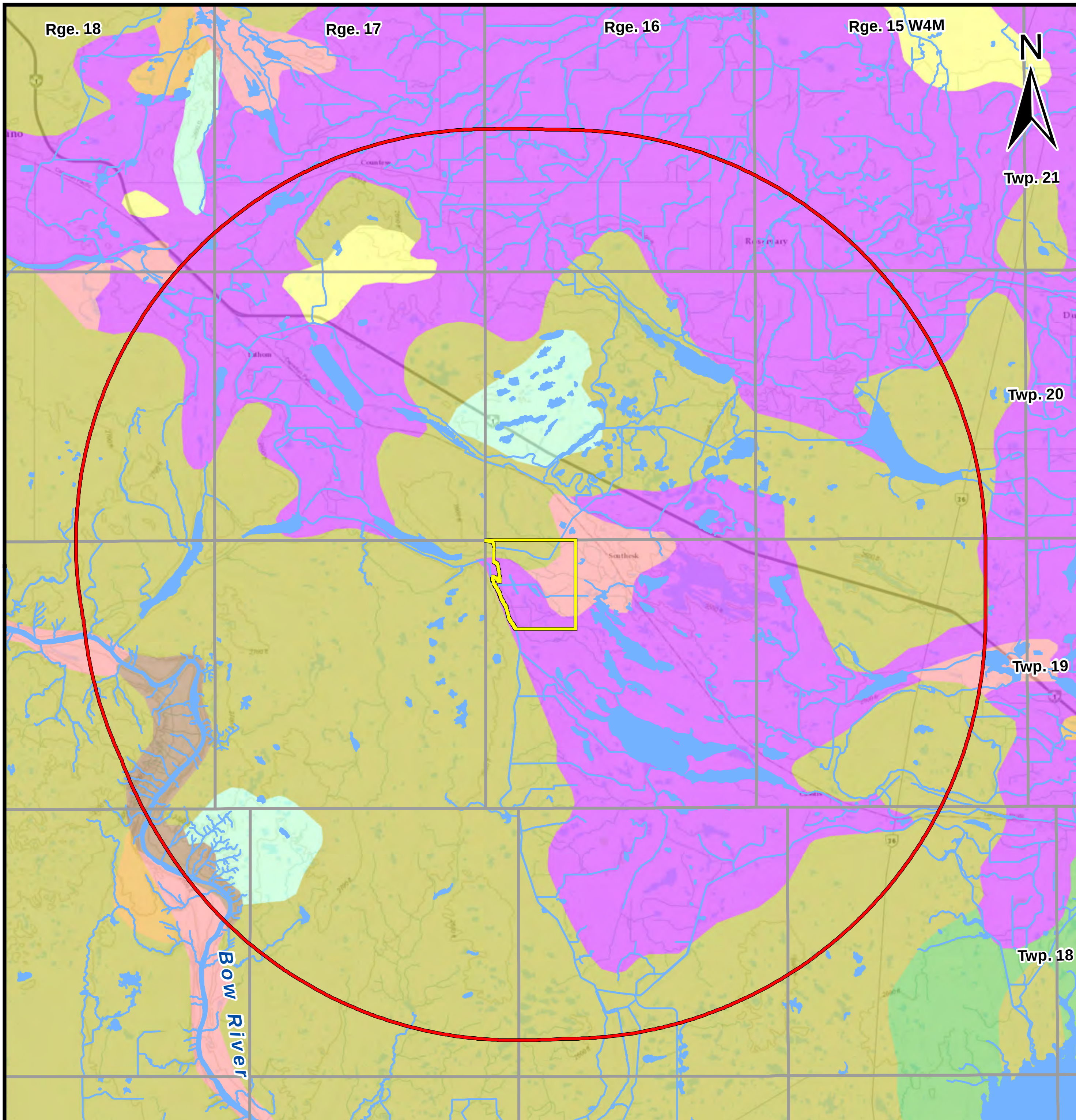
EID

Bedrock Geology of the Terrestrial Regional Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-11



SCALE: 1:200,000

1.5 0 1.5 3 Km

Drafted:	JNB	Date:	Mar 17, 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.
Soils: AGRASID 2024.

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

Routing:

- Terrestrial Regional Study area
- Snake Lake Reservoir Expansion Project Area

Surficial Geology:

- Colluvial
- Fluvial
- Eolian
- Glaciolacustrine
- Glaciofluvial
- Moraine
- Stagnant Ice Moraine
- Ice-thrust Moraine

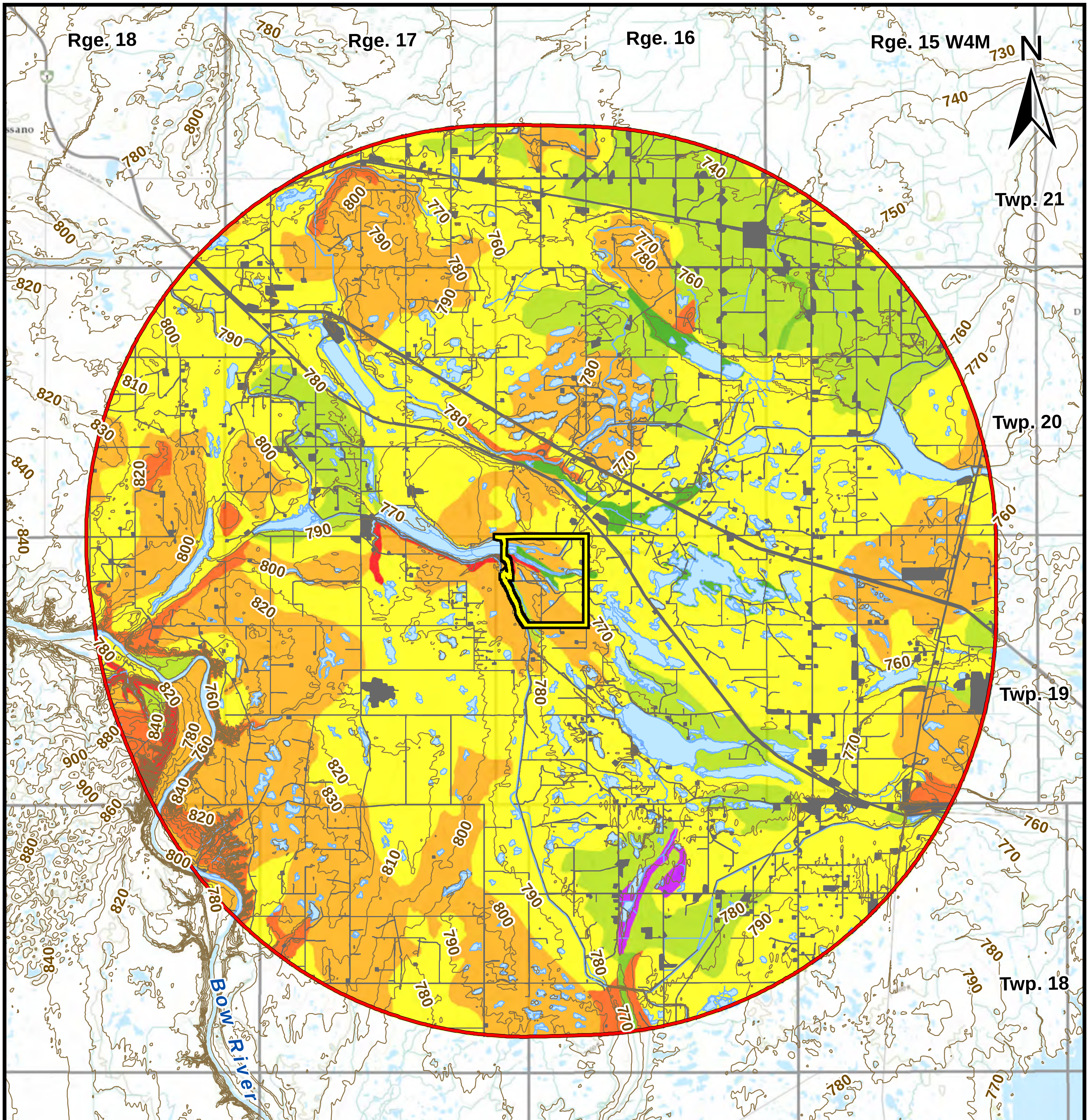
EID

Surficial Materials of the Terrestrial Regional Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-12



SCALE: 1:200,000

1.5 0 1.5 3 Km

Drafted:	NM	Date:	Mar 17, 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.
Soils: AGRASID 2024

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.

Routing: **Legend**

- Terrestrial Regional Study area
- Snake Lake Reservoir Expansion Project Area

Slope Class:

- 1-2: Level to Nearly Level
- 1-4: Level to Gentle Slopes
- 2: Nearly Level
- 2-3: Nearly Level to Very Gentle Slopes
- 3-4: Very Gentle to Gentle Slopes
- Contours (10m)
- 4-5: Gentle to Moderate Slopes
- 5-6: Moderate to Strong Slopes
- Unmapped
- Disturbance
- Water Feature

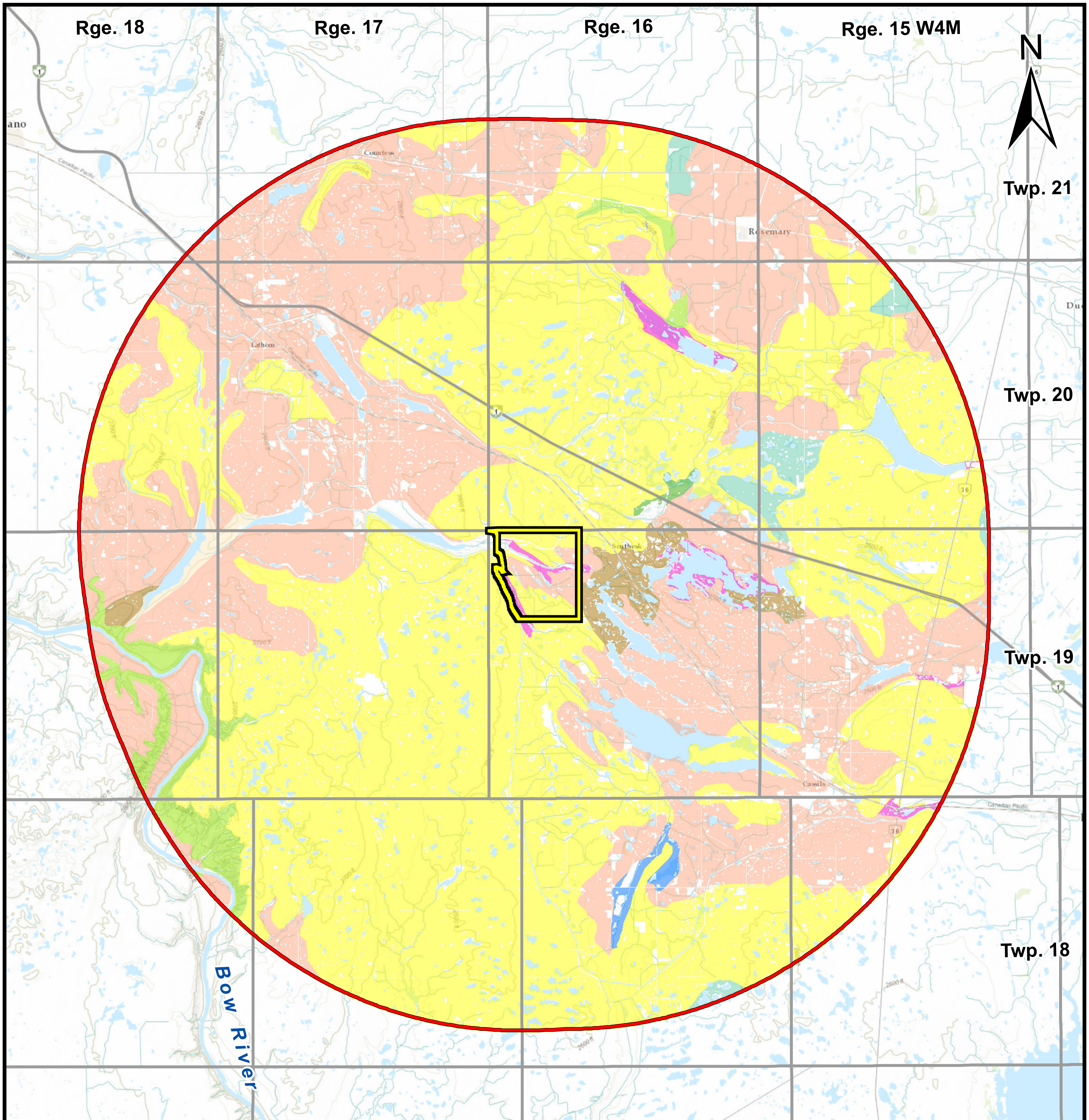
EID

Landforms and Topography of the Terrestrial Regional Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-13



SCALE: 1:200,000

1.5 0 1.5 3 Km

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

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.
Soils: AGRASID 2024

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

Routing:

- Terrestrial Regional Study Area
- Snake Lake Reservoir Expansion Project Area

Soil Orders

- Chernozemic
- Chernozem-Gleysolic
- Chernozem-Solonetzic
- Gleysolic
- Regisolic
- Solonetzic
- Solonetzic-Chernozemic
- Solonetzic-Gleysolic
- Water

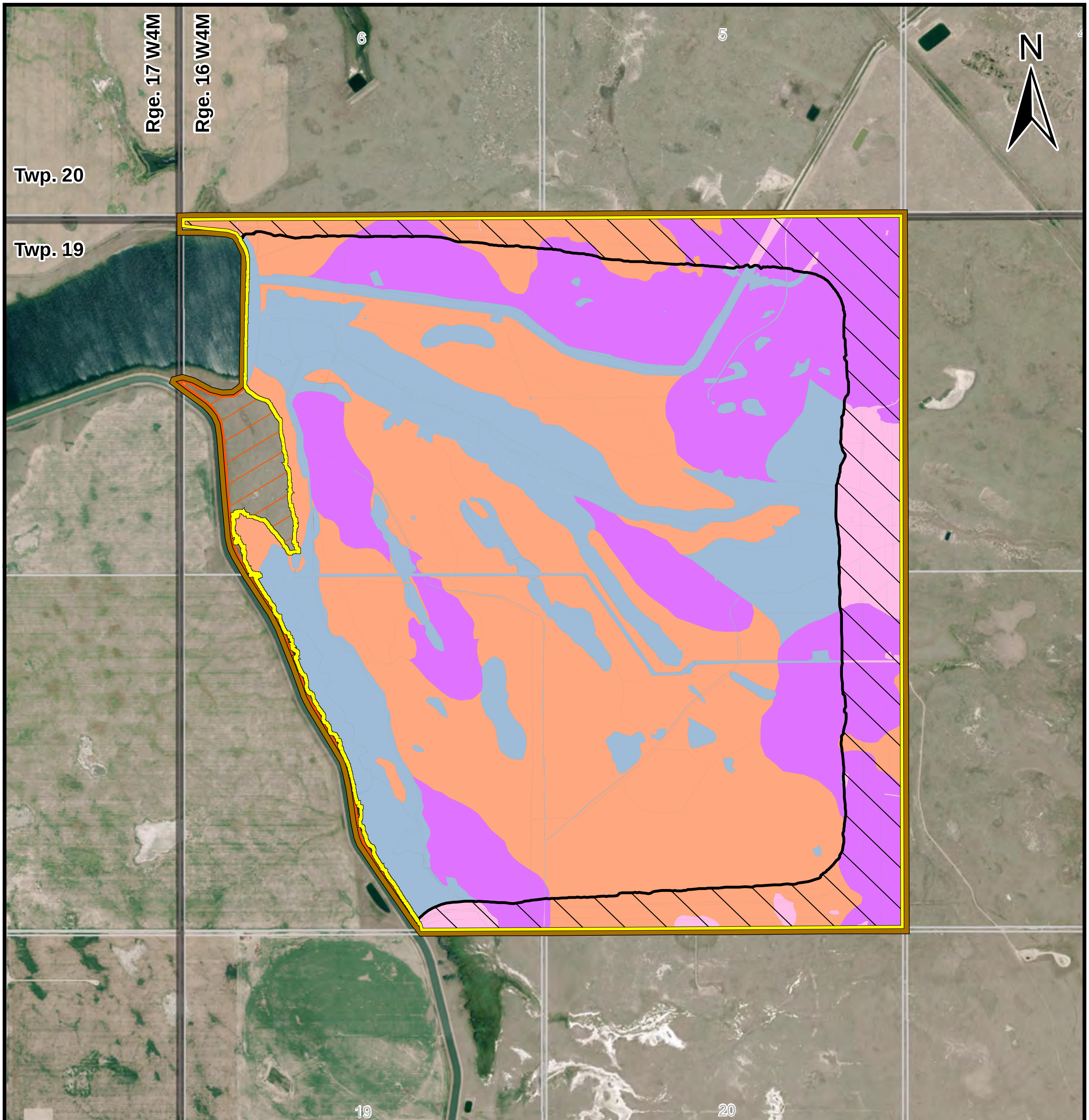
EID

Soil Orders of the Terrestrial Regional Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-14



SCALE: 1:25,000

200 0 200 400 m

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

Data Sources:
Imagery: ESRI. Date: 2021/07/10
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 of that discrepancies may be present.

Legend

Routing:

- Soil and Terrain Local Study Area
- Snake Lake Reservoir Expansion Project Area

Topsoil and Subsoil Groups:

- Area to be all Stripped Under Berm and TWS
- Undisturbed Soils
- Suitable Topsoil and Subsoil - Stripped
- Suitable Topsoil Only - Stripped
- Unsuitable Soil Stripped and Removed
- Unsuitable Soil - Not Stripped

EID

Suitability of Topsoil and Subsoil for Stripping in the Soil and Terrain Local Study Area

March 2025

REF.: AARES21-127 (Soils)

Figure G1-15

Appendix G2: Photo Plates

Plate G2-1: Halliday soil unit, with brown solid soil class in undulating native prairie (July 23, 2021; 1-31-19-16 W4M)

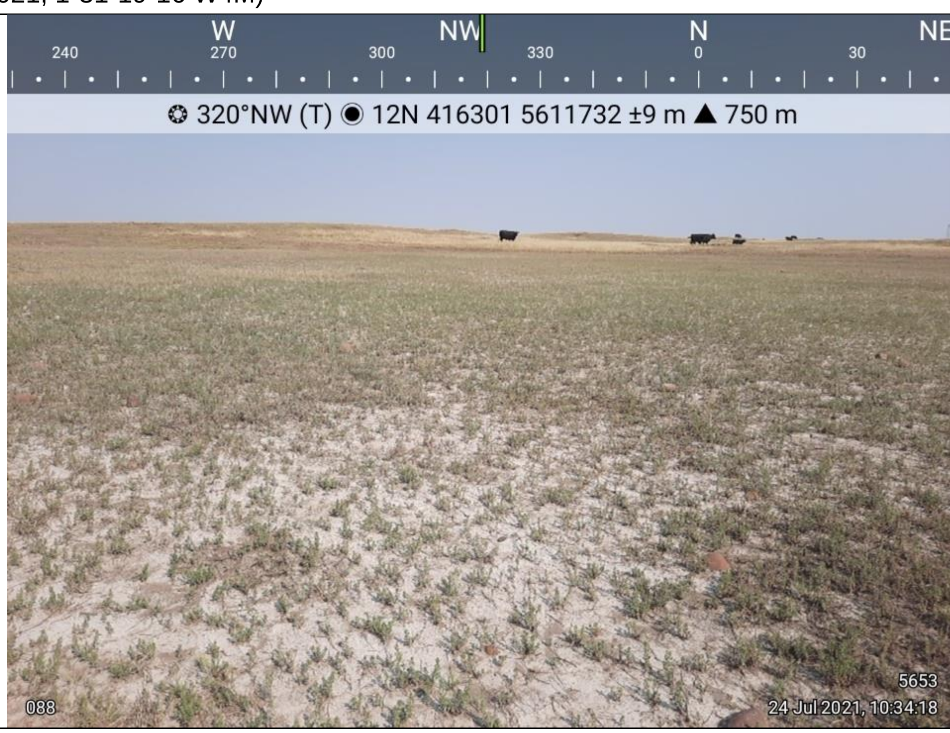


Plate G2-2: Saline intermittent wetland within Ronalaine soils (July 24, 2021; 7-32-19-16 W4M).
Note: Solonetzic Brown Chernozem on loam to clay loam textured till

Plate G2-3: A remnant ditch 80 to 100 cm deep, runs east to west near the centre of the project area (July 23, 2021; 2-31-19-16 W4M)
Note: Disturbed soils occur throughout the project site. This is within Maleb Soils, in the Orthic Brown Chernozem class

Plate G2-4: Soils with higher moisture content occur on the west side of the study area, likely influenced by seepage from the east Branch Canal
(July 23, 2021; 2-30-19-16 W4M)
Note: This site is a Brown Solod in the saline Halliday soil series

Plate G2-5: Rolling terrain associated with a glacial meltwater channel in the northwest end of the project
(July 24, 2021; 6-31-19-16 W4M)
Note: This is the Dishpan soil series and is classified as saline Rego Gleysol

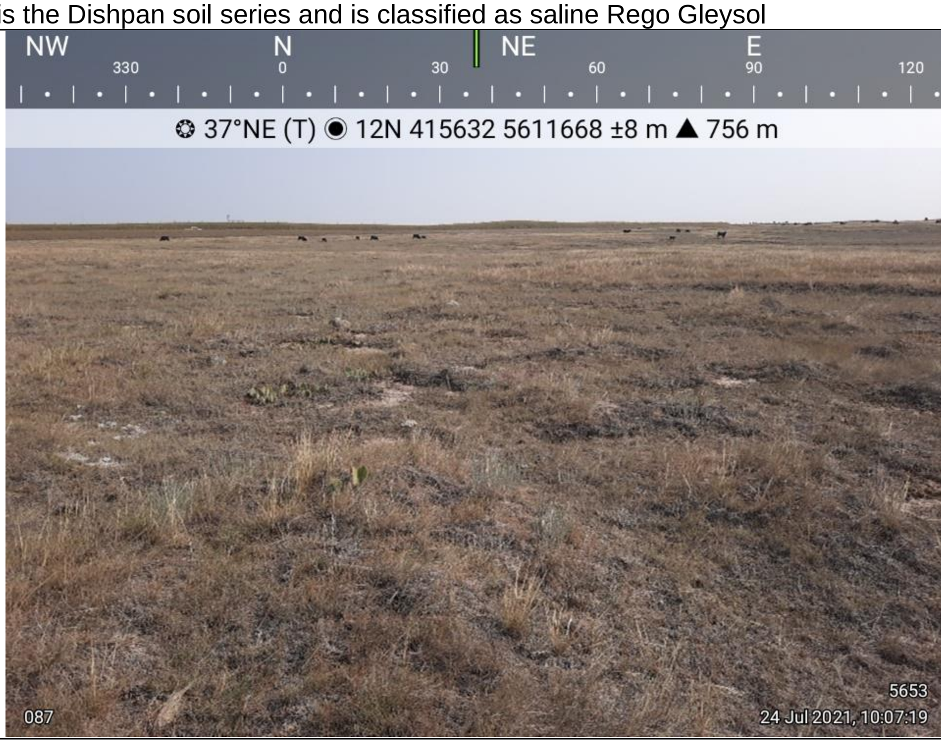


Plate G2-6: Solonetzic blowout soils occur leaving sodic clay patches surrounded by deeper topsoil areas
(July 23, 2021; 5-32-19-16 W4M)
Note: This is Hemaruka Soil Series classified as Brown Solodized Solonetz

Plate G2-7: Intermittent saline open water wetlands occur in many low lying basins
(July 25, 2021; 12N 415784 5609723; 3-29-19-16 W4M)
Note: This is Hemaruka soil series classified as Brown Solodized Solonetz

Plate G2-8: Higher relief landscape, with 10-15% slopes
(July 24, 2021; 3-32-19-16 W4M)
Note: Maleb soil series Orthic Brown Chernozem

Appendix G3: Soil Unit Detailed Summaries

The Soil Units identified in the study area are described on the following pages. A key to the soils is presented in Table 9-4. Laboratory analyses of sampled soils are provided in Table 9-8.

Bingville (BVL) Soils

SOIL CLASSIFICATION: Orthic Brown Chernozem

PARENT MATERIAL: Sandy loam textured glaciofluvial

DRAINAGE: Well

SURFACE STONINESS: Stone-free to slightly stony (S0-1)

TOPOGRAPHY: Gently undulating to undulating (0.5-5% slopes)

PROFILE DESCRIPTION: Site 3

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-6	dark brown	SL	w.f.gran.	very friable
Bm	6-65	yellowish brown	SL	w.f.sbk.	very friable
Cca	65-100	light gray	SL	single grain	very friable

COMMENTS:

- These soils are common in the southeastern portion of the study area.
- Topsoil thickness varies from 6-9 cm. There is good colour differentiation between topsoils and subsoils.
- These soils are sandy loam in texture. The depth of sand is greater than a metre.
- Bingville soils are generally non-saline to weakly saline and sodic.
- Bingville soils are somewhat coarse textured and therefore susceptible to wind erosion when the vegetation is disturbed.

Dishpan (DHP) Soils

SOIL CLASSIFICATION: Orthic and Rego Gleysols

PARENT MATERIAL: Loam to clay textured glaciolacustrine or till

DRAINAGE: Poorly

SURFACE STONINESS: Stone-free to moderately stony (S0-2)

TOPOGRAPHY: Depressional to nearly level (0-0.5% slopes)

PROFILE DESCRIPTION: Site 12

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ahsakg	0-10	dark brown	L	m.f.gran.	firm
Bsg	10-50	mottled dark brown	C	massive	firm
Cskg	50-80	mottled grayish brown	C	massive	firm

COMMENTS:

- These soils are restricted to most of the low, poorly drained areas in the study area.
- Topsoil thickness varies from 0-10 cm and topsoils are not easily distinguished from subsoils by colour.
- The underlying subsoil is usually strongly saline and sodic. The topsoil, when it occurs, may also be strongly saline and sodic. Some of these areas have a white crust of salts on the surface and are very strongly saline and sodic (Sites 21 and 31).
- These poorly drained and fine textured soils are highly susceptible to soil compaction and rutting.

Gopher (GPH) Soils

SOIL CLASSIFICATION: Brown Solodized Solonetz

PARENT MATERIAL: Sandy loam textured glaciofluvial veneer overlying loam to clay loam textured till

DRAINAGE: Well to moderately well

SURFACE STONINESS: Stone-free to slightly stony (S0-1)

TOPOGRAPHY: Gently undulating to undulating (0.5-5% slopes)

PROFILE DESCRIPTION: Site 8

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-8	dark yellowish brown	SL	w.f.gran.	very friable
Bm	8-48	yellowish brown	SL	w.f.sbk.	friable
IIBnt	48-68	dark brown	CL	s.c.sbk. and columnar	very firm
IICsk	68-100	light yellowish brown	CL	massive	firm

COMMENTS:

- These soils are of minor extent and are confined to the northeastern and extreme western portions of the study area.
- Topsoil thickness varies from 4-8 cm and topsoils are not easily distinguished from subsoils by colour.
- These soils are characterized by 15-48 cm of sandy loam textured glaciofluvial material overlying loam to clay loam textured till. A Bnt horizon usually occurs in the underlying finer textured till (IIBnt horizon) but occasionally occurs in the glaciofluvial sands. The Bnt or IIBnt horizon is non-saline and moderately sodic while the IICsk horizon is weakly to moderately saline and strongly sodic. The IICsk horizon occurs at 45-68 cm below the surface.
- The sandy textured surface material is susceptible to wind erosion when the vegetation is disturbed.

Halliday (HDY) Soils

SOIL CLASSIFICATION: Brown Solod

PARENT MATERIAL: Loam to clay loam textured till

DRAINAGE: Well to moderately well

SURFACE STONINESS: Slightly to very stony (S1-3)

TOPOGRAPHY: Gently undulating to moderately rolling (0.5-15% slopes)

PROFILE DESCRIPTION: Site 14

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-10	brown to dark brown	L	w.f.gran.	friable
AB	10-16	yellowish brown	L	m.f.sbk.	friable to firm
Bnt	16-50	dark brown	L-CL	s.m.sbk. and columnar	firm
Csk	50-120	brown to dark brown	L-CL	massive	firm

COMMENTS:

- These soils occur sporadically throughout the study area.
- Topsoil thickness varies from 4-10 cm, but most profiles have about 5 cm of topsoil. Topsoils are not easily distinguished from subsoils by colour.
- Halliday soils are characterized by a friable to firm AB horizon below the topsoil horizon that is 5-10 cm thick and is non-saline and non-sodic.
- The underlying Bnt horizon is columnar structured but breaks down easily to subangular blocky structure with slight pressure. The Bnt horizon can be strongly saline and sodic.
- The Csk horizon occurs at 28-50 cm below the surface and is strongly saline and sodic.
- Halliday soils that display salts at or near the surface are identified as **saline Halliday (saHDY) soils**. Topsoil thickness is about 10 cm and the topsoil is strongly saline and sodic. These soils are confined to the extreme southwestern portion of the study area where likely canal seepage occurs.

Hemaruka (HUK) Soils

SOIL CLASSIFICATION:	Brown Solodized Solonetz
PARENT MATERIAL:	Loam to clay loam textured till
DRAINAGE:	Moderately well
SURFACE STONINESS:	Slightly to very stony (S1-3)
TOPOGRAPHY:	Gently undulating to undulating (0.5-5% slopes)
PROFILE DESCRIPTION:	Site 16

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-4	dark brown	L	w.f.gran.	friable
Ae	4-10	light gray	SiL	w.-m.m.plty.	friable
Bnt	10-28	very dark grayish brown	CL	s.c.column & s.m.sbk.	very firm
Csk	28-70	olive brown to dark brown	CL	massive	firm

COMMENTS:

- Hemaruka soils occur throughout the study area but are more common in the southern portion than northern portion.
- Topsoil thickness varies from 3-6 cm. Colour differentiation between topsoils and subsoils is poor, however, the structure and consistence can be used to differentiate topsoils from subsoils. Topsoils have a granular structure and friable consistence while subsoils have a strong columnar structure and very firm consistence. Usually there is a lighter coloured Ae horizon between the topsoil and subsoil which can be used as a differentiating criteria to separate topsoils from subsoils.
- Subsoils are weakly to strongly saline and strongly sodic.
- Hemaruka soils that are strongly saine and sodic at or near the surface are identified as **saline Hemaruka (saHUK) soils**. These soils occur on the north side of the drain that traverses the study area where they occupy 2.4 ha. Topsoil thickness is less than 5 cm and very strongly saline conditions occur at the surface.

Maleb (MAB) Soils

SOIL CLASSIFICATION:	Orthic Brown Chernozem
PARENT MATERIAL:	Loam to clay loam textured till
DRAINAGE:	Well
SURFACE STONINESS:	Slightly to very stony (S1-3)
TOPOGRAPHY:	Gently undulating to moderately rolling (0.5-15% slopes)
PROFILE DESCRIPTION:	Site 25

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-4	dark brown	L	m.f.gran.	friable
AB	4-12	yellowish brown	L	w.f.sbk.	friable
Bm	12-32	dark yellowish brown	L-CL	m.f.sbk.	friable to firm
Ck	32-80	light olive brown	CL	massive	firm

COMMENTS:

- These soils are more common in the northern portion than southern portion of the study area.
- Topsoil thickness varies from 4-10 cm. Colour differentiation between topsoils and subsoils is fair.
- Maleb soils are generally non-saline and non-sodic to the one metre depth.
- Maleb soils along with Bingville (BVL) soils are the most favourable soils of the study area.

Pemukan (PUN) Soils

SOIL CLASSIFICATION:	Orthic Brown Chernozem
PARENT MATERIAL:	Coarse sand and gravel textured glaciofluvial
DRAINAGE:	Rapidly
SURFACE STONINESS:	Slightly to very stony (S1-3)
TOPOGRAPHY:	Gently undulating to undulating (1-5% slopes)
PROFILE DESCRIPTION:	Site 6

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-8	brown to dark brown	SL	single grain	loose
Bm	8-80	yellowish brown	gvSL	single grain	loose
Cca	80-120	light yellowish brown	SL	single grain	loose

COMMENTS:

- These soils are confined to an area in the east-central portion of the study area.
- Topsoil thickness varies from 5-10 cm. Topsoils are not easily distinguished from subsoils by colour.
- These coarse textured soils lack cohesion properties which will result in unstable trench walls when vertically ditched. They are also susceptible to wind erosion when the vegetation is disturbed.
- The coarse sand and gravels usually occur within 20 cm of the surface.
- These coarse textured soils are non-saline and non-sodic.

Ronalaine (ROL) Soils

SOIL CLASSIFICATION: Solonetzic Brown Chernozem

PARENT MATERIAL: Loam to clay loam textured till

DRAINAGE: Well to moderately well

SURFACE STONINESS: Slightly to moderately stony (S1-2)

TOPOGRAPHY: Gently undulating to undulating (0.5-5% slopes)

PROFILE DESCRIPTION: Site 34

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-4	dark brown	L	w.f.gran.	friable
AB	4-15	brown to dark brown	L	m.f.sbk.	friable
Btnj	15-36	dark yellowish brown	L-CL	weak columnar breaking easily to m.m.sbk.	friable to firm
Csk	36-80	light olive brown	L	massive	firm

COMMENTS:

- These soils occur sporadically throughout the gathering system.
- Topsoil thickness is generally quite thin, varying from 4-8 cm. Topsoils are not easily distinguished from subsoils by colour.
- These soils are characterized by a friable to firm Btnj horizon within 15 cm of the surface. The Btnj horizon is usually non-saline but can be strongly sodic.
- The Btnj horizon breaks down easily to individual peds.
- The Ck or Csk horizon occurs at 35-40 cm below the surface and is usually non-saline to weakly saine and moderately to strongly sodic.

Peaty Ventre (ptVET) Soils

SOIL CLASSIFICATION: peaty Rego Gleysol

PARENT MATERIAL: Silty clay loam textured till

DRAINAGE: Poorly

SURFACE STONINESS: Stone-free to slightly stony (S0-1)

TOPOGRAPHY: Depressional and nearly level (0-0.5% slopes)

PROFILE DESCRIPTION: Site 40

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Om	22-0	brown to dark brown		sedge peat	
Cg1	0-35	mottled bluish gray	SiCL	massive	sticky
Cg2	35-80	mottled bluish gray	SiCL	massive	sticky

COMMENTS:

- These soils are confined to a poorly drained area near the canal on the west side of the study area that was formerly treed.
- There is not topsoil (Ah horizon) at the surface. Instead, there is an organic horizon (Om horizon) at the surface that is about 22 cm in thickness
- There are very few stones in the mineral material and the subsoil texture is silty clay loam.
- These soils are very strongly acidic, non-saline and moderately sodic.
- These moderately fine textured, poorly drained soils are susceptible to soil compaction and rutting.

Miscellaneous Land Units

During the soil survey, three miscellaneous land unit, were identified:

- Reservoir Berm (B) occurs in the extreme northwestern portion of the study area.
- Irrigation canal (C) traverses the northern portion of the study area.
- Disturbed Land (DL) is a small area of prior gravel excavation in the northeastern portion of the study area.

Table G3-1: Key to the Soils

Soil Symbol	Soil Name	Soil Classification	Parent Material	Texture Class	Drainage Class
BVL	Bingville	Orthic Brown Chernozem	glaciofluvial	sandy loam	well
DHP	Dishpan	saline Rego Gleysol	glaciolacustrine or till	loam to clay	poorly
GPH	Gopher	Brown Solodized Solonetz	glaciofluvial veneer overlying till	sandy loam overlying loam to clay loam	well to moderately well
HDY	Halliday	Brown Solod	till	loam to clay loam	well to moderately well
HUK	Hemaruka	Brown Solodized Solonetz	till	loam to clay loam	moderately well
MAB	Maleb	Orthic Brown Chernozem	till	loam to clay loam	well to moderately well
ptVET	peaty Ventre	peaty Rego Gleysol	till	silty clay loam	poorly
PUN	Pemukan	Orthic Brown Chernozem	glaciofluvial	gravelly sandy loam to sand	rapidly
ROL	Ronalaine	Solonetzic Brown Chernozem	till	loam to clay loam	well to moderately well
Miscellaneous Land Units:					
B	Berm	reservoir berm			
C	Canal	main irrigation canal from the reservoir			
DL	Disturbed Land	land disturbed due to gravel excavation			
Soil Phases:					
pt	peaty	Gleysolic soils that have 20-50 cm of peat at the surface			
sa	saline	Solonetzic soils that are strongly saline and sodic at or near the surface.			