Highlights of the Northeast BC Carbon Capture and Storage Atlas

Natalie L Sweet, MSc, P. Geo
Canadian Discovery Ltd

Allison J Gibbs, P. Geo
Canadian Discovery Ltd

John Xie, P. Eng
Canadian Discovery Ltd

Summary

Carbon capture and storage (CCS) provides an opportunity to help British Columbia reach “net zero” carbon dioxide (CO_2) emissions by 2050 (CleanBC, 2018, 2021). This project was commissioned to address a lack of coordinated public information about geological formations suitable for long-term CO_2 storage in BC’s portion of the Western Canada Sedimentary Basin (WCSB). Its goals included the identification of favourable geology for CO_2 storage in Northeastern British Columbia (NE BC) (Figure 1), and developing an understanding of ultimate CO_2 volumes that may be stored geologically. This information is needed to improve decision-making for policy, regulation and industry.

There are many recent technical studies in the public domain characterizing reservoirs within the WCSB. This project follows seminal work by Bachu (2006). The atlas has collated available public information and studies, while CDL provided geological support to fill in any gaps between previously existing datasets. The atlas is a compilation of maps and a comprehensive report identifying the formations and areas that may be most favourable for carbon sequestration. Identifying areas with sufficient storage potential, in conjunction with the locations of stationary CO_2 emitters and existing infrastructure, will assist in the evaluation and informed decision making for potential carbon storage and hydrogen projects.

The atlas identifies 4.3 Gt of CO_2 storage potential in formations in NE BC. Storage potential was calculated in depleted gas pools and saline aquifers for 12 formations (or groups of formations) that met some basic screening criteria, and had sufficient information available for a high-level quantification of storage potential. The atlas also provides an overview of CO_2 capture, separate formation chapter summaries and storage calculations.

Study Workflow and Deliverables

Storage reservoirs within a geological formation, or grouping of related formations, were viewed as viable carbon storage candidates if they host depleted gas pools and/or aquifers, and are part of a “storage complex”, with possible storage reservoir(s) and sealing units above and below. A further high level look at geology, reservoir quality and conditions, and hydrodynamic continuity of the reservoirs within each complex determined whether a formation might be suitable for carbon storage and whether an estimate of how much CO_2 the formation might potentially hold could be attempted.

For each formation/formation grouping that met the basic criteria, a chapter was compiled that included an overview of the areal extent of favourable storage reservoirs, pertinent reservoir characteristics, and estimated CO_2 storage potential. Formation structure and net reservoir maps were created from public data and existing studies, with additional mapping provided by CDL.

A preliminary analysis of filtered core data produced estimates of the porosity distribution within the storage reservoir and showed porosity-permeability correlations. A high-level hydrodynamic analysis using available drillstem test data (DSTs) helped delineate the approximate extent of aquifers and to understand the relationship between aquifers and depleted pools. DSTs also provided reservoir pressure and temperature information needed to estimate CO_2 density at reservoir conditions. Pertinent transitions to indicate the regions where reservoir pressure and temperature are expected to support injection of CO_2 in the supercritical phase (at least 7,500 kPa and 31°C, respectively) are shown on the maps. From the compiled information, estimates were made regarding how much CO_2 the depleted gas pools or aquifers could potentially hold.

For depleted gas pools, storage estimates were based on previous fluid production. The theoretical CO_2 storage potential of a depleted or nearly depleted pool represents the mass of CO_2 that can be stored in the pool assuming that the volume occupied previously by the produced gas will be occupied entirely by the injected CO_2. The theoretical CO2 storage estimates were provided by the BC Oil and Gas Commission (BC OGC), and were used by CDL to estimate the effective CO_2 storage potential, which represents the mass of CO_2 that can be stored in hydrocarbon reservoirs after taking into account intrinsic reservoir characteristics and flow processes, such as aquifer support. The estimated effective CO_2 storage potential reduces the theoretical storage potential by as little as 13% and as much as 75%.

For aquifers, a theoretical CO_2 storage potential can be calculated using the mapped pore volume of the reservoir and CO_2 density, and assumes that the pore volume will be occupied entirely by the injected CO_2. We know this is not the case however, since the pore space is already occupied by water and the water will need to be displaced in the process. As a result, a storage efficiency factor is introduced into storage potential calculations that accounts for the presence of both water and CO_2 in the aquifer. The storage efficiency factor is a function of reservoir and fluid properties and dynamics, including the geometry of the trap, gravity segregation, reservoir heterogeneity, permeability distribution and pressure, and may reduce the theoretical storage potential by as much as 95 to 99% in a regional evaluation. The values used in this study were similar to those in the Third, Fourth and Fifth editions of U.S. DOE-NETL CCS Atlas publications (2010, 2012, 2015) of 0.5% for the 10th percentile, 2.0% for the 50th percentile, and 5.4% for the 90th percentile. It should be noted, however, that there are a wide range of static storage efficiency factors available in literature; some are very small, which better reflect large-scale long term storage, and others are larger values that better represent local plume migration on a shorter timescale. Ideally, any factors used in planning a project should be tested and verified by models, which are able to capture dynamic aspects of plume migration.

Project Outcomes

The atlas identifies 4.3 Gt of CO_2 storage potential in formations in NE BC. Figure 2 shows the total storage potential per formation (or groups of formations) for depleted gas pools, while Figure 3 shows the estimated P10, P50 and P90 storage potential in the mapped aquifers.

Recommended areas of focus were identified where there are multiple storage opportunities coincident with stationary emitters and infrastructure. Figure 4 is a map of depleted gas pools with greater than 5 Mt of CO_2 calculated storage potential. Several depleted pools with greater than 25 Mt of storage potential exist in the Fort St. John area. Figure 5 is a map of the study area highlighting areas of total estimated P50 effective CO_2 storage potential combined (stacked) for all aquifers. A clearly defined fairway of stacked aquifers with significant storage potential has been identified in the Peace River block near Fort St. John (PRA Stacked Aquifer Fairway). Another substantial aquifer fairway exists further north near Fort Nelson (Middle Devonian Carbonates Aquifer Fairway).

For the regions identified in this study, further analyses of the pore space and surrounding seals at a sub-regional level and site level are crucial next steps in confirming the feasibility of CCS and identifying risks to containment, capacity and injectivity.

Depending on the storage and area needs, there are opportunities for small and large local CCS, as well as potential for hub model or cluster networks providing a variety of solutions in the NEBC region. The Atlas and supporting data are available to the public and can be downloaded from the Geoscience BC website https://www.geosciencebc.com/projects/2022-001/

Acknowledgements

The project partners acknowledge that this research concerns the territory of the Treaty 8 First Nations of British Columbia. We encourage anyone considering new development or activities in their territories to engage early and engage often with appropriate Indigenous groups. We thank the project partners for their support of this project, including Geoscience BC, the BC Centre for Innovation & Clean Energy (CICE), and the BC Hydrogen Office. CICE and Geoscience BC are grateful to the Province of British Columbia for funding this project.

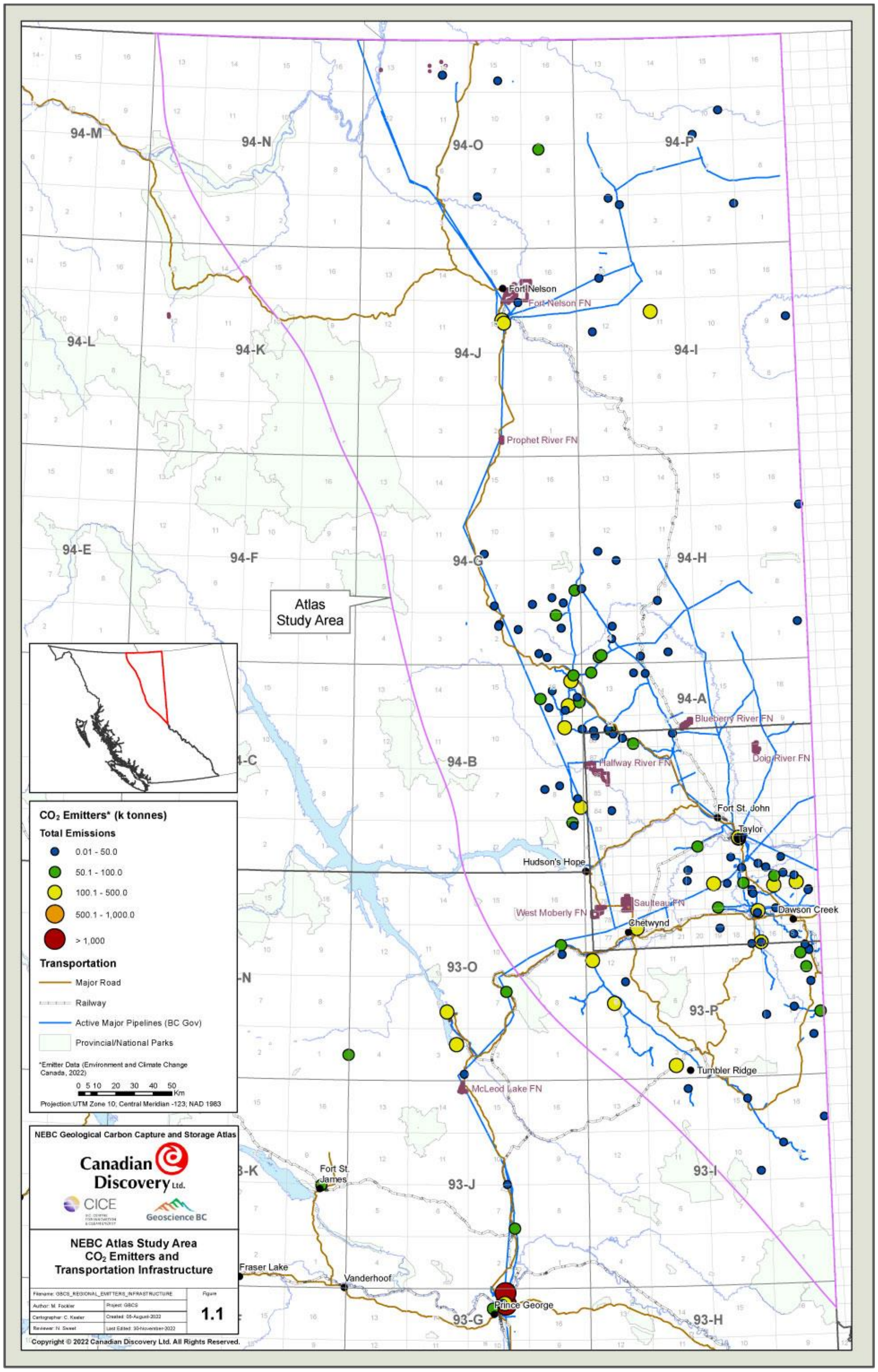


Figure 1 Study area with emitters and infrastructure

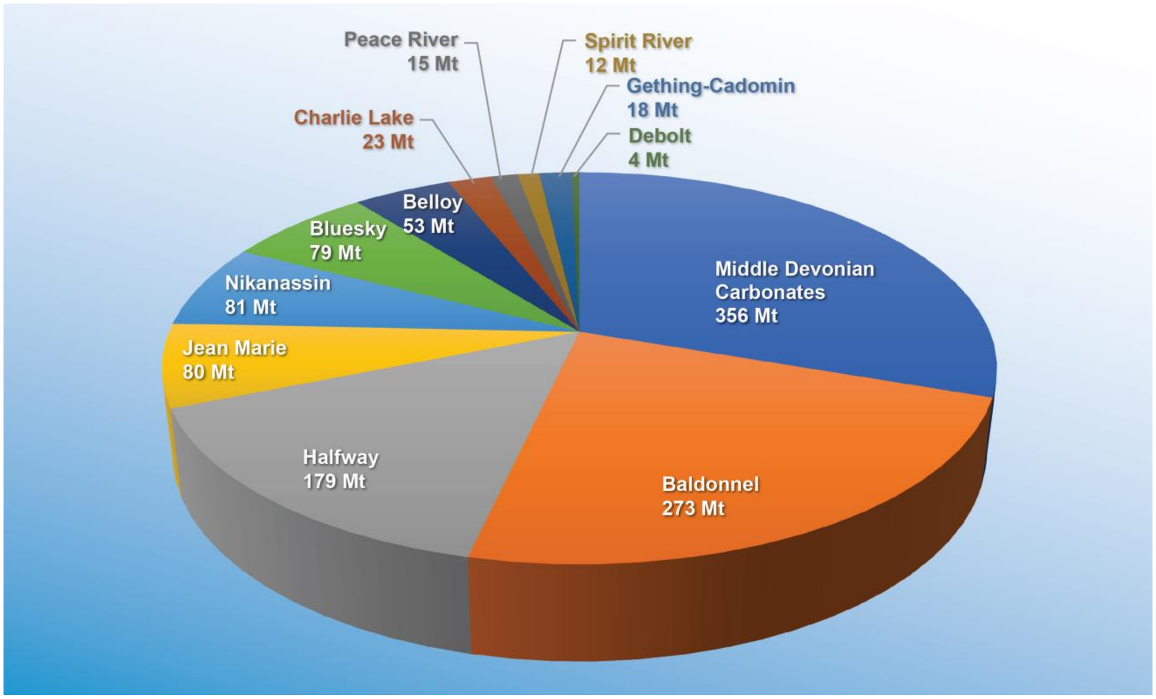
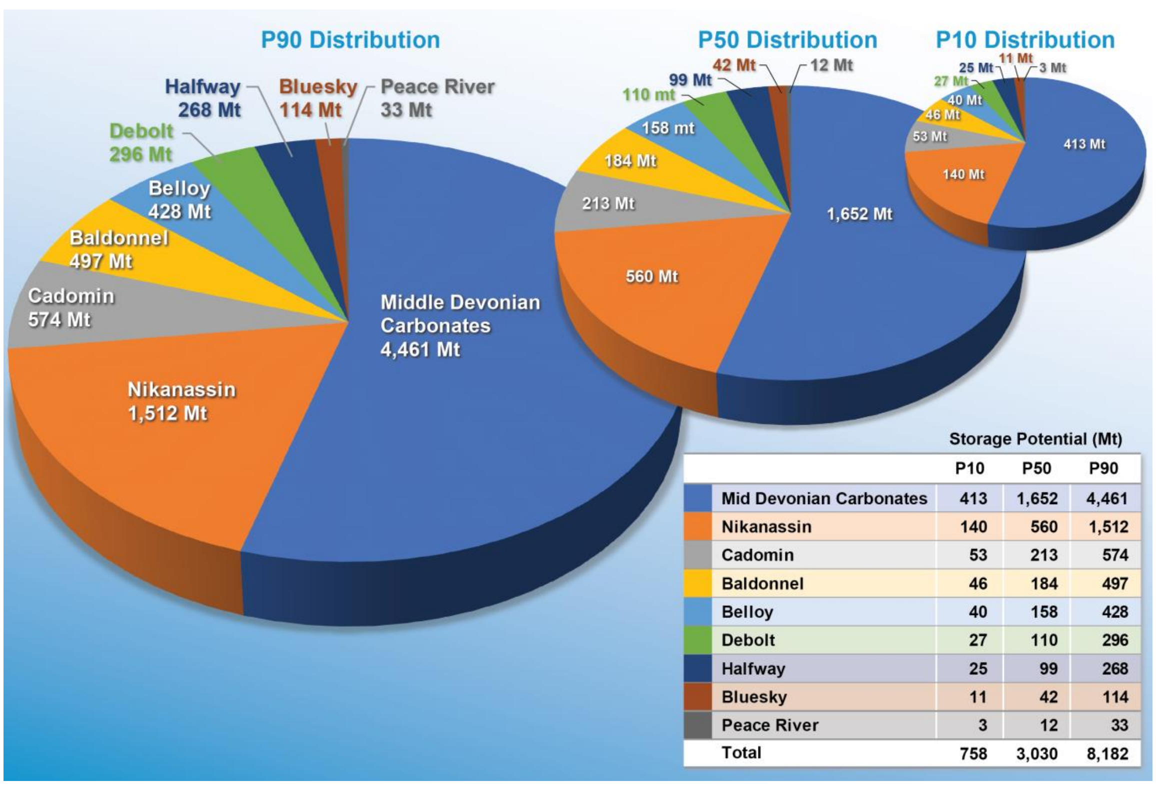


Figure 2. Depleted pool storage potential per formation



Storage Potential (Mt)

	P10	P50	P90
Mid Devonian Carbonates	413	1,652	4,461
Nikanassin	140	560	1,512
Cadomin	53	213	574
Baldonnel	46	184	497
Belloy	40	158	428
Debolt	27	110	296
Halfway	25	99	268
Bluesky	11	42	114
Peace River	3	12	33
Total	758	3,030	8,182

Figure 3. Estimated P10, P50 and P90 storage potential in the mapped aquifers

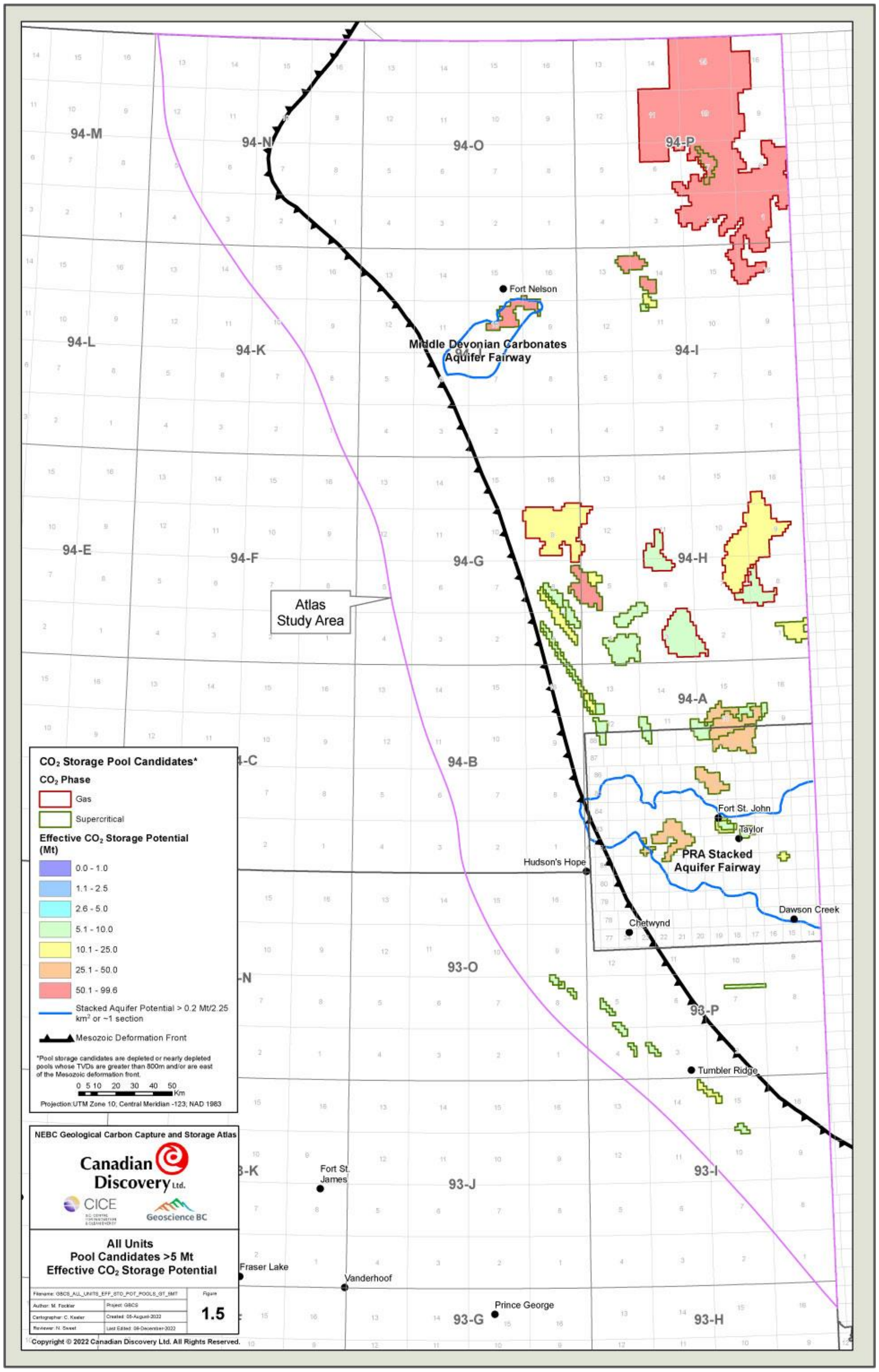


Figure 4. Depleted pools with greater than 5Mt of storage potential

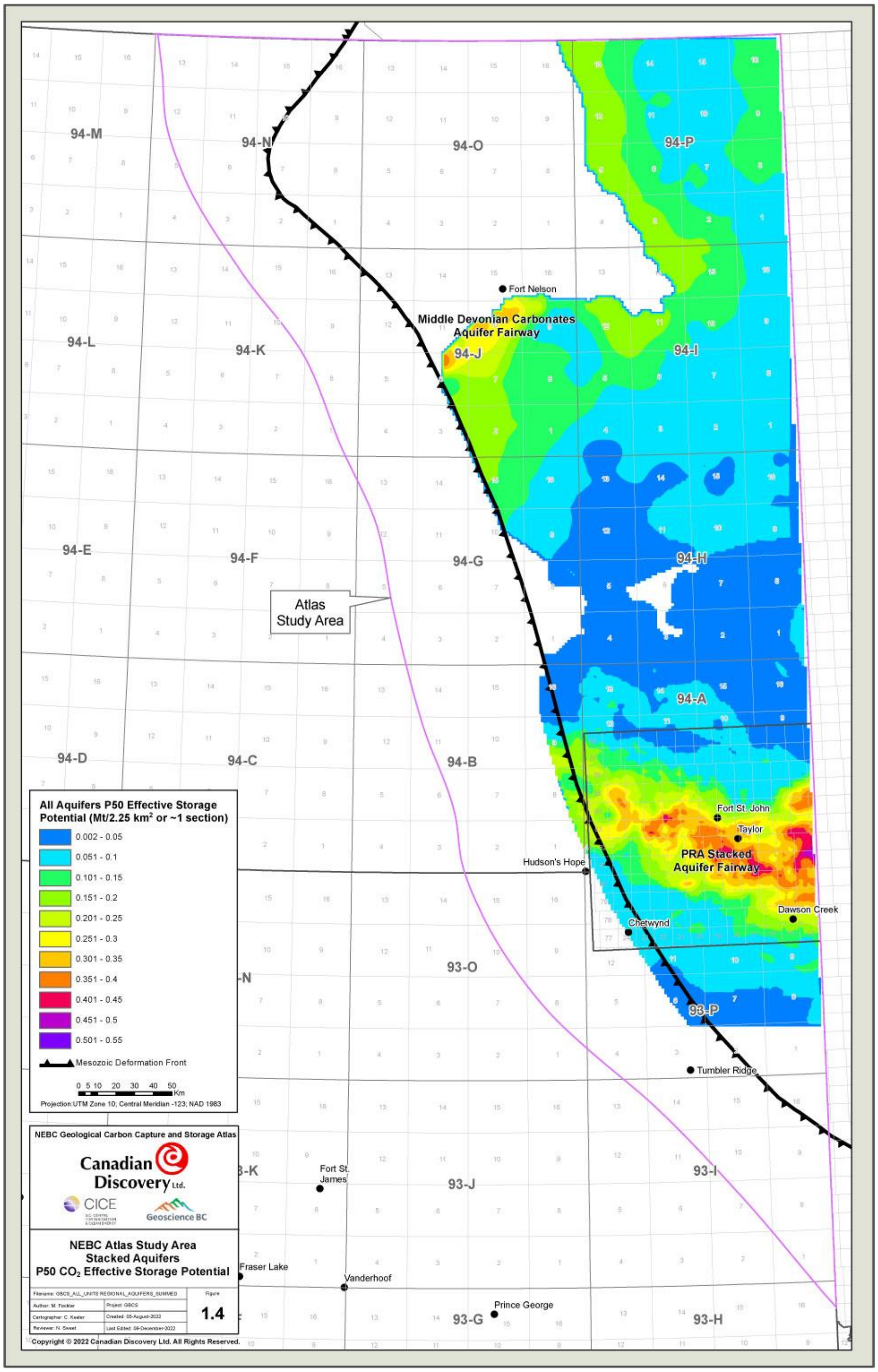


Figure 5. Total estimated P50 effective CO_2 storage potential combined (stacked) for all aquifers

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