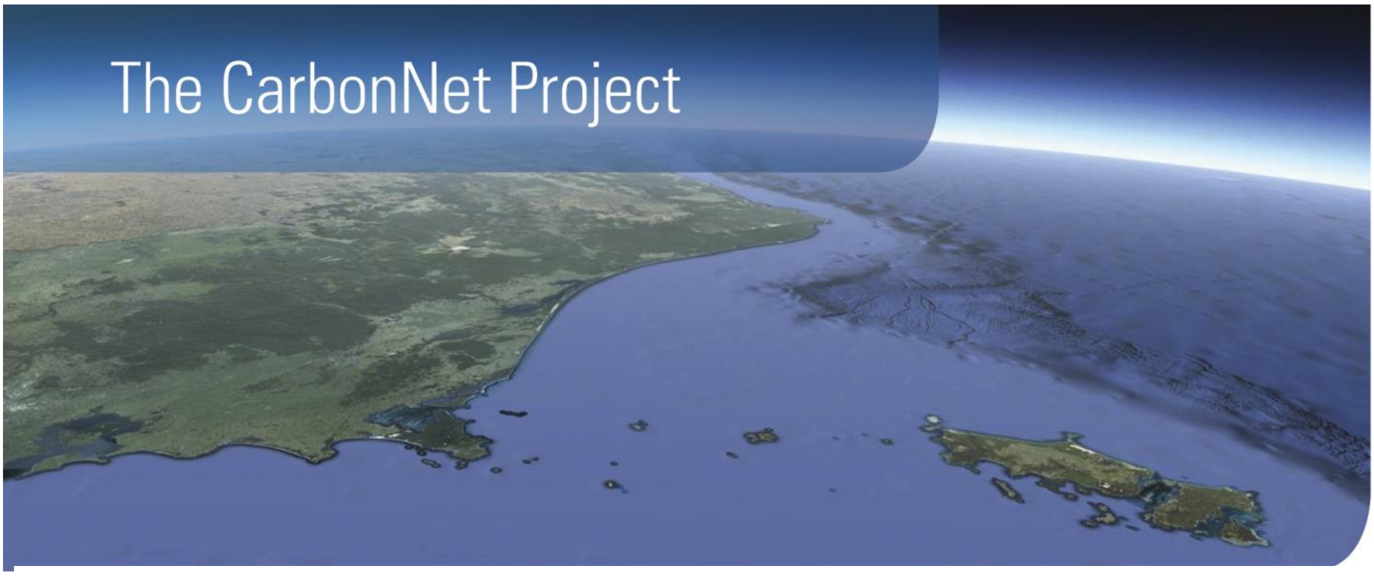

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Integrity of Wells in the Near-shore Area Gippsland Basin Victoria

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April 2015

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Authorised by the Department of Economic Development, Jobs, Transport and Resources

ISBN 978-1-74326-649-0 (print)
ISBN 978-1-74326-470-6 (online)

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Acknowledgements

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AAPG 2015

Integrity of Wells in the Nearshore Area Gippsland Basin Victoria

Todd Goebel, Nick Hoffman and Barry Nicholson, The CarbonNet Project, Victoria, Australia, September 2015

Abstract

The CarbonNet Project is investigating CO_2 storage sites in the nearshore area of the Gippsland Basin of Victoria, Australia. The project objective is to provide permanent and safe storage for 25 to 125 Mt of CO_2.

The integrity of legacy or existing wells (which includes abandoned, production, injection, mineral/water bores and Measurement, Monitoring and Verification (MMV) wells) is recognised around the world as one of the most significant operational risks to CO_2 storage projects. The number of wells and quality of completions can vary significantly in different basins and jurisdictions. Furthermore, the drilling and completion requirements for onshore and offshore wells are subject to various regulatory, industry and operator standards and practices.

The Gippsland Basin has been an active oil and gas production province since the 1960's and there is a reasonable database of well data and parameters to assess well integrity. In the nearshore area of the Gippsland Basin, the integrity of fourteen (14) wells has been assessed by CarbonNet and risks were identified. The assessment was based on existing documentation lodged with the regulator under Australia's comprehensive offshore petroleum legislation. The assessment concludes that the risk of leakage to surface from the fourteen (14) legacy wells reviewed is very low. At an intraformational level, some wells are less securely completed and therefore appropriate mitigation measures are proposed – generally, to avoid intraformational storage concepts at these sites and locations.

Ultimately for any CO_2 storage project, there is a requirement to demonstrate how to safely monitor legacy wells. In an Australian regulatory context, the requirement is to demonstrate they are not active leakage pathways and to outline plans for remediation of wells if they are shown to have problems. Options are discussed for completion and monitoring of future petroleum wells and other boreholes to avoid any new risks.

Introduction

Well integrity is one of the key issues discussed for CO_2 storage because it can present one of the most significant operational risks to CO_2 storage projects, particularly onshore in areas where large numbers of wells have been drilled for petroleum and water supply purposes. The number of wells and quality of completions varies significantly in different basins and jurisdictions, depending on the history of exploration for resources, and the level of infrastructure developed in the basin. Furthermore, the drilling and completion requirements for onshore and offshore wells are subject to various regulatory, industry and operator standards and practices, which have evolved through time. It is important, therefore, to understand the prior history of each basin proposed for CO_2 storage, and to conduct careful examination of the state of records, and to make a careful and objective risk assessment based on observable facts and documented evidence.

The Gippsland Basin in south-eastern Victoria is one of Australia's major crude oil and natural gas provinces. The commercial oil and gas fields contained recoverable reserves of more than four billion barrels of oil and more than nine trillion cubic feet of sales gas. This basin was discovered in the mid-1960's as one of the early step-outs of oil exploration into the nearshore and open ocean environment. The commercial success of the basin has led to large amounts of seismic and well data being collected. Australia has a long standing strong regulatory environment and an open-access data requirement. Consequently, very good digital and scanned analogue records of even the earliest exploration efforts are available to all parties.

CarbonNet Project Background

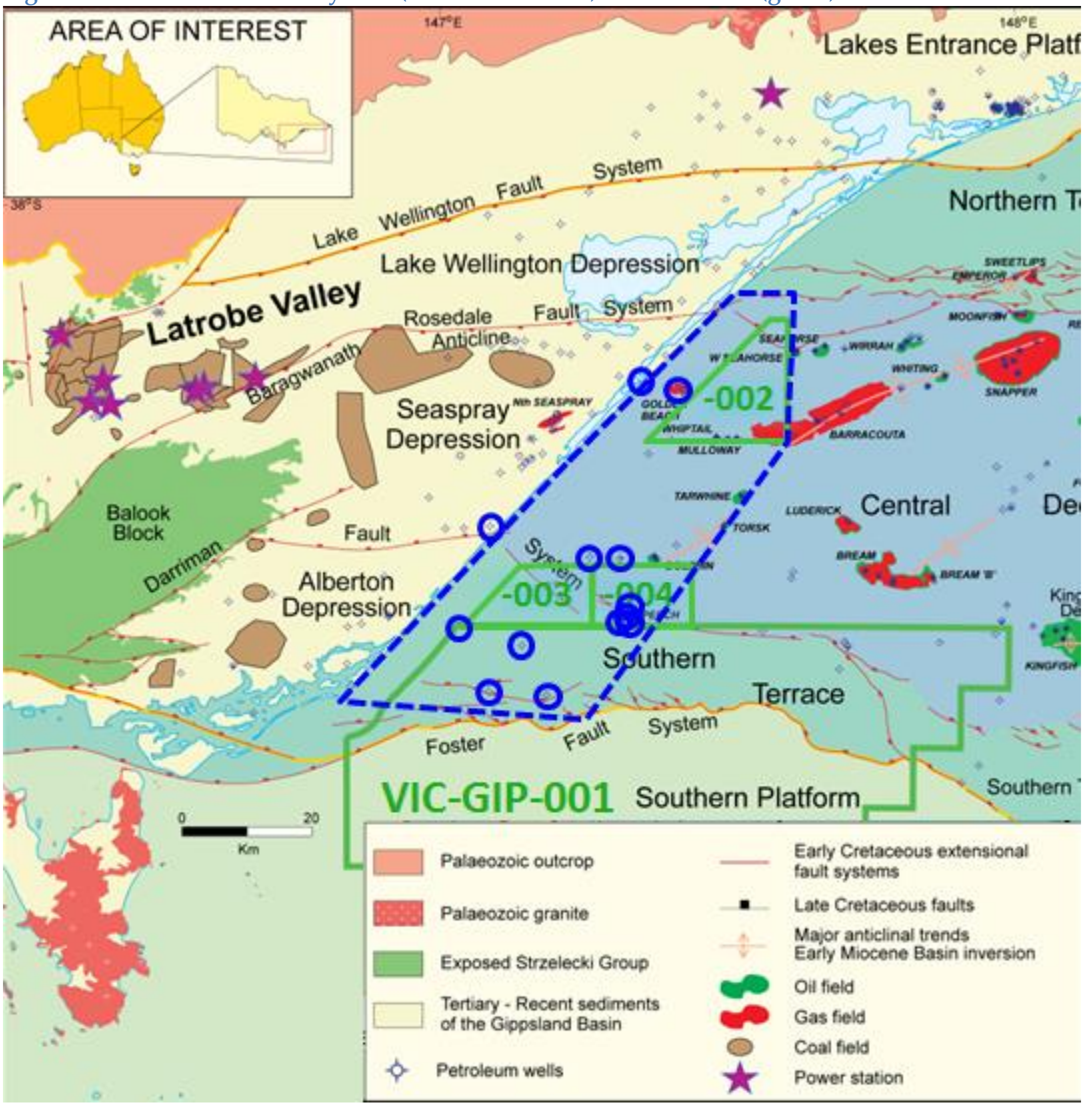
The CarbonNet project is an initiative of the Victorian State Department of Economic Development, Jobs, Transport and Resources (DEDJTR) and is investigating the feasibility of sequestering 1 to 5Mtpa of CO_2 in the nearshore area of the Gippsland Basin, within 25 km of the coastline. As part of that effort, a portfolio of potential injection sites is being assessed, targeting the Cobia and Halibut subgroups of the Latrobe Group. The potential reservoirs within the Latrobe Group are coarse-grained heterogeneous shoreface/barrier bar and lower coastal plain fluvial sands with high porosity and permeability, with intraformational coal/shale seals and baffles as the primary CO_2 seal (Hoffman et al., 2015a, b), and the shales and marls of the Lakes Entrance Formation acting as ultimate top seal (Hoffman et al 2012).

The CarbonNet project has built-up a significant level of understanding of the nearshore region of the Gippsland Basin and has demonstrated the fundamental suitability of a portfolio of three sites for the storage of 25 - 125Mt of CO_2, which could be injected over 25 years operational period. This was achievable for two reasons; (1) The basin is a successful and prolific petroleum province, and therefore there is a large amount of industry data (wells and seismic surveys) and many detailed studies, reports, and scientific papers about the oil and gas accumulations, their reservoirs and seals, and the basin stratigraphy, depositional setting, and tectonic history, and (2) Australia has a comprehensive open-file data system where petroleum data is released after a time period of 3-5 years and stored for free public access. Without this foresighted regime, only established petroleum companies would be able to work-up sites for CO_2 storage with existing confidential data that they already own or have access to through trades or other arrangements.

Well Database

Over 1500 exploration and development wells are drilled in the basin of which some 49 are located in the focus area considered by CarbonNet for CO_2 storage which is shown in Figure 1. Of these wells, up to fourteen (14) are in the general proximity of sites that CarbonNet has assessed for offshore CO_2 injection. It is important to analyse these 14 wells carefully in order to evaluate their integrity against contact with modelled CO_2plumes to determine the key technical risks, and the magnitude of the overall well integrity risk, and hence to determine whether the plume needs to avoid the specific wells. This assessment may lead to some storage concepts or injection well locations being identified as unusable, due to elements of the risk profile. Other concepts/locations may be usable, with additional focus on injection well location and on specific monitoring technologies and targets that are cost-effective in the nearshore environment.

Figure 1: Overall view of study area (blue dashed line) GHG Permits (green) and well locations



Wells of Interest

The fourteen (14) wells under study are highlighted in blue in Figure 1. Reservoir modelling studies show that in some scenarios, these may be in the general proximity of injected CO_2 plumes associated with injection concepts in CarbonNet's four GHG permits (Figure 1). These wells are listed with general parameters in Table 1.

Table 1: General well details

Well Name	Operator	Spud Date	Total Well Depth[1] (mKB)	Well Depth Subsea (m)	Formation Potentially Exposed to CO2[2]
Amberjack-1	BHP	4th May 1990	1750 m	-1729.0 m	Halibut
Broadbill-1	Lakes Oil	17th Jan 1998	1345 m	-1314.3 m	Halibut/T2/Cobia
Golden Beach-1A	Burmah	3rd May 1967	2905 m	-2892.8 m	Halibut
Golden Beach West-1	Woodside	11th Sep 1965	2290 m	-2278.1 m	Halibut/T2/Cobia
Kyarra-1A	Australian Aquitaine	16th Feb 1983	1280 m	-1249.5 m	Halibut
Palmer-1	Esso	12th Aug 1981	1723 m	-1702.0 m	Halibut/T2
Perch-1	Esso	13th Mar 1968	2867 m	-2857.5 m	Halibut/T2/Cobia
Perch-2	Esso	11th Feb 1985	1321 m	-1300.0 m	Halibut/T2
Perch-3	Esso	10th Oct 1989	1301 m	-1258.7 m	Halibut/T2/Cobia
Perch-4	Esso	1st Feb 1995	2052 m	-1247.0 m	T2/Cobia
Salt Lake-1	Woodside	12th Apr 1970	1670 m	-1620.7 m	Halibut/T2/Cobia
Tommyruff-1	BHP	20th May 1990	1550 m	-1529.0 m	Halibut/T2/Cobia
Wasabi-1	Apache	14th Feb 2008	2313 m	-2274.0 m	Halibut/T2/Cobia
Wyralla-1	Australian Aquitaine	16th Apr 1984	1160 m	-1139.0 m	Halibut/Cobia

For most of these wells, the likely target for CO_2 injection is the Cobia Subgroup or the underlying Halibut Subgroup (Figure 2). Depending on the planned injection zone, cement plugs and/or cemented casing across both the regional Lakes Entrance Formation seal (Cobia Subgroup storage) and the deeper intraformational seals at base Cobia (Halibut Subgroup storage) are important for well integrity for CO_2 injection and storage.

If these plugs (or adequately cemented casing) are absent, then CarbonNet storage concepts will need to be modified to avoid the stratigraphic levels at risk, to avoid some wells entirely or to remediate those wells.

[1] Plugged back TD, measured depth below kelly bushing (KB)
[2] Any formation potentially exposed to CO2 injected into the Halibut or Cobia Subgroups

Figure 2 shows the stratigraphy including seal formations and potential injection formations.

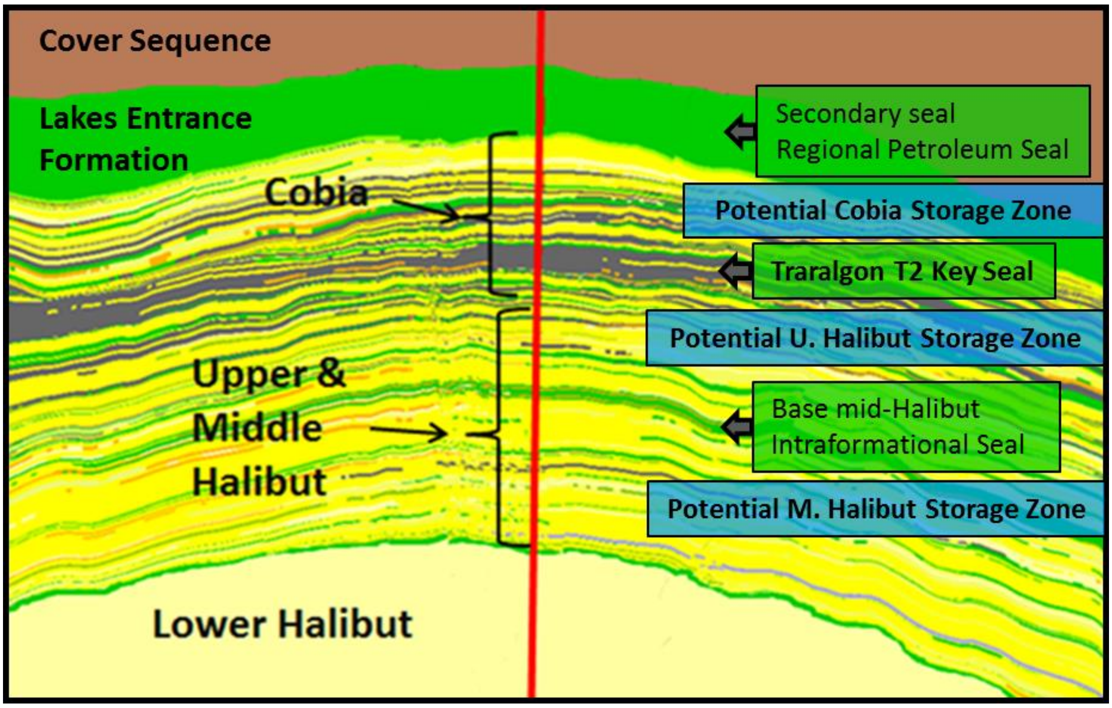


Figure 2: Stratigraphy of Seal and Storage Formations

The Operators listed are those originally responsible for drilling the wells, as determined from the well completion reports and the list does not account for organisational change or expiry of permits. As a general comment, all the companies involved in these wells are experienced and competent operators and have used their internal procedures and standards to produce documented abandonments which were approved by the petroleum regulator prior to rig release. Wells were abandoned for the general purposes of aquifer protection in accordance with standard practice of the period in a petroleum context.

Analysis of these wells shows that the objectives of completion for aquifer protection have been met satisfactorily. Examples will be noted where completion for petroleum and aquifer purposes does not offer the full desired protection for CO_2 storage. An important implication of the prospective Carbon, Capture and Storage (CCS) industry is that future Petroleum well completion and abandonment requirements may require additional intervals to be fully cemented, additional wellbore plugs to be included, and for CO_2-resistant materials to be considered in basins where CO_2 storage is being actively considered. This may include changes to the cement rheology and the metallurgy of casing strings over key zones in some circumstances.

Figure 3 below provides a general picture of where abandonment plugs are likely to be required for containment of oil, gas and CO_2 in the Gippsland Basin.

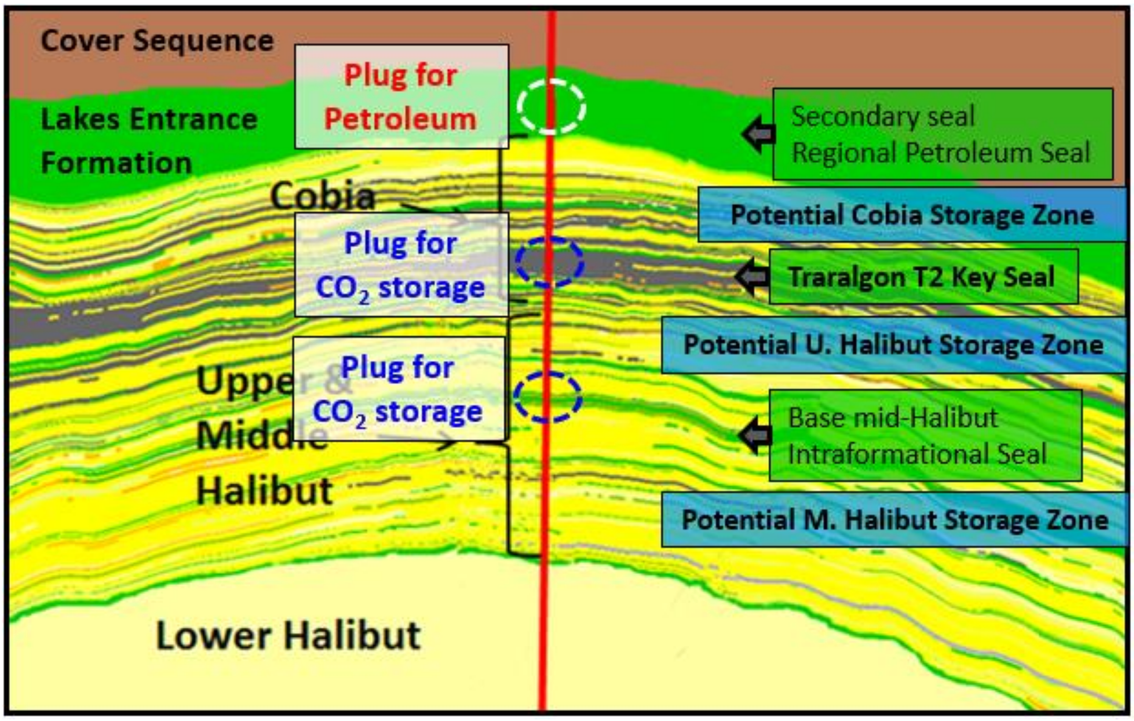


Figure 3: Stratigraphy of formations with general abandonment plug location vs CO_2 storage requirements

Well Assessments

All wells in the Gippsland Basin have been completed to petroleum industry standards, focussing particularly on well integrity at the top of the regional Latrobe Group reservoirs, with competent completion across the Lakes Entrance Formation topseal. Deeper intervals have been completed in a less systematic manner and some of the intraformational seals that could be of value for storage (Hoffman et al., 2015b) may have been compromised. In most cases, good data is available but for certain wells, the documentation is less complete (red well names in Figure 4). Additional original paper records may be available from long-term storage via the regulator, or directly from the well operator. At this time, those records have not been requested.

The path the CO_2 takes depends on injection well location and the CO_2 may come into contact with existing petroleum exploration wells that have been plugged. These wells are reviewed here for their integrity.

For reference, a summary of well abandonment details vs formation tops is provided in Figure 4.

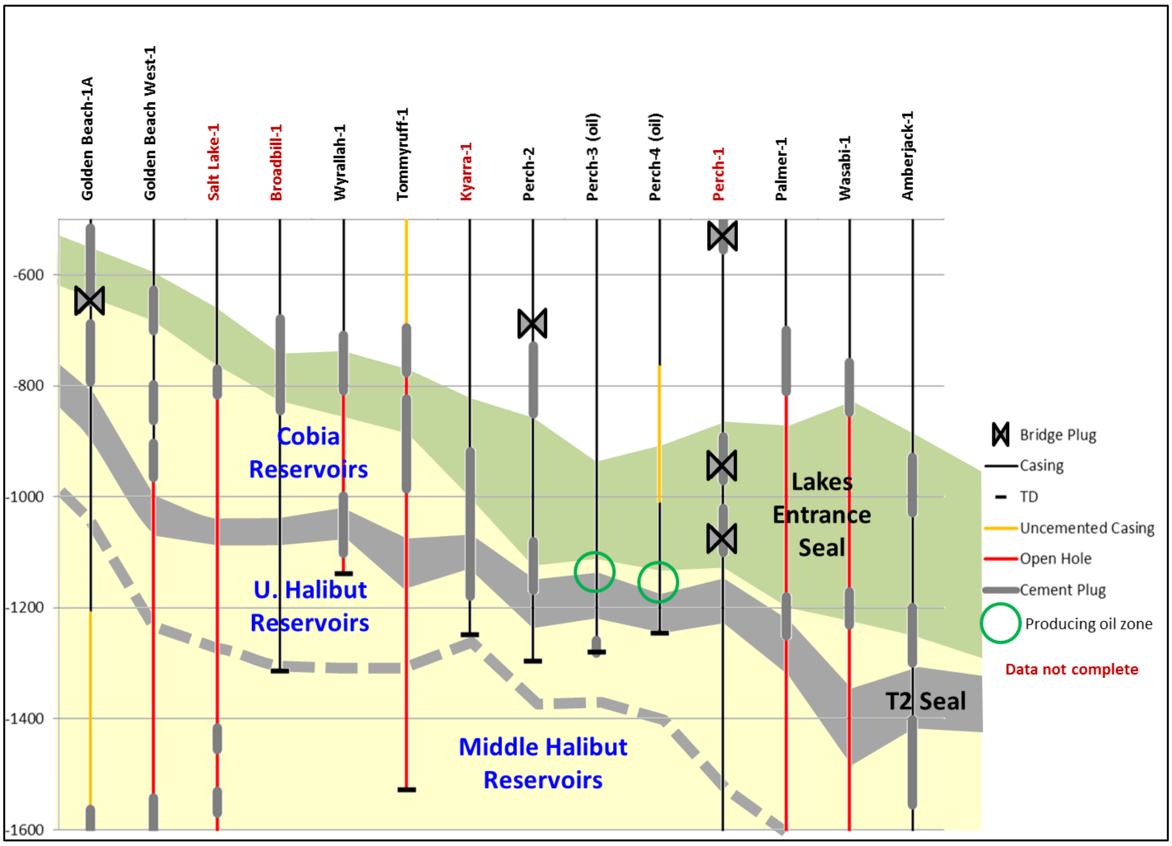


Figure 4: Well details vs formation tops

Amberjack

The Amberjack-1 well completion and abandonment data provides details on cement type and plug testing that was carried out on the abandonment plugs. A cement bond log was run due to problems during the cementing of the 9-5/8” casing, and showed that there was poor to no cement across the cover section in an interval from 325 to 525m. As a result, a squeeze cementing operation was carried out to remediate the cement job and ensure isolation. Casing is now believed to be securely cemented. The well was abandoned with 4 cement plugs and the top of the Halibut Subgroup in this well is at 1507m, which is covered by the lowest cement plug. The possibility of leakage here is considered low risk.

Broadbill

The Broadbill-1 well is not expected to be contacted by injection operations, according to simulations to date, but it has been included for completeness. The well completion data is reasonably complete, but lacking in details on plug integrity testing. The well was properly abandoned with 4 cement plugs and 1 hydraulic set plug, however, due to lack of detailed data, the risk level is considered to be medium risk, unless better documentation can be obtained.

Golden Beach

Golden Beach-1A and Golden Beach West-1 have comprehensive cement records for both completion and abandonment phases, and were effectively plugged with a combination of hydraulic set cement retainers and balanced cement plugs. In Golden Beach-1A, the Lakes Entrance Formation was perforated and flow-tested at the level of the small hydrocarbon gas pool discovered at top Cobia. This zone was cement squeezed and a cement plug within casing covers this zone, so a double-layer of protection still exists. The target CO_2 storage zone (Halibut Subgroup) is covered by cemented casing that protects both T2 and base Upper Halibut seals, therefore this well is assessed as low risk for intraformational CO_2 storage.

The original Golden Beach-1 borehole was abandoned before reaching the Lakes Entrance Formation regional seal and is therefore not a potential leakage pathway for hydrocarbons or CO_2.

In Golden Beach West-1 there is an open hole section in the Halibut and T2 presenting a high level risk of intraformational flow, ***if*** CO_2 were to reach this section of the wellbore. Since this well is onshore and the CarbonNet injection project is designed so the CO_2 plume will not to reach the shore, this well will be intentionally avoided and the post-mitigation risk is therefore low.

Kyarra

For the Kyarra-1 well, details are given on cement type but there is sparse data on the cementing operation. Only two cement plugs were set in this well and no test data on the plugs was provided. Nevertheless, based on the information provided in the WCR, the cement plugs are long, at 260m and 70m, respectively. An extensive cement plug is reported across the T2 seal and entire Cobia reservoir section, extending into the Lakes Entrance Formation regional petroleum seal. If the well were to be contacted by CO_2 the chance of leakage is considered low due to the length and position of the plugs, but this well has been flagged as medium risk, due to the limited documentation available.

Perch

Perch is a producing hydrocarbon field, with two plugged and abandoned exploration wells (Perch-1 and -2) and two producers (Perch-3 and -4). Except for Perch-1, the open-file WCR's contain full details of the completion and cementing programmes which are comprehensive. The existing data indicates that the well was cemented and abandoned in a very secure manner which included packers for squeeze cementing as well as balanced cement plugs. Cement bond logs were run in wells Perch-1 and Perch-4, and these have been obtained and reviewed. The Perch-1 CBL appears satisfactory, and therefore the risk of this well has been reduced to low.

For Perch-4, the CBL relates to an unsuccessful casing cement job that is documented in the WCR. A remedial squeeze cement job was completed, but there is no record of a CBL post-squeeze. It is reasonable to assume that for a producing oilfield, casing and cement integrity would be assured on the topseal of the oil column (Lakes Entrance Formation). It is anticipated that at some future time the Perch platform will reach the end of its production life and wells Perch-3 and Perch-4 will then be abandoned in an appropriate manner with the perforations squeezed and a cement plug set across the Cobia reservoir zone and up into the Lakes Entrance regional petroleum seal.

All Perch field wells are fully cased and cemented across the T2 seal interval and, with the proviso that future abandonment of Perch-3 and -4 is assumed to be adequate, these wells will all present low risk for intraformational CO_2 storage.

Palmer

The Palmer-1 well has a complete record of cementing and abandonment operations, with the latter containing both cement plugs and a hydraulic set bridge plug, providing an adequate abandonment.

However, the Palmer-1 well contains significant intervals of open hole. Although top and base Lakes Entrance, and the entire Cobia reservoir interval are covered by cement plugs, the lower part of the T2 seal is not protected and the deeper base Upper Halibut seal interval is also open. As a consequence, the Palmer-1 well is currently rated medium risk for intraformational storage of CO_2, requiring a further detailed analysis of seal lithology vs cement emplacement depth in the event that storage were to be contemplated at this location.

Salt Lake

The information available on the database for the Salt Lake-1 abandonment is sparse. There is no volume, type or test information on the plugs. However, the information that is available indicates that good oilfield cementing and abandonment plugging procedures were followed using four cement plugs. For intraformational storage, this well is assessed as high risk since the entire Halibut and Cobia reservoir interval, and all intraformational seals are left as open hole.

Tommyruff

At Tommyruff-1, a 43 metre long cement plug has been placed across the N. asperus sands and into the main seal of the Lakes Entrance Formation, in the open hole section of the well. There is therefore good integrity at Lakes Entrance Formation level protecting the Latrobe aquifer and precluding fluid escape towards the surface. However, for intraformational storage, this well is assessed as high risk since the entire Halibut and Cobia reservoir interval, and all intraformational seals are left as open hole.

Wasabi

In a similar manner to Tommyruff-1, this well has also been cemented with three cement plugs, one above the permeable sands, one from the casing shoe into the open hole and a third near surface.

Despite what appears to be adequate plugging at top Cobia and Lakes Entrance Formations, there are long open-hole sections in the Halibut, T2 and Cobia that present this well as a high risk for intraformational storage. In addition, the WCR does not record any pressure tests or tagging of plugs during abandonment, therefore these are rated as untested.

Wyrallah

Well Wyrallah-1 was drilled in 1984 and completed open-hole below the Lakes Entrance Formation. However, extensive cement plugs were set across the T2 seal interval and the majority of the Lakes Entrance, overlapping with the casing shoe. The well is therefore assessed as being securely completed and offers low risk at intraformational seal level.

Discussion

Pure CO_2 is not corrosive, but when dissolved into formation water, acidic solutions will result. These are capable of etching or completely penetrating normal oilfield steel tubulars and ordinary cements within a relatively short period of time (decades) compared with the requirement for secure storage for thousands of years or longer. For this reason, CO_2-resistant materials are recommended for new wells. For existing wells, an analysis must be made of the likelihood of chemical erosion or perforation of the cements and tubulars, if dissolved CO_2 arrives at that well. CarbonNet dynamic simulations show that a front of acidic water will be pushed ahead of the plume of buoyant CO_2, and therefore it is the arrival of the dissolved CO_2 plume that is an important factor in assessing well integrity. However, even if a well was corroded by this acidic water, if buoyant CO_2 does not arrive at that weakened well, then no leakage of buoyant CO_2 can occur. The consequences are therefore less serious, but must still be fully assessed in terms of impacts on aquifers and nearby oil and gas operations.

The key observation is that if there is no sustained flow of fluids, then only minimal etching or surface alteration occurs (Connell et al., 2014). If there is a pre-existing flowpath, then this may be progressively widened and weakened by flow of acidic fluids. It is therefore vital to have a secure completion with no defects. In this condition, conventional well completions have resisted CO_2 for decades in EOR operations and in oil and gas fields with high natural CO_2 content. For example, the Kipper gas field in the Gippsland Basin has a CO_2 content of 13% to 40%, yet the wells are completed with conventional materials and have not developed leaks through time since the discovery wells were drilled in 1986-87.

Published laboratory study results vary from extensive reactivity (Duguid et al. – Schlumberger Carbon Services) to limited reactivity (Kutchko et al., 2009) and depend on the imposed conditions (T,P, fluid, etc.). Only a small portion of the CO_2 of the liquid or injected CO2 (in a supercritical phase) is expected to dissolve in the liquid water phase, and almost none of the liquid water phase will dissolve in the CO_2 phase. Field observations (Carey et al., IJGGC 2007) show CO_2-induced alteration similar in character to some laboratory experiments but without significant CO_2 leakage.

In addition, there are several independent analysis papers which conclude there is no significant effect on the cement due to contact with CO_2 saturated water. Most studies conclude that a more likely route for leaks is channelling, contamination or microanulli that occurred during the original cement job.

Despite the lack of field evidence for CO_2 leakage risk due to interaction with materials, it is necessary to examine the potential for leakage or seepage due to poor completion or plugging practice and the consequences of any volumetrically significant release in the remote case that the recorded well data is incorrect.

Each well was assessed for the ***likelihood*** and ***consequence*** that **if a CO_2 plume approaches/impacts a well there could be surface leakage and endanger the public or environment.** Risk Assessment Criteria Matrix in Table 2 is from page 55 of HB 436:2004 issued by Standards Australia to support the Australia / New Zealand Standard for Risk Management (AS/NZS 4360)**.**

The risk was judged to be low to very low in all wells, due to the high standards of protection applied to the Lakes Entrance Formation regional petroleum seal, which is also the top of the Latrobe aquifer and the top of petroleum-prospective Cobia reservoirs. It is satisfying to see that the intention of aquifer and resource protection is being achieved.

The alternative risk proposition that ***Intraformational*** **CO_2 storage at the well may be compromised by completion quality** was not evident for all wells.

Table 2 Risk Assessment Criteria Matrix

			Consequence Criteria				
			1 – Insignificant	2 – Minor	3 – Moderate	4 – Major	5 – Catastrophic
Likelihood	A	The consequence is almost certain to occur in most circumstances	Medium (M)	High (H)	High (H)	Very High (VH)	Very High (VH)
	B	The consequence is likely to occur frequently	Medium (M)	Medium (M)	High (H)	High (H)	Very High (VH)
	C	Possible and likely for the consequence to occur at some time	Low (L)	Medium (M)	High (H)	High (H)	High (H)
	D	The consequence is unlikely to occur but could happen	Low (L)	Low (L)	Medium (M)	Medium (M)	High (H)
	E	The consequence may occur but only in exceptional circumstances	Low (L)	Low (L)	Medium (M)	Medium (M)	High (H)

Table 3 shows the concluding assessment of risk and risk management for intraformational storage at the fourteen wells of interest. Five of the fourteen wells offer a low risk for intraformational storage of CO_2. A further two currently-producing wells are expected to be abandoned at some future time and are expected to be cemented in a secure manner. For the remaining seven wells, CarbonNet has modified its plans to avoid the stratigraphic levels at risk, or to avoid some wells entirely with any probable CO_2 plume.

Table 3 Risk Register and Action Plan

Identified Risks	**Analysis & Evaluation**			**Further Actions**			
***Intraformational* CO_2 storage at the well will be compromised by completion quality**	**Consequence** (1, 2, 3, 4, or 5)	**Likelihood** (A, B, C, D or E)	**Risk level** (L, M, H or VH)	**How to manage the risk.**	**Accept Risk** (Y or N)	**How to reduce this risk**	**Post-mitigation Risk level** (L, M, H or VH)
Amberjack-1	2	E	L	No action required	Y	N/A	L
Broadbill-1	3	D	M	Avoid contact with Plume unless better documentation can be inspected	N	Seek additional paper records / Ensure not contacted by CO_2	L-M
Golden Beach West-1	3	C	H	Avoid contact with Plume at Halibut/T2 level. Top Cobia is OK.	Y	Plan storage to avoid CO_2 at this location	L
Golden Beach-1A	2	E	L	Monitor during injection	Y	N/A	L
Kyrra-1	3	D	M	Avoid contact with	N	Seek additional	L-M

				Plume unless better documentation can be inspected		paper records / Plan storage to not require seal at this level – i.e. assume that plume ***will*** rise to top Cobia.	
Palmer-1	**2**	**D**	**M**	Avoid storage at Halibut/T2 level. Top Cobia is OK.	Y	Plan storage to not require seal at this level – i.e. assume that plume ***will*** rise to top Cobia.	L
Perch-1	**2**	**E**	**L**	No action required	Y	Check for detailed full WCR	L
Perch-2	**2**	**E**	**L**	No action required	Y	N/A	L
Perch-3	**2**	**C-D**	**L-M**	Avoid contact with producing oil zone. Halibut is OK.	Y	Influence final abandonment	L
Perch-4	**2**	**C-D**	**L-M**	Avoid contact with producing oil zone. Halibut is OK.	Y	Seek further information from well operator. Influence final abandonment	L
Salt Lake-1	**3**	**B**	**H**	Avoid storage at Halibut/T2 level. Top Cobia is OK.	Y	Plan storage to not require seal at this level – i.e. assume that plume ***will*** rise to top Cobia.	L
Tommyruff-1	**3**	**D-C**	**M-H**	Avoid storage at Halibut/T2 level. Top Cobia is OK.	Y	Plan storage to not require seal at this level – i.e. assume that plume ***will*** rise to top Cobia.	L
Wasabi-1	**3**	**C**	**H**	Avoid contact with Plume	N	Locate injector updip to avoid CO_2 contact	L
Wyrallah-1	**2**	**E**	**L**	No action required	Y	N/A	L

Independent review

The review of well integrity was undertaken by CarbonNet. However, CarbonNet seeks to ensure public confidence in its assessment of CO_2 storage potential and so has a process of independent review of various elements of its program. Three organisations have reviewed CarbonNet's work, including on well integrity, and all support its assessment.

- Senergy is a Lloyd's Register company that provides independent assurance and expert advice. Senergy managed risk workshops for CarbonNet, including examining well integrity.
- Schlumberger Carbon Services has worked with CarbonNet in developing an Appraisal Plan to appraise its storage leads in a secure manner.
- DNV is a global company that provides certification services. It has established a series of Recommended Practices for CO_2 storage against which proposed activities can be assessed. CarbonNet has committed to achieving certification and has passed the first two stages.

Conclusion

Analysis of these wells shows the objectives of completion and abandonment have been met satisfactorily and to acceptable oilfield standard and practices of the period. Although some elements of documentation are brief or occasionally absent, they provide a suitable level of detail to assess risk levels imposed by legacy wells. Some of the completions undertaken for petroleum and aquifer purposes do not offer the level of desired protection for future CO_2 storage at some specific sites. An important implication of this is that future petroleum well completion and abandonment requirements may require additional intervals to be fully cemented, additional wellbore plugs to be included, and for CO_2-resistant materials to be considered in basins where CO_2 storage is being actively considered. This type of action would mitigate the risks associated with CO_2 injection. These changes may be implemented through regulatory requirements or voluntary actions by petroleum operators undertaking drilling activities in potential CO_2 storage provinces.

CarbonNet has identified that five (5) out of the fourteen (14) wells assessed may potentially offer moderate to high levels of risk at intraformational storage levels and therefore seal at these levels should not be invoked for storage of CO_2 in the nearshore Gippsland Basin. Two additional wells (Broadbill-1, Kyarra-1) have limited data availability and ***may*** pose a risk. Unless and until a more complete set of records are located, intraformational storage at these wells should also be avoided. Two currently producing wells appear to present low risk, but final judgement must be reserved until the field is depleted and the wells are finally abandoned. It is expected these wells will be plugged and abandoned in accordance to appropriate CO_2 and petroleum standards.

In summary, none of the fourteen wells analysed, present any significant risk of leakage through the Lakes Entrance Formation, demonstrating that the regulatory intention of aquifer and resource protection is being achieved, and that there is negligible risk of CO_2 rising to near-surface levels where it might present a risk to the environment or the general public.

However, only five of the fourteen wells offer a low risk for intraformational storage of CO_2. Therefore, CarbonNet has modified its plans to avoid the stratigraphic levels at risk, or to avoid some wells entirely with any probable CO_2 plume.

Acknowledgements

The CarbonNet Project is supported under the Commonwealth GHG Flagships Fund and by the State of Victoria. Technical input and discussions with colleagues and external experts have significantly assisted with the preparation of this paper. In particular, we would like to thank Alan Partridge, Alan Tait, Louise Goldie-Divko for their knowledge, advice, and insights into the basin, and Geoff Collins for his stalwart skills in reviewing multiple rough drafts. The preparation of this paper is part of a funding agreement for Knowledge Share Acitivities with the Global Carbon Capture and Storage Institute (GCCS().

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