CAGS Technical Workshop

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QUEENSLAND CO_2 GEOLOGICAL STORAGE ATLAS – RESULTS

Queensland Government

Outline

1. Atlas Scope

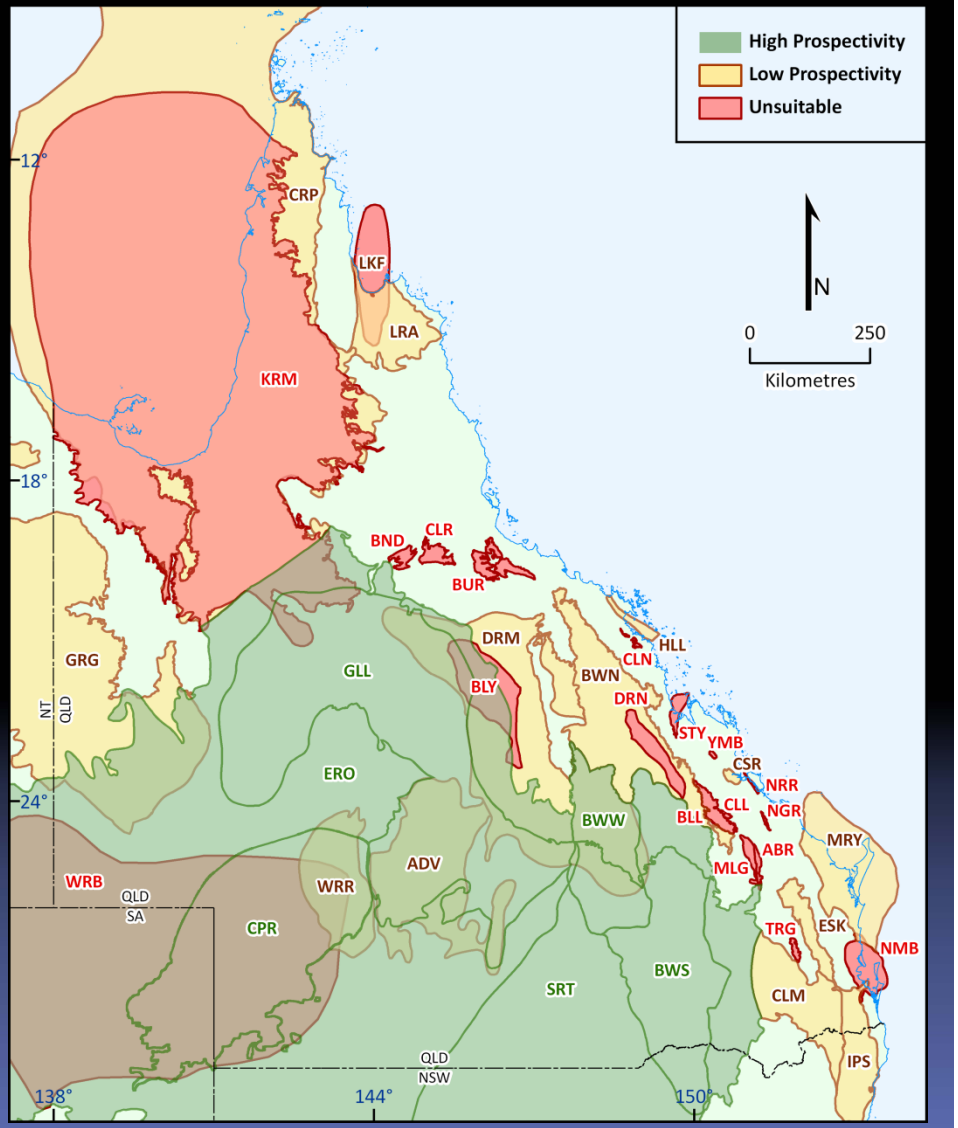
2. Assessment results from 5 High Prospectivity basins

3. Summary of low prospectivity basins

4. Summary of unsuitable basins

5. Discussion of storage in depleted oil & gas fields

6. Discussion of potential for storage in unmineable coals and ECBM

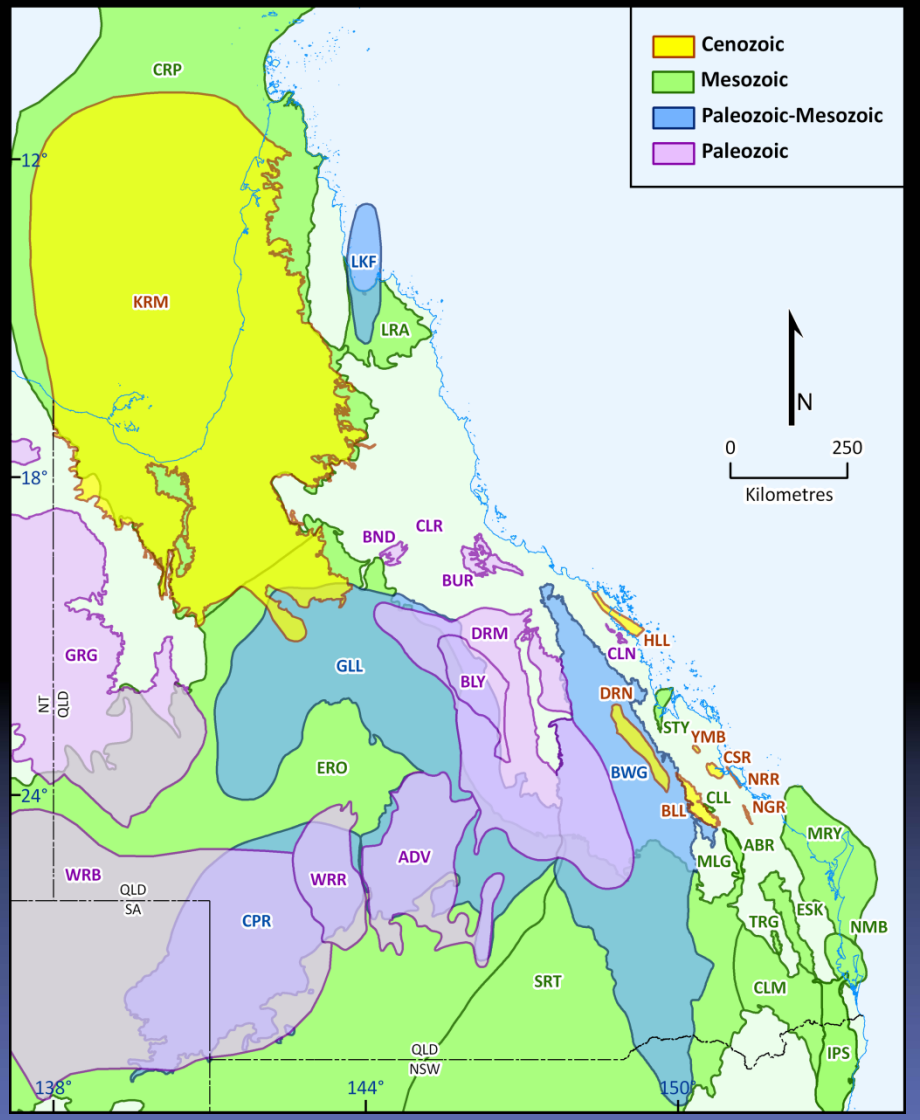


Basin prospectivity based on ranking methodology

ATLAS SCOPE

Queensland CO_2 Storage Atlas

- Aim to identify with highest possible certainty prospective basins for geological storage in onshore Queensland (36 basins).
- Geological assessment – excludes existing resources or site economics
- Options assessed include: regional reservoirs (saline reservoirs & aquifers); depleted oil & gas fields; deep unmineable coal seams; and salt caverns.
- Greatest potential in regional reservoirs using migration assisted storage (MAS) – focus of presentation.

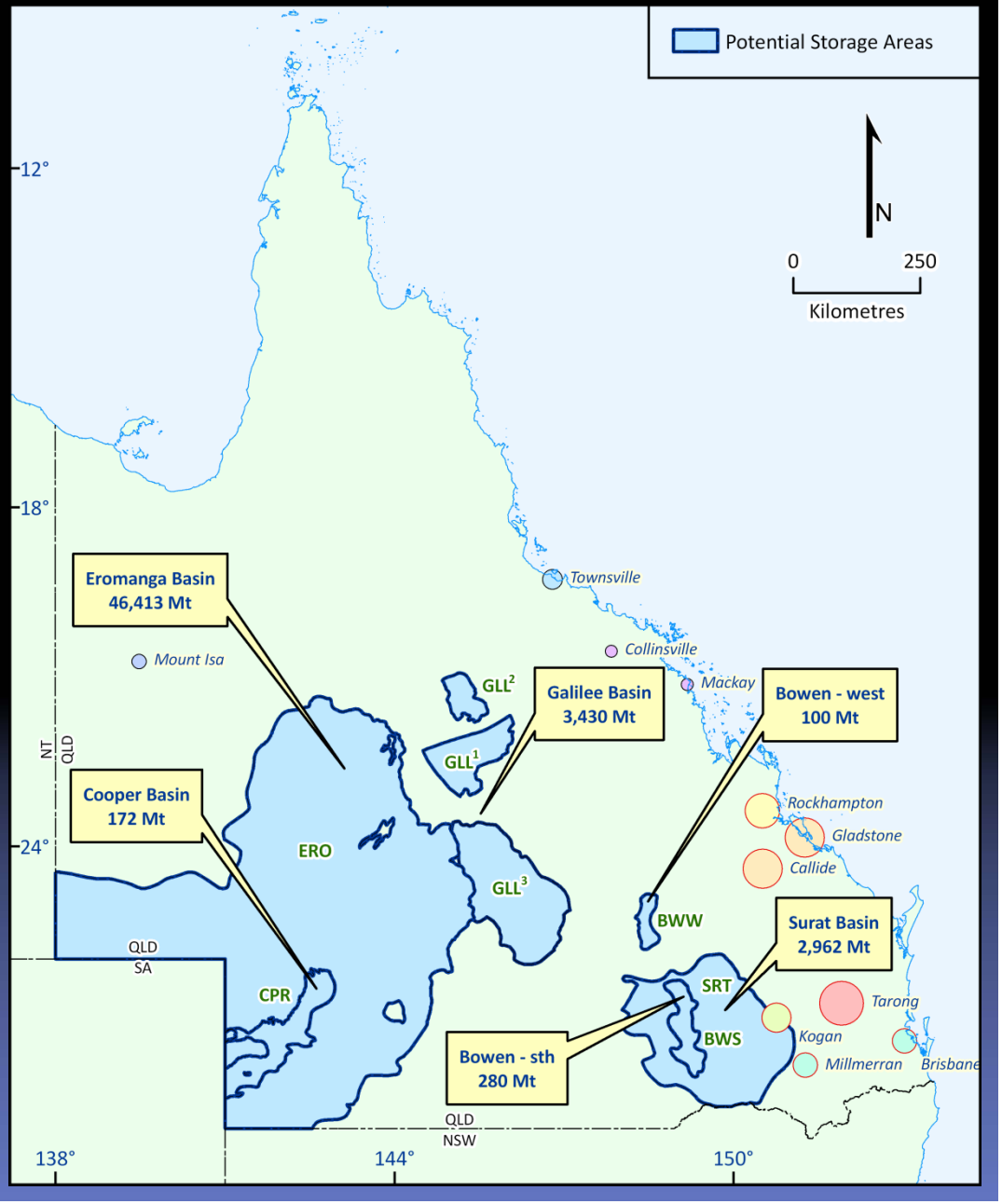


Assessed sedimentary basins classified by age

HIGH PROSPECTIVITY

High Prospectivity Areas – Summary

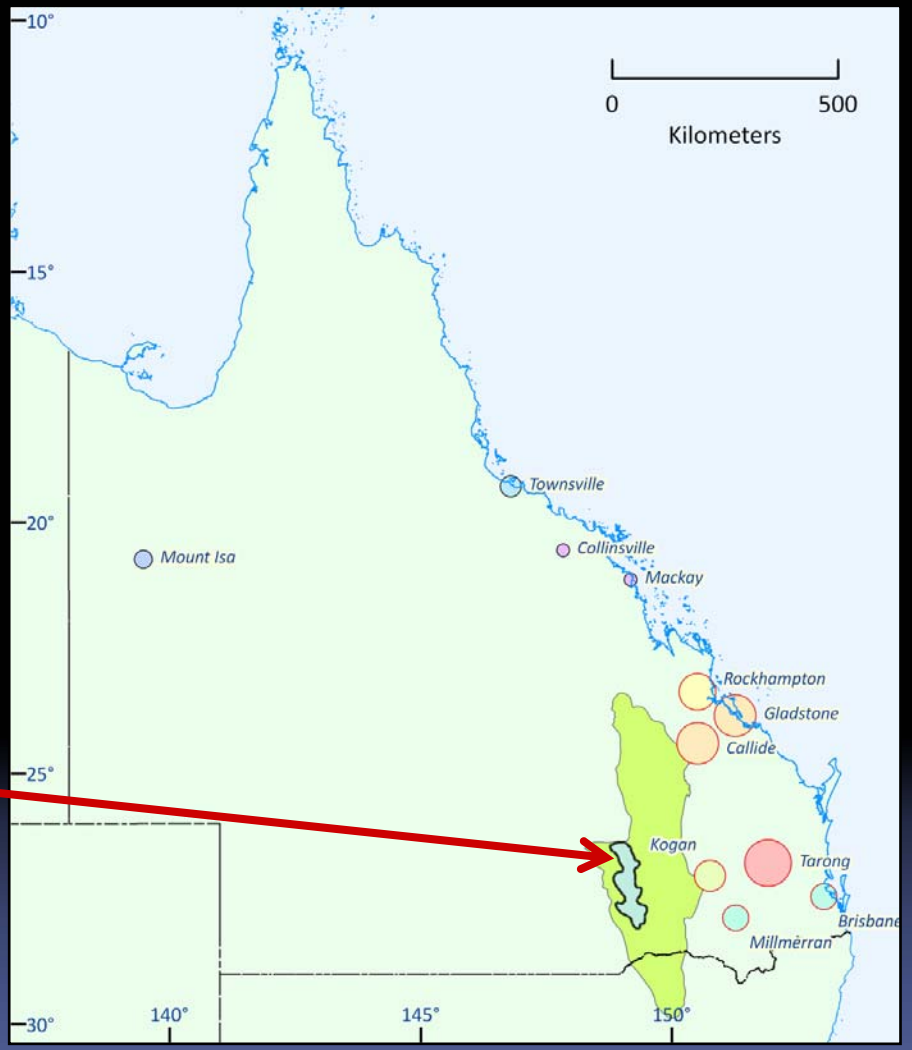
- Contain at least one reservoir-seal interval with demonstrated effectiveness for injection, storage and containment of CO_2 (i.e. have a total ranking score ≥ 13).
- Twenty reservoirs from five basin areas (Bowen, Cooper, Eromanga, Galilee and Surat basins).
- Most reservoirs have either produced hydrocarbons, and/or are major groundwater aquifers.
- Have sufficient data sets to establish their prospectivity.



HIGH PROSPECTIVITY

Southern Bowen Basin

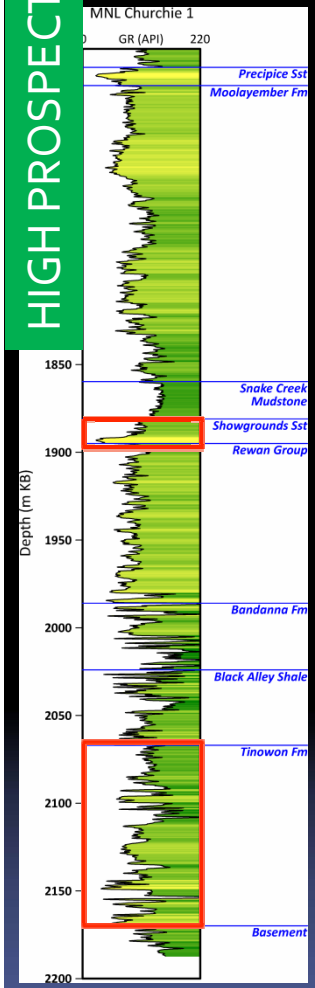
- Large north-south trending foredeep located close to major emission hubs.
- Mature hydrocarbon province in Queensland: ~76 conventional fields (OIP resources ~ 400 Bcf gas & 10 MMbbl oil) – most near depleted; 5 commercial CSG fields (~450 Bcf)
- Maximum potential storage area defined over western flank (Roma Shelf/Wunger Ridge area) where most conventional hydrocarbons are trapped and reservoir fairway located.



Potential geological storage area in the Southern Bowen Basin (blue polygon) & locations of major emissions nodes

Southern Bowen Basin

HIGH PROSPECTIVITY



Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			Total Score
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	
Moolayember Fm	Intraformational shales and mudstones, generally > 100 m thick, known to seal gas accumulations													
Moolayember Fm	Roma Shelf & Wunger Ridge	Net pay 17 (av = 7; n =5)	Median 14; Max 35; n = 512	Highly variable; Med 2.3; Max 6,200; n = 312	Intraformational	Structural/ residual gas saturation	1	C	2	3	2	2	3	12
Snake Creek Mudstone	Regionally extensive mudstones (lacustrine mfs), < 50 m thick, known to seal gas accumulations													
Showgrounds Sandstone	Roma Shelf & Wunger Ridge	Net pay 13 (av = 5; n = 21)	Median 13; Max 37; n = 1634	Highly variable; Med 14; Max 9,577; n = 1410	Snake Creek Mudstone	Structural/ residual gas saturation	1	C	3	3	2	2	3	13
Rewan Group	Intraformational siltstones and mudstones, > 100 m thick, known to seal gas accumulations													
Rewan Group	Roma Shelf & Wunger Ridge	Net pay 14 (av = 8; n = 11)	Median 11; Max 37; n = 932	Highly variable; Med 0.5; Max 2,245; n = 664	Intraformational	Structural/ residual gas saturation	1	C	2	3	2	2	3	12
Bandanna Formation	Intraformational siltstones, mudstones and tuffs, < 100 m thick													
Bandanna Formation	Roma Shelf & Wunger Ridge	Net pay 8 (av = 6; n = 2)	Median 11; Max 16; n = 17	Low; Median 0.6; Max 24; n = 16	Intraformational	Structural/ residual gas saturation	1	C	2	3	2	1	3	Fail
Black Alley Shale	Regionally extensive shale (marine mfs), < 50 m thick, known to seal gas accumulations													
Tinowan Formation/ Back Creek Group	Roma Shelf & Wunger Ridge	Net pay 38 (av = 17; n = 5)	Median 12; Max 40; n = 684	Highly variable; Med 1.6; Max 9,440; n = 512	Intraformational & Black Alley Shale	Structural/ residual gas saturation	1	C	3	3	2	2	3	13

- 5 reservoir units were ranked – best potential units are the Showgrounds Sandstone sealed by the Snake Creek Mudstone and Tinowon Formation sealed by the Black Alley Shale.
- These reservoirs are well sealed but have highly variable reservoir quality.

HIGH PROSPECTIVITY

Southern Bowen Basin

Basin:	Southern Bowen	Ranked Reservoir Unit:	Showgrounds Sandstone	Storage Mechanism:	Residual Gas Saturation

Estimated theoretical carbon dioxide storage resource of the Southern Bowen Basin - Showgrounds Sandstone reservoir is 191 Megatonnes

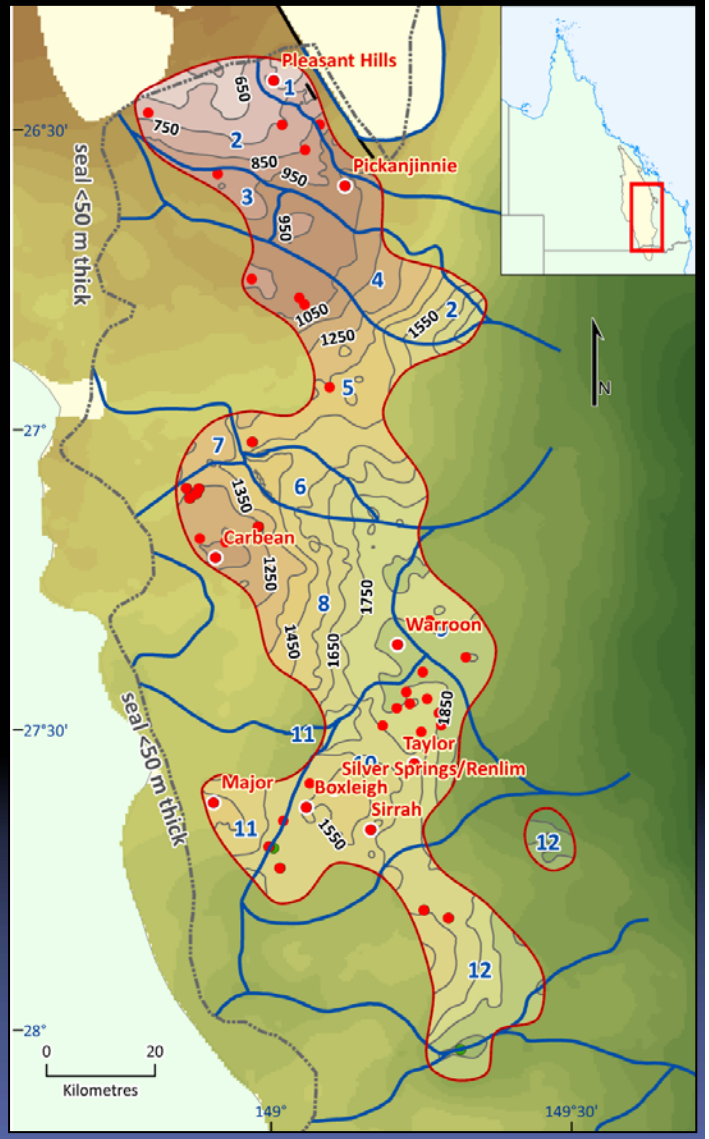
Regional Storage Volume Estimation - Data Quality		Comment
Structural Surface Constraints:	Good	Regional GA/GSQ interpretation - considered likely to be accurate ± 100 m.
Reservoir Thickness Constraints:	Fair	Braided fluvial channels - generally trending east west - intersected randomly by wells.
Reservoir Porosity Constraints:	Good	Measured porosities from QPED database.
Reservoir Sg. Constraints:	Fair	Average value of 10% of total pore volume used across entire porosity range.

Regional Carbon Dioxide Density Estimation - Data Quality		Comment
Temperature Profile Constraints:	Probable Temperature Profile	Data from CSIRO - selectively edited and final regional temperature profile estimated by GGSS.
Pressure Profile Constraints:	Probable Pressure Regime	Data from CSIRO - selectively edited and final regional pressure profile estimated by GGSS.

Theoretical Storage Resource		Comment
Storage Volume Estimation Method:	Statistical	Net pay zone thicknesses from limited field log analysis. Storage efficiency factor is 1.
Subjective Estimate Accuracy:	Average	

Estimated Potential Storage:	191	Megatonnes (theoretical storage resource)	NB: Residual Gas Saturation storage has been approximated using unit specific storage cut-offs (See Volumetric Methodology Section for discussion).

- Volumetric calculations were completed for 3 reservoir units (Showgrounds Sandstone, Rewan Formation and Tinowan Formation).
- Reservoir net pay zone thicknesses from WCR's and average porosity from QPED database used in calculations.
- Total maximum theoretical storage volume 363 Mt - greatest theoretical capacity in Showgrounds Sandstone (191 Mt).

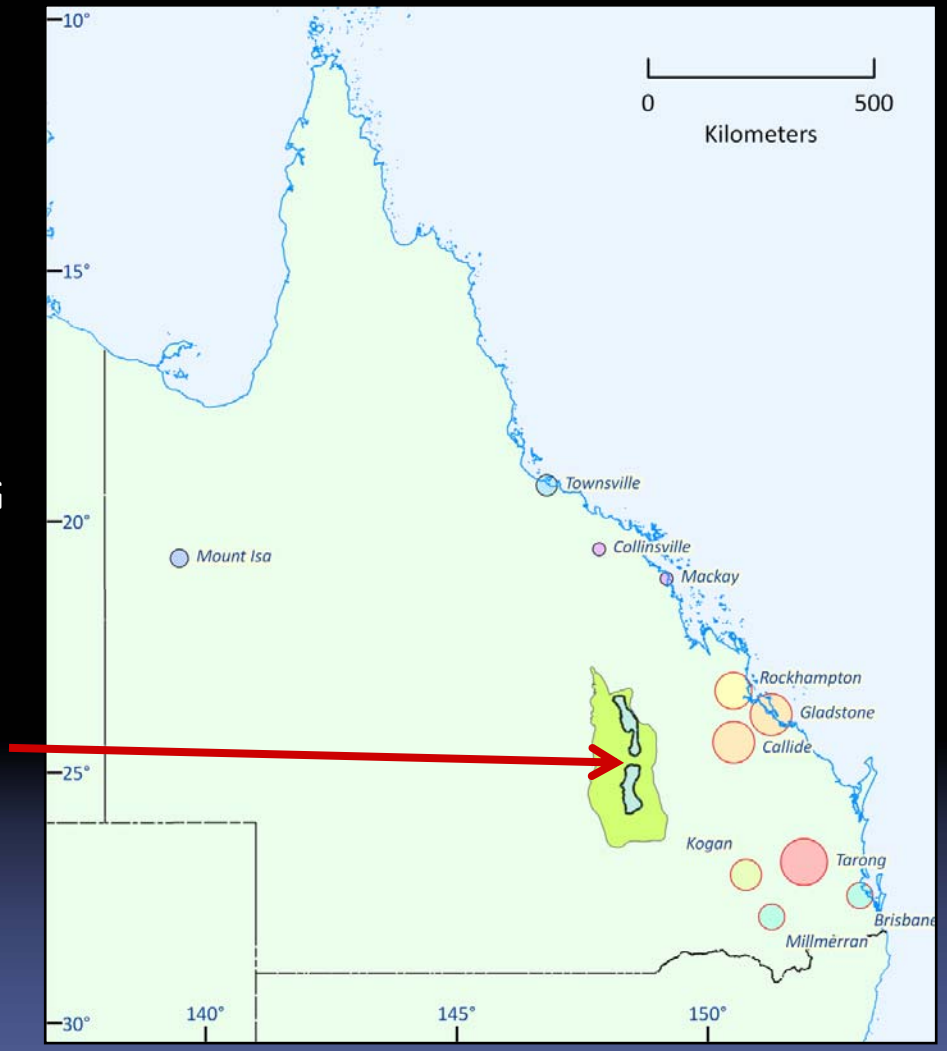


Showgrounds Sandstone storage. Also shown are drainage cell interpretations and hydrocarbon fields (red circles).

HIGH PROSPECTIVITY

Western Bowen Basin

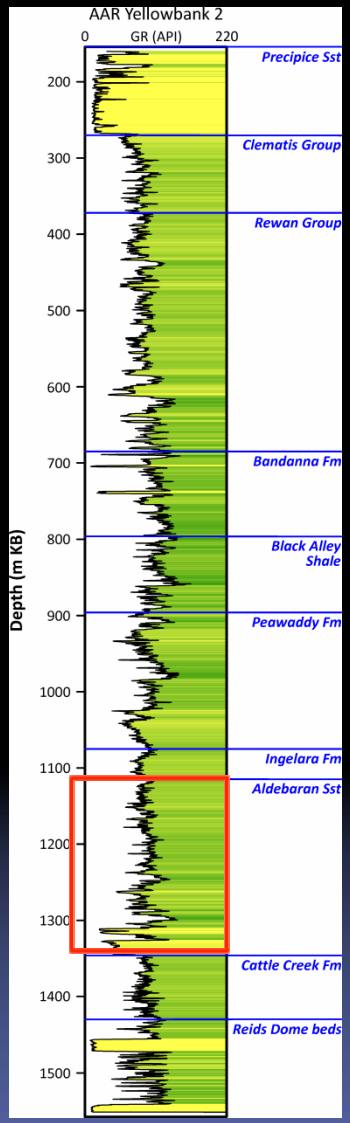
- Inverted extensional basin located close to major emission hubs.
- Mature hydrocarbon province in Queensland: 13conventional gas fields (OIP resources 374 Bcf) – tight gas fields with recent reserves growth; 2 world-class CSG fields (2925 Bcf)
- Maximum potential storage areas defined over northern and southern parts of Denison Trough where conventional hydrocarbons are trapped in large fault-propagation anticlines.



Potential geological storage area in the Western Bowen Basin (blue polygon) & locations of major emissions nodes

HIGH PROSPECTIVITY

Southern Denison Trough

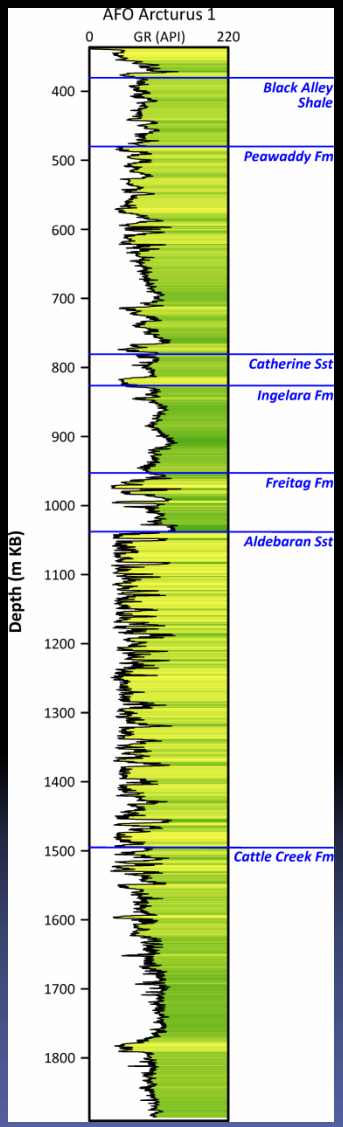


Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			Total Score
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	
Moolayember Fm	Intraformational shales and mudstones													
Clematis Group	South Denison Trough	Insufficient data	Insufficient data	Insufficient data	Truncated by Juarssic unconformity	Unknown		C	1	2	2	2	1	Fail
Rewan Group	Intraformational siltstones and mudstones, generally > 100m thick													
Rewan Group	South Denison Trough	Gross 434	Median 19; Max 25; n=24	Median 0.8; Max 489; n=19	Intraformational	Structural	1	C	2	2	3	2	1	10
Bandanna Fm	South Denison Trough	Insufficient data	Insufficient data	Insufficient data	Rewan or Intraformational?	Unknown		U	2	2	2	2	1	9
Black Alley Shale	Regionally extensive shales, siltstones and tuffs (marine mfs), >100 m thick, known to seal accumulations in north													
Peawaddy Fm	South Denison Trough	Gross 222	Median 13; Max 19; n=138	Median 0.4; Max 89; n=47	Black Alley Shale	Structural/ residual gas saturation	1	C	3	2	3	1	2	Fail
Peawaddy Fm	Regionally extensive siltstones and shales (marine mfs), >100 m thick, known to seal accumulations in northern trough													
Catherine Sst	South Denison Trough	Gross 47	Median 12; Max 17; n=21	Median 0.3; Max 13; n=9	Peawaddy Fm	Structural/ residual gas saturation	1	C	3	2	3	1	2	Fail
Ingelara Fm	Regionally extensive siltstones, shales (marine mfs), minor tuffs, >200 m thick, known to seal gas accumulations													
Freitag Fm	Intraformational siltstones, mudstones, <100 m, known to seal accumulations in northern trough													
Freitag Fm	South Denison Trough	Net pay 11.5 (n=1)	Median 14; Max 20; n=39	Median 1.4; Max 53; n=28	Intraformational Ingelara Fm	Structural/ residual gas saturation	1	C	3	2	3	1	3	Fail
Aldebaran Sst	Intraformational siltstones, shales, >100 m, known to seal gas accumulations													
Aldebaran Sst	South Denison Trough	Net pay 33 (av=14, n=10)	Median 13; Max 26; n=417	Highly variable; Median 2.1; Max 1390; n=302	Intraformational & Freitag/ Ingelara Fms	Structural/ residual gas saturation	1 2	C	3	2	3	2	3	13
Cattle Creek Fm	Intraformational siltstones, mudstones, >100 m, known to seal gas accumulations in northern trough													
Cattle Creek Fm	South Denison Trough	Gross 354	Median 10; Max 18; n=31	Median 1.1; Max 19; n=19	Intraformational	Structural/ residual gas saturation	1 3	C	3	2	2	1	3	Fail
Reids Dome Beds	Intraformational mudstones >100 m, known to seal gas accumulations													
Reids Dome Beds	South Denison Trough	Gross 2,768	Median 10; Max 24; n=110	Median 1.4; Max 28; n=50	Intraformational & Cattle Creek Fm	Structural/ residual gas saturation	1 3	C	3	2	2	1	3	Fail

- 9 reservoir units were assessed – only high prospectivity unit is the Aldebaran Sandstone.
- Reservoir well sealed but highly variable, generally low permeability sandstones.

HIGH PROSPECTIVITY

Northern Denison Trough

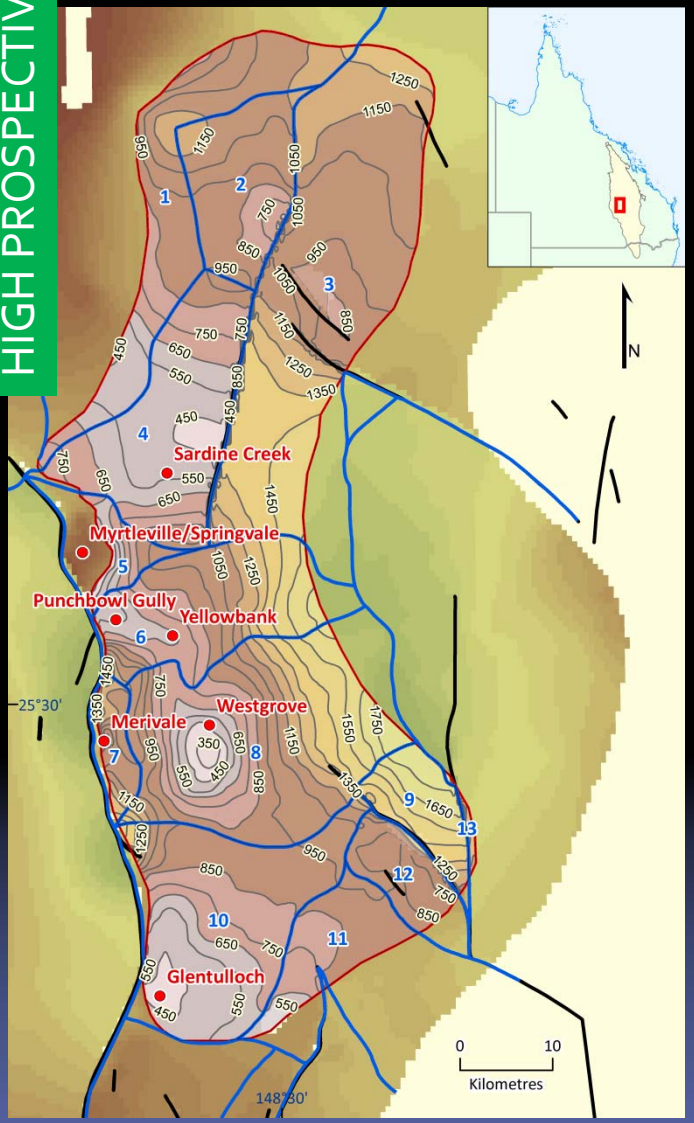


Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			Total Score
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	
Bandanna formation	North Denison Trough	Insufficient data	Insufficient data	Insufficient data	overlying units extensively eroded	None	1	None	1	1	2	2	1	Fail
Black Alley Shale	Regionally extensive shales, siltstones (marine mfs), coal and tuffs >100 m thick													
Peawaddy Fm (Mantuan Fm)	North Denison Trough	Gross 202	Insufficient data at depths >800m	Insufficient data at depths >800m	Black Alley Shale	Structural/ residual gas saturation	1 2	C	2	2	2	2	1	9
Peawaddy Fm	Regionally extensive siltstones, shales, >100 m thick, known to seal gas accumulations													
Catherine Sst	North Denison Trough	Net pay 4.4 (n=1)	Median 12; Max 10; n=10	Highly variable; Median 0.1; Max 0.1; n=8	Peawaddy Formation	Structural/ residual gas saturation	1 3	C	2	2	3	2	2	11
Ingelara Fm	Regionally extensive siltstones, shales (marine mfs), minor tuffs, >200 m thick, known to seal gas accumulations													
Freitag Fm	Intraformational siltstones, sandy mudstones, <100 m, known to seal gas accumulations													
Freitag Fm	North Denison Trough	Net pay 20 (av=8, n=4)	Median 11; Max 27; n=59	Highly variable; Median 1.5; Max 51; n=67	Intraformational & Ingelara Fm	Structural/ residual gas saturation	1 4	C	2	2	3	2	3	12
Aldebaran Sandstone	Intraformational siltstones, shales, coal, >100 m, known to seal gas accumulation													
Aldebaran Sandstone	North Denison Trough	Net pay 36 (av=22, n=5)	Median 23; Max 26; n=4	Limited data	Intraformational & Freitag/ Ingelara fms	Structural/ residual gas saturation	1 5	C	2	2	3	2	3	12
Cattle Creek Formation	Intraformational siltstones, mudstones, >100 m, known to seal gas accumulation													
Cattle Creek Formation	North Denison Trough	Gross 767	Median 7.6; Max 15; n=58	Median 0.2; Max 225; n=57	Intraformational	Structural/ residual gas saturation	1 6	C	2	2	1	1	3	Fail
Reids Dome beds	Intraformational mudstones >100 m, known to seal gas accumulations in southern trough													
Reids Dome Beds	North Denison Trough	Gross 1262	No reservoir quality sandstones	No reservoir quality sandstones	Intraformational & Cattle Creek Fm	Structural/ residual gas saturation	1 7	C	2	2	1	1	3	Fail

- 7 reservoir units were assessed – low potential for reservoirs in Catherine Sandstone, Freitag Formation and Aldebaran Sandstone (generally low permeability reservoirs).
- Structural traps present but seals often truncated and subaerially exposed.

HIGH PROSPECTIVITY

Western Bowen Basin



Aldebaran Sandstone potential storage area – southern Denison Trough. Also shown are drainage cell interpretations and hydrocarbon fields (red circles).

Basin:	Western Bowen	Ranked Reservoir Unit:	Aldebaran Sandstone	Storage Mechanism:	Residual Gas Saturation

Estimated theoretical carbon dioxide storage resource of the Western Bowen - Aldebaran Sandstone reservoir is 100 Megatonnes

Regional Storage Volume Estimation - Data Quality		Comment
Structural Surface Constraints:	Average	Regional GA/GSQ interpretation.
Reservoir Thickness Constraints:	Fair	Based on net pay zone thicknesses - highly variable - function of facies, provenance and diagenesis.
Reservoir Porosity Constraints:	Average	Measured porosities from QPED database.
Reservoir S_g, Constraints:	Fair	S_g, set to 10%.

Regional Carbon Dioxide Density Estimation - Data Quality		Comment
Temperature Profile Constraints:	Probable Temperature Profile	Data from CSIRO - selectively edited and final regional temperature profile estimated by GGSS.
Pressure Profile Constraints:	Probable Pressure Regime	Data from CSIRO - selectively edited and final regional pressure profile estimated by GGSS.

Theoretical Storage Resource		Comment
Storage Volume Estimation Method:	Statistical	Net pay zone thicknesses from limited field log analysis. Storage Efficiency Factor is 0.6.
Subjective Estimate Accuracy:	Fair	

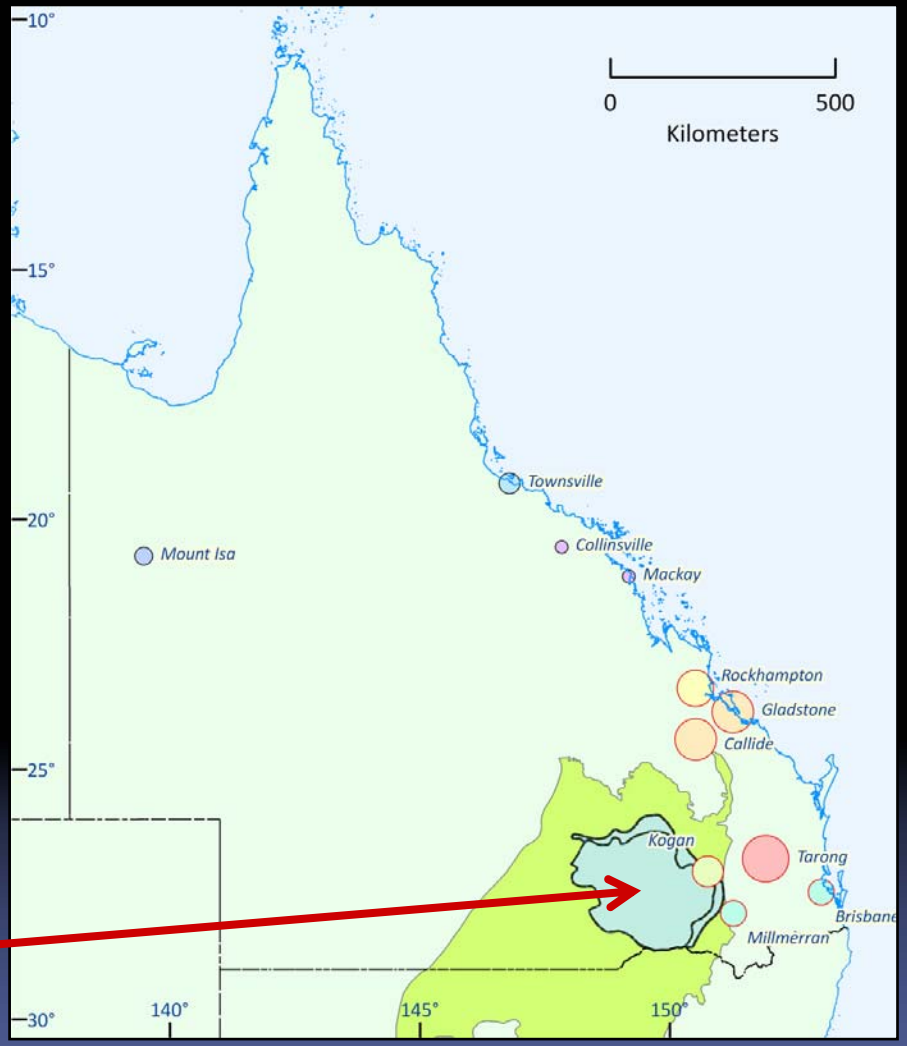
Estimated Potential Storage:	100	Megatonnes (theoretical storage resource)	NB: Residual Gas Saturation storage has been approximated using unit specific storage cut-offs (See Volumetric Methodology Section for discussion).

- Volumetric calculations were completed for 4 reservoir units (Aldebaran sandstone – sth Denison Trough; Aldebaran Sandstone nth Denison Trough; Freitag Fm; Catherine Sandstone).
- Reservoir net pay zone thicknesses from WCRs & average porosity from QPED database used in calculations.
- Total maximum theoretical storage volume 250 Mt.
- Greatest theoretical capacity in Aldebaran Sandstone over southern Denison Trough (100 Mt).
- Injectivity into low permeability reservoirs main uncertainty.

HIGH PROSPECTIVITY

Surat Basin

- Large intracratonic basin (overlies Bowen Basin) located close to major emission hubs.
- Mature hydrocarbon province in Queensland: ~45 fields (OIP resources ~500 Bcf gas & 50 MMbbl oil) – most near depleted; 19 commercial CSG fields (~1140 Bcf)
- Groundwater heavily utilised in populated areas.
- Large maximum potential storage area defined over much of basin area (regionally extensive reservoirs and seals extend over broad structural depression) – ideal basin for RGS trapping.



Potential geological storage areas in the Surat Basin (blue polygons) & locations of major emissions nodes

HIGH PROSPECTIVITY

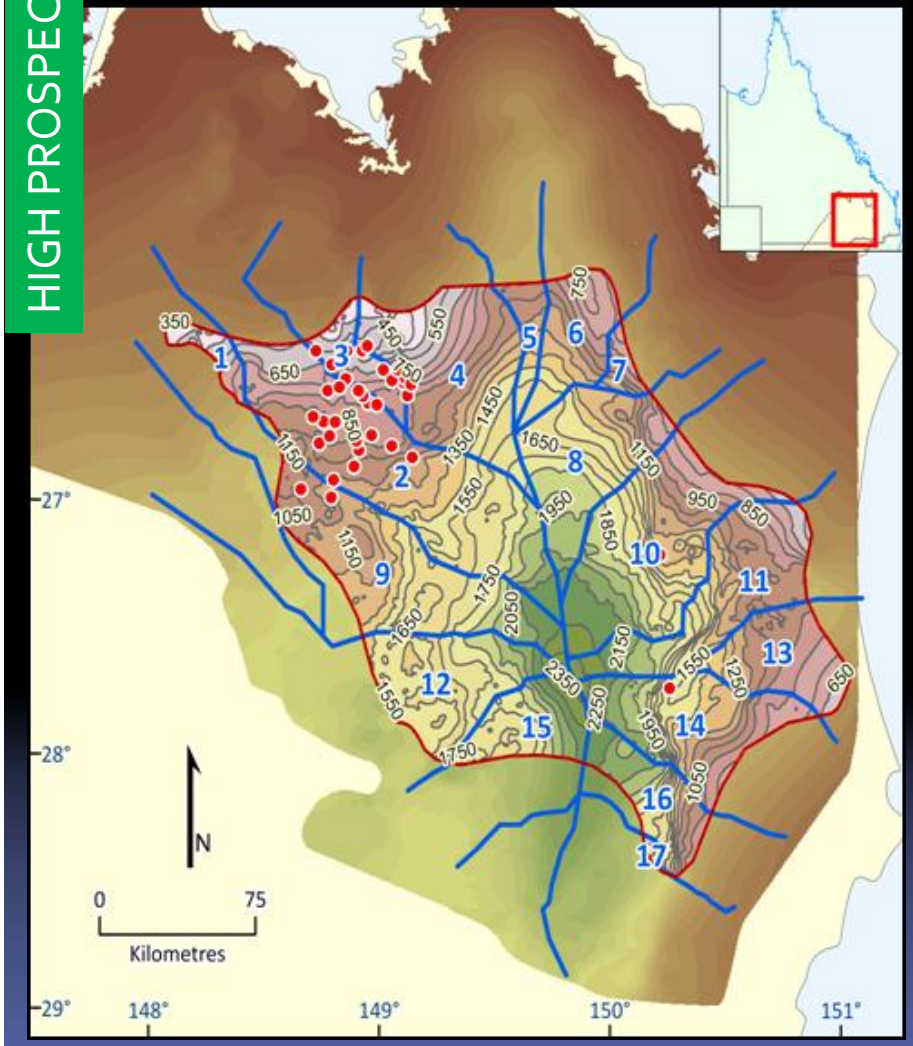
Surat Basin

Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			Total Score
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	
Griman Creek Formation	Basinwide	346 (gross)	Median 29; Max 33; n=27	Variable; Med 74; Max 954; n=27	Nil	Structural & Residual gas saturation		None	1	3	3	3	1	Fail
Surat Siltstone	Basinwide	125 (gross)	Median 25.5; Max 29; n=4	Variable; Med 66; Max 309; n=2	Nil	Structural & Residual gas saturation		None	1	3	3	3	1	Fail
Wallumbilla Formation	Interbedded marine mudstone and siltstone, > 100 m thick													
Bungil Formation	Basinwide	195 (gross)	Median 27; Max 92; n=78	Median 23.5; Max 4,130; n=70	Wallumbila Formation	Structural & Residual gas saturation	1	C	3	3	3	3	1	13
Mooga Sandstone	Basinwide	178 (gross)	Median 23.6; Max 35.8; n=69	Median 45; Max 5,820; n=65	Wallumbila Formation	Structural & Residual gas saturation	1, 2	U	2	3	3	3	1	12
Orallo Formation	Basinwide	226 (gross)	Median 27.8; Max 37; n=83	Median 311.5; Max 6,324; n=80	Wallumbila Formation	Structural & Residual gas saturation	1, 2	U	2	3	3	3	1	12
Gubberamunda Sandstone	Basinwide	73 (gross)	Median 26.4; Max 31.8; n=5	Median 150; Max 8,720; n=5	Wallumbila Formation	Structural & Residual gas saturation	1, 2	U	2	3	2	2	1	10
Westbourne Formation	Interbedded siltstone, sandstone and claystone up to 153 m thick, known to seal hydrocarbons													
Springbok Sandstone	Basinwide	116 (gross)	Median 23.1; Max 30.2; n=15	Median 7.8; Max 496; n=15	Intarformational & Westbourne	Structural & Residual gas saturation	3	C	2	3	3	2	3	13
Walloon Subgroup	Interbedded siltstone, sandstone, claystone and coal up to 420 m thick, known to seal hydrocarbons													
Hutton Sandstone	Basinwide	275 (gross)	Median 17.8; Max 34.3 n=2,649	Variable; Med 98; Max 13,600; n=2,451	Intarformational & Walloon	Structural & Residual gas saturation	3	C	2	3	3	3	3	14
Evergreen Formation	Sequence of mudstone, fine-grained sandstone, siltstone and shale: <100 m thick, known to seal hydrocarbons													
Boxvale Member	Roma Shelf	25 (gross)	Median 15.9; Max 33.4; n=475	Highly variable; Med 7.1; Max 7,380; n=426	Evergreen	Structural & Residual gas saturation	4	C	3	3	3	2	3	14
Basal Evergreen Unit	Roma Shelf	41 (gross)	Median 17.9; Max 33.4; n=32	Highly variable; Med 5.4; Max 3,420; n=32	Evergreen	Structural & Residual gas saturation	4	C	3	3	3	2	3	14
Precipice Sandstone	Roma Shelf	82 (gross)	Median 17; Max 33.9; n=900	Highly variable; Med 6.4; Max 7,908; n=835	Evergreen	Structural & Residual gas saturation	4	C	3	3	3	2	3	14
Precipice Sandstone	Mimosa Syncline	138.7 (gross)	Median 17.9; Max 36.9; n=802	Variable; Med 59.5; Max 2,000; n=730	Evergreen & Intarformational	Structural & Residual gas saturation	4	C	3	3	3	3	3	15

- The Precipice, Basal Evergreen, Boxvale , Hutton and Springbok (ranked 13-15) are the most important reservoir units in the basin. Four of these are the 'traditional' reservoirs targeted for oil exploration and are below the regional seal units
- Reservoirs that ranked 12 have good reservoir quality but they are < 800 m deep.
- 2 units failed due to lack of regional seal.

HIGH PROSPECTIVITY

Surat Basin



Precipice Sandstone reservoir map showing depth (mSS) structure surface. Also shown are drainage cell interpretations and hydrocarbon fields (red circles).

Basin:	Surat	Ranked Reservoir Unit:	Precipice Sandstone	Storage Mechanism:	Residual Gas Saturation

Estimated theoretical carbon dioxide storage resource of the Surat Basin - Precipice Sandstone reservoir is 1289 Megatonnes

Regional Storage Volume Estimation - Data Quality		Comment
Structural Surface Constraints:	Good	Regional GA/GSQ interpretation - considered likely to be accurate to within ±100m.
Reservoir Thickness Constraints:	Good	Net pay zone thicknesses from limited field log analysis.
Reservoir Porosity Constraints:	Very Good	Measured porosities from QPED database.
Reservoir S_{gr} Constraints:	Fair	S_{gr} set to 10%.

Regional Carbon Dioxide Density Estimation - Data Quality		Comment
Temperature Profile Constraints:	Probable Temperature Profile	Data from CSIRO - selectively edited and final regional temperature profile estimated by GGSS.
Pressure Profile Constraints:	Probable Pressure Regime	Data from CSIRO - selectively edited and final regional pressure profile estimated by GGSS.

Theoretical Storage Resource		Comment
Storage Volume Estimation Method:	Statistical	Net pay zone thicknesses from limited field log analysis. Storage efficiency factor is 1.
Subjective Estimate Accuracy:	Average	

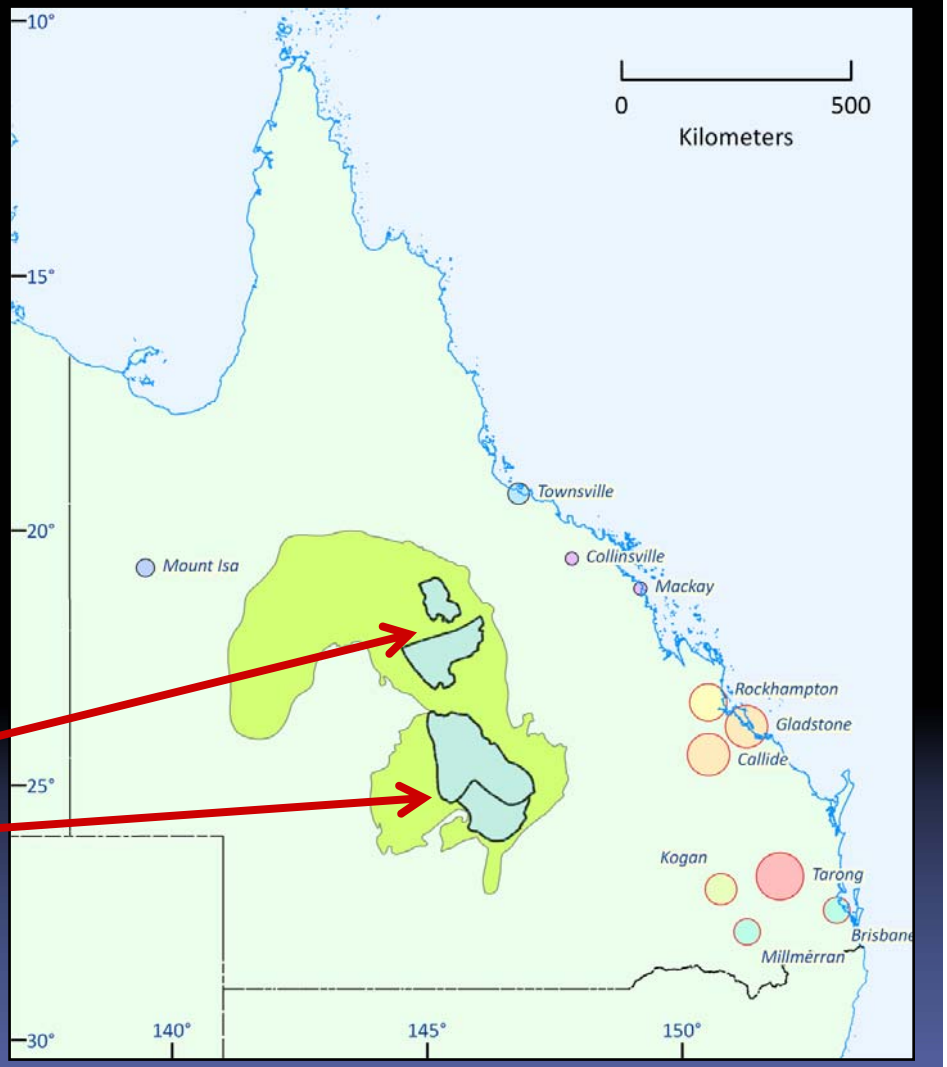
Estimated Potential Storage:	1,289	Megatonnes (theoretical storage resource).	NB: Residual Gas Saturation storage has been approximated using unit specific storage cut-offs (See Volumetric Methodology Section for discussion).

- Volumetric calculations were completed for 4 reservoir units (Precipice, Basal Evergreen, Boxvale, Hutton)
- Reservoir net pay zone thicknesses from WCR's and average porosity from QPED database used in calculations.
- Maximum theoretical storage capacity using residual gas saturation trapping totals 2,962 Mt in the evaluated reservoirs – greatest capacity in Precipice Sandstone (1,289 Mt).

HIGH PROSPECTIVITY

Galilee Basin

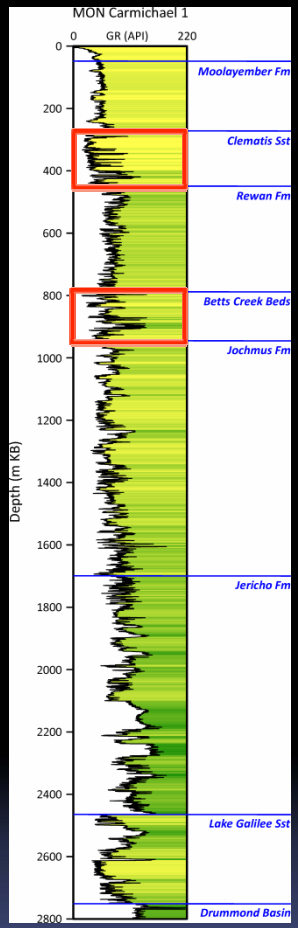
- Large and relatively shallow basin remotely located from major emission hubs.
- No commercial hydrocarbons discovered despite ~50 years exploration – current focus on CSG resources.
- Contains good quality groundwater resources.
- Several potential storage areas mapped over the northern and southern basin areas (low dipping strata in north; southwest plunging ridges in south).
- Only regional well and seismic data available to evaluate storage potential.



Potential geological storage areas in the Galilee Basin (blue polygons) & locations of major emissions nodes

HIGH PROSPECTIVITY

Northern Galilee Basin

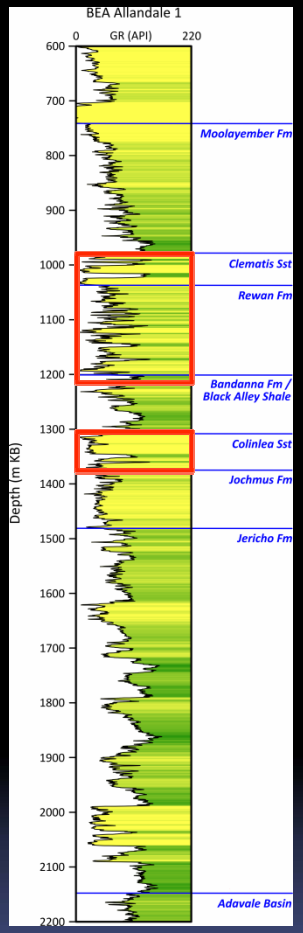


Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	Total Score
Moolayember Formation	Fluvial and lacustrine mudstones and siltstones (>50 m thick)													
Clematis Sandstone	northern Koburra Trough	180 (Gross)	Insufficient data	Insufficient data	Moolayember Formation	Residual gas saturation	1 2 3	C	2	3	3	3	2	13
Rewan Formation	northern Koburra Trough	390 (Gross)	Median 17.2; Max 23 n = 7	Median 309; Max 472 n = 3	Moolayember Formation	Residual gas saturation	1 2 3	U	2	3	3	3	2	13
Rewan Formation	Thinly interbedded fluvial siltstones, mudstones and sandstones (>100 m thick)													
Betts Creek beds	southern Koburra Trough	220 (Gross)	Median 17; Max 28 (n = 82)	Median 29; Max 5,852 (n = 60)	Rewan Formation	Structural/ residual gas saturation	1 2 4	U	2	2	3	3	3	13
Aramac Coal Measures	southern Koburra Trough	265 (Gross)	Median 18; Max 23 (n = 23)	Median 1.6; Max 429 (n = 22)	Rewan Formation	Structural/ residual gas saturation	1 4	U	2	2	3	1	3	Fail
Jochmus Formation	Koburra Trough	755 (Gross)	Median 18; Max 30 n = 83	Median 13; Max 1,634; n = 58	Rewan Formation	Stratigraphic/ residual gas saturation	1 4	U	2	2	3	2	3	12
Jericho Formation	Several thick intraformational fluvial and lacustrine siltstone and mudstone intervals (>50 m thick)													
Jericho Formation	Koburra Trough	804 (Gross)	Median 15; Max 26 n = 73	Median 6.4; Max 279; n = 58	Intraformational	Stratigraphic/ residual gas saturation	1 5	C	3	2	2	2	3	12
Lake Galilee Sandstone	Koburra Trough	287 (Gross)	Median 7; Max 11; n = 15	Median 0.3; Max 1; n = 6	Jericho Formation	Stratigraphic/ residual gas saturation	1	C	3	2	1	1	3	Fail

- 7 reservoir units were ranked – best potential units are the Clematis Sst/Rewan Fm sealed by Moolayember Formation; Betts Creek beds with unconventional Rewan Formation seal.
- These reservoirs have good-excellent & moderate-good measured porosity & permeability based on limited well data.

HIGH PROSPECTIVITY

Southern Galilee Basin

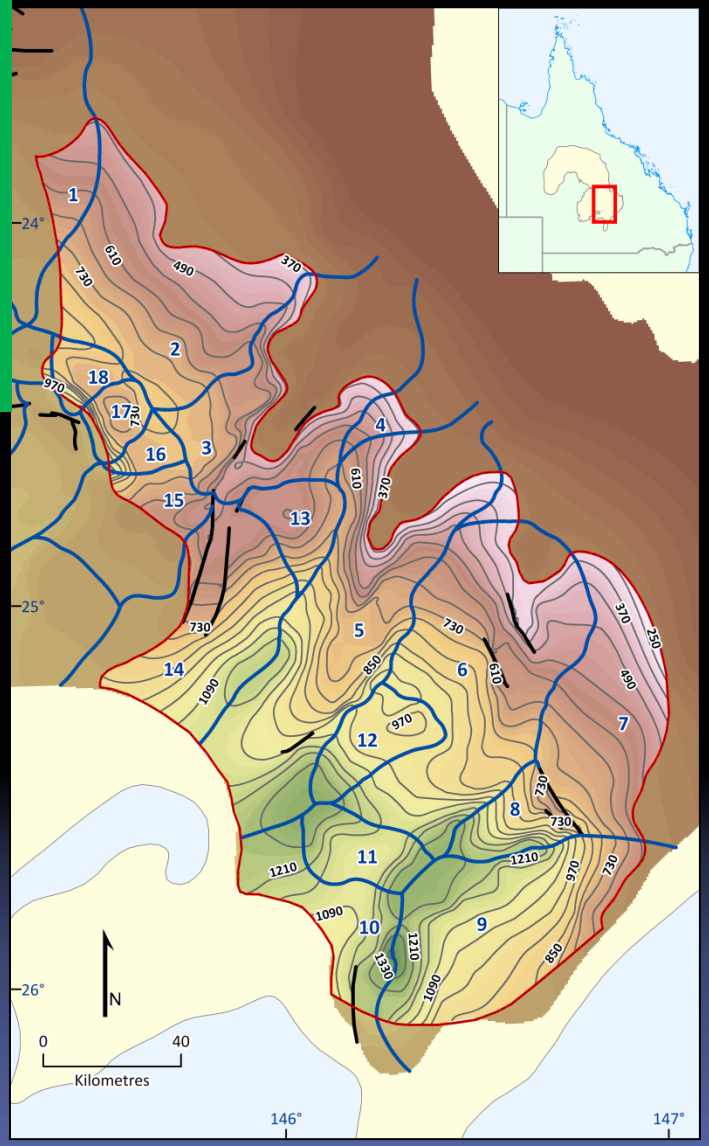


Unit	Reservoir Summary Information							Seal Ranking			Reservoir Ranking			
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms	Footnotes	Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	Total Score
Moolayember Formation	Fluvial and lacustrine mudstones, siltstones and sandstones (>50 m thick)													
Clematis Sandstone	Southern Galilee	60 (Gross)	Median 21 Max 28 Count = 20	Median 231 Max 1,747 Count = 16	Moolayember Formation	Structural/ residual gas saturation	1 2 3	C	2	2	3	3	3	13
Rewan Formation	Southern Galilee	181 (Gross)	Median 23 Max 30 Count = 33	Median 87 Max 4,770 Count = 24	Moolayember Formation	Structural/ residual gas saturation	1 2 3	U	2	2	3	3	3	13
Bandanna/Black Alley	Coastal plain mudst[illegible]nes, siltstones and sandstones (50-100 m thick)													
Colinlea Sandstone	Southern Galilee	64 (Gross)	Median 23 Max 28 Count = 24	Median 245 Max 5,738 Count = 23	Black Alley & Bandanna	Structural/ residual gas saturation	1 2 3	C	2	2	3	3	3	13
Jochmus Formation	Southern Galilee	319 (Gross)	Median 20 Max 26 Count = 7	Median 6 Max 147 Count = 7	Black Alley & Bandanna	Structural/ residual gas saturation	1 3	U	2	2	3	2	3	12
Jericho Formation	Several thick intraformational fluvial and lacustrine siltstone and mudstone intervals (>50 m thick)													
Jericho Formation	Southern Galilee	736 (Gross)	Median 11 Max 25 Count = 30	Median 10 Max 436 Count = 19	Intraformational	Structural/ residual gas saturation	1 4	C	3	2	2	2	3	12

- 6 reservoir units were ranked – best potential units are the Clematis/Rewan sealed by Moolayember Formation; Colinlea Sandstone sealed by Black Alley/Bandanna Fm.
- These reservoirs have good-excellent measured porosity & permeability based on limited well data.

HIGH PROSPECTIVITY

Galilee Basin



Southern Galilee Clematis Sst/Rewan Fm depth (mSS) structure surface with drainage cells.

Basin:	*Galilee*	Ranked Reservoir Unit:	*Clematis Sandstone/Rewan Fm*	Storage Mechanism:	*Residual Gas Saturation*

Estimated theoretical carbon dioxide storage resource of the Galilee Basin - Clematis Sandstone/Rewan Fm reservoir is 982 Megatonnes

Regional Storage Volume Estimation - Data Quality		Comment
Structural Surface Constraints:	Average	Regional seismic interpretation - considered likely to be accurate ± 60 m.
Reservoir Thickness Constraints:	Poor	Estimated net sandstone thickness - actual reservoir pay zone likely to be less.
Reservoir Porosity Constraints:	Fair	Limited porosity measurements from QPED database.
Reservoir Sg_r Constraints:	Poor	Sg_r set to 10%.

Regional Carbon Dioxide Density Estimation - Data Quality		Comment
Temperature Profile Constraints:	Probable Temperature Profile	Data from CSIRO - selectively edited and final regional temperature profile estimated by GGSS.
Pressure Profile Constraints:	Probable Pressure Regime	Data from CSIRO - selectively edited and final regional pressure profile estimated by GGSS.

Theoretical Storage Resource		Comment
Storage Volume Estimation Method:	Statistical	Very limited well data over storage area. Storage efficiency factor is 0.10.
Subjective Estimate Accuracy:	Poor	

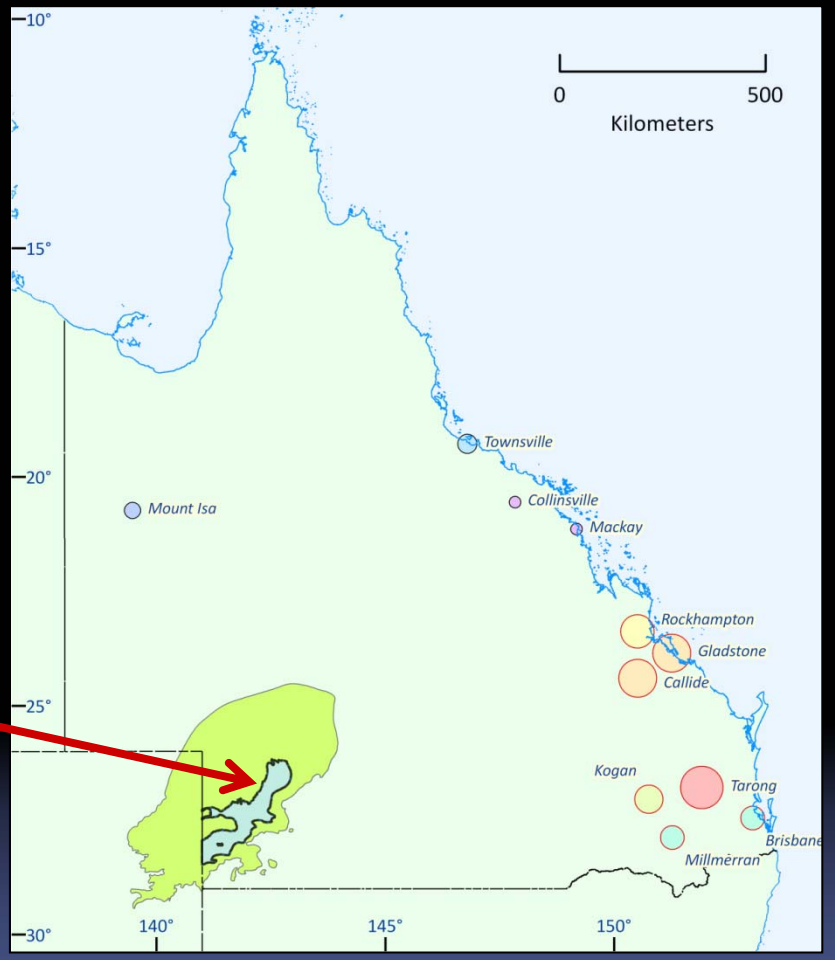
Estimated Potential Storage:	*982*	Megatonnes (theoretical storage resource)	NB: Residual Gas Saturation storage has been approximated using unit specific storage cut-offs (See Volumetric Methodology Section for discussion).

- Volumetric calculations were completed for 4 reservoir units (Clematis Sst, Rewan Fm, Betts Creek beds and Colinlea Sst).
- <u>Not possible to define reservoir fairways or pay zones</u> with regional well data coverage – reservoir data is largely unconstrained, storage volumes should therefore be used with caution.
- Large theoretical storage volumes: Southern Galilee 2,302 Mt ; Northern Galilee Basin 1,128 Mt.
- Clematis Sandstone/Rewan Formation in Southern Galilee has estimated capacity of 982 Mt.
- Seal capacity & faults through seal key uncertainty – <u>needs addressing through fully cored wells & modern seismic.</u>

HIGH PROSPECTIVITY

Cooper Basin

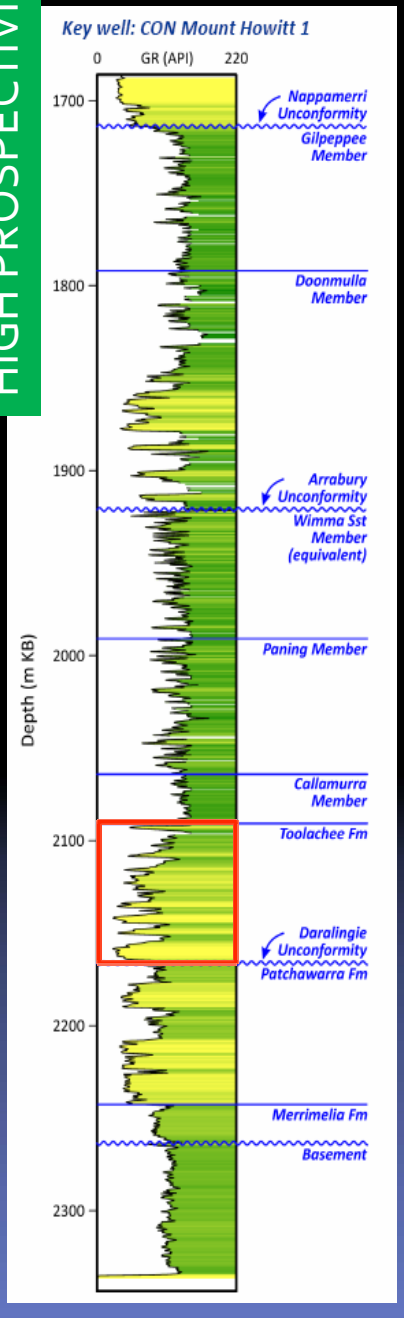
- Large intracratonic depocentre located very remotely from major emission hubs.
- Mature hydrocarbon province in Queensland: 81 conventional fields (OIP resources: ~1500 Bcf gas, 30 MMbbls oil) – most near-depleted
- Maximum potential storage area defined over southeastern basin area where most hydrocarbons are trapped – potential for RGS trapping using low dipping basin flanks.



Potential geological storage area in the Cooper Basin (blue polygon) & locations of major emissions nodes

HIGH PROSPECTIVITY

Cooper Basin

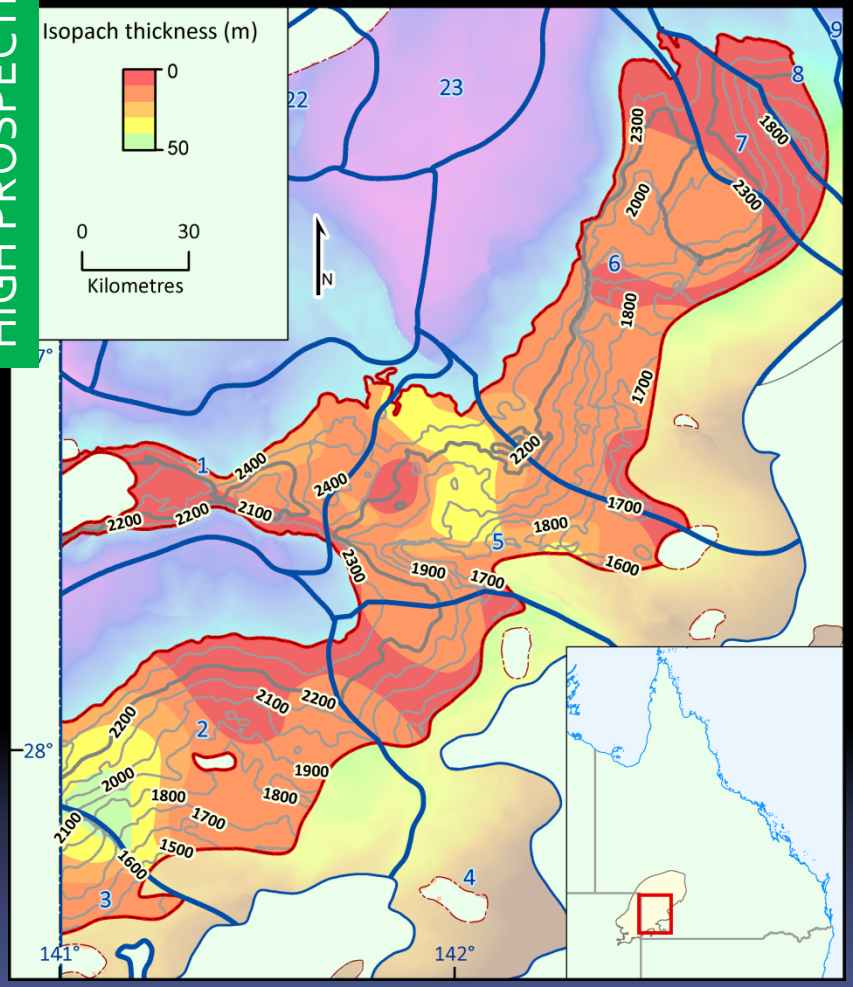


Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			Total Score
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanisms		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	
Gilpeppee Member	Grey-green siltstone and mudstone, only northern of JNP, to a maximum ~100 m thick.													
Doonmulla Member	northern sub-basin	~180	Average 8.4 Max 14.0 n=7	Average ~30 Max 203 n=7	Gilpeppee Member	Structural RGS	1	C	3	2	2	2	3	12
Wimma Sandstone Member	north-western edge of basin	~100	Average 11.1 Max 26.3 n=36	Average 1.7 Max 11 n=36	Doonmulla/ Gilpeppee	Structural RGS	2	U	2	2	2	2	3	11
Paning Member	Maximum thickness ~150 m. There may be reservoir options in this unit but generally fairly poor reservoir quality.													
Callamurra Member	170 m maximum thickness, thins to the north and in places < 50 m thick.													
Toolachee Formation	basinwide	190	Average 10.2 Max 22.9 n=1163	Average 96.5 Max 7100 n=1163	Callamurra Member	Structural RGS	3	C	3	2	2	3	3	13
Daralingie Formation	south of JNP trend	96	Probably as above	Probably as above	Toolachee/ Callamurra	Structural RGS	4	U	2	2	2	2	3	11
Roseneath Shale	Significant development south of JNP; maximum thickness 99 m generally 50-80 m thick.													
Epsilon Formation	south of JNP trend	92	Average 13.8 Max 17.9 n=17	Average 5.72 Max 20.2 n=17	multiple	Structural RGS	4	C	3	2	3	2	3	13
Murteree Shale	Significant development south of JNP; maximum thickness 71 m generally ~50 m thick.													
Patchawarra Formation	basinwide	400	Average 8.65 Max 21.1 n=844	Average 47.5 Max 3478 n=844	multiple	Structural RGS	5	C	3	2	2	2	3	12
Tirrawarra Sandstone	basinwide but patchy	70	Average 7.4 Max 10 n=27	Average 0.65 Max 4.4 n=27	multiple	Structural RGS	6	U	2	2	1	1	3	Fail
Merrimelia Formation	basinwide but patchy	84	Probably Poor	Probably Poor	multiple	Structural RGS	6	U	2	2	1	1	3	Fail

- 7 reservoir units were ranked – best potential units are the Toolachee Fm and Epsilon Fm (latter not regionally extensive).
- Variable reservoir quality main issue (80% failure at depths >2400 mSS).

HIGH PROSPECTIVITY

Cooper Basin



Toolachee Fm top depth-structure contours (mSS), isopach (m) and drainage cell areas.

Regional Storage Volume Estimation - Data Quality		Comment
Structural Surface Constraints:	Good	Regional P horizon depth map.
Reservoir Thickness Constraints:	Good	Isopach thickness based on sand isopach from Draper (2002) and QPED database.
Reservoir Porosity Constraints:	Fair	Porosity estimated from QPED database. Very scattered data.
Reservoir S_g Constraints:	Poor	S_g value of 10% used across entire range.

Regional Carbon Dioxide Density Estimation - Data Quality		Comment
Temperature Profile Constraints:	Probable Temperature Profile	Regional spread of extrapolated BHTs.
Pressure Profile Constraints:	Probable Pressure Regime	Formation pressure data points from DSTs that flowed WTS.

Theoretical Storage Resource		Comment
Storage Volume Estimation Method:	Nett Reservoir Isopach	Net to gross ratio set at 100%. Depth dependent reservoir quality loss included.
Subjective Estimate Accuracy:	Average	Storage efficiency factor estimated at 0.4 (average reservoir thickness 22m)

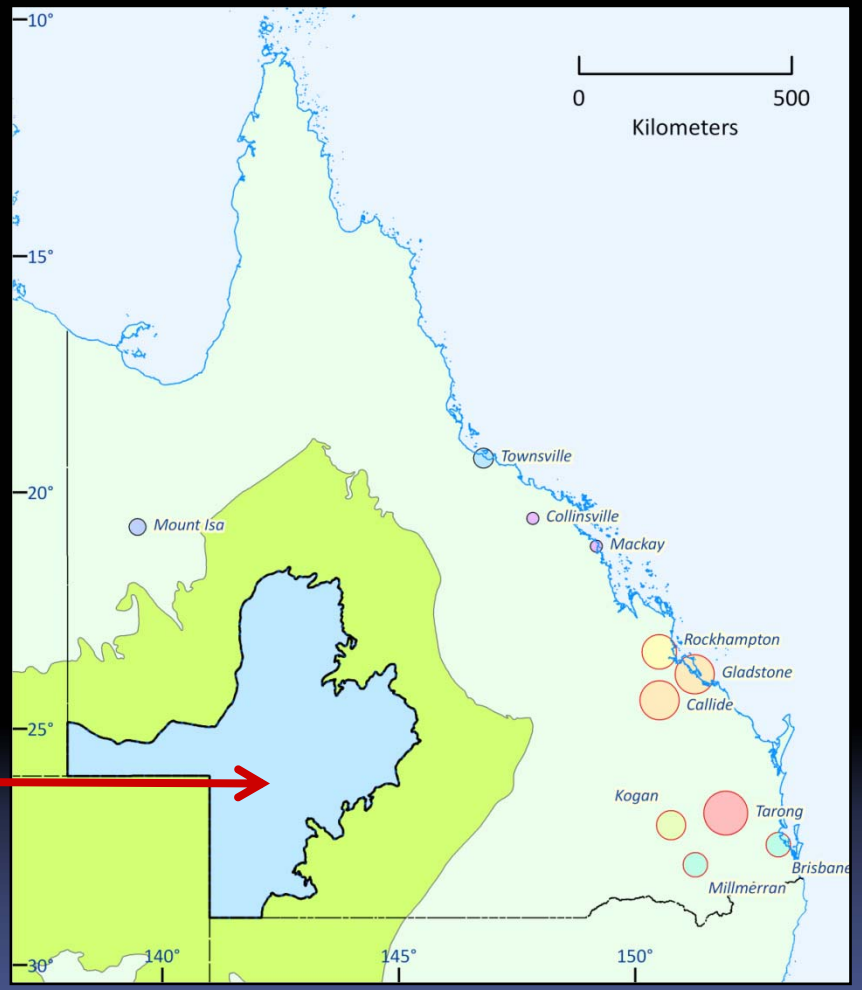
Estimated Potential Storage:	172	Megatonnes (theoretical storage resource)	NB: Residual Gas Saturation storage has been approximated using unit specific storage cut-offs (See Volumetric Methodology Section for discussion).

- Volumetric calculations were completed for one reservoir unit the Toolachee Formation
- Reservoir thickness was derived from isopach mapping (using Interpretation from Draper et al 2002)
- Calculated maximum theoretical storage volume: 172 Mt

HIGH PROSPECTIVITY

Eromanga Basin

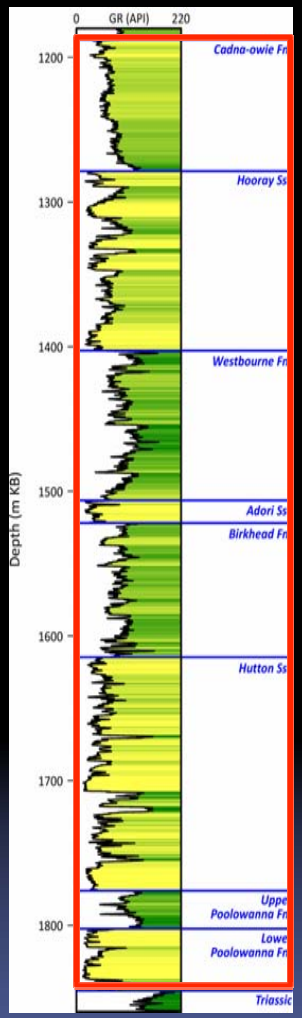
- Large intracratonic basin remotely located from major emission hubs.
- Sub-mature oil province in Queensland: ~80 fields (OIP resource ~300 MMbbl oil) – several sub-economic pools also discovered.
- Groundwater heavily utilised in populated areas.
- Very large maximum potential storage area defined over much of basin area (regionally extensive reservoirs and seals at depths >800 m BGL).
- Excellent conditions for storing CO_2 through RGS trapping or in dry structures.



Potential geological storage area in the Eromanga Basin (blue polygon) & locations of major emissions nodes

HIGH PROSPECTIVITY

Eromanga Basin

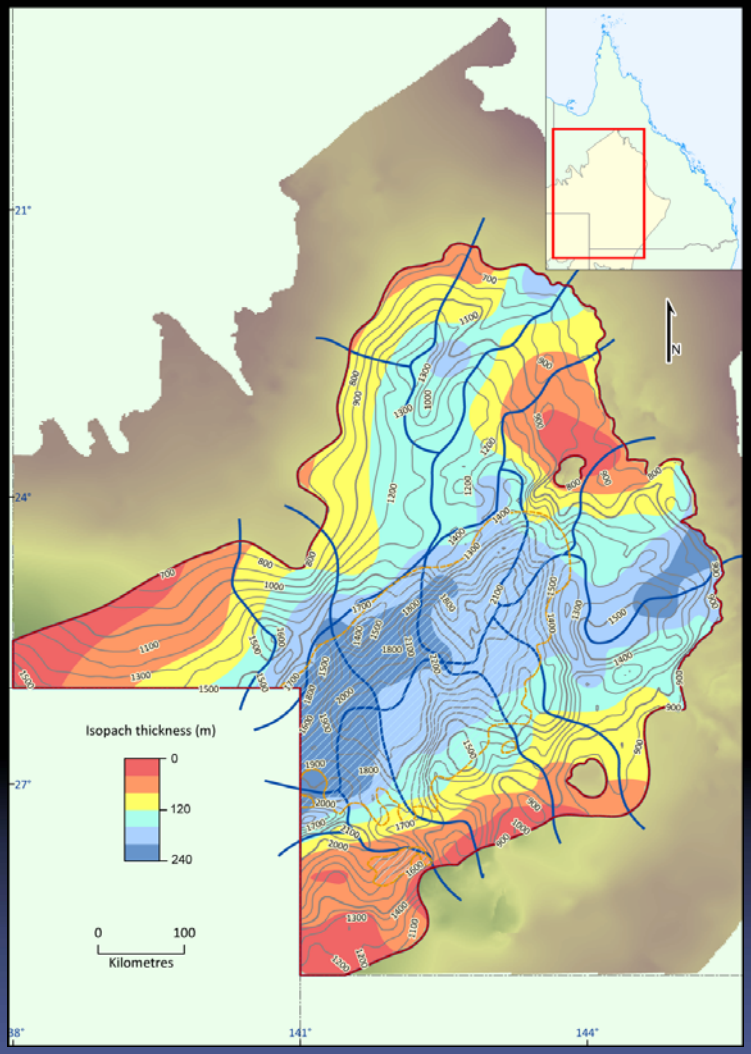


Unit	Reservoir Summary Information						Footnotes	Seal Ranking			Reservoir Ranking			Total Score
	Location	Maximum Thickness (m)	Porosity %	Permeability (mD)	Regional/Sub Regional Seal(s)	Potential Trap Mechanism		Seal Type	Bulk Seal Effectiveness	Faults through Seal	Porosity	Permeability	Depth at Base Seal Adequate	
Winton Formation	basinwide	1000	estimated at 10-25%	unknown, but likely to be favourable for injection	nil	structural		None	1	2	3	3	1	*Fail*
Mackunda Formation	basinwide	100	estimated at 10-25%	unknown	nil	structural		None	1	2	3	3	2	*Fail*
Allaru Mudstone	Regionally extensive succession up to 400 m thick; consists primarily of marine mudstone interbedded with siltstone.													
Wallumbilla Formation	Regionally extensive succession up to 350 m thick; consists primarily of interbedded marine mudstone and siltstone.													
Cadna-owie Formation (Wyandra Sandstone Member)	basinwide	~10	Median 17; Max 37; n = 373	Highly variable (0.01 - 12000 mD) - see footnote 1	Allaru/ Wallumbilla	structural / RGS	1	C	3	2	3	3	3	*14*
lower Cadna-owie Formation	Coarsening upward succession of mudstone, siltstone and sandstone up to 130 metres thick; demonstrated seal in hydrocarbon													
Hooray Sandstone	basinwide	165	Median 17; Max 46; n = 1984	Highly variable (0.01 - 7520 mD) - see footnote 2.	multiple	structural / RGS	2	C	2	2	3	3	3	*13*
Westbourne Formation	Interbedded sequence of siltstone, sandstone and claystone up to 160 metres thick; demonstrated seal in hydrocarbon fields.													
Adori Sandstone	basinwide	55	Median 19.8; Max 32; n = 82	Median 403; Max = 8091; n = 78	multiple	structural / RGS		C	2	2	3	3	3	*13*
Birkhead Formation	Interbedded sequence of siltstone, sandstone and claystone up to 110 metres; demonstrated seal in hydrocarbon fields.													
Hutton Sandstone	basinwide	210	Median 17; Max 34; n = 2505	Median 91; Max > 10000; n = 2321	multiple	structural / RGS		C	2	2	3	3	3	*13*
upper Poolowanna Formation	Interbedded sequence of siltstone, sandstone and claystone up to 100 metres thick; demonstrated seal in hydrocarbon fields.													
lower Poolowanna Formation	central depocentre	120	Median 12; Max 22; n = 525	Highly variable (0.01 - 2700 mD) - see footnote 3	multiple	structural / RGS	3	C	2	2	3	3	3	*13*

- 7 reservoir units were ranked – 5 of these are the 'traditional' reservoirs targeted for oil exploration and are below the regional seal units; 2 units are above the regional seal and 'fail' due to lack of seal.
- Those units below the regional seal are generally characterised by moderate-excellent reservoir quality.
- Bulk seal effectiveness of the intraformational seals (Birkhead, Westbourne etc) may be limited on a regional scale is effective locally as demonstrated by the occurrence of hydrocarbon accumulations.

HIGH PROSPECTIVITY

Eromanga Basin



Hutton Sandstone top depth-structure contours (mSS), isopach (m) and drainage cell areas

Regional Storage Volume Estimation - Data Quality		Comment
Structural Surface Constraints:	Good	Based on C horizon depth map, using QPED well tops data.
Reservoir Thickness Constraints:	Good	QPED Database - numerous wells across the basin.
Reservoir Porosity Constraints:	Poor	Average porosity values estimated from QPED core database subset. Minimal data points.
Reservoir S_g Constraints:	Poor	S_g value of 10% used across entire porosity range.

Regional Carbon Dioxide Density Estimation - Data Quality		Comment
Temperature Profile Constraints:	Probable Temperature Profile	Regional spread of extrapolated BHTs.
Pressure Profile Constraints:	Probable Pressure Regime	Formation pressure estimated from DSTs that flowed WTS.

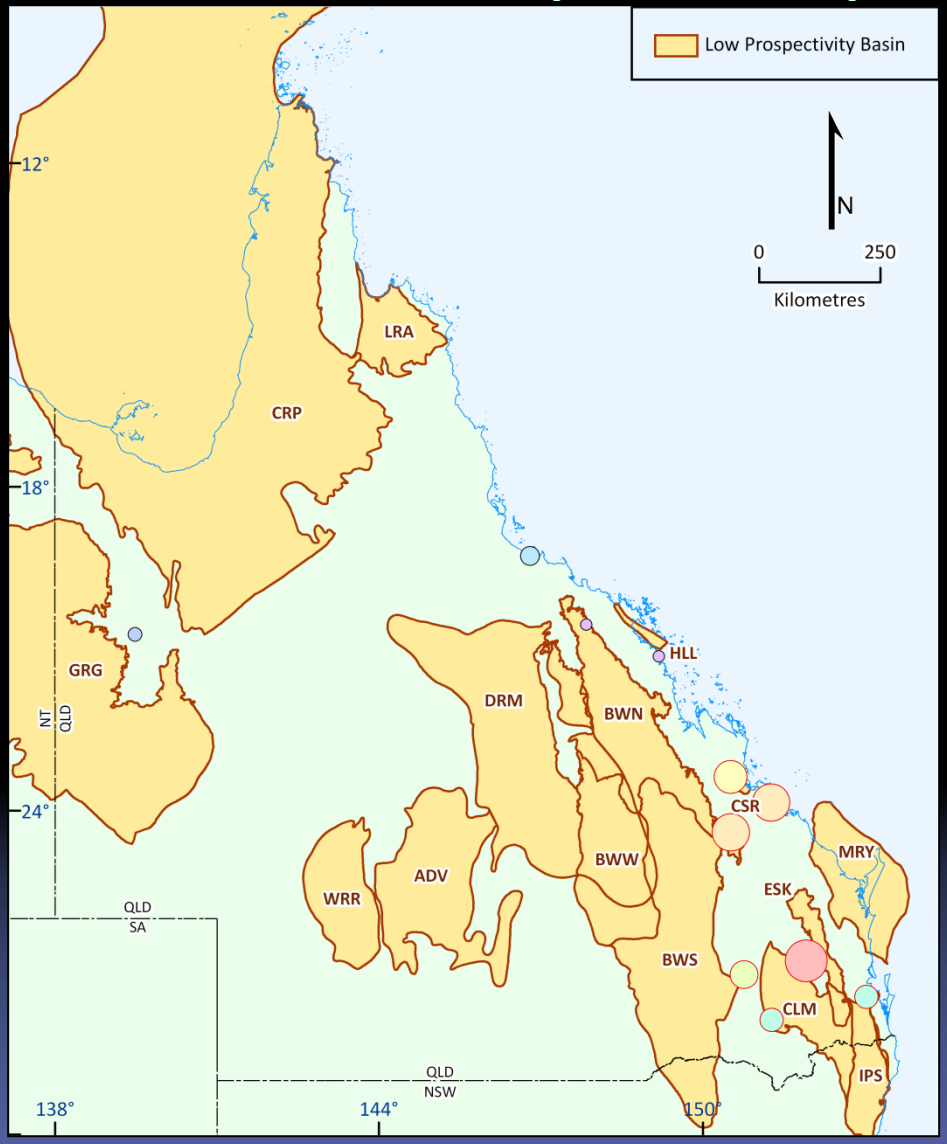
Theoretical Storage Resource		Comment
Storage Volume Estimation Method:	Gross Reservoir Isopach	Net to gross ratio estimated at 75% and depth dependant reservoir quality loss estimation included.
Subjective Estimate Accuracy:	Average	Storage efficiency factor 0.4.

Estimated Potential Storage:	6,474	Megatonnes (theoretical storage resource)	NB: Residual Gas Saturation storage has been approximated using unit specific storage cut-offs (See Volumetric Methodology Section for discussion).

- Volumetric calculations were completed for 5 reservoir units (Poolowanna Fm, Hutton Sst, Adori Sst, Hooray Sst & Wyandra Sst).
- Reservoir thickness was derived from isopach mapping (using QPED formation top data).
- Porosity vs depth function incorporated into calculations.
- The combined maximum theoretical capacity for these reservoirs is massive (46,499 Mt) – reflects the extensive nature and thickness of reservoir units.
- Hutton Sandstone capacity is estimated at 12,262 Mt of CO_2.

LOW PROSPECTIVITY

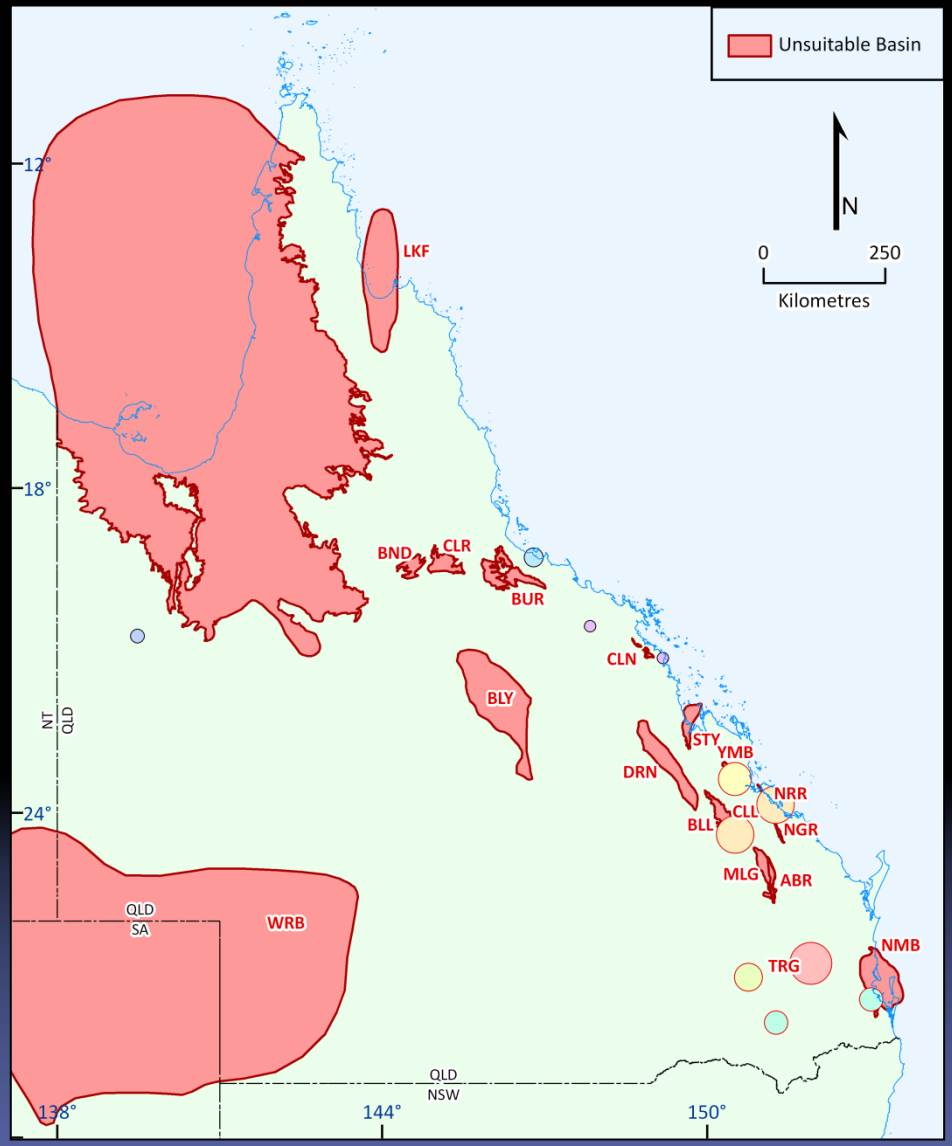
Results: Low Prospectivity Basins



- 13 basins evaluated as having low prospectivity.
- Contain reservoir-seal interval/s with uncertain effectiveness due to either limited data to evaluate their prospectivity, or high variability in the quality of reservoirs and seals.

UNSUITABLE

Results: Unsuitable Basins

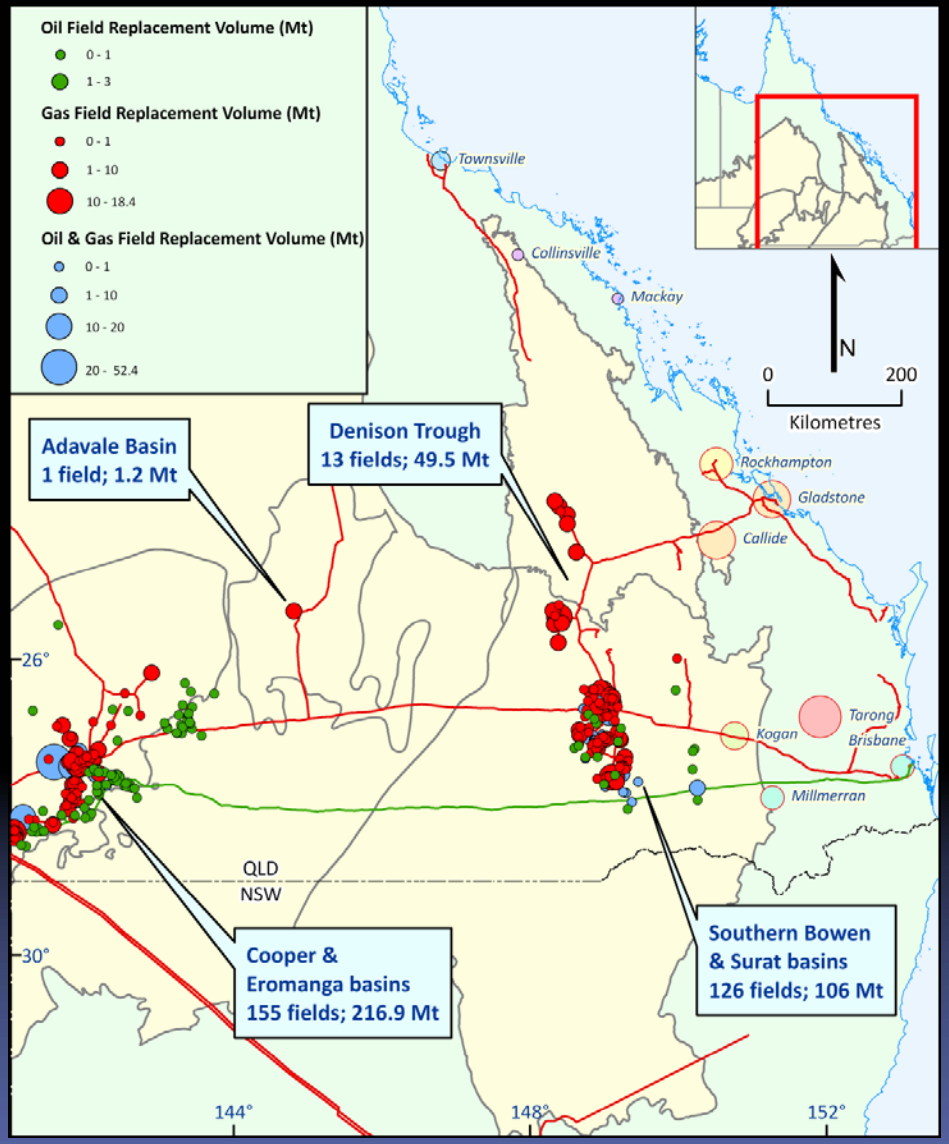


19 unsuitable basins are known to be unprospective as their reservoirs and/or seals are all below the minimum criteria

DEPLETED FIELDS

Depleted Fields

- A maximum theoretical replacement volume (MTRV) calculated on original in place resources as reported by QDEDDI 2008
- A MTRV of 374 Mt CO_2 is estimated for 295 gas and/or oil fields and ~485 reported producing reservoir pools in Queensland
- However, most large fields are still producing and are unlikely to be available for CO_2 storage in the near-future. Only 99 fields are either depleted or near-depleted (<5 % original 2P reserves remaining), which have a combined MTRV of 64.6 Mt CO_2

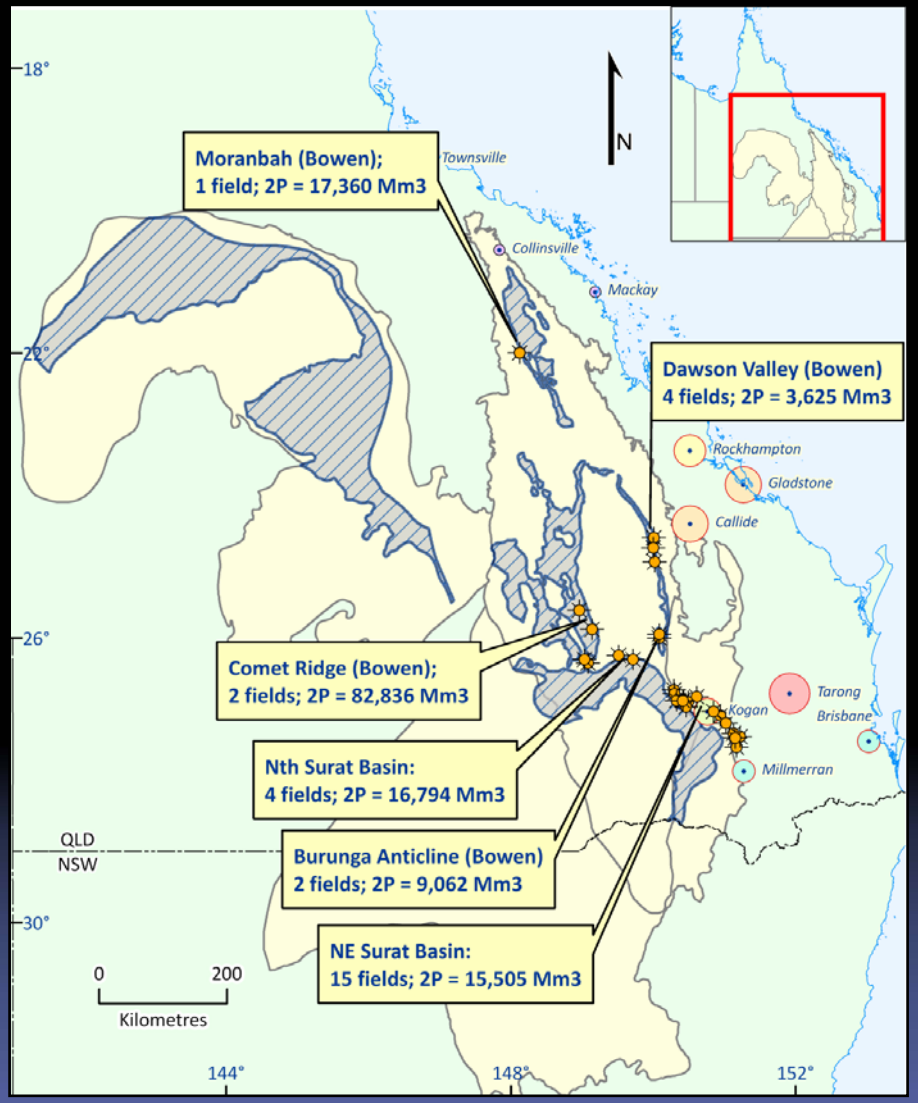


Location of oil, gas and oil and gas fields scaled by MTRV. Also shown are major emissions nodes and gas (red lines) and oil (green lines) pipelines

COAL STORAGE

Potential Coal Storage Areas

- Potential storage areas defined in major coal basins (Bowen, Surat & Galilee basins) using depth cut-offs of >400 m (sub-economic depth for mining) and <1,000 m (permeability).
- Storage volumes have not been calculated – know that these will be unrealistically large – injectivity is real issue
- Results show best potential is in CBM exploration sweet spots – mainly an option for ECBM recovery over the Comet Ridge & Dawson Valley

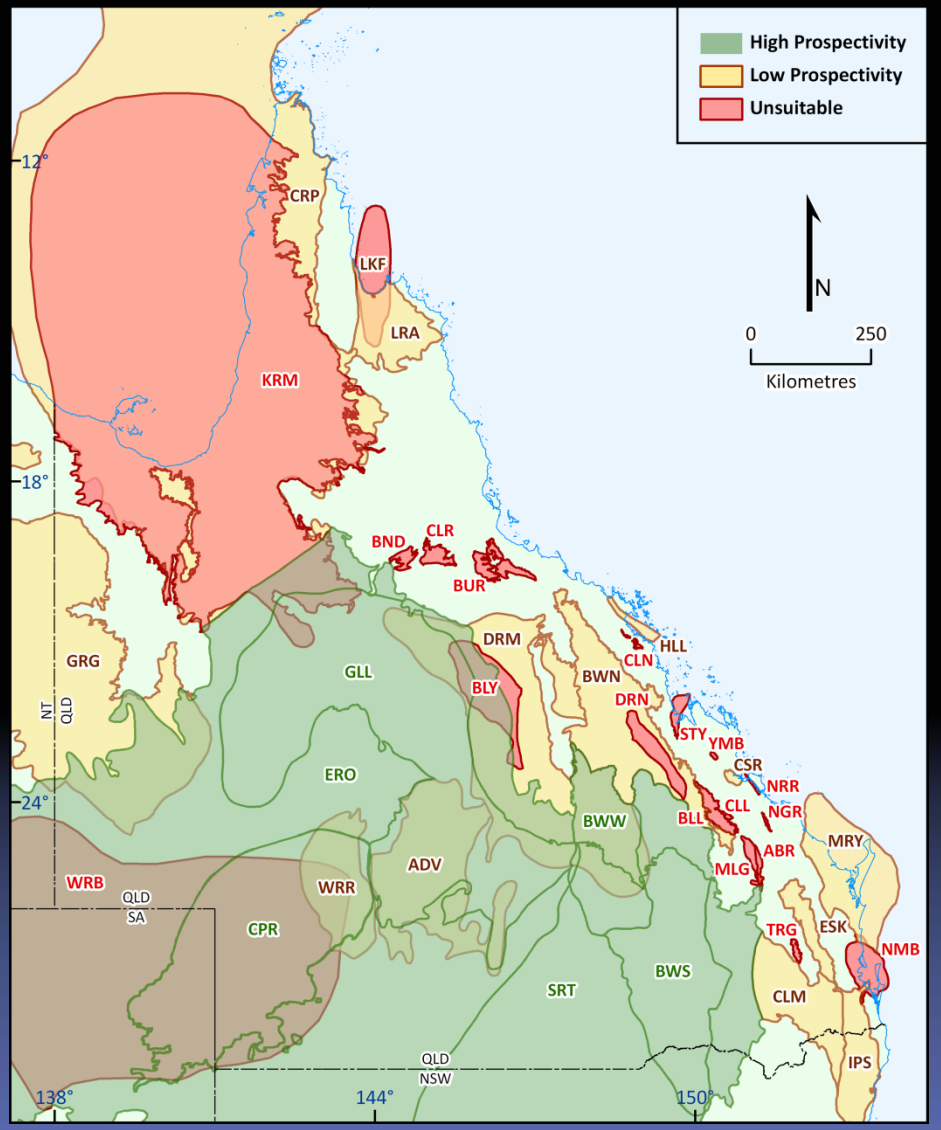


Location of thick extensive coal measures at depths >400 and <1000m (grey hatched polygons). Also shown are CSG fields and 2P resources (June 2008)

Summary

- The greatest potential for storage is using RGS trapping in regionally extensive reservoir-seal intervals rather than depleted fields or coal seams
  - Good opportunities for geological storage are most evident in the Bowen, Cooper, Eromanga, Galilee and Surat basins, but:
    - further drilling and exploration is required in many parts of these basins to fully document the quality of their storage prospectivity

- Queensland Government have legislation (*Greenhouse Gas Storage Act 2009*) that will come into effect Feb 2010
  - Soon to have gazettal rounds in place for permits to:
    - explore for underground storage reservoirs
    - storage of greenhouse gases to take place



Basin prospectivity based on ranking methodology

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- John Bradshaw
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- Lynton Spencer
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- Greg Tobin
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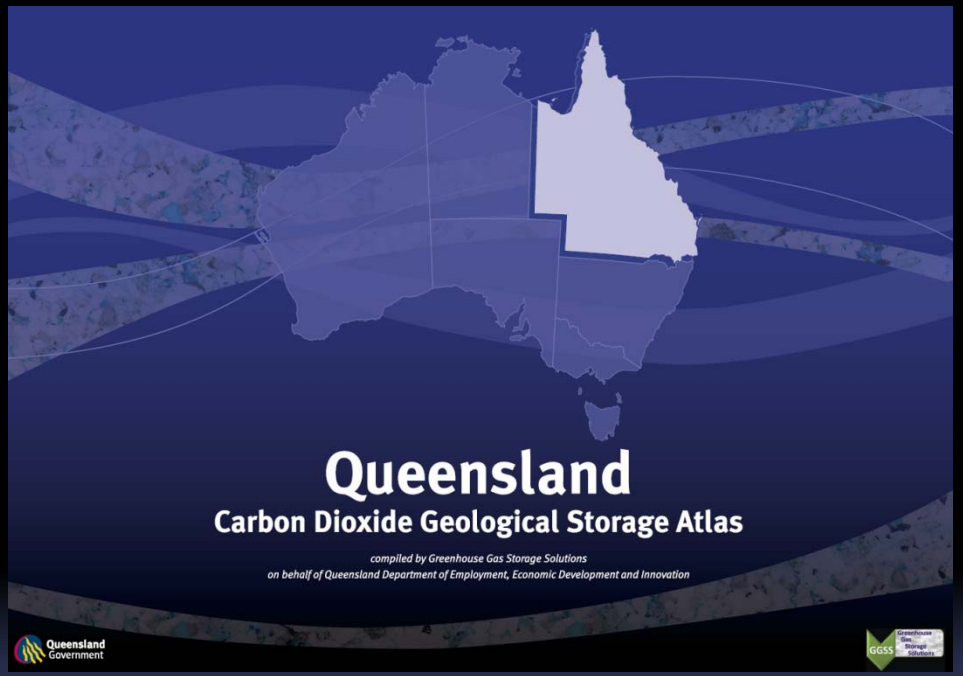
- Kat Norman
- James Woodger



Plus QDEEDI team: John Draper, Jonathan Hodgkinson, Mike McKillop, Micaela Preda and Owen Dixon.

CO_2 Geological Storage Solutions
CGSS

Queensland Government