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Hydrogeological Overview of the Edmonton–Calgary Corridor, Central Alberta

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Hydrogeological Overview of the Edmonton–Calgary Corridor, Central Alberta

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Abstract

The Edmonton–Calgary Corridor occupies approximately 50 000 km^2 of Alberta and presents a wide variety of hydrogeological conditions. This report summarizes efforts to characterize the hydrogeological attributes of the Edmonton–Calgary Corridor that were determined primarily from the Alberta Environment and Parks Alberta Water Well Information Database. In addition to a description of the broad-scale groundwater flow dynamics, this report also incorporates spring locations, soil types, wetlands locations and surface water information. This report contains maps depicting water well density, water table elevation, potentiometric surfaces, vertical hydraulic head gradients, and inferred recharge/discharge areas. This work provides the hydrogeological context for a large region of the province, and a foundation to develop models or more detailed investigations within the Edmonton–Calgary Corridor.

1 Introduction

The Alberta Geological Survey (AGS) and Alberta Environment and Parks have been cooperatively mapping and characterizing the nonsaline groundwater resources of Alberta since 2008 under the Provincial Groundwater Inventory Program. The Edmonton–Calgary Corridor (ECC) was the first study area selected because of the rapid urban and industrial development and increasing demand for water in the region. This report contains information that complements annual water budget analysis and physical characterization of the hydrogeological framework of the ECC as compiled in the ECC Groundwater Atlas (Barker et al., 2011), and the report on the regional hydrology (Riddell et al., 2014).

The objective of this report is to describe selected hydrogeological attributes of the ECC that could be derived from publicly available data sources. The ECC is the most developed and populated part of the province and has abundant hydrogeological information and data. The available hydrogeological information and data enables construction of detailed two-dimensional hydrogeological maps using spatial analysis and geostatistical Geographic Information System (ArcGIS) tools. Results presented in this report are similar to the hydrogeological map series published by the Alberta Research Council (ARC) (Lemay and Guha, 2009). However, this study used a quantitative geostatistical approach for mapping available hydrogeological data, many of which were collected since the previous ARC mapping efforts. The results presented in this report are intended to enhance the understanding of the hydrogeology of the ECC and guide subsequent more-detailed characterization efforts. The results presented in this report may also assist in: watershed characterization, formulation of management and policy decisions, and identifying areas within the ECC that may be under stress from groundwater withdrawals.

1.1 Study Area

The ECC occupies approximately 50 000 km^2 within Alberta and lies within portions of National Topographic Map Sheets 83A, 83B, 83G, 83H, 82J, 82I, 82P, and 82O forming a study area approximately 200 km wide from west to east, and 300 km from north to south (Figure 1). The study area is dominated by the White Zone of Alberta consisting of agricultural and urban areas, with a small portion of the western margin of the study area designated as the Green Zone, or undeveloped natural area, including Elk Island National Park. Land use in the study area is dominated by agriculture, grazing, and oil and gas activities. The undeveloped western margin of the ECC is dominantly used for forestry and recreation.

The study area was delineated by taking the outer boundaries of ten sub-basins from major rivers that drain surface water in the area between Edmonton and Calgary. Four sub-basins of the North Saskatchewan River, the headwater sub-basin of the Battle River, four sub-basins to the Red Deer River (including the Little Red Deer River), and one sub-basin of the Bow River constitute the land area occupied by the ECC (Figure 1). The study area included the densely populated portion of central Alberta and honoured physical boundaries or surface water drainage divides between sub-basins.

The ECC project boundary encompasses diverse climate, topography, and geology. Average annual precipitation rates range from over 600 mm/year in mountainous western areas to less than 400 mm/year in semi-arid southeastern areas (Barker et al., 2011). Elevations range from greater than 2300 metres above mean sea level (amsl) in the southwest to less than 550 m amsl in the northeast at the outflow of the North Saskatchewan River from the project boundary (Barker et al., 2011). The footprint of the ECC covers the subcrop areas of several different bedrock formations including the Paskapoo, Scollard, Battle, Horseshoe Canyon, and the Bearpaw formations and a portion of the Belly River Group (Figure 2).

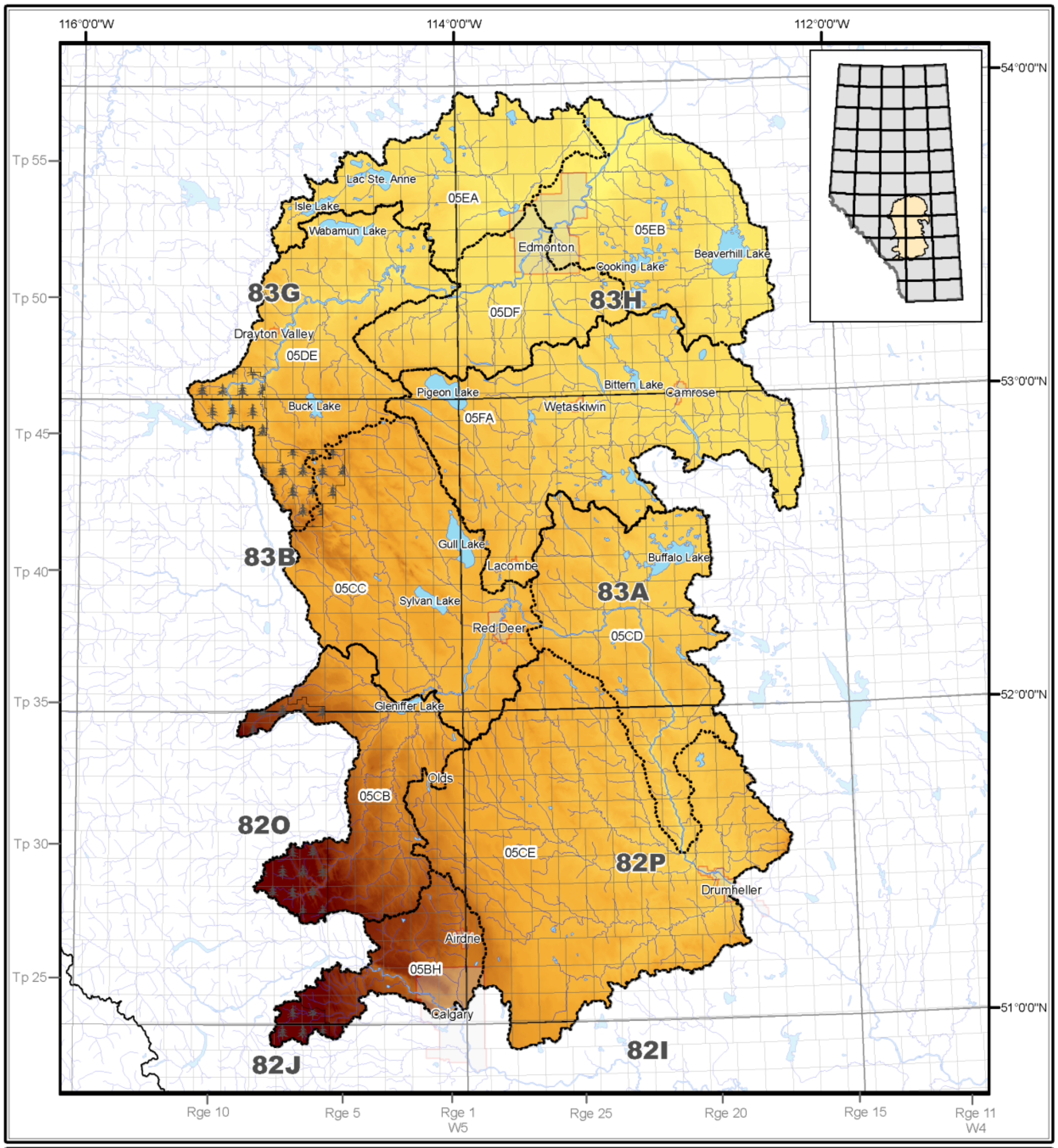

Figure 1. Study area and land surface elevation of the ECC

Land surface elevation (m amsl)

2350

590

05CC Environment Canada Sub-basins

Green Zone

0 12.5 25 50 75 100 km

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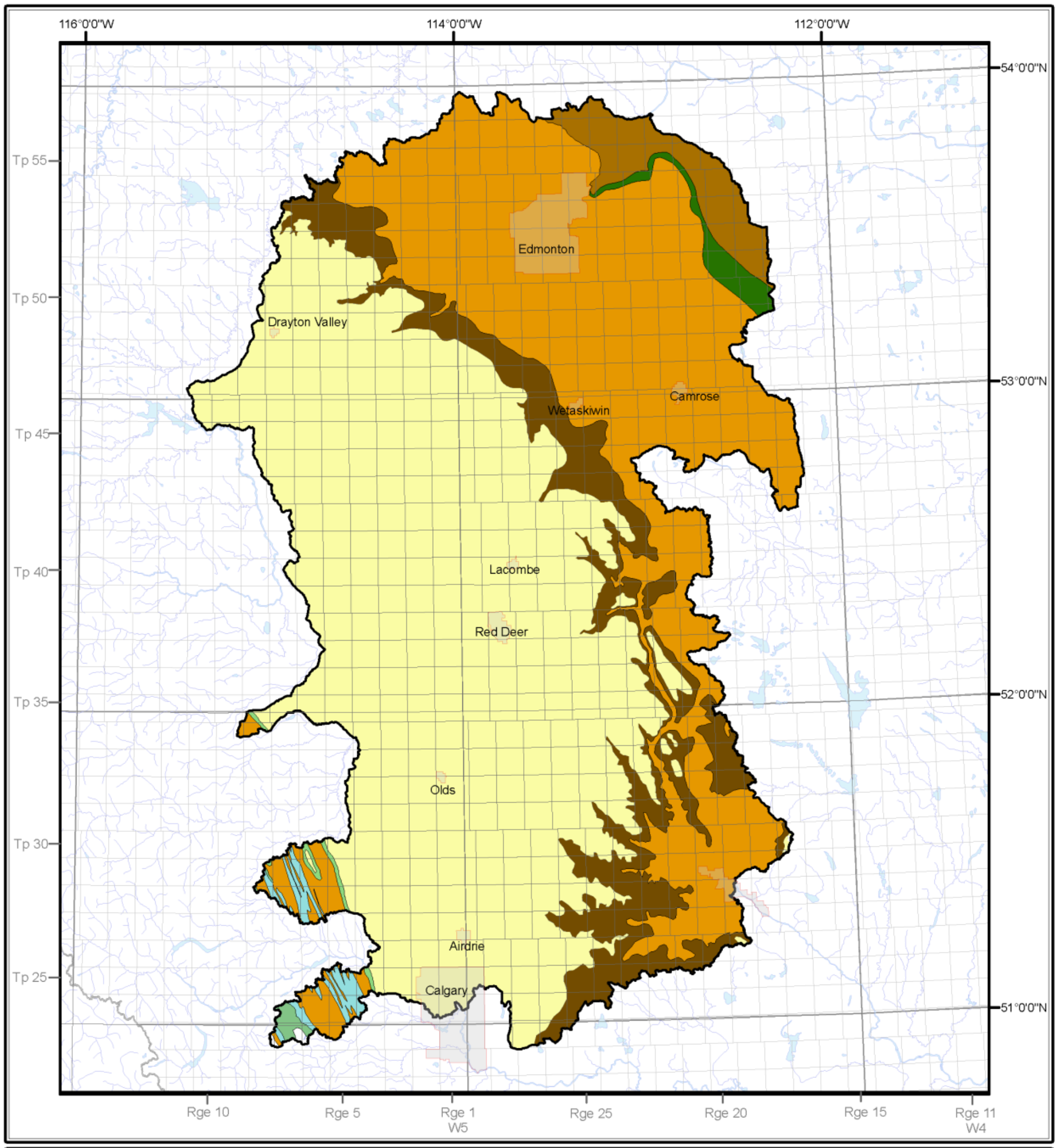

Figure 2. Bedrock geology in the study area

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2 Methods

This study focused on delineating the regional-scale groundwater flow dynamics in approximately the upper 150 m of sediments where groundwater is typically nonsaline, potable, and economically extractable for domestic, agriculture, or small-industry use. While determining hydrodynamics at depths greater than 150 m is of interest, there is relatively little groundwater data available at these depths.

Mapping was completed using ArcGIS, where the hydrogeological attributes represent geospatial data displayed on a geo-referenced map as denoted with a user-specified symbology. The maps identified in the following sections display a number of different hydrogeological attributes including water well density, groundwater use, and location of springs.

2.1 Data Sources

The Alberta Water Well Information Database (AWWID) was the principal source of data used in this study (http://aep.alberta.ca/water/reports-data/alberta-water-well-information-database/default.aspx). The AWWID contains information submitted to Alberta Environment and Parks by licensed water well drillers including: static water levels, lithological logs, well construction details~~,~~ and, in some cases, pumping test data. Additional data used in this study was obtained through an AGS borehole drilling program (Riddell et al., 2009).

Supplemental data and information used included: the mapped locations of springs discharging at the land surface (Stewart, 2014), the AgraSID 3.0 soil mapping database (Alberta Agriculture and Rural Development, 2010), the locations of wetlands and organic deposits (Shetsen, 1987; Shetsen, 1990), the 60 m Satellite Remote Tomography Mission digital elevation model (DEM) (U.S. Geological Survey, 2000), and physiographic (Pettapiece, 1986) and surface geological mapping (Shetsen 1987: Shetson 1990) of the study area. Supplemental data were used to constrain geostatistical surfaces and hydrogeological parameters.

2.2 Water Well Density

Water well density was calculated based on the number of wells present in each cell of a 1 km by 1 km grid across the ECC study area. The grid was aligned with the NAD 1983 Forest 10 TM AEP UTM projection. Calculations were made using the ArcGIS “Point Density” tool to generate the density of water wells per km^2. The water well density map is important to consider when interpreting the potentiometric data as it indicates the density of data control points used to generate the interpolated surfaces.

2.3 Groundwater Use

Three annual groundwater use maps were generated for the ECC study area including the categories of: (i) domestic plus stock/domestic; (ii) licensed groundwater use; and, (iii) cumulative groundwater use (i.e., total groundwater use from both domestic and licensed groundwater wells). The lack of reporting requirements for domestic and stock wells in Alberta makes the corresponding domestic and stock groundwater use difficult to estimate. Available regulations and assumptions based on the expected duration of groundwater well use allow for some constraints on groundwater use estimates. The Alberta Water Act stipulates that annual extraction of groundwater shall not exceed 1250 m^3 for domestic wells and 6250 m^3 for stock/domestic wells. Also, many older water wells do not produce sufficient groundwater volumes for domestic and stock watering requirements due to well deterioration issues such as bio-fouling and siltation. As such, only water wells less than 25 years old with drilling completion dates ranging from 1985 to 2010 were included in the estimates of groundwater use. This assumption may cause underestimation of groundwater use if wells 25 years old or greater are still in service. Well records that were less than 25 years old were assigned annual extraction volumes based on allowable maximums permitted under the Alberta Water Act for the recorded purpose (i.e., domestic or domestic/stock).

ArcGIS was used to convert point locations of the domestic and stock/domestic wells to a raster format in which each cell represented the estimated total groundwater use per square kilometre. Cells that contained no domestic or stock/domestic wells were assigned a groundwater use value of zero. A similar procedure was used to generate the licensed groundwater use map. Alberta Environment and Parks provided AGS with a listing of active licensed wells, including location and volume of annual groundwater use. This information was converted into a raster format with total licensed groundwater use per square kilometre, with null areas assigned a use value of zero.

The overall groundwater use map for the ECC provides an estimate of the water used for domestic, domestic/stock, and licensed purposes. This map was created by summing values associated with each cell in the two individual raster maps for domestic and licensed water use using the spatial analyst tool in ArcGIS.

2.4 Groundwater Flow System Mapping

The Geostatistical Analyst extension in ArcGIS was used to create interpolated (or modelled) surfaces of the water table elevation and potentiometric surfaces for a number of depths. The geostatistical approach to generating continuous surfaces honours observed data values at a given location and minimizes the error of the generated surface in areas without data. For this project, continuous interpolated surfaces were generated to help understand the distribution of hydraulic heads, which in turn help to conceptualize movement of groundwater within the ECC.

This study also presents a map of the known locations of spontaneously flowing holes and a map of known locations of discharging springs within the ECC. The presence of flowing holes and spring discharge can be used to assist in the interpretation recharge/discharge and vertical gradient maps as they are both indicators of upward groundwater flow.

2.4.1 Water Table

The water table is the surface defined by the elevation to which water rises in a tightly cased well open to the atmosphere. In general, the water table follows similar contours to the land surface but with less abrupt changes in elevation. The water table manifests itself on the land surface as lakes, ponds, and springs, which are found in low lying areas such as valley bottoms and localized depressions. Upland areas typically have deeper water tables relative to the land surface. Knowledge of the water table elevation allows estimation of other hydrogeological characteristics— such as the unsaturated or vadose zone thickness and the localized groundwater flow direction—and assists in identifying shallow aquifers.

The water table map was generated using several data sources including static water levels from water wells completed in unconsolidated sediments or installed in bedrock within 5 m of the ground surface (AWWID), permanent surface water feature elevations from a digital elevation model, known groundwater spring locations (Stewart, 2014), and locations of hydric soil (Alberta Agriculture and Rural Development, 2010). Approximately 350 000 data points were used to interpolate the water table surface across the ECC. Of these data points, less than 3900 represent static water levels measured in unconsolidated materials or at depths of less than 5 m below the top of bedrock. Though only a small proportion of the total data represent direct measurements of water table elevation, all data points provided important control on water table elevation especially in upland areas. To generate a realistic surface, the water table was set to a depth of one metre below ground surface where geostatistical interpolation resulted in a water table elevation above land surface in areas not classified as a permanent water feature. The geostatistical model used to construct water table elevations is regional in nature and does not accurately reflect water table elevations on a local scale.

2.4.2 Potentiometric Surfaces

A potentiometric surface is a two-dimensional representation of the elevation that water would rise to in a tightly cased well open to the atmosphere which has been completed within a confined aquifer. Potentiometric surfaces illustrate how hydraulic head varies in space and provide a generalized indication of the direction of groundwater flow in homogenous isotropic aquifers. As previously indicated, hydraulic head values were not grouped by geological formation. Rather, hydraulic head values from a series of 10 m depth intervals that were grouped to infer groundwater conditions. The 10 m depth intervals are relative to the land surface (e.g., 10–20 m bgs) and in this report are referred to by the midpoint of the depth interval (i.e., 15 m for the 10–20 m bgs depth interval). Vertical hydraulic head gradient maps were derived by subtracting two potentiometric surfaces of different depth intervals.

Bedrock potentiometric surfaces were generated using ArcGIS to interpolate static hydraulic head between control points within a given depth interval below ground surface. Table 1 shows the number of control points (i.e., wells with sufficient data records for this analysis) present within selected depth intervals as measured in metres below ground surface (m bgs).

Table 1. Control points at selected depth intervals used in the construction of potentiometric surfaces.

Depth Interval (m bgs)	Number of Control Points
10–20	11 152
20–30	11 121
30–40	10 824
40–50	6445
50–60	3730
60–70	2430
70–80	1618
100–125	432
≥100	636
≥200	40

2.4.3 Limitations of Mapping Approach

The relatively poor spatial resolution of well locations available in AWWID (often the centroid of a legal subdivision) combined with uncertainties inherent in the available land surface DEM result in not being able to attribute individual water wells to specific geological formations. To overcome this limitation, the potentiometric surfaces were constructed at selected intervals below land surface without regard to geological unit. For the relatively flat-lying or shallow-dipping stratigraphy, the approach of selected intervals is likely to intercept the same geological formation, thus providing a representative potentiometric surface.

The study area contained more than 100 000 water well records. As such, an automated technique was required to interpolate hydraulic head data to create a geostatistically generated water table and potentiometric surfaces. Interpolation of geospatial data introduces some inaccuracies in the corresponding representations of subsurface conditions. Error in an interpolated surface typically occurs in areas without nearby data to inform the best unbiased linear estimate. However, errors in interpolated surfaces can also occur in areas with ample data due to the data source. Static water levels contained in the AWWID database are typically measured shortly after well installation. The AWWID database contains water level measurements dating from 1900 to present and as such, represent water table and potentiometric surfaces that are time averaged.

Geospatial interpolation techniques used in our study inherently assume input data represents a hydrologic system that is at steady state. In reality, there has likely been some variability in hydraulic head within the upper 150 metres of our study area attributable to natural variations in groundwater recharge and discharge rates over the past approximately 100 years. Generally, fewer data points are available with increasing depth and, consequently, correspondingly greater interpolation errors can be expected. Furthermore, water well installations in the region sometimes have completion intervals greater than 30 m in length, or perforated/open-hole intervals which can straddle multiple geological units. This introduces some uncertainty regarding allocating the hydraulic head observation to a specific geological formation.

2.5 Recharge and Discharge Areas

Potential recharge and discharge area maps were derived by subtracting the 15 m and 75 m potentiometric surfaces from the digital elevation model of the land surface. Where the result is positive, the land surface is the higher elevation, and there is potential for groundwater recharge. Where the result is negative, the potentiometric surface is the higher elevation, and there is potential for groundwater discharge. Using the 35 m and 75 m potentiometric surfaces allows qualitative examination of the shallow and deeper groundwater flow systems, respectively. It is important to note that the resulting recharge/discharge map does not correspond to areas of actual groundwater recharge or discharge, but rather the potential for occurrence based on difference in hydraulic head conditions.

3 Results and Discussion

The results of the mapping and analysis are described below and summarized in Table 2. The uncertainty of each of the surfaces is discussed below within each subsection.

Table 2. Summary of report figure number, mapped attribute or surface, grid spacing, and data sources.

Fig.#	Name/Theme	Type	Grid Spacing	Data Sources
3	Well Density	Attribute	1 km	AWWID
4	Domestic/Stock Groundwater Use	Attribute	1 km	AWWID Alberta Water Act (max. allocations)
5	Licensed Groundwater Use	Attribute	1 km	Alberta Environment and Parks
6	Overall Groundwater Use	Attribute	1 km	Sum of Maps 4 and 5
7	Spring Locations	Attribute	N/A	Stewart, 2014
8	Flowing Hole Locations	Attribute	N/A	AWWID
9	Water Table Elevation	Surface	500 m	AWWID AGRASID 3.0 Soil Database, Digital Elevation Model, Wetland Mapping
10	Potentiometric Surface (35 m bgs)	Surface	1 km	AWWID
11	Vert. Gradient Map (25 to 45 m bgs)	Derivative	1 km	AWWID
12	Vert. Gradient Map (35 to 115 m bgs)	Derivative	1 km	AWWID
13	Recharge/Discharge Map (15 m bgs)	Derivative	1 km	AWWID Digital Elevation Model (Land Surface)
14	Recharge/Discharge Map (75 m bgs)	Derivative	1 km	AWWID Digital Elevation Model (Land Surface)

3.1 Water Well Density and Groundwater Use

The distribution of well density in the ECC ranges from 0–1 to 12–16 wells per square kilometre (Figure 3). Well density is highly correlated to the distribution of suburban and rural populations in the ECC. This is particularly evident in locations of relatively dense suburban housing developments near Edmonton and Calgary. Well density of 6–10 wells per square kilometres are also found around Sylvan Lake and Pigeon Lake.

Annual domestic plus domestic/stock groundwater use in the ECC study area (Figure 4) ranges from approximately 0 to 0.25 millimetres per square kilometre (mm/km^2), equivalent to 0 to 250 m^3 for each 1 km x 1 km cell. Annual licensed groundwater use in the ECC study area (Figure 5) ranges from approximately 0 to 1.35 mm/km^2 (0 to 1350 m^3). Annual total groundwater use (the sum of domestic, domestic/stock and licensed) in the ECC study area (Figure 6) ranges from approximately 0 to 1.35 mm/km^2 (0 to 1350 m^3).

Maximum annual allowable withdrawal volumes were used to calculate the domestic plus domestic/stock groundwater use shown in Figure 4. As such, information shown in Figure 4 likely represents an overestimate of domestic and stock groundwater use within the ECC. Patterns of potential use shown in Figure 4 suggest that groundwater demand in the ECC is focussed in relatively small areas.

As would be expected, well density and groundwater use are highly correlated. Groundwater used for public supply typically comes from deeper bedrock aquifers that contain better water quality than is available from shallower unconsolidated aquifers. Well density is an important constraint on the accuracy of the attribute and derivative maps and of the interpolated surfaces presented in this report. For example, maps and surfaces representing areas having fewer control points derived from AWWID data are likely to have a greater degree of uncertainty than maps and surfaces representing areas with many wells.

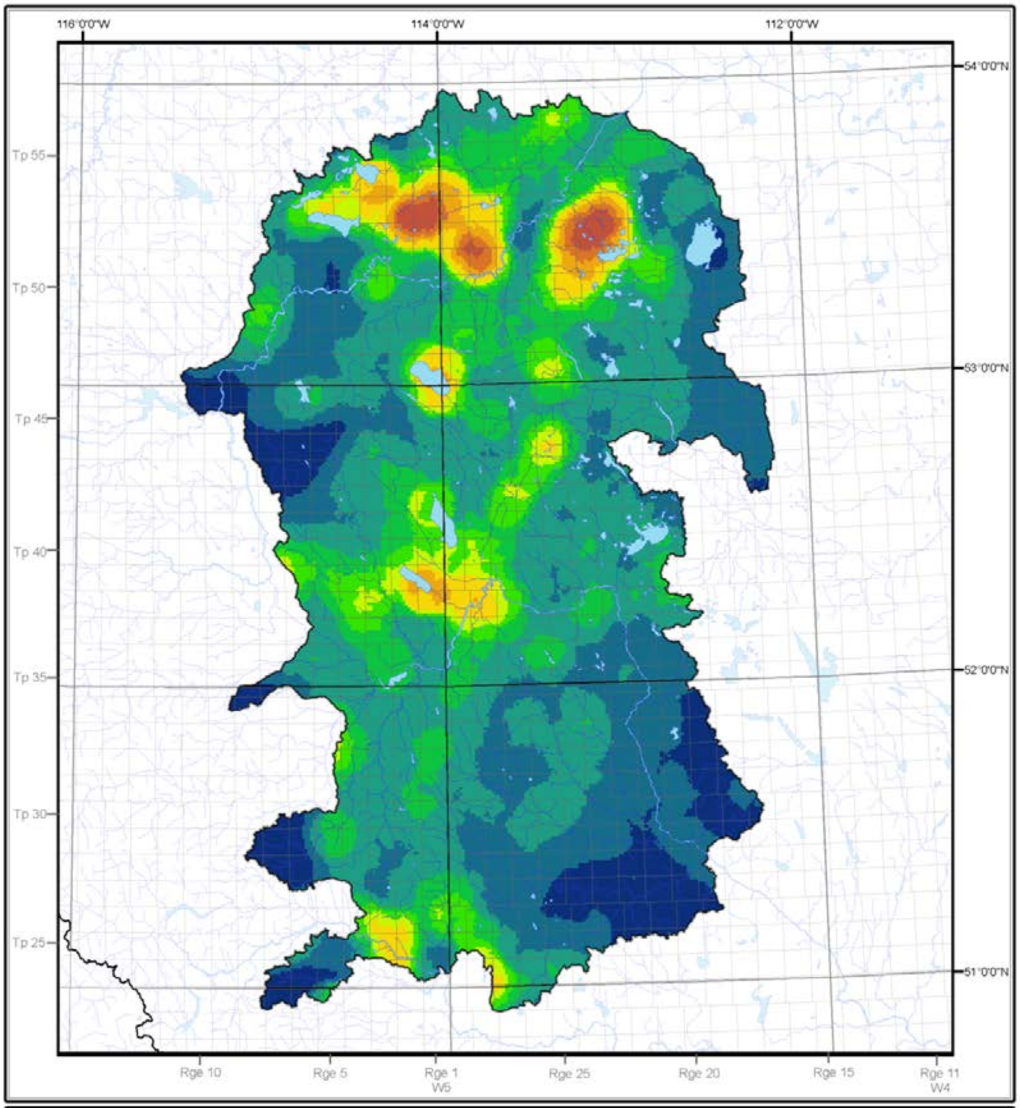
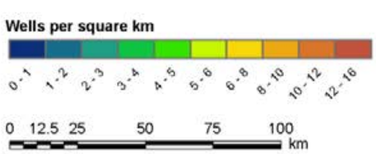


Figure 3. Water well density in the ECC



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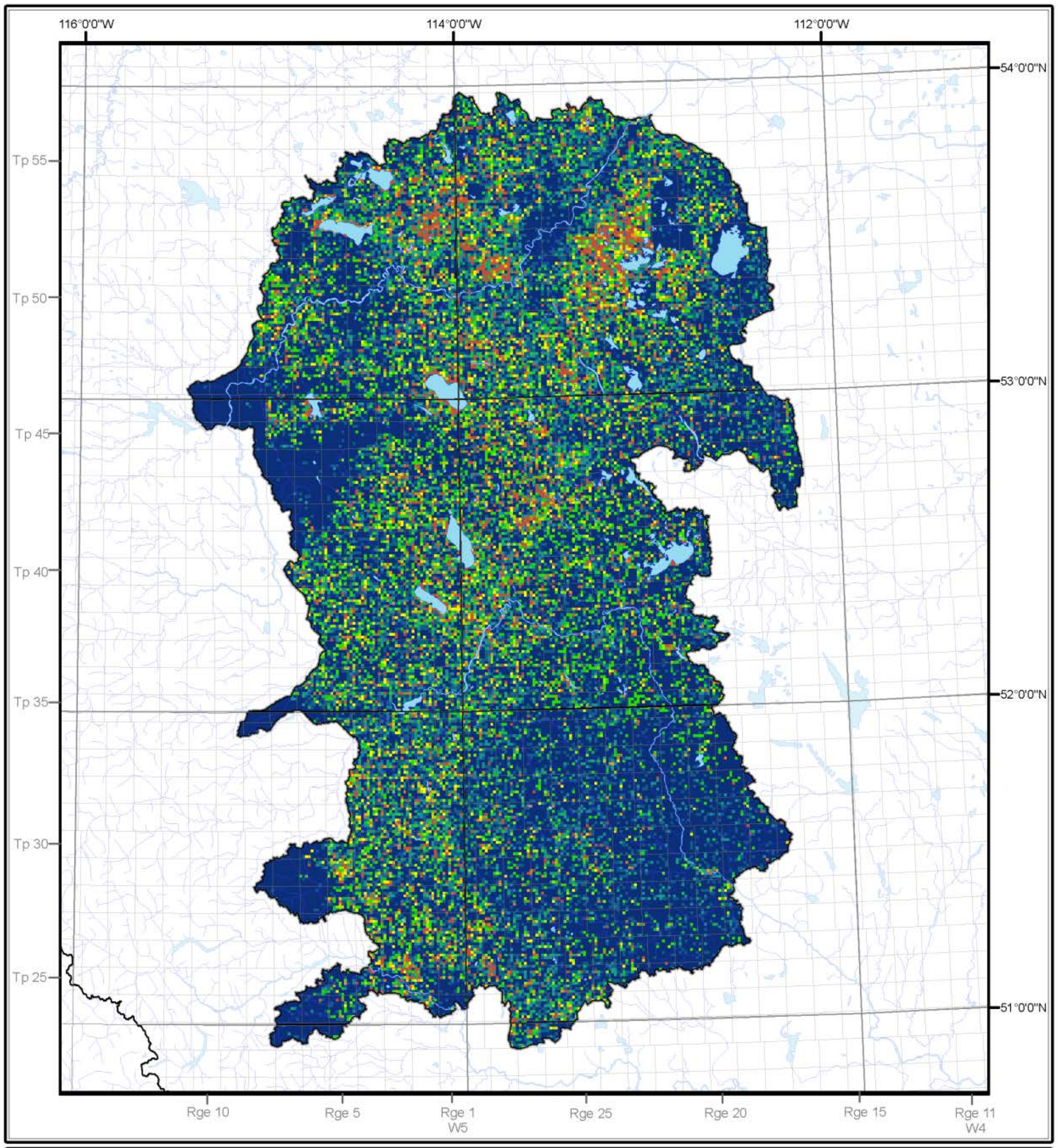

Figure 4. ECC annual domestic and domestic/stock groundwater use

Annual Domestic & Domestic/Stock Groundwater Use
(mm/km²)
0.25
0

0 12.5 25 50 75 100 km

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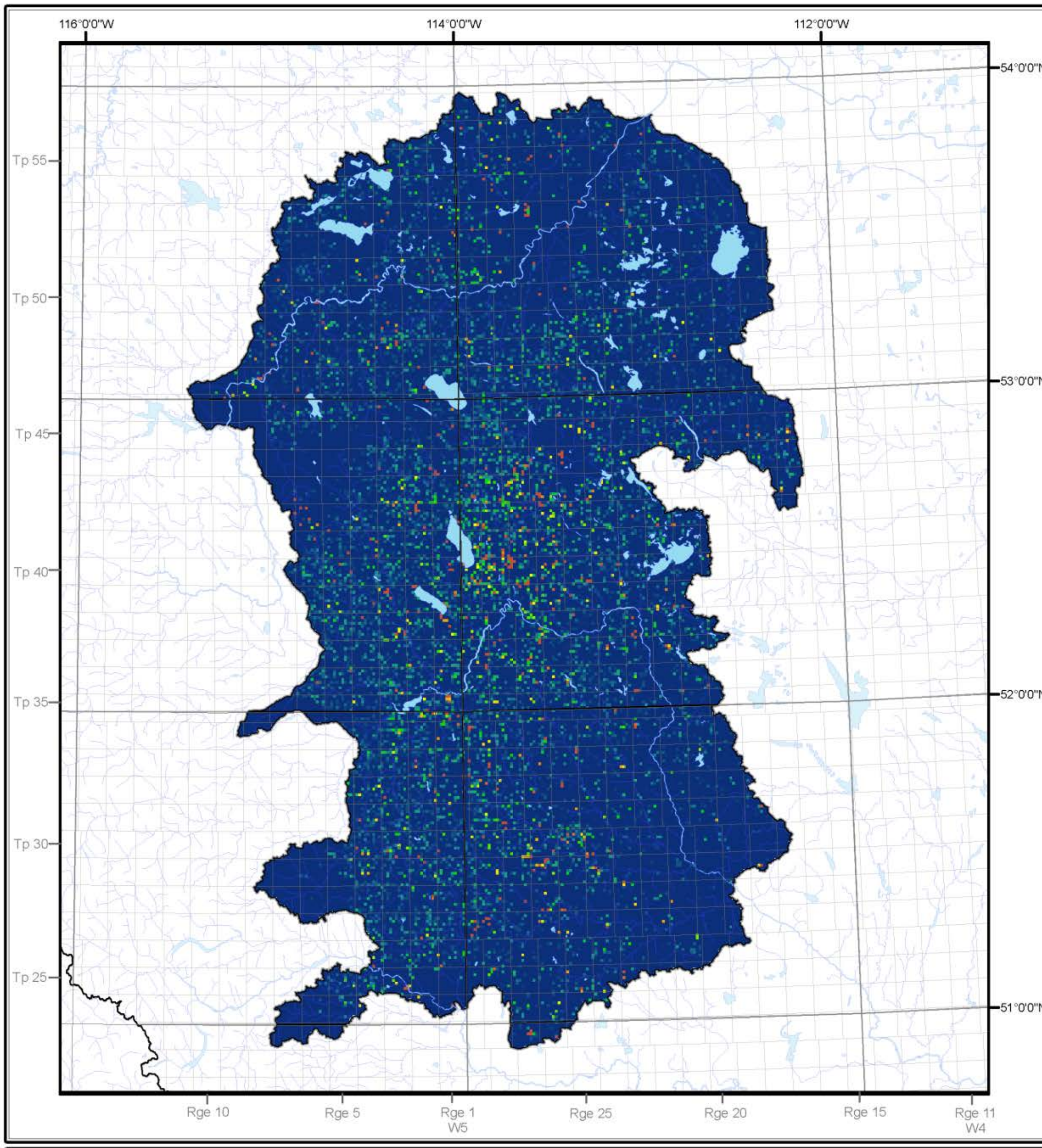

Figure 5. ECC annual licensed groundwater use

Licensed Groundwater Use
(mm/km²)

1.35

0

0 12.5 25 50 75 100 km

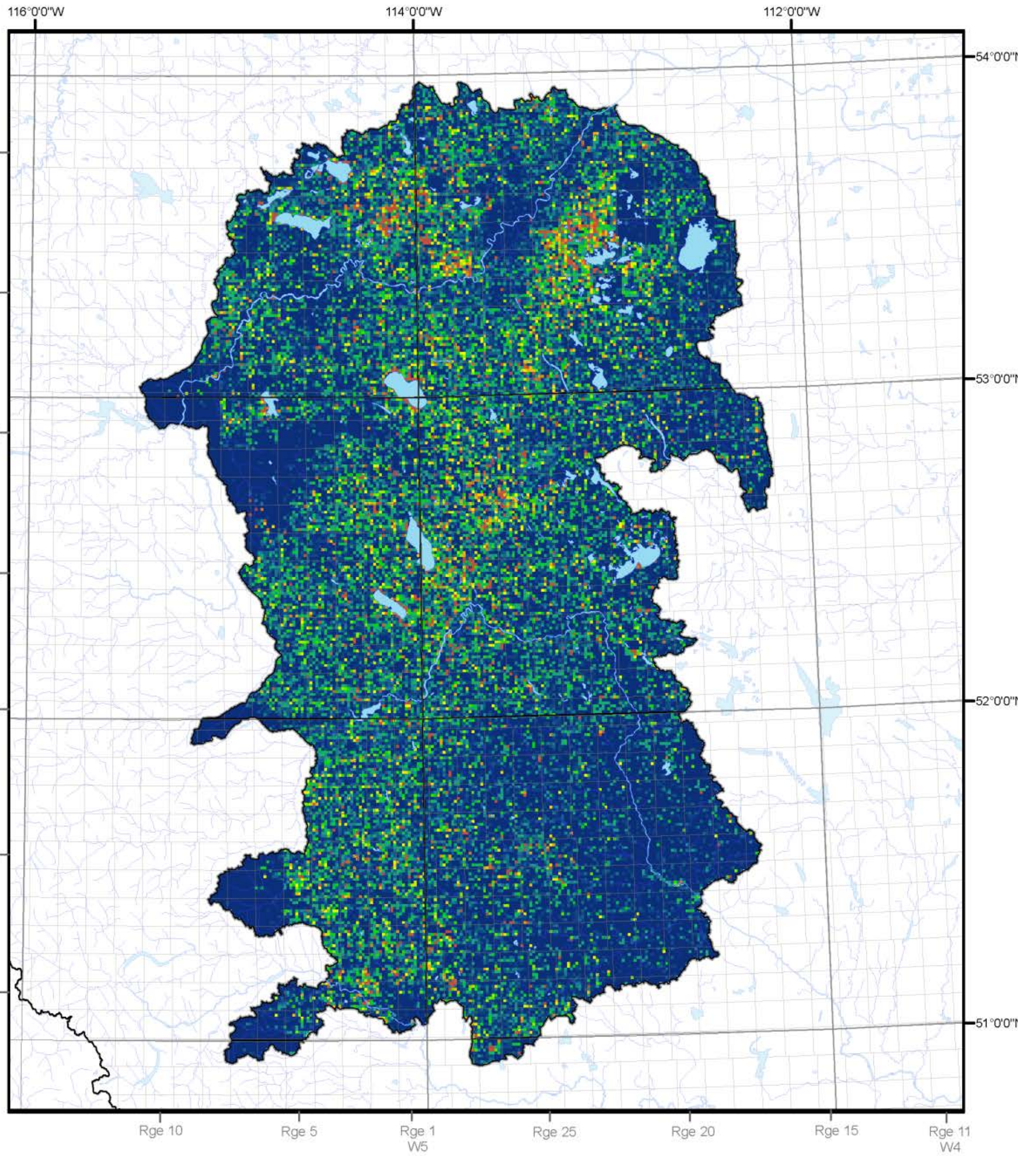

Figure 6. ECC annual total groundwater use

Groundwater Use

(mm/km²)

1.35

0

0 12.5 25 50 75 100 km

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3.2 Groundwater Flow System Mapping

Attribute data, such as documented locations of springs and flowing wells, can be useful in interpreting vertical gradient and recharge/discharge area maps. Springs indicate that groundwater is discharging at the land surface and corroborate the presence of shallow upward groundwater flow. The presence of flowing holes also corroborates the potential for upward groundwater flow. Reports of flowing holes typically lack associated potentiometric values. However, plotting the location of flowing holes is useful for corroborating areas of potential upward groundwater flow identified on the basis of apparent hydraulic gradients derived from interpolated potentiometric surfaces. Figure 7 shows the known locations of springs throughout the ECC study area as reported by Stewart (2014). Figure 8 shows the known locations of flowing holes throughout the ECC study area.

The water table surface was gridded at a resolution of 500 by 500 metres and ranges in elevation from approximately 500 to 2250 m amsl (Figure 9). The standardized root mean square error of the generated surface compared to the original dataset was 1.43 m for the ECC as a whole with an average standardized prediction error of approximately 3.5 m. The water table surface closely resembles land surface topography within the ECC study area.

The water table map represents a snapshot of a dynamic surface that changes over seasonal and longer time scales. The spatial resolution of the water table elevation map (500 m^2) is reasonable given the land area occupied by the ECC. However, this resolution can allow errors in the generated surface where high topographic relief is present. Many areas within the ECC are characterized by steep elevation gradients such as the foothills area surrounding the Little Red Deer River, the mountainous or alpine portion of the Bow River subbasin west of Calgary, and steeply incised drainages in the plains areas. The water table surface may be predicting elevations lower than actual conditions in the west-central portion of the ECC where the Paskapoo Formation is the subcropping bedrock formation. In this area, the uplands are composed of bedrock ridges with thin cover of unconsolidated glacial sediments which contain very few shallow water-level control points. Additionally, this study does not account for the potential effects of perched water tables within the ECC.

Ten potentiometric surfaces, ranging from 10 to 200 m bgs, were generated using data from the AWWID database. Control points become sparse for depths greater than approximately 60 m bgs resulting in interpolated surface being informed by fewer data with increasing depth. Figure 10 shows the potentiometric surface for 35 m bgs (i.e. 30–40 m bgs depth interval). The apparent groundwater flow direction in this interval is generally west to east with lateral hydraulic gradients generally increasing westward. This particular interval was chosen to show within this report due to the relatively high data density available for this interval and the interval represents a depth commonly used for water supply wells in the ECC.

Vertical gradient maps were generated showing the gradient between 25 and 45 m bgs (Figure 11) and between 35 and 115 m bgs (Figure 12). The shallower vertical gradient shows red recharge zones that highlight local upland potential recharge areas and green potential discharge areas in associated valley bottoms. The vertical gradient map generated from deeper potentiometric data shows a pattern similar to the shallower vertical gradient map and are not presented in this report. However, the deeper flow system is generally less influenced by higher frequency variations in land surface topography.

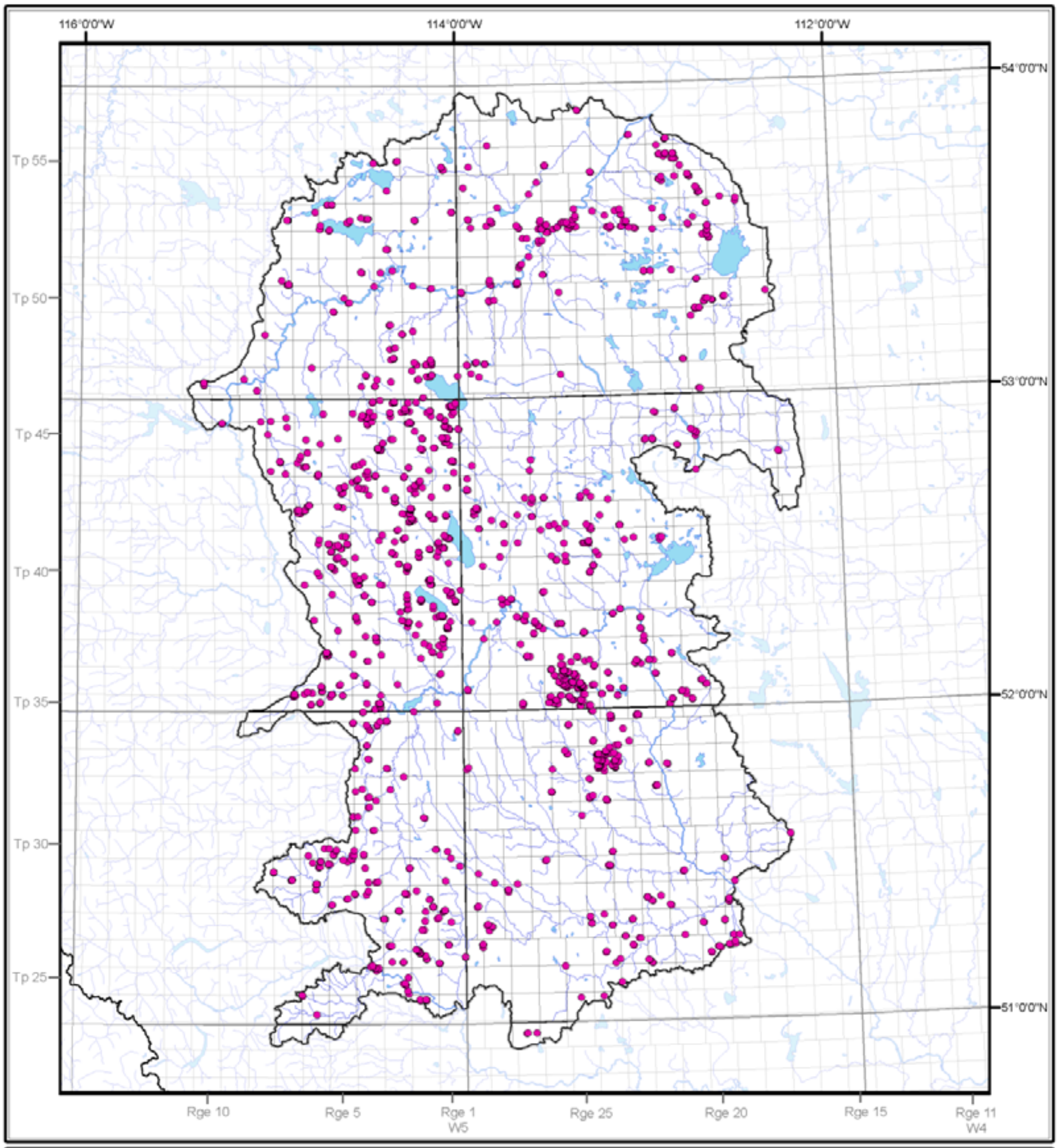

Figure 7. Documented spring locations in the ECC

Spring Location

0 12.5 25 50 75 100 km

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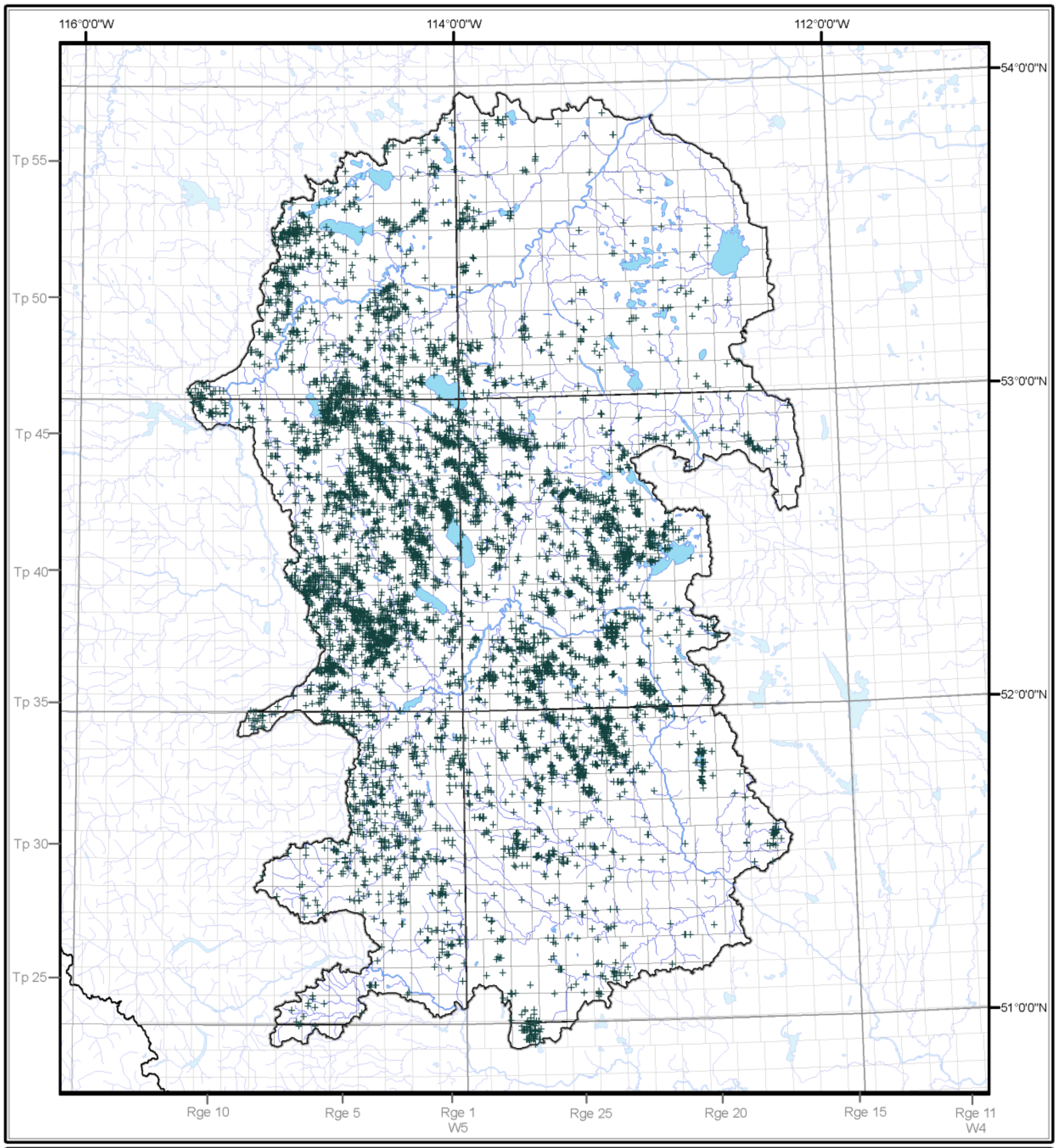

Figure 8. Documented flowing hole locations in the ECC

+ Flowing Hole Location

0 12.5 25 50 75 100 km

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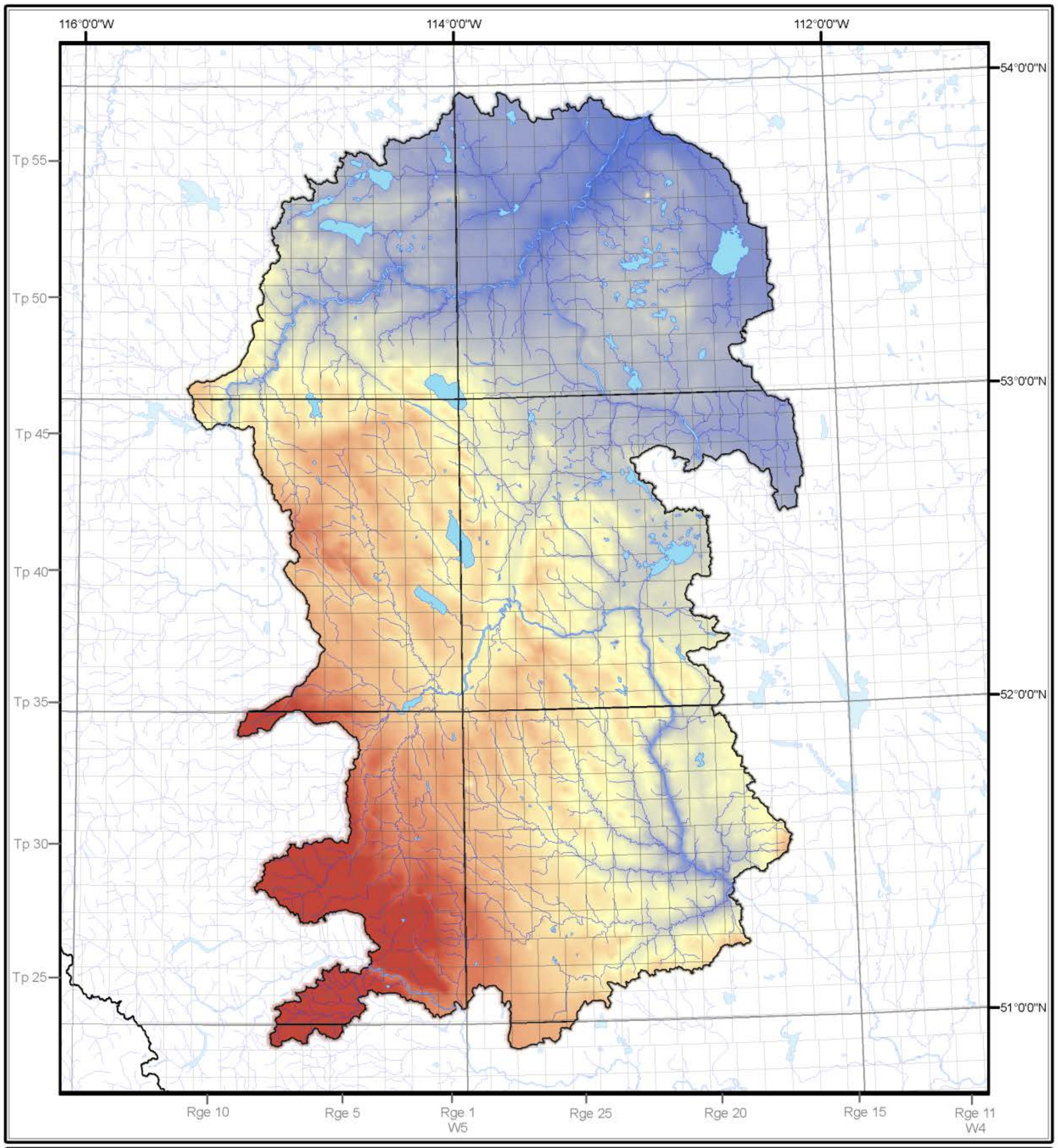

Figure 9. Water table elevation in the ECC

Water Table Elevation
(m amsl)

2250

500

0 12.5 25 50 75 100 km

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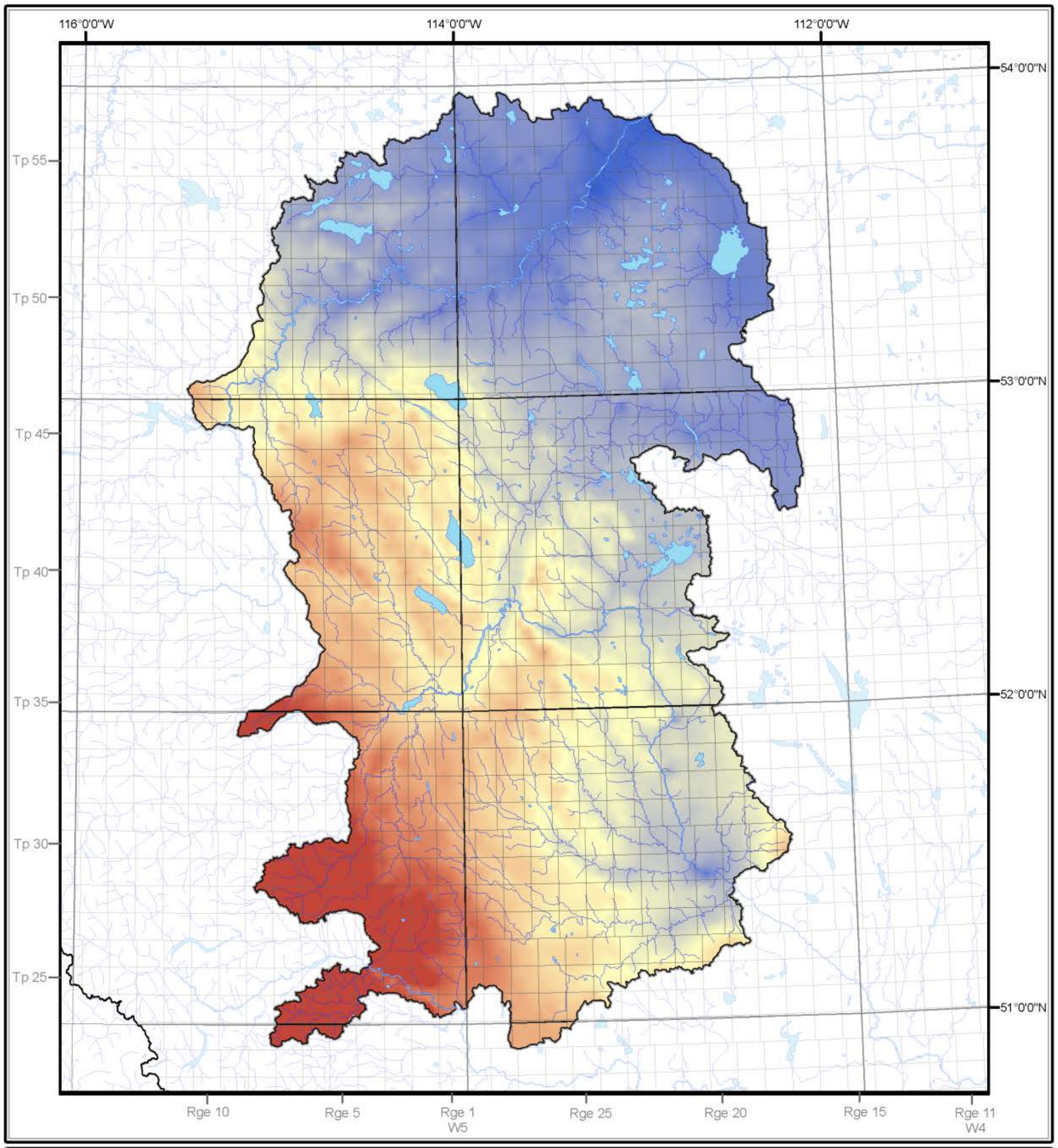

Figure 10. ECC potentiometric surface (35 m bgs)

35 m Potentiometric Surface
(m amsl)

2250

500

0 12.5 25 50 75 100 km

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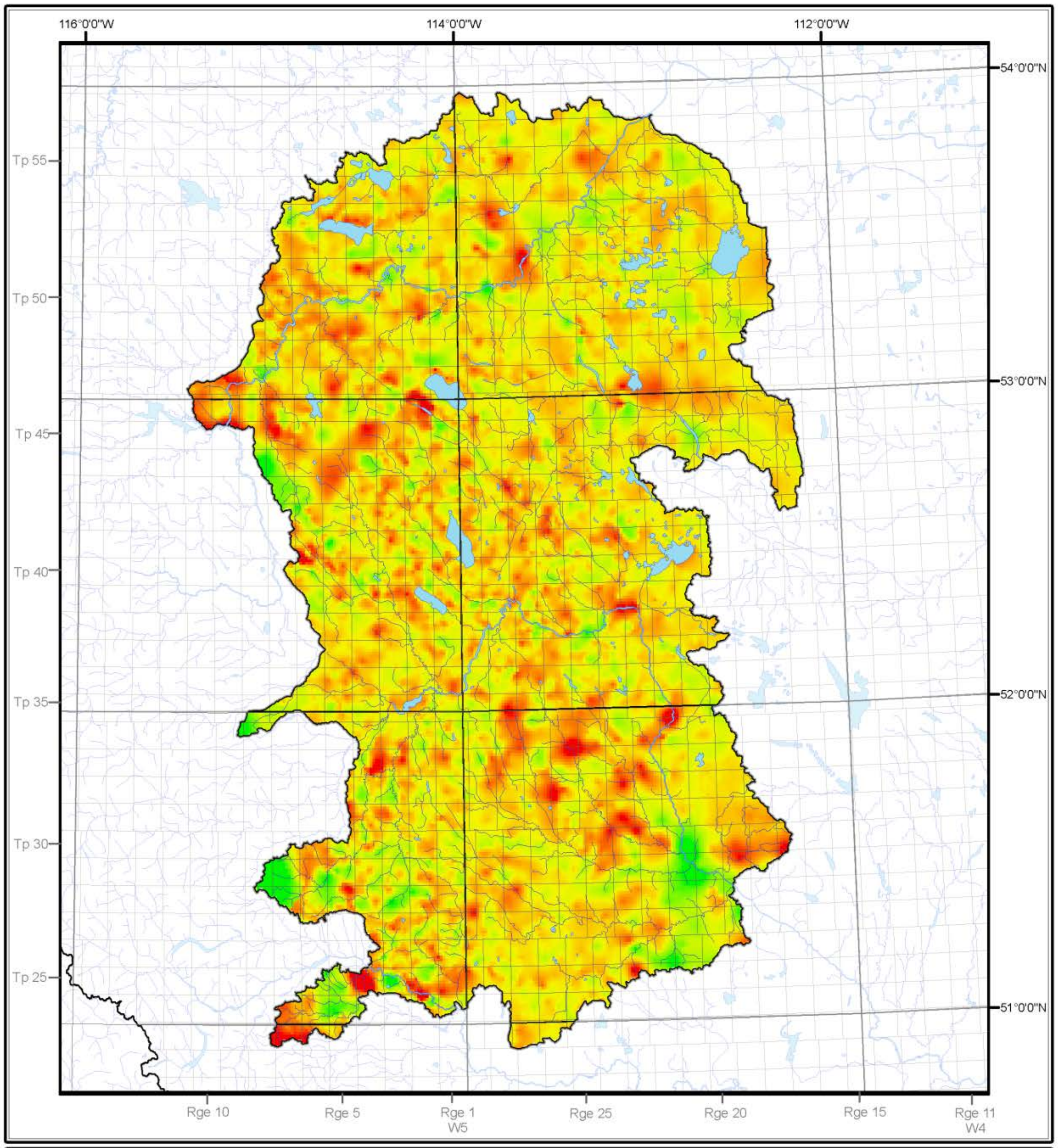

Figure 11. ECC vertical gradient (25 m - 45 m bgs)

Vertical Gradient

Strong Downward Flow

Strong Upward Flow

0 12.5 25 50 75 100 km

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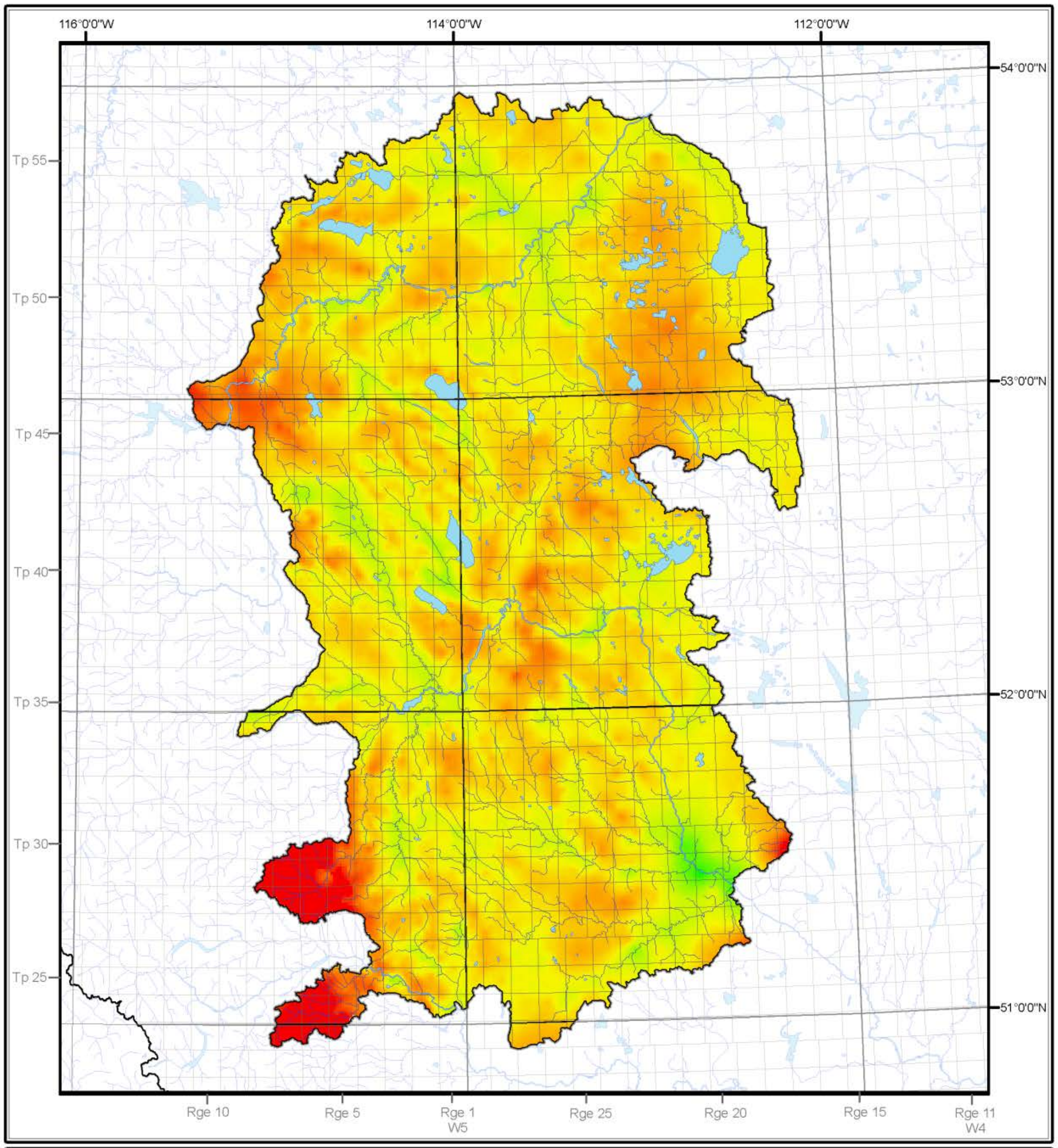

Figure 12. ECC vertical gradient (35 m - 115 m bgs)

Vertical Gradient

Strong Downward Flow

Strong Upward Flow

0 12.5 25 50 75 100 km

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3.3 Recharge/Discharge Maps

Recharge areas are generally topographically elevated parts of the landscape where meteoric water enters a groundwater flow system. Discharge areas are found where groundwater flows upwards towards the land surface or where the water table intersects the land surface. Discharge can occur as isolated springs that focus discharge in small areas, or over broad areas, such as riparian areas. Discharge areas are generally in topographically low areas where lakes, rivers, or groundwater fed wetlands (fens) can exist. Discharge areas, especially areas that lie in regional topographic lows, may receive groundwater from a both local-scale and regional-scale flow systems.

Figure 13 shows potential areas of discharge and recharge based on the difference between land surface elevation and the 15 m bgs potentiometric surface. Figure 14 shows potential areas of discharge and recharge based on the difference between land surface elevation and the 75 m bgs potentiometric surface. The northwest to southeast trend in potential recharge areas identified at both depth intervals corresponds well with areas of elevated topography across the ECC. Stream valleys correspond well with potential discharge area across the ECC. The patterns in recharge and discharge shown in Figure 14 are similar to those shown in Figure 13 suggesting that streams within the ECC play a role in focusing the discharge of groundwater even at depths approaching 100 m. In addition, Figure 14 suggests that recharge associated with larger groundwater flow systems may occur in elevated areas along the western boundary of the ECC.

Figure 15a shows the known locations of springs plotted on the shallow recharge/discharge area map. Figure 15b shows the locations of flowing holes plotted on the shallow vertical gradient map. Figures 16a and 16b show known spring and flowing-hole locations plotted on recharge/discharge and vertical gradient maps derived from deeper interpolated potentiometric surfaces.

There is an association between the known locations of springs and the presence of discharge areas as calculated using both the shallower and deeper potentiometric surfaces. The association of known spring locations with both shallow and deeper hydraulic gradients suggests that these springs may serve as discharge points for shallow and potentially deeper groundwater flow systems.

No apparent association is present between the locations of flowing holes and the shallow vertical hydraulic gradient. However, there is an association between the locations of flowing holes and areas of potentially upward groundwater flow based on the vertical gradient maps derived from the deeper interpolated potentiometric surface.

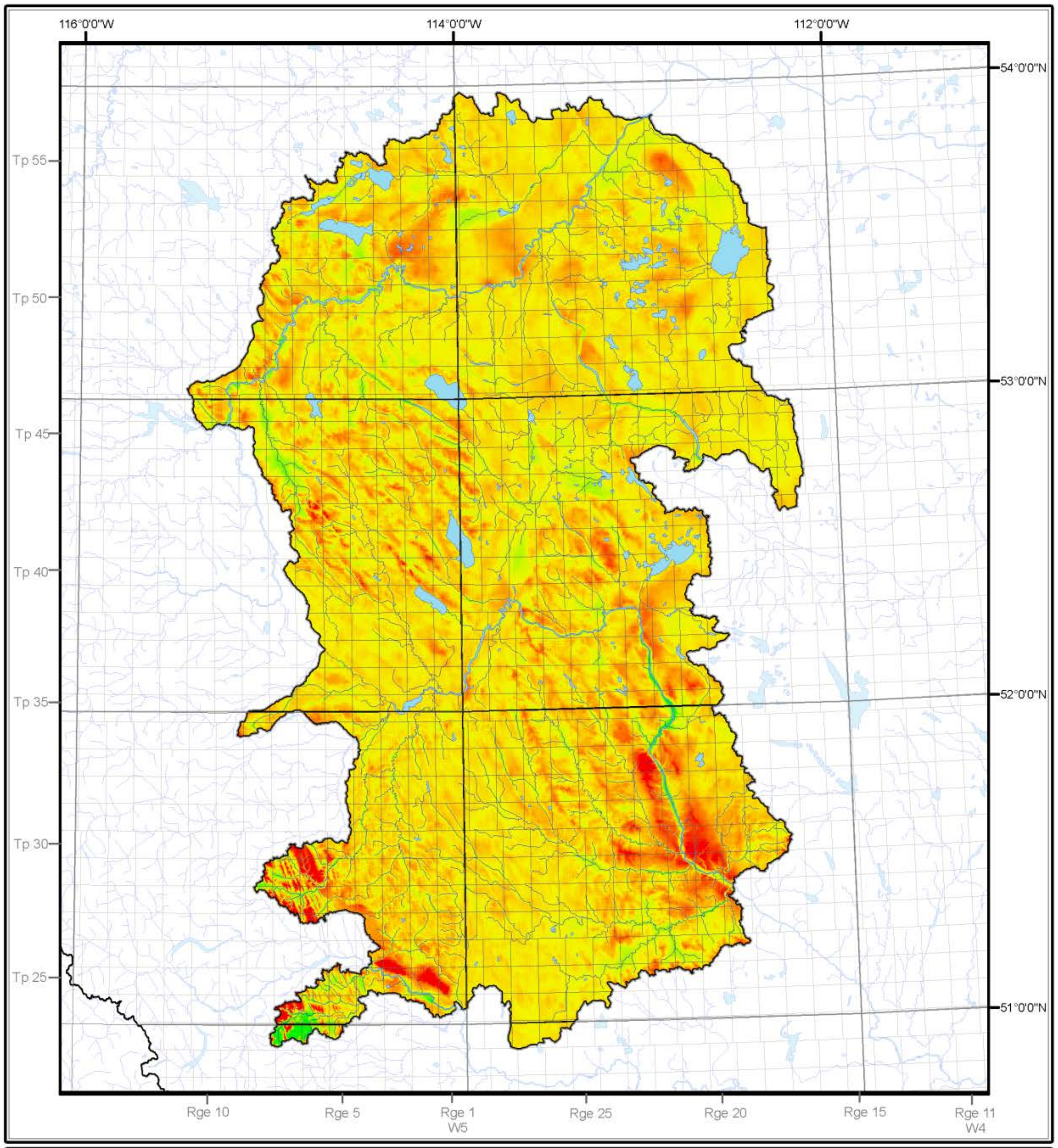
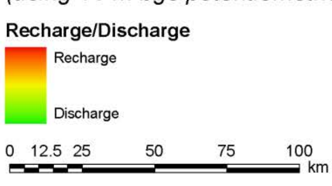


Figure 13. ECC recharge/discharge
(using 15 m bgs potentiometric surface)



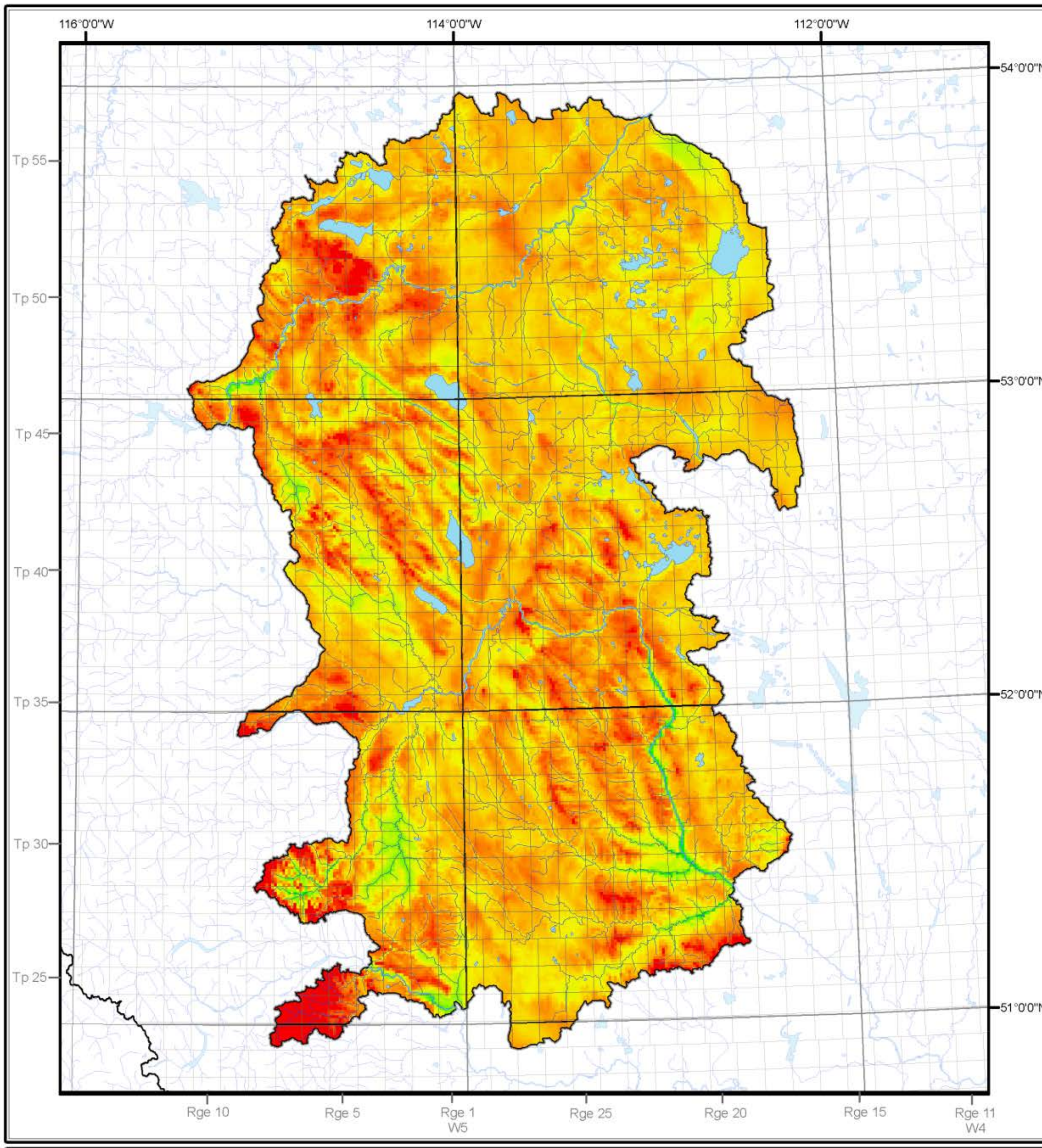


Figure 14. ECC recharge/discharge
(using 75 m bgs potentiometric surface)

Recharge/Discharge

Recharge

Discharge

0 12.5 25 50 75 100 km

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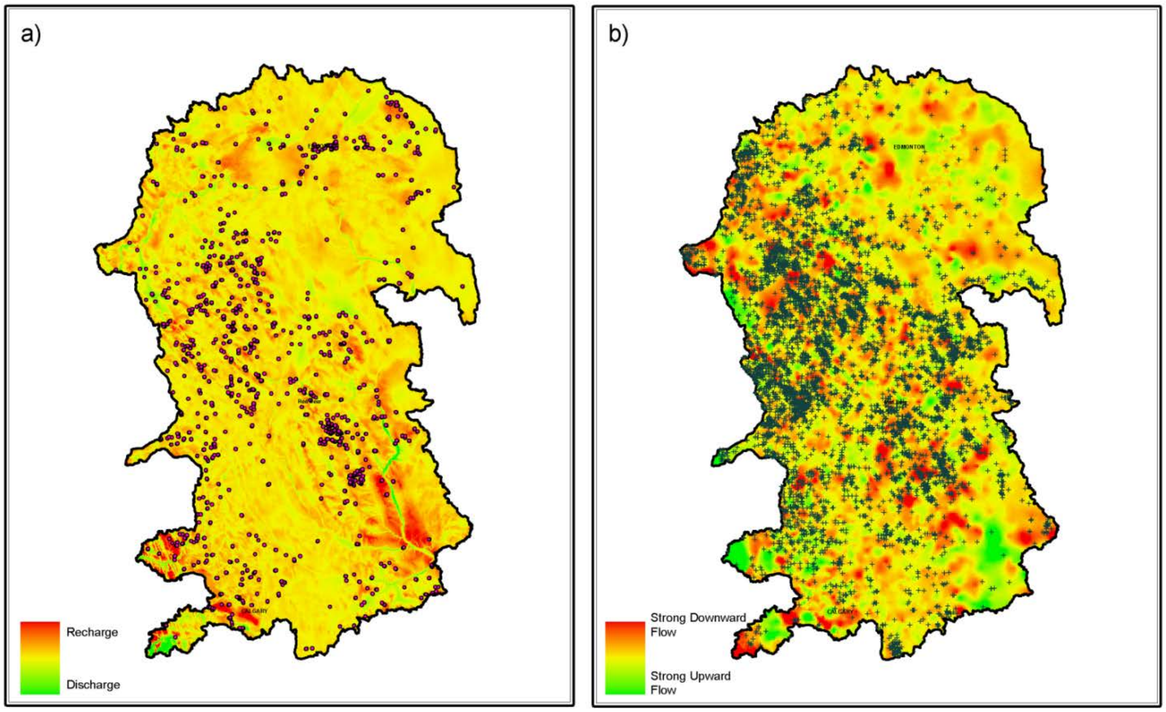

Figure 15. Comparison of shallow hydrogeological conditions with point observations: (a) shallow recharge/discharge (Figure 13) and spring locations (Figure 7); and (b) shallow vertical gradient (Figure 11) and flowing hole locations (Figure 8).

0 12.525 50 75 100 km

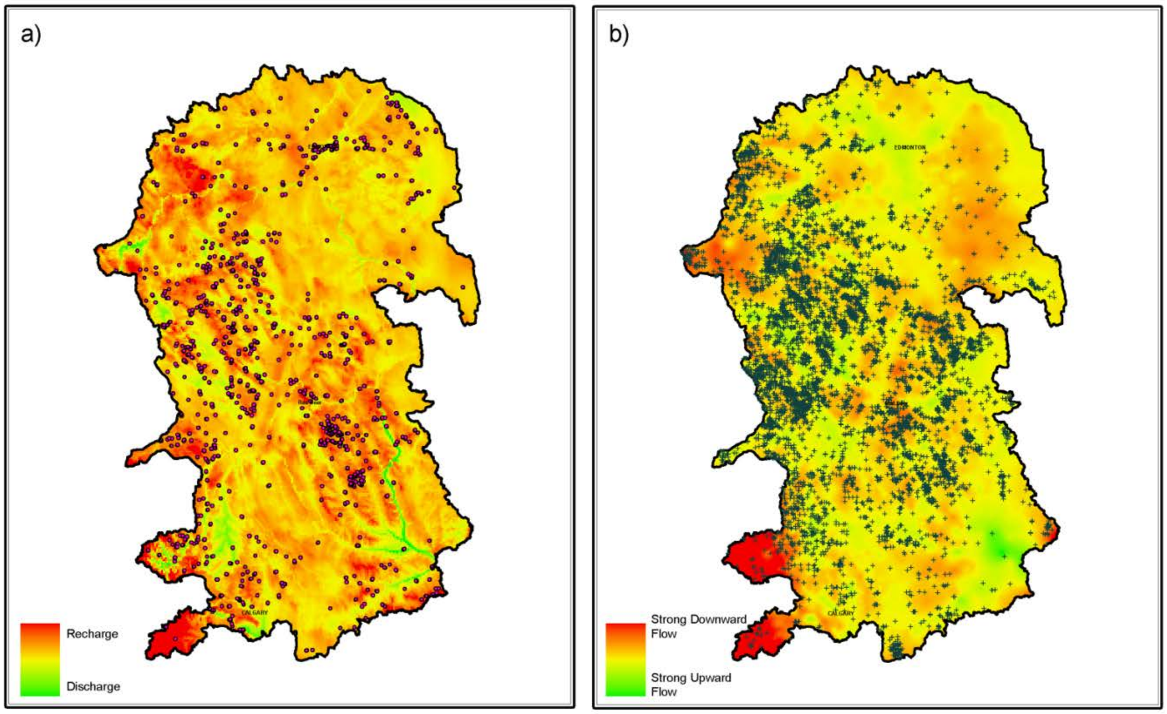

Figure 16. Comparison of deep hydrogeological conditions with point observations: (a) deep recharge/discharge (Figure 14) and spring locations (Figure 7); and (b) deep vertical gradient (Figure 12) and flowing hole locations (Figure 8).

0 12.525 50 75 100 km

4 Conclusions

The maps and analyses presented in this report represent a broad scale hydrogeological overview of the ECC. The information contained in this report should assist in future characterization of the hydrogeology of the ECC and in informing policy makers and regulators as to the current state of the groundwater resources of the ECC. Conclusions specifically derived from the mapping completed for this study include:

- Well density in the ECC ranges from 0–1 to 12–16 wells per square kilometre.
- Well density is highly correlated to the locations of relatively dense housing developments present around the periphery of major centres like Edmonton and Calgary and recreational property areas such as Sylvan Lake and Pigeon Lake.
- Annual total groundwater use (the sum of domestic, domestic/stock and licensed) in the ECC study area ranges from approximately 0 to 1.35 mm/km^2 (1350 m^3). Annual domestic plus domestic /stock and total groundwater uses are highly correlated with well density.
- The water table surface closely resembles land surface topography within the ECC study area.
- The potentiometric surface for a depth of 35 m bgs shows an apparent groundwater flow direction to be west to east with lateral hydraulic gradients generally increasing westward.
- Potential groundwater recharge areas show a northwest to southeast trend that corresponds well with areas of elevated topography across the ECC.
- Groundwater discharge is principally focused in stream valleys, major lakes, and broad low-lying wetland areas.

The regional framework allows for physically based boundary conditions to be applied to subregional numerical models based on the regional understanding of spatial patterns of groundwater usage, delineation of flow systems, vertical hydraulic head gradients, and recharge/discharge areas. Further, the information contained within this report is of utility to construction/infrastructure projects with a large linear footprint such as roads, utility corridors and pipelines as the regional groundwater framework provides a good indication of where project interactions with groundwater are most likely to occur.

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