Carbon Dioxide Storage Application Guide

VERSION 1.3: February 2024

About the Regulator

The British Columbia Energy Regulator (Regulator) oversees the full life cycle of energy resource activities in B.C., from site planning to restoration. The Regulator ensures activities are undertaken in a manner that protects public safety and the environment, supports reconciliation with Indigenous peoples, conserves energy resources and fosters a sound economy and social well-being. We work collaboratively across government and industry sharing policy and technical expertise in support of B.C.'s transition to low-carbon energy and helping meet future global energy needs.

Vision, Mission and Values

Vision

A resilient energy future where B.C.'s energy resource activities are safe, environmentally leading and socially responsible.

Mission

We regulate the life cycle of energy resource activities in B.C., from site planning to restoration, ensuring activities are undertaken in a manner that:

- Protects public safety and the environment
- Supports reconciliation with Indigenous peoples and the transition to low-carbon energy
- Conserves energy resources
- Fosters a sound economy and social well-being

Values

Respect is our commitment to listen, accept and value diverse perspectives.

Integrity is our commitment to the principles of fairness, trust and accountability.

Transparency is our commitment to be open and provide clear information on decisions, operations and actions.

Innovation is our commitment to learn, adapt, act and grow.

Responsiveness is our commitment to listening and timely and meaningful action.

Additional Guidance

As with all Regulator documents, this document does not take the place of applicable legislation. Readers are encouraged to become familiar with the acts and regulations and seek direction from Regulator staff for clarification.

The Regulator publishes both application and operations manuals and guides. The application manual provides guidance to applicants in preparing and applying for permits and the regulatory requirements in the planning and application stages. The operation manual details the reporting, compliance and regulatory obligations of the permit holder. Regulator manuals focus on requirements and processes associated with the Regulator's legislative authorities. Some activities may require additional requirements and approvals from other regulators or create obligations under other statutes. It is the applicant and permit holder's responsibility to know and uphold all legal obligations and responsibilities. For example, Federal Fisheries Act, Transportation Act, Highway Act, Workers Compensation Act and Wildlife Act.

Throughout the document there are references to guides, forms, tables and definitions to assist in creating and submitting all required information. Additional resources include:

- Glossary and acronym listing on the Regulator website.
- Documentation and guidelines on the Regulator website.
- Frequently asked questions on the Regulator website.
- Advisories, bulletins, reports and directives on the Regulator website.
- Regulations and Acts listed on the Regulator website.

In addition, this document may reference some application types and forms to be submitted outside of the Application Management System but made available on the Regulator's website. Application types and forms include:

- Heritage Conservation Act, Section 12
- Road use permits
- Water licences
- Master licence to cut
- Certificate of restoration
- Waste discharge permit
- Experimental scheme application
- Permit extension application

Manual Revisions

The Regulator is committed to the continuous improvement of its documentation. Revisions to the documentation are highlighted in this section and are posted to the Energy Professionals section of the Regulator's website. Stakeholders are invited to provide input or feedback on Regulator documentation to ServiceDesk@bc-er.ca or submit feedback using the feedback form.

Version Number	Posted Date	Effective Date	Chapter Section	Summary of Revision(s)
1.0	July 27, 2021	July 27, 2021	Various	This is a new document. Users are encouraged to review in full.
1.1	Aug. 17, 2022	Aug. 17, 2022	Pg.4	New updated contact info last paragraph
1.2	Dec. 05, 2023	Dec. 05, 2023	Various	Replace BCOGC with BCER; OGAA with ERAA; new logos, references and associations
1.3	Feb.08, 2024	Feb.08, 2024	Various	Specific provisions of the Energy Statutes Amendment Act (ERAA) expanded CCS responsibility to include all sources of CO_2. Previous responsibility was limited to emissions related to oil and gas activities.

Carbon Capture and Storage

Carbon capture and storage (CCS) is a recognized greenhouse gas emissions mitigation technology.

The British Columbia Energy Regulator (BCER) regulates CCS projects that store carbon dioxide (CO_2) in subsurface reservoirs, under the authority of the Energy Resource Activities Act (ERAA), for CO_2 for all sources. Carbon capture projects which do not result in subsurface storage, such as generating elemental carbon or introduction into above-surface mining tailings, are not regulated by the BCER.

Sources of CO_2 that may be suitable for CCS include, but are not limited to:

- flue or stack gas CO_2 generated from the combustion of fuel for power, process heat, or industrial process
- formation CO_2 which is a by-product of raw natural gas production, but does not contain H_2S*
- CO_2 generated as a by-product of a process such as hydrogen production
- direct air capture of CO_2

*for injection of combined CO_2 and H_2S, see Application-Guideline-for-Acid-Gas-Disposal-Well.pdf (bc-er.ca)
*a CCS CO2 stream may be injected utilizing a well also be used for acid gas disposal, with each stream metered prior to blending

CSA Standard Z741 defines CO_2 stream, in part, as a stream of carbon dioxide that has been captured from an emission source, that may include any incidental associated substances derived from the source materials or the capture process and any substances added to the stream to enable or improve the injection process and/or trace substances added to assist in CO_2 migration detection.

This guide provides a listing of information expected to be included in an application, addressing the use of wells and the storage reservoir for CCS service. The application must identify and address all risks, with the amount of detail commensurate with the complexity of the factors to be considered in the specific situation. A CCS project may consist of anywhere from a single injection well to multiple injection and observation wells, utilizing more than one reservoir.

A CCS Project application is made once well and reservoir data is available, following drilling and testing. An approval order, per section 75 (1) (c.1) of the Energy Resource Activity Act (ERAA), is required prior to operation, however limited test injection may occur prior to making an application to access the suitability of wells and reservoirs. Separate permit applications are required for wells, facilities, and pipelines associated with a CCS project, as specified in the Oil and Gas Activity Application Manual.

Proponents are encouraged to engage with the BCER early in the planning process. The BCER reviews and responds to “pre-application” submissions, containing incomplete information for a full application but sufficient to gauge the potential suitability of a reservoir and wells for CCS service. Note that pre-applications are a lower priority than complete applications for BCER review and response. Consultation with stakeholders, communities, and First Nations is an important aspect of project development.

A CCS project must store the injected CO_2 for geologic time. This requires impermeable strata bounding the porous storage reservoir to keep the fluid contained. Sedimentary formation reservoirs may be either saturated with saline water or depleted oil and gas pools, either of which have demonstrated fluid containment for millions of years. Such reservoirs have been successfully utilized for the disposal of oil and gas by-product produced water and acid gas. Solubility and eventual mineralization of the CO_2 are additional trapping mechanisms. Though not a regulatory requirement, CCS injection most commonly occurs in liquid or ‘dense phase’ conditions of pressure and temperature,

reducing the physical volume of the CO_2 to maximize the use of available storage space. This requires the storage formation be of sufficient depth/pressure to result in the fluid in a dense phase, at the start of injection or eventually as storage reservoir pressure increases.

Other CCS technologies include dissolving CO_2 into water at or near the surface before the injection of this increased density carbonated water into the subsurface. Such projects require an environmentally sustainable water source, corrosion resistant well construction, adequate reservoir storage size and the ability to demonstrate containment of injected CO_2 and water.

A subsurface storage of carbon dioxide project approval issued as a section 75 Special Project order under the *Energy Resource Activities Act* contains conditions for initial inspection, ongoing operation, monitoring, measurement, testing, and reporting.

Note also that Section 80 Storage Reservoirs in the Drilling and Production Regulation states:

> (3) *A well permit holder of a well that is part of a special project for carbon dioxide storage designated under section 75 of the Act must construct and operate the well in accordance with CSA Standard Z741.*

A specific concern to be addressed in the application is the program to mitigate risks from potential future wells drilling through or conducting hydraulic fracture stimulations in proximity to the storage reservoir, when accessing other resources.

A condition of a CCS Project order is the submission to the Regulator of Progress Reports at regular specified intervals. The content of the report will closely align those listed in the Acid Gas Disposal Progress Report Requirements document. The content required is adjusted to include information appropriate to the specific project. Progress Reports support MMV (monitoring, measurement & verification) success of the project. The applicant should consider including, in the application, a program for baseline testing of soils and aquifers over various seasons prior to the commencement of operation, for comparison values. This is especially relevant for CCS projects outside of the Western Canadian Sedimentary Basin, in areas where subsurface reservoirs are not as well studied. For example, a wider area baseline and monitoring data is appropriate in an area of limited knowledge of the extent of a top seal due to the lack of area drilling.

For further information on project applications and approval, please contact Reservoir@bc-er.ca.

CCS approval and operation requires control of tenure of the subsurface storage reservoir and formations in which any injection and observation wells are completed. Storage rights are held as either a petroleum and natural gas lease, or a storage reservoir licence, administered by the Titles section of the Ministry of Energy, Mines and Low Carbon Innovation. More information on tenure can be found here:
Guide_Subsurface Tenure Carbon Storage_Final_ Dec2022 (gov.bc.ca)

For guidance on government policy and regulatory developments related to CCS, as well as information on existing, and anticipated economic incentives aimed at promoting CCS deployment in the province, please contact the Ministry of Energy, Mines and Low Carbon Innovation.

An application for approval for Subsurface Storage of Carbon Dioxide, as a Special Project under Section 75 of the *Energy Resource Activities Act* should contain, when applicable, the information listed below. CCS proposals that

contain novel aspects should be discussed with the Regulator prior to making an application to ensure that the key principles of verifiable and secure storage, safety, and environmental protection are addressed.

Please Note:
All submissions made to the Regulator in support of an application or a regulatory requirement that include work relating to the practice of professional engineering or professional geoscience are expected to accord with the Professional Governance Act, [SBC 2018], c. 47 and the Bylaws of Engineers and Geoscientists British Columbia (EGBC). This includes any requirements relating to authentication of documents.

GENERAL INFORMATION

- ❒ Introduction, discussion, and justification for storage of carbon dioxide in the proposed reservoir using well(s), as expanded below.
- ❒ Well permit number(s), well name and location (surface and bottom, if different) of the proposed injection and monitoring wells. Indicate if the well is deviated or horizontal.
- ❒ A map illustrating tenure and registered owners, in the storage formation, within the proposed project area, and the surrounding areas that may be impacted.
- ❒ A map of the locations of surface rights owners within the project area and a 2-kilometre radius of the surface location of any injection well if that radius extends beyond the project area.

WELL CHRONOLOGY

- ❒ Chronological summary of well events of proposed injection wells including drilling, rig release, completion and activity history. Include any production and re-completion, logging or testing work to prepare the storage zone. Specify dates, durations, depths and outcomes as well as indicating which section of the application contains the test results. Table format preferable.
- ❒ Report of the existing and proposed injection-well completion, including; wellbore schematic, completion intervals, squeeze details, casing and tubing details and packer depth.
- ❒ A schematic of the proposed injection-well completion, including; existing and proposed completion intervals, squeeze details, casing and tubing details and packer depth.

CASING, CEMENTING AND HYDRAULIC ISOLATION

- ❒ A full-length casing inspection log, required for any existing well greater than 10 years old being converted for injection service. Include log interpretation. A recent log may be suitable if well has not undergone significant changes since conducted.
- ❒ Cement integrity/inspection logs (radial log displaying 3' amplitude, 5' VDL and cement map with non-pressure pass and pressure pass) – less than 10 years old.
- ❒ Evidence of hydraulic isolation of the storage zone, typically a temperature log following a fluid injection test. Alternatives may be proposed by operator. A Distributed Temperature Survey is preferred.
- ❒ Before injection operations begin, a pressure integrity test is required. This is standard pressure testing requirement when any completion or workover is conducted on a well. The casing or casing/tubing annulus must be pressure tested to a minimum pressure of 7,000 kPa for 10 minutes prior to the commencement

of injection operations. (See the Chapter 9 of the Oil and Gas Activity Operations Manual requirement for activating suspended wells and for suspending wells). A pressure test is considered successful if the pressure does not vary by more than three per cent during the test period. This pressure test is required before injection begins but is not the same requirement as the annual packer isolation test.

❒ Table of surface casing vent flow (SCVF) test history including test dates and results. Must have tested in past 12 months.

❒ Plan for annulus fluid maintenance, to ensure corrosion and frost protection.

❒ A map illustrating the status, completion zones for all wells within the project area, and within the impacted reservoir area, including at a minimum of 3 kilometers of injection wells. For abandoned wells, include abandonment date.

❒ A table listing wellbores within the project area, and within the impacted reservoir area, including at a minimum of 3 kilometers of injection wells km radius, or further if penetrating the same mapped pool proposed for storage containment, detailing casing age, OD, grade, weight, collapse and burst pressures. Order table by proximity to injection location. The maximum collapse strength of wellbores intersecting the storage formation in the area must be considered. Where storage will be into a depleted hydrocarbon pool, with CO_2 in a gas phase in the reservoir, the condition of all wells intersecting the pool must be considered for containment. Each well in the pool requires a review of cement coverage, cement depth, surface casing depth, surface casing vent flows test history, remedial cement squeeze records and anything else that may affect the integrity of offset wellbores. This report may assist in this review.

GEOLOGY

❒ A discussion of the relevant geology and rock properties of the reservoir formation. Include:

_____average porosity	_____permeability	_____water saturation
_____gas-oil contact	_____gas-water contact	_____oil-water contact

❒ Cross-sections, structural contour and isopach maps with details of top and base of pay and net pay.

❒ Reservoir Seals - A discussion of the reservoir bounding base and caprock, including; rock properties, continuity and thickness, evidence of fracturing and effective pool boundaries. Include caprock formation fracture pressure, if available.

❒ Aquifer details - stratigraphic traps, dip and strike and estimates of the volume and areal extent of the aquifer.

❒ Maps showing known, or postulated, faults within 20 km of the proposed injection location. Include 2 or 3-D seismic mapping, showing structures and faulting for the area.

❒ Any seismicity within a 20 km radius. Natural Resources Canada website is one source for this information.

❒ Discuss core sample and image log with respect to natural fractures.

RESERVOIR

❒ If depleted pool, include the producing history of the proposed injection well and other wells in pool. As well, address remaining reserves, economic factors and rationale for pool selection.

❒ Initial reservoir pressure, citing data source, dates and calculations to convert to depth of injection well.

❒ Proposed wellhead & bottom hole injection pressure, and formation fracture pressure (fracture closure pressure (FCP), or fracture parting pressure (FPP).

❒ A detailed report of one of the following:

- **(Preferred)** Mini-frac or DFIT stimulation of proposed well. Determine and interpret ISIP and fracture closure pressure. Calculation of maximum allowable wellhead injection pressure will include bottom hole fracture closure pressure (FCP), hydrostatic head, friction losses and a safety factor.
- Step-rate injectivity test performed to ascertain fracture parting pressure (FPP) of the formation. Must conform to test methods as outlined in AER Directive 65 Appendix O or SPE Paper 16798.

Data confirming the formation fracture gradient, from proximal analog wells, where available.

❒ Proposed well testing schedule to monitor reservoir pressure in the storage formation.

❒ Expected injectivity performance (rate and injection pressure) and life, based on maximum limiting average reservoir pressure value (120% of Pi) and available voidage capacity. Note that for a depleted pool, the maximum pressure limit is typically the pool discovery pressure, or less, depending in individual circumstances.

❒ Results of production testing for hydrocarbon potential in the proposed storage zone. The analysis of the native reservoir fluid, and typical and maximum compositions of the storage gas stream, including phase behavior for the expected range of pressures and temperatures.

❒ Reservoir plume model prediction indicating vertical and lateral extent of fluid contact, over intervals in time, when injection has ceases, and when stabilized.

❒ A plan for monitoring potential storage fluid migration to other formations, and near wells where feasible.

FACILITES AND MEASUREMENT

❒ Method/type/facility for metering of injection fluid.

❒ Method of continuous measurement and recording of wellhead injection and casing annulus pressures, and temperature of injected fluid at the wellhead. Include a plan for alarming the casing pressures. Tubing pressure must not exceed the Order and casing pressure variance must be closely monitored.

GROUNDWATER

❒ Base of groundwater depth, using the methodology outlined in INDB 2016-09 Technical Guidance for Determining the "Base of Usable Groundwater"

❒ Discussion of freshwater wells within the project area.

NOTE: Pro-active monitoring of penetrated shallow aquifers is recommended practice, though not required at present, and it is advisable to include a monitoring plan in the application.

EMERGENCY RESPONSE

❒ Estimated blowout release rates and temperatures – through tubing and casing

❒ A plan to ensure public safety including an emergency response plan (ERP) – a CO_2 well Emergency Planning Zone must be calculated at the maximum release rate assuming the maximum wellhead

release rate (AOF) at the maximum allowed reservoir storage pressure and the maximum expected CO_2 content.

LETTERS

- Written statements of no objection to the proposed project from all parties that may be affected, indicating their reaction to the proposed carbon dioxide storage project. Examples of such statements are provided here Consent to Inclusion in a Reservoir Project or here No Objection to Reservoir Project.

The application should be submitted to the Supervisor, Reservoir Engineering Branch, BC Energy Regulator, via email at Reservoir@bc-er.ca.

Notice of an application is posted on the Regulator's website for a 21-day period to solicit any potential technical objection. The applicant is responsible for providing a copy of the application, upon request, to third parties during the period of public notice. After the notice period ends, a copy of the application may be requested by the Regulator's Data Centre.