



CARBON CAPTURE & STORAGE

Summary Report of the
Regulatory Framework
Assessment

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TABLE OF CONTENTS

Letter from the Chair	6
Executive Summary.....	7
1 Introduction.....	10
2 Purpose of This Document.....	15
3 What is Carbon Capture and Storage?.....	20
4 The Importance of Carbon Capture and Storage to Alberta and Developments to Date	24
5 Public Safety	32
6 CO₂ Capture	33
7 CO₂ Transportation	37
7.1 Overview.....	37
7.2 Pipeline Technical Requirements.....	38
7.3 Pipeline Open Access	40
8 CO₂ Sequestration Project Lifecycle	45
9 Site Selection Period.....	46
9.1 Site Selection and Characterization	46
9.2 Sequestration Quality Pore Space Resource	49
10 Initial Application and Permitting Period.....	50
10.1 Overview	50
10.2 Regulatory Roles and Responsibilities	52
10.3 Tenure and Tenure Requirements	54
10.3.1 Pore Space Tenure: Process	54
10.3.2 Pore Space Competition and Access.....	64
10.4 Discretionary Activity Review and Potential Environmental Impact Assessment.....	77
10.5 Energy Resources Conservation Board (ERCB) Approvals.....	79
10.5.1 Stakeholder Engagement	79
10.5.2 Well Classification and CCS Schemes	82

11	Pre-injection Period	85
11.1	Overview	85
11.2	Pre-injection Monitoring, Measurement and Verification (MMV)	86
11.3	Injection Well Drilling, Completion and Testing	86
12	Injection Period.....	90
12.1	Overview	90
12.2	Monitoring, Measurement and Verification.....	91
12.3	Reporting	92
12.4	Post-closure Stewardship Fund and Financial Security.....	94
13	Closure Period.....	98
13.1	Overview	98
13.2	Entering the Closure Period.....	99
13.3	Closure Period Activities	101
13.4	Requirements for a Closure Certificate	102
14	Closure Point and the Post-Closure Period	106
14.1	Overview	106
14.2	Assumption of Liability	108
14.3	Allowable Uses of the Post-closure Stewardship Fund	110
14.4	Post-closure Monitoring and Remediation.....	111
15	Related Activities.....	112
16	Progress and the Path Forward	116

Appendix A. RFA Participants	A1
Appendix B. RFA Abbreviations	B1
Appendix C. RFA Glossary of Working Terms.....	C1
Appendix D. RFA Issue Recommendation Documents	D1
D1. Approvals, Permits and Regulatory Process	D2
D2. Closure and Transfer of Liability	D8
D3. CO ₂ Classification.....	D15
D4. CO ₂ Enhanced Oil Recovery and Acid Gas Disposal	D20
D5. CO ₂ Transportation and Composition.....	D25
D6. Competition with Other Resources	D29
D7. Environmental Assessments	D33
D8. Environmental Impacts, Mitigation and Remediation.....	D37
D9. Monitoring, Measurement and Verification.....	D43
D10. Pipeline Open Access	D49
D11. Pore Space Open Access	D55
D12. Post-closure Stewardship Fund and Financial Security.....	D60
D13. Public Engagement and Stakeholder Consultation.....	D68
D14. Public Safety.....	D73
D15. Risk Assessment	D76
D16. Site Closure	D79
D17. Site Selection.....	D82
D18. Surface Access.....	D85
D19. Surface Reclamation	D87
D20. Tenure Process	D89
D21. Well Construction	D91
Appendix E. Photo Credits.....	E1



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November 21, 2012

Honourable Mr. Ken Hughes

Minister of Energy
404 Legislature Building
Edmonton, Alberta T5K 2B7

Dear Minister Hughes:

The Steering Committee of the Carbon Capture and Storage (CCS) Regulatory Framework Assessment is pleased to present its final report to you. This report recommends regulatory changes related to the technical, environmental, safety, and monitoring requirements for the safe deployment of CCS as well as other actions to increase the body of knowledge on CCS-related topics.

The Regulatory Framework Assessment was initiated in March 2011 in response to Alberta's \$1.3 billion investment in two commercial-scale CCS projects in the province. These projects will provide a starting point for CCS in Alberta, and are a key part of the province's efforts to reduce greenhouse gas emissions. As well, projects of this scale will reaffirm Alberta's commitment to innovation and environmental sustainability.

This report is the result of a multi-stakeholder process, which included the steering committee, a panel of international experts and four specialized working groups. Each of these bodies had participants from around the world, including senior members of several Canadian provincial governments, the federal government, industry, academia, and non governmental organizations. The collaborative working environment fostered by the Assessment's process, combined with the breadth and depth of expertise of participants, has produced these comprehensive recommendations.

I would like to personally thank each contributor to the Assessment for their expertise and for their dedication to the process. I believe I can speak for all of the Assessment's participants in expressing that it has been both a pleasure and an honour to serve Albertans with our efforts. This report continues Alberta's success as a world leader in the development of this important technology to address climate change.

Yours truly,

A handwritten signature in blue ink that reads "W. Ellis".

Jim Ellis
Deputy Minister
Chair, Regulatory Framework Assessment Steering Committee

EXECUTIVE SUMMARY

Alberta is committed to addressing climate change by reducing greenhouse gas emissions such as carbon dioxide (CO₂). Carbon capture and storage (CCS) will be a fundamental piece of the equation. Alberta's Climate Change Strategy (2008) identifies CCS as a key mitigation technology, which will provide 70 percent of the province's targeted greenhouse gas emission reductions by 2050.¹

Carbon capture and storage is a process that captures CO₂ from large industrial CO₂ emitters and injects it deep underground for permanent storage. Carbon capture and storage is the internationally recognized terminology for this process. However, this report refers to CO₂ sequestration to differentiate this process from other temporary underground storage activities. CCS is a key technology to advance the responsible and sustainable development of Alberta's energy resources while addressing greenhouse gas emissions from large CO₂ sources.

The oil and gas industry, and electricity production are important contributors to the economy and quality of life in Alberta. However, these industries emit about 60 percent of Alberta's total CO₂ emissions. CCS is one of the few ways to substantially reduce CO₂ emissions from these industries while ensuring that the economic benefits they create for Albertans continue.

The Government of Alberta is taking action to deploy CCS and has committed over \$1.3 billion to two commercial-scale CCS projects in the province. These projects will reduce Alberta's greenhouse gas emissions by approximately 2.76 megatonnes (Mt, or million tonnes) per year by 2016. They will also provide momentum for reaching the province's long term greenhouse gas reduction targets. To address regulatory barriers to the deployment of CCS, several legislative changes have been made, including the clarification of pore space ownership and disposition, and a procedure to enable the transfer of long term liability for CO₂ sequestration sites from industry to the Government of Alberta.

In order to make sure that the right regulations are in place before full-scale CCS projects start operating, the Government of Alberta initiated a process called the Regulatory Framework Assessment (RFA) in March 2011. This process looked at the regulations that currently apply to CCS in Alberta as well as regulations and best practices in other parts of the world. It examined in detail the technical, environmental, safety, monitoring and closure requirements that apply to a CCS project. To ensure that the regulatory review was complete and balanced, many Canadian and international experts from industry, universities, research organizations, environmental groups and provincial and national governments participated. This multi-stakeholder process was guided by a steering committee and included an international expert panel, and four specialized working groups that examined various CCS-related issues in detail. The RFA concluded in December 2012.

The CCS RFA process resulted in 71 individual recommendations and 9 conclusions, which can be combined into 25 actionable items for the Government of Alberta to consider. These recommendations are summarized below by theme.

Applications, Approvals and Regulatory Framework

Issues and Gaps

- CCS, CO₂-Enhanced Oil Recovery (CO₂-EOR), and Acid Gas Disposal (AGD) projects share many similarities and may overlap, but are subject to different regulatory frameworks.
- The regulatory and approval processes for CCS need to be clearer and more efficient.
- CCS projects do not currently require an Environmental Impact Assessment (EIA).
- There are no industry-wide standards or limits on the level of impurities in CO₂ streams.
- CO₂ sequestration may impact or be impacted by the development of other resources.
- CCS expansion may result in a large number of pipelines and a shortage of sequestration sites.

Summary of Recommendations

- Clearly define how projects will be classified as CCS, CO₂-EOR or AGD, and the process for CO₂-EOR projects to become CCS projects. Evaluate if differences in the three regulatory frameworks are appropriate.
- Define the roles and responsibilities of each regulator of CCS operations and create clear industry guidance documents.
- Determine the conditions under which an EIA should be required, and make EIAs mandatory in the interim.
- Require monitoring, measurement and verification (MMV) plans and closure plans to accompany all CCS-related applications to the regulator and all tenure applications to the Department of Energy.
- Consider subsurface CO₂ injection applications on a case-by-case basis, and give the regulator flexibility to determine the activities a proponent must undertake before approval.
- Have the Crown Mineral Disposition Review Committee review all applications for CCS tenure to determine if surface restrictions are required to protect the environment.
- Evaluate all resource development applications on a case-by-case basis for their potential to impact other resources (including pore space), and inventory Alberta's pore space.
- Promote efficient and fair development of CCS by:
 - Encouraging CCS project proponents to work together,
 - Allowing proponents to apply for access to another operator's pipelines or sequestration site(s) if private negotiations have failed and established conditions have been met, and
 - Changing tenure agreements to enable tenure to be revoked if it remains unused.
- Require CCS projects to report any production or atmospheric release of CO₂ and reconcile earned emission credits.

Risk Assessment, Monitoring, and Technical Requirements

Issues and Gaps

- CO₂ sequestration projects are not explicitly required to submit risk assessments or monitor effects beyond the injection site.
- Alberta's current use of amines (and resulting impacts) are unknown, but would be increased by CCS.
- Current regulations do not include technical criteria for defining the capacity of a CO₂ sequestration site.
- Existing requirements for evaluating and addressing legacy wells may not be sufficient.

Summary of Recommendations

- Require MMV and closure plans to be based on a project-specific risk assessment, and include the use of best available technologies to monitor the atmosphere, surface, ground and surface water, and subsurface.

- Determine if Alberta should adopt all or part of the new CSA standard for geological storage of CO₂.
- Conduct research on Alberta's use of amines and their effects, and determine if further regulation of post-combustion capture technologies is needed.
- Require CO₂ sequestration sites to demonstrate sufficient capacity, injectivity, and containment parameters.
- Define the concentrations of other components at which an injection well will be classified as Class IIIa.
- Require Class IIIa well casing strings to be cemented from the well base to the surface, or equivalent.
- Evaluate if further research is needed on methods for detecting leaks from CO₂ pipelines.

Public Consultation and Notification, Surface Access, and Public Safety

Issues and Gaps

- Current public consultation and notification requirements were not designed specifically for CCS.
- It is unclear if CCS projects will require establishment of an emergency planning zone (EPZ).
- Existing legislation does not explicitly allow applications for surface access to conduct monitoring activities beyond the surface lease site or by the Government of Alberta after the transfer of liability.

Summary of Recommendations

- Review and update notification and consultation requirements to ensure that they are appropriate for CCS, including the requirement that everyone within the tenure boundary be informed about a CCS project.
- Develop requirements for EPZs around CCS project infrastructure.
- Improve public access to information on the regulatory process for CCS. Make pipeline integrity management plans available on request.
- Clarify that CCS operators (including the Government of Alberta after transfer of liability) can apply for access to conduct MMV or reclamation activities over the entire area of their carbon sequestration lease.

Site Closure and Long Term Liability

Issues and Gaps

- The Carbon Sequestration Tenure Regulation provides little detail on what a closure plan must contain.
- The *Mines and Minerals Act* does not specify what performance criteria must be met to receive a closure certificate.
- Assumed liabilities by the Government of Alberta do not include liability for CO₂ credits under climate change legislation.

Summary of Recommendations

- Clarify the process for closing a CO₂ sequestration site and the information that closure plans must contain.
- Establish performance criteria for closing a CO₂ sequestration site, including that the CO₂ is behaving as predicted, there are no significant risks to people or the environment, required closure activities have been carried out, and at least 10 years have passed since approval of the final closure plan.
- Transfer liability for CO₂ credits to the Crown when a closure certificate is issued.
- Set project-specific PCSF rates that cover the costs of long term monitoring and maintenance, CO₂ credits liability, and costs associated with unforeseen events. Pool PCSF payments to cover costs from any project.
- Require operators to post financial security to pay for site closure and reclamation if they become defunct.

1 INTRODUCTION

Carbon capture and storage (CCS) is a key technology to advance the responsible and sustainable development of Alberta's energy resources while addressing greenhouse gas emissions from large CO₂ sources. Alberta's Climate Change Strategy (2008)² identifies CCS as a key mitigation technology, which will provide 70 percent of the greenhouse gas emission reductions to meet the 2050 targets. For example, deployment of CCS will reduce emissions from oil sands development and electricity generated using the province's vast coal reserves. World consumers of fossil fuels are demanding greener energy production and emissions management, and CCS is a technology that will enable Alberta to continue to be a responsible and competitive producer of energy in a carbon-constrained future.

The Government of Alberta is taking action to deploy CCS and has committed over \$1.3 billion to two commercial-scale CCS projects in the province. These projects will reduce Alberta's greenhouse gas emissions by approximately 2.76 megatonnes (Mt, or million tonnes) per year by 2016, and will provide momentum for reaching the province's long term greenhouse gas reduction targets. To address regulatory barriers to the deployment of CCS, several legislative changes have been made including the clarification of pore space ownership and disposition, and a procedure to enable the transfer of long term liability for CO₂ sequestration sites from industry to the Government of Alberta.

2 Government of Alberta, *Alberta's 2008 Climate Change Strategy*, 2008.
Retrievable at: <http://environment.gov.ab.ca/info/library/7894.pdf>

To be sure that the regulations for the sequestration of carbon dioxide (CO₂) are comprehensive and transparent, the Government of Alberta initiated the Regulatory Framework Assessment (RFA) in March 2011. The RFA was a multi-stakeholder process that reviewed the technical, environmental, safety and monitoring requirements for CCS, and recommended regulatory changes to enable the deployment of CCS in a safe, responsible and efficient manner. Additionally, the RFA identified a number of issues related to CCS that were beyond the original scope of the review. In response, the RFA has made several recommendations identifying areas where additional review may be warranted. The RFA concluded in December 2012.

This multi-stakeholder process was guided by a steering committee and included an international expert panel, and four specialized working groups that examined various CCS-related issues in detail. The organizational structure of the RFA is illustrated in Figure 1.



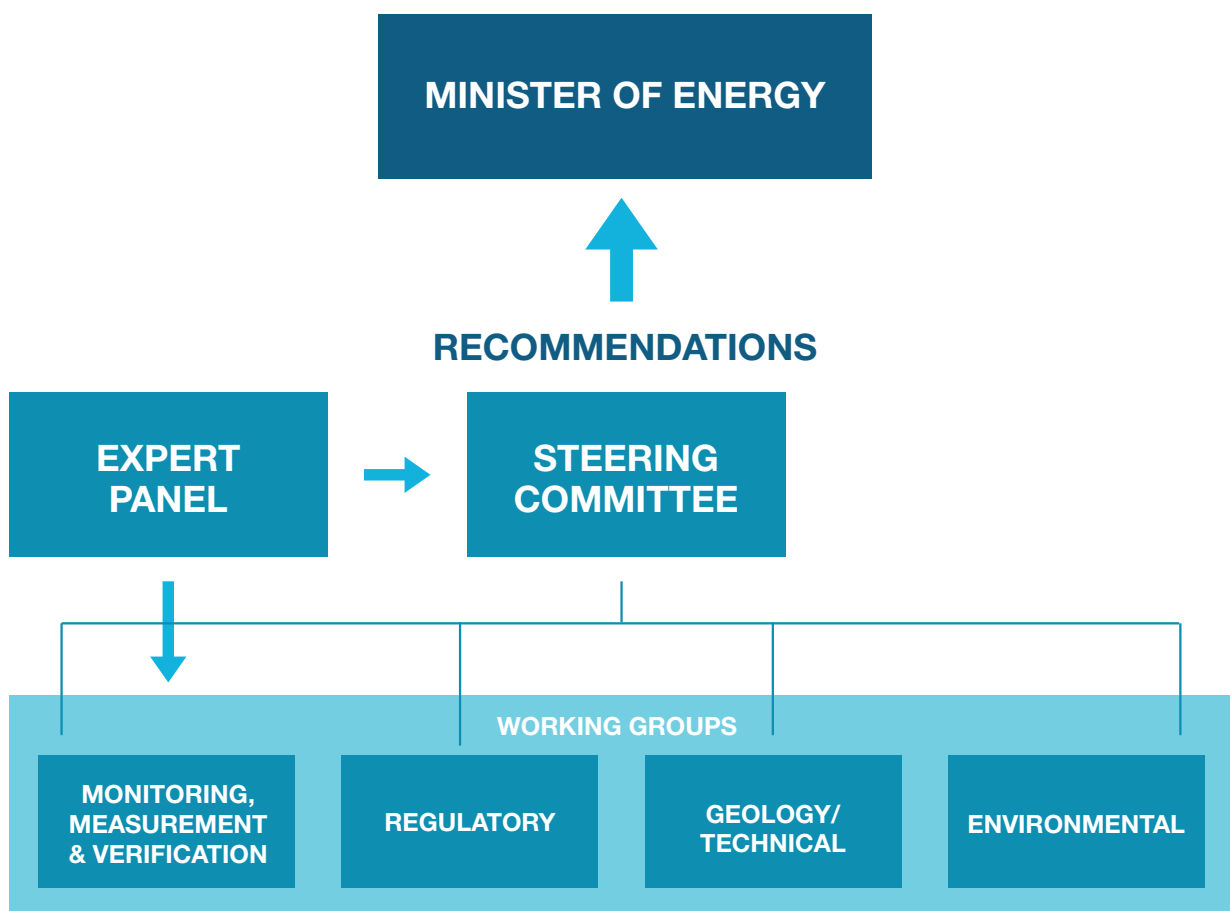


Figure 1. Organizational Chart of the Regulatory Framework Assessment

The steering committee included senior executive members from:

- Governments of Alberta, British Columbia and Saskatchewan
- Government of Canada
- industry leaders
- academic community
- non-governmental organizations.

The steering committee defined the scope of the assessment, guided and provided feedback to the working groups, consulted with the expert panel and approved working group recommendations to be provided to the Minister of Energy for consideration and decision.

The expert panel included internationally-recognized engineers and scientists in CCS and related fields from Australia, Canada, the United Kingdom and the United States. The expert panel was responsible for advising the steering committee and working groups on the scope and content of the review and the resulting recommendations.

The working groups included members from government, industry, academia, research community and non-governmental organizations. The working groups addressed issues related to the large scale deployment of CCS in Alberta. The primary role of the working groups was to review technical, environmental, safety and monitoring requirements for CCS in Alberta and to provide recommendations to address requirements for large scale CCS and opportunities for an effective regulatory framework. Working group members attempted to reach consensus; when consensus was not achieved, the non-consensus items were identified and are noted in this report.

Over the course of the RFA, guiding principles were identified for CCS to be deployed in a safe, responsible and efficient manner. These principles are:

- CCS activities must be conducted in a manner that ensures public safety.
- The regulatory framework must provide a high level of protection for the environment.
- Underground sources of potable water must be afforded a high level of protection within the regulatory framework.
- The long term liability for sequestered CO₂ must not become a financial burden to Albertans.
- Regulations must be robust, enable science-based assessment and adaptive management of CCS projects.
- The regulatory framework must be transparent and must be openly and clearly communicated to all stakeholders.
- The Government of Alberta and CCS project operators must make use of site-specific risk management for CCS activities.
- Subsurface resource development, including CO₂ sequestration, must consider potential resource interactions.
- The Government of Alberta must seek to gain and share knowledge internationally with regard to CCS.
- CCS expertise and analogous experience in the oil and gas industry must be leveraged to successfully deploy CCS.

These principles have guided the RFA recommendations for enhancing Alberta's regulatory framework for CCS. Implementation of these recommendations will result in a regulatory framework that is consistent with the standards Albertans expect; namely, a regulatory framework that is comprehensive, transparent, ensures public safety and environmental sustainability.



2 PURPOSE OF THIS DOCUMENT

This report is a summary of the analysis and the recommendations of the RFA. The recommendations roughly follow the sequential order of the regulatory process for CCS activities. The order is described in the following sections:

- CO₂ capture
- CO₂ transportation
- the lifecycle of a CO₂ sequestration project.

This report assumes familiarity with CCS and is intended for those with a specific interest in policy development and/or the regulatory framework for CCS. The Government of Alberta recognizes the important role stakeholders and the public play as CCS is deployed in the province. To increase public awareness of CCS, the Government of Alberta undertook a public education and outreach campaign in 2011. The campaign provided information about CCS to the public via newspaper inserts, a website (www.SolutionsStartHere.ca), and television commercials. This website provides information of general interest on CCS and the Government of Alberta's CCS development program.

The recommendations and conclusions in the main body of this report have been modified to improve readability and to increase consistency in wording across recommendations and conclusions. These modifications do not change the intended meaning of the recommendations and conclusions. For this reason it is important for the reader to refer to the issue-specific recommendations located in Appendix D for the original text approved by the steering committee. Appendix D also contains important additional background on the recommendations. Table 1 provides a list of the report recommendations, the related topics and the corresponding location in the report and appendix.

Table 1. List of Recommendations and Conclusions

Issue	Topic	Location in Report: Recommendation/ [conclusion] number (page number)	Appendix number, Recommendation number
Approvals, Permits and Regulatory Process	Roles and Responsibilities	#18 (pg. 52)	D1, #1
	MMV and Closure Plan	#23 (pg. 57)	D1, #2
	Guidance Document	#19 (pg. 53)	D1, #3
	Scheme Approach	#46 (pg. 83)	D1, #4
	Regulatory Alignment	#70 (pg. 115)	D1, #5
	CCS Research Activities	#22 (pg. 56)	D1, #6
	CO ₂ Accounting	#52 (pg. 93)	D1, #7
Closure and Transfer of Liability	Closure Process Outline	#58 (pg. 99)	D2, #1
	Closure Plan Requirements	#30 (pg. 63)	D2, #2
	Closure Plan Requirements	#29 (pg. 62)	D2, #3
	Closure Period	#60 (pg. 100)	D2, #4
	Minimum Closure Period	#62 (pg. 103)	D2, #5
	Final Closure/MMV Report	#64 (pg. 105)	D2, #6
	Data Management	#51 (pg. 93)	D2, #7
	Climate Liability	#65 (pg. 109)	D2, #8
CO₂ Classification	CO ₂ Classification	[3] (pg. 38)	D3, #1
CO₂ Enhanced Oil Recovery and Acid Gas Disposal	Definition	#68 (pg. 114)	D4, #1
	Regulatory Differences	#69 (pg. 114)	D4, #2
	CO ₂ -EOR Transition to CCS	#71 (pg. 115)	D4, #3
CO₂ Transportation and Composition	CO ₂ Pipelines Non-routine	[1] (pg. 38)	D5, #1
	CSA Standard	[2] (pg. 38)	D5, #2
	CO ₂ Stream Composition	#6 (pg. 39)	D5, #3
	CO ₂ Leak Detection	#8 (pg. 40)	D5, #4
	Pipeline Integrity Management	#7 (pg. 40)	D5, #5

Table 1. Continued

Issue	Topic	Location in Report: Recommendation/ [conclusion] number (page number)	Appendix number, Recommendation number
Competition with Other Resources	Pore Space Inventory	#16 (pg. 49)	D6, #1
	Pore Space Inventory	#17 (pg. 49)	D6, #2
	Subsurface Resource Interaction	#32 (pg. 66)	D6, #3
	Stacking and Joint Utilization	#33 (pg. 69)	D6, #4
Environmental Assessments	Environmental Impact Assessments	#41 (pg. 78)	D7, #1
Environmental Impacts, Mitigation and Remediation	Shallow Groundwater Monitoring	#28 (pg. 61)	D8, #1
	Amines	#5 (pg. 36)	D8, #2
	Post-combustion CO ₂ Capture	#4 (pg. 35)	D8, #3
Monitoring, Measurement and Verification	Performance Criteria for Closure	#63 (pg. 104)	D9, #1
	MMV Plans	#26 (pg. 60)	D9, #2
	MMV Plans	#27 (pg. 60)	D9, #3
	MMV Reporting	#50 (pg. 92)	D9, #4
Pipeline Open Access	Market Considerations	#9 (pg. 41)	D10, #1
	Common Carrier System	#10 (pg. 41)	D10, #2
	CO ₂ Capture Facility Approval	#2 (pg. 33)	D10, #3
	Common Carrier Considerations	#13 (pg. 43)	D10, #4
	Open Season	#11 (pg. 42)	D10, #5
	Shared Transportation Infrastructure	#12 (pg. 43)	D10, #6
	Regional Planning	#14 (pg. 44)	D10, #7

Table 1. Continued

Issue	Topic	Location in Report: Recommendation/ [conclusion] number (page number)	Appendix number, Recommendation number
Pore Space Open Access	Market Considerations	#34 (pg. 70)	D11, #1
	Collaboration	#31 (pg. 64)	D11, #2
	Tenure	#35 (pg. 71)	D11, #3
	Third Party Access Criteria	#36 (pg. 73)	D11, #4
	Compensation	#37 (pg. 74)	D11, #5
	Liability	#38 (pg. 75)	D11, #6
	Site Transfer	#39 (pg. 76)	D11, #7
	Tenure Term	#40 (pg. 76)	D11, #8
	Pore Space Availability	#3 (pg. 33)	D11, #9
Post-closure Stewardship Fund and Financial Security	Financial Security	#56 (pg. 96)	D12, #1
	PCSF Rate	#53 (pg. 94)	D12, #2
	PCSF Rate	#54 (pg. 95)	D12, #3
	Allowable Uses	[9] (pg. 110)	D12, #4
	Allowable Uses	#66 (pg. 110)	D12, #5
	Pooling	#55 (pg. 95)	D12, #6
	Future PCSF Review	#57 (pg. 97)	D12, #7
Public Engagement and Stakeholder Consultation	Review of Requirements	#42 (pg. 80)	D13, #1
	Information Sharing	#43 (pg. 81)	D13, #2
	Public Information Documents	#44 (pg. 81)	D13, #3
Public Safety	Emergency Planning Zones	#1 (pg. 32)	D14, #1
Risk Assessment	Requirement	#24 (pg. 58)	D15, #1
	Guidelines	#25 (pg. 59)	D15, #2
	CSA Standard	#47 (pg. 84)	D15, #3

Table 1. Continued

Issue	Topic	Location in Report: Recommendation/ [conclusion] number (page number)	Appendix number, Recommendation number
Site Closure	Well Abandonment	[8] (pg. 105)	D16, #1
	Closure Plan Content	#59 (pg. 100)	D16, #2
Site Selection	Criteria	#15 (pg. 48)	D17, #1
Surface Access	MMV Activities	#49 (pg. 91)	D18, #1
	Post-closure MMV Activities	#67 (pg. 111)	D18, #2
	Pre-tenure	[4] (pg. 47)	D18, #3
Surface Reclamation	Surface Reclamation	[7] (pg. 102)	D19, #19
Tenure Process	Information Sharing	#21 (pg. 55)	D20, #1
	Tenure Review	#20 (pg. 54)	D20, #2
Well Construction	Well Classification	#45 (pg. 82)	D21, #1
	Well Completion	#48 (pg. 88)	D21, #2
	Well Completion	[5] (pg. 89)	D21, #3
	Well Completion	[6] (pg. 89)	D21, #4
	Well Abandonment	#61 (pg. 101)	D21, #5

3 WHAT IS CARBON CAPTURE AND STORAGE?

CCS is an integrated activity that includes the capture, compression, transportation, injection, and geological sequestration of anthropogenic carbon dioxide (CO_2) from large industrial sources (see Figure 2). The objective of CCS is to mitigate global climate change by reducing the amount of industrial CO_2 emissions entering the atmosphere. Although CCS is a relatively new activity, there are several integrated CCS projects operating globally. Furthermore, in Alberta, there exists significant expertise in all of the individual elements that constitute CCS (e.g. capture, transportation and injection). The recovery and processing of resources have provided Albertans with the experience and the technical capability to accomplish CCS in a safe and responsible manner.

Carbon capture and storage is the internationally recognized terminology for this process. However, this report refers to CO_2 sequestration to differentiate this process from other temporary underground storage activities.

Table 2 describes the different elements of a CCS project and examples of how they compare to other activities in Alberta.



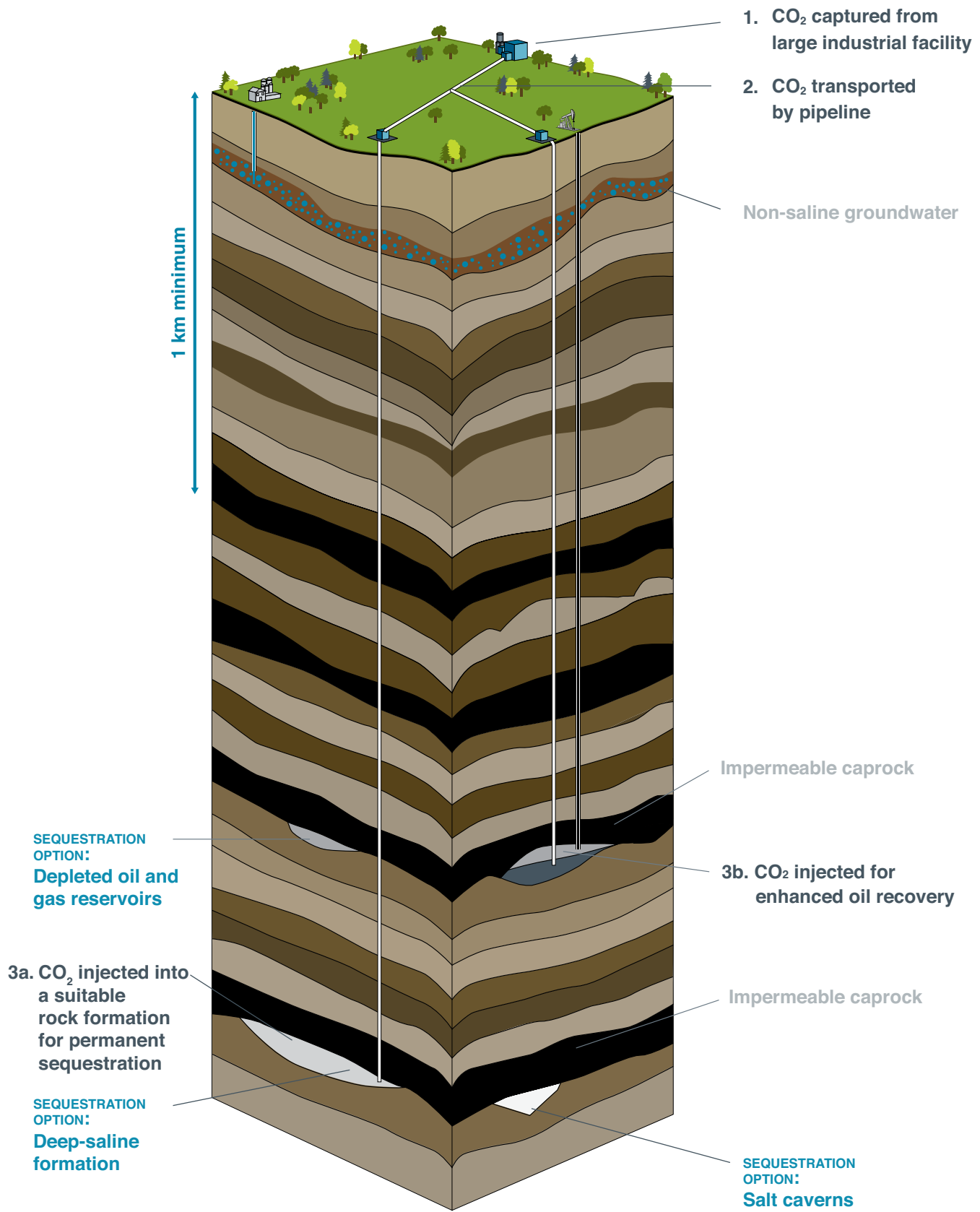


Figure 2. Carbon Capture and Storage as an Integrated Activity

Table 2. Elements of CCS and Similarities to Comparable Activities in Alberta

Carbon Capture and Storage

CCS involves the separation of CO₂ from gas streams at large stationary anthropogenic sources of emissions. Typical sources of CO₂ for CCS include fossil-fuel power plants, ethanol plants, fertilizer plants, upgraders and refineries, and cement and steel plants.

The captured CO₂ stream is compressed to enable efficient transportation typically by pipeline. Rail or truck transportation could be used for smaller volumes.

CO₂ is injected into a deep well to the target geological formation.

CO₂ sequestration occurs in a sequestration complex containing multiple geological formations with impermeable seals (caprocks). CO₂ is held in the pore spaces present in the sequestration formation, and seals will ensure that the CO₂ stays permanently in place. Sequestration formations include saline formations, depleted oil and natural gas reservoirs, and unmineable coal seams. Alberta legislation requires that sequestration must take place at a depth of more than 1000 metres below the surface.

After CO₂ has been injected into the sequestration formation, it is monitored to ensure it is contained and is behaving as expected. All CCS projects in Alberta must develop a detailed monitoring, measurement and verification (MMV) plan to ensure that the project is meeting requirements.

Analog to Other Activities in Alberta

CAPTURE

CO₂ capture uses similar techniques such as separating CO₂ and hydrogen sulfide (H₂S) from sour natural gas at a gas processing plant.

TRANSPORT

Alberta has a vast network of pipelines. Similar to other commodities, CO₂ pipelines must meet design, construction and operation standards. Pipelines and gathering fields in Alberta use pump and compressor stations to move a variety of fluids.

INJECTION WELLS

Alberta's oil and gas sector has extensive experience with wells for multiple applications, including injection wells. Drilling and completion of a well for CO₂ injection is similar to the well construction practices used for conventional resource developments.

SEQUESTRATION

Alberta's oil and natural gas resources were formed and have been held underground by geological seals for millions of years. The same type of geology that has resulted in the province's rich oil and gas reserves also makes the province suitable for CCS. Exploration and production of oil and natural gas has also provided industry and government with knowledge of the subsurface geology of the province. This knowledge will enable the most suitable sites to be chosen for CO₂ sequestration.

MONITORING

Techniques used to monitor oil and natural gas production and to explore for new reserves can also be used to monitor CO₂ sequestration sites. In addition, techniques already used to monitor water, soil and air quality can be employed to assure there are no adverse effects to the environment as a result of CCS projects.



4 THE IMPORTANCE OF CARBON CAPTURE AND STORAGE TO ALBERTA AND DEVELOPMENTS TO DATE

To prevent adverse changes to the climate, significant reductions in CO₂ emissions are required to stabilize greenhouse gas concentrations in the atmosphere. The International Energy Agency believes that a portfolio of mitigation technologies will be needed to achieve this stabilization, and attributes one-fifth of the total projected global greenhouse gas emissions reduction through 2050 to the large scale deployment of CCS.³

In Alberta, the Alberta Sedimentary Basin⁴ provides many suitable sites for CO₂ sequestration as shown in Figure 3. CO₂ can be sequestered in several types of geological formations including deep saline formations, depleted oil and gas reservoirs and unmineable coal seams. The North American Carbon Storage Atlas⁵ provides a midrange estimate of CO₂ sequestration potential of at least 46 gigatonnes (billion tonnes) in Alberta. Within this report, sequestration quality pore space refers to subsurface pore space that meets injectivity, capacity and containment criteria for CO₂ sequestration activities.

The Government of Alberta's Climate Change Strategy estimates that by 2050 the rate of CO₂ sequestration will have to be 139 megatonnes of CO₂ per year to meet the 2050 targets. At that rate, Alberta will have approximately 330 years of sequestration capacity.⁶ These estimates demonstrate why CCS can provide such a significant contribution to Alberta's Climate Change Strategy.

3 International Energy Agency, *Energy Technology Perspectives*, 2012.

4 What is commonly referred to as the Western Canadian Sedimentary Basin comprises the Alberta Basin (in Alberta and Northeastern British Columbia) and the Williston Basin (in Saskatchewan and Manitoba). These basins are geologically different.

5 Retrieval at http://www.netl.doe.gov/technologies/carbon_seq/refshelf/NACSA2012.pdf

6 This is based on a mid-range estimate of total sequestration capacity.

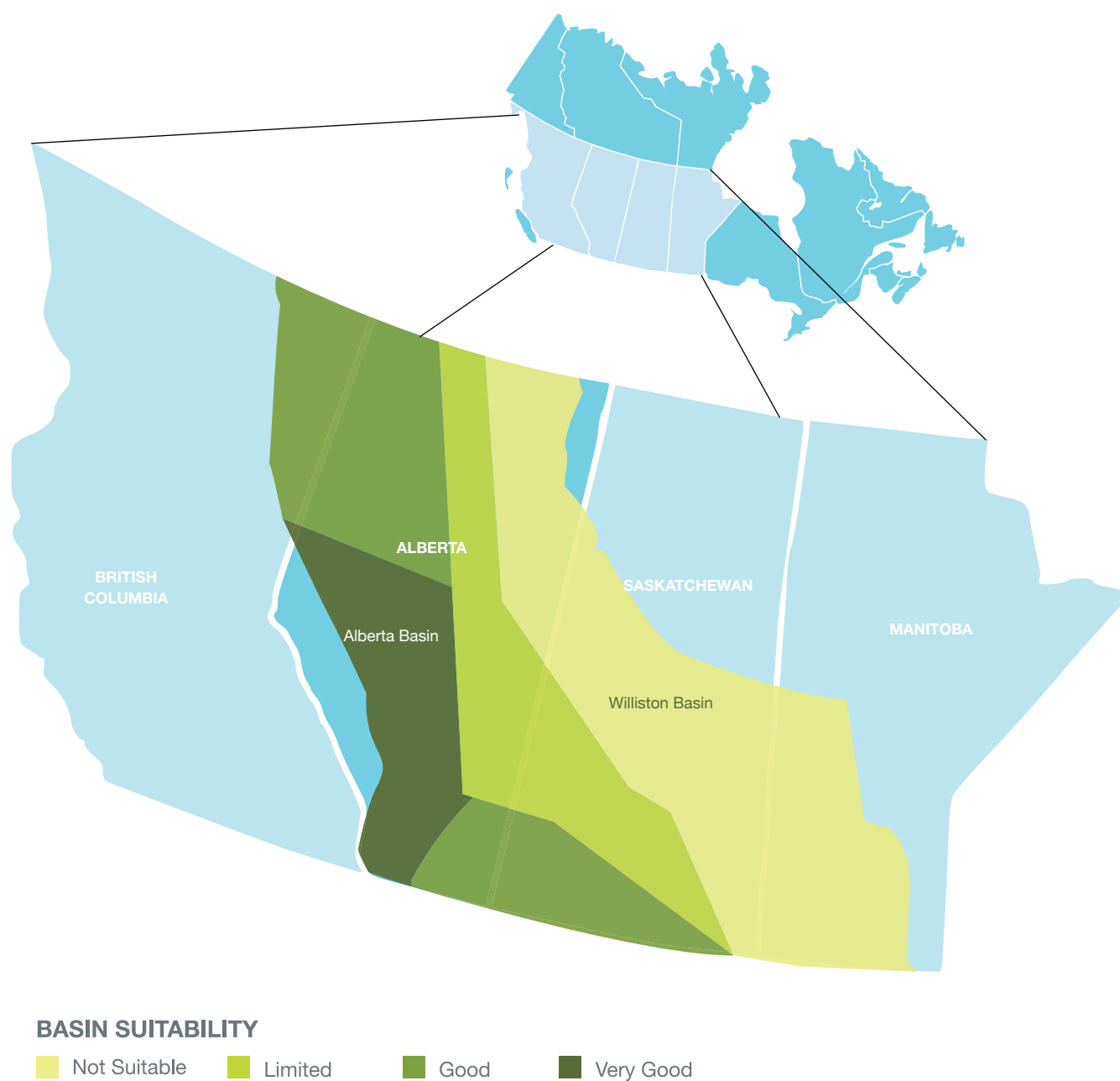


Figure 3. CO₂ Sequestration Suitability in the Western Canadian Sedimentary Basin⁷

⁷ Adapted from: Bachu, S. and S. Stewart, 2002, Geological sequestration of anthropogenic carbon dioxide in the Western Canada Sedimentary Basin, *Journal of Canadian Petroleum Technology*, 41(2).



CCS is a key technology to advance responsible and sustainable development of Alberta's energy resources while addressing greenhouse gas emissions. CCS is an important part of Alberta's greenhouse gas emissions mitigation portfolio because Alberta's emissions profile consists primarily of large point source industrial emitters, including coal-fired power plants and oil and gas facilities. As shown in Figure 4 below, approximately two-thirds of Alberta's anthropogenic greenhouse gas emissions originate from large industrial sectors that are potential candidates for application of commercial-scale CCS.

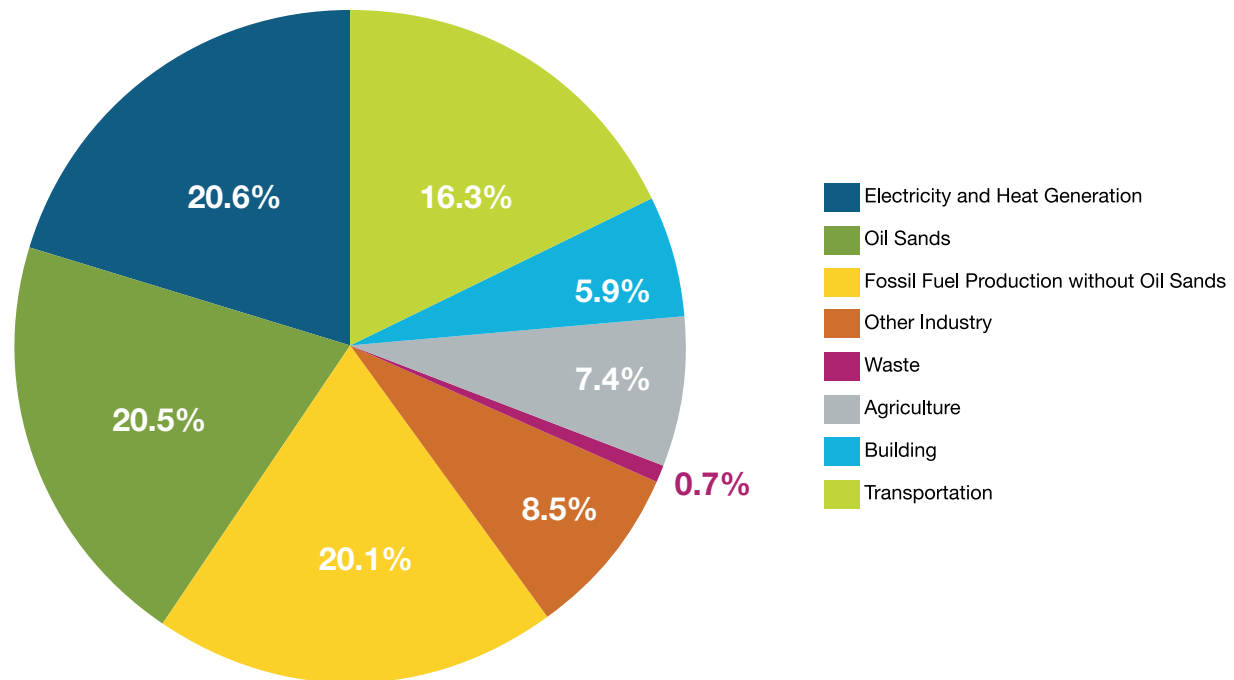


Figure 4. Contribution of 2010 Alberta Greenhouse Gas Emissions by Sector⁸

In 2008, the ecoENERGY Carbon Capture and Storage Task Force provided a final report⁹ to the Government of Alberta and the Government of Canada and identified the need for public funding for the first CCS projects, regulatory clarity, and a collaborative advisory group.

⁸ Government of Canada, *National Inventory Report 1990-2010: Greenhouse gas sources and sinks in Canada*, 2012.
⁹ Canada's Fossil Energy Future: The Way Forward on Carbon Capture and Storage, 2008.

To respond to the recommendations from the Task Force, the Government of Alberta formed the Alberta Carbon Capture and Storage Development Council. In 2009, the Development Council released a report, *Accelerating Carbon Capture and Storage Implementation in Alberta*.¹⁰ This report provides a blueprint for successfully achieving widespread adoption of CCS in Alberta, and includes policy, regulatory and technology recommendations. The key recommendations coming out of the report include:

- Financial investment from federal and provincial governments and the use of CO₂ for enhanced oil recovery (CO₂-EOR) are necessary to offset the financial disadvantages of CCS.
- Funding and policy mechanisms should be put in place to promote large scale deployment of CCS.
- The ownership of pore space and long term storage liability should be clarified by the Government of Alberta.

The report also notes that CCS will have a positive impact on the Alberta economy as it enables the continued development of the province's conventional oil reserves by using captured CO₂ for CO₂-EOR. For example, the incremental oil produced from injecting CO₂ into oil reservoirs could translate to an additional \$105 billion of revenue over the life of the development. This revenue, and the associated royalties and taxes would benefit all Albertans. Revenues generated from CO₂-EOR will also help offset the initially high capital costs of CCS, as well as promote the development of infrastructure necessary for large scale CCS deployment. Experience gained from CO₂-EOR activities will also enhance existing knowledge of geological sequestration of CO₂.

Developing CCS technology represents a way to extract the economic benefits of Alberta's petroleum resources, including oil sands, while maintaining strong environmental objectives. Deployment of CCS will also enable Alberta to produce cleaner electricity from hydrocarbon resources, including continued development of the province's coal reserves. This will ensure a diversified portfolio of power generation technologies for a reliable supply of electricity for Albertans.

In response to the Task Force and Development Council recommendations, and to enable the development of large scale CCS projects, the Government of Alberta made several key regulatory changes. The *Carbon Capture and Storage Funding Act* was passed in 2009 to encourage and expedite the design, construction and operation of CCS projects in Alberta. Under this Act, the Government of Alberta has committed over \$1.3 billion to two CCS projects, which are expected to reduce Alberta's greenhouse gas emissions by approximately 2.76 megatonnes per year by 2016. These projects include:

- The Alberta Carbon Trunk Line – a 240 kilometre pipeline that will transport CO₂ from an existing fertilizer plant and an oil sands refinery to CO₂-EOR projects in central Alberta.
- Quest – an integrated CCS project that will capture CO₂ from an existing oil sands upgrader, and transport it by pipeline for sequestration underground in a deep saline formation.

10 Government of Alberta, *Accelerating Carbon Capture and Storage Implementation in Alberta*, 2009. Retrievable at: http://www.energy.gov.ab.ca/Org/pdfs/CCS_Implementation.pdf



The Government of Alberta also recognized the Task Force and Development Council's recommendation regarding regulatory and policy barriers facing the deployment of commercial-scale CCS and has implemented legislation to address these issues. The *Carbon Capture and Storage Statutes Amendment Act, 2010* updated several key pieces of legislation and was essential to enable the Government of Alberta to proceed with the two funded projects. This Act:

- Clarifies that all pore space is owned by the province, except pore space under federally owned land.
- Enables the Minister of Energy to enter into agreements to grant pore space rights.
- Allows the province to accept long term liability for sequestered CO₂.
- Creates the Post-closure Stewardship Fund (PCSF) to ensure that money is available when the province assumes liability for a CCS site.

Prior to passage of the *Carbon Capture and Storage Statutes Amendment Act, 2010*, the Energy Resources Conservation Board (ERCB) was already designated as the provincial regulator for permitting CCS operations in Alberta. The ERCB is an independent quasi-judicial agency of the Government of Alberta which regulates the province's energy resources. Section 39 of the *Oil and Gas Conservation Act* requires ERCB approval for the storage or disposal of any substances to an underground formation through a well.

The RFA made recommendations relevant to current government agencies and governance structures, including the ERCB and Alberta Environment and Sustainable Resource Development. However, in November 2012, the Alberta Legislature passed the *Responsible Energy Development Act*, which creates a single regulator for all oil, gas, oil sands, coal, and CCS projects in the province. The Energy Resources Conservation Board (ERCB) was the regulator when the RFA was developing this report. As this report is being released at the time when the ERCB transitions to the new Alberta Energy Regulator, references to the regulator throughout the report will refer to the Alberta Energy Regulator when the transition is finalized. References to ERCB directives have been left in this report.

To support the *Carbon Capture and Storage Statutes Amendment Act, 2010* the Carbon Sequestration Tenure Regulation was passed in April 2011. The regulation addresses four main aspects of tenure for CCS, including:

- Allowing operators to acquire a permit for the evaluation of a potential storage site to investigate the geology and determine the suitability of the site for CO₂ sequestration.
- Allowing operators to obtain leases for large scale CO₂ sequestration at suitable storage sites.
- Specifying what criteria must be included in MMV and closure plans in order to gain Ministerial approval.
- Stipulating that pore space tenure can only be granted at depths greater than 1000 metres.

In addition to these legislative changes, the RFA addressed a number of remaining regulatory issues and identified opportunities for improving the regulatory framework. These recommendations and other conclusions are highlighted in the blue boxes throughout this report. The rest of the report is organized as follows:

- Section 5 outlines the review undertaken by the RFA regarding potential public safety impacts from CCS projects.
- Sections 6 through 14 describe the regulatory process for CCS activities and offer recommendations for opportunities to improve Alberta's regulatory framework for CCS.
- Section 15 includes recommendations related to CO₂ enhanced oil recovery and acid gas disposal.
- Section 16 concludes the report.



5 PUBLIC SAFETY

Public safety is the primary concern in the regulation of upstream oil and gas developments, which include CCS activities. A review of the scientific literature was conducted to ensure potential impacts to public safety from a CCS project are fully addressed in Alberta's regulatory framework. This review identified hazards and analyzed potential acute health impacts on the public from an accidental release of CO₂, and associated impurities, during transportation and injection. While hazards and potential impacts are project-specific, the information contained in the literature review could provide further insight into how public safety can be addressed for large scale CCS projects.

To address potential incidents that could present hazards to the public and the environment, oil and gas licensees in Alberta must ensure that they are fully prepared to respond to any level of emergency as required by ERCB Directive 071.¹¹ Directive 071 outlines the requirements for a corporate-level emergency response plan (ERP) and stipulates that these plans must have preplanned procedures that will aid in effective response to an emergency. An ERP for a CCS project does not currently require approval from the regulator. However, the regulator may review the ERP upon request.

An emergency planning zone (EPZ) is a geographical area surrounding a well, pipeline or facility containing a hazardous product that requires specific emergency response planning by the licensee. The licensee is required to carry out notification and education for the public who live within the EPZ. Directive 071 requires an EPZ to be calculated if the operation contains or produces either one of the two identified hazardous substances – H₂S or high vapour pressure hydrocarbons. While corporate ERPs are required for CCS projects, currently EPZs may not be required if CO₂ streams have a H₂S content below the amount specified in ERCB Directive 071.

To ensure public safety and build confidence, a conservative and precautionary approach should be taken to include the development of EPZ requirements for CCS. The information, science and modelling that are used to inform emergency response and planning measures should be specific to the properties of CO₂ to ensure public safety. Based on the review of potential hazards of an accidental release during transportation and injection, and the requirements for emergency preparedness in Alberta, the steering committee recommends that:

RECOMMENDATION 1

The regulator should develop emergency planning zone requirements specific to CCS project infrastructure as part of ongoing efforts to ensure adequate emergency response and planning.¹²

¹¹ Energy Resources Conservation Board, Directive 071: Emergency Preparedness and Response Requirements for the Petroleum Industry, 2008.
¹² Refer to Appendix D14.

6 CO₂ CAPTURE

CO₂ capture for CCS focuses on separation of CO₂ from gas streams at large anthropogenic sources of emissions. Examples of capture sources include electricity generators, upgraders, cement plants, ethanol plants, fertilizer plants and oil refineries. In Alberta, these types of operations are primarily overseen by the Energy Resources Conservation Board (ERCB), Alberta Utilities Commission (AUC), and Alberta Environment and Sustainable Resource Development.

Alberta's Climate Change Strategy forecasts that CCS will account for 139 megatonnes of CO₂ reductions per year by 2050. Assuming that an average facility captures one to two megatonnes annually, this level of CO₂ reduction could result in 80 to 100 commercial-scale capture facilities. Therefore, it is important that appropriate planning is carried out to ensure that there is adequate transportation infrastructure and opportunity for CO₂ sequestration or utilization. As a result, the steering committee recommends that:

RECOMMENDATION 2

When applying for regulatory approval of a new CO₂ capture facility, the proponent should be required to demonstrate that it has, or can reasonably obtain, access to both a CO₂ sequestration site, including CO₂ enhanced oil recovery fields, and pipeline capacity to transport CO₂ to that site.¹³

Presently, greenhouse gas emissions are managed in Alberta through the *Climate Change and Emissions Management Act*. If the Government of Alberta considers new policies that will significantly increase the amount of captured CO₂, it is important to give adequate consideration to operators' ability to suitably dispose of captured CO₂. Therefore, the steering committee recommends that:

RECOMMENDATION 3

The availability and capacity of sequestration sites (or markets for captured CO₂) should be one of the factors considered if the Government of Alberta contemplates setting regulations that mandate carbon capture operations.¹⁴

¹³ Refer to Appendix D10.

¹⁴ Refer to Appendix D11.

The working groups also reviewed CO₂ capture technologies to determine potential environmental impacts that could result from large scale operation of CO₂ capture facilities. As Alberta moves toward large scale deployment of CCS, liquid-solvent-based CO₂ capture systems will likely be the primary technology for capture.

Post-combustion capture involves removing CO₂ from a flue gas stream after a fuel has been combusted with air. This type of process can be retrofitted onto existing facilities such as coal-fired power plants. Figure 5 shows an example of post-combustion capture applied to a power plant. Instead of flowing directly up the flue stack and into the atmosphere, a slip-stream of the flue gas is cooled and then treated to separate the CO₂ at an adjoining capture plant. Currently, the most common way to separate the CO₂ is to bring it into contact with a liquid solvent, such as an amine or ammonia. The CO₂ binds to the solvent, thereby removing it from the other gases in the flue gas stream. Other gases (mostly nitrogen (N₂) and water vapour (H₂O)) are then returned to the flue stack. The solvent is then heated to release the CO₂ in a process called regeneration, and is then reused. The CO₂ stream released from the solvent undergoes further processing and is compressed to pipeline pressure specifications and/or requirements.

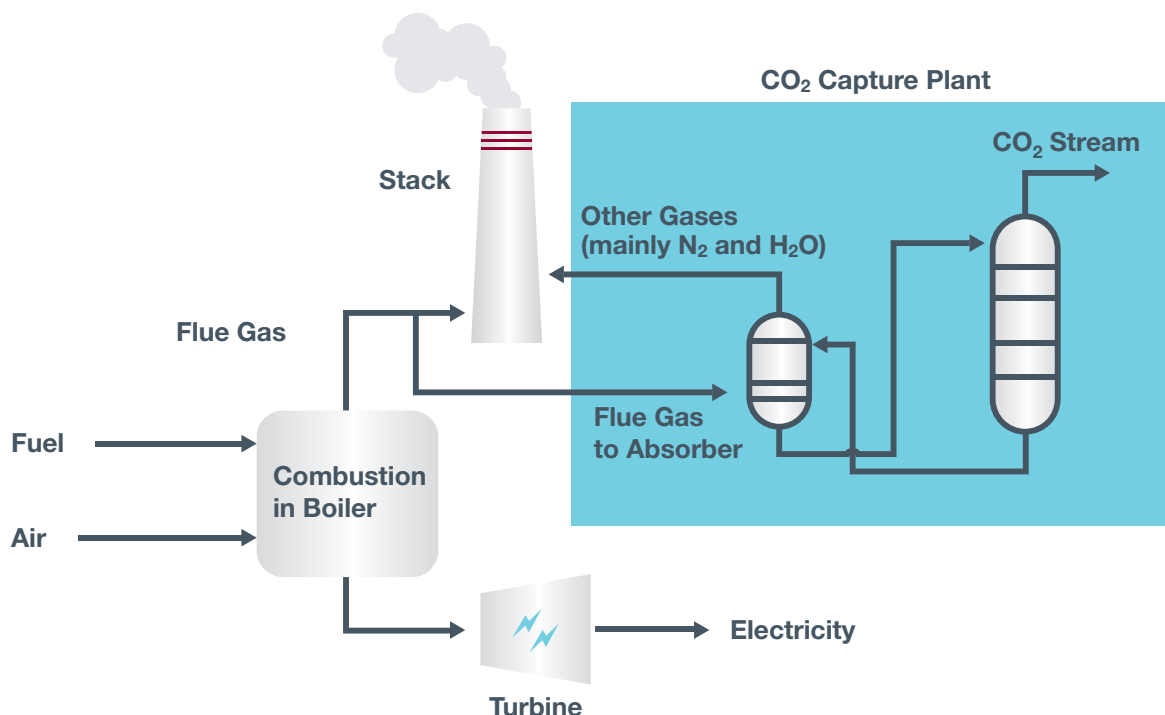


Figure 5. Schematic Representation of Post-combustion Capture Applied to a Power Plant

Amines have been used industrially to remove CO₂ and other components such as H₂S from gas streams for more than 70 years, for example from natural gas as is shown in Figure 6. Whether the process is cleaning natural gas or capturing CO₂ in a post-combustion system, a very small percentage of amine remains in the treated gas stream leaving the absorber. In natural gas processes the cleaned gas is handled in a closed system until it is used. The difference with post-combustion capture systems is that the treated gas stream is returned to the flue stack. This presents a potential increase in the amount of amines or associated degradation products released to the environment; however the concentrations of amines in the stack exhaust would be very low.

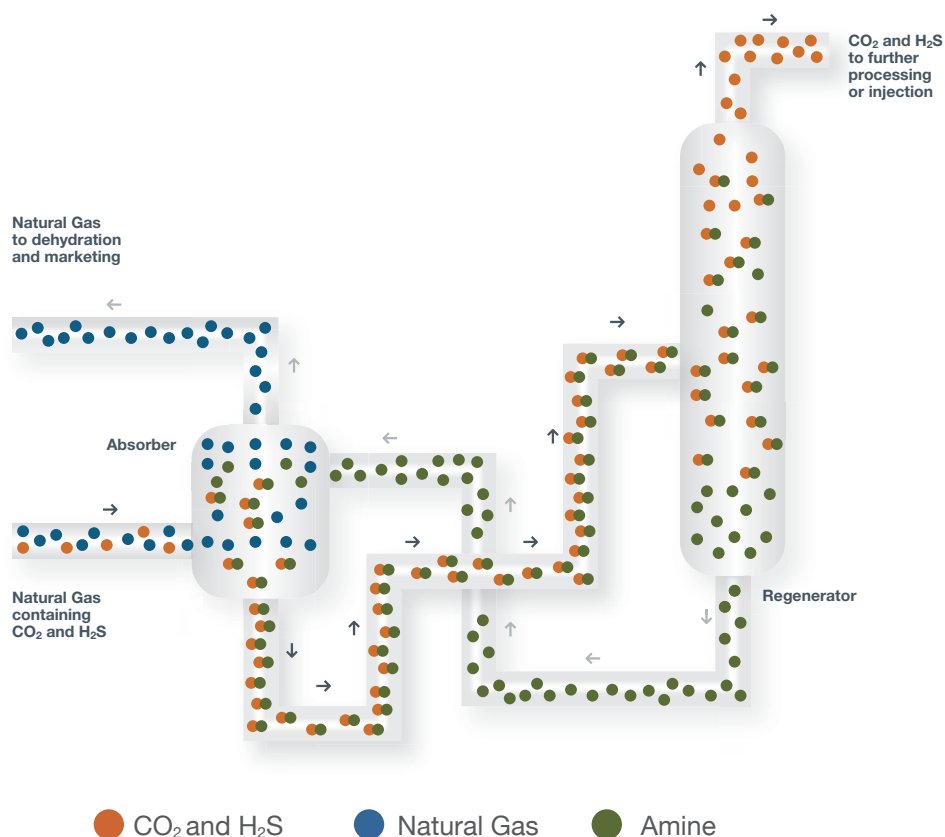


Figure 6. Schematic Representation of Natural Gas Sweetening by Removing CO₂ and H₂S

While there are alternative technologies for separating CO₂ which may become widely used in the future (e.g. zeolites and membranes), liquid-based technologies that use amines or ammonia will be the dominant process used by CCS projects in Alberta in the near future. Regarding ammonia, Alberta has established an Ambient Air Quality Objective of two parts per million that is based on low odour thresholds and the Air Monitoring Directive¹⁵ specifies the manner in which an owner/operator must monitor and report ammonia emissions. Based on these requirements, the steering committee agreed that the current legal and regulatory framework in Alberta regarding the use of ammonia for CCS projects is adequate. However, as noted earlier, the use of amines for CCS could potentially increase the quantity of amine released into the environment. Also, there may be novel amines introduced to the environment whose potential health and environmental effects are poorly understood. Research is being undertaken worldwide to better understand the potential impacts of these solvents and emerging technologies. Therefore, the steering committee recommends that:

RECOMMENDATION 4

The Government of Alberta should determine whether further regulation of the use of post-combustion CO₂ capture technologies is warranted. To achieve this, the Government of Alberta should join international efforts to fill important knowledge gaps relating to the use of post-combustion CO₂ capture technologies for CCS projects, such as amine usage, so that an understanding of their potential environmental impacts can be attained.¹⁶

¹⁵ Alberta Environment, Air Monitoring Directive, 1989.

¹⁶ Refer to Appendix D8.



Amines have been used in Alberta for many years. However, there are concerns regarding the potential release of amines and their degradation products, and the potential health and environmental impact they could have. It was found that little information is available regarding the quantity of amines that are used in the province. As a result, understanding the relative proportion of amine use stemming from anticipated CO₂ capture operations is difficult. Therefore, the steering committee recommends that:

RECOMMENDATION 5

The Government of Alberta should assess the volumes of amines used for CO₂ capture in Alberta to provide context for the relative scope and scale of amine use for CCS projects.¹⁷

7 CO₂ TRANSPORTATION

7.1 OVERVIEW

Alberta has excellent geology for CCS in the Alberta Basin with a significant number of suitable sequestration sites. It will be necessary to transport CO₂ to these sequestration sites from the large and numerous point sources of CO₂. Given the quantities of CO₂ needed to be sequestered to meet Alberta's Climate Change Strategy targets, transportation will likely be by pipeline. CO₂ pipelines are not new in North America. There are about 6,500 kilometres of CO₂ pipelines in the United States, transporting CO₂ for enhanced oil recovery projects.¹⁸



7.2 PIPELINE TECHNICAL REQUIREMENTS

In Alberta, CO₂ pipelines are regulated by the ERCB under the *Pipeline Act*. Pipelines that cross provincial or national borders are regulated by the National Energy Board.¹⁹ Regulatory requirements for CO₂ pipelines generally cover important design elements such as: size, materials selection, design pressure, resistance to degradation, protection from damage, appropriate monitoring facilities, safety systems and siting considerations.

Under ERCB Directive 056,²⁰ an application for a CO₂ pipeline is considered non-routine. Such a designation triggers an in-depth review of the application. The review also considers the anticipated concentrations of impurities in the CO₂ stream, and limits may be placed on impurities based on project-specific criteria. As CO₂ pipelines for CCS become more common in Alberta, it may be possible to consider CO₂ pipeline applications routine at some point in the future. Until that time, the steering committee concludes that:

CONCLUSION 1

It is appropriate for licence applications for all CO₂ pipelines (for the purposes of CCS) to be treated as non-routine.²¹

The Pipeline Regulation contains the technical requirements for pipelines in Alberta, including those recommended in the latest published edition of several Canadian Standards Association (CSA) standards, particularly CSA Z662.²² This detailed and descriptive standard allows for engineering judgment to address site-specific issues and incorporate improvements to materials and design techniques. Even though CSA Z662 is intended to apply to CO₂ pipelines used in CO₂-EOR schemes, the existing requirements and standards adequately address CO₂ pipeline design, operation and maintenance for large scale CCS projects. To ensure that the most up-to-date standard is used to evaluate future applications for CO₂ pipelines in Alberta, the steering committee concludes that:

CONCLUSION 2

It is appropriate for the regulator to reference the most recent Canadian Standards Association Standard Z662: Oil and Gas Pipeline Systems.²³

Currently there is no single, definitive classification for CO₂ in Alberta and in Canada. How CO₂ is classified depends on how it is produced, its concentration, what it is used for and what legislation it falls under. When transporting CO₂ by pipeline, the *Pipeline Act* would apply. Currently the *Pipeline Act* has no explicit classification for CO₂, although it would fall under the definition of a gas. The steering committee does not believe that the lack of a single classification will have a negative impact on CCS deployment or public safety in Alberta. As a result, the steering committee concludes that:

CONCLUSION 3

There is no need to change how CO₂ is currently classified in Alberta.²⁴

¹⁹ The recommendations in this document do not apply to the National Energy Board.

²⁰ Energy Resources Conservation Board, Directive 056: Energy Development Applications and Schedule, 2011.

²¹ Refer to Appendix D5.

²² Canadian Standards Association, Z662: *Oil and Gas Pipeline Systems*, 6th Edition, 2011.

²³ Refer to Appendix D5.

²⁴ CO₂ classification was also reviewed for the capture and sequestration components, and similarly it was concluded that there is no need to change how CO₂ is currently classified in Alberta. Refer to Appendix D3.

The working groups reviewed purity requirements for CO₂ pipelines for CCS. It was found that the composition of the CO₂ stream and the associated impacts to phase behaviour, water solubility, toxicity and corrosivity must be understood in order for CCS projects to be designed to minimize the risks to public safety and the environment. The composition of the CO₂ stream is affected by many factors, including feedstock composition, capture technologies and operating conditions. However, it is difficult to set an industry-wide standard or limit for any impurity. This could be due to the lack of available data on the interactions of multiple impurities and other interrelated variables that affect stream composition.

Although there are no prescribed limits for impurities in CO₂ streams used for CCS, the existing regulatory framework considers impurities when designing and operating the different components of a CCS project. Materials and operating parameters are selected according to the anticipated stream characteristics. Currently, acid gas projects need to consider impurities in their design and are evaluated on a case-by-case basis. This includes compositions that may have impacts on public safety and confidence. However, the total percentage of impurities in a CO₂ stream would likely not exceed 10 percent.

In cases when a new stream with a different composition is introduced to an existing CO₂ pipeline, pipeline operators and CO₂ stream suppliers would monitor the stream composition in order to determine if the stream meets the pipeline specifications and approval conditions. Additionally, re-evaluation may be necessary if there are changes to the stream composition that could negatively impact infrastructure and/or public safety. Individual impurities have very different effects on the behaviour of the CO₂ stream and their concentrations are what drive design considerations, not solely the concentration of CO₂.

In Alberta, CO₂ stream composition is not specified in the current regulatory regime for CCS. It is addressed as an inherent issue during the specification and design of CO₂ pipelines and is reviewed in the approvals process. In regard to CO₂ stream composition, the steering committee recommends that:

RECOMMENDATION 6

The composition of the CO₂ stream should continue to be tracked over time and evaluated by the regulator on a case-by-case basis to ensure that the physical and chemical properties conform to the design capabilities of the infrastructure used to capture, transport and inject the CO₂ stream. Any composition standards or specifications that may arise from subsequent regulatory reviews should be based on the concentrations of impurities that might be present in the stream. The stream should be predominantly CO₂ in order to satisfy the intended purpose of using the stream for CCS.²⁵

In addition to pipeline design and operation, pipeline integrity is addressed in Alberta's regulatory requirements. A pipeline licensee is required to develop and implement a pipeline integrity management program, to ensure that pipelines are capable of transporting product safely. The steering committee recognized that Albertans may wish to have access to these plans; therefore, the steering committee recommends that:

RECOMMENDATION 7

Pipeline integrity management programs for CO₂ pipelines, as required under Energy Resources Conservation Board Directive 077: Pipelines – Requirements and Reference Tools, should be made available by CO₂ pipeline operators to the public on request.²⁶

Monitoring pipelines is an operational requirement in Alberta, regulated by the ERCB. There are methods in place to detect leaks from pipelines such as operational monitoring, site inspections, infrared cameras, flyovers, the addition of odorants, as well as leak detection and repair programs. Although Alberta has experience with CO₂ pipelines, the volume of CO₂ being transported will increase with widespread deployment of CCS. Because there may be monitoring methods specific to CO₂ pipelines that would benefit the operational, public safety and public confidence aspects of leak detection, the steering committee recommends that:

RECOMMENDATION 8

The Government of Alberta should investigate the possibility of conducting research and/or experiments on leak detection methods for CO₂ pipelines.²⁷

7.3 PIPELINE OPEN ACCESS

As the number of commercial CCS operations increases, the demand for access to CO₂ transportation will rise. As a result, the number of CO₂ pipelines in the province is expected to increase. To promote an economically-efficient pipeline system, ensuring reasonable access to sequestration opportunities, and minimizing the environmental impact of the pipeline system, the working groups considered recommending policy or regulatory drivers to incent or compel third party access to pipelines.

²⁶ Refer to Appendix D5.

²⁷ Refer to Appendix D5.

In general, upstream pipelines are not subject to any form of economic regulation other than general competition law. In this market-based system, parties construct their own facilities or obtain access to other parties' facilities through private negotiations. The working groups found that market principles should be the primary driver for CO₂ pipeline development, as they currently are in the oil and gas industry in Alberta. As a result, the steering committee recommends that:

RECOMMENDATION 9

Market considerations should be the primary driver behind access to CO₂ pipelines. In this regard, pipeline operators and third parties should be expected to explore all reasonable avenues of private negotiation before applying to the regulator for access.²⁸

Alberta does not currently have any existing regulatory requirements for third party access to CO₂ pipelines. The system used for upstream oil and gas pipelines is the common carrier order. However, Sections 48, 49 and 55 of the *Oil and Gas Conservation Act* do not include CO₂ pipelines in the common carrier system.

The common carrier order is available to parties when private negotiations for pipeline access break down. When this system is employed, a party desiring access to another party's pipeline can apply to the regulator to request a common carrier order. In general, the applicant must demonstrate:

- The need for access (i.e. producible reserves and a reasonable expectation of a market).
- That the pipeline operator is acting unreasonably in negotiations.
- That the pipeline is:
 - the only economically feasible way or the most practical way to transport the product or
 - clearly superior environmentally.

If the regulator designates a pipeline as a common carrier, then the pipeline owner must provide non-discriminatory access to the pipeline. The regulator can also direct the proportion of production to be taken by the common carrier from each producer using the pipeline to make capacity available for a new party. This concept is referred to by the working groups as prorationing. If the parties cannot agree on the tariff to be paid for use of the pipeline once a common carrier order is in place, either party can apply to the Alberta Utilities Commission to set the tariff.

In the analysis of this issue the working groups recognized that, even though pipeline operators are expected to negotiate in good faith and provide access to pipelines in a non-discriminatory manner, private negotiation will not always lead to satisfactory results. It is also important to have a method to prevent a pipeline operator from controlling access to the transportation network or imposing unreasonable conditions as a result of market position. A process is needed whereby parties can apply to the regulator for access to a CO₂ pipeline. Therefore, the steering committee recommends that:

RECOMMENDATION 10

The common carrier system should be expanded to apply to all CO₂ pipelines.²⁹

²⁸ Refer to Appendix D10.

²⁹ Refer to Appendix D10.



It is important that careful planning on pipelines takes place so that new capture operators' access to CO₂ pipelines does not affect the transportation capacity for existing users. Recommendation 2 was provided to ensure that new capture facilities applying for approval demonstrate appropriate access to transportation. Planning can also be addressed in the development of a new pipeline. One such way to do this is to hold an open season, a process whereby a proponent planning a new pipeline provides or posts information on the project and allows potential shippers to submit capacity requests. This process can help to ensure that the pipeline is correctly sized to meet regional needs and therefore help reduce the likelihood of applications for common carrier orders. An open season will help achieve efficient development of CCS infrastructure, resulting in reduced costs, increased deployment of CCS, reduced environmental impact of CO₂ transportation, and increased safety and support to the development of CO₂-EOR markets. Furthermore, it will help protect pipeline operators against future access claims by ensuring that proponents take reasonable steps to assess demand for pipeline access. Therefore, the steering committee recommends that:

RECOMMENDATION 11

Pipeline operators should undertake some form of open season, where the operator seeks interest from other parties desiring access to the pipeline.

The open season should be evaluated by the regulator when reviewing applications for common carrier orders. This evaluation should include examining:

- a) The adequacy of the open season conducted when hearing arguments why the order should not be granted.
- b) Whether or not the third party engaged with the pipeline operator during the open season when hearing the third party's reasons why the order should be granted.³⁰

In order to minimize the incremental environmental footprint and reduce industry costs, CO₂ sequestration operations should be encouraged to share transportation infrastructure whenever reasonable and feasible to do so. This is particularly true for operations that are stacked (vertically overlaid).³¹ Consistent with current ERCB policies, the steering committee recommends that:

RECOMMENDATION 12

All CO₂ sequestration operations should be encouraged to use shared transportation infrastructure whenever feasible and reasonable.³²

In a review of open access requirements for CO₂ pipelines, significant attention was paid to the issue of prorationing. Prorationing impacts oil and gas producers, but to a lesser extent than it would be expected to impact a CO₂ capture facility and/or sequestration operator. If an oil or gas producer's access to a pipeline is reduced, the product remains in the ground waiting to be produced and would still be brought to market at a later time. For CO₂ capture facilities, reduced access to a pipeline would mean that the capture facility would vent a portion of the captured CO₂, with multiple environmental and financial consequences. As a result, the operator's emissions would likely increase, leading them to be in contravention of their emissions reduction requirements. In addition, the operator's per tonne abatement costs would increase because capital and operating costs would not change, but the amount of CO₂ sequestered (and subsequent credits or CO₂ enhanced oil recovery sales) would decrease. Although prorationing could have significant consequences for capture facility operators, it should be an option for the common carrier system to be effective. When hearing a common carrier application for a CO₂ pipeline and considering prorationing, the regulator should carefully consider all factors to decide if it is appropriate to prorate existing users of the pipeline. In most cases it would likely be appropriate to prorate new users for the excess capacity before prorationing existing ones.

Recognizing the consequences that the risk of prorationing can have for capture and/or sequestration operators, the working groups developed a list of considerations to ensure that prorationing is used as an option of last resort. The considerations also suggest that the regulator gives adequate attention to the impacts of prorationing. The requirements necessary for the applicant to show that a common carrier designation is appropriate would be relatively difficult to demonstrate, particularly if the pipeline is already full. Prorationing could have significant consequences for capture facility and/or sequestration operators, but prorationing should be an option for the common carrier system to be effective. Therefore, the steering committee recommends that:

RECOMMENDATION 13

When hearing an application for a common carrier order, the regulator should consider the multiple impacts and implications of making a common carrier declaration on a case-by-case basis. This includes, but is not limited to, the impact on companies that would be affected by the decision, the effect on CCS/CO₂ system dynamics and the historical operating context of the pipeline. Common carrier orders, and more specifically the application of prorationing within a common carrier order, should be the option of last resort.³³

31 Refer to the discussion on pore space competition and access in Section 10.3.2.

32 Refer to Appendix D10

33 Refer to Appendix D10 for further information and a non-consensus viewpoint.



The Government of Alberta has expended significant effort developing regional plans under the Land Use Framework to address the unique aspects and needs of each region in the province. These regional plans will provide context to help make decisions to better balance conservation and development of Alberta's land and natural resources. The Government of Alberta takes a role in the planning of some types of pipelines (e.g. water) and should consider whether or not there is a need for similar involvement in CO₂ pipeline planning. The steering committee recommends that:

RECOMMENDATION 14

The Government of Alberta should consider taking a larger role in the regional planning of CO₂ pipeline infrastructure, particularly if there is government funding involved. This will help to ensure that infrastructure development meets the goals of the region and the needs of CCS deployment in Alberta.³⁴

8 CO₂ SEQUESTRATION PROJECT LIFECYCLE

The Regulatory Framework Assessment focused on CO₂ sequestration activities. The lifecycle of a sequestration project includes the following periods (as shown in Figure 7):

- Site selection and characterization period
- Initial application and permitting period
- Pre-injection period
- Injection period
- Closure period
- Closure point
- Post-closure period

The following sections provide a brief overview of each period and background information on the associated regulatory process. Each period is described in more detail in Sections 9 through 14 and associated recommendations are presented.

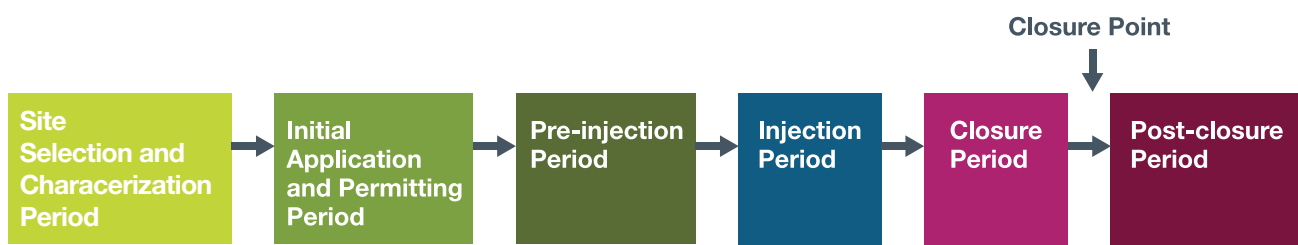


Figure 7. Periods of a CO₂ Sequestration Project

9 SITE SELECTION PERIOD

9.1 SITE SELECTION AND CHARACTERIZATION

For CO₂ sequestration to contribute to mitigating climate change, long term isolation of the injected CO₂ from the atmosphere must be ensured. A well-chosen sequestration site safeguards against future loss of containment. Sites that will provide safe and secure long term sequestration are selected based on a number of criteria. For a CO₂ geological sequestration site to be technically feasible, three major parameters are considered to be essential:

- The sequestration complex must have sufficient capacity to sequester all the volume of CO₂ requested in any application for geological sequestration.
- Injection zones in the sequestration complex must have sufficient injectivity to sequester CO₂ at the required rate (i.e. at the rate supplied by the capture facility).
- The sequestration complex must have adequate seals to contain all injected and displaced fluids.



In order to choose sites that best meet the parameters above, proponents will review existing data from oil and gas exploration and production activities and may gather new data. The data compiled for site selection may form part of the baseline data set in the monitoring, measurement and verification (MMV) plan that will be developed for the project. The working groups reviewed the process for obtaining access to land in order to collect data for site selection. Prior to issuing an evaluation permit, this process requires coming to an agreement with the land owner through direct negotiation similar to oil and gas activities. The steering committee concludes that:

CONCLUSION 4

The current process for obtaining access for pre-tenure activities is adequate. Specific surface access provisions for pre-tenure activities are not required.³⁵



Geological sequestration sites are unique and therefore the approach to proper site selection should be tailored to the characteristics of each site. Sequestration site management should be informed by a site-specific risk assessment and management plan. This will reduce uncertainties and enhance site understanding through iterative data collection and analysis throughout the entire life of the project. A risk-based approach is the most prudent for CO₂ sequestration as attention is directed towards potential adverse events specific to that site. Adopting a risk-based approach to site selection provides the proponents with more flexibility in the project design. Levels of acceptable risk should be defined by the regulator on a case-by-case basis for each project through an interactive dialogue between project proponents and the regulator.

In their application for CO₂ sequestration, proponents must demonstrate that the sequestration complex has adequate capacity, sufficient injectivity and suitable containment. This includes a review of all wells within the area of review³⁶ that penetrate the sequestration complex.

Adoption of general criteria for site selection will assist proponents in demonstrating achievement of these objectives. Examples of parameters for which criteria should be developed include fracture pressure, pressure front evaluation and induced seismicity. Such criteria will help ensure public safety of CCS projects and contribute to the acceleration of CCS activities in the province. Therefore, the steering committee recommends that:

RECOMMENDATION 15

The Government of Alberta should adopt general site selection criteria and the regulator should review the requirements that apply to CO₂ sequestration to ensure that they adequately reflect the overarching objectives of adequate sequestration volume capacity, sufficient injectivity and suitable containment.³⁷

³⁶ See Appendix C for a description of this term.

³⁷ Refer to Appendix D17.

9.2 SEQUESTRATION QUALITY PORE SPACE RESOURCE

Currently, decision makers in the private or public sector do not typically consider pore space as a resource. In the near future, this could impede the ability to achieve the emissions reduction targets attributed to CCS if high quality pore space for CO₂ sequestration is not effectively managed. Thus, the steering committee recommends that:

RECOMMENDATION 16

The Government of Alberta should promote and/or facilitate the development and periodic updating of an inventory of sequestration-quality pore space in the province.³⁸

Currently, the *Oil and Gas Conservation Act* requires a project proponent to demonstrate that a CO₂ sequestration project will not interfere with the recovery, conservation, or storage of oil or gas. A number of pore space inventories have already been developed, or are currently under development, by various federal and provincial organizations and in collaboration with other jurisdictions. Although estimates have been made, more work needs to be done by the Government of Alberta to accurately inventory sequestration-quality pore space in Alberta. An increasingly detailed inventory of sequestration pore space in the province would be a useful tool for pore space management and subsurface resource decision making in the province. Therefore, the steering committee recommends that:

RECOMMENDATION 17

When developing the inventory of sequestration-quality pore space, and when practical, the Government of Alberta should identify potential areas of interaction between subsurface resources and sequestration-quality pore space, particularly those interactions with resources that have a higher development priority.³⁹

The working groups identified that a well-chosen site is a key outcome of sequestration risk management. Development of CO₂ sequestration projects requires careful site selection to ensure that CO₂ is permanently contained in the deep subsurface. Once an appropriate site is identified, proponents must acquire the legal rights and necessary regulatory approvals to proceed with the sequestration project, as outlined in the next section.

³⁸ Refer to Appendix D6.

³⁹ Refer to Appendix D6.

10 INITIAL APPLICATION AND PERMITTING PERIOD

10.1 OVERVIEW

The initial application and permitting period begins when a proponent applies for a tenure agreement for the chosen site and includes granting of all initial regulatory approvals required. There are several stages to this process, which can be described as:

- initial acquisitions
- discretionary activity review and potential Environmental Impact Assessment (EIA)
- regulatory approvals.

The permitting process is outlined in Figure 8.



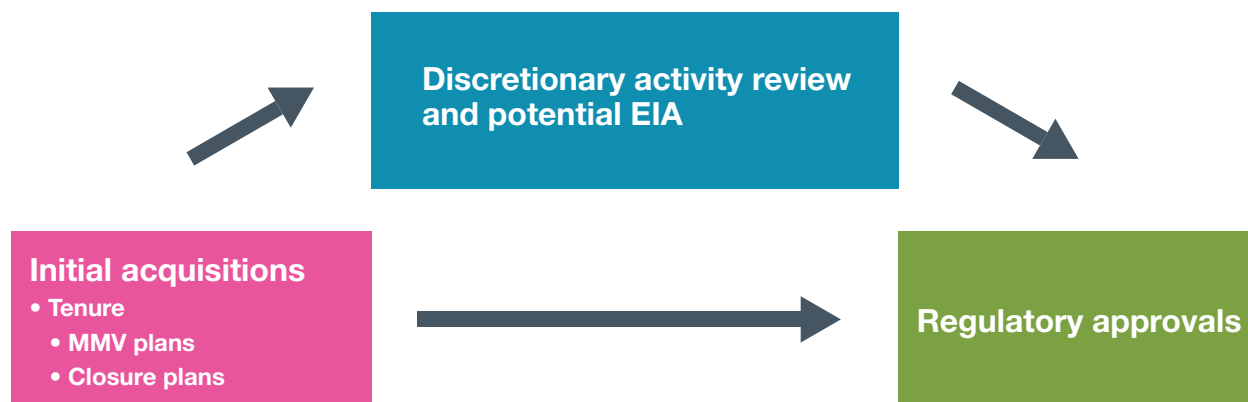


Figure 8. Diagram of Initial Application and Permitting Processes for a CO₂ Sequestration Site

The initial acquisitions stage includes obtaining subsurface and surface rights. Any other requirements needed to conduct exploration activities to further characterize the chosen site must also be met. For CO₂ sequestration, subsurface rights agreements include evaluation permits and carbon sequestration leases. After subsurface rights are obtained, surface rights must be acquired because permission is required to access the land. The process differs for private versus public land. Private land requires an agreement between the lessee and the landowner. On public lands, a mineral surface lease must be obtained from Alberta Environment and Sustainable Resource Development.

Following the initial acquisitions stage, a review is completed to determine whether a project requires a provincial Environmental Impact Assessment (EIA).⁴⁰ EIAs are administered by Alberta Environment and Sustainable Resource Development. CCS projects are not specifically listed in the regulation as requiring EIAs. However, an assessment may be triggered through a review of the project as a discretionary activity. It is important to note that a completed EIA does not mean that the project is approved. The EIA provides the regulator with the data in order to make an informed decision that is in the public interest.

A well licence application can be completed while the project is in the initial acquisitions stage. Under the ERCB Directive 056,⁴¹ any petroleum industry development that includes wells, pipelines or other structures requires a licence from the ERCB to construct and operate. These requirements are intended to ensure environmental protection, public safety and effective resource management. It also requires applicants to consider stakeholder issues. For a CCS project, an evaluation well(s) may be drilled to acquire specific information needed for approval of an injection scheme. A CCS proponent must apply to ERCB for approval of injection and monitoring wells under ERCB Directive 051⁴² which sets out the technical requirements of an injection well.

After drilling, completion and testing of an injection well, proponents can apply for an injection scheme approval under ERCB Directive 065⁴³. Directive 065 currently requires an applicant to have all proposed injection wells completed and test results available prior to scheme approval. Applications under this directive provide information necessary for the ERCB to determine that there will be containment of the disposal fluid. Injection wells must also meet the requirements of Directive 051.

Prior to the ERCB providing final approval for schemes for CO₂ sequestration, the application is referred to the Minister of Alberta Environment and Sustainable Resource Development for review and approval. As part of this review the Minister may impose additional conditions. Once final approval is obtained from the ERCB the project can commence subject to conditions and regulatory requirements.

40 There are also Environmental Assessments required for certain projects under federal law. These requirements are not contemplated in the RFA recommendations.

41 Energy Resources Conservation Board, Directive 056: Energy Development Applications and Schedule, 2011.

42 Energy Resources Conservation Board, Directive 051: Injection and Disposal Wells – Well Classifications Completion, Logging and Testing Requirements, 1994.

43 Energy Resources Conservation Board, Directive 065: Resources Applications for Oil and Gas Reservoirs, 2012.

10.2 REGULATORY ROLES AND RESPONSIBILITIES

For some aspects of the regulatory process for CCS, the division of roles and responsibilities among the ERCB and other various government departments is unclear. In order to ensure the effectiveness and efficiency of the CCS regulatory system, and to reduce uncertainty for project proponents, the Government of Alberta should clarify those roles and responsibilities, and make this information readily available.

One of the areas where roles need to be clarified and possibly changed is the role of the regulator in the issuance of closure certificates. It will be important for the regulator to have a significant role in this process either as the entity that issues the certificate or by providing advice to the Minister of Energy on closure certificate applications. The Government of Alberta will need to determine how best to involve the regulator in this role. Therefore, the steering committee recommends that:

RECOMMENDATION 18

The Government of Alberta should clarify the regulatory roles and responsibilities related to the regulatory process for CCS. Particular attention should be given to determine the regulator's role in issuing closure certificates. This process should also aim to identify and implement efficiencies in the regulatory and approval process to promote the timely review and approval of CCS project applications.⁴⁴

Presently, there is limited information available on the regulatory process for CCS, and most of it is either outdated or difficult to access. For example, the ERCB has in place Bulletin 2010-22 ERCB Processes Related to Carbon Capture and Storage Projects.⁴⁵ This bulletin provides a high-level overview of ERCB processes and approvals. However, the bulletin has become outdated and does not contain sufficient detail of the entire regulatory process to represent a stand-alone guidance document useful to all stakeholders. The ERCB has another document entitled Upstream Oil and Gas Authorizations and Consultation Guide⁴⁶ that is a reference document that identifies the common authorizations (approvals, licenses, dispositions, permits, and registrations) required by Alberta regulatory agencies and government departments for upstream oil and gas development activities. However, the guide does not currently offer specific information for CCS projects.

⁴⁴ Refer to Appendix D1.

⁴⁵ Energy Resources Conservation Board, Bulletin 2010-22 ERCB Processes Related to Carbon Capture and Storage Projects, 2010

⁴⁶ Energy Resources Conservation Board, *Upstream Oil and Gas Authorizations and Consultation Guide*, 2010.

The regulatory process and requirements for CCS must be openly and clearly communicated to project proponents, operators, stakeholders and the public. A comprehensive document detailing the full regulatory process for CCS is important to:

- Ensure that the CCS regulatory framework is transparent.
- Provide regulatory certainty for CCS project proponents.
- Help proponents efficiently navigate the regulatory process.
- Provide assurance to stakeholders and the public that the CCS regulatory process and framework is robust, and that CCS is being managed properly.

Therefore, the steering committee recommends that:

RECOMMENDATION 19

The Government of Alberta and the regulator should coordinate the development of a CCS Regulatory Guidance Document, similar to the existing Upstream Oil and Gas Authorizations and Consultation Guide,⁴⁷ that clearly:

- a) Provides detailed information on all approvals and authorizations related to CCS.
- b) Documents roles and responsibilities for regulators and government departments.
- c) Provides detailed information on the process for acquiring pore space tenure and a permit to inject CO₂.
- d) Provides detailed information on the requirements for the issuance of a closure certificate.
- e) Includes process maps, regulatory flow charts, web links, etc.⁴⁸

⁴⁷ Available at <http://authorizationsguide.ercb.ca>
⁴⁸ Refer to Appendix D1.

10.3 TENURE AND TENURE REQUIREMENTS

10.3.1 Pore Space Tenure: Process

After identifying a site for CO₂ sequestration, project proponents must acquire pore space tenure before they can seek regulatory approvals to drill evaluation wells, injection and monitoring wells, or sequester captured CO₂. Like the Crown mineral tenure for petroleum and natural gas, pore space tenure is administered by Alberta Energy. Pore space rights are granted to project proponents on a first-come, first-served basis, and are subject to various requirements depending on the type of tenure agreement that a proponent seeks to acquire.

The Carbon Sequestration Tenure Regulation creates two separate pore space agreements which are the primary mechanisms for proponents to acquire rights to pore space for CCS purposes. The first agreement is known as an evaluation permit which has a five-year term (non-renewable) and grants proponents the right to conduct evaluations and testing of subsurface reservoirs for the purposes of determining their suitability for CO₂ sequestration. The second type of agreement is a carbon sequestration lease which has a renewable 15-year term and grants proponents the right to drill wells, conduct evaluation and testing and inject captured CO₂ into subsurface reservoirs for permanent sequestration.

For Crown mineral tenure, once an application has been received, Alberta Energy examines the requested rights to ensure that they have not been allocated, and refers the request to the multi-agency Crown Mineral Disposition Review Committee (CMDRC) for a review of any potential surface access restrictions relating to the requested lands. The CMDRC reviews, at the request of Alberta Energy, all surface restrictions affecting Crown mineral rights (e.g. petroleum and natural gas, oil sands, metallic and industrial minerals, and ammonite shell) to consider the possible effects of mineral exploration and development activities on the environment within and adjacent to the requested rights prior to leasing them. The CMDRC may recommend that lands be withdrawn from disposition, or that the proposed disposition be granted with or without special terms and conditions. To ensure the same level of rigour for reviews of applications of pore space tenure, the steering committee recommends that:

RECOMMENDATION 20

Sequestration tenure applications submitted to Alberta Energy's Tenure Branch should be subject to review by the Crown Mineral Disposition Review Committee.⁴⁹

Alberta Energy's website contains detailed information on the tenure process and application requirements for Crown resources. To facilitate an efficient and transparent tenure process, and to increase public knowledge about the CCS industry, it is important for clear information about pore space and the tenure process to be available to CCS project proponents, stakeholders and the public. To enhance the transparency of the tenure process for pore space, the steering committee recommends that:

RECOMMENDATION 21

All requirements for acquiring a sequestration tenure agreement and information on pore space should be accessible to industry and the public on Alberta Energy's website.⁵⁰

In Alberta, the Crown owns the pore space found below the surface of the land, excluding the pore space found below land owned by the Government of Canada. As a pore space owner, the Crown is responsible for the disposition for CCS and other subsurface activities. Currently, the Crown grants access to pore space through the mechanisms outlined in the Carbon Sequestration Tenure Regulation as well as section 54(5) of the *Mines and Minerals Act*.

This legislation offers a mechanism for project proponents to obtain rights to pore space. Section 54(5) is used to provide tenure for undisposed Crown rights where resource tenures do not currently apply. This section is commonly used to grant access to pore space for acid gas disposal (AGD) schemes, where a proponent is proposing injection into an area with no petroleum or natural gas tenure. Applications for section 54(5) authorizations are rigorously reviewed by Alberta Energy, and the standard ERCB application and approval process applies for all facilities and wells included within a project. Depending on project characteristics, the project may also require approval from Alberta Environment and Sustainable Resource Development.



In order to support the development of CCS knowledge both within Alberta, and globally, it is important for the Government of Alberta to facilitate CCS research projects within the province. In some instances, it may be appropriate to allow small-scale CCS research projects to operate at depths shallower than 1000 metres. Section 54(5) outlines the way these projects may acquire pore space tenure in lieu of evaluation permits or a carbon sequestration lease, which are only applicable for pore space deeper than 1000 metres below the surface of the land.⁵¹ Therefore, the steering committee recommends that:

RECOMMENDATION 22

The Government of Alberta should use the Ministerial letter of consent under the authority of section 54(5) of the *Mines and Minerals Act* to facilitate CCS research activities in the province.⁵²

10.3.1.1 Measurement, Monitoring and Verification (MMV) and Closure Plans

Under the Carbon Sequestration Tenure Regulation, carbon sequestration lease applicants are required to submit an MMV plan and an initial closure plan. Proponents applying for an evaluation permit are required to submit an MMV plan, but not a closure plan. The MMV plan sets out the monitoring, measurement and verification activities that a project proponent will undertake for the term of the permit or carbon sequestration lease. The closure plan sets out a description of the activities that a lessee will undertake to close down sequestration operations and facilities. Both MMV and closure plans must also contain an analysis of the likelihood that a project will interfere with other mineral recovery activities in the area.

⁵¹ Refer to the Carbon Sequestration Tenure Regulation, Section 1(c), 2011.

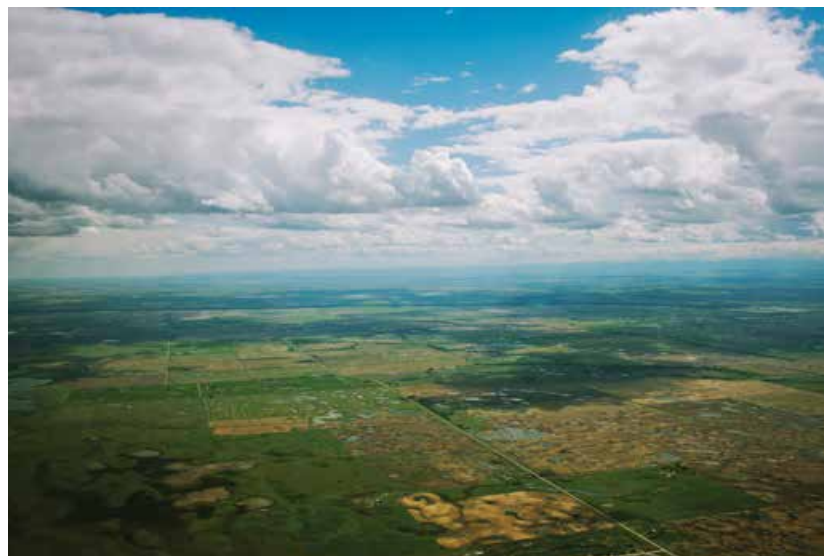
⁵² Refer to Appendix D1.

Presently, the Minister of Energy is responsible for the approval of MMV and closure plans as part of the tenure application process. These plans are an important component of the application package that is submitted to Alberta Energy as they contain pertinent information to inform its decision on allocation of pore space tenure, including information related to potential impacts on other mineral resources. However, these plans will also contain specific technical performance criteria requirements and outline proposed MMV and closure activities. It is important for the regulator to undertake a detailed review and approve these plans to ensure that the reviews are transparent for the public. Therefore, the steering committee recommends that:

RECOMMENDATION 23

Submission of a monitoring, measurement and verification (MMV) plan and closure plan should be a requirement for all CCS related applications to the regulator, and should continue to be a requirement for tenure applications to Alberta Energy (closure plans for sequestration lease applications; monitoring, measurement and verification plans for both evaluation permit and sequestration lease applications).⁵³

The purpose of MMV is to address health, safety and environmental risks, evaluate sequestration performance and provide evidence that the site is suitable for closure. MMV is central to CO₂ sequestration risk management. There are no requirements for the submission of a risk assessment of CO₂ sequestration projects in Alberta legislation. However, the *Mines and Minerals Act* allows for the creation of regulations that require applicants to conduct risk assessments before being granted an agreement for CO₂ sequestration.⁵⁴



⁵³ Refer to Appendix D1.

⁵⁴ *Mines and Minerals Act*, Part 9, Section 124(a), 2000.



The submission of a risk assessment will allow for more thorough risk management throughout the life of the project. MMV and closure plans are developed in response to the risks identified. Requiring a risk assessment will enable the proponent to communicate to the regulator and stakeholders what the MMV and closure plans are based on. The ongoing development of the risk assessment over the life of the project could be used as a tool to communicate sequestration performance and permanence of greenhouse gas reductions when applying for transfer of liability and transferring MMV infrastructure. As a result the steering committee recommends that:

RECOMMENDATION 24

The Government of Alberta should require risk assessment as an integral part of the MMV plan and closure plan submissions for carbon sequestration projects. A risk assessment provides the foundation for the MMV and closure plans and should be performed, reviewed and updated together as required to support the regulatory process.⁵⁵

The project proponent should determine, in consultation with the regulator, the methodology appropriate to the project to ensure that the risk assessment meets the requirements of the regulator. Although different risk assessment methods are in use, appropriate methods will contain similar analytical elements and will identify similar threats and consequences for any given project. For CO₂ sequestration risk assessments, the steering committee recommends that:

RECOMMENDATION 25

The Government of Alberta should endorse the following guidelines for risk assessments:

- a) Risk assessments should be iterative, systematic, technically defensible, transparent and available to the public as integral to monitoring, measurement and verification, and closure plans.
- b) Modelling and simulations should be undertaken (as applicable on a site-specific basis) to evaluate and predict the behaviour of the CO₂ sequestration complex and inform the risk assessment.
- c) Records of risk assessments (including all iterative updates and comparisons of predicted behaviour of the sequestered CO₂ with measured performance) should be retained for the life of the project to support MMV plans and closure certificate applications.
- d) Non-technical risks related to public acceptance of MMV should be identified and addressed by project proponents.⁵⁶

CO₂ sequestration projects are monitored extensively to address health, safety and environmental risks, and to collect data regarding containment, conformance and utilization of pore space. MMV plans are developed by the project operator to meet regulatory requirements and conditions specified in project approvals. Sufficient data must be collected regarding the behaviour of the sequestered CO₂ for several purposes. Measurement and monitoring of the injection facilities, geological sequestration site and surrounding environment provide assurance that CO₂ is confined to the sequestration complex (containment). Verification refers to the comparison of measured and predicted performance and is used to ensure sequestration sites are operating as predicted and permitted (conformance). MMV plans should be fit for purpose and developed to include several elements identified by the working groups. Therefore, the steering committee recommends that:

RECOMMENDATION 26

The Government of Alberta should require MMV plans to be risk-based and site-specific.⁵⁷

Technology selection for MMV plans must address the site-specific nature of CO₂ sequestration. A wide range of technologies are available for different monitoring tasks. In development of a MMV plan, monitoring tasks are identified and suitable technologies are selected to provide comprehensive data. The steering committee recommends that:

RECOMMENDATION 27

The Government of Alberta should recognize that MMV plans require a comprehensive suite of technologies to address health, safety and environmental risks, evaluate sequestration performance and provide evidence to support the issuance of a closure certificate.

Monitoring should take place in each domain of review⁵⁸ and technologies should be selected based on a site-specific evaluation of the ability of the technology to perform the identified monitoring task. As there is no single technology that can provide complete data on sequestration performance, a comprehensive suite of complementary technologies should be selected to provide the information required.⁵⁹

⁵⁷ Refer to Appendix D9.

⁵⁸ Refer to Appendix C for a description of this term.

⁵⁹ Refer to Appendix D9.

The protection and monitoring of potable groundwater is an important consideration in the site selection and development of a CO₂ sequestration project and associated MMV plan. In Alberta, the *Water Act* provides a framework⁶⁰ for protection of non-saline groundwater and the *Environmental Protection and Enhancement Act* prohibits the release of a substance in an amount that may cause a significant adverse effect. Groundwater monitoring above the base of groundwater protection (BGWP) is important to establish baseline data for freshwater aquifers. It also protects the quality of the drinking water and provides assurance to the public. The steering committee recommends that:

RECOMMENDATION 28

The Government of Alberta should require shallow groundwater monitoring programs as part of the MMV plan for CO₂ sequestration projects. Programs should be project-specific and risk-based.⁶¹

Under the *Carbon Capture and Storage Statutes Amendment Act*, the Government of Alberta assumes long-term liability for a CCS storage site once a closure certificate is issued. When the Government of Alberta issues a closure certificate it will indicate that a lessee has met the regulatory requirements of Alberta Energy, Alberta Environment and Sustainable Resource Development, and the ERCB concerning closure (activities, plan and period) and the behaviour of the sequestered CO₂ is trending toward stability. Closure plans set out a description of the activities that a lessee will undertake to close down CO₂ sequestration operations, and contains specific informational requirements that a project operator is required to track and report on throughout the life of the project. The purpose of the closure plan is to minimize the risks associated with liabilities assumed by the Crown after a closure certificate is issued.

⁶⁰ In Alberta, the *Water Act* defines saline groundwater as water that has total dissolved solids (TDS) exceeding 4000 milligrams per litre. Aquifers with total dissolved solids less than 4000 mg/L are described as non-saline.

⁶¹ Refer to Appendix D8.

The Carbon Sequestration Tenure Regulation sets out the requirements for what must be included in interim closure plans that are submitted every three years for review and renewal.⁶² The steering committee believes all closure plans should fulfill these requirements and recommends additional requirements for project proponents to systematically communicate sequestration performance, and project updates to the Government of Alberta and the regulator. Therefore, the steering committee recommends that:

RECOMMENDATION 29

In addition to requirements already in the *Mines and Minerals Act* and Carbon Sequestration Tenure Regulation, information required to be in a closure plan should include, but not be limited to, the following:

- a) project overview
- b) storage performance criteria for site closure
- c) storage performance evidence
- d) operating plan updates
- e) description of current and potential surface or subsurface interactions
- f) proposed closure activities
- g) any other information required by the regulator, other departments or agencies of the Government of Alberta.⁶³

⁶² Carbon Sequestration Tenure Regulation, Section 19(3), 2000.

⁶³ Refer to in Appendix D2.

Project proponents are required to submit an initial closure plan with their tenure (carbon sequestration lease) application. In addition, lessees are required to submit a revised interim closure plan to Alberta Energy and the ERCB every three years for renewal. This three-year review offers the opportunity for the Government of Alberta and the operator to continuously assess and monitor the state of the project and identify any risks. Finally, operators should also be required to submit a final closure plan when applying for site closure. To provide clarity for project proponents, operators and the public, and to ensure consistency among a lessee's different closure plans, all closure plans (initial, interim and final) should contain, at a minimum, all of the required information categories established by the Government of Alberta. It is important for this information to be easy to understand and access for project proponents, operators and the public. This ensures that the regulatory framework is transparent, and that the requirements for closure are clearly communicated to all stakeholders. As a result, the steering committee recommends that:

RECOMMENDATION 30

The Government of Alberta should develop a regulation, directive or guidance document outlining the categories of information required for all closure plans. This detailed information should allow for the closure plans to be project-specific.

At a minimum, the categories of information currently required in an interim closure plan should be present in all plans. If the Government of Alberta or a project proponent feels supplementary information is beneficial or necessary, additional categories can be included when a plan is renewed.

In cases where a category is not applicable (e.g. because the project is in early stages), the proponent should provide an explanation of its expectations for that category and/or why it is not applicable.⁶⁴

10.3.2 Pore Space Competition and Access

In addition to tenure process considerations, the working groups also undertook a review of high level policy objectives related to pore space to determine opportunities to improve pore space management and development in the province.

In the Climate Change Strategy, Alberta predicted that CCS will account for 139 megatonnes of CO₂ emissions reductions per year by 2050. Assuming average capture rates of one to two megatonnes annually, this level of CO₂ reduction would result in 80 to 100 commercial scale facilities. If each facility were to have its own sequestration site, this could result in a similar number of sequestration sites across the province. This potential proliferation of sequestration sites introduces policy challenges related to resource competition and pore space management and development. As the CCS regulatory process progresses, there are important policy issues that Alberta Energy needs to consider during the tenure process.

Based on the rate of CO₂ that needs to be sequestered to meet the 2050 goals, it is important that industry make reasonable attempts to collaborate on CO₂ sequestration projects. This will allow industry to capture economies of scale, share knowledge and experience, maximize pore space utilization, and reduce the incremental environmental impact (e.g. surface infrastructure) of CCS. The steering committee does not believe that such collaboration should be required. However, it would be prudent to encourage industry to adopt these practices. This collaboration would ideally be achieved prior to the tenure application, during the site selection phase. Any additions to a project after tenure is issued would likely require additional tenure to be allocated. As a result, the steering committee recommends that:

RECOMMENDATION 31

Proponents of CO₂ sequestration projects should be encouraged to solicit indications of interest from other large CO₂-emitting facilities to attempt to identify opportunities for collaboration on CO₂ sequestration and receive additional sources of CO₂ for injection where appropriate and feasible.⁶⁵

As with all subsurface resource development projects, CO₂ sequestration projects can interact with and impact other subsurface resources and developments. Sedimentary basins that have high CO₂ storage potential also host fossil fuel, groundwater, minerals and geothermal energy resources. They also provide options for gas storage and the permanent disposal of waste materials. These subsurface interactions can have negative impacts, leading to competition for pore space. The interactions can also be positive and provide the opportunity for development synergies. During the pore space tenure review process, the proponent must identify and assess any potential interactions that a proposed CCS project may have with other subsurface resources. The Government of Alberta will then make decisions on subsurface resource development priorities.

Presently, the Government of Alberta manages potential interactions between CO₂ sequestration and hydrocarbon resources. Prior to the RFA, the Government of Alberta took steps to manage the interaction between CCS and hydrocarbon resources by amending a number of pieces of legislation explicitly mandating that CCS projects will not interfere with or negatively impact hydrocarbon projects in the province. Within the MMV plan submitted for evaluation permits and carbon sequestration leases, project proponents must analyze the likelihood that their project will interfere with other mineral recovery operations. If there is potential for a CCS project to interact with hydrocarbon resources, then Alberta Energy must decide whether to deny pore space tenure, or grant tenure and leave it to the regulator to evaluate if the potential resource interactions can be effectively managed to prevent negative impacts on mineral recovery. The current ERCB process is guided by Government of Alberta resource development policies, and is well-suited for evaluating and managing mineral resource interactions with CCS development.

Conservation of hydrocarbon resources is currently the prime resource development priority for the Government of Alberta, and the pore space tenure process is the primary process to ensure that CCS development will not negatively impact the hydrocarbon development industry in the province. As illustrated by the recent surge in development of coalbed methane and shale oil and gas, it is important to recognize that the definition of 'resource' and 'resource development priorities' are constantly changing.

In the future other resources such as geothermal and dissolved minerals in saline brine may increase in value and importance. Therefore, it is important that the Government of Alberta and the regulator identify the full suite of potential subsurface resource interactions related to CCS development, and evaluate them based on realistic expectations for future resource development opportunities and priorities.



When considering subsurface resource applications, it will be important for the Government of Alberta and the regulator to evaluate the impact that other resource developments may have on high-quality pore space resources and seals (e.g. caprock). Currently, most decision makers in the private or public sector do not consider pore space a resource because it is viewed as having no value and does not need to be considered when making trade-off decisions relating to resource development and planning. This could impede the Government of Alberta's ability to achieve the emissions reduction targets from CCS outlined in the Climate Change Strategy. Therefore, the steering committee recommends that:

RECOMMENDATION 32

When reviewing subsurface resource development applications, the Government of Alberta and the regulator should continue to evaluate potential resource and development interactions on a case-by-case basis based on resource development policies of the day and realistic future resource development opportunities and priorities. Moreover, the Government of Alberta should:

- a) Explicitly consider the impact on sequestration-quality pore space, seals (e.g. caprock) and existing stored CO₂ when making decisions relating to subsurface resource development and planning in the province.
- b) Identify potential subsurface resource interactions when reviewing CCS applications.⁶⁶

In addition to the need to manage potential interactions between pore space tenure and other resources and resource developments through the tenure process, it will also be important for the Government of Alberta to manage the development of the province's pore space resources to ensure they are used to their full potential.

Presently, CCS project proponents submit an application for carbon sequestration tenure for a tract of pore space that is available and meets their project specifications, including: depth, porosity, permeability and location. As CCS becomes a prominent activity in the province, demand for pore space, especially in those regions with high numbers of large industrial facilities, may compel project proponents to acquire pore space tenure in geological zones with close proximity to other pore space tenure areas. For example, project proponents could apply for pore space tenure in zones that are stacked or vertically overlaid (see Figure 9). Moreover, project proponents may apply for tenure adjacent to other tenure zones in order to operate as close as technically feasible in order to maximize pore space utilization in a particular area – referred to as jointly utilized (see Figure 10).

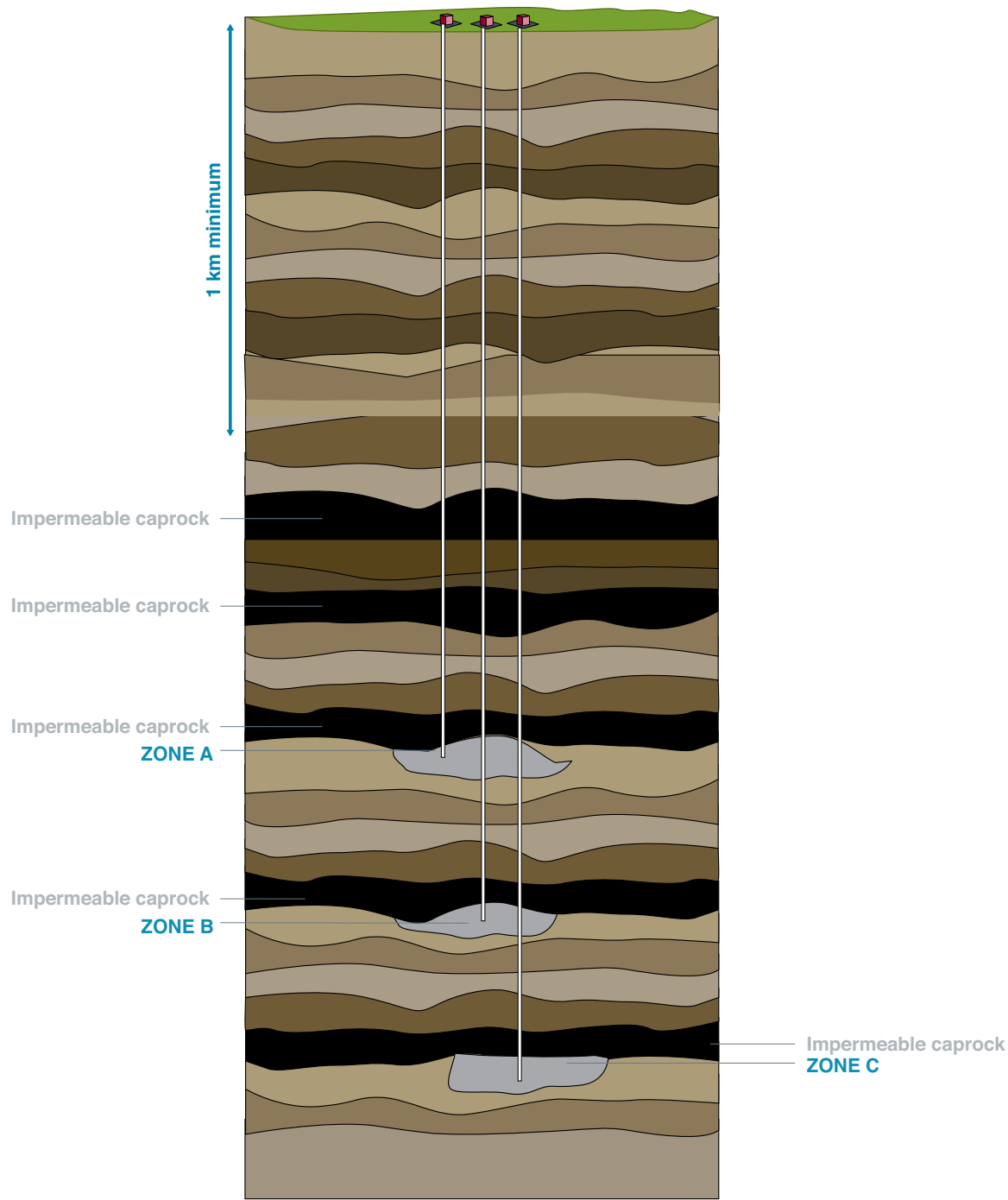


Figure 9. Illustration of Stacked or Vertically Overlaid Sequestration Zones



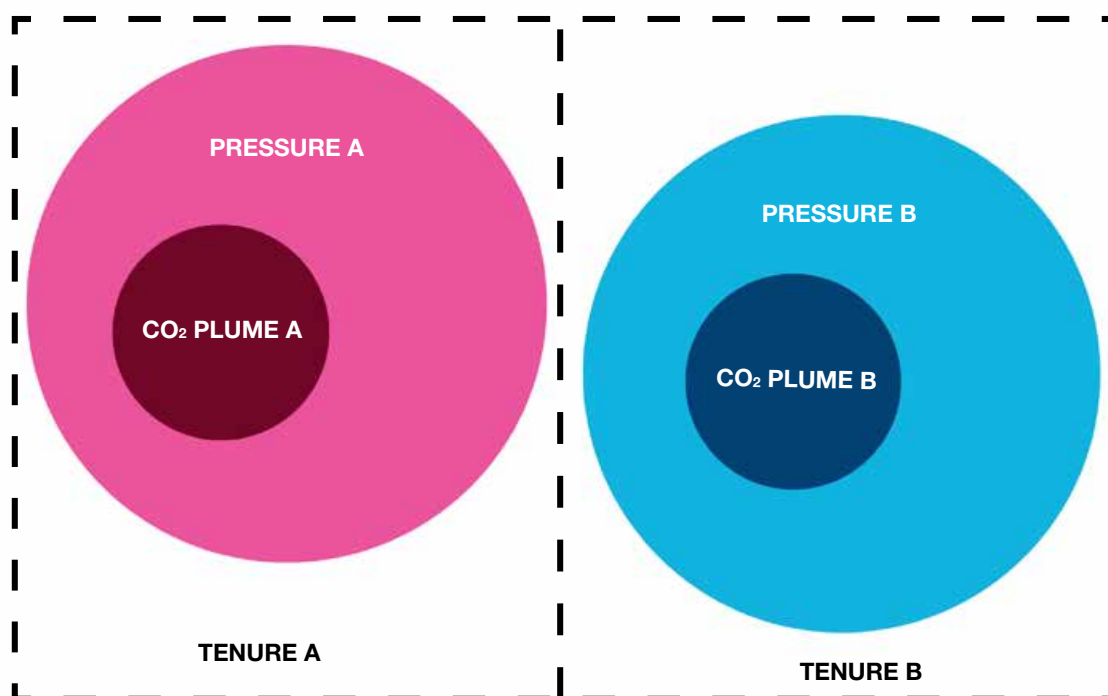


Figure 10. Illustration of Adjacent or Joint Pore Space Utilization

Both of these development scenarios present potential opportunities for Alberta Energy to maximize pore space utilization in a particular zone through tenure allocation, which could become increasingly important if CCS becomes a significant activity in the province. However, both scenarios also present a number of potential technical and regulatory challenges that suggest that there are reasons to be cautious about granting overlapping or adjacent leases to different parties. Competing CO₂ sequestration operations have the potential to affect one another in terms of injectivity, monitoring, liability and through overlapping pressure fronts. Therefore, when reviewing pore space tenure applications, and when reviewing project approvals, the steering committee recommends that:

RECOMMENDATION 33

Applications for ‘stacked’ or ‘jointly utilized’ CCS projects should be considered on a case-by-case basis.⁶⁷

Situations may arise where there is a high demand for pore space tenure agreements in regions that already contain existing agreements. In these situations where demand for pore space tenure outweighs the supply, it will be important for the Government of Alberta to introduce policy or regulations to incent or compel third party access to pore space for CO₂ sequestration to facilitate the development of CCS in Alberta.

There is currently no regulation in Alberta directly dealing with third party access or open access to pore space or CO₂ sequestration. There are, however, some portions of the *Mines and Minerals Act* and Carbon Sequestration Tenure Regulation that allow for the transfer of tenure between parties, and that give the Minister of Energy the authority to reduce the area of a permit or lease upon application of the permittee or lessee.

When confronted with unbalanced supply and demand for pore space tenure in an area, market principles and private negotiation should in most cases lead to appropriate agreements between parties, and there is no compelling reason to regulate third party access to tenured pore space without first exhausting reasonable avenues of private negotiation. It is important that regulations, legislation and directives do not pose unreasonable barriers to voluntary negotiations. Therefore, the steering committee recommends that:

RECOMMENDATION 34

Market considerations should be the primary driver behind third party access to sequestration tenure and CO₂ injection. In this regard, sequestration site operators and other parties are expected to explore all reasonable avenues of private negotiation before applying to the regulator for access. Therefore, voluntary third party access to CO₂ disposal should be encouraged and should not be prohibited by regulations or legislation.⁶⁸

In situations where private voluntary negotiations for third party pore space access have failed, the Government of Alberta should introduce policy or regulations to compel third party access to pore space for CO₂ sequestration. There are two primary policy drivers behind pore space open access regulations. First, the policy could be used to mitigate market power to prevent a few operators from controlling access to sequestration sites or imposing unreasonable conditions as a result of a favourable market position. Second, the policy could be used to ensure that the public-good aspects of CCS are fully realized, including reduced environmental footprint of CCS operations in Alberta and lower costs for industry and government.

The process for compelling third party access to another party's pore space tenure refers to a situation where the regulator grants a CCS operator access to another party's pore space tenure. Compelling third party access to pore space in this way is not a preferable course of action for CCS development in the province. A key concern with the policy is the potential negative impact that it could have on the original tenure holder and on the management of the sequestration complex. CCS projects are complex undertakings and require large financial investments by project proponents.

When developing regulations for pore space open access, it will be important for the Government of Alberta to balance the need for investment certainty for CCS tenure holders, and the need to promote the fair and efficient development of the province's pore space for the public good. The Government of Alberta should not have the authority to allow other operators onto a tenure-holder's site or to unilaterally transfer a portion of an operator's tenure to another party. Only the site operator will have the most complete knowledge of the site's geology and other characteristics necessary to ensure proper site operation. Therefore, the steering committee recommends that:

RECOMMENDATION 35

The Government of Alberta should not impose orders that give other parties the right to conduct their own injection operations on an operator's sequestration site (i.e. within the operator's tenure). Similarly the Government of Alberta should not have the authority to remove an operator's sequestration tenure for the sole purpose of allocating it to another party.⁶⁹

There are certain situations where it may be necessary for the Government of Alberta to order a sequestration site operator to inject another party's CO₂ when adequate sequestration sites are scarce (see Figure 11). When sites are scarce, this may lead to projects being sited close to each other, increasing the risk of pressure front and/or plume interactions. Additionally, pore space open access may also be justified if high quality sequestration sites which have been allocated through leases are not being used to their full potential (e.g. captured CO₂ is being sold to CO₂-EOR operators instead of being injected into the sequestration site).

69

Refer to Appendix D11.

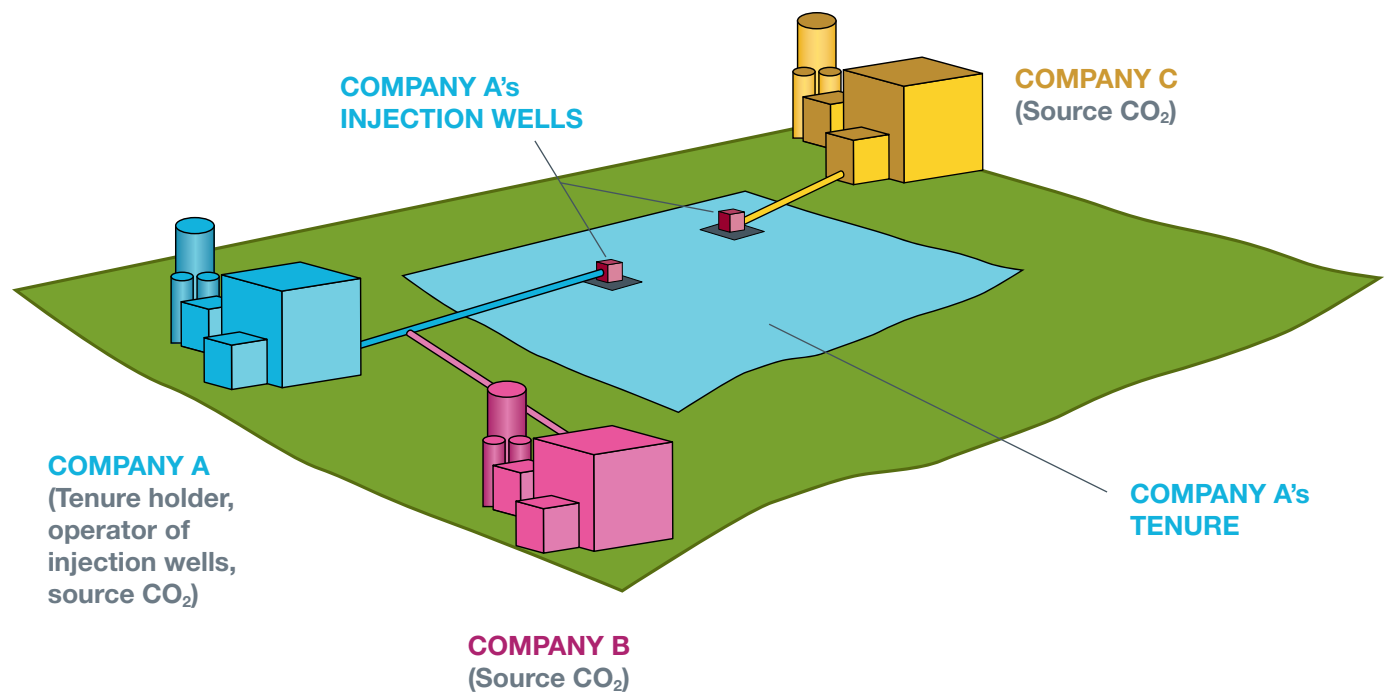


Figure 11. CO₂ Sequestration Project Open Access

In the event that there are compelling reasons to require an operator to inject another party's CO₂, a mechanism should be in place to enable mandated access. However, it is critical that the burden of proof be on the party requesting access to demonstrate that there is sufficient justification for an access order. The conditions that a requesting party must satisfy should be relatively difficult to demonstrate, especially in the early days of the CCS industry, because mandated access is not a desirable outcome unless absolutely necessary. Therefore, the steering committee recommends that:

RECOMMENDATION 36

The Government of Alberta should create a mechanism whereby other parties can apply to the regulator to have their CO₂ injected by an existing CCS operator. Such an application should only be considered if the applicant can demonstrate all of the following:

- a) There is sufficient capacity (over the life of the project, but taking into consideration pressure effects and the integrity of the sequestration complex) within the sequestration site to accommodate the applicant's CO₂
or
The sequestration site's capacity can reasonably be increased (including acceptable cost sharing provisions) to accommodate the applicant's CO₂.
- b) Injection of the applicant's CO₂ will not restrict the ability of the site operator to inject its own CO₂ and/or other CO₂ the operator is contractually obligated to inject.
- c) The sequestration site operator is not negotiating reasonably with the applicant and the applicant has exhausted all reasonable avenues of private negotiation.
- d) The sequestration site is the only economically feasible way, or the most practical way for the third party to inject the CO₂, or is clearly superior environmentally to other options.
- e) The sequestration site operator's pore space tenure would not be affected and no additional tenure would be required.
- f) The applicant's CO₂ meets the technical requirements, including CO₂ composition, of the sequestration project.
- g) Injection of the applicant's CO₂ will not compromise the integrity of the sequestration complex.⁷⁰

If a party requesting pore space access is able to demonstrate all of the conditions outlined above, then any orders for access should include a determination of compensation to be paid to the sequestration site operator by the other party (the applicant) to ensure that the operator does not suffer economic harm, unless terms of settlement are agreed by the parties. Therefore, the steering committee recommends that:

RECOMMENDATION 37

The mechanism for other parties to apply to the regulator to have their CO₂ injected by an existing CCS operator should include provisions for the setting of reasonable rates of compensation to be paid to the sequestration site operator by the applicant. Determination of this compensation should take into account, but not be limited to, the following:

- a) Any necessary increases in MMV activities.
- b) Increases in operational and capital costs.
- c) A reasonable share of upfront costs and financial risks for the project.
- d) Liability for injected CO₂, including greenhouse gas liability (e.g. CO₂ credits).
- e) Additional payments into the Post-closure Stewardship Fund (PCSF).⁷¹



When mandating third party access to a sequestration site, the Government of Alberta will also need to consider issues related to liability for CO₂. Under normal operating conditions, a CCS tenure holder is fully liable for all of the CO₂ injected into the subsurface (and related PCSF payments). Because potential orders for third party access would require an operator to inject another party's CO₂, and not allow other operators into the storage site, liability (including PCSF payments) for the CO₂ should continue to rest with the tenure holder. Any costs associated with this liability and PCSF payments can be recovered through compensation paid by the third party for injecting its CO₂. Companies should be permitted to enter into private agreements to share liability burdens; however, it is important that the Government of Alberta and landowners have complete certainty that they only need to deal with a single legal entity regarding liability for an operation, and that entity is the tenure holder. Therefore, the steering committee recommends that:

RECOMMENDATION 38

When a pore space tenure holder injects another party's CO₂, whether via voluntary private negotiation or by order of the regulator, liability for that CO₂ should remain with the holder of pore space tenure until the transfer of liability to the Government of Alberta. Furthermore, the tenure holder should be responsible for paying into the Post-closure Stewardship Fund for that additional injected CO₂.⁷²

The fact a sequestration site operator has been ordered by the regulator to inject a third party's CO₂ should not affect the operator's ability to cease operations when it so desires. As long as satisfactory terms of transfer can be agreed upon and the Government of Alberta is satisfied that the third party is capable of effectively operating the sequestration operation, there should be no prohibition against transferring the operation to that third party. Encouraging such a transfer when a sequestration operator wishes to cease operations would allow the third party's CO₂ to continue to be injected without the investment required to develop a new project. This can help to reduce costs for CCS and reduce the overall environmental impact (e.g. surface infrastructure). Therefore, the steering committee recommends that:

RECOMMENDATION 39

If a sequestration site operator that is injecting a third party's CO₂ wishes to cease operation of the site, then, if both parties and the Government of Alberta agree and satisfactory terms can be arranged, a transfer of the site to the third party should be allowed and encouraged.⁷³

The mechanisms for third party access outlined above are relevant in situations where a tenure holder has injection infrastructure already developed on site. However, there may be situations where tenure is completely unused at a site and where no injection infrastructure has been constructed. In these situations it would be unreasonable for the Government of Alberta to require a tenure holder to construct injection infrastructure in order to accommodate and inject a third party's CO₂. In this case, it may be necessary for the Government of Alberta to have the ability to rescind or revoke tenure that is wholly unused.

Under the *Mines and Minerals Act* and the Carbon Sequestration Tenure Regulation, the Government of Alberta does not currently have the ability to revoke unused tenure, except to elect not to approve renewal of the tenure (a carbon sequestration lease) at the end of the 15-year term. Therefore, a mechanism should be created to allow the Minister of Energy to make changes to tenure after a defined period of time, if it is not being used. It is important that the Government of Alberta have the flexibility to decide what period of time is appropriate for each application for pore space tenure. To ensure that investors have a reasonable level of certainty in their tenure, it is important that the lessee know, when the tenure is issued, under what conditions and after what period of time the tenure could be revoked. The conditions and time period should be discussed with the lessee during review of the tenure application. This is similar to provisions in mineral tenure. Therefore, the steering committee recommends that:

RECOMMENDATION 40

The Government of Alberta should consider restructuring carbon sequestration leases so that the Minister of Energy has the authority to revoke or rescind tenure that has not been used after a defined period of time.⁷⁴

⁷³ Refer to Appendix D11.

⁷⁴ Refer to Appendix D11.

10.4 DISCRETIONARY ACTIVITY REVIEW AND POTENTIAL ENVIRONMENTAL IMPACT ASSESSMENT

An Environmental Impact Assessment (EIA) is an assessment of the potential positive or negative impacts that a proposed project may have on the environment. Project proponents are responsible for evaluating the project-specific and cumulative impacts that a project may have on the environment and reporting that information to the regulatory decision makers. The purpose of an EIA is to ensure that decision makers consider all of the potential impacts of a proposed project before making a decision to allow it to proceed.

In Alberta the governing legislation for environmental assessment is the *Environmental Protection and Enhancement Act*, and is administered by Alberta Environment and Sustainable Resource Development. Alberta's environmental assessment process has three basic goals:

- gather information
- provide a forum for public involvement
- support sustainable development in the province.

In Alberta, EIAs are a useful tool to gather information about a proposed activity, but they are not the mechanism by which a proponent is given approval to construct and operate a facility. This is accomplished via approvals granted under the *Environmental Protection and Enhancement Act*, *Water Act*, *Public Lands Act*, *Oil and Gas Conservation Act*, *Pipeline Act*, ERCB directives, and other legislation and regulations. These approval processes are the mechanisms by which the province can set conditions and requirements for the operation of the various components of a CCS project.

The Environmental Assessment (Mandatory and Exempted Activities) Regulation determines whether an environmental assessment is required for a particular project. This regulation defines the type of projects requiring an EIA and what projects specifically do not require an EIA. If a proposed activity is not on either the mandatory or exempt list, the Director (as designated by the Minister of Alberta Environment and Sustainable Resource Development) has the discretion to determine if the proposed activity warrants further environmental assessment.

Presently, the capture component of a CCS project is not on the mandatory or exempt list within the Environmental Assessment (Mandatory and Exempted Activities) Regulation. It also does not need an approval under the *Environmental Protection and Enhancement Act* unless it is part of a larger facility that is required to undergo that level of scrutiny. Similarly, the transportation and subsurface CO₂ sequestration components of a project are not on the mandatory or exempt list within the regulation, and do not require an *Environmental Protection and Enhancement Act* approval. Therefore, CO₂ capture and sequestration projects are only required to undertake an EIA if directed to do so by the Director of Alberta Environment and Sustainable Resource Development.

Alternatively, as with Quest, project proponents may elect to undertake a provincial EIA voluntarily. To date, no CCS projects have been required to undergo an EIA by the Government of Alberta. Due to funding from the Government of Canada, federal environmental assessments were required by the federal government for the Alberta Carbon Trunk Line and Quest.

To ensure a robust and efficient regulatory framework, it will be important for the Government of Alberta to determine the specific conditions under which an EIA would provide greater understanding of the project than the current regulatory process provides. While there is local and worldwide experience with various components of CCS technology, large scale integrated CCS is a relatively new development. For this reason, it will be important for the Government of Alberta to build public confidence in the regulatory framework. EIAs are one regulatory tool to collect information on the potential environmental and social impacts of a CCS project.

In the meantime, it will be important for the Government of Alberta to demonstrate to the public that CCS is subject to a high level of scrutiny. Requiring EIAs to be mandatory for CCS projects over the next three years, while a government review of EIA requirements for CCS is underway, will demonstrate the Government of Alberta's commitment to public safety and the protection of the environment. Therefore, the steering committee recommends that:

RECOMMENDATION 41

By the end of 2015, the Government of Alberta should determine the specific conditions under which an Environmental Impact Assessment (EIA) provides significantly greater understanding of potential impacts stemming from CCS projects or components than the understanding that can be achieved through other regulatory requirements. From that, the government should evaluate:

- a) If EIAs should be mandatory for CCS projects (or project components).
- b) Whether threshold criteria should be established that would call for mandatory EIAs for CCS projects.
- c) Whether a comprehensive assessment process specific to CCS should be developed that is appropriate for the unique aspects of CCS projects and builds upon current regulatory processes.

Until the above evaluation is complete, EIAs should be mandatory for CCS projects.⁷⁵



10.5 ENERGY RESOURCES CONSERVATION BOARD (ERCB) APPROVALS⁷⁶

After a project proponent acquires pore space tenure for CO₂ sequestration, they must acquire approvals from the ERCB to drill wells and to operate a CO₂ injection scheme. Approval for the operation of a CCS scheme in Alberta is the responsibility of the ERCB under the *Oil and Gas Conservation Act*. Currently, applicants for a CO₂ sequestration project use the acid gas disposal scheme requirements, which require approval for both surface and subsurface development, including ERCB's Directive 056, Directive 051 and Directive 065 approvals.

10.5.1 Stakeholder Engagement

One of the first steps an applicant must complete before submitting an application to the regulator is to develop and implement a participant involvement program. Alberta has a comprehensive regulatory framework in place for oil and gas developments which emphasizes the importance of effective, early and ongoing public engagement. Broadly, public engagement serves to inform local stakeholders and address concerns.

Participant involvement requirements and expectations exist within ERCB Directive 056, Directive 065, and Directive 071 that must be considered both in advance of submitting an application for energy development and throughout the life of that development. Prior to filing an application, the applicant must address all questions, objections and concerns regarding the proposed development and attempt to resolve them. This includes concerns and objections raised by members of the public, industry, government representatives, First Nations, Métis and other interested parties.

ERCB requirements and expectations for stakeholder engagement apply to First Nations and Métis stakeholders. The Government of Alberta also has policy⁷⁷ and guidelines⁷⁸ related to First Nations Consultation on land management and resource development. Consultation will be required if it is deemed that a project may adversely impact the Rights and Traditional Uses (e.g. by affecting animal populations on nearby lands on which a First Nation exercises a treaty right to hunt those animals for food). Proponents are strongly encouraged to begin notifying First Nations early on when planning their projects and, where possible, consult First Nations before applying for government approvals. The steering committee did not identify any need to make CCS-specific recommendations regarding First Nations and Métis engagement requirements.

⁷⁶ In November 2012, the Alberta Legislature passed the *Responsible Energy Development Act*, which creates a single regulator for all oil, gas, oil sands, coal, and CCS projects in the province. This means that the ERCB is transitioning into the Alberta Energy Regulator at the time of writing of this report. Any reference to the ERCB in this report is also intended to refer to the Alberta Energy Regulator.

⁷⁷ Government of Alberta, *The Government of Alberta's First Nations Consultation Policy on Land Management and Resource Development*, 2005.

⁷⁸ Government of Alberta, *Alberta's First Nations Consultation Guidelines on Land Management and Resource Development*, 2007.

Effective public engagement and participant involvement programs are critical to promote long term relationships that will foster a collective and amenable approach to CCS in Alberta. A sound process for participant involvement exists in Alberta. However, the challenges associated with analogous approaches and uncertainties around public acceptance of CCS underline the need for CCS-specific requirements. These requirements will provide clear and transparent direction to industry, provide opportunity for communication and feedback, and continue to make public safety and confidence paramount. Therefore, the steering committee recommends that:

RECOMMENDATION 42

The regulator should review consultation and notification requirements for CO₂ sequestration projects and implement industry-wide minimum requirements specific to CCS and the inherent challenges and risks. The review should achieve, but not be limited to, the following outcomes:

- a) Parties that may be affected through activities that require surface access must be identified and included in a participant involvement program. Consultation with these parties should include discussion of a MMV plan.
- b) Notification of land owners, occupants and residents, including First Nations and Métis, should occur over a wider range than is currently required. This will increase transparency, public assurance and acceptance, and decrease the chance of misinformation. Identification of the range of formal notification activities should occur on a case-by-case basis considering elements relevant to the project application. This could include the extent of MMV activities, inherent risks of the project, subsurface CO₂ dispersion and precedents set.
- c) Due to the extent and nature of large scale CO₂ sequestration operations, requirements to notify subsurface resources stakeholders, as defined in ERCB Directive 065, should extend beyond the 1.6 kilometres minimum currently required, but not further than the boundary of the sequestration lease.
- d) Establishment of the required consultation and notification distances for the purposes of emergency response planning with reference to the properties of CO₂ (e.g. heavier than air, odourless, potential risks to human health, public safety) and expected air dispersion.⁷⁹

Formal notification and consultation requirements would likely apply to a smaller area than that of the sequestration lease area. However, to promote public awareness and enhance public acceptance of CCS, it is important that all landowners, occupants and residents within the lease boundary have an opportunity to learn about the project outside of formal notification and consultation activities. Therefore, the steering committee recommends that:

RECOMMENDATION 43

Land owners, occupants and residents (including First Nations and Métis) within the sequestration lease boundary should be informed about the project by the operator of the project through activities that may include, but not be limited to:

- a) an expansion of consultation and notification requirements
- b) open houses
- c) information packages
- d) advertising in local media
- e) public outreach and education initiatives.

The scope of these activities should be developed in consultation with the regulator.⁸⁰

For many energy development projects, the regulator often requires operators to distribute standardized fact sheets as part of their project-specific information package that answer frequently asked questions on energy development topics (i.e. ERCB EnerFAQs). These documents are useful tools for increasing energy literacy in the province. Currently, the regulator does not have public information documents on CCS available for distribution. Because CCS is a relatively new process in Alberta, public acceptance and knowledge about it will be key to ensuring successful implementation. Therefore, the steering committee recommends that:

RECOMMENDATION 44

The Government of Alberta should develop public information documents on CCS.⁸¹

80 Refer to Appendix D13.

81 Refer to Appendix D13.

10.5.2 Well Classification and CCS Schemes

Upon development and implementation of a stakeholder engagement program, project proponents can submit applications to drill wells and develop a CO₂ injection scheme. There are several techniques to determine if a reservoir is suitable for CO₂ sequestration, among them drilling wells to confirm the characteristics of the subsurface geology. There are two main ERCB Directives that outline the requirements for acid gas/CO₂ injection wells. The requirements and procedures for filing energy development applications are set out in Directive 056. Directive 056 authorizations also include approvals to construct and operate any petroleum energy development, including surface facilities, pipelines and wells.

Once a well licence has been granted, proponents are then permitted to drill, log and complete a well. Several existing ERCB directives regulate well completion, including:

- Directive 008⁸², which regulates the minimum requirements for the depth of surface casing.
- Directive 009⁸³ and Directive 010⁸⁴, which regulate the minimum requirements for cementing and design.
- Directive 036⁸⁵, which regulates the requirements for drilling blowout prevention.

The ERCB requirements for initial drilling, completing, and open hole logging for acid gas well constructions are appropriate to meet the needs of CO₂ sequestration for large scale CCS injection wells.

Once a well has been drilled, logged and completed, an applicant must confirm the wellbore is suitable for acid gas injection. Directive 051 requirements are used to determine whether a well is both suitable and properly completed to handle the type of fluid proposed for injection or disposal. Directive 051 also clarifies completion, logging, testing, monitoring, and application requirements for injection and disposal wells, and specifies procedures designed to protect the subsurface environment, including potable groundwater and hydrocarbon-bearing zones.

Currently, CO₂ injection wells are classified as Class III wells under Directive 051. The Class III well classification covers a wide range of fluids and project activities. The ERCB is currently reviewing Directive 051 well classifications, and has proposed a new Class IIIa classification for injection wells for acid gas and impurities. The proposed new classification was reviewed by the working groups during the RFA, and it has been suggested that the proposed revisions and Class IIIa classification should consider all the various components and concentrations of fluids within the acid gas stream. This is important because there may be a continuum of gases in an acid gas stream, including CO₂ and H₂S, among others. Therefore, the steering committee recommends that:

RECOMMENDATION 45

Classification of CO₂ injection wells needs to be more specific and indicate the concentrations of other components at which a well will be classified as Class IIIa. All Class IIIa wells should be evaluated against the same criteria regardless of the purpose for which they are to be used.⁸⁶

82 Energy Resources Conservation Board, Directive 008: Surface Casing Depth Requirements, 2010.

83 Energy Resources Conservation Board, Directive 009: Casing Cementing Minimum Requirements, 1990.

84 Energy Resources Conservation Board, Directive 010: Minimum Casing Design Requirements, 2009.

85 Energy Resources Conservation Board, Directive 036: Drilling Blowout Prevention Requirements and Procedures, 2006.

86 Refer to Appendix D21.

Once the applicant determines that the well and reservoir are suitable for an acid gas disposal scheme, the applicant can file a disposal scheme application with regulator. Presently, CO₂ injection for CCS is regulated under the acid gas disposal section of ERCB Directive 065.⁸⁷ Directive 065 requires an applicant to provide the regulator with information regarding reservoir characteristics and details of the proposed scheme.

Directive 065 requires applicants to provide significant details to demonstrate a full understanding of the geology for a CO₂ injection scheme. These requirements have been designed to ensure containment of the disposal fluid within a defined area, and the protection of offset hydrocarbon-bearing zones and groundwater. Therefore, the standard Directive 065 approval process requires proponents to drill and complete all wells (each requiring an ERCB Directive 056 approval) prior to receiving approval for a sequestration scheme.

This standard Directive 065 approval process may not always be appropriate for some large scale CCS projects containing multiple potential wells. Multiple-well CCS projects will typically develop in phases over a number of years. During initial operation, only a select number of the potential wells are required. As a project matures, and the CO₂ plume migrates away from the initial injection wells, it may become necessary to drill additional injection wells to maintain or increase injection rates. Because some of the anticipated wells may not be needed initially, requiring all wells to be drilled at the outset of a project could increase the project risk by introducing unnecessary potential leakage pathways.

To address some of these challenges, the regulator should adopt a scheme approach for approval of long term, multiple-well CCS projects. An example of a scheme approach would be where a project proponent acquires Directive 065 scheme approval after drilling some, but not all, of the proposed wells for a project. This is similar to the modified application process that is used for in-situ oil sands projects, and was followed for a CCS project already under development. The scheme approach allows the project proponent, in consultation with the regulator, to define a range of project descriptions that can be refined over time. The scheme approach will allow the regulator to approve a reasonable number of initial wells to be drilled that will still ensure a sufficient understanding of the geology and other aspects of a CCS scheme. It may also provide an opportunity to enhance public engagement throughout the entire development of a CCS scheme. Therefore, the steering recommends that:

RECOMMENDATION 46

The regulator should adopt a scheme approach for approval of CCS projects involving multiple wells. These applications should continue to be considered by the regulator on a site-specific, case-by-case basis, based on risk analysis.⁸⁸

⁸⁷ Energy Resources Conservation Board, Directive 065: Resource Applications for Oil and Gas Reservoirs.
⁸⁸ Refer to Appendix D1.

After the ERCB has reviewed both Directive 065 and Directive 051 applications, and has a sufficient understanding of the project and all the potential impacts, a disposal scheme approval document is created. The approval document contains specific operating conditions, monitoring requirements, and reporting requirements for the specific disposal scheme. Transparency of information is important; as such, the regulator and industry should ensure easy public access to this information.

Current acid gas disposal scheme approvals require reporting to the ERCB on an annual basis to verify that the licensee is complying with the conditions stated in the approval. All standard monitoring and reporting is required for acid gas disposal schemes and wells, in addition to the monitoring and reporting requirements specified in the approval document.

To ensure that Alberta's regulatory framework for CCS is robust and adaptive in how it regulates projects, it will be important for the Government of Alberta to continue to leverage local and global CCS expertise and knowledge. One important piece is the Canadian Standards Association (CSA) document Z741-12: Geological Storage of Carbon Dioxide. The standard is the first of its kind in the world and proposes guidelines for regulatory agencies, industry and others involved with CCS projects. A review of this standard would identify similarities and differences between the standard and the principles, guidelines and requirements already in place in Alberta legislation (regulations, standards and directives). Therefore, the steering committee recommends that:

RECOMMENDATION 47

The Government of Alberta should undertake a review of the Canadian Standards Association Z741: Geological Storage of Carbon Dioxide following its final publication. The review would inform the decision as to whether the standard, or parts thereof, should be adopted by the province.⁸⁹

11 PRE-INJECTION PERIOD

11.1 OVERVIEW

The pre-injection period refers to the time from when the required initial regulatory approvals are received to the start of sustained injection. Several permits are required at this point in the development of a CO₂ sequestration project from different Government of Alberta departments and agencies. Certain activities can begin upon receipt of the initial permits and prior to final approval being granted to the project. As a result, some overlap will occur between the pre-injection period and the initial application and permitting period. Activities in the pre-injection period can include gathering additional information such as baseline monitoring data, drilling and completion of evaluation wells and an injection well, well integrity testing, and sequestration complex testing. Following final approval, construction of additional infrastructure can begin.



11.2 PRE-INJECTION MONITORING, MEASUREMENT AND VERIFICATION (MMV)

Following the selection of a sequestration site, several pre-injection tasks should take place with regard to monitoring. An initial monitoring, measurement and verification (MMV) plan is submitted with the application for an evaluation permit or a carbon sequestration lease. Once tenure is granted, the MMV plan will be refined during the pre-injection period. In the MMV plan, monitoring tasks are identified based on a site-specific risk assessment. The specific technologies to monitor areas of potential leakage are screened, evaluated and selected. The frequency of monitoring is determined and a schedule is proposed. Appropriate baseline data are acquired for monitoring targets using technologies selected. Some data used to characterize and select the site (e.g. seismic data) may form part of the baseline data set. Approvals for CO₂ sequestration projects may contain conditions from the ERCB or Alberta Environment and Sustainable Resource Development. Any additional monitoring and/or baseline data requirements identified by the regulator are incorporated into the MMV plan during the pre-operational period.

11.3 INJECTION WELL DRILLING, COMPLETION AND TESTING

As noted previously, an applicant must determine that the well and reservoir are suitable for a CO₂ sequestration scheme as per ERCB Directive 065. Once a well license is received, an operator can drill, complete and test an injection well. The particular requirements for this fall under ERCB Directive 051. This directive clarifies completion, logging, testing, monitoring, and application requirements for injection and disposal wells. Procedures and practices to protect the subsurface environment, including all potable groundwater, formation waters of potential economic value and hydrocarbon-bearing zones are specified. Within Directive 051, CO₂ injection wells are classified as Class III wells. It is of note that Directive 051 is one of a series of directives currently being reviewed by the ERCB. Figure 12 represents the construction of an injection well.

Other ERCB directives applicable to CO₂ well design and integrity that were also investigated include:

- Directive 008: Surface Casing Depth Requirements
- Directive 020: Well Abandonment
- Directive 009: Casing Cementing Minimum Requirements
- Directive 010: Minimum Casing Design Requirements.

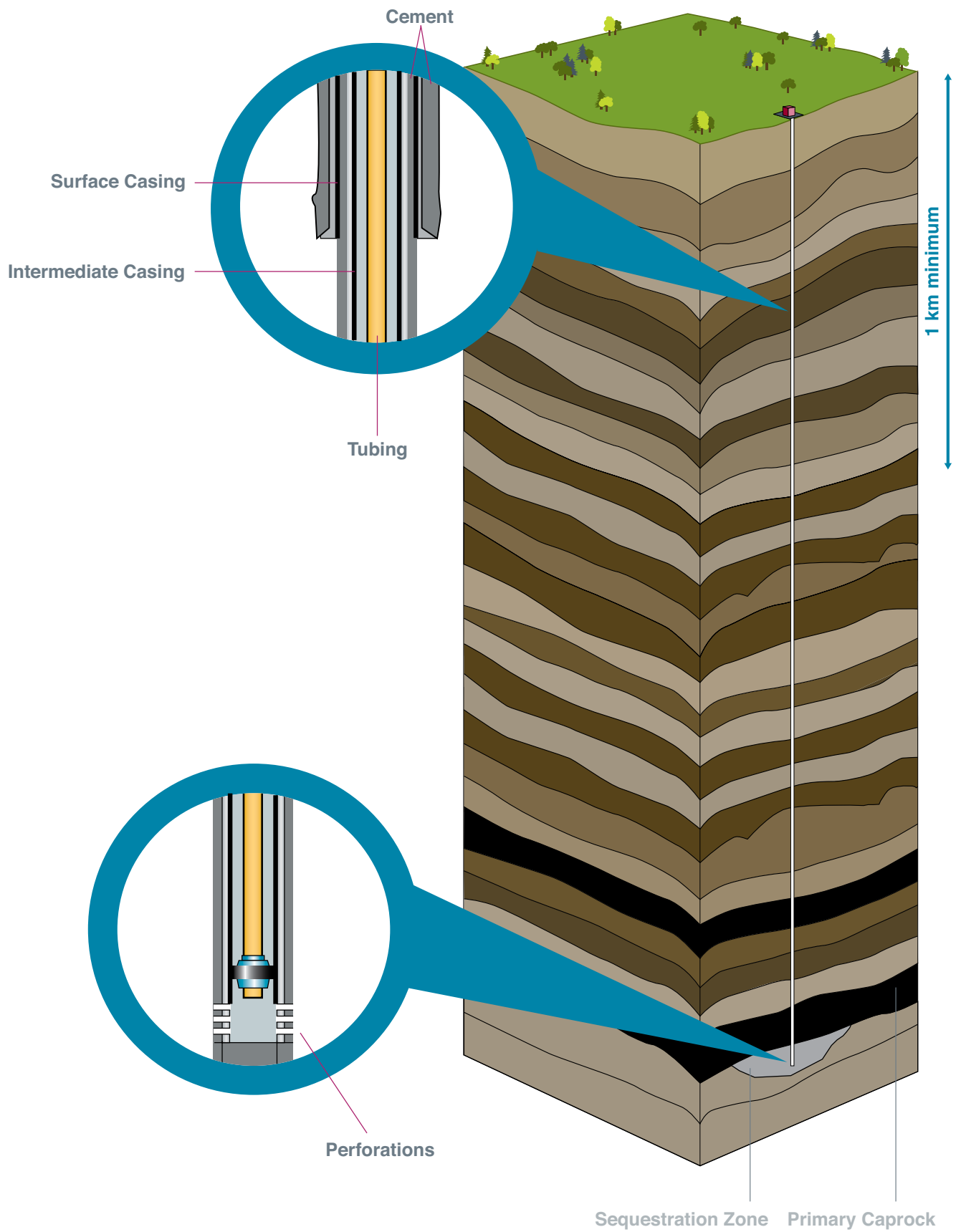


Figure 12. Schematic Representation of an Injection Well.

A study that reviewed CO₂ and acid gas injection well failures in Alberta concluded that cementing to the surface is a key element for reducing the incidence of well failures. This includes surface casing vent flow and gas migration.⁹⁰ The ERCB draft revision of Directive 051 proposes that CO₂ injection wells (proposed Class IIIa) require cementing to surface for both the surface and the next casing string run (see Figure 12). It was determined that, if implemented, the proposed requirements in conjunction with other casing and cementing measures may be adequate for the purposes of CO₂ sequestration.

Cementing to surface from both the surface and next casing string is the norm for new acid gas injection wells in Alberta. However, there may be reasons for a proponent to propose a modified well completion to the regulator including the need to implement specialized MMV technologies, or to obtain reservoir fluid samples that have not been contaminated by cement. A proponent may also wish to propose a modified well completion if they intend to convert existing wells, which currently do not meet the new Class IIIa cementing requirement, into injection wells. Based on the review of the current and proposed well construction requirements, the steering committee recommends that:

RECOMMENDATION 48

The regulator's proposed requirements for surface casing, cementing the surface casing, and the next external casing string from the base of well (casing shoe) to the surface will generally be adequate for the purposes of CCS. However, if additional casing strings are used, the combined casing strings must isolate all formations from the base of the well to the surface.

These requirements should be applicable to all Class IIIa wells (new wells and conversions). However, the proponent may propose a modified well completion which will be reviewed by the regulator using a performance-based approach as is the current practice. The reasons for a modified well completion may include:

- a) Differences in the age, construction and prior use of converted wells (i.e. existing wells may be suitable for conversion to injection in an enhanced oil recovery scheme using the current risk-based assessment practice).
- b) The implementation of special MMV technology (such as a downhole fluid sampling apparatus).
- c) The need to obtain fluid samples that have not been contaminated by cementing.⁹¹

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S. Bachu and T.L. Watson, *Review of failures for wells used for CO₂ and acid gas injection in Alberta, Canada*, Energy Procedia 1 (2009), p. 3536. Refer to Appendix D21.

ERCB Directive 010 details minimum casing design requirements and includes information and requirements on various design criteria, including burst and yield strengths, alternative design methods and casing wear considerations. Licensees must also follow Directive 010 appendices to select the proper material specifications for all wells, taking into account composition and design factors, to determine the appropriate material specifications. When selecting materials, the licensee must consider current and anticipated future reservoir environments. Based on the review of the current requirement, the steering committee concludes that:

CONCLUSION 5

ERCB directives adequately cover material selection, casing and well head pressure requirements.⁹²

The proposed Directive 051 update will prescribe many of the requirements, including the frequency for hydraulic isolation and casing inspection logging. To address ongoing integrity and hydraulic isolation, Directive 065 also has minimum measurement and reporting requirements for well operation, corrosion protection and hydraulic isolation logs. The working groups found that current requirements for CO₂ injection wells are appropriate for large scale CO₂ sequestration projects and adequately protect underground sources of potable water. Therefore, the steering committee concludes that:

CONCLUSION 6

Current and proposed regulations adequately address the integrity and hydraulic isolation of well construction and testing requirements for new CO₂ repository wells.⁹³

⁹² Refer to Appendix D21.

⁹³ Refer to Appendix D21.

12 INJECTION PERIOD

12.1 OVERVIEW

Once all project regulatory approvals are granted and construction is complete, a CO₂ sequestration project can begin operation and enter the injection period. The injection period is from the start of sustained injection (consistent with project applications) to permanent cessation of injection (with no further intent to resume operations). During this time, the project operator is responsible for operating the project as required by the regulations and within the parameters of the approval. Ongoing compliance is ensured by the ERCB and Alberta Environment and Sustainable Resource Development. The operator conducts monitoring as outlined in the project monitoring, measurement and verification plan and as required in the project approval. Reporting and updates to approvals and plans are submitted to the regulator as required throughout the injection period. Operators also have an obligation in this period to pay a fee-per-tonne rate into the Post-closure Stewardship Fund.



12.2 MONITORING, MEASUREMENT AND VERIFICATION (MMV)

During the injection period, monitoring is undertaken to demonstrate compliance with legislation, applications and approvals. At this point, data are gathered to demonstrate containment, conformance and use of the pore space. Monitoring results are used to inform and optimize project operations as well as trigger the investigation of non-conformance and mitigation and/or remediation activities as required. Monitoring data are used to ensure public safety and to confirm that the environment and availability of underground sources of drinking water are not adversely affected.

Updated MMV plans are submitted every three years along with an updated closure plan. Risk assessment is an iterative activity, and monitoring results are used to inform and update the project risk assessment. Monitoring technologies are evaluated during the injection period to ensure effectiveness. Results will also be incorporated into simulations and models so that actual and predicted behaviour can be compared and the MMV plan can be updated as necessary. This process will enable a systematic improvement of model predictive capability throughout the injection period. Ongoing dialogue with the regulator ensures that time-sensitive data are collected when available and to the extent required.

Conducting MMV activities are imperative in order to demonstrate conformance and containment of sequestered CO₂. The majority of MMV activities will occur in the areas overlying and surrounding the CO₂ plume, however there may be some activities required beyond them. Certain MMV techniques cannot provide complete data if access cannot be gained to key monitoring areas.

If access to land is required for MMV activities, an operator would typically negotiate with the private land owner (or Alberta Environment and Sustainable Resource Development for public land) to reach an agreement around land access. These agreements would also include compensation measures and address land owner concerns. If negotiations are unsuccessful, the *Surface Rights Act* enables the Surface Rights Board to issue a Right of Entry Order to an operator in order to conduct MMV activities. However, there is currently uncertainty as to whether the *Surface Rights Act* allows an operator access to land beyond the surface lease site (i.e. lands associated with wells, installations, pipelines or other lands required to give the operator access to the drilling operations). As a result, the steering committee recommends that:

RECOMMENDATION 49

The *Surface Rights Act* should be amended to enable the Surface Rights Board to grant an operator a Right of Entry Order for any land within the carbon sequestration lease or evaluation permit boundary in order to conduct required MMV activities as outlined in an approved MMV plan pursuant to Part 9 of the *Mines and Minerals Act*.⁹⁴

It is crucial that the process to review applications for Right of Entry Orders is rigorous and transparent to ensure that the process is fair to landowners and that their rights are adequately taken into account. The Government of Alberta's recent Property Rights Task Force recognized this point, which led the government to commit to a review of the *Surface Rights Act* and *Expropriation Act*, and create a Property Rights Advocate. Recommendation 49 should be considered by the Government of Alberta in light of this need for a rigorous and transparent process and should take into consideration the results of reviewing those two acts.

12.3 REPORTING

The Carbon Sequestration Tenure Regulation presently requires an annual report to the Minister of Energy containing the findings and observations from MMV activities conducted for carbon sequestration lease holders.⁹⁵ Reporting requirements have been reviewed and it was found that there are well established regulatory processes in place for reporting of volumetric data and monthly operations (e.g. injected volume and well status). These same requirements for measurement and production reporting would be applicable to carbon sequestration projects. The regulator acts as a data repository and manager, and handles public requests for information for upstream petroleum operations. The steering committee considers that this existing reporting system should be extended to include MMV data for carbon sequestration projects, and therefore the steering committee recommends that:

RECOMMENDATION 50

Reporting of MMV results by the project operator should fall under the jurisdiction of the regulator, following similar processes for approval of specific reporting requirements for upstream petroleum operations.⁹⁶

For the Government of Alberta to act as the operator after transfer of liability, it will need sufficient information about the project. To ensure that the Government of Alberta will receive all the necessary data, and that the lessee will know well in advance what data it will need to transfer, these data requirements should be discussed early in the project life and reviewed regularly. Designation of an authority with the sufficient experience to deal with this information will help to ensure the appropriate management of submitted data. As a result, the steering committee recommends that:

⁹⁵ Carbon Sequestration Tenure Regulation, Section 17(2), 2011.
⁹⁶ Refer to Appendix D9.

RECOMMENDATION 51

The Government of Alberta should designate an agency (either existing or a new one) to be responsible for the management of data submitted by operators of CCS projects.

This agency should develop and implement standards for the transfer and management of project data to the Government of Alberta. These standards will ensure that data are in a consistent, accessible, readable and interpretable format, and will prevent the loss of data.⁹⁷

Under Alberta's Specified Gas Emitters Regulation, the use of offset credits is one of three compliance options available to regulated facilities (industrial facilities in Alberta emitting over 100,000 tonnes of CO₂ equivalent per year) to reduce emissions intensity. The Quantification Protocol for Capture of CO₂ and Permanent Storage in Deep Saline Aquifers is being finalized and will apply to CO₂ sequestration projects in deep saline formations. With respect to the offset protocol, the MMV plan will provide evidence of permanent containment of CO₂ in the sequestration complex, and that there is no release of CO₂ to the atmosphere. To ensure that offset credits for CO₂ sequestration are real and permanent reductions are achieved, the steering committee recommends that:

RECOMMENDATION 52

If any CO₂ is produced and/or released that was injected under a carbon sequestration lease, it must be accounted for and reported, and previously earned emissions reduction credits must be reconciled and/or properly accounted for under any other potential future provincial climate change policies.⁹⁸

The Government of Alberta should determine the appropriate threshold of CO₂ volume produced or released that would trigger this requirement.

97 Refer to Appendix D2.

98 Refer to Appendix D1.

12.4 POST-CLOSURE STEWARDSHIP FUND AND FINANCIAL SECURITY

The Government of Alberta passed legislation to assume regulatory and civil liabilities and obligations of the lessee upon the issuance of a closure certificate.⁹⁹ To ensure that costs associated with those liabilities and obligations will not become a burden to Albertans, the Post-closure Stewardship Fund (PCSF) was created in 2010 with passing of the *Carbon Capture and Storage Statutes Amendment Act, 2010*. The PCSF was established to cover the costs associated with some of those liabilities and obligations in the post-closure period, and to protect the Alberta public from bearing those costs. Holders of carbon sequestration leases must pay into the PCSF at a yet to be specified rate per tonne of CO₂ injected. Section 122 of the *Mines and Minerals Act* establishes the PCSF and sets out the allowable uses. Currently, the PCSF can be used for monitoring injected CO₂, paying for expenses related to orphan facilities and fulfilling the other obligations assumed by the Government of Alberta upon issuance of a closure certificate.

The rates that commercial operators will pay into the PCSF should be determined based on the allowable uses of the fund. Therefore, the steering committee recommends that:

RECOMMENDATION 53

The Post-closure Stewardship Fund (PCSF) rate should include three components:

- a) monitoring and maintenance,
- b) unforeseen events and,
- c) administrative costs associated with management of the PCSF and management of the data submitted by the lessee.

These components should be used only for calculating the PCSF rate. Money collected into the PCSF should not be segregated into these components.¹⁰⁰

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A discussion of the liabilities and obligations assumed by the Government of Alberta upon the closure of a sequestration site is found in Section 14. Refer to Appendix D12.

The Government of Alberta should set a PCSF rate (fee per tonne of injected CO₂) for each project individually. This means the rate would be calculated based only on the risks and cost obligations of each respective project. The rate for a project would not be changed directly as a result of withdrawals from the fund to cover costs associated with other projects. Because CCS as an integrated activity is relatively new, there is still uncertainty about the potential costs the Government of Alberta will be required to bear after a closure certificate is issued. As a result, the rate and financial security requirements (see recommendation 56 below) should be periodically reviewed. These reviews will allow the rate to incorporate knowledge and operating history of the project. To ensure that the rate paid by lessees is appropriate and reasonable, the steering committee recommends that:

RECOMMENDATION 54

The Post-closure Stewardship Fund rate that lessees pay should:

- a) Be set on a risk-based and probability-weighted basis.
- b) Be based only on the specifics of the lessee's project.
- c) Not increase due to withdrawals from the PCSF, or risks associated with other projects.
- d) Be reviewed, along with the security posted by the lessee, every three years in accordance with the above requirements. Any adjustments to the PCSF rate during these reviews should be on a go-forward basis only and not be retroactive.¹⁰¹

The funds paid into the PCSF by lessees should be pooled into a common fund. Pooling of PCSF funds will help ensure that sufficient money is available in the unlikely event of an incident. Therefore the steering committee recommends that:

RECOMMENDATION 55

Funds paid into the PCSF should be pooled amongst all PCSF payees.¹⁰²

101 Refer to Appendix D12.

102 Refer to Appendix D12 for further information and a non-consensus viewpoint.

In Alberta, the Orphan Well Fund is used to cover the costs incurred by the ERCB for the abandonment and reclamation of orphaned upstream oil and gas wells, facilities and pipelines. Contributions to the Orphan Well Fund are collected from industry participants on an annual basis, and some operators must post financial security as outlined by the regulator in Directive 006.¹⁰³ The existing provisions for financial security do not currently extend to CCS projects. Therefore, to reduce the rate paid by lessees to cover the costs associated with orphaned facilities as stipulated by the *Mines and Minerals Act*, and to avoid operators paying for orphaned facilities from other companies, the steering committee recommends that:

RECOMMENDATION 56

The Government of Alberta should require lessees to post financial security sufficient to cover the full anticipated cost of suspension, abandonment, remediation and reclamation, including surface and subsurface costs, in case a CO₂ sequestration operation becomes orphaned before the issuance of a closure certificate. The acceptable forms of security instruments and the calculation of the amount of security required should be determined by the regulator. This security would be returned to the lessee when a closure certificate is issued.¹⁰⁴

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Energy Resources Conservation Board, Directive 006: Licensee Liability Rating Program (LLR) Program and Licence Transfer Process, 2009.
Refer to Appendix D12.



The requirement to post this security would only be applied to CO₂ sequestration projects, and not to capture or transport facilities and infrastructure. The regulator already has experience, expertise and established processes for financial security. Therefore it is appropriate for the regulator to make these determinations for CCS operations.

As three-year rate reviews are completed and more projects enter the industry, the rate setting process and other PCSF policies should be reviewed to determine whether or not they are still appropriate. For example, if it becomes apparent rates are generally similar or within the same range, there may be justification for switching to a uniform rate or a set of rate classes. Thus the steering committee recommends that:

RECOMMENDATION 57

As the number of CCS projects increases, and the Government of Alberta and lessees gain experience with CCS and the rate setting process, the recommendations related to the PCSF, and the associated policies, should be reviewed.¹⁰⁵

13 CLOSURE PERIOD

13.1 OVERVIEW

The closure period is the time between permanent cessation of injection and the closure point, when the closure certificate is issued. During this period, monitoring continues to ensure conformance of the sequestered CO₂, while abandonment and reclamation occur to the extent required by the regulator.



13.2 ENTERING THE CLOSURE PERIOD

The closure process is new in Alberta and needs to be detailed to provide transparency to project proponents, operators and the public. As a result the steering committee recommends that:

RECOMMENDATION 58

The Government of Alberta and the regulator should develop an outline of the closure process. This outline should detail the criteria and order of events necessary for closure from submission of the initial closure plan to issuance of a closure certificate.¹⁰⁶

A suggested outline would include an initial closure plan, interim closure plans, a final closure plan, and a final closure and MMV report. Project operators and regulatory agencies should communicate throughout the injection period to ensure that MMV and closure plans evolve as required. As a project progresses, a staged approach to reporting and the review of closure criteria will help ensure that time-sensitive data are collected when available and to the extent required by the regulator. This process is depicted in Table 3.

Table 3. Timeline of the Closure Process

Tenure Application	Injection Period	Closure Period	Closure Point
Initial closure plan (submitted with tenure application)	Interim closure plans (submitted every three years)	Final closure plan (submitted to enter the closure period)	Final closure and MMV report (submitted as part of closure certificate application)

In the development of MMV and closure plans, a site-specific risk assessment is used to identify adverse events, assess the likelihood of their occurrence and to inform project risk management activities. One area of concern for CO₂ sequestration is the wells that penetrate the sequestration complex within the area of review as some of these wells could provide potential pathways for loss of containment. During the injection period, the movement of the CO₂ plume within the area of review may be different than that initially predicted (i.e. due to subsurface conditions, modelling techniques and/or changes in operation). The actual movement of the plume and pressure front could impact wells penetrating the sequestration complex that were not initially anticipated to be affected. Both existing and new wells need to be addressed in the closure plans,¹⁰⁷ and as a result the steering committee recommends that:

RECOMMENDATION 59

The Government of Alberta should require that interim and final closure plans include assessment of all the wells that have penetrated the sequestration complex within the area of review¹⁰⁸ to ensure that the evolution of the CO₂ plume or pressure front over the life of the project has not introduced potential leakage pathways that were not anticipated.¹⁰⁹

To enter the closure period it is recommended that a final closure plan be submitted outlining:

- Intentions to stop injecting CO₂ and enter the closure period.
- How compliance with closure requirements will be achieved.

The closure period begins at a time authorized by the regulator. This is when the final closure plan is approved, and not before the permanent cessation of injection has occurred. Appropriate advance notice is necessary so that the regulator and the lessee can discuss the lessee's intent to enter the closure period. Therefore, the steering committee recommends that:

RECOMMENDATION 60

Notwithstanding other obligations for suspension and abandonment of facilities, the closure period should be considered to begin on a date authorized by the regulator when it is reviewing and approving the final closure plan. This date should be no earlier than the time at which the lessee permanently ceases CO₂ injection (planned or unplanned), or if the Government of Alberta withdraws approval, or the lease expires.

The lessee should be required to provide the regulator with appropriate advance notice of intent to enter the closure period and submit the final closure plan for approval at that time. The lessee should be required to continue normal operational monitoring until initiation of a formal closure plan.¹¹⁰

107 Licensees of third-party petroleum and natural gas wells penetrating the sequestration complex retain perpetual liability for well abandonment and site reclamation.

108 See Appendix C for a description.

109 Refer to Appendix D16.

110 Refer to Appendix D2.



13.3 CLOSURE PERIOD ACTIVITIES

During the closure period, CO₂ sequestration project operators must continue certain monitoring activities to demonstrate containment and conformance of the sequestered CO₂. Well abandonment and surface reclamation activities are completed to the extent possible as agreed upon with the regulator. When requested, the project operator will also provide information to the regulator regarding appropriate MMV techniques that could be used in the post-closure period.

To help ensure that the sequestered CO₂ is permanently isolated, abandonment of the injection wells is required unless they are converted into monitoring wells. ERCB directives address timeframes and technical requirements for well abandonment. The objective of a well abandonment as described in Directive 020 is to protect all non-saline groundwater and to isolate all porous zones with cement. Acid resistant cement is not a prescribed requirement. However, CO₂ sequestration wells undergo a detailed review and have more stringent abandonment requirements than conventional oil and gas wells. As a result, the steering committee recommends that:

RECOMMENDATION 61

ERCB directives provide adequate guidance for the abandonment of CO₂ injection wells. A best practices review should be undertaken to determine whether acid-resistant cement should be required.¹¹¹

Proposed abandonment plans for CO₂ sequestration wells are reviewed and approved as part of the closure plan. With current technology, abandonment of down-hole monitoring equipment will also occur as wells are abandoned. The timing of well abandonment activities must take into consideration the requirements and availability of data.

Reclamation activities will also occur during the closure period. Complete site reclamation in the closure period may not be desired for CO₂ sequestration projects as MMV equipment and access to the site may be required by the regulator for monitoring in the post-closure period. Arrangements are made between the regulator and the operator for the transfer of any MMV equipment that the regulator requires to be left in place at the point of closure. It must be assured that any down-hole MMV equipment left in place will not compromise the long term integrity of the abandoned wells. Proposed reclamation activities will be included in the final closure plan and will be approved by the regulator. The Government of Alberta's existing surface reclamation requirements under the Conservation and Reclamation Regulation for both injection well sites and pipelines are scientifically and technically sound. There is no evidence that CO₂ injection wells and pipelines will cause surface disturbances that differ from those currently created by well sites or pipelines. As a result, the steering committee concludes that:

CONCLUSION 7

It is appropriate for the Government of Alberta to continue requiring the following for surface reclamation for CCS:

- a) CO₂ injection site reclamation follows the current physical and technical requirements for upstream oil and gas projects.
- b) CO₂ pipeline site reclamation follows the current physical and technical reclamation requirements for pipelines.
- c) Operators remain accountable for site reclamation, while allowing for required infrastructure to remain in place where necessary for long term monitoring activities.¹¹²

13.4 REQUIREMENTS FOR A CLOSURE CERTIFICATE

The steering committee recommends that an operator receive a closure certificate once they can demonstrate that the site is in compliance with performance criteria for closure, and not before a minimum period has passed. While the sustained compliance with performance criteria is the primary requirement, a minimum closure period is necessary to allow the Government of Alberta to be confident the site is in compliance before accepting future liability for the site. This will also enhance public confidence in the process.

112 Refer to Appendix D19.

Because CCS is new as an integrated activity, and minimum closure periods vary widely among other jurisdictions, it is difficult to determine what the minimum time period should be. After analysis, the steering committee decided it was most appropriate to accept the recommendation of the Alberta CCS Development Council and recommend a 10-year minimum period.¹¹³ This is shorter than in most other jurisdictions, but it is proposed as a non-discretionary minimum and is backed by the sustained performance criteria. This approach means that if there are any issues with performance, a longer period of time may be necessary to demonstrate sustained compliance. The regulator must determine how sustained compliance should be interpreted and implemented based on risk analysis on a case-by-case basis. In regard to the closure period, the steering committee recommends that:

RECOMMENDATION 62

The Government of Alberta should only grant a closure certificate after a period no shorter than 10 years after commencement of the closure period and when the lessee has demonstrated sustained compliance with required performance criteria for closure.

As more experience is gained in CCS, the Government of Alberta should re-evaluate the appropriateness of the performance criteria for closure and the minimum closure period.¹¹⁴

113 Government of Alberta, *Accelerating Carbon Capture and Storage Implementation in Alberta*, 2009. Retrievable at: http://www.energy.gov.ab.ca/Org/pdfs/CCS_Implementation.pdf

114 Refer to Appendix D2.

Demonstration of compliance with closure requirements for a site should include interpretation of MMV data, simulations and modelling, and completion of all surface reclamation and well abandonments. The regulator and the project operator should agree on how the project will demonstrate that CO₂ behavior is predictable and trending towards stability for the site and how the evidence being collected supports these criteria. The steering committee recommends that:

RECOMMENDATION 63

The Government of Alberta should require the following performance criteria for closure of a project:

- a) Sequestered CO₂ and affected fluids are conforming to the objectives and regulatory requirements as described in the project application and approvals.
- b) There is no significant adverse effect of sequestered CO₂ or affected fluids to health, the environment and other resources (including but not limited to hydrocarbons, non-saline groundwater and pore space outside of the operator's sequestration lease).
- c) Sequestered CO₂ and affected fluids are contained in the sequestration complex.
- d) Sequestered CO₂ is behaving in a predictable manner.
- e) Sequestered CO₂ is expected to continue to behave in a predictable manner and is trending towards stability.
- f) The project-specific risk profile is decreasing and the risk of future leakage or adverse effects on health, the environment or other resources is acceptable.
- g) Decommissioning and abandonment is complete as required by the regulator.
- h) Surface reclamation is complete to the extent agreed upon with the regulator for the post-closure period.¹¹⁵

Current regulatory requirements for well abandonment were reviewed and it was found that testing, subsurface isolation and subsurface abandonment practices are adequate to ensure conformance and containment of wells used for the purpose of CO₂ sequestration. Any applicable advances in abandonment techniques and practices should be incorporated into abandonment requirements for wells in the future. The steering committee concludes that:

CONCLUSION 8

The current ERCB Directive 020 adequately addresses the conformance and containment requirements for abandonment of wells used for CO₂ sequestration.¹¹⁶

To apply for a closure certificate, the lessee must demonstrate how it has complied with the closure requirements and fulfilled the terms of its closure plan. The lessee should also be expected to provide evidence that other requirements have been met such as well abandonment, satisfaction of financial obligations and reconciliation of CO₂ credits. As a result, the steering committee recommends that:

RECOMMENDATION 64

Lessees should be required to submit a final closure and MMV report as part of the application for a closure certificate. This report should detail how the lessee addressed items within the closure plan and achieved the requirements for closure, including compliance with performance criteria.¹¹⁷

¹¹⁶ Refer to Appendix D16.

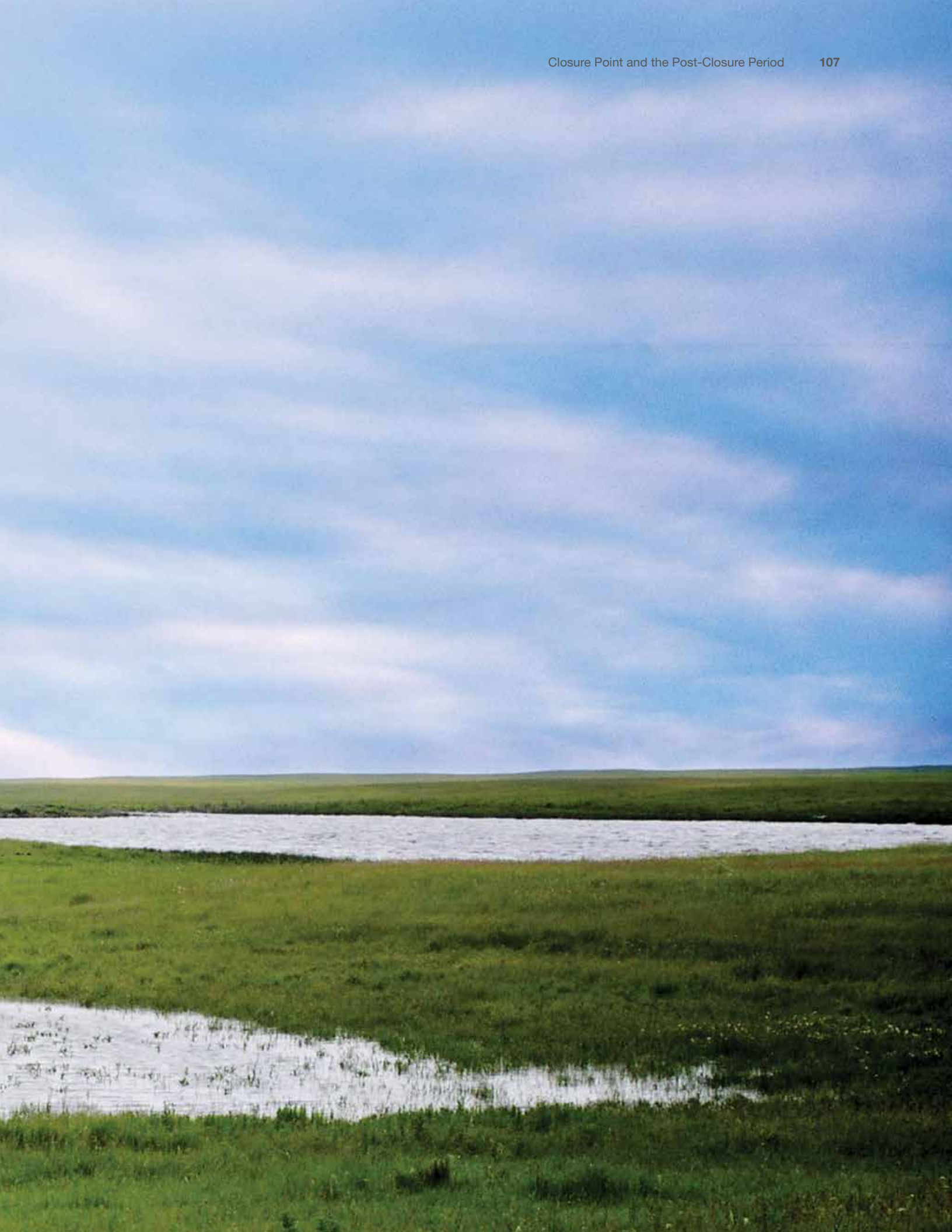
¹¹⁷ Refer to Appendix D2.

14 CLOSURE POINT AND THE POST-CLOSURE PERIOD

14.1 OVERVIEW

Following the recommended minimum 10-year closure period, and upon meeting performance criteria, an operator can apply for a closure certificate. Upon receipt of a closure certificate application, the Government of Alberta will undertake a detailed review to determine if all the requirements for closure have been met. The issuance of a closure certificate to a project operator signifies that a project has successfully reached the closure point. At this point responsibility and long term liability for the sequestered CO₂ are transferred from the project operator to the Government of Alberta. The post-closure period starts with the closure point and continues in perpetuity.







14.2 ASSUMPTION OF LIABILITY

Under the *Carbon Capture and Storage Statutes Amendment Act, 2010* the Government of Alberta assumes long term liability for a CCS storage site once a closure certificate is issued. CCS projects are long term, and the CO₂ sequestered during a project remains trapped underground for hundreds, and potentially, thousands of years. Due to these long timeframes, it is conceivable that the sequestered CO₂ will remain in place much longer than any corporation or company operating a project would be expected to exist. Therefore, the Government of Alberta made a policy decision to assume long term responsibility for the sequestered CO₂ to ensure that it will be monitored and, if necessary, managed in the future. This assumption of liability for the sequestered CO₂ differs from the perpetual liability that operators hold for other upstream petroleum operations. The Government of Alberta's policy decision to assume long term liability for CCS was also designed to incent CCS development, and to ensure long term stewardship of the sequestered CO₂. The requirements for closure, outlined in both closure and MMV plans, have been designed to minimize the risks to the province in accepting long term liability for the sequestered CO₂.

The *Mines and Minerals Act*¹¹⁸ sets out the liabilities and obligations that the Government of Alberta will assume when it issues a closure certificate. When issuing a closure certificate, the Government of Alberta becomes the owner of all injected CO₂, and assumes all obligations of the lessee, including responsibilities related to wells and facilities, the environment and land.

118 Refer to Appendix D2.

In addition to the obligations already included in the *Mines and Minerals Act*, the working groups identified liability for CO₂ credits as another liability that should be assumed by the Government of Alberta following the issuance of a closure certificate. Alberta has a regulated carbon offset market where offset credits can be purchased by large industrial emitters or other interested parties. CCS offers an opportunity for large industrial emitters to generate offset credits by sequestering their CO₂ emissions deep underground. These industrial facilities can then use the credits to meet their own compliance obligations with the province's greenhouse gas emissions reduction program, or sell the credits that they generate to other industrial emitters who need to comply with the reduction program.¹¹⁹ Offset credits would be generated for every tonne of sequestered CO₂ from eligible and participating projects.¹²⁰

If there is loss of CO₂ containment from a sequestration site in the post-closure period, it will be necessary to account for the quantities of CO₂ released in order to ensure accurate greenhouse gas accounting and reporting in the province. As owner of the CO₂ in the post-closure period, the Government of Alberta should accept liability for reconciling CO₂ credits or other climate change obligations that may be required. Assumption of these liabilities will be important for building confidence in Alberta's climate change accounting and reduction program. The closure requirements outlined in the MMV and closure plans are important tools that the Government of Alberta will be able to use to ensure that these liabilities will not become a burden for Albertans. By issuing a closure certificate, the Government of Alberta will signal that it is confident that the CO₂ has been permanently and safely sequestered at the site. Therefore, to be consistent with the treatment of other CCS liabilities, and to support Alberta's greenhouse gas emission reduction goals, the steering committee recommends that:

RECOMMENDATION 65

Section 121(1)(b) of the *Mines and Minerals Act* should be amended to include responsibilities under the *Climate Change and Emissions Management Act* and other provincial climate change legislation in the list of liabilities that transfer to the Crown when a closure certificate is issued.¹²¹

119 See the Alberta *Climate Change and Emissions Management Act* and related regulations for more information.

120 A draft Quantification Protocol for the Capture of CO₂ and Storage in Deep Saline Aquifers is currently being reviewed by Alberta Environment and Sustainable Resource Development.

121 Refer to Appendix D2.

14.3 ALLOWABLE USES OF THE POST-CLOSURE STEWARDSHIP FUND

The Post-closure Stewardship Fund (PCSF) was established in order to ensure that liabilities for the sequestered CO₂ assumed by the Government of Alberta will not become a burden to Albertans by protecting the public from bearing the costs of post-closure liabilities. Funds are collected from the CCS operator during the injection period of a project to cover potential costs for liabilities arising during the post-closure period.

The *Mines and Minerals Act* also outlines the allowable uses of the PCSF. Currently, the PCSF can be used for monitoring the sequestered CO₂, paying for expenses related to orphan facilities and fulfilling the other obligations assumed by the Government of Alberta upon issuance of a closure certificate. Given that the steering committee is recommending that climate change liabilities under the *Climate Change and Emissions Management Act* be added to the list of assumed liabilities transferred to the Government of Alberta upon closure, those future costs should be included in the rate calculation and be allowable uses of the PCSF. Therefore, the steering committee recommends that:

RECOMMENDATION 66

The allowable uses of the PCSF should be expanded to include covering costs associated with the assumption of liabilities under the *Climate Change and Emissions Management Act* and other provincial climate change legislation.¹²²

When amending the *Mines and Minerals Act*, the Government of Alberta made a policy decision to indemnify lessees against liability for tort damages that may arise in the post-closure period.¹²³ Costs associated with any actions in tort brought against a closed sequestration site by another party will be the responsibility of the Government of Alberta. The costs associated with indemnifying the operator against tort damages, however, are not currently covered by the PCSF, despite being included as a transferred liability upon closure. The policy decision to exclude post-closure tort indemnification from the PCSF was intended to provide an incentive to encourage CCS development, by decreasing the amount of money that operators will have to pay into the PCSF.

Recognizing that deployment of CCS is vital for reducing greenhouse gas emissions, the Government of Alberta's decision to exclude tort indemnification as an allowable use of the PCSF is appropriate and necessary at this time. Rather than paying into the PCSF to cover the long term costs associated with tort indemnification, the Government of Alberta can use the stringency of site selection, MMV, and closure requirements to minimize the public's exposure to potential risks in the post-closure period. Therefore, the steering committee concludes that:

CONCLUSION 9

The Government of Alberta's previous decision to exclude costs associated with indemnification against tort damages (Section 121(2) of the *Mines and Minerals Act*), as an allowable use of the PCSF is appropriate.¹²⁴

¹²² Refer to Appendix D12.

¹²³ *Mines and Minerals Act*, Section 121(2), 2000.

¹²⁴ Refer to in Appendix D12 for further information and a non-consensus viewpoint.



14.4 POST-CLOSURE MONITORING AND REMEDIATION

Post-closure monitoring and remediation (in the case of unforeseen CO₂ release from the sequestration complex) is important for developing and maintaining public support for CCS development. Once a CO₂ sequestration project is closed, and ownership and liability for the CO₂ has been transferred to the Government of Alberta, the province will be responsible for conducting post-closure monitoring and any potential remediation. The degree and type of post-closure monitoring will be determined on a site-specific and risk-based basis.

CO₂ sequestration projects can occupy vast geographic areas, requiring multi-technology monitoring programs. It will be important for the Government of Alberta to be able to gain surface access to lands above the sequestration complex in order to monitor the sequestered CO₂. The *Carbon Capture and Storage Statutes Amendment Act, 2010* made changes to surface access, enabling the Surface Rights Board to issue a Right of Entry Order to an operator to allow them to conduct the required monitoring, measurement and verification specified in an approved MMV plan. A Right of Entry Order can only be granted once all avenues of private negotiation have been exhausted. Currently, no provisions exist to enable the Government of Alberta to gain surface access to conduct MMV activities following the transfer of liability. Therefore, the steering committee recommends that:

RECOMMENDATION 67

All necessary legislation should be amended to enable the Government of Alberta to gain surface access in order to conduct MMV and reclamation activities after transfer of liability.¹²⁵

15 RELATED ACTIVITIES

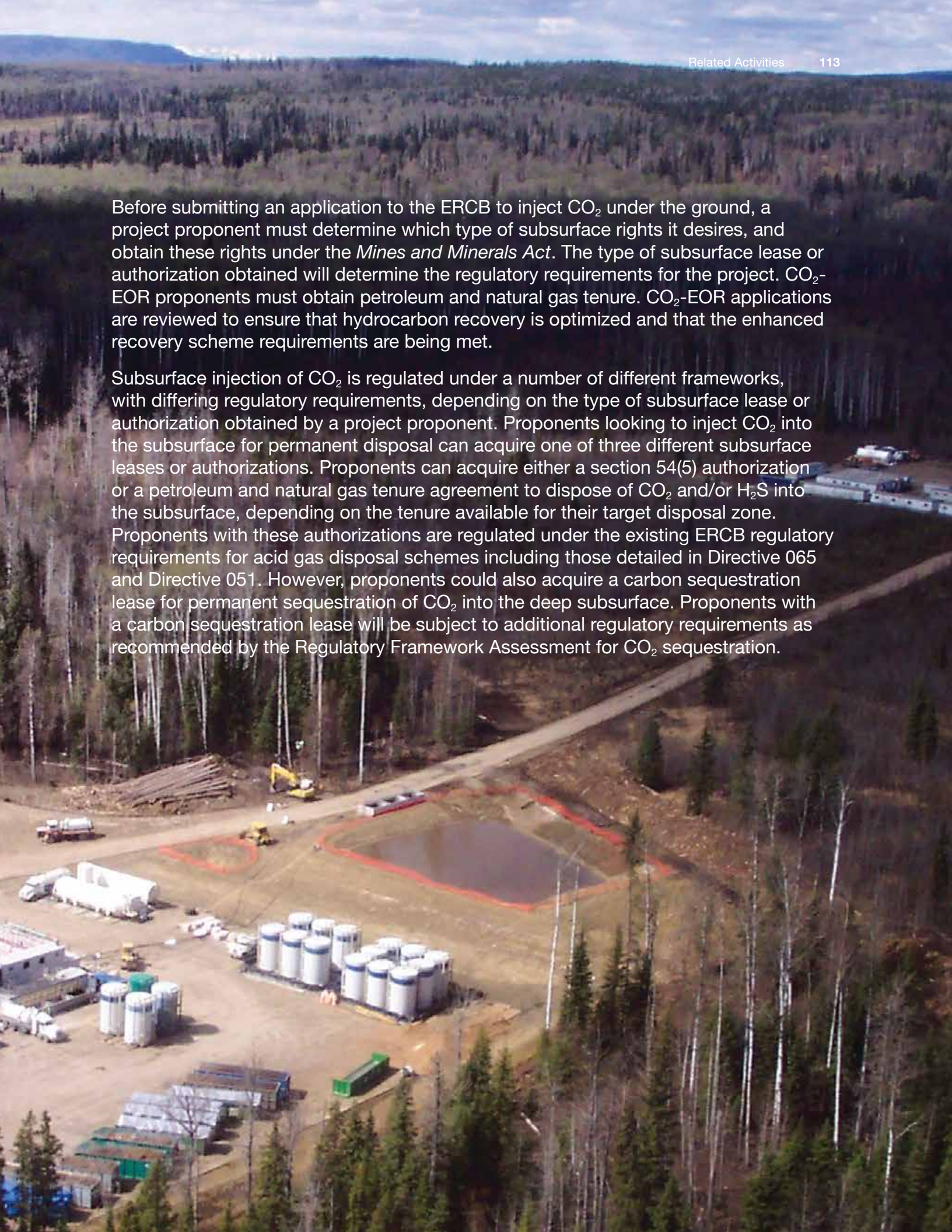
In Alberta, and around the world, CO₂ is injected underground in order to achieve a number of different objectives. Within the oil and gas industry, CO₂ is injected into depleted petroleum reservoirs as a means of improving oil recovery, a process called CO₂ enhanced oil recovery (CO₂-EOR). CO₂-EOR provides the opportunity to increase knowledge about CO₂ sequestration and continue development of conventional hydrocarbon reserves, benefiting all Albertans.

In other oil and gas operations, CO₂ and H₂S are injected as waste products into the subsurface for permanent disposal, a process called acid gas disposal. Finally, as detailed in the preceding sections, CO₂ will also be injected into the subsurface to mitigate climate change, a process called CO₂ sequestration. Although these three activities differ in objective, they are fundamentally similar in that they all involve injecting CO₂ into the subsurface.



Before submitting an application to the ERCB to inject CO₂ under the ground, a project proponent must determine which type of subsurface rights it desires, and obtain these rights under the *Mines and Minerals Act*. The type of subsurface lease or authorization obtained will determine the regulatory requirements for the project. CO₂-EOR proponents must obtain petroleum and natural gas tenure. CO₂-EOR applications are reviewed to ensure that hydrocarbon recovery is optimized and that the enhanced recovery scheme requirements are being met.

Subsurface injection of CO₂ is regulated under a number of different frameworks, with differing regulatory requirements, depending on the type of subsurface lease or authorization obtained by a project proponent. Proponents looking to inject CO₂ into the subsurface for permanent disposal can acquire one of three different subsurface leases or authorizations. Proponents can acquire either a section 54(5) authorization or a petroleum and natural gas tenure agreement to dispose of CO₂ and/or H₂S into the subsurface, depending on the tenure available for their target disposal zone. Proponents with these authorizations are regulated under the existing ERCB regulatory requirements for acid gas disposal schemes including those detailed in Directive 065 and Directive 051. However, proponents could also acquire a carbon sequestration lease for permanent sequestration of CO₂ into the deep subsurface. Proponents with a carbon sequestration lease will be subject to additional regulatory requirements as recommended by the Regulatory Framework Assessment for CO₂ sequestration.



The Government of Alberta and project proponents need clarity on where projects fit under Alberta's various regulations for subsurface injection of CO₂. The Government of Alberta should clearly indicate the criteria and parameters for which projects can qualify as CO₂ sequestration, CO₂-EOR, and acid gas disposal. Therefore, the steering committee recommends that:

RECOMMENDATION 68

The Government of Alberta should define what qualifies as CO₂ sequestration, CO₂-EOR and acid gas disposal, with particular attention to the distinction between CO₂ sequestration and acid gas disposal.¹²⁶

In addition, the Government of Alberta needs to carefully examine how CO₂ injection is regulated under each of the CO₂-EOR, acid gas disposal and CO₂ sequestration regulatory frameworks. The public may question why there are different regulatory requirements for CO₂-EOR, acid gas disposal and CO₂ sequestration projects, and this could impact the deployment of CCS in the province. In light of the recommendations from the RFA, it may be appropriate for the Government of Alberta to conduct a review of CO₂-EOR and acid gas disposal policies and regulations to identify, address and/or justify any regulatory differences in how CO₂ subsurface injection is regulated. Therefore, the steering committee recommends that:

RECOMMENDATION 69

The Government of Alberta should identify differences in how CO₂ injection and storage activities are regulated as CO₂ sequestration, CO₂ enhanced oil recovery and acid gas disposal, and address them appropriately to ensure regulatory consistency and/or that regulatory differences can be justified.¹²⁷

126 Refer to Appendix D4.

127 Refer to Appendix D4.

Following these reviews, and the implementation of the RFA recommendations, it will be important for the regulator to consider how it could best align and/or amend the current regulations and directives related to the injection of CO₂ to add clarity to the regulatory framework. This work will increase the transparency of the regulatory framework for CO₂ sequestration, acid gas disposal and CO₂-EOR by providing stakeholders and the public with clear information about the requirements and regulatory processes for each activity. Therefore, the steering committee recommends that:

RECOMMENDATION 70

The regulator should align and/or amend its regulations and requirements to explicitly cover CO₂ sequestration, as deemed appropriate (e.g. Directive 065).¹²⁸

There are a number of significant differences between CO₂ sequestration and CO₂-EOR in terms of their regulatory frameworks and physical operations. However, a CO₂-EOR project operator may want to transition to a CO₂ sequestration project in the future. Although this transition is not explicitly contemplated or prohibited by current legislation, the regulatory process to do so is not presently defined. The steering committee recognizes that a clear regulatory process to transition a CO₂-EOR project to a CO₂ sequestration site is necessary. Therefore, the steering committee recommends that:

RECOMMENDATION 71

The Government of Alberta should review the requirements for CO₂-EOR projects requesting to transition to CO₂ sequestration to ensure that they meet the same objectives as the requirements for CO₂ sequestration projects.¹²⁹

128 Refer to Appendix D1.

129 Refer to Appendix D4.

16 PROGRESS AND THE PATH FORWARD

In conclusion, CCS is a key technology to advance responsible and sustainable development of Alberta's energy resources while addressing greenhouse gas emissions. Alberta's Climate Change Strategy identifies CCS as a key mitigation technology, which will provide 70 percent of the greenhouse gas emissions reductions to meet the 2050 targets. World consumers of fossil fuels are demanding greener energy production and emissions management, and CCS is a technology that will enable Alberta to be a responsible and competitive supplier of energy in a carbon-constrained future.



The recommendations from the steering committee in this report identify specific opportunities to improve the Alberta regulatory framework for large scale CCS activities. Implementation of these recommendations will result in a regulatory framework that is consistent with the guiding principles identified throughout the assessment, namely that CCS activities provide for increased public safety, improved environmental sustainability and are comprehensively and transparently addressed in Alberta's regulatory framework.





APPENDIX A.

RFA PARTICIPANTS

The work of the RFA would not have been possible without the significant contributions of knowledge and time made by the many members of the steering committee, expert panel and working groups. The RFA began with an opening workshop in March 2011, and the efforts made by all the contributors are summarized in this final report. The recommendations from the RFA will guide the development of legislation, regulations and the regulatory processes for CCS in Alberta.

The following individuals participated on the steering committee. The steering committee members provided guidance throughout the process and approved final content of recommendations for delivery to the Government of Alberta.

NAME	AFFILIATION ¹³⁰
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The following individuals participated on the expert panel. The expert panel members advised the steering committee and working groups by providing subject matter expertise and identified gaps and potential solutions.

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The following individuals participated on at least one of the four working groups (Environmental, Geology/Technical, Regulatory, and Monitoring, Measurement & Verification). The working groups analyzed technical, environmental, safety and monitoring issues related to CCS in Alberta, and drafted recommendations to address requirements for large scale CCS and opportunities for an effective regulatory framework.

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APPENDIX B.

RFA ABBREVIATIONS

AUC	Alberta Utilities Commission
BGWP	Base of Groundwater Protection
CCS	Carbon Capture and Storage
CMDRC	Crown Mineral Disposition Review Committee
CO ₂	Carbon Dioxide
CO ₂ -EOR	Carbon Dioxide Enhanced Oil Recovery
CSA	Canadian Standards Association
CSA Z662	Canadian Standards Association, Z662: Oil and Gas Pipeline Systems
Development Council	Alberta Carbon Capture and Storage Development Council
Directive 010	ERCB Directive 010: Minimum Casing Design Requirements
Directive 020	ERCB Directive 020: Well Abandonment
Directive 051	ERCB Directive 051: Injection and Disposal Wells- Well Classifications Completion, Logging and Testing Requirements
Directive 056	ERCB Directive 056: Energy Development Applications and Schedule
Directive 065	ERCB Directive 065: Resources Applications for Oil and Gas Reservoirs
Directive 071	ERCB Directive 071: Emergency Preparedness and Response Requirements for the Petroleum Industry
EIA	Environmental Impact Assessment
EOR	Enhanced Oil Recovery
EPZ	Emergency Planning Zone
ERCB	Energy Resources Conservation Board
ERP	Emergency Response Plan
ESRD	Alberta Environment and Sustainable Resource Development
H ₂ S	Hydrogen Sulphide
MMV	Monitoring, Measurement and Verification
Mt	Megatonne
PCSF	Post-closure Stewardship Fund
ppm	Parts Per Million
RFA	Regulatory Framework Assessment
Task Force	ecoEnergy Carbon Capture and Storage Task Force

APPENDIX C.

RFA GLOSSARY OF WORKING TERMS

The Regulatory Framework Assessment identified common working terms that are compiled in this appendix. These terms are not intended to be formal definitions for implementation, but rather to describe the context of the terms as used in the RFA final report and appendices.

Adverse effect: defined by the *Environmental Protection and Enhancement Act* (EPEA) to mean ‘impairment of or damage to the environment, human health or safety or property.’

Affected fluid: the reservoir fluid that has been impacted due to the injection of CO₂; either as a result of mixing with CO₂ or as a result of displacement caused by CO₂ and/or pressure increase.

Amine: the class of nitrogen-containing organic compounds that are being proposed for large scale capture of CO₂.

Area of Influence: the spatial footprint of the maximum connected pore volume in the sequestration complex affected by an increase in pore pressure. The area of influence is a useful concept for the regulator to provide assurance for the allocation of pore space within a sequestration complex and on how close other injection activities could be placed.

Notes:

- a) The area of influence will be proposed by the operator and agreed by the regulator.
- b) The operator can apply to the regulator to modify (expand or limit) the area of influence based on agreement between monitoring data and long term predictions of pressure elevation.
- c) Additional projects which increase subsurface fluid pressure in the area of influence should be restricted until the impact on the project is understood and the operator agrees that it will not compromise the project's injection objectives.
- d) The area of influence should be a subset of the assessment area.
- e) The area of influence should be based both on the physical (pressure) boundaries of the sequestration complex determined through site characterization, and the limits of the dynamic pressure anomaly through modeling/simulations of the pressure elevation.
- f) For a non-closed system where the pressure anomaly may be decreasing asymptotically towards the background pressure level, a reasonable judgment needs to be made on the pressure contour which defines the boundary of the dynamic effect.
- g) The area of influence should account for geological uncertainties that impact the pressure increase.

Area of review: is the surface area within which potential adverse effects may occur due to CO₂ plume migration and pressure elevation. The purpose of the area of review is to assist the regulator and all stakeholders in assuring that that sequestration risks are being appropriately managed.

Notes:

- a) The area of review will be a subset of the area of influence.
- b) The area of review should be proposed by the proponent/operator and must be agreed with the regulator.
- c) Within the area of review the proponent/operator is obliged to show that the risk associated with any event has been reduced to an acceptable level for the proposed injection plan.
- d) The area of review should be defined prior to commencement of baseline monitoring.
- e) After commencement of injection the operator has the option of updating the area of review with each submission of the interim closure plan as uncertainty on plume expansion and/or pressure elevation is reduced by ongoing conformance monitoring.
- f) Specific monitoring methodologies will be chosen to address specific risks in the area of review, and may only address a subset of the total area of review.
- g) The risks addressed in the area of review will include:
 - The potential for loss of containment of the sequestration complex either through geological seals or along wellbores and the impact on groundwater and oil and gas operations.
 - The potential for induced seismicity and its impact.
 - Any risks related to surface heave.
- h) The area of review should account for geological uncertainties that impact the CO₂ plume expansion or pressure elevation.

Assessment area: refers to the surface geographic footprint of a volume (from the sequestration complex to the surface) which has undergone assessment for CO₂ sequestration suitability. The purpose of the assessment area is to provide assurance of the site selection and suitability of the area of influence.

Notes:

- a) While applying for an evaluation permit the operator should indicate an initial assessment area along with the existing basic geological, geophysical, geochemical and hydrological data within that area which provides the regional geological context for the selection of the sequestration site.
- b) Within the initial assessment area the operator should identify:
 - Any potential conflicts with any other known resources (including oil and gas, potable groundwater, water used for industrial purposes, mineral and/or geothermal resources, and disposal and/or storage operations and other carbon storage complexes).
 - Any potential conflicts with any subsurface rights.
- c) While applying for a carbon sequestration lease the operator should indicate an assessment area along with the existing and additional data gathered under the evaluation permit which provides the input to the site characterization/modeling and simulation to support the area of influence/area of review definitions.
- d) There may be different scales for each investigation in an assessment area. This may be due to data that are restricted to a specific area or to specific requirements for a particular numerical simulation.

Base of groundwater protection: is the assigned elevation above which groundwater is deemed non-saline or useable without treatment. Alberta Environment and Sustainable Resource Development defines an aquifer containing non-saline groundwater as any strata capable of producing water with a total dissolved solid content less than 4000 mg/L.¹³¹

Carbon capture and storage (CCS): means the capture and transport of carbon dioxide from large stationary anthropogenic sources of emissions, and the injection of the captured carbon dioxide into an underground complex of geologic formations for long term isolation from the atmosphere.

Carbon sequestration lease: Alberta's Carbon Sequestration Tenure Regulation has defined a carbon sequestration lease as an agreement under section 116 of the *Mines and Minerals Act* issued in the form of a lease under section 9.

CO₂ plume: is the free-phase injected CO₂ in the sequestration complex.

CO₂ sequestration project: the activity of injection and geologic sequestration of CO₂ under a carbon sequestration lease.

Closure period: the period of time extending from the permanent cessation of injection to the closure point.

Closure point: the point in time when responsibility and long term liability are transferred to the Government of Alberta and a closure certificate is issued to the project operator.

Conformance: the degree to which the sequestered CO₂ behaves as predicted, as informed by monitoring. For example, demonstration of conformance could include:

- Output from models match monitored data within acceptable limits, and the need to modify static and dynamic model parameters has been systematically reduced over a certain time period.
- Final models are within acceptable confidence limits of the history match.

Where the time period and acceptable limits are developed based on a technical assessment of comprehensive site and project data.

Consultation: involves direct communication with nearby stakeholders including land owners, residents, occupants, and municipalities. ERCB Directive 056 may require project operators to confirm that stakeholders do not have objections to the project (i.e. confirmation of non-objection). In this context, if confirmation of non-objection is not obtained, the project may proceed to a hearing. Note: This use of the term consultation is not intended to account for the Crown's duty to consult First Nations under section 35 of the *Constitution Act*.

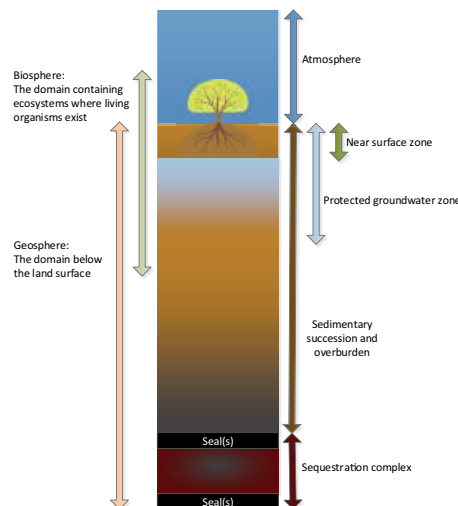
Containment: retention of injected CO₂ and affected fluids within the sequestration complex.

Domains of review: Within the area of review several domains have been identified as listed below and as represented in Figure 13.

131 Lemay, T.G. (2008): *Description of the Process for Defining the Base of Groundwater Protection*; Energy Resources Conservation Board, ERCB/AGS Open File Report 2009-04.

Complementary monitoring techniques should be employed to provide areal and depth coverage.

- **Atmosphere:** the layer of air above the Earth's surface.
- **Near-surface zone:** the zone that comprises the soil and its biological processes, including ecosystems and surface water.
- **Protected groundwater zone:** the zone where water salinity measured as a concentration of total dissolved solids is less than 4000 milligrams per liter.¹³²
- **Sedimentary succession and overburden:** the sedimentary succession and overburden that overlies the sequestration complex.
- **Sequestration complex:** refers to the succession of geological formations that contribute to providing secure long term sequestration of CO₂. It may include one or more seals and one or more zones that have the potential to sequester CO₂.



Emission: a substance that is emitted or released into the air.

Environmental impact assessment: a process that allows companies and government decision makers to examine the effects that a proposed project may have on the environment.

The information gathered during the environmental assessment process helps the appropriate regulator determine if the project should be approved. In Alberta, Alberta Environment and Sustainable Resource Development administers the laws governing environmental assessment under the *Environmental Protection and Enhancement Act* and *Water Act*.

Evaluation permit: a form of tenure granted by Alberta Energy that grants the right to conduct evaluations and testing into deep subsurface reservoirs to evaluate their suitability for CO₂ sequestration.¹³³

Initial application and permitting period: the period from when a proponent applies for lease of the chosen site to the granting of all initial regulatory approvals (e.g. agreements, licences and permits) as required.

Injection period: the period from the start of sustained injection to permanent cessation of injection with no further intent to resume operations.

Life of a project: the time extending from the project tenure submission to the closure point.

Monitoring, measurement and verification (MMV): monitoring and measurement are surveillance activities necessary for ensuring the safe and reliable operation of a CO₂ sequestration project. Verification refers to the comparison of measured and predicted performance, which is also known as conformance.

Mitigation: an action or planned action to reduce the likelihood and/or severity of an unwanted event to an acceptable level.

Notification: differs from personal consultation in that communication can take place through written correspondence rather than face-to-face or telephone conversations. Notification is less onerous and can involve the mailing of information packages to assist in understanding the project and typically occurs in a geographical area larger than that of consultation.

¹³² Alberta Environment and Sustainable Resource Development has defined saline groundwater as water that has total dissolved solids exceeding 4000 milligrams per litre in the Water (Ministerial) Regulation, Section 1(1), 1998.

¹³³ Carbon Sequestration Tenure Regulation, 2011.

Orphan: a project that does not have any legally responsible or financially able party to deal with its abandonment and reclamation.

Pore Space: defined by the Carbon Sequestration Tenure Regulation as the pores contained in, occupied by or formerly occupied by minerals or water below the surface of land. In the context of RFA documents, pore space refers to subsurface pore space that meets injectivity, capacity and confinement criteria for CO₂ sequestration activities.

Post-closure period: the period following the closure point and transfer of liability to the Government of Alberta.

Potable water: water that is suitable for human consumption.¹³⁴

Predictable: behaving in a manner that can be forecast by analytical modelling and verified by monitoring. The regulator and the project operator should agree on the specific criteria and data by which the project will demonstrate that behavior is predictable for the site.

Pre-injection period: the period from when required initial regulatory approvals are received to the start of sustained injection. Commonly includes the gathering of baseline data, site preparation and construction of field facilities. There may be some overlap between the pre-injection period and the initial application permitting period for some activities.

Prorationing: if the regulator has already designated a pipeline as a common carrier, prorationing refers to the proportion of production to be taken by the common carrier from each producer or owner offering production to be gathered, transported, handled, or delivered by means of a pipeline.

Remediation: defined by the Remediation Certificate Regulation under EPEA to mean reducing, removing or destroying substances in soil, water or groundwater through the application of physical, chemical or biological processes. Within the CCS RFA, remediation takes into account measures that reduce significant adverse effects in all domains of review including the subsurface.

Risk: the product of the probability or likelihood of an unwanted event and the potential impact of the event. In regards to the acceptability of risk, the United Kingdom Health and Safety Executive have developed a framework for the risk tolerance, and have classified risks as:¹³⁵

- *Unacceptable risk:* risks that are regarded as unacceptable whatever the level of benefits associated with the activity. Any activity or practice giving rise to risks falling in this category, would, as a matter of principle, be ruled out unless the activity or practice can be modified to reduce the degree of risk so that it falls in one of the regions below, or there are exceptional reasons for the activity or practice to be retained.
- *Tolerable risk:* a tolerable risk falls between the unacceptable and broadly acceptable risk categories.
- *Acceptable risk:* risks falling into this region are generally regarded as insignificant and adequately controlled. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks.

The factors that determine the tolerability of a risk are dynamic in nature, governed by the particular circumstances, time and environment in which the activity giving rise to the risk takes place.

Risk assessment: the process of risk identification, risk analysis and risk evaluation.

Saline groundwater: water with total dissolved solids exceeding 4000 milligrams per litre.¹³⁶

134 *Environmental Protection and Enhancement Act*, 2000.

135 Health and Safety Executive, *Reducing risks, protecting people: HSE's decision making process*, HSE Books, 2001. Retrieval from <http://www.hse.gov.uk/risk/theory/r2p2.pdf>

136 Water (Ministerial) Regulation, Section 1(1), 1998.

Seals: one or more geological formations above and/or below the injection formation that restrict fluid migration. Seals have very low permeability, are continuous over the area of influence, and may be regionally consistent. Seals act as capillary barriers to the escape of CO₂ from the sequestration complex.

Sequestration: defined by the *Mines and Minerals Act* to mean permanent disposal.

Sequestration complex: the succession of geological formations that contribute to provide secure long term sequestration of CO₂. It may include one or more seals and one or more zones that have the potential to sequester CO₂.

Sequestration performance: measure of containment, conformance and utilization of pore space.

Site characterization: part of the site selection process and consists of a detailed evaluation of at least the area of review of one or more candidate sites for CO₂ sequestration to confirm and refine containment integrity, sequestration capacity, and injectivity estimates. Site characterization provides basic data for initial predictive modelling of fluid flow, geochemical reactions, geomechanical effects, risk assessment, and monitoring measurement and verification program design.

Site selection and characterization period: the period in which screening and characterization are carried out to identify a suitable site for a CO₂ sequestration project.

Stable: since many trapping methods continue to operate over a significant time-scale (hundreds to thousands of years), complete cessation of movement of the CO₂ plume is unlikely to occur in many storage formations during the closure period. A state of stability is considered to be attained when key parameters and acceptable limits have been reached. These parameters and limits are developed based on a technical assessment of comprehensive site and project data. For example, such an assessment could show that:

- The calibrated models predict eventual stability of the CO₂ plume within the sequestration complex.
- Key monitored parameters are within an acceptable range and the rate of change is small and declining.

Surface reclamation: the process of returning disturbed areas of land to an equivalent capability as the pre-disturbed state through replacement and preparation of soil materials and establishment of a protective vegetative cover.