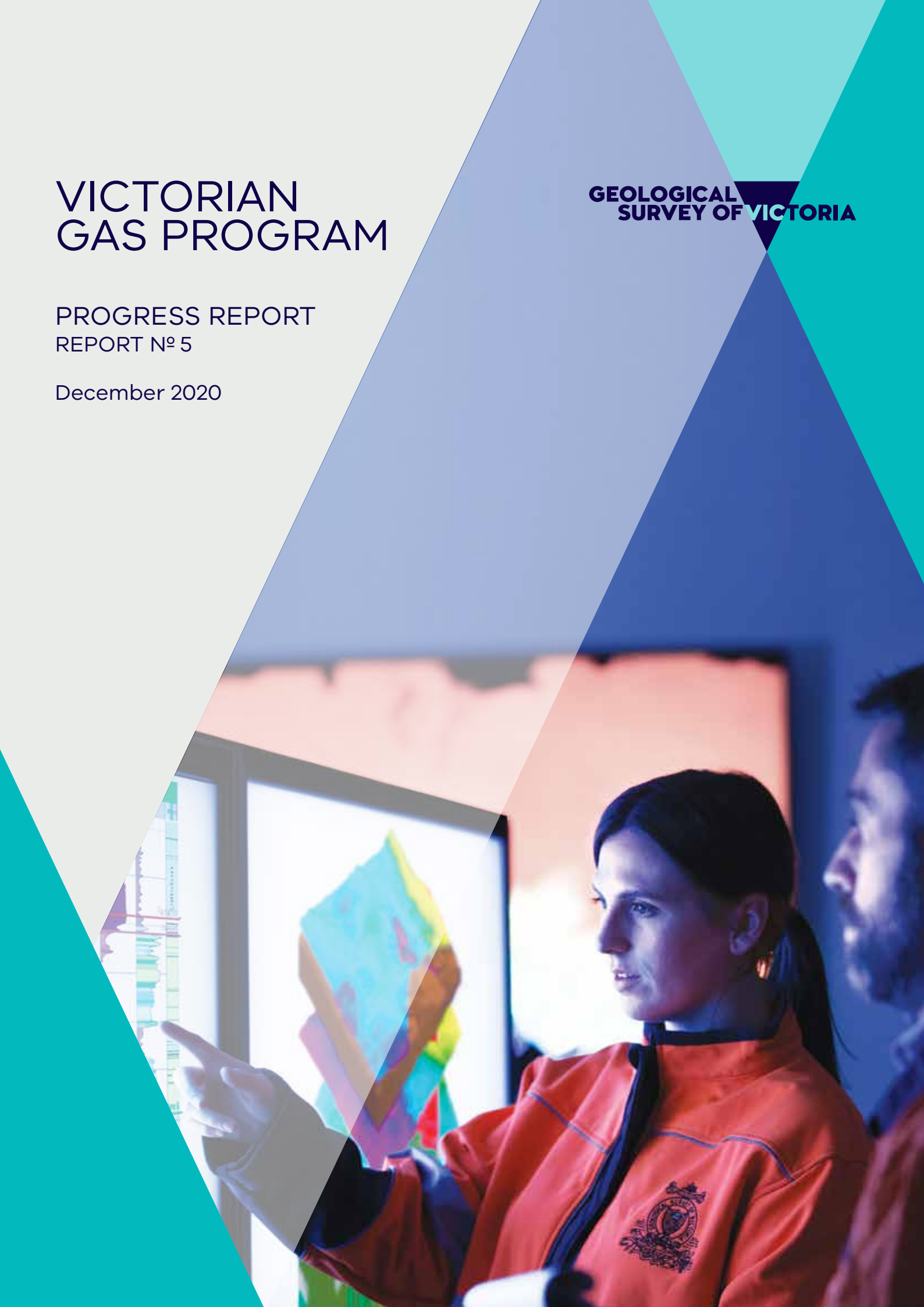
VICTORIAN GAS PROGRAM

GEOLOGICAL SURVEY OF VICTORIA

PROGRESS REPORT
REPORT № 5

December 2020

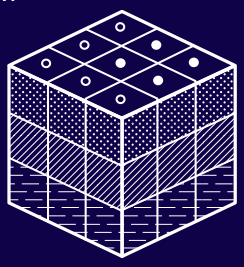


The Victorian Gas Program

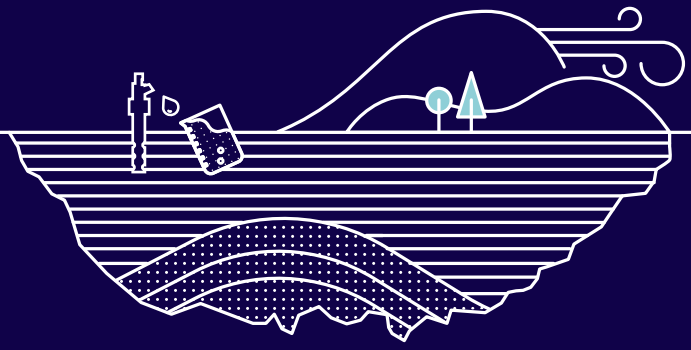
A new evidence base of scientific research on which to make better decisions, taking into account the interests of the environment, communities and the economy.

Regional 3D geological models of the Otway and Gippsland basins to support resource estimates in prospective areas.

Modelling to assess potential groundwater and surface water impacts if conventional gas development were to occur.



Environmental snapshots of the Otway and Gippsland basins using up-to-date groundwater chemistry data and air quality measurements.



A social baseline of the diverse views in regional Victoria regarding onshore conventional gas development.

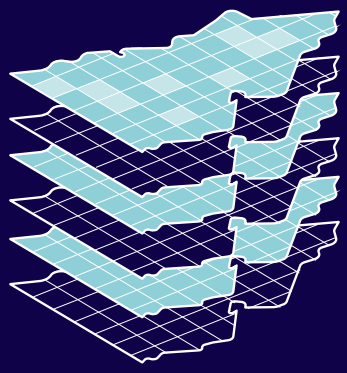
Oversight from independent scientists and a stakeholder panel representing the regional community, farmers, an anti-fracking group, an environment group, industry and a union.

The Victorian Gas Program timeline

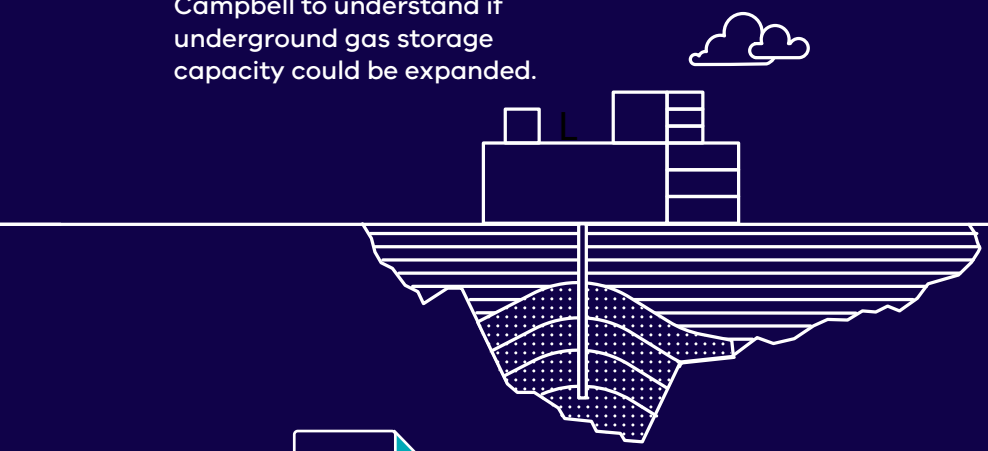
July 2017

Data acquisition

Resource and land use planning models of the Otway and Gippsland basins to identify important features in areas where gas may be found.



Investigations of depleted gas fields around Port Campbell to understand if underground gas storage capacity could be expanded.



Published peer-reviewed reports and datasets on the geoscientific, environmental and social studies.

New controls to improve government's ability to regulate onshore conventional gas activities, and support confidence in industry.

June 2020

We are here

Data analysis

Conclusions

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This document is also available in an accessible format at djpr.vic.gov.au

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About the Victorian Gas Program

The Victorian Gas Program was a comprehensive science-led program, incorporating geoscientific and environmental research to assess the risks, benefits and impacts of potential onshore conventional gas exploration and production.

The program also investigated the potential for further discoveries of onshore conventional and offshore gas in the Otway and Gippsland geological basins, and assessed the feasibility of additional onshore underground gas storage in depleted reservoirs around the Port Campbell area.

The program included an extensive, proactive and phased community and stakeholder engagement program, through which the results of the scientific studies have been communicated.

Study results and reports from the program are available at earthresources.vic.gov.au/gasprogram.

About the Geological Survey of Victoria

The Geological Survey of Victoria (GSV) is the Victorian Government's geoscience agency and sits within the Department of Jobs, Precincts and Regions.

The GSV provides evidence-based knowledge and information about Victoria's earth resources to government, industry, academia and the community, using the latest geoscience methods and technologies.

For more details visit earthresources.vic.gov.au/gsv.

Acknowledgements

The Geological Survey of Victoria would like to acknowledge the following groups for their contributions to this report:

- Victoria's Lead Scientist, Dr Amanda Caples for her oversight and feedback.
- The Victorian Gas Program Control Board for its governance oversight of the Victorian Gas Program.
- The Stakeholder Advisory Panel for Onshore Conventional Gas for their oversight and feedback. Membership of this panel included:
    - Jo Beard, Great South Coast Group
    - Stephen Bell, Qenos
    - Linda French, Beach Energy
    - Ben Davis, Australian Workers Union
    - Jonathan La Nauze, Environment Victoria
    - Gerald Leach, Victorian Farmers Federation
    - Alison Marchant, Community / Frack Free Moriac
    - Tennant Reed, Australian Industry Group.
- The Victorian Gas Program Scientific Reference Group for their expert peer review. Membership of this group included:
    - Dr Steve Mackie, Subsurface geoscientist
    - Dr Marita Bradshaw, Petroleum geologist
    - Prof Dayanthi Nugegoda, Ecotoxicologist
    - Prof Peter Gell, Palaeoecologist
    - Prof Damian Barrett, Environmental scientist
    - Dr Andrew Barton, Water resources engineer.

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Executive summary

In 2017, the Geological Survey of Victoria embarked on a three-year suite of geoscientific, environmental and social studies known as the Victorian Gas Program. The program aimed to:

- investigate Victoria's potential for new onshore conventional and offshore gas discoveries
- assess the risks, benefits and impacts of onshore conventional gas exploration and development.

The program achieved its aims and is now complete. It included extensive community and stakeholder engagement, to share the results of the scientific studies. Findings have been made publicly available via a series of technical and progress reports.

This report is the final Victorian Gas Program Progress Report. It presents:

- a summary of the onshore conventional gas studies, including data from geoscientific environmental and social research
- the outcome of the 2018 Victorian Offshore Acreage Release
- the results of investigations into potential underground gas storage sites
- the final resource and land use planning model for the Gippsland Basin
- an overview of the *Petroleum Legislation Amendment Act 2020*, and the upcoming opportunities for communities, industry and local government to engage with government to prepare the supporting regulations.

Technical reports with detailed results from the individual scientific studies are available with accompanying datasets at earthresources.vic.gov.au/gasprogram.

The Victorian Gas Program did not study onshore unconventional gas (fracking and coal seam gas), which government permanently banned in 2017.

Program highlights – better baseline data to guide responsible exploration, development and environmental interaction

The Victorian Gas Program identified potentially significant onshore conventional gas resources, particularly in the Otway Basin. The Otway Basin already supports a productive onshore gas industry across the border in South Australia, and operations associated with offshore gas production.

The program included Victoria's largest ever airborne gravity survey, regional air and groundwater testing, as well as the assessment of thousands of rock samples. The data collected informed the development of new predictive geological models, which highlight the deep rock layers and structures of the Otway and Gippsland basins.

The results of the geoscientific, environmental and social studies comprise the scientific legacy of the Victorian Gas Program. The data that has been collected is a valuable reference point for the state. Victoria now has better baseline data to guide responsible gas exploration, development and environmental interaction than any other jurisdiction. The baselines have been established in the absence of gas development, so if changes arise in future, they can be identified with more certainty.

For communities, this means that important questions about onshore conventional gas activities have been investigated and answered with scientific evidence. The social baseline provides a statistically robust understanding of regional communities' diverse attitudes about gas exploration and development.

For industry, this means that world-class data is available to inform more accurate and responsible exploration within Victoria, which has potential for new discoveries of conventional gas resources.

For government, this means that Victoria now has a scientific evidence base on which to make better decisions, taking into account the interests of the environment, communities and the economy. Data will guide upcoming work to improve the regulatory framework, entrenching leading industry practice through project transparency and community engagement obligations. Information is also available about potential underground gas storage sites that could be used to bolster Victoria's energy security, should this be needed in future.

The Victorian Gas Program's regional-scale data will not replace project-specific information required under the regulatory framework. Project proposals must include information to meet regulatory controls, which are scrutinised by government as part of the assessment process. Gathering this information requires project-specific investigations such as environmental assessments.

Orderly restart of onshore conventional gas industry – a science-led decision

The Victorian Gas Program's geoscientific investigations concluded that there is likely to be 128-830 petajoules of commercially feasible onshore conventional gas yet to be discovered in the state. Developing this gas would supplement Victoria's diminishing domestic supplies, and support regional jobs and economic development over a number of years.

Production of the estimated gas resources could generate around $300 million annually for regional economies and create up to 6400 jobs over the lifespan of these projects. South-West Victoria and Gippsland would be the main regions to benefit, where potentially significant onshore conventional gas resources were identified.

The program's environmental studies showed that developing these gas resources to secure local gas supply would not compromise the state's groundwater supplies or agricultural sector. If these resources were developed, it would support approximately two million Victorians customers who currently depend on gas for heating, cooking and industrial uses. It would have a negligible impact on Victoria's greenhouse gas emissions.

Following consideration of the program's independently reviewed findings, the Victorian Government committed to an orderly restart of the onshore conventional gas industry once improvements are made to the regulatory framework. On-ground exploration and development activity can begin again from 1 July 2021, once a best practice regulatory framework is put in place. The Victorian Parliament passed the *Petroleum Legislation Amendment Act 2020* to implement the decision.

Program governance – independently testing our methodology and results

The Victorian Gas Program was subject to strong governance to ensure scientific integrity, quality and independent oversight.

The methodology and results of the program's studies were tested under the guidance and advice of the independent Stakeholder Advisory Panel for Onshore Conventional Gas and the Scientific Reference Group, both chaired by Victoria's Lead Scientist Dr Amanda Caples.

The Stakeholder Advisory Panel included representatives of the regional community, farmers, an environmental group, industry and local government. The panel played a vital role in linking the diverse groups of stakeholders with an interest in gas with the scientific evidence collected.

Community engagement – sharing the science and answering important questions

The Victorian Gas Program's team engaged with local government, industry, farmers, school students, and environmental and community groups throughout the program – 950 individual stakeholders were reached across South-West Victoria, Melbourne and Gippsland through 780 events.

Victorian Gas Program geoscientists shared their knowledge and passion for geology by presenting to over 1400 primary and high school students in South-West Victoria, many of whom viewed the state's three-dimensional geological model.

Resource and land use planning models – identifying areas of significance and sensitivity to potential conventional gas industry

To make sure that any onshore conventional gas activities proposed in the future can consider information about the local context, the Victorian Gas Program developed resource and land use planning models for the Otway and Gippsland basins. Each model incorporates over 140 datasets and displays features spatially, allowing existing and potential future land uses and landscape sensitivities to be identified.

The models highlight areas where sensitive or significant landscape features may exist, that would need to be considered prior to any exploration or development proceeding.

The models can be used to identify potential issues or land use conflicts requiring mitigation early in the regulatory process, to promote multi and sequential land use. The models will also support government to understand potential interactions with other land uses during impact assessments or acreage releases.

Next steps – working with industry and communities to underpin best practice

Restarting Victoria's onshore conventional gas industry from 1 July 2021 provides time for government to work with stakeholders to improve the regulatory framework and build a common understanding of expectations for the sector.

The *Petroleum Legislation Amendment Act 2020* provides the foundations for improving conventional gas project transparency and community engagement, as recommended by the Victorian Gas Program. The government will engage with communities, industry and local government to prepare the supporting regulations. These regulations must be remade by 24 May 2021, when the existing Petroleum Regulations 2011 sunset.

Victorians will be able to have their say on the regulations through the Regulatory Impact Statement process in early 2021, which includes community consultation. This process offers an important opportunity to discuss proposed regulatory changes and requires thorough consideration of the costs and benefits of proposals. Input from a diverse range of stakeholders will help to ensure that any new requirements are effective and regulatory burden is minimised.

An onshore conventional gas industry is expected to create economic benefits for Victorians and not compromise the state's environmental and agricultural credentials. Exploration and development in the Otway or Gippsland basins would create employment growth and increase the economic output of the regions. If conventional gas is discovered and proceeds to production, further benefits would be realised through increased government revenue from royalties and taxes, as well as increased local gas supply to meet Victoria's needs.

1. Overview

This Progress Report summarises the findings and outcomes of the Victorian Gas Program, a three-year suite of geoscientific, environmental and social studies undertaken by the Geological Survey of Victoria. This report is the final in a series of published progress reports that provide a comprehensive overview of the program. Technical reports on the scientific studies have also been published, along with supporting datasets.

This report builds on work completed previously and provides the final results of the onshore conventional gas and offshore gas studies, and the investigations into underground gas storage. It also presents the results and status of supporting activities which were informed by the program findings, including:

- an extensive engagement program with farmers, industry, local government and regional communities
- resource and land use planning
- potential future regulatory improvements.

Technical reports share the results of the Victorian Gas Program studies. These results provide an evidence base to guide community, industry and government on potential onshore conventional gas exploration and development activities. The reports with accompanying datasets are available at earthresources.vic.gov.au/gasprogram.

2. Onshore conventional gas studies

A comprehensive program of geoscience and environmental research focused on the onshore Otway and Gippsland basins has been delivered. Victoria's gas prospectivity has been assessed and issues associated with gas exploration and development have been investigated, providing the evidence base to understand the risks, benefits and impacts of onshore conventional gas.

2.1 Geoscience studies

2.1.1 Otway Basin summary

The geoscience studies in the Otway Basin incorporated:

- **Rock characterisation studies**, to enhance understanding of properties such as porosity, permeability and organic content in reservoir, seal and source rocks. This involved sampling existing rock specimens from the Geological Survey of Victoria's Werribee Drill Core Library for analysis in specialist laboratories.
- **Three-dimensional geological models**, to define the stratigraphic and structural framework of the Otway Basin, in both the onshore and offshore. These supported subsequent petroleum systems modelling, a prospectivity assessment and resource estimate. Regional three-dimensional (3D) geological framework models incorporated previously collected geological data, including two-dimensional (2D) and 3D seismic surveys, well data, gravity and magnetics data and surface geological mapping.
- **Gas prospectivity assessments and resource estimates**, to assess the likelihood of finding more hydrocarbons, the locations in which there is a higher probability of finding hydrocarbons, and to predict how much gas might be found and developed as a result of industry exploration programs in the future.

2.1.1.1 Rock characterisation studies

More than 7170 rock specimens from the Otway Basin were sampled, yielding over 300,000 new measurements and observations. Laboratory analyses of the specimens ranged from routine tests such as porosity, permeability, density and total organic content, to specialist tests and interpretations such as chemostratigraphy, which uses inductively coupled plasma-optical emission spectrometry (ICP-OES) and mass spectrometry to chemically delineate lithofacies and organofacies within source, seal and reservoir rock units.

All rock characterisation studies were published in 2019 and early 2020. These included analyses of new porosity and permeability (Whittam et al., 2019) and seal capacity measurements (Goldie Divko & Karolia, 2019), analysis of rock mineralogies (Power & Goldie Divko, 2019), source rock geochemistry and kinetics (Revie, 2019; Revie et al., 2019; Revie & Crosdale, 2019), biostratigraphy (Charles et al., 2019; Gallagher & Stanislaus, 2019) and chemostratigraphy (Forbes et al. 2020). All these studies have been integrated into mapping and modelling the prospectivity assessment and resource estimate.

2.1.1.2 Three-dimensional geological models

The Victorian Gas Program developed a new regional 3D geological framework model, including:

- **Element 1** – a regional 3D model of the Victorian Otway Basin (onshore and offshore)
- **Element 2** – a more detailed 3D model of the Port Campbell Embayment and Shipwreck Trough.

An interpretation of seismic and well data was included. The model includes all mappable sedimentary units in the basin between the top of the Palaeozoic basement and the present-day bathymetric or land surface.

The interpretation included a Kingdom™ project in two-way-time (TWT) and depth-converted forms that incorporated regional stratigraphic horizons: the top of the Heytesbury Group, Nirranda Group, Wangerrip Group, Sherbrook Group, Shipwreck Group (mainly offshore), Eumeralla Formation (including sub-crop and outcrop within the study area boundary), the top of the Crayfish Subgroup, Casterton Formation and Palaeozoic basement. Other stratigraphic horizons were mapped where present and possible, including the top of the Pretty Hill and Laira formations, the Windermere and Heathfield sandstones and the Killara Coal Measures within the Otway Group. Mapped structural features included faults, basement highs and troughs.

Seismic interpretation was undertaken using 2D and 3D seismic data acquired by industry over the past 50 years. The data is publicly available in the Geological Survey of Victoria's archives (earthresources.efirst.com.au). Nine regional horizons were mapped across approximately 15,000 kilometres of 2D seismic lines and 4000 square kilometres of 3D seismic data. More than 150 wells and boreholes across the Otway Basin were included in the interpretation. The horizons are tied to 242 wells using time depth relationships calculated from 90 key wells, distributed across the onshore and offshore Otway Basin.

2.1.1.3 Gas prospectivity assessments and resource estimates

The Victorian Gas Program has identified all rock formations that may potentially host gas, and the geographic distribution of those locations. Parts of the Otway Basin have rock formations with the right characteristics and in the right sequence to potentially host conventional gas (Geological Survey of Victoria, 2020).

Prospective areas were determined by integrating all available legacy data and all new data and interpretations from the geoscience technical studies (i.e. rock characterisation, the 3D geological model and petroleum systems modelling). The data was compiled to produce a series of maps that categorise conventional gas prospectivity across the basin. The main objective of the prospectivity assessment was to produce a map that shows how resource prospectivity changes across the region to the margin of that area (that is, to the point where there is no prospectivity).

A resource estimate range was determined for the onshore Otway Basin based on the prospectivity assessment. The prospective resource range along with the prospectivity mapping, was used as the basis for the hypothetical exploration and development scenarios in the risks, benefits and impacts assessment for the Otway Basin (Geological Survey of Victoria, 2020).

2.1.2 Gippsland Basin summary

The geoscience studies in the Gippsland Basin included regional 3D geological model construction, petroleum systems modelling, a prospectivity assessment and resource estimate.

2.1.2.1 Three-dimensional geological models

A new regional 3D geological framework model of the onshore and nearshore Gippsland Basin has been built (Powell et al., 2020), using existing seismic and well data held by the Geological Survey of Victoria. This study represents a new and comprehensive compilation, analysis and interpretation of the available geological and geophysical data, including data and knowledge from previous studies and interpretations.

In this study, the geological units that were interpreted include the top of the pre-Cretaceous basement, top of the Strzelecki Group, top of the Emperor, Golden Beach and Halibut subgroups, top of the Latrobe Group, near top of the Lakes Entrance Formation, near top of the Gippsland Limestone and near top of the Jemmys Point Formation. The top of the Latrobe Group is where most oil and gas has been found to date in the Gippsland Basin, and the Lakes Entrance Formation is the regional seal for the hydrocarbon discoveries. Hydrocarbon accumulations have also been discovered in geological units within and below the Latrobe Group. Mapping of these formations reveals the depositional history and evolution of the geographical features of the Gippsland Basin (that is, the palaeogeography). The mapping was required to inform petroleum systems modelling, prospectivity assessments and a resource estimate.

The Geological Survey of Victoria engaged PetroAus Pty Ltd to construct a regional 3D geological framework model of the onshore Gippsland Basin. The project used all available seismic and well data acquired from previous petroleum exploration and data from groundwater and coal boreholes. Data from gravity surveys and geological studies were also incorporated in the construction of the 3D model.

A total of 2916 line-kilometres of onshore 2D seismic data acquired between 1961 and 2015 was available for interpretation. In addition, 9622 line-kilometres of offshore 2D seismic was available. This seismic data, together with 745 wells and boreholes, was loaded into an IHS Kingdom™ (v. 2017) project, which was used for seismic interpretation and structural mapping. Non-seismic datasets such as wells and boreholes were used for subsurface mapping in regions where the seismic data coverage was sparse or non-existent.

The regional 3D geological framework model covers most of the onshore Gippsland Basin and extends approximately 35 kilometres offshore to ensure that the new interpretation could be tied to an existing offshore model of the basin.

A 3D two-way time model was constructed from the interpretation at key stratigraphic levels. A 3D velocity model was also built, using a combination of well-derived velocity information and seismic stacking velocities. This velocity model was then used to convert the time surfaces to depth, and the resulting depth surfaces, along with the interpreted faults, were used to construct a 3D depth model.

Regional surface (time structure) maps were produced from merged horizon interpretations including a previous offshore interpretation. The final depth model (Powell et al., 2020), which includes geological attributes relevant to the different stratigraphic layers, provides a reference for future analysis and is available at the Geological Survey of Victoria's archives (earthresources.efirst.com.au).

2.1.2.2 Gas prospectivity assessments and resource estimates

Prospective areas were determined for the onshore Gippsland Basin by integrating all available legacy data and all new data and interpretations from the geoscience technical studies (i.e. existing rock property data, the new 3D geological model and petroleum systems modelling). The data was compiled to produce a series of maps that categorise conventional gas prospectivity across the basin. The main objective of the prospectivity assessment was to produce a map that shows how resource prospectivity changes across the region to the margin of that area (that is, to the point at where there is no prospectivity). This mapping informed the hypothetical scenarios that were included in an assessment on the risks, benefits and impacts of development scenarios for potential new onshore conventional gas exploration and development in Victoria (Geological Survey of Victoria, 2020).

2.2 Environmental studies

The Victorian Gas Program's environmental studies have improved our understanding of current environmental conditions, and the potential impacts should onshore conventional gas development occur. These studies have established a baseline reference of groundwater chemistry, atmospheric methane and stygofauna populations, and provide insights into groundwater and methane throughout the Otway and Gippsland regions. The data collected is a valuable environmental reference point for Victoria.

In parallel, the Geological Survey of Victoria assessed the environmental impacts of onshore petroleum wells using the regional baseline data collected and site scale groundwater impact modelling. Regional scale groundwater impact modelling was then used to assess the potential impacts of gas development on water resources.

2.2.1 Otway Basin summary

2.2.1.1 Environmental baselines

Three environmental baselines were established across the onshore Otway Basin.

Groundwater chemistry baseline

The groundwater chemistry baseline included an assessment of the major ion chemistry, environmental isotopes, dissolved methane and hydrocarbon occurrence in the groundwater of the onshore Otway Basin. This study is the most complete deep groundwater chemistry dataset collected in the Otway Basin by the Victorian Government to date.

Eighty-one groundwater samples were collected across the basin using low flow sampling techniques, covering a depth below surface range of 8 to 1500 metres. Of these samples, 73 were collected from State Observation Bore Network groundwater bores and eight were collected from town water supply bores. Each sample was analysed for 144 analytes. Detailed sampling, collection and analytical methods have been published (Iverach et al., 2020h).

Major ion chemistry showed that most groundwater samples were of suitable quality for irrigation and stock use, and variable for drinking water use. Environmental isotopes revealed groundwater recharge via rainfall is the main mechanism of replenishing aquifers in the basin, and that the groundwater in the basin is generally between zero (modern water) and 30,000 years old. Methane occurs in very low concentrations and generally increases with depth. The isotopic composition of the methane and its relationship with ethane suggests that the methane has been produced naturally by microbes in the groundwater. An overview of the baseline chemistry and methane content for each aquifer (Iverach et al., 2020d), and detailed geochemical interpretations have been published (Iverach et al., 2020f).

Stygofauna baseline

A regional stygofauna survey was part of the groundwater baseline study, as stygofauna are highly sensitive to water quality changes and therefore may be useful indicators of groundwater health. The survey sampled 80 State Observation Bore Network groundwater bores, which provided a baseline dataset to assist in identifying subsurface groundwater dependent ecosystems.

A total of 149 individual animals, representative of five stygofauna taxa, were identified from six of the 80 groundwater bores sampled (Figure 2.1). All stygofauna identified were collected from upper unconfined aquifers. The low abundance of stygofauna suggests that the fine-grained nature of sediments is limiting for the presence of diverse stygofauna populations. Complete results have been published (Bold et al., 2020b).

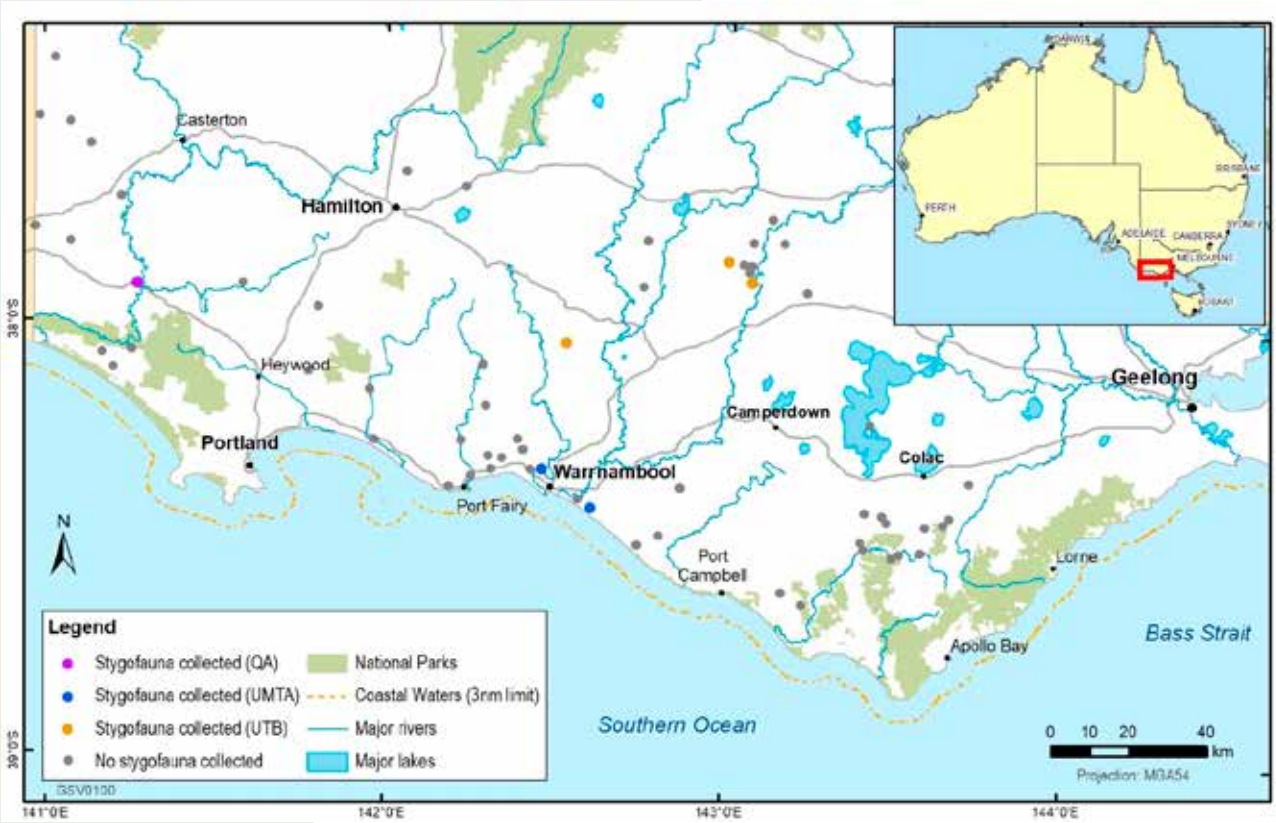


Figure 2.1 Locations of groundwater bores sampled for the stygofauna baseline study in the onshore Otway Basin.

Baseline of atmospheric conditions

Atmospheric measurements were taken of methane, carbon dioxide and ethane to establish a baseline of atmospheric conditions in the onshore Otway Basin. Concentrations were measured by sampling air continuously via tubing mounted on the front of a vehicle, using a Picarro Cavity Ringdown Spectrometer. Two surveys were undertaken, covering 12,000 kilometres of roads.

The surveys recorded average methane and carbon dioxide concentrations comparable with those recorded at the CSIRO Cape Grim Baseline Air Pollution Station. Average methane concentrations recorded in both surveys were lower than the global average (Figure 2.2). The main sources of atmospheric methane identified were biomass burning, cattle, gas infrastructure and landfill emissions. All concentrations observed were significantly lower than Environment Protection Authority Victoria licence and monitoring regulations. Results and interpretations have been published (Iverach et al., 2020b).

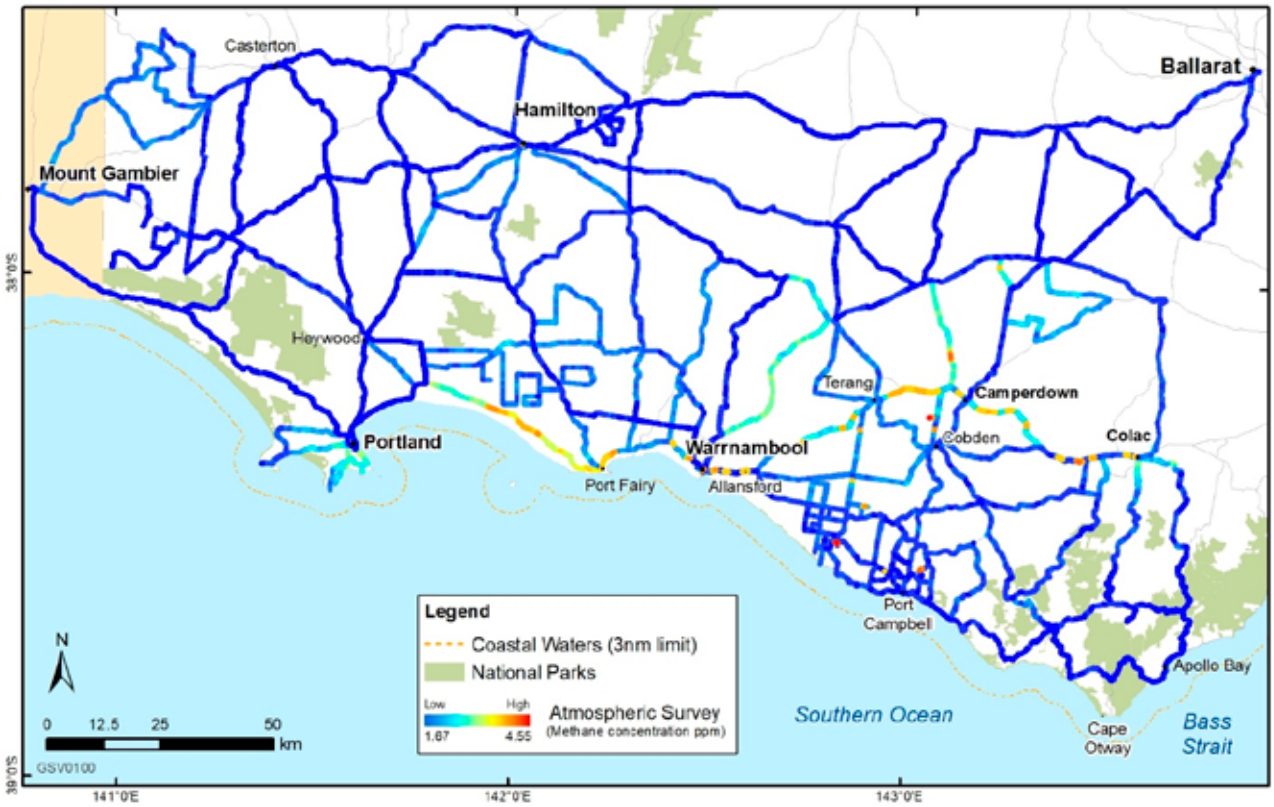


Figure 2.2 Average methane concentrations recorded for the regional atmospheric baseline study in the onshore Otway Basin.

2.2.1.2 Environmental assessment of legacy petroleum wells

The environmental impacts of legacy petroleum wells in the onshore Otway Basin were assessed using regional baseline data (Section 2.2.1.1). One hundred and fifty-one petroleum wells have been drilled in the onshore Otway Basin since 1921, with all disused wells cased and plugged. The results of field testing over the course of the Victorian Gas Program's environmental studies suggests that the presence of petroleum wells has had a negligible environmental impact in the onshore Otway Basin.

The regional atmospheric and groundwater chemistry baseline datasets from field testing were analysed to determine any spatial correlation between petroleum wells and variations in the measurements from these datasets. The analysis showed that no atmospheric methane could be attributed to legacy petroleum wells, as atmospheric methane concentrations were equally likely to increase or decrease within five kilometres of a disused well. Groundwater samples collected from 12 monitoring bores located within two kilometres of a well were compared with the regional baseline and no significant difference was observed.

2.2.1.3 Site scale groundwater impact assessment

The potential for environmental impacts in the onshore Otway Basin were also assessed at a site-scale using groundwater impact modelling. Groundwater modelling was undertaken to estimate the potential impacts of petroleum wells on groundwater quality and quantity. Through the modelling, potential mixing between aquifers and reservoirs was assessed. The modelling assumed that the aquifer and reservoir were in communication via a completely open borehole. This method was used to gauge the maximum potential interaction and environmental impact, although an open borehole would not be used for petroleum exploration in Victoria due to the regulatory requirement for wells to be cased.

The results from the modelling showed that low pressure within the aquifer (the Dilwyn Formation) would create a pressure difference between aquifers and reservoirs within the Otway Basin, and that this pressure difference could potentially drive groundwater flow through an open borehole. This movement of groundwater could impact groundwater quality in the receiving aquifer and groundwater quantity in the transmitting aquifer. Groundwater movement would likely be concentrated between aquifers, with a minor contribution (two per cent) from petroleum reservoirs. The impacts on groundwater quantity and

quality observed from the modelling simulation were localised: groundwater quantity impacts were within 1.1 kilometres of the well and groundwater quality impacts within 2.8 kilometres of the well. The results from the simulation suggest that the optimum distance for monitoring a well to detect localised changes in groundwater quality and quantity is likely to be less than 1.1 kilometres.

2.2.1.4 Regional scale groundwater impact assessment

A regional groundwater model was developed to quantify potential groundwater and surface water impacts if onshore conventional gas development were to occur. The Otway Basin groundwater model was developed in three stages:

1. Construct a conceptual groundwater model.
2. Develop and calibrate a numerical groundwater model.
3. Apply hypothetical gas development scenarios to assess potential impacts to existing groundwater conditions in the Otway Basin.

An assessment of the regional setting, hydrostratigraphic units and groundwater processes showed that there is a complex system of aquifers and aquitards throughout the Otway Basin. The conceptualisation of the groundwater system proposed that the regional stratigraphy can be described by a sequence of 12 model layers, which incorporate both aquifer and aquitard units (Figure 2.3). The model extent contains a total of 1367 groundwater production bores, 631 State Observation Bore Network groundwater observation bores and 20 gas production bores. The area considered extends approximately 50 kilometres offshore. The complete conceptual framework for the South-West region groundwater model has been published.

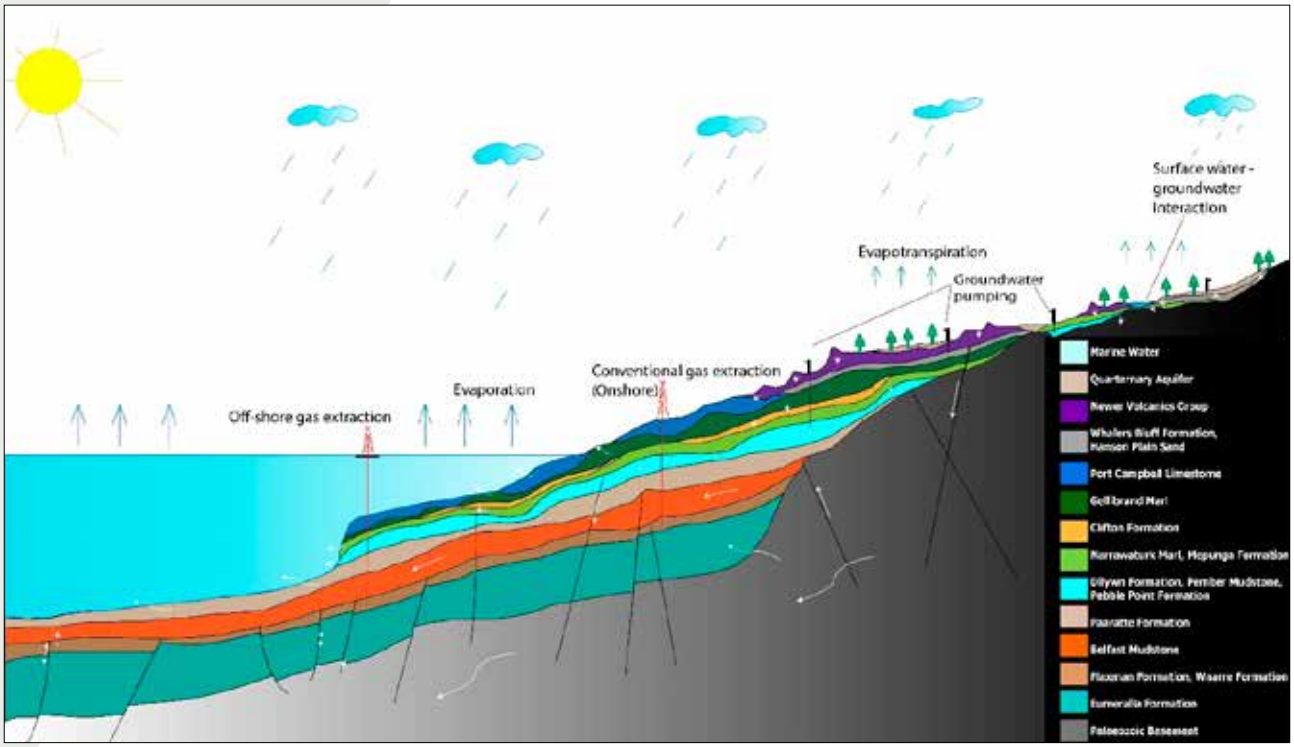


Figure 2.3 Regional stratigraphy described in layers for the conceptual Otway Basin groundwater model.

The numerical model was developed and calibrated to build on the construction of the conceptual model. The model was required to simulate the impact that hypothetical onshore conventional gas development scenarios may have on groundwater and surface water in the Otway Basin. The model was calibrated using automated and manual methods to ensure aquifer parameters and calibration targets remained within acceptable ranges. Available groundwater monitoring data was considered for both the steady-state and transient model calibrations. Primary calibration targets were depth to watertable and modelled versus measured (residual) groundwater levels.

The calibrated steady-state model showed that modelled flow paths and potentiometric surfaces were generally in agreement with observed flow paths and surfaces. Transient conditions were simulated for the period 1980 to 2018, which revealed good correlation between modelled and measured data during the

initial 20 years of simulation. A review of the spatial and temporal model calibration data and the results of sensitivity analysis confirmed that the numerical groundwater model developed is appropriate for assessing groundwater level changes under the proposed scenarios of onshore conventional gas development. Details regarding the development and calibration of the numerical groundwater model have been published.

The final component of the regional groundwater impact assessment was to apply gas development scenarios to assess potential impacts to existing groundwater conditions. The calibrated regional-scale groundwater model considered combinations of future gas developments to simulate the potential impacts that hypothetical onshore conventional gas development may have on groundwater. Complete results of each hypothetical gas development scenario have been published.

Gas development phases were simulated under both steady-state (long-term average) and transient (time-varying) conditions. The steady-state impact assessment of all prospective sites indicated the maximum possible extent of impact on groundwater levels. Transient simulations were then conducted to determine groundwater level changes within the life of proposed gas production until equilibrium conditions were attained. The impact of each predictive scenario was assessed based on a comparison with the baseline run (no gas production) in either steady-state or transient conditions.

Four gas production volume scenarios were considered: minimum, low, medium, and high-volume production cases. No significant impact on the watertable, aquifer storage volume or surface water flow was identified for any gas production volume scenario. The results suggest that gas depressurisation associated with onshore conventional gas extraction has a negligible impact on groundwater level and storage in the overlying groundwater resource aquifers. Steady-state results show that maximum drawdown impacts extend furthest in three target gas formations: Waarre Formation, Pretty Hill Formation and the Heathfield Sandstone. Predicted regional drawdown in the overlying Dilwyn Formation was around 0.2 metres, due to the intervening units.

Drawdown impacts of up to 20 metres in the target gas formations result in a drawdown impact of 0.1 metres in the overlying Dilwyn Formation in the transient simulation. Groundwater volume impacts vary depending on the gas production scenario, with a minimum removal volume from the Dilwyn Formation of approximately 81 megalitres per year (under the minimum-volume production case) and a maximum of 660 megalitres per year (under the high-volume production case). Impact times were predicted for the medium and high production volume scenarios, with a total recovery time of 15 years and 29 years respectively. The impact results presented here are insignificant compared to current groundwater extraction volumes in the basin by other sectors.

2.2.2 Gippsland Basin summary

2.2.2.1 Environmental baselines

Three environmental baselines were established across the onshore Gippsland Basin.

Groundwater chemistry baseline

The groundwater chemistry baseline in the onshore Gippsland Basin similarly included an assessment of the major ion chemistry, environmental isotopes, dissolved methane and hydrocarbon occurrence. In total, 22 groundwater samples were collected across the basin covering a depth below ground level range of 15 to 1100 metres. All samples were collected from State Observation Bore Network monitoring bores. Each groundwater sample was analysed for 144 analytes, making this baseline study the most complete dataset collected by the Victorian Government to date. Detailed sampling, collection and analytical methods have been published (Iverach et al., 2020g).

Major ion chemistry showed that most groundwater samples were of suitable quality for irrigation and stock use, and variable for drinking water use. Stable water isotopes revealed groundwater recharge via rainfall is the main mechanism of replenishing the aquifers in the basin. Groundwater residence times ranged from approximately 200 to 25,000 years. Methane occurs throughout the groundwater in the basin with concentrations generally increasing with depth. Most of the methane detected in the groundwater has been produced naturally by microbes in the groundwater. In some samples near the coast, data suggests that there may be a minor natural gas component in the methane. Further details have been published, including an overview of the baseline chemistry for each aquifer (Iverach et al., 2020c) and detailed geochemical interpretations (Iverach et al., 2020e).

Stygofauna baseline

The stygofauna baseline sampled 20 State Observation Bore Network groundwater bores (Figure 2.4) to determine what stygofauna taxa exist within the groundwater of the onshore Gippsland Basin. Five individual animals of one stygofauna taxon were identified from one groundwater bore in the basin. These stygofauna were collected within the upper unconfined Quaternary Aquifer. This low abundance of stygofauna is likely attributed to the fine-grained nature of the sediments in the basin. Complete results have been published (Bold et al., 2020a).

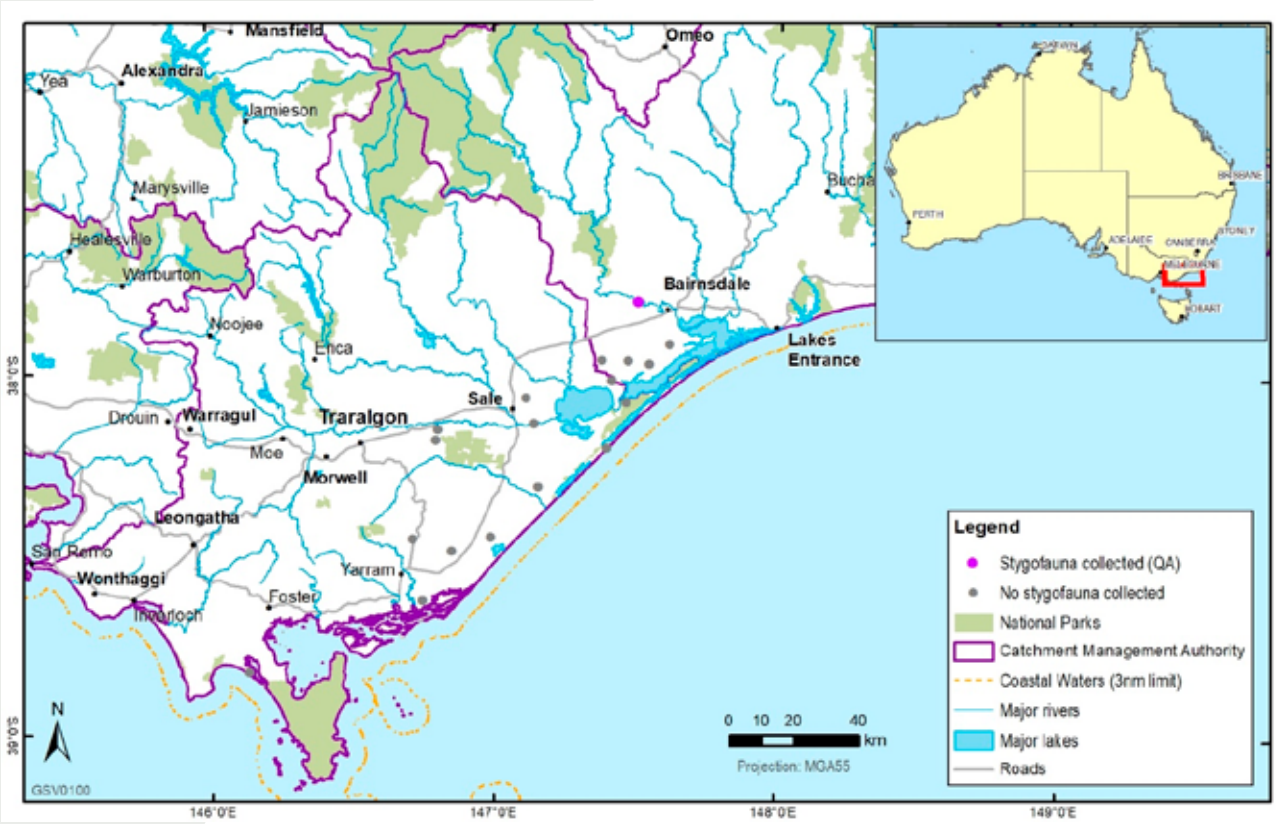


Figure 2.4 Locations of groundwater bores sampled for the stygofauna baseline study in the onshore Gippsland Basin.

Baseline of atmospheric conditions

Baseline atmospheric measurements of methane, carbon dioxide, and ethane were taken in the onshore Gippsland Basin using a Picarro Cavity Ringdown Spectrometer (Figure 2.5). Two surveys were conducted, covering 8000 kilometres of roads in June 2018 and October 2018.

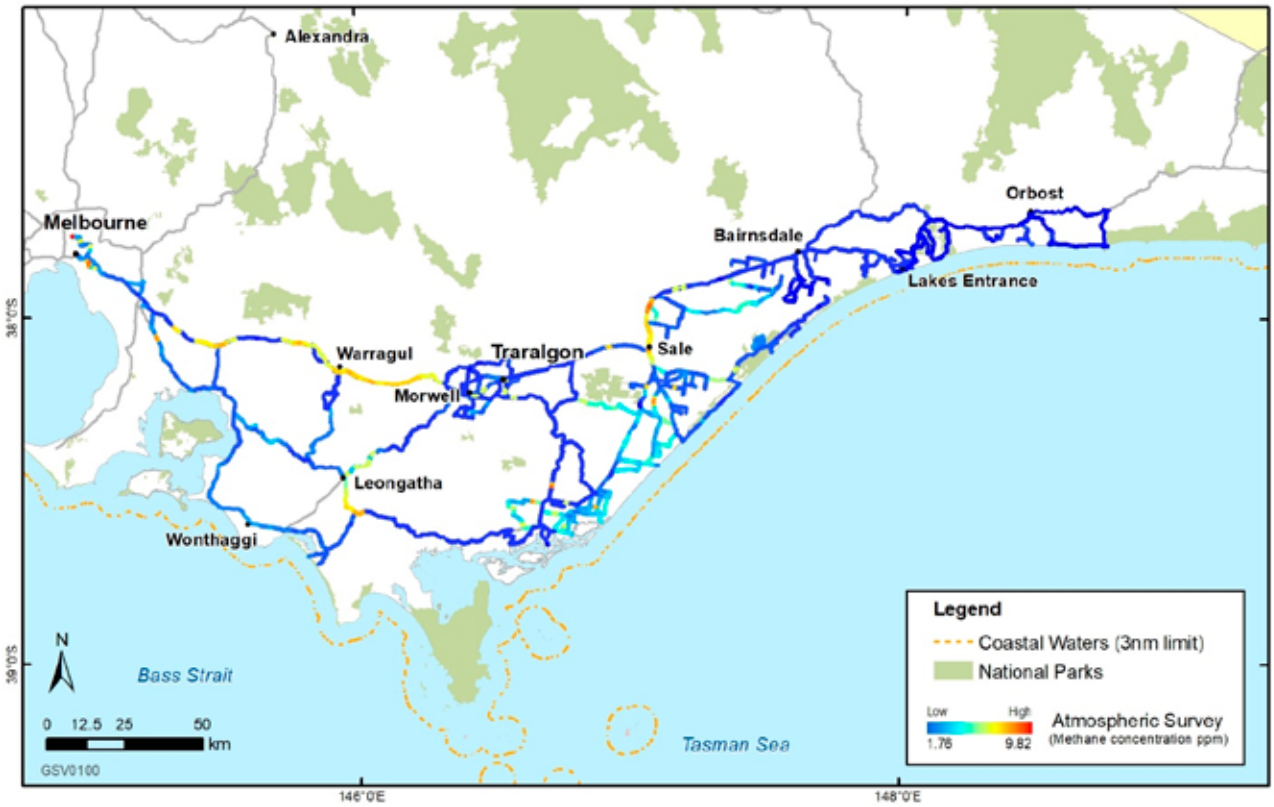


Figure 2.5 Average methane concentrations recorded for the regional atmospheric baseline study in the onshore Gippsland Basin.

Both surveys recorded average methane and carbon dioxide concentrations comparable with those recorded at the CSIRO Cape Grim Baseline Air Pollution Station. Average methane concentrations recorded in both surveys were slightly higher than the global average. The main sources of atmospheric methane identified were the same as those identified in the Otway Basin: biomass burning, cattle, gas infrastructure and landfill emissions. All concentrations observed were significantly lower than Environment Protection Authority Victoria licence and monitoring regulations. Results and interpretations have been published (Iverach et al., 2020a).

2.2.2.2 Environmental assessment of legacy petroleum wells

The environmental impacts of legacy petroleum wells in the onshore Gippsland Basin were assessed using regional baseline data (Section 2.2.2.1). One hundred and ninety-four petroleum wells have been drilled in the onshore Gippsland Basin since 1921, with all disused wells cased and plugged.

The regional atmospheric and groundwater chemistry baseline datasets from field testing were analysed to determine any spatial correlation between petroleum wells and variations in the measurements from these datasets. The analysis showed that for 103 legacy petroleum wells there was no observable trend in methane concentration data. In 41 legacy petroleum wells, an increase in methane concentrations towards the wells was measured. In the case of 42 legacy petroleum wells, a decrease in methane concentrations towards the wells was measured. The analysis did not conclusively attribute any atmospheric methane to legacy petroleum wells.

Field observations showed that increased methane concentrations could be attributed to biomass burning, livestock and landfill in most instances. Groundwater samples collected from eight monitoring bores located within two kilometres of legacy wells were compared with the regional baseline and no significant difference was observed. One bore had elevated concentrations of methane that had a minor natural gas component, which is likely due to the natural migration of hydrocarbons in the Gippsland Basin.

2.2.2.3 Site scale groundwater impact assessment

The potential for environmental impacts in the onshore Gippsland Basin were also assessed at a site-scale using groundwater impact modelling. Groundwater modelling was undertaken to estimate the potential impacts of petroleum wells on groundwater quality and quantity. Through the modelling, potential mixing between aquifers and reservoirs was assessed. The modelling assumed that the aquifer and reservoir were in communication via a completely open borehole. This method was used to gauge the maximum potential interaction and environmental impact, although an open borehole would not be used for petroleum exploration in Victoria due to the regulatory requirement for wells to be cased.

The results from the modelling showed that long-term pressure declines within the Latrobe aquifer have created high pressure differentials between aquifers and reservoirs within the Seaspray Depression. This pressure difference could potentially drive groundwater flow through an open borehole, which would impact groundwater quality in the receiving aquifer and groundwater quantity in the transmitting aquifer. Groundwater movement would likely be concentrated between aquifers, with a minor contribution (0.4 per cent) from petroleum reservoirs. The impacts on groundwater quantity and quality observed from the modelling simulation were localised: groundwater quantity impacts were within 2.1 kilometres of the well and groundwater quality impacts within 1.2 kilometres of the well. The results from the simulation suggest that the optimum distance for monitoring a well to detect localised changes in groundwater quality and quantity is likely to be less than 1.2 kilometres.

2.2.2.4 Regional scale groundwater impact assessment

A regional groundwater model was developed by the Victorian Government as part of the Victorian Water Science Studies in 2015. The numerical model was re-calibrated for the Victorian Gas Program. The model calculates potential impacts from hypothetical onshore conventional gas developments, including changes to groundwater levels and pressures, and changes to river baseflows.

The Gippsland groundwater model was revised in two stages:

1. Re-calibrate the numerical groundwater model to simulate conventional gas development using the previously constructed conceptual groundwater model.
2. Apply hypothetical gas development scenarios to assess potential impacts to existing groundwater conditions in the Gippsland Basin.

Model calibration was undertaken by automated and manual methods to ensure aquifer parameters and calibration targets remained within acceptable ranges. All available groundwater monitoring data was compiled and included for both the steady-state and transient model calibrations. Primary calibration targets were the depth to watertable and the modelled versus measured (residual) groundwater levels.

Calibration of the steady-state model showed that the modelled flow paths were generally in agreement with the flow paths in the conceptual model. Calibration of the transient model was based on a split calibration/verification approach. Parameter optimisation was applied for the period 1990 to 1999, then verified over the subsequent years from 2000 to 2018.

Review of the spatial and temporal model calibration data, and the results of sensitivity analysis, confirmed that the numerical groundwater model is appropriate for assessing predicted groundwater level changes under the proposed onshore conventional gas development scenarios. The development and re-calibration of the regional numerical groundwater model has been published.

The re-calibrated regional groundwater model then considered combinations of future gas developments and climate scenarios to simulate the potential impacts that hypothetical onshore conventional gas development may have on groundwater in the Gippsland Basin. Scenario details and results have been published.

Gas development phases were simulated under transient conditions to determine groundwater level changes within the life of the proposed gas developments.

The results suggest that there would be some groundwater depressurisation effects on overlying water resource aquifers as a result of onshore conventional gas extraction. These groundwater drawdowns would primarily impact the Upper Latrobe Group, with a maximum drawdown of approximately two metres observed under the high production scenario. Negligible impacts in the overlying Boisdale Formation and no impacts in the watertable aquifer were observed under any scenario. Time to initial groundwater level impact of the low and medium volume production scenarios was approximately 0.5 to 1.5 years, with the high production scenario predicting initial impact within three years of commencement of gas production. Time to total groundwater recovery in the water resource aquifers was generally between 5 and 30 years, depending on the production volume scenario (low, medium or high volume) and scenario location.

3. Offshore gas

Natural gas is a vital part of Victoria's energy supply network, which has been extracted in waters off Victoria's coast for decades. It is a major source of gas supply for domestic households and industry along Australia's east coast, but future supply depends on new gas discoveries.

The Victorian Gas Program has supported commercial exploration for discoveries of new gas resources off Victoria's coast which could increase gas supply, by:

- over 32,000 line-kilometres of innovative airborne gravity/gradiometry data, providing new evidence about rock structures below the seafloor
- 3D geological models, providing insights into where rocks that may host gas are present.

New scientific data has been acquired and interpreted alongside existing data to identify prospective areas in the offshore Otway Basin. These studies underpinned the 2018 Victorian Offshore Acreage Release and continue to support commercial exploration for gas discoveries off the Victorian coast now that exploration permits have been granted.

3.1 Offshore gas studies

The offshore gas geoscience studies improved the understanding of gas prospectivity at a sub-basin scale by acquiring, processing and interpreting a new airborne gravity gradiometry dataset and via onshore gas geoscience studies, such as the 3D geological framework modelling (see Section 2.1.1.2).

3.1.1 Airborne gravity gradiometry interpretation

Between August 2018 and January 2019, an airborne gravity gradiometry survey was conducted over 16,000 square kilometres of the Otway Basin, including state onshore and offshore areas and Commonwealth waters (Figure 4.1). The survey is the largest airborne gravity dataset ever collected in Victoria. The new data set (Carter et al., 2019) provides superior quality gravity imagery in South-West Victoria, compared with pre-existing data.

The objectives of this survey were to provide a valuable pre-competitive geoscientific open-file dataset and to improve the Geological Survey of Victoria's geological models by improving the geometric characterisation of the Otway Basin.

The survey used a FALCON® airborne system, which can acquire airborne gravity and gradiometry data at the same time. Conventional gravity is good for imaging deeper geological structures, while gradiometry is more effective at imaging shallow structures. Magnetic data was acquired, as well as laser scanner data, to terrain correct the dataset. The dataset is available (Carter et al., 2019) via the Geological Survey of Victoria's archives (earthresources.efirst.com.au).

Resolving 3D shapes of geological structures can be done quantitatively using 3D forward and inversion modelling. 3D forward modelling allows construction of 3D geological computer models, assigning existing rock property data (such as density) to packages of rocks and calculating the gravity response of the theoretical model. This calculated gravity response of the model can be compared with the observed response, which was acquired by the aircraft. The difference between the calculated and observed response (the residual gravity response) indicates a mismatch, where changes need to be made to the 3D model.

3D inversion modelling is a stepwise process where the boundaries between geological horizons are iteratively adjusted by computation to achieve a match between the calculated and observed response. The shape (or geometry) of geological bodies and structures is constrained using datasets including surface observations, well data and seismic interpretations. Refinement of geometries through inversion causes the model to become inconsistent with these constraints, so modifications are made to the model before further inversion. The process is iterative with the aim to search for a balance between honouring geological constraints and a model that is consistent with the gravity data.

The approach for the Otway Basin was to use the existing seismic interpretations as a starting model, then attempt to refine the geological horizons (Figure 4.2). As the observed gravity data is the total

response of the gravity signature of all rocks from the surface down to the Moho, the geology of the entire crust needs to be modelled. It also means that the high amplitude gravity signature, which is most likely attributed to geology in the basement, must be explained first before any refinements can be made to the comparatively small gravity variations attributed to undulations in the sedimentary basin. The basement must be accounted for appropriately, so the inversion process does not make large changes to the basin's sedimentary horizons in an attempt to explain gravity variations that reside within the basement.

The forward and inversion modelling results suggest that gravity anomalies are being caused by structures in the basement, and that the shape of the Moho is having a significant impact on the gravity response. Previous models of Victoria's crustal architecture are being used as a starting point to build structures within the basement under the Otway Basin. Once this is complete, focus will be directed to refining the geometry of horizons within the basin.

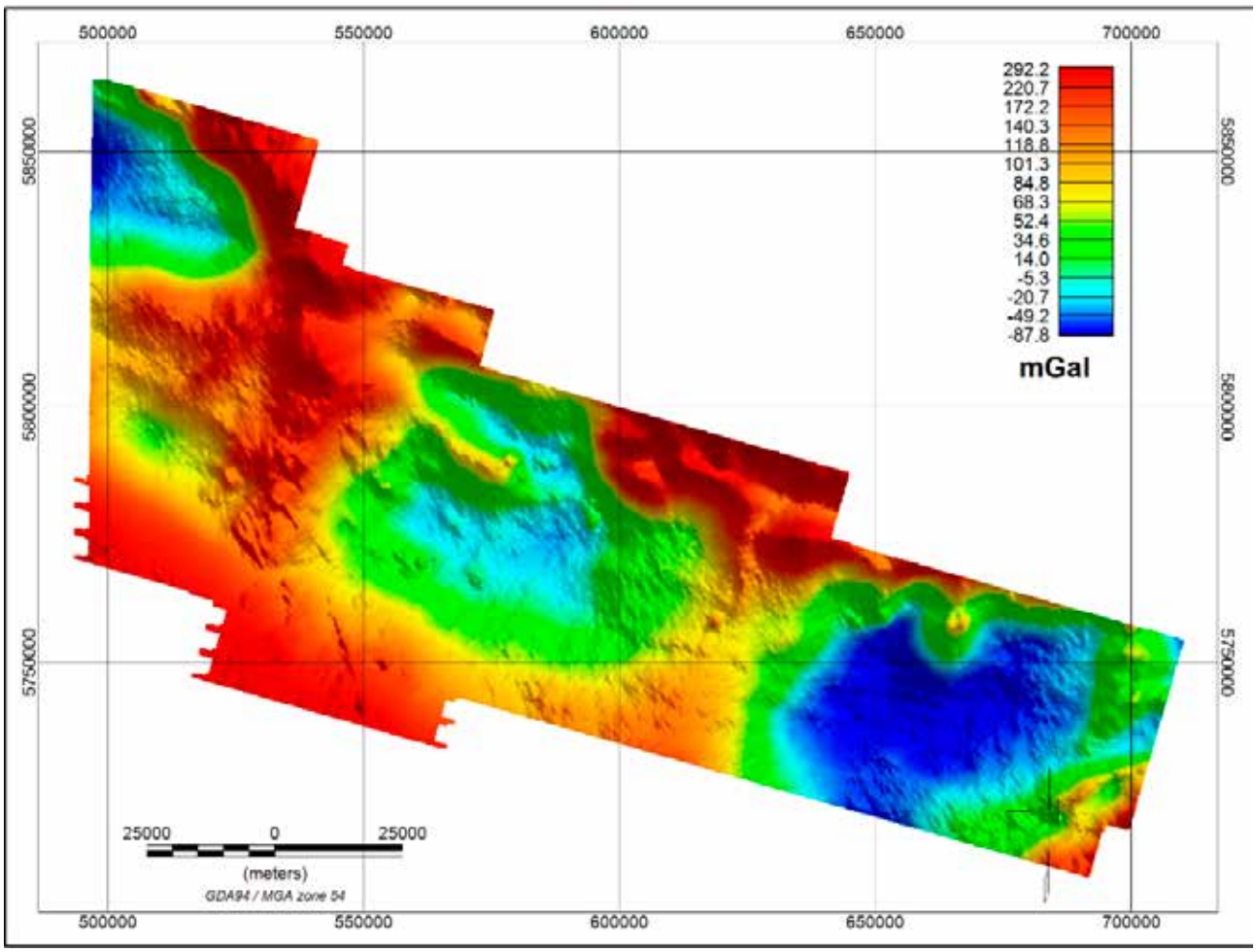


Figure 3.1 Airborne gravity dataset used for forward and inversion modelling.

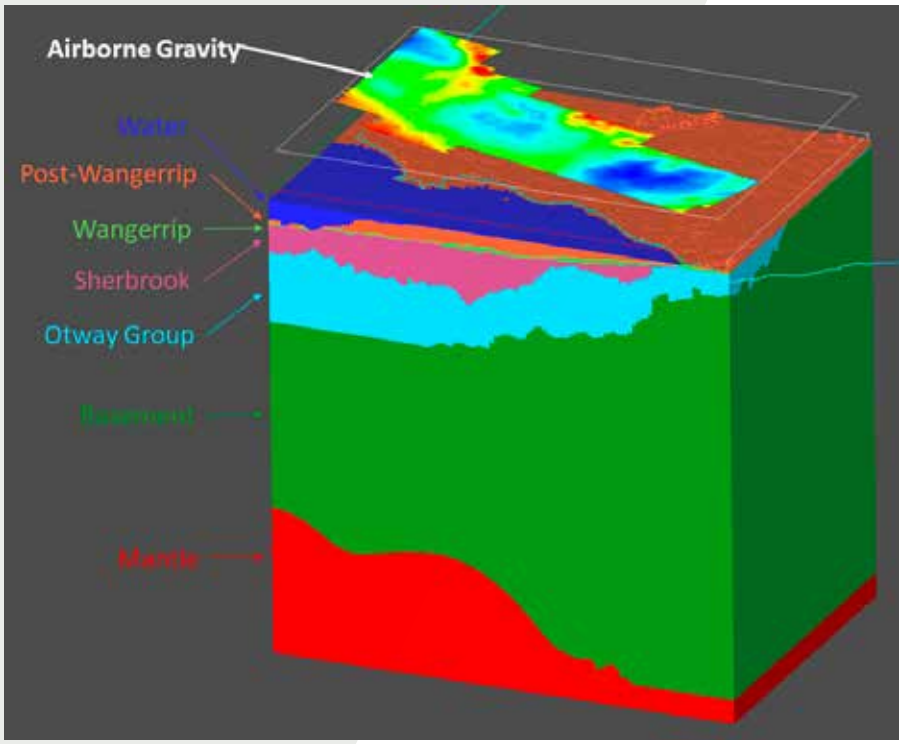


Figure 3.2 Quantitative 3D model showing the geological layers used to calculate the synthetic gravity response.

3.2 Acreage release and exploration permit grant

To stimulate commercial exploration for gas resources, the Victorian Government released five new offshore acreage areas in the Otway Basin for tender in May 2018. The acreage areas were in state-controlled waters, which extend three nautical miles from the coast. The areas were located between Port Campbell and the South Australian border, with a combined surface area of 1318 square kilometres. The areas were underexplored, with limited seismic acquisition and no previous exploration drilling. The areas were within the proven Austral 2 petroleum system and two of the areas adjoined existing producing gas fields in the Shipwreck Trough.

The Geological Survey of Victoria created geological datasets to support the acreage release, using existing information. Data from the Victorian Gas Program's Otway Basin airborne gravity survey was also made available, which connected the geological modelling of the offshore and onshore parts of the basin at a new granular level. To support local gas supply, government outlined its expectation that Australian consumers be given the first genuine and reasonable offer to buy any new gas produced from the acreage release areas. This expectation was made law through amendments included in the *Petroleum Legislation Amendment Act 2020* (see Section 7.1).

Following an assessment of tender applications by the Earth Resources Regulator, permits to explore two of the five areas were granted by the Minister for Resources in July 2020. Applications were assessed on the proposed work program, a summary of financial and technical capability and records of past performance in exploration and development operations, both in Australia and overseas.

Table 3.1 Exploration permits granted following the 2018 Victorian Offshore Acreage Release

Permit holder	Exploration permit	Area size
• Beach Energy (Operations) Ltd	• VIC/P007192(V)	• 24 km^2
• Bridgeport (Eromanga) Pty Ltd	• VIC/P007191(V)	• 439 km^2

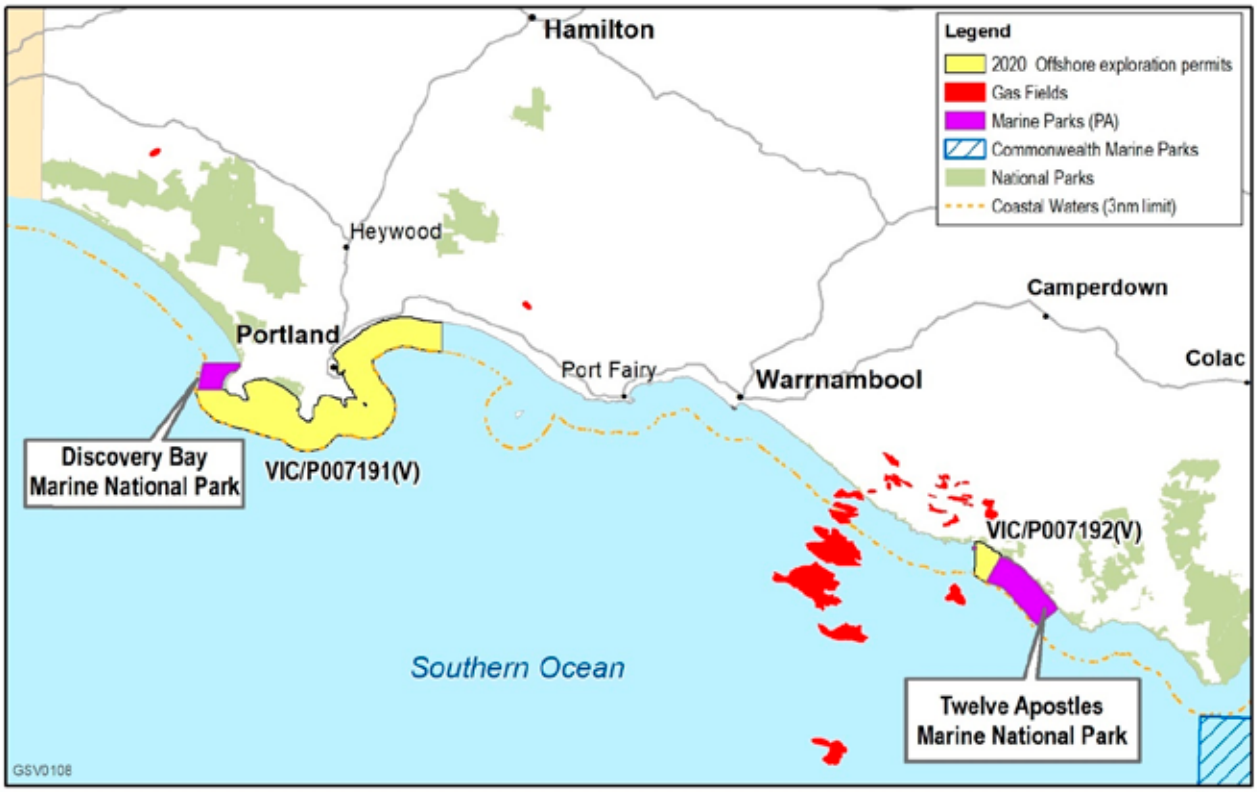


Figure 3.3 Locations of exploration permits granted to Beach Energy (Operations) Ltd and Bridgeport (Eromanga) Energy Pty Ltd.

Beach Energy and Bridgeport Energy are now required to work closely with the commercial fishing industry, local communities and government bodies along the south-west coast as they conduct their exploration programs. Each exploration permit is granted for a period of six years.

Understanding the offshore exploration process

The granting of an exploration permit is the beginning of the offshore exploration process. Exploration typically takes several years, and there is no guarantee that it will result in a producing gas field.

Marine national parks are excluded from new offshore acreage areas, and from any gas exploration or development. Strict environmental controls are in place to protect Victoria's coastal areas if exploration is authorised.

The first stage of commercial exploration focuses on desktop geological studies and modelling. If seismic surveying is required in future years, a separate authorisation is needed. Consultation with any potentially impacted industries would be required. Proposed marine seismic surveys must include an environmental protection plan that identifies any risks to flora and fauna and planned mitigations. No seismic survey work would be permitted during whale migrations.

If a commercially viable reservoir of gas is discovered in the future, and a company wishes to develop it, a separate and regulatory process would commence.

If new gas fields are found to be viable, safe to extract and appropriate to the local context, there would be positive implications for jobs and economic development in the region.

The geoscience studies completed as part of the Victorian Gas Program will continue to support commercial exploration for gas discoveries off the Victorian coast.

4. Underground gas storage

4.1 Underground gas storage summary

The Victorian Gas Program investigated whether additional underground gas storage would create benefits for Victoria. The assessment showed that expanding Victoria's underground gas storage capacity could help to secure more reliable gas supplies and mitigate short-term price peaks, particularly during interruptions in the gas supply system. Expansion of the industry would also create new jobs in Victoria during construction and for ongoing operations.

The Geological Survey of Victoria engaged SEAL Energy Pty Ltd to carry out a suite of technical studies to investigate the potential for additional underground gas storage at depleted gas fields in the onshore Otway Basin. Investigations focused on thirteen depleted or unproduced gas fields around Port Campbell. Six fields were selected through a ranking process (Bagheri, 2019) for static and dynamic modelling, to quantify their potential capacity for underground gas storage. The six gas fields selected were Croft, Fenton Creek, McIntee, Mylor, Penryn and Tregony.

4.2 Modelling of potential underground gas storage sites

4.2.1 Static modelling

Static geological models were constructed for each of the six fields selected, to characterise the depleted gas fields for use in dynamic modelling. A summary of the static modelling workflow (SEAL Energy, 2020) is presented in Table 5.1.

Table 4.1 Summary of the static modelling workflow for the potential underground gas storage sites

Static modelling workflow
Database review and conditioning
• Compilation, review and analysis of publicly available data • Confirmation of well coordinates, well tops and well directional survey data • Depositional environment models and identification of controls on sedimentary facies • Provision of six electrofacies each associated with a flow zone indicator
Structural modelling
• Review of structural framework • Depth conversion • Geocellular model parameters • Horizon and zone modelling
Property modelling: Object and sequential indicator simulation-based scenarios
• Facies modelling based on implementation of depositional environment concepts with petrophysical electrofacies • Porosity modelling based on porosity distributions encountered in each electrofacies • Permeability and water saturation modelling
Outputs
• A model which integrates well and seismic structural data, geological principles and interpreted lithology, porosity and permeability data • Volumetrics to quantify gross rock volume, pore volume and original gas in place. • Static geological model for use in dynamic simulations

Publicly available data was compiled, analysed and reviewed for each of the six gas fields. A depositional model was developed to predict facies trends for input into the property model. Then a structural model was built, honouring well and seismic interpretation. Three structural surfaces were used to model the area of interest: the top of the Belfast Mudstone, top of the Waarre Formation (Figure 5.1) and top of the Eumeralla Formation. These represent the top of the seal, and the top and base of the reservoir, respectively.

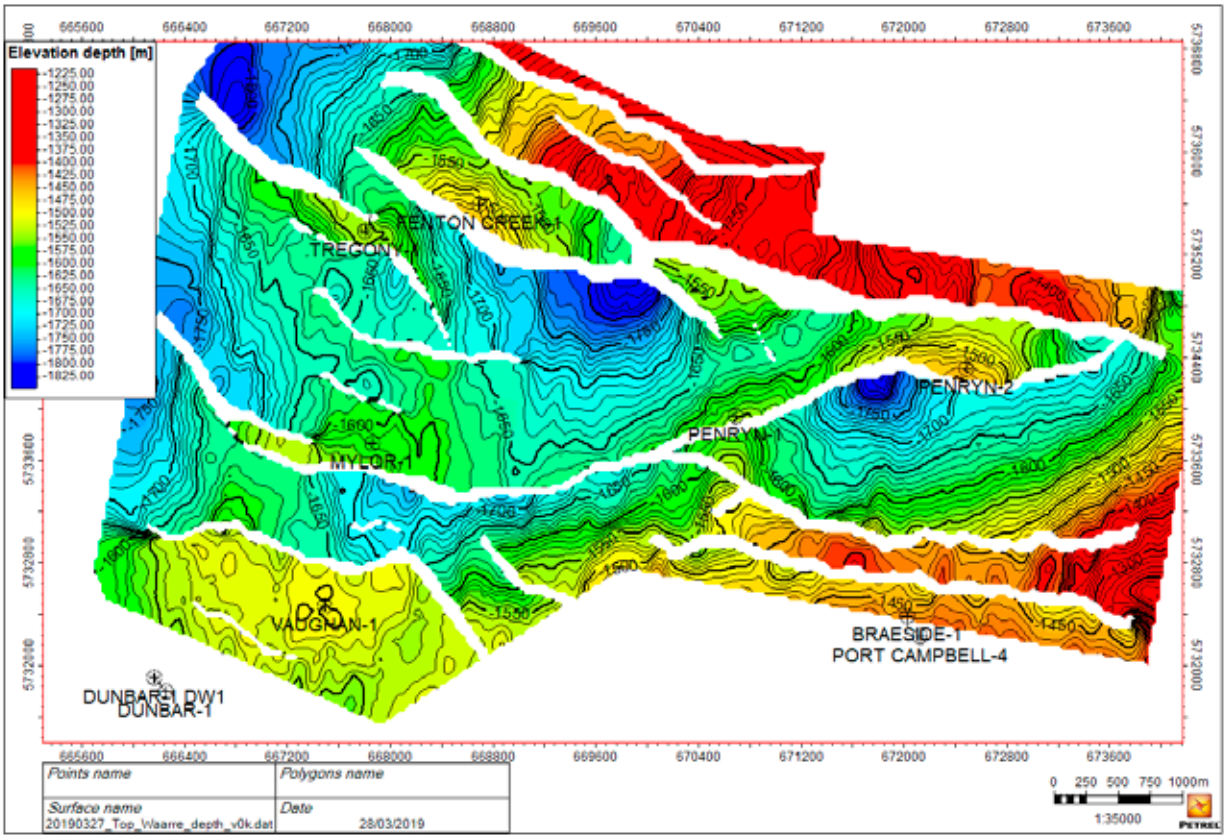


Figure 4.1 Top of the Waarre Formation depth horizon over the Mylor, Tregony, Fenton Creek and Penryn gas fields.

Zone modelling was then performed to capture the structural features between these surfaces, including the Flaxman Formation and Waarre Formation units B and A. Lastly, the model was populated with reservoir properties including porosity (Figure 5.2), permeability (Figure 5.3) and water saturation (Figure 5.4). Two different methods were followed to provide dynamic simulators with a suite of static models to use for fluid flow simulations. The resultant static models allow for volumetric calculations to quantify gross rock volume, pore volume and original gas in place.

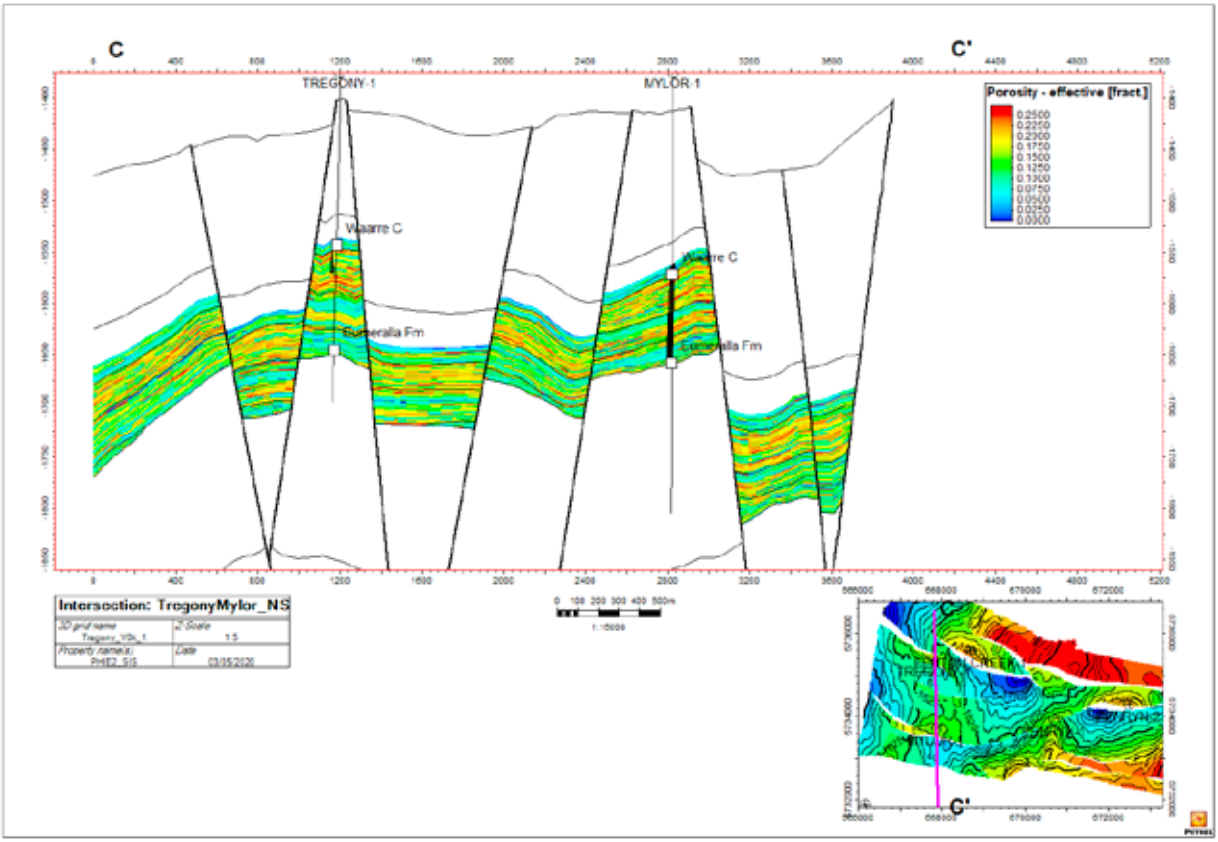


Figure 4.2 Cross section of modelled porosity distribution within the Waarre Formation for the Tregony and Mylor gas fields.

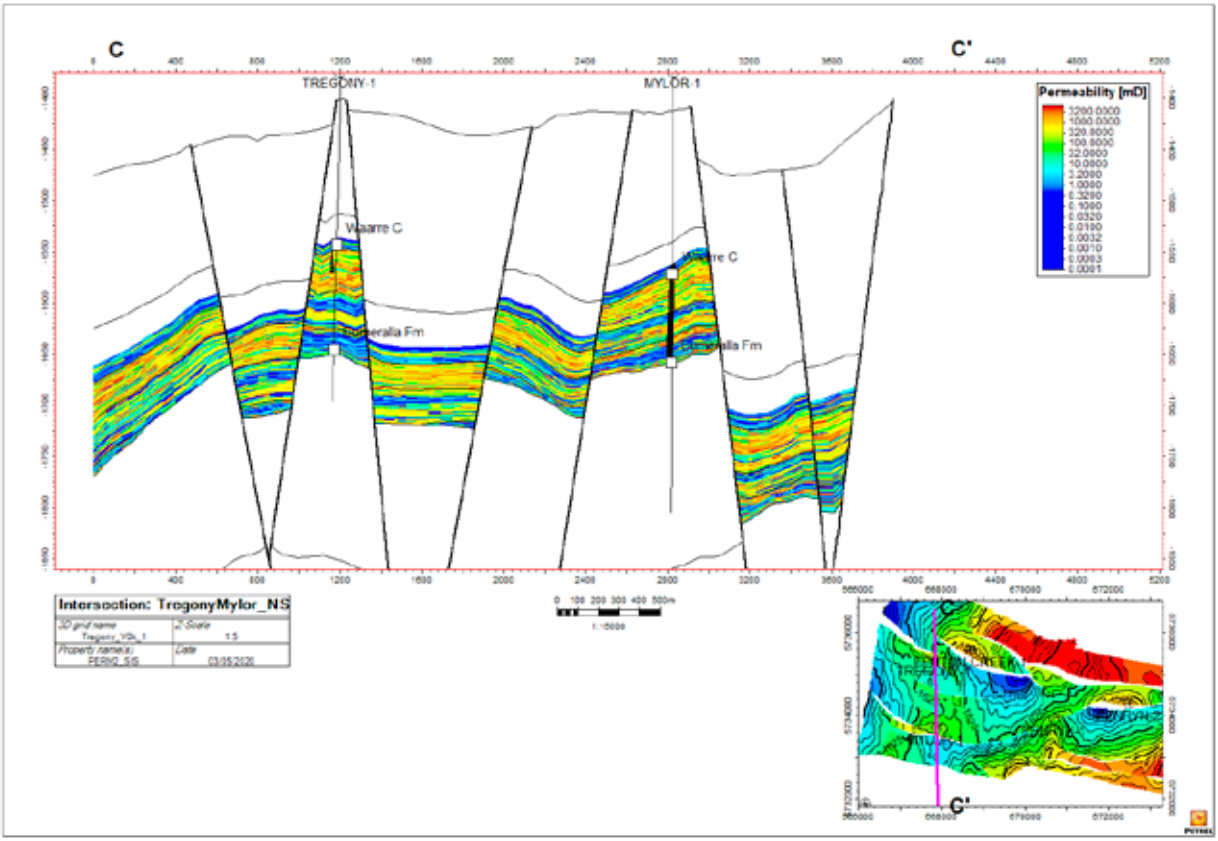


Figure 4.3 Cross section of modelled permeability distribution within the Waarre Formation for the Tregony and Mylor gas fields.

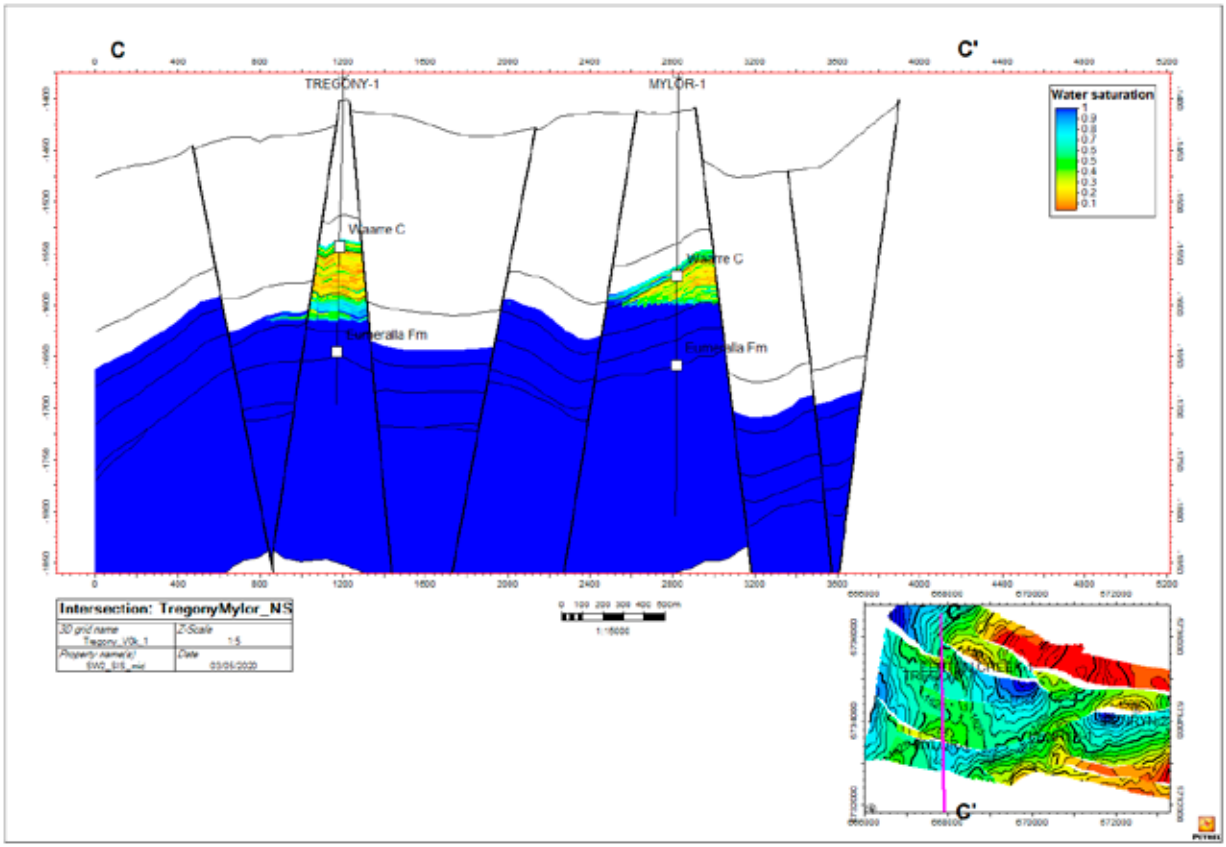


Figure 4.4 Cross section of modelled water saturation distribution for the Tregony and Mylor gas fields.

The final static models honour well and seismic structural data, the interpreted lithologies, and porosities and permeabilities derived from the well cores and well logs. These were used in dynamic modelling to characterise the depleted gas fields and understand their underground gas storage potential. Specific volumetric calculations for each gas field are reported in six static modelling technical reports. Each static model technical report is accompanied by the static model for each depleted gas field.

4.2.2 Dynamic modelling

Dynamic modelling was used to estimate the dynamic capacity of the depleted gas fields for potential underground gas storage. A summary of the dynamic modelling workflow is presented in Table 5.2.

Table 4.2 Summary of the dynamic modelling workflow for the potential underground gas storage sites.

Dynamic modelling workflow
Database review and analysis
• Extensive reservoir engineering data review and analysis • Fluid composition and gas gravity • Relative permeability and end point parameters • Capillary pressure • Gas water contact analysis • Vertical lift performance
Analytical original gas in place
• Review of calculated original gas in place • Material balance analysis
Dynamic modelling
• History matching • Scenario simulation modelling
Outputs
• Original gas in place volumes from dynamic modelling • Estimate of the dynamic capacity of the sites for underground gas storage • Recommendation of case scenarios for commercial modelling

Prior to dynamic modelling, publicly available data was compiled, analysed and reviewed for each of the six gas fields. This included detailed reservoir engineering analysis on fluid properties, relative permeability, capillary pressure analysis and gas water contacts. This allowed for an analytical original gas in place volume to be calculated using material balance methods, which assisted the history matching processes. History matching involves adjusting the reservoir model until it closely reproduces historical production and pressure behaviours in the reservoir prior to dynamic modelling. A successful history match was achieved for each of the six fields by adjusting key parameters such as horizontal permeability, water drive, relative permeability and fluid contacts. An example of the initial (pre-production) and history matched (post-production) Tregony model is illustrated in Figure 5.5 and Figure 5.6, respectively. Figure 5.7 presents the historical gas rate and cumulative production (red dots) versus simulated results (green line). The model is able to replicate the gas production rate, demonstrating a successful history match.

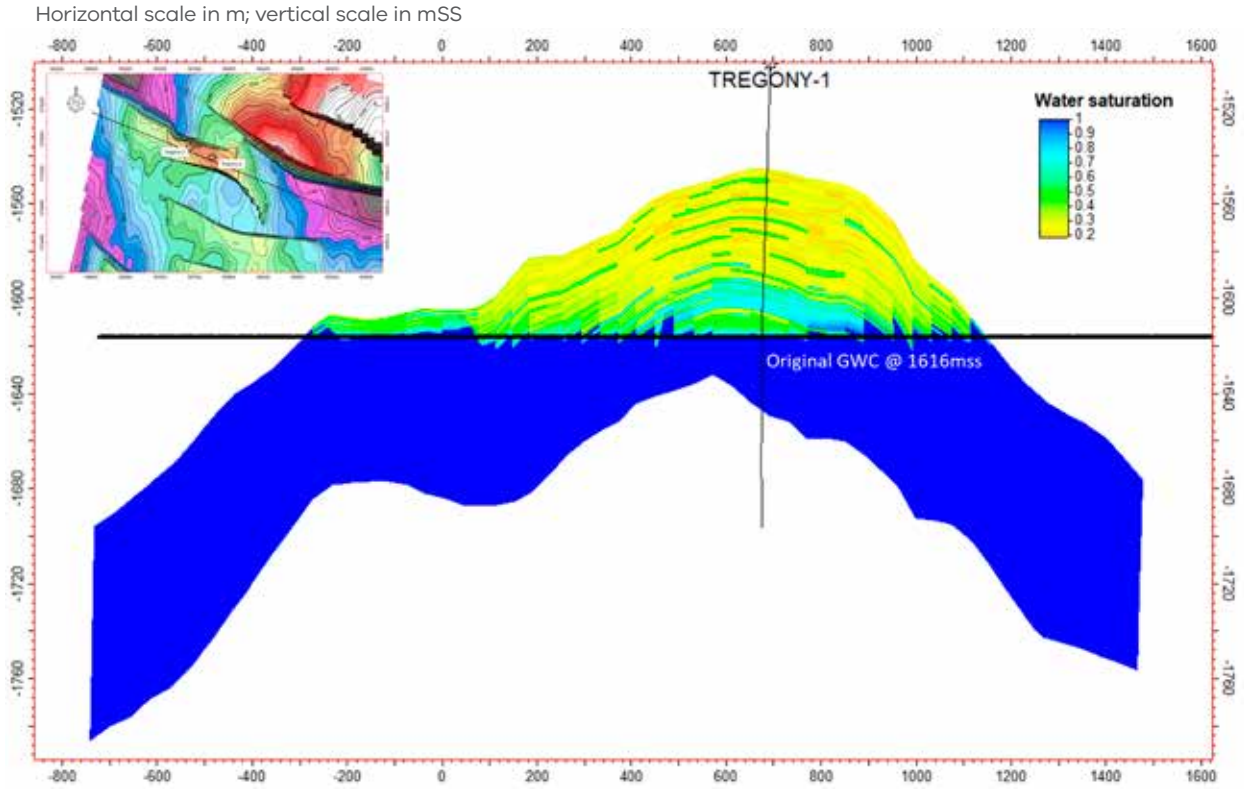


Figure 4.5 Northwest-southeast cross-section through Tregony-1 illustrating initial water saturation in the reservoir.

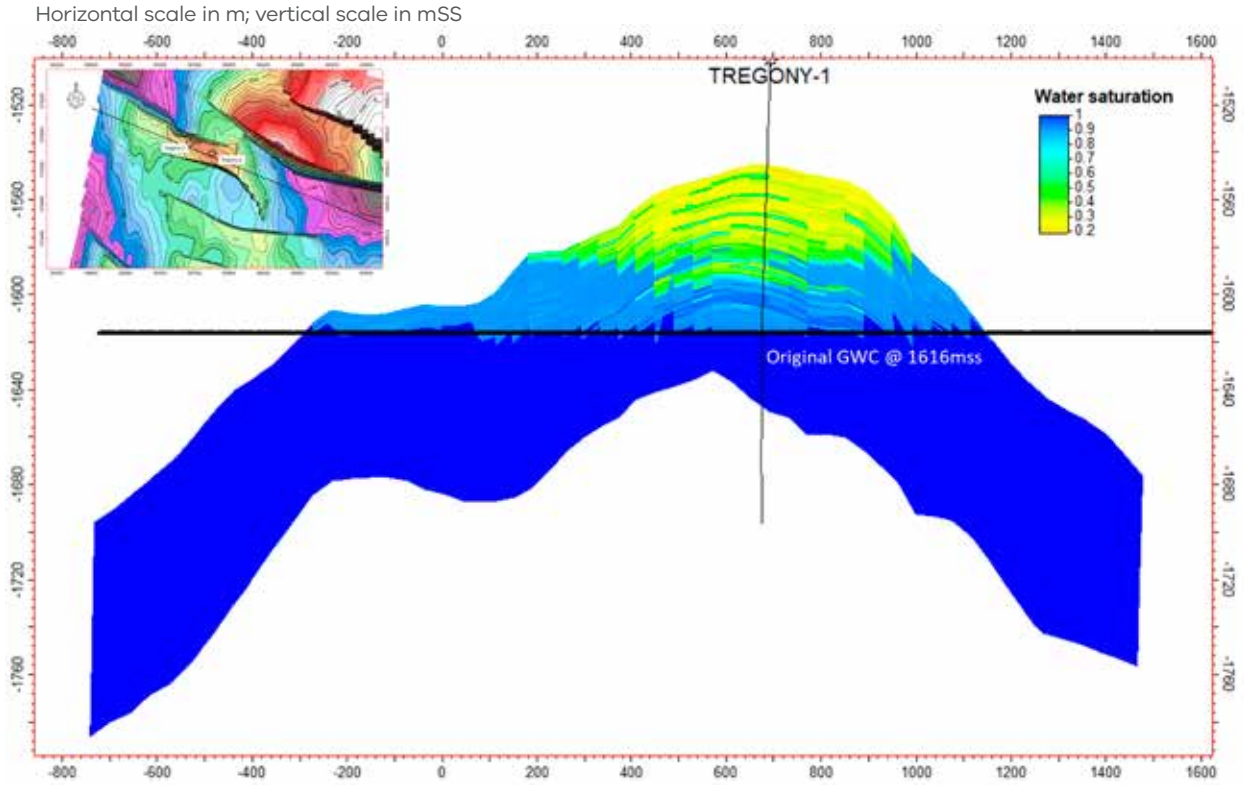


Figure 4.6 Northwest-southeast cross-section through Tregony-1 illustrating initial water saturation post-production, prior to scenario modelling.

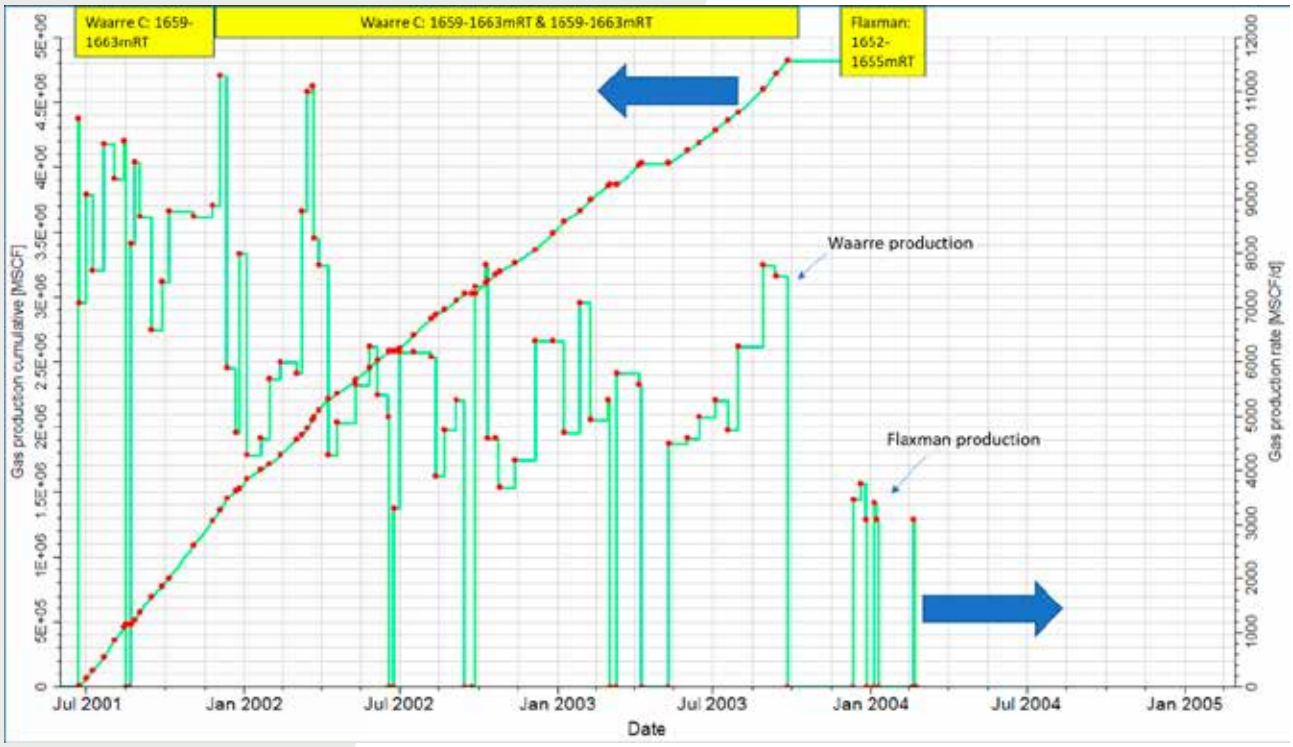


Figure 4.7 Water gas rate and cumulative production at Tregony. The red dots show historical data and the green line shows the simulation results.

The history matched model allowed for nine scenarios to be simulated by varying the number of wells, tubing size and distribution rates. Periodic injection/withdrawal cycles of nine and three months, respectively, were simulated for an operational period of 15 years. The dynamic capacity of each site was investigated by changing the cycle volume for each scenario to understand the volume the depleted gas fields can utilise as storage. The cycle volume is the total injection and production volume in each cycle. Development options were investigated by assessing how many wells would be required to achieve an optimal storage capacity and the sensitivity of the capacity to wellhead pressure and tubing size. An example of the water saturation at the end of the first injection cycle and at the end of the operational period at Tregony is illustrated in Figure 5.8 and Figure 5.9, respectively.

Horizontal scale in m; vertical scale in mSS

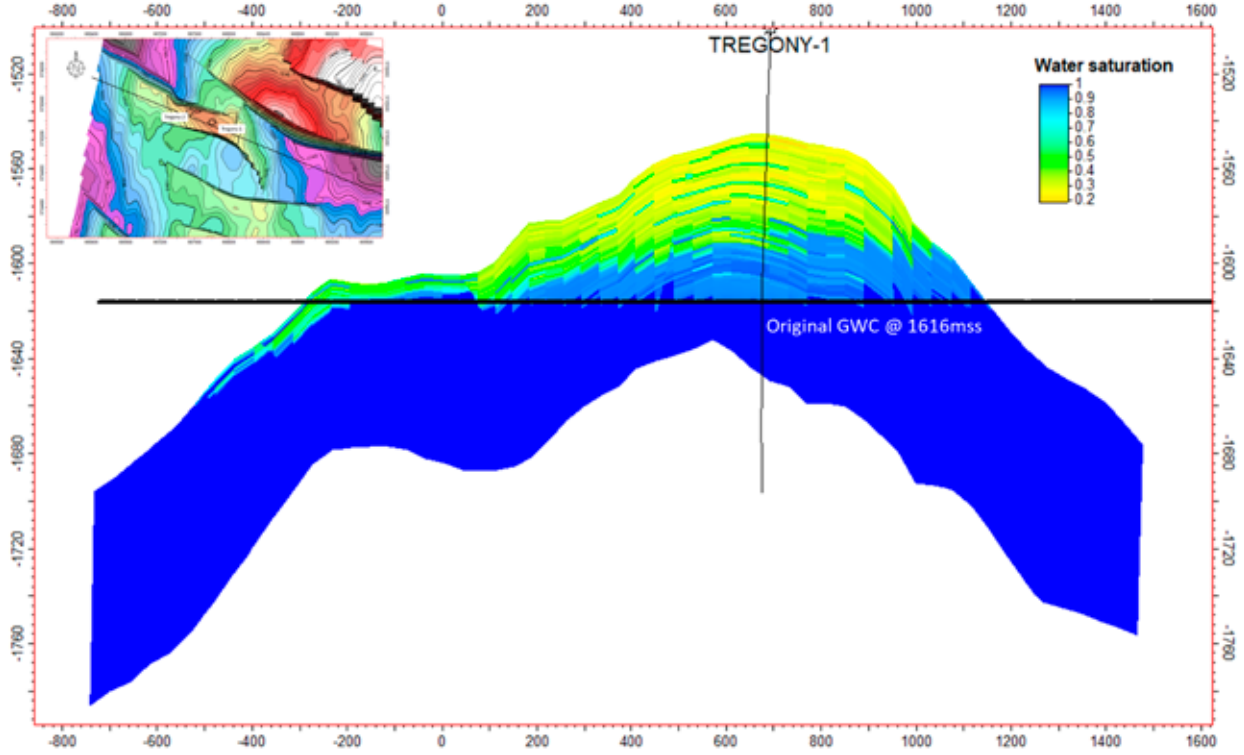


Figure 4.8 Northwest-southeast cross-section through Tregony-1 illustrating water saturation at the end of the first injection cycle.

Horizontal scale in m; vertical scale in mSS

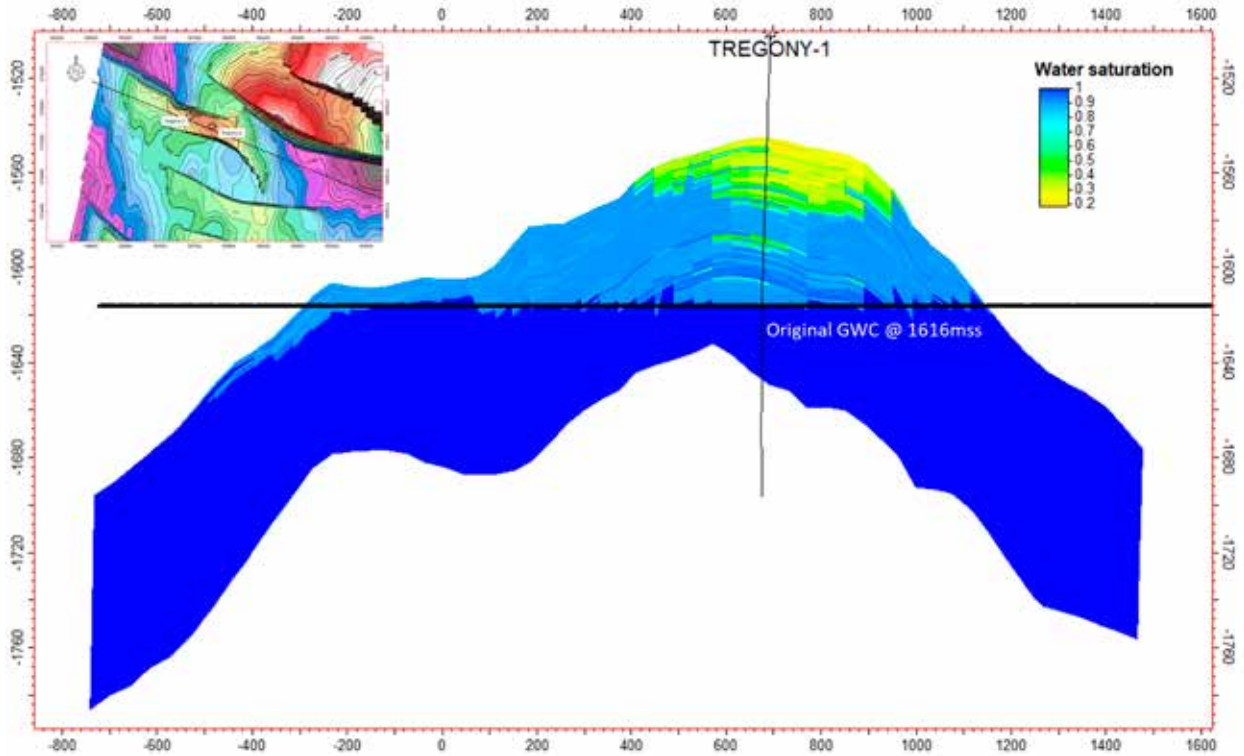


Figure 4.9 Northwest-southeast cross-section through Tregony-1 illustrating water saturation at the end of the operational period.

The resulting storage capacity and the recommended development options for each field are reported in six dynamic modelling technical reports. A summary is presented in Table 5.3. Each dynamic model technical report is accompanied by the dynamic model and simulation results for each depleted gas field.

Table 4.3 Gas storage capacity of six potential gas storage fields

Gas field	Original Gas in Place (petajoules)	Potential gas storage capacity (petajoules)		
		Base	Mid	High
Croft	8.1	1.9	2.4	2.8
McIntee	22.3	2.9	3.8	4.8
Mylor	18.9	1.9	2.9	3.8
Tregony	9.0	1.9	2.6	3.0
Fenton Creek	5.2	2.6	2.8	3.4
Penryn	6.9	1.4	1.9	2.4
Total	70.4	12.6	16.4	20.2

Note: Petajoules calculated from estimated volumes using a heating value of 38 megajoules per cubic metre.

4.2.3 Commercial modelling

The Geological Survey of Victoria engaged AWT International (Australia) Pty Ltd to understand the commercial feasibility of developing the additional onshore underground gas storage sites. The results of the dynamic modelling were used in this assessment. The assessment estimated development and operational costs, and considered the potential financial return for three scenarios:

- Field operations with third party processing.
- Field operations using the capacity of an existing plant for processing.
- Field operations using a new processing plant.

The results for the high capacity case, considering an internal rate of return of greater than 10 per cent, are summarised in Table 5.4.

Table 4.4 Summary of commercial feasibility of individual gas fields

Gas field	Commercial feasibility of processing options for high case, internal rate of return, 10 per cent		
	Field operations only, third party processing	Field operations using an existing plant	Field operations using a new processing plant
Croft	✓	✓	×
McIntee	✓	✓	×
Mylor	✓	✓	×
Tregony	✓	✓	×
Fenton Creek	✓	✓	×
Penryn	✓	✓	×

Four combination cases were also considered using the high capacity cases. The findings demonstrate that all combination cases result in a positive economic outcome as summarised in Table 5.5.

Table 4.5 Summary of commercial feasibility of combined gas fields

Combination of gas fields	Commercial feasibility of processing options for high case, internal rate of return, 10 per cent		
	Field operations only, third party processing	Field operations using an existing plant	Field operations using a new processing plant
Mylor, Tregony, Fenton Creek	✓	✓	✓
Mylor, Tregony, Fenton Creek, Penryn	✓	✓	✓
Mylor, Tregony, Fenton Creek, Penryn, McIntee	✓	✓	✓
Mylor, Tregony, Fenton Creek, Penryn, McIntee, Croft	✓	✓	✓

Results from the investigations are available at earthresources.vic.gov.au/gasprogram, including technical reports on the six sites which could potentially be used to expand Victoria's underground gas storage capacity. If required, this capacity could be incorporated into the Victorian gas network to support resilience and flexibility in future gas supply. All six sites were found to be commercially feasible if developed, both individually and when certain sites were combined.

5. Victorian Gas Program governance

The Victorian Gas Program was subject to strong governance to ensure scientific integrity, quality and independent oversight.

The methodology and results of the program's studies were tested under the guidance and advice of the independent Stakeholder Advisory Panel for Onshore Conventional Gas and the Scientific Reference Group, both chaired by Victoria's Lead Scientist Dr Amanda Caples.

5.1 Stakeholder Advisory Panel for Onshore Conventional Gas

The Stakeholder Advisory Panel included representatives of the regional community, farmers, an environmental group, industry and local government. The panel membership was designed to represent the different onshore conventional gas views and interests in Victoria.

The panel met quarterly throughout the program. The panel advised the Minister for Resources on the risks, benefits and impacts of onshore conventional gas exploration and development during the moratorium, with particular attention paid to social, economic and environmental factors. The panel played a vital role in linking the diverse groups of stakeholders with an interest in gas with the scientific evidence collected.

The work of the panel was highlighted in government's announcement of its intention to allow for an orderly restart of onshore conventional gas exploration and production, on 17 March 2020.

The panel formally met on twelve occasions: 17 August 2017, 10 November 2017, 8 March 2018, 7 June 2018, 6 September 2018, 14 February 2019, 9 May 2019, 8 August 2019, 21 November 2019, 13 February 2020, 23 April 2020 and 11 June 2020.

Communiques for these meetings are provided in Appendix 1. The communiques are also available on the Lead Scientist's web page at djpr.vic.gov.au/victorias-lead-scientist.

5.2 Victorian Gas Program Scientific Reference Group

Victoria's Lead Scientist also chaired the Victorian Gas Program Scientific Reference Group. This group provided independent peer review advice to the Lead Scientist on the study scope and outputs of the program. Members with relevant expertise reviewed Victorian Gas Program activities related to their field of study on an 'as required' basis, to ensure the scientific and technical outputs were robust. The group also met formally when required.

The group provided peer review input and advice on the final outputs of the risks, benefits and impacts assessment published in Progress Report No. 4 (Geological Survey of Victoria, 2020) to ensure their robustness. The group advised that the assessment had been undertaken with strong technical rigour and was suitable for informing government in its decision making.

6. Supporting program components

6.1 Community engagement

An extensive community and stakeholder engagement program was delivered alongside the scientific components of the Victorian Gas Program. Engagement was focused on the communities closest to the Otway and Gippsland basins and aimed to:

- inform and educate stakeholders, communities and the public about the Victorian Gas Program and its scientific findings
- build the capacity of stakeholders and communities to offer informed input
- build trust and strengthen relationships
- enable the community to have a voice throughout the Victorian Gas Program.

Over three years, the program engaged with more than 950 people across South-West Victoria, Melbourne and Gippsland, via more than 780 events (including briefings, meetings, forums, emails and telephone calls). Stakeholders were diverse and included:

- farmers
- environmental groups
- local and state governments authorities
- community members
- traditional owners
- business and industry groups
- water authorities.

People were given the opportunity to ask questions and get answers throughout the program. Engagement activities and matters raised by the public were recorded in the Victorian Gas Program engagement database. People in the database received information about the program regularly, through progress reports and Stakeholder Advisory Panel communiques (see Appendix 1). Database members also received notice of program events in regional areas, such as the community workshops to test and refine the preliminary resource and land use planning models (see Section 6.2).

This approach allowed people to develop a deeper understanding of the scientific studies undertaken as part of the program and the geology of the Otway and Gippsland basins. Many of the group engagement sessions included a presentation of the Geological Survey of Victoria's world-class 3D geological models of the basins, from senior geoscientists.

A geological education program was delivered in South-West Victoria to support the engagement program. Insights into the geological origins of Australia, the rock cycle, dating the earth, the formation of geological basins and careers in geoscience were shared with approximately 1400 students in Years 5 to 9.

6.1.1 Social research into regional communities' attitudes towards onshore conventional gas development

Independent social research was undertaken by CSIRO as part of the Victorian Gas Program. The objective of the research was to provide a statistically robust understanding of attitudes towards onshore conventional gas development in the Otway and Gippsland basins.

CSIRO's research involved an independent telephone survey, which was undertaken between September and October 2019. A total of 801 residents were surveyed: 501 in the Otway Basin and 300 in the Gippsland Basin. Participants were randomly selected using databases of landline and mobile telephone numbers to provide a non-biased representation of the total population.

To ensure a representative survey sample was obtained, quotas for age, gender and subregion were used. Data was weighted to achieve representativeness by municipality, subregion, age, gender, and working status according to 2016 census data. All procedures adhered to the National Statement on Ethical Conduct in Human Research, as well as the ethical review processes of the CSIRO, whose ethics committee approved the survey.

The results provide insight into the South-West Victorian and Gippsland communities' perceptions about onshore conventional gas, and the levels of social acceptance if development were to take place. Results have been published (Walton & McCrea, 2020a; Walton & McCrea, 2020b). The reports also include information about community health and resilience, and what would be required for the communities to have confidence in onshore conventional gas development.

The Victorian Government last surveyed people's views on onshore gas in 2014. The latest survey results highlight a diversity of views in South-West Victoria and Gippsland about onshore conventional gas and provide a baseline for future measurement of social acceptance of onshore conventional gas activities.

6.2 Resource and land use planning

Strategic land assessments of South-West Victoria and Gippsland were undertaken as part of the Victorian Gas Program, to ensure that any onshore conventional gas activities proposed in the future can take the local context into account.

Existing land uses and landscape features were considered in a multi-criteria analysis, which incorporated community views to identify the best land use options. Resource and land use planning models for the Otway and Gippsland basins were then developed.

The models allow a high-level, regional-scale assessment of land within the Otway and Gippsland basins in relation to its suitability for onshore conventional gas development. The models take into account the potential impacts of conventional gas development on the natural and socio-economic environment, and integrates them into high-level spatial analysis of land use suitability.

Over 140 spatial data layers were collated to map the Otway and Gippsland basins' unique natural, cultural, environmental and social land uses, to build a land use inventory. Seven land use themes were assessed:

- environmental value
- climate change vulnerability
- topography
- heritage value
- social value
- infrastructure
- regional significance.

These helped to better understand the sensitivities and values across the basins.

The analysis used authoritative data from state and federal government agencies. The data was overlaid with a scoring framework to identify locations where the land may be constrained, which could therefore impact the potential for onshore conventional gas development.

After combining this data, a resource and land use planning model was produced for each basin. The models display features spatially, allowing existing and potential future land uses and landscape sensitivities to be identified. It highlights areas where features of sensitivity or significance may exist that would need to be considered and addressed prior to any gas exploration or development proceeding.

Each model enables a useful assessment that could be undertaken in conjunction with the regulatory assessment process for proposed onshore conventional gas activities. The model could identify potential issues in the early stages of an application process, which could be addressed to mitigate land use conflicts and promote multi and sequential use. These will support government to better understand potential interactions with other land uses, particularly during impact assessments and acreage releases.

The Otway Basin resource and land use planning model was presented in Progress Report No. 4 (Geological Survey of Victoria, 2020). The Gippsland Basin model is presented below.

6.2.1 Gippsland Basin resource and land use planning model

6.2.1.1 Preliminary Gippsland Basin model

The preliminary Gippsland resource and land use planning model was developed by collecting authoritative datasets to map the region's unique natural, built and heritage features. These include distinctive rural and coastal landscapes, productive agricultural land and environments with significant biodiversity value.

The preliminary Gippsland model (Figure 6.1) indicated that all areas in the Gippsland Basin were constrained for onshore conventional gas development. Therefore, all areas would require appropriate planning and management if development were to take place.

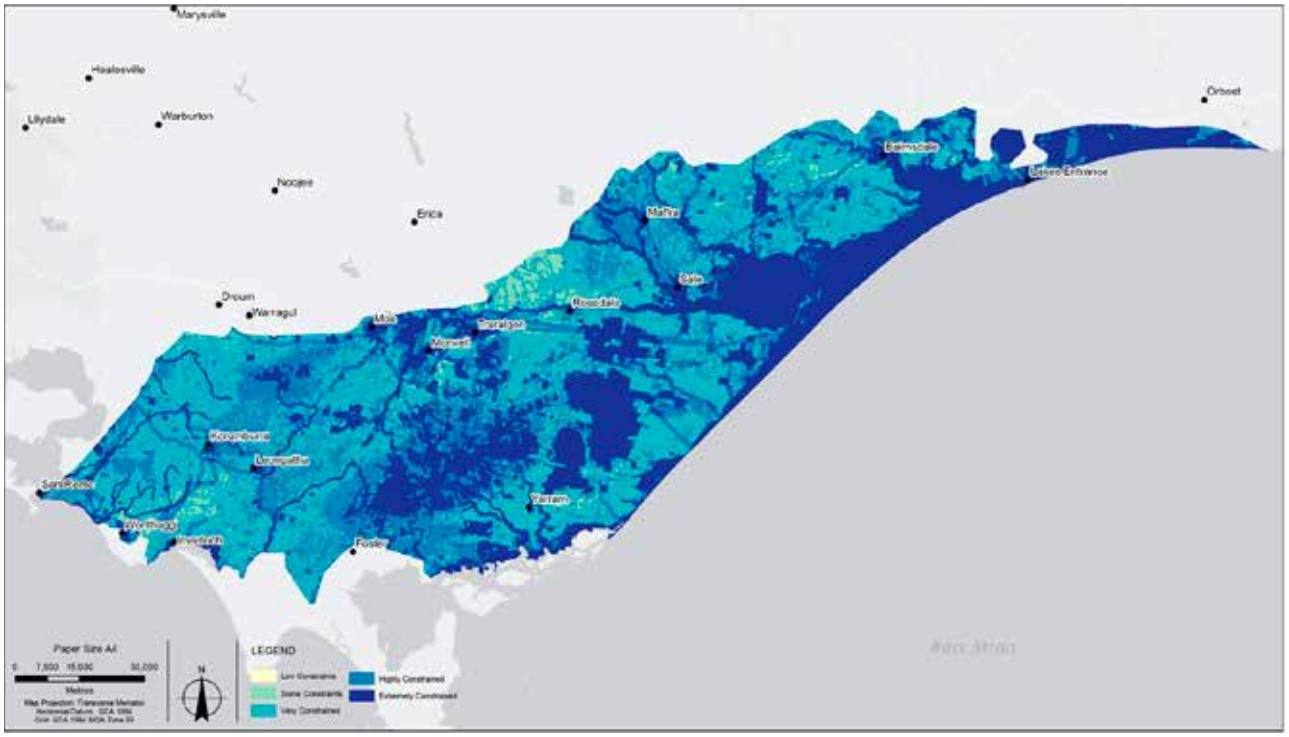


Figure 6.1 Preliminary Gippsland resource and land use planning model.

6.2.1.2 Consultation and workshops in Gippsland

To finalise the Gippsland resource and land use planning model, a community and stakeholder engagement program was delivered alongside the desktop study. The engagement targeted government agencies and stakeholders, subject matter experts and the Gippsland community. The program was designed to test the resource and land use planning model framework and to identify local values, insights and concerns.

To test and refine the preliminary model, a series of online workshops were held in February and March 2020 with stakeholders from local and state government, and other agencies that focus on the Gippsland region. These stakeholders are typically broadly familiar with land use planning processes and issues.

A separate workshop was held in Traralgon in March 2020. It was attended by representatives from Wellington Shire Council, Latrobe City Council, South Gippsland Shire Council, the Department of Environment, Land, Water and Planning (DELWP), West Gippsland Catchment Management Authority, and the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) Traditional Owners Group.

Community workshops were initially scheduled across Gippsland in April 2020. The workshops were intended to be held in person, in the same format as those held in South-West Victoria for the Otway Basin resource and land use planning model (Geological Survey of Victoria, 2020). However, the Gippsland workshops were delayed due to bushfires in the region and then physical distancing restrictions during the coronavirus (COVID-19) pandemic. Given the importance of the engagement to the resource and land use planning

methodology, an online engagement model was developed. The online approach meant that community workshops could still be held and community feedback on the preliminary model could still be captured.

A total of 150 people attended ten online community workshops. Eight sessions captured insights from the four local government areas within the study area: Wellington, South Gippsland, East Gippsland and Latrobe. Two region-wide online workshops were also held.

The workshops were promoted through a newspaper advertising campaign in the *Bairnsdale Advertiser*, *Lakes Entrance Post, Latrobe Valley Express, Foster Toora Mirror, Sale Gippsland Times* and *The Weekly Times*. A direct email with the workshop details was sent to over 85 Gippsland people in the Victorian Gas Program engagement database. Several community groups promoted the workshops to their members via social media.

Community feedback on the preliminary resource and land use planning model was generally positive, particularly in relation to the depth of work and volume of data incorporated. Feedback included the need for the model to represent food security and to identify and protect agricultural land, along with environmental values, particularly in relation to water supplies.

A total of 235 community comments about the model were recorded in Social Pinpoint, an online tool to capture comments and feedback by location (Figure 6.2). Comments were grouped by theme, actioned, and fed back into the model where appropriate. The environmental and social value themes generated the most comments, as shown in Table 6.1.

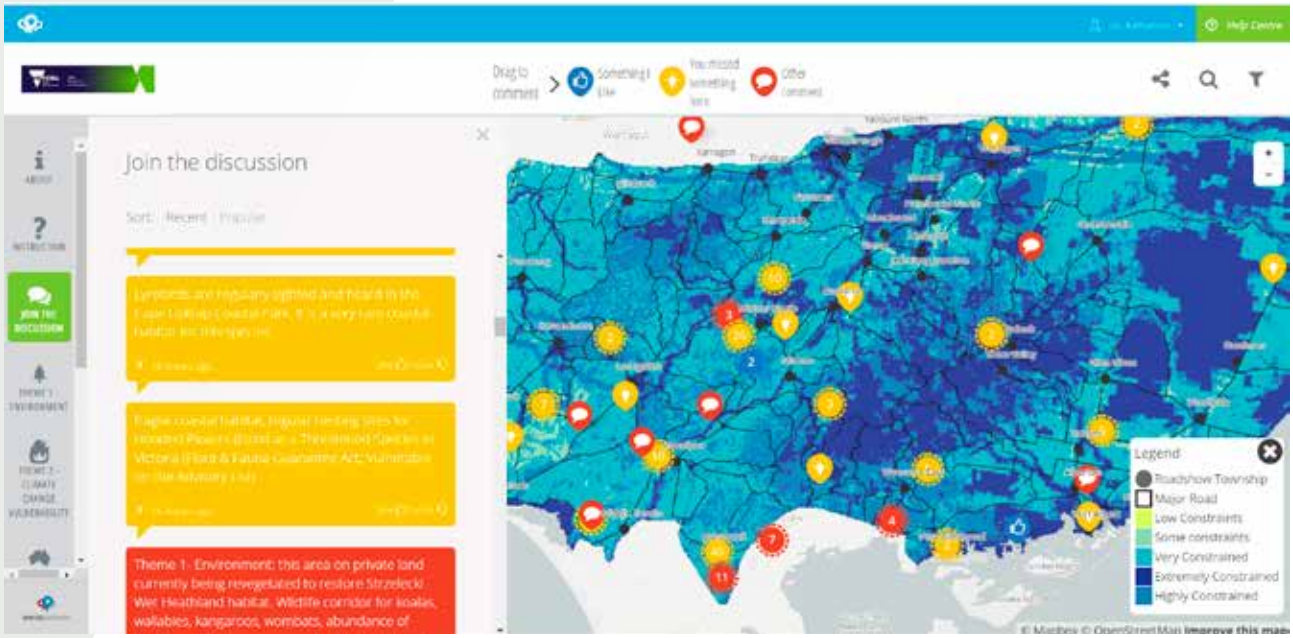


Figure 6.2 Location of Gippsland community comments on the preliminary resource and land use planning model.

Table 6.1 Gippsland community comments on the preliminary resource and land use planning model by theme

Community feedback theme	Number of comments received
Social values	83
Environmental values	79
Regional significance	5
Heritage values	3
Infrastructure	3
Climate change vulnerability	2
Topography	1
General (outside of scope)	59
Total	**235**

Common feedback included site locations of environmental features, such as vulnerable and endangered flora and fauna. These features had already been captured in the preliminary resource and land use planning model, so no change was required.

Some feedback identified species that required protection for reasons other than endangered or vulnerable status, which had not been captured in the preliminary model. The superb lyrebird was identified as an important drawcard for tourism in the Gippsland region. To action this feedback, locations of sightings of the superb lyrebird registered in the Victorian Biodiversity Atlas were incorporated into the final model as a constraint, with a 100 metre radius buffer. Typically, these locations fall within rainforests, parks and reserves which are already highly constrained in the model.

The koala population was also identified as requiring protection, in order to maintain genetic diversity of the species. The Strzelecki Koala is a genetically unique population of wild koalas found in the Strzelecki Ranges. Registered sightings of koalas in the Victorian Biodiversity Atlas have been incorporated into the model as a constraint, with a 100 metre radius buffer. These locations are scattered throughout the Strzelecki Ranges, and typically fall within parks and reserves which are already constrained in the model.

Some feedback highlighted that the model did not include the locations of certified organic farms, or scenic views and vistas. Datasets of these areas do not currently exist, but could be developed and incorporated in a future version of the model.

General feedback mostly related to sentiments towards onshore conventional gas. There were requests for clarification on government policy, gas markets, prioritisation of gas for local users, the work of the Victorian Gas Program, climate change, and opposition to ongoing reliance on fossil fuels. This feedback was recorded but is outside of the scope of the Gippsland resource and land use planning model.

6.2.1.3 Final Gippsland Basin model

The final model (Figure 6.3) indicates that all areas in the Gippsland Basin have some level of constraint for onshore conventional gas development.

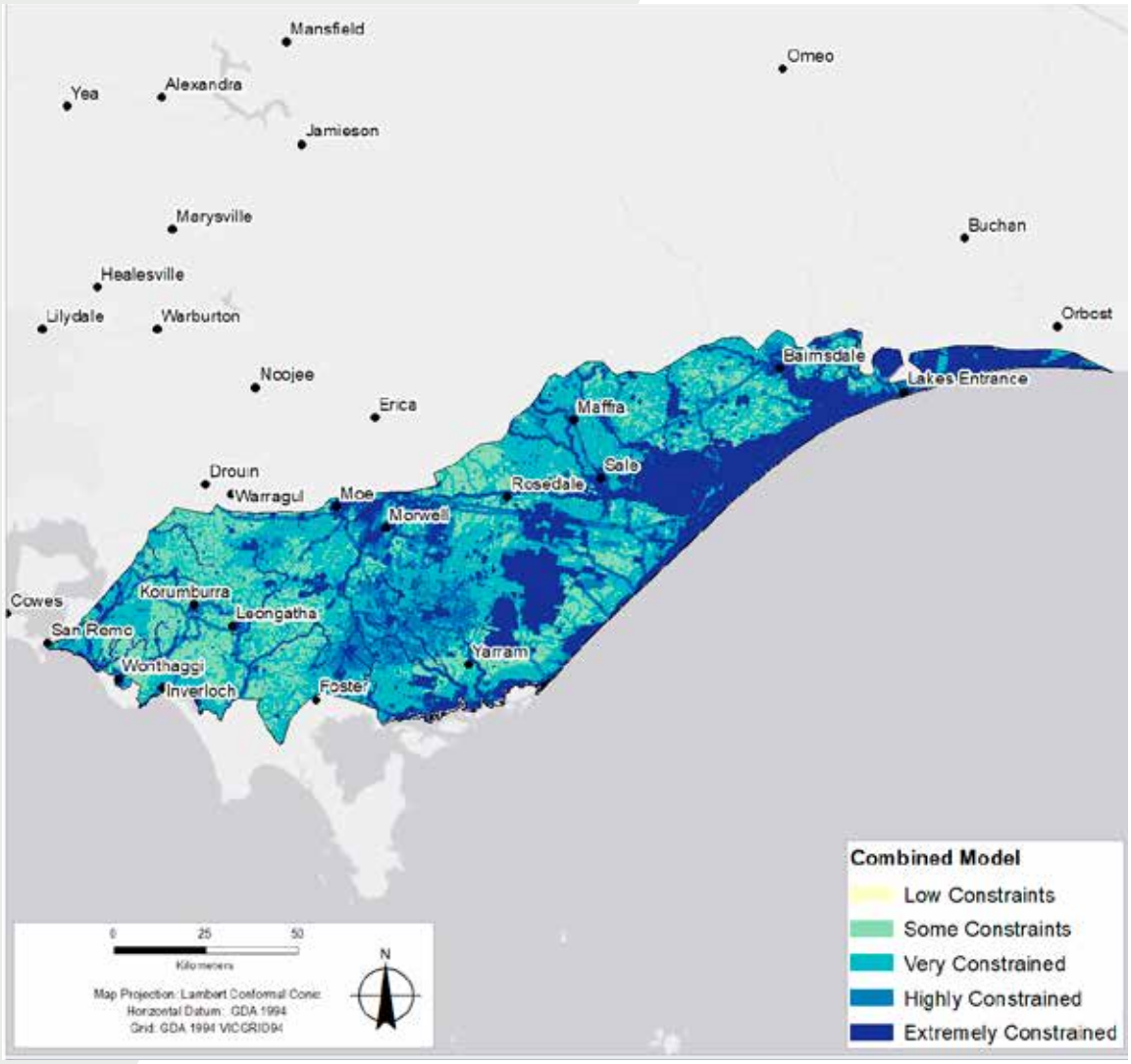


Figure 6.3 Final Gippsland resource and land use planning model.

Twenty-nine per cent of land was scored as extremely constrained, indicating land features or values that would need to be addressed prior to, and appropriately managed throughout any potential gas development.

Areas and/or features identified in the model as highly constrained include:

- areas already prohibited and restricted through existing legislation
- areas within and surrounding townships and residential zones
- areas along rivers and near water bodies and coastal areas
- vegetation, habitat or species of environmental significance
- cultural heritage or landscape values of significance
- areas with exposure to natural or environmental hazards such as fire, flood or other
- other areas identified through the model.

The model allows a high-level regional assessment that can be used to aid site selection or approval, to inform community engagement, or to support appropriate environmental risk management or mitigations before exploration or development occurs.

The model is dynamic and can be built on and re-analysed for future use as required, so potential onshore conventional gas exploration and development can be informed by the local context.

7. Regulatory reform

7.1 Orderly restart – Overview of the Amendment Act

Why was a moratorium on onshore conventional gas activities put in place?

In 2017, the Victorian Government imposed a moratorium on all onshore conventional gas exploration and development until 30 June 2020.

The moratorium was put in place to allow time for government to undertake scientific, technical, environmental and social studies on the risks, benefits and impacts of an onshore conventional gas industry. These studies were undertaken as part of the Victorian Gas Program.

Orderly restart of onshore conventional gas industry – a science-led decision
The Victorian Gas Program identified potentially significant onshore conventional gas resources, particularly in the Otway Basin, which stretches across the border to South Australia where a productive industry has been established. The program's scientific investigations revealed that if these resources were developed, it would have a negligible impact on the state's groundwater supplies and agricultural industries. Production of Victoria's estimated resources could generate around $300 million annually for regional economies and create up to 6400 jobs over the lifespan of these projects.

The assessment of the risks, benefits and impacts of potential onshore gas exploration and development published in Progress Report No. 4 (Geological Survey of Victoria, 2020) tied together the program's scientific, technical, environmental and social studies. This assessment was undertaken by Ernst & Young and incorporated economic and greenhouse gas modelling.

An independent Stakeholder Advisory Panel (see Section 3.1) oversaw and provided feedback on the assessment. An independent Scientific Reference Group (see Section 3.2) provided peer review input and advice, and found that the assessment was technically rigorous and suitable for informing government decision making.

These findings informed government's decision to restart the onshore conventional gas industry.

The *Petroleum Legislation Amendment Act 2020* – strengthening controls to support confidence
The *Petroleum Legislation Amendment Act 2020* (the Amendment Act), passed by the Victorian Parliament on 16 June 2020, provides for an orderly restart of the onshore conventional gas industry by extending the moratorium on exploration and development to 30 June 2021.

The amendments were informed by a regulatory gap analysis that highlighted opportunities to improve the existing onshore petroleum regulatory framework. The gap analysis included an interjurisdictional review to identify current regulatory trends and leading practices. The gap analysis showed that while the existing framework was relatively robust for managing environmental and safety risks, it could be improved in areas relating to:

- community engagement obligations
- considering and managing broader industry impacts in regulatory decision making
- transparency of regulatory decisions and industry activities.

Accordingly, the Amendment Act was drafted to:

- Require increased consultation with the Victorian community to ensure local community views and interests are heard and considered by industry who propose onshore conventional gas activities.
- Enable consideration of additional social, economic and environmental factors when certain decisions are made under the Act (such as awarding acreage and granting authorities).
- Enable the publication of certain information relating to government decisions and industry activity, to increase transparency to Victorian communities.

The Amendment Act also includes provisions to transition existing authority holders, whose operations have been on hold, back to operations.

These amendments are a tangible strengthening of legislative controls designed to support community confidence in industry and improve government's ability to regulate the sector.

Underground gas storage – no legislative constraints to further development
The *Petroleum Act 1998* provides a framework for the regulation of both conventional petroleum development activities and underground gas storage activities in Victoria's onshore area. Accordingly, the rationale for and the provisions of the Amendment Act apply to both industries. The Victorian Gas Program's regulatory gap analysis also examined the petroleum regulatory framework for any constraints in relation to underground gas storage specifically, and found:

- there are no additional issues specific to underground gas storage that require legislative amendment
- no legislative barriers that would constrain further development of Victoria's underground gas storage industry.

Accordingly, no specific underground gas storage amendments were included in the Amendment Act.

Domestic gas prioritisation – supporting local consumers with local gas supply
The Victorian Gas Program's analysis highlighted opportunities to improve local energy security, by ensuring that Victorian gas is prioritised towards Victorian businesses and households.

Following an assessment of Victoria's unique gas supply circumstances, it was determined that this could be most effectively achieved by placing an obligation on gas producers to provide domestic consumers with a right of equal access on reasonable terms to buy new gas that is discovered in Victoria. It should place the onus on industry to report to the Minister if there is a contract for sale of gas to liquified natural gas exporters, and there should be an ability to investigate any breaches and impose sanctions if required.

The analysis showed that a greater level of intervention was not required as the most likely customers for Victorian gas are those closer to the supply source, because the only avenue for gas export in the east-coast gas market is through Gladstone in Queensland. This was a function of market dynamics.

The analysis also showed that implementing a true gas reservation strategy, similar to that in Western Australia, would be extremely challenging for Victoria. This is because Victoria is part of an interconnected east-coast gas market and the Australian Constitution prevents any impediment to trade between the states and territories.

The Amendment Act includes provisions to amend the Victorian *Offshore Petroleum and Greenhouse Gas Storage Act 2010*, to create the domestic gas prioritisation obligation for future offshore production licences. This was included in the Amendment Act to enable government to honour its commitment in the 2018 Victorian Offshore Acreage Release (see Section 4.2). Gas producers will be required to prioritise domestic gas consumers by making first reasonable and genuine offers to the domestic market for any gas produced.

As part of the decision to restart onshore conventional gas industry, the government also committed to requiring future onshore producers to prioritise production towards the domestic market. The offshore provision will be piloted for its effectiveness before government extends it to the onshore petroleum regulatory framework.

Offshore petroleum – a fit-for-purpose framework that follows international leading practice
In state waters, up to three nautical miles from the Victorian coast, petroleum activities are regulated under the Victorian *Offshore Petroleum and Greenhouse Gas Storage Act 2010*. In Commonwealth waters, more than three nautical miles from the Victorian coast, petroleum activities are regulated under the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*.

As part of the Offshore Constitutional Settlement agreement, the Victorian *Offshore Petroleum and Greenhouse Gas Storage Act 2010* is harmonised with the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. Victoria only makes amendments that deviate from the Commonwealth Act if there is justification to do so.

The Victorian Gas Program regulatory gap analysis did not identify any issues beyond the domestic gas prioritisation amendment that warranted changes to the Victorian Act. The analysis found that the *Offshore Petroleum and Greenhouse Gas Storage Act 2010* provides a robust risk-based framework that follows national and international leading practice.

The Department of Jobs, Precincts and Regions will continue to liaise with other relevant state and Commonwealth agencies to ensure best practice regulatory administration is maintained for offshore oil and gas activities in Victoria.

Developing Victoria's estimated resources – a small impact on greenhouse gas emissions
The government acknowledges that in the medium to longer term, emissions associated with natural gas usage need to be reduced to align to Victoria's net zero emissions future. With around two million Victorian customers currently dependent on gas for heating, cooking and industrial uses, it is also important Victoria has a secure and reliable supply of gas as the state transitions to renewable sources of energy.

The government is committed to meeting the requirements of the *Climate Change Act 2017* to achieve net zero emissions by 2050, and to set five-yearly interim targets and prepare sector pledges that keep the state on a pathway to meeting the 2050 target. Allowing onshore gas exploration and development to restart will not compromise this commitment to delivering strong action on climate change.

The Victorian Gas Program's assessment of the risks, benefits and impacts of onshore conventional gas (published in Progress Report No. 4; Geological Survey of Victoria, 2020) incorporated economic and greenhouse gas emissions modelling. The modelling showed that developing Victoria's onshore conventional gas resources is a positive for energy security and is not expected to increase consumption because the gas extracted would displace other sources of supply. Therefore, the only additonal emissions from producing gas domestically will be those related to looking for the resource and getting it out of the ground.

This assessment showed that if Victoria's potential onshore gas resources were to be developed, it would have a very small impact on the state's greenhouse gas emissions. The estimated additional emissions from producing the gas domestically onshore would be between 122,000 to 329,000 tonnes CO_2-e annually. This is equivalent to 0.1 to 0.3 per cent of Victoria's net greenhouse gas emissions in 2017.

These emissions would have a negligible impact on Victoria's emission profile. From a global emissions perspective, further Victorian gas production would avoid greenhouse gas emissions associated with transporting gas from its point of production.

7.2 Next steps

7.2.1 Remake of the Petroleum Regulations

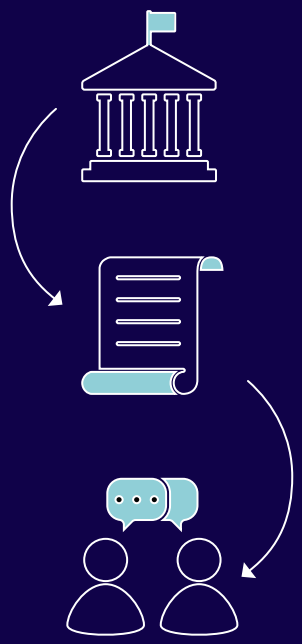
The *Petroleum Act 1998* establishes the broad legal framework for the regulation of petroleum exploration and production in Victoria. The Petroleum Regulations 2011 contain specific details designed to give effect to the broad principles established under the Act. For example, the regulations contain details of what must be included in an operation plan or an environment management plan. As these details can be quite extensive, it is appropriate that they be included in the regulations rather than in the Act itself. This is typical of modern risk-based legislative frameworks.

Work is underway to remake the Petroleum Regulations 2011, which sunset on 24 May 2021. The new regulations will set out how the new provisions in the Amendment Act will be implemented. They also provide an opportunity to make further regulatory improvements in line with the findings of the Victorian Gas Program. For example, the assessment of the risks, benefits and impacts of a potential onshore conventional gas industry (published in Progress Report No. 4; Geological Survey of Victoria, 2020) identified that despite the risks being low, the introduction of a transparent groundwater monitoring regime would align with leading practice and would provide confidence that the sector is not impacting Victoria's groundwater supplies. Such a requirement could use the groundwater baseline data collected as part of the Victorian Gas Program and could be designed so that it is effective without creating a large regulatory impost on industry.

The orderly restart approach provides the necessary time for the Victorian Government to work with stakeholders to build a common understanding of expectations for the sector, and to develop the requirements of the Petroleum Regulations 2011. The remake of the regulations will involve public consultation around draft regulations and a Regulatory Impact Statement, as required under the *Subordinate Legislation Act 1994*. This will ensure that the new requirements are effective and regulatory burden is minimised.

To complement the regulations and ensure the sector is effectively regulated, operational policies and industry guidance are being prepared by Earth Resources Regulation, and regulatory capability is being improved.

The way forward for onshore conventional gas



The *Petroleum Legislation Amendment Act 2020* allows for industry to restart from 1 July 2021.

In the lead up to the restart, government will work with stakeholders to improve the regulatory framework in line with the Victorian Gas Program findings, particularly in relation to project transparency and community engagement requirements.

Victorians will be able to have their say on the draft regulations through the Regulatory Impact Statement process in early 2021.

7.2.2 Working to improve land access arrangements

The Victorian Gas Program's assessment of the risks, benefits and impacts of a potential onshore conventional gas industry (published in Progress Report No. 4; Geological Survey of Victoria, 2020) considered the extent to which different exploration and development scenarios could affect land access and use.

The assessment showed that the existing legislative provisions for land access and land compensation were robust and fit-for-purpose. There was also anecdotal evidence that industry goes above this requirement, ensuring that landholders benefit from operations on their land. This could include rent being paid at the industry value, which is greater than the farm value, and provides a supplementary and diversified income stream.

It was noted that negotiating land access and compensation agreements is not core business for landholders, who in many cases are farmers. These negotiations happen rarely and landholders may need support to negotiate confidently.

Typically, industry operators wishing to conduct exploration activities on a property would contact the landowner and explain what they seek to do, how long it will take, and what the expected impacts will be. The operator would offer a compensation agreement that the company uses. These agreements vary in length and detail.

The Victorian Gas Program identified that a Commercial Consent Land Access tool, similar to the tool currently being trialled for mineral exploration, provides an opportunity to improve land access arrangements in the petroleum sector.

The Commercial Consent Land Access tool was developed by government, the Victorian Farmers Federation, the Minerals Council of Australia, the Association of Mining and Exploration Companies and the Prospectors and Miners Association of Victoria. The tool is being piloted as part of the Stavely Minerals Exploration Initiative and feedback to date has been positive. Use of the tool is voluntary and does not require legislation to implement. It has been designed to give landholders confidence in negotiating:

- access to the land for the exploration company
- the conditions under which the company may enter the land (including biosecurity, livestock and crops)
- compensation, and how it may be calculated if it is applicable
- communications requirements, to keep both landowners and exploration companies informed
- dispute resolution, including how to get help if relationships break down.

A similar Commercial Consent Land Access tool for onshore conventional gas exploration could be developed in future, if it is needed.

The strengthened landowner engagement requirements being introduced by the Amendment Act, particularly around rehabilitation, will also work to improve land access and use arrangements.

8. Conclusion

This Progress Report summarises the findings and outcomes of the Victorian Gas Program, a three-year suite of geoscientific, environmental and social studies undertaken by the Geological Survey of Victoria which concluded in June 2020.

This report is the final in a series of published progress reports that provide a comprehensive overview of the program. Technical reports on the scientific studies have also been published, along with supporting datasets. These are available at earthresources.vic.gov.au/gasprogram.

The data that has been collected is a valuable reference point for Victoria. It provides a new evidence base of scientific research on which to make better decisions, taking into account the interests of the environment, communities and the economy.

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Glossary

Term	Explanation
Basin	A geological depression filled with sediments.
Exploration	The phase of operations in which a company searches for oil or gas by carrying out detailed geological and geophysical surveys, followed up where appropriate by exploratory drilling in the most prospective locations.
Fault	A break or planar surface in a brittle rock across which there is an observable displacement.
Hydrocarbons	Organic compounds consisting entirely of hydrogen and carbon. Hydrocarbons are the principal components of oil and natural gas.
Permeability	The degree to which gas or fluids can move through a rock.
Petroleum	Liquid, gaseous and solid hydrocarbons; includes oil, natural gas, gas condensate, ethane, propane, butane and pentane.
Play	An area in which hydrocarbon accumulations or prospects of a given type occur.
Porosity	The amount of pore space in between the grains in a rock that are available for air, water, other fluids or gas to be stored.
Production	The phase of bringing well fluids to the surface and separating them, and storing, gauging and otherwise preparing the product for transportation.
Prospective resources	Petroleum that is potentially recoverable from undiscovered accumulations.
Prospectivity	An assessment, whether qualitative or quantitative, of the potential for prospective resources.
Reservoir	A rock or geological formation that may hold petroleum within the pore spaces in the rock.
Seal	An impermeable rock that forms a barrier or cap above reservoir rocks such that fluids cannot migrate beyond the reservoir.
Source rock	A rock rich in organic matter, which, if heated sufficiently and placed under sufficient pressure, will generate oil or gas.
Trap	Any barrier to the upward movement of oil or gas, allowing either or both to accumulate.

Source: APPEA (2020); Geoscience Australia (2020); Schlumberger (2020); SPE International (2020).

Appendix 1: Stakeholder Advisory Panel for Onshore Conventional Gas communiques

Communique 1 – August 2017

On 17 August 2017, I chaired the inaugural meeting of the Stakeholder Advisory Panel for onshore conventional gas studies, which is part of the State Government's Victorian Gas Program (http://earthresources.vic.gov.au/earth-resources/victorian-gas-program).

The Panel has been established by the [former] Minister for Resources, the Hon. Wade Noonan, to oversee the onshore conventional gas geoscientific and environmental studies over the next three years.

The role of the Panel is to provide the Minister for Resources with advice on the risks, benefits and impacts related to onshore conventional gas, with particular attention paid to social, economic and environmental factors.

The Panel will meet regularly over the next three years and includes a broad range of views, including farmers, industry, local government and the community. Panel members are able to provide feedback from the community and other stakeholders as the studies are undertaken.

The Panel members appointed are:

- Mr Stephen Bell, Chief Executive Officer, Qenos
- Mr Ben Davis, Secretary Australian Workers' Union Victorian Branch
- Mr Gerald Leach, Chair of the Victorian Farmers' Federation Land Management Committee
- Ms Alison Marchant, Secretary of Frack Free Moriac
- Ms Linda French, Community Development Manager, Lattice Energy (formerly Origin Energy)
- Mr Tennant Reed, Principal National Adviser, Public Policy, Australian Industry Group
- Cr Joanne Beard, Mayor of Corangamite Shire and representative of the Great South Coast Group
- Mr Mark Wakeham, Chief Executive Officer, Environment Victoria

Minister Noonan welcomed the panel at its inaugural meeting. For the benefit of the panel, the Minister reiterated the course the Victorian Government had taken to legislate to permanently ban hydraulic fracturing (fracking) and coal seam gas, while extending the moratorium on onshore conventional gas to 30 June 2020. He said the moratorium would allow time for a scientific program to assess the potential onshore conventional gas resources of the State. The program will include environmental baseline studies and the community will be actively engaged over the life of the studies. The results of the study and the panel's work would help guide future decisions about the prospects for onshore conventional gas exploration and development beyond the middle of 2020.

During the meeting, representatives from Geological Survey of Victoria (GSV), the Government's geoscience unit, gave a briefing on the schedule of onshore conventional gas geoscientific and environmental studies that will be conducted.

The focus of the studies will be on the Otway Basin in south west Victoria, particularly between Warrnambool and Port Campbell. The GSV has identified this area as having the greatest potential for onshore conventional gas. Some studies will be done in the Gippsland Basin, although based on existing data, the GSV considers this basin to be less likely to hold onshore conventional gas resources than the Otway Basin.

The geoscience studies will involve rock characterisation studies and analysis of current geoscience data. The results will assist in the development of 3D models for the Otway and Gippsland geological basins. The environmental studies in the field will provide baseline data on groundwater chemistry and atmospheric conditions across the Otway and Gippsland basins.

GSV representatives emphasised the importance of community engagement to support the geoscientific and environmental studies. This included insights of engagement activity undertaken to date with local regional councils, community groups, peak industry bodies, water catchment management authorities, gas exploration companies and academics.

An important part of the community engagement program is to progressively provide the results of the studies to the public. Factual information from the studies will be provided to farmers, industry, local government and regional communities. A local team of geology specialists and a dedicated community engagement officer based in Warrnambool will ensure the community remains involved and informed about the studies. In practical terms, this means that there are people on the ground who can answer questions for local residents and landholders.

As Victoria's Lead Scientist and panel chair, I am looking forward to working with the Panel over the next three years. I am sure the advice we will provide the Minister will assist the Government to make the best decisions possible about onshore conventional gas for all Victorians.

For more information visit the Victorian Gas Program on the Earth Resources website at http://earthresources.vic.gov.au/earth-resources/victorian-gas-program.

Communique 2 – November 2017

The second meeting of the Stakeholder Advisory Panel for onshore conventional gas studies was held in South-West Victoria on 9 and 10 November 2017 at Port Campbell and Camperdown and surrounding areas. This region of Victoria in the Otway geological basin is a focus of the Victorian Gas Program.

The meeting commenced on 9 November 2017 with a visit to the Otway Gas Plant and the Halladale and Speculant Well site, near Port Campbell.

The tour of Origin Energy's facility provided the Panel with a first-hand view of a gas processing plant. Origin Energy representatives explained how the facility's design and operational procedures ensure stringent health, safety and environment regulations are met.

The Panel then moved to Nirranda to see the Victorian Gas Program groundwater science team in action, sampling and recording trace chemistry at a groundwater monitoring bore as part of the environmental baseline studies of the Program.

On 10 November 2017, the second day of the Stakeholder Advisory Panel's meeting was held in Camperdown.

The discussions covered progress reports on the geoscientific studies, environmental studies and community and stakeholder engagement to date.

The Panel received a briefing on the $1.62 million 3D geological models of the Otway Basin (onshore and offshore) that will be built and how they form the foundation for providing a gas resource estimate. The Panel heard that rock characterisation studies (including chemostratigraphy, porosity and permeability analysis) – key inputs into the 3D geological models – have also commenced.

The onshore environmental science project intends to sample over 100 deep groundwater bores and undertake an atmospheric methane survey to establish regional baseline conditions during 2017 and 2018. To date, 14 water bores have been sampled.

Later in 2018, the environmental program will also investigate existing exploration wells to determine more local baseline conditions.

The Stakeholder Advisory Panel at the Otway Gas Processing Plant.

The Stakeholder Advisory Panel learning about the groundwater monitoring program.

The overview of the engagement program highlighted that over 80 individual engagements have occurred to date, covering local governments, gas explorers, gas users, regulators and environmental and community groups. Most engagements have been one-on-one discussions and small group meetings. As the Geological Survey of Victoria Warrnambool team reaches full complement more sophisticated engagements and presentations will commence.

Five media articles about the Victorian Gas Program had been featured in newspapers in south west and regional Victoria since the program was announced. Additionally, while the Stakeholder Advisory Panel was in Camperdown, I gave an interview to ABC South-West regional radio about the Panel's work.

The Panel's review of the projects to date is providing valuable insights and suggestions to ensure that the scientific studies are meeting the concerns and interests of the various stakeholders connected to the onshore conventional gas studies.

The next Stakeholder Advisory Panel meeting is scheduled for March 2018.

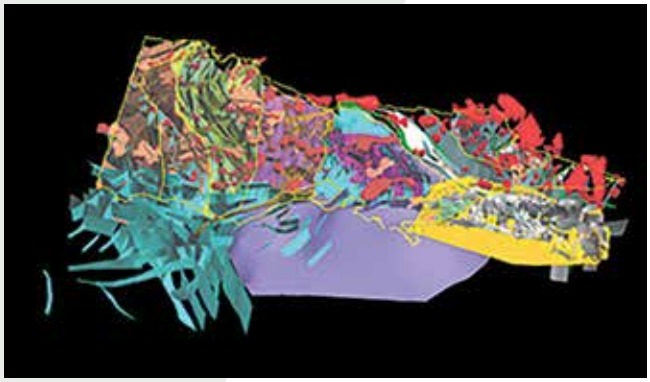
Communique 3 – March 2018

The third meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's Onshore Conventional Gas Studies was held in Melbourne on Thursday, 8 March 2018.

The meeting commenced with a presentation from the Geological Survey of Victoria on the current 3D geological models of the Otway and Gippsland basins. These models capture the sub-surface structure of each basin and will ultimately provide a picture of the presence of onshore conventional gas resources.

A significant objective of the Victorian Gas Program is to refine the current models through seismic data analysis together with rock characterisation studies to produce a much more detailed understanding of each basin's geological structure. The Geological Survey of Victoria is currently presenting these 3D geological models to councils in South-West Victoria to explain the scientific approach being taken by the Victorian Gas Program.

At the meeting, Panel members discussed the national gas market, the contribution of Victoria's offshore gas resources, and the possible impact of any onshore conventional gas resources identified through the Victorian Gas Program on gas supply and pricing. I acknowledged that the scientific work being undertaken is at a very early stage and highlighted that it will provide the State with the best picture of Victoria's potential for onshore conventional gas resources. This information will assist government to make future evidence-based decisions about any development of onshore conventional gas resources.



Geological model of rock outcrops across Victoria

Public attending one of the Geological Survey of Victoria's 3D model presentations at Sungold Field Days

The use of gas as an energy source in the context of the state's carbon emission targets and commitments on climate change was also discussed. A consolidated picture of how government is improving energy efficiency in businesses and households to reduce demand, including initiatives to increase supply of renewable energy, is being prepared to inform the Panel.

A major task of the Panel is to eventually provide government with advice on the risks, benefits and impacts of onshore conventional gas. At the meeting, the Panel began to consider the scope of work needed to be undertaken for this study. An initial environmental risk assessment framework was tabled for Panel members to consider. The study's scope will receive independent expert advice from the Scientific Reference Group throughout the Program.

The Director of Geological Survey of Victoria updated the Panel on the progress of the Victorian Gas Program. Key highlights included:

- Following months of data review and planning, the geoscience team is in the process of selecting rock samples for analysis of source, seal and reservoir rocks (necessary components of a petroleum resource system). Approximately 1400 samples have been selected for analysis, and a further 1700 samples will be analysed to establish mineral and fossil content.
- The environmental studies team has now sampled 25 groundwater bores for chemistry content and 42 bores for stygofauna (a miniature creature that may indicate the health of groundwater) in South-West Victoria. Groundwater bore testing will begin in Gippsland in late April, and air quality surveying in the Otway Basin is expected to begin in April. This data will help to establish the existing environmental baseline conditions, which would provide a benchmark for considering the potential risks and impacts of conventional gas activities.
- To support commercial exploration for further discoveries of gas off Victoria's coast an airborne gravity survey of the Otway Basin will be undertaken. The survey will measure minute differences in gravitational force from different rock strata both onshore and offshore. The data collected will provide a dataset of varying rock densities across the basin.
- The community engagement program continues to connect with strategic stakeholders in South-West Victoria and Gippsland. A major community engagement initiative was held at Sungold Field Days, one of the largest agricultural shows in South-West Victoria, in February 2018. A marquee cinema showing 3D projections of Victoria's geology was set up to show the geology of the Otway Basin and introduce the VGP to farmers, students and community groups.

The next Stakeholder Advisory Panel meeting will be held in June 2018.

Communique 4 – June 2018

The fourth meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was held in Melbourne on Thursday, 7 June 2018.

The Minister for Resources, Tim Pallas, opened the meeting and reinforced the Panel's key role in understanding and discussing the VGP's scientific findings and the risks, benefits and impacts of any onshore conventional gas development. He highlighted the importance of informed debate and the need for government to understand both the needs of industry and the diversity of views across the community.

The Minister responded to a range of questions from the Panel on regulatory issues such as landowner rights and community benefits, including how best to secure domestic supply from local resources. He also addressed contextual issues such as government's commitment to CO_2 emission reduction targets, how we manage the transition from coal to renewable energy technologies and the need for greater transparency in energy distribution and retail markets.

The Minister was followed by Ms Kylie White, Deputy Secretary, Energy, Environment and Climate Change in the Department of Environment, Land, Water and Planning (DELWP). Ms White reiterated the Victorian Government's commitment to an affordable, reliable and renewable energy future – with legislated targets and support for transition to zero (net) emissions by 2050. Ms White confirmed that Victoria is on track to achieving the Victorian Renewable Energy Target of 25% by 2020 with renewables producing over 16 per cent of Victoria's electricity in 2017, up from around 11 per cent in 2014. She provided an overview of current initiatives such as the *Energy Efficiency and Productivity Strategy*, the *Renewable Energy Action Plan*, the *Victorian Renewable Energy Target Program Reverse Auction* and the *Victorian Energy Upgrades* program.

Ms White responded to questions from Panel Members who sought to understand how government is working with industry to reduce gas demand; clarification of the definition of zero emissions; and government plans to respond to the capacity of different sectors to transition from fossil fuels faster than others.

The Director of the Geological Survey of Victoria (GSV) advised the Panel that the VGP's scientific work is on schedule. The new 3D geological framework model for the Otway Basin is only a few months away. The geoscience team will next focus its efforts on filling critical knowledge gaps through a 'stratigraphic' drilling program to provide new rock samples for analysis.

I was delighted to talk about the Victorian Gas Program in April to over 70 members from the Business and Professional Women South West Association at Deakin University Warrnambool campus.

He also advised that the baseline air quality surveying (measuring methane and carbon dioxide concentrations) of the Otway Basin, has commenced and will continue until July 2018.

The panel was also updated on several upcoming VGP announcements, including:

- a collaborative project between GSV and the Iona Gas Plant, near Port Campbell, to share analytical drill core data that could assist in understanding the potential for storing gas in depleted onshore gas fields in the area, and
- details of the supplier, timing and flight area of an airborne gravity survey of south west Victoria to better understand the regional, large-scale geology of the Otway Basin, both onshore and offshore.

The geoscience overview was followed by a community engagement update. The reach of the program to date now includes 290 stakeholders across south west Victoria, Melbourne and Gippsland.

GSV has presented its 3D geological models to Councillors across the Otway Basin and briefed Mayor and Chief Executive Officers across Gippsland on the VGP. Other regional networks such as farmer organisations, catchment management authorities, environmental groups, economic development associations and community groups have also been engaged.

The next Stakeholder Advisory Panel meeting will be held in September 2018.

Communique 5 – September 2018

The fifth meeting of the Stakeholder Advisory Panel (SAP) for the Victorian Gas Program's (VGP) Onshore Conventional Gas was held in Camperdown on Thursday, 6 September 2018.

The Panel received their first briefing on the VGP's regulatory reform project, which will develop policy, administrative and legislative reform proposals for Government once the broader scientific findings regarding the potential for onshore conventional gas are known.

The presentation covered the Government's current policy on gas, including the moratorium on onshore conventional gas in place until mid-2020. It detailed the legislative and regulatory controls currently in place through the Victorian Petroleum Act 1998 and Petroleum Regulations 2011 and where there might be opportunities to harmonise regulatory frameworks.

The onshore conventional gas regulatory reform program will include assessing best practice arrangements around gas exploration and production from other jurisdictions (including other Australian states and territories, New Zealand, North America, Canada and Europe) and recommendations from relevant reviews and inquiries. There is also potential for a social baseline assessment to be undertaken as part of building an evidence base of community attitudes to future gas exploration.

Panel members identified that landholders often had little knowledge about their rights and regulatory processes when dealing with gas explorers and developers, suggesting the need for better information products to support landholders. Members also discussed the lengthy time scale of resources projects and how communities would often be concerned about environmental impact and land rehabilitation. It was also suggested the regulatory reform program should look at the Victorian Pipelines Act 2005 to evaluate if the Act's provisions for dealing with landholders were superior to the Petroleum Act 1998.

Panel members recommended that as the Gippsland and Otway Basins were the focus of the VGP, workshops on how gas exploration and production were regulated should be prioritised for communities in those regions.

The Panel was updated on VGP activities including:

- the airborne gravity survey currently underway in South-West Victoria, including the engagement and community awareness campaign
- the completion of the rock sampling data collection phase, and the commencement of the analysis of source, seal and reservoir rock measurements
- progress on building the petroleum systems model, combining all available new and existing data and interpretations to estimate hydrocarbon resources (gas) in the Otway Basin
- 50% completion of groundwater bore sampling for chemistry in South-West Victoria, providing data that will assist to build a gas field groundwater impact assessment scenario model
- progress on the regional air quality survey program of the Gippsland and Otway Basins
- engagement of over 500 individual stakeholders across South-West Victoria, Melbourne and Gippsland through more than 420 events (i.e. briefings, meetings, forums, emails and telephone calls)
- progress on the geoscientific assessment of underground gas storage potential of depleted reservoirs around Port Campbell.

Following the meeting, a number of SAP members attended the official opening of the Geological Survey of Victoria's South West Regional Office at Deakin University Warrnambool. The office is undertaking a range of VGP scientific studies and engaging with the community.

The next Stakeholder Advisory Panel meeting will be held in November 2018.

(Please note: The November 2018 Stakeholder Advisory Panel meeting was postponed due to the Government being in caretaker mode prior to the State Election.)

Communique 6 – February 2019

The sixth meeting of the Stakeholder Advisory Panel for the Victorian Gas Program (VGP) Onshore Conventional Gas Studies was held in Melbourne on Thursday, 14 February 2019.

Minister for Resources, Jaclyn Symes, spoke at the beginning of the meeting via teleconference. The Minister's remarks included her appreciation for the work of panel members in bringing diverse perspectives and advice on the issue of onshore conventional gas.

As scientists at the Geological Survey of Victoria gather and model the available data on the Otway Basin, critical gaps in information have emerged. The VGP provides scope for stratigraphic drilling to fill such data gaps and better understand rock layer changes across the basin. The Panel received their first briefing on how the VGP would prepare to undertake this work. Panel members asked questions about the need for undertaking the drilling activity and the benefit it would provide in terms of data and information. Questions were also raised about risks and how they would be mitigated, including engagement with the local community. A decision on whether to proceed with stratigraphic drilling will be taken later this year.

Late in 2019, the onshore areas of the Otway Basin with potential for conventional gas resources will be known. These areas will then be the focus of Resource Land Use Planning studies to understand the unique environmental, social and economic land use features of each area. The Panel was briefed on the methodology and process planned to undertake these assessments.

Amanda Caples and Corangamite mayors Victorian Gas Program hydrogeologists spent time at Sungold Field Days agriculture event in February, talking to farmers and others about groundwater in South-West Victoria.

- Completion of the airborne gravity survey across 16,000 km2 of South-West Victoria, identifying extremely small variations in the earth's gravitational field. The interpreted data will be publicly available later in the year.
- Continuing geoscientific analysis and interpretation of new and existing rock measurements. The results will be incorporated into the petroleum systems modelling, along with existing data and interpretations, to help provide an estimate of hydrocarbon (gas) resources in the Otway Basin.
- Progress of sampling groundwater bores in South-West Victoria. A groundwater sampling campaign will commence in Gippsland in March 2019. The collected data will provide a comprehensive baseline of current groundwater conditions and will improve the understanding of groundwater processes.
- Completion of the second atmospheric baseline survey for Gippsland and South-West Victoria. The results were similar to the first survey round with slight increases of methane concentrations in urban areas, cattle yards and proximity to native vegetation burn off. Raised methane concentration readings were also repeated around the Port Campbell gas storage facility. All concentrations were well below EPA guidelines.
- Commencement of a desktop review of socio-economic and environmental receptors. These receptors will provide the baseline data to underpin a risk, benefit and impact assessment of a hypothetical onshore conventional gas development, once the detailed findings of the geoscientific and environmental studies are known.
- Engagement with over 580 individual stakeholders across South-West Victoria, Melbourne and Gippsland through more than 480 events (i.e. briefings, meetings, forums, emails and telephone calls).
- Commencement of detailed geoscientific assessment of the depleted gas reservoirs in the Port Campbell area. This work will continue to rank and differentiate the depleted reservoirs regarding their potential storage capabilities.

The next Stakeholder Advisory Panel meeting will be held in May 2019.

Communique 7 – May 2019

The seventh meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was held in Camperdown on Thursday, 9 May 2019.

Victoria's Lead Scientist and Chair of the Stakeholder Advisory Panel, Dr Amanda Caples, opened the meeting and welcomed newly appointed panel member Jonathan La Nauze, Chief Executive Officer Environment Victoria. Dr Caples also provided details of her activities since the last Panel meeting including attendance at the Australian Domestic Gas Outlook conference and a meeting with Friends of the Earth and Environment Victoria representatives to be briefed on key Victorian Gas Program activities.

Groundwater sampling

Key presentations to the Panel included:

- An update on the progress of the Resource Land Use Planning studies, which will assist in understanding the unique environmental, social and economic features of each prospective resource area (a zone with the geology to potentially host conventional gas) identified by the VGP's studies. The Panel will be involved in a workshop to determine the criteria and value weightings for the land use framework at its next meeting.
- A briefing on the commencement of a case study regarding the risks, benefits and impacts of the Otway Basin gas production and processing facility in Port Campbell. This work will inform the next phase of work, which is a risk, benefit and impact assessment of hypothetical onshore conventional gas developments, based on the outcomes of the VGP's studies.
- An update on potential policy and regulatory reform development, including the preliminary identification of practices to improve a social licence to operate, along with an assessment of the adequacy of the current regulations to manage these areas. Initial findings indicate that the regulations are quite robust but with potential areas for improvement, including; community and landholder engagement as well as transparency of industry activities.
- An update on the stratigraphic drilling project to fill in key geological data gaps in the northern part of the onshore Otway Basin. If the project proceeds, an extensive community engagement program would be undertaken. Members discussed the proposed communications and engagement activities and raised queries about how climate change factors would be acknowledged.

Panel members were also updated on other VGP activities including:

- The start of the release of technical reports on new data acquired from the geoscientific studies of the Otway Basin.
- The completion of the data acquisition phase of the airborne gravity survey of the Otway Basin. The data will improve interpretation and visualisation of the deep rocks and structures of the Otway Basin.
- Deep groundwater bore sampling in the Otway Basin is now finished, and sampling in the Gippsland Basin is nearing completion.
- Scientific studies investigating the potential to expand Victoria's underground gas storage capacity are progressing well. Several depleted gas fields around Port Campbell are being assessed in terms of their geophysics, geology and commerciality for repurposing to provide underground gas storage.
- The potential timing for the announcement of preliminary resource areas for the Otway geological basin. Panel members discussed and made recommendations about a communications and engagement approach to support the announcement.

To date, over 620 individual stakeholders have been engaged across South-West Victoria, Melbourne and Gippsland through more than 550 events (i.e. briefings, meetings, forums, emails and telephone calls).

Communique 8 – August 2019

The eighth meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was held in Melbourne on Thursday, 8 August 2019.

The meeting began with an update on the geological modelling of areas in the south west that may have the rock characteristics, sequence and structure to potentially host onshore conventional gas.

The Panel's questions about the modelling included clarification about the methodology used to determine an area's prospectivity and its resource estimate. There was also discussion about the types of exploration activities that would be required to confirm if a prospective area had a commercial quantity of conventional gas.

Panel members also participated in a Resource and Land Use Planning workshop to examine and prioritise the key themes for a new land use model of the Otway Basin. The model seeks to identify areas of sensitivity and significance that may need to be considered if the moratorium on exploration of onshore conventional gas was allowed to sunset in 2020.

Some of the Geological Survey of Victoria team sharing the science at Sheepvention 2019 in Hamilton.

Members provided advice and input on the model's themes, priorities and data sources. An overview of the proposed community and stakeholder consultation workshops across the Otway Basin to explain the model and seek public feedback was also discussed.

Panel members were updated on VGP activities, including:

- Progress of the rock characterisation studies, including sampling of close to 7,000 South-West Victorian rock specimens resulting in over 300,000 new measurements. This new data is being fed into the modelling of the prospective resource areas in the Otway Basin. The data will be a key input to estimating Victoria's undiscovered gas potential.
- The near completion of 3D geological models for the Otway Basin. A similar 3D framework model is also being built for the Gippsland Basin.
- The release of the largest airborne gravity dataset ever collected in Victoria. Modelling using the new data will improve current understanding of deep structures in the Otway Basin, especially in areas where there is currently
  very little data.
- Completion of the second atmospheric baseline concentration survey (carbon dioxide and methane) for both Gippsland and south west Victoria.
  The results are similar to the first round, which showed levels were within normal Environmental Protection Authority ranges.
- Finalisation of the groundwater sampling program for both the Otway and Gippsland basins, with 113 deep groundwater samples collected.
- Completion of the investigations into opportunities for further underground gas storage. The reports will be made publicly available in late 2019/early 2020.
- Engagement with over 660 individual stakeholders across South-West Victoria, Melbourne and Gippsland through more than 550 events (i.e. briefings, meetings, forums, emails and telephone calls).
- Presentations to over 1,200 primary and secondary students in south west Victoria to increase their understanding of geoscience and their regional geology.
- The commencement of a social research survey across the Otway and Gippsland basins that will examine communities' perceptions of onshore conventional gas exploration and development.
- The upcoming release of Progress Report 3 and other VGP technical reports.

The Panel also received a presentation on the Victorian Hydrogen Investment Program by a representative from the Department of Environment, Land, Water and Planning. The State Government backed program will support hydrogen research, trials and demonstrations, creating a new base of industry knowledge and skills to assist in diversifying Victoria's energy future. More information can be found at the Energy website.

The next Stakeholder Advisory Panel meeting will be held in November 2019.

Communique 9 – November 2019

The ninth meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was held in Camperdown on Thursday, 21 November 2019.

The meeting began with an update on the results of the geoscientific studies, including analysis of the data from the rock characterisation studies and the airborne gravity survey. The new chemostratigraphy data has provided greater understanding of the Otway Basin's prospectivity for onshore conventional gas than was initially anticipated. As a result, it has been decided not to proceed with stratigraphic drilling in the Penola Trough, west of Casterton, as the project is unlikely to provide significant new geological insights at a regional level.

The new 3D geological models for both the Otway and Gippsland basins are also on track to help complete the prospectivity assessments and resource estimates. The data from these models will also be coupled with groundwater impact modelling for both basins.

Panel members received an update on the Resource and Land Use Planning project for the Otway Basin. Seven community workshops were held across the region in October and November 2019. Local residents viewed and provided comment on the model. Developed from over 140 authoritative datasets, the model seeks to identify areas of sensitivity and significance that may need to be considered if the moratorium on exploration or development of onshore conventional gas ends in 2020. A similar model will be built for the Gippsland Basin and displayed at local community workshops in early 2020.

The Panel was also briefed on the commencement of the VGP's assessment of the risks, benefits and impacts of future potential onshore conventional gas developments. A consulting group will work closely with the Stakeholder Advisory Panel to deliver the assessment. Their work will feature hypothetical gas development scenarios based on the VGP's geoscience and environmental studies, resource and land use planning models and social baseline research. Panel members provided feedback on the methodology and issues and inputs to be incorporated into the assessment.

Public workshops were held across the south west in late 2019 to seek feedback on a new resource and land use planning model.

Other program updates included:

- Preliminary findings of the geoscience studies, indicating that some areas of the onshore Otway Basin have the potential to host conventional gas.
- Preliminary findings of the environmental studies' modelling and regional groundwater impact scenarios in the Otway Basin, indicating negligible impacts on groundwater as any potential gas resource would be over a kilometre below aquifers.
- Engagement with over 740 individual stakeholders across South-West Victoria, Melbourne and Gippsland through more than 640 events (i.e. briefings, meetings, forums, emails and telephone calls).
- Presentations to over 1,390 primary and secondary students in south west Victoria to increase local understanding of geoscience and regional geology.
- Completion of a social research survey of communities across the Otway and Gippsland basins that examines communities' perceptions of onshore conventional gas exploration and development. The final report is expected to be ready in early 2020.
- Findings from the VGP's policy and regulatory review, including analysis indicating that the onshore petroleum regulatory framework is robust for managing environmental and safety risks.
- The upcoming release of Progress Report 3, which provides a summary about where the various studies are at, and other VGP technical reports.

The next Stakeholder Advisory Panel meeting is planned for February 2020.

Communique 10 – February 2020

The tenth meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was held in Melbourne on Thursday, 13 February 2020.

The primary purpose of the meeting was to undertake a detailed review of the assessment of the risks, benefits and impacts (RBI) of a potential onshore conventional gas industry, which underpins the Panel's advice to the Minister for Resources.

The Geological Survey of Victoria is regularly explaining and discussing onshore conventional gas at regional community events.

The RBI assessment looks at seven hypothetical onshore conventional gas exploration and development scenarios in the Otway and Gippsland basins and considers them against 17 economic, social and environmental receptors. It also incorporates economic and greenhouse gas modelling.

The RBI assessment ties together the VGPs studies, which panel members have overseen for the past two and a half years, including:

- areas in both the Otway Basin and Gippsland Basin that have the potential for new discoveries of onshore conventional gas
- estimated ranges of how much onshore conventional gas could be discovered in Victoria
- groundwater impact modelling in both basins against a range of scenarios based on how much gas could be extracted
- regional groundwater and atmospheric baseline measurements of the Otway and Gippsland basins, and
- resource and land use planning models of the Otway and Gippsland basins to understand the suitability of different areas in each region to host onshore conventional gas exploration and development.

The RBI assessment also includes social research undertaken by CSIRO. The Panel reviewed the findings of a telephone survey undertaken in late 2019 of 800 people across the Gippsland and Otway basins. Survey respondents were interviewed about their perceptions of community wellbeing and regional attitudes to onshore conventional gas development. The results provide insights into a range of local views about onshore conventional gas development and factors important to communities if exploration and development were allowed.

The next meeting of the Stakeholder Advisory Panel will be held in April 2020.

Communique 11 – April 2020

The eleventh meeting of the Stakeholder Advisory Panel for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was an online gathering on Thursday, 23 April 2020.

This was the first meeting of the Panel since the Victorian Government announced its intention to allow for an orderly restart of onshore conventional gas exploration and development.

The Government's announcement highlighted the work of the Stakeholder Advisory Panel in providing oversight of the scientific studies undertaken to understand the potential for further discoveries of onshore conventional gas and the risks, benefits and impacts of developing the resource.

The Panel was briefed on the ongoing publication of the VGP's final technical reports and the continuing engagement with councils, stakeholders and community groups to explain the detailed findings of the scientific studies.

The Panel was also updated on the Petroleum Legislation Amendment Bill 2020 (Petroleum Bill) currently before Parliament.

The Petroleum Bill provides for the orderly restart of on-ground petroleum exploration and production activities under the Petroleum Act on 1 July 2021. The new amendments will also require:

- increased consultation with the Victorian community by gas explorers and producers
- decision-makers to consider additional social, economic and environmental factors
- the publication of information about certain outcomes under the Petroleum Act.

The Stakeholder Advisory Panel's terms of reference have now been completed and the remit of the Panel will finish on 30 June 2020. It is intended that the Panel meets in June 2020 to discuss the final reports of the VGP.

Letter to the Editor, April 2020

To highlight the work of the Stakeholder Advisory Panel, a letter to the editor was released to regional newspapers in South-West Victoria and Gippsland in April 2020.

To the Editor,

For the past three years I have chaired the independent Stakeholder Advisory Panel overseeing the Victorian Gas Program's onshore conventional gas studies.

After fracking was banned in 2017, the Victorian Government wanted to understand two things about onshore conventional gas (which doesn't need fracking): what's the potential for new discoveries and what are the risks, benefits and impacts of allowing it to be developed.

The Panel includes diverse and passionate representatives from farming, environmental, industry, community and local government backgrounds. The eight Panel members care deeply about their role and about advocating strongly for the people they represent.

The Panel and I took a close and careful look into the geoscientific, technical and environmental research to better understand Victoria's undiscovered onshore conventional gas resources.

We found a high likelihood of conventional gas onshore in South West Victoria and to a lesser extent in Gippsland. If developed, this gas would improve energy security while Victoria transitions to a low carbon economy.

The science told us that a responsible and well-regulated onshore conventional gas industry would not risk Victoria's groundwater supplies or agricultural production. It could create a boost to regional jobs, economies and communities.

Panel members did not always agree with each other or arrive at a consensus. But they agreed with the science and the integrity of the processes followed.

The Panel provided its advice to the Minister for Resources in early 2020. The Victorian Government announced on 17 March 2020 its intention for an orderly restart of the onshore conventional gas industry in Victoria.

Overseeing the science while continuously engaging with the community has been an important feature of our work. To learn more about the work delivered and resulting analysis, please visit earthresources.vic.gov.au/gasprogram.

Dr Amanda Caples
Victoria's Lead Scientist

Communique 12 – June 2020

The twelfth and final meeting of the Stakeholder Advisory Panel (SAP) for the Victorian Gas Program's (VGP) Onshore Conventional Gas Studies was an online gathering on Thursday, 11 June 2020.

The meeting was also attended by the Minister for Resources, Agriculture and Regional Development, Jaclyn Symes.

The Minister took the opportunity to congratulate the Panel on its oversight of the Victorian Gas Program's scientific studies into onshore conventional gas over the past three years. She also thanked panel members for their vital role in linking the diverse groups of stakeholders interested in conventional gas with the scientific evidence that had been collected.

Minister Symes reiterated the Government's intention for an orderly restart of onshore conventional gas exploration and development, and for the legislated fracking ban to be enshrined in Victoria's Constitution.

SAP members were also briefed on the Petroleum Legislation Amendment Bill 2020, which was before Parliament. Once passed, the new legislation:

- provides for the restart of on-ground petroleum exploration and production activities under the Petroleum Act on 1 July 2021
- requires increased consultation with the Victorian community at various decision-making points under the Petroleum Act
- requires decision-makers under the Petroleum Act to consider additional social, economic and environmental factors
- enables the publication of information about certain outcomes under the Petroleum Act.

The Panel noted that planning work had begun to remake the Petroleum Regulations 2010, which need to be replaced by 24 May 2021. The regulations will establish specific details that give effect to the Petroleum Act objectives, and new obligations included in the Amendment Bill. Public consultation on the draft Petroleum Regulations and a Regulatory Impact Statement will be undertaken to support this process, early in 2021.

The Panel was also briefed on the publication of the VGP's final technical reports and the continuing engagement with regional councils, stakeholders and community groups to explain the detailed findings of the scientific studies and next steps in the lead up to the restart of onshore conventional gas development.

Panel members will also review the VGP's final progress report that is currently in development.

In accordance with the Terms of Reference of the SAP, the Panel finishes on 30 June 2020, and this is the final communique from the Panel.

PS. The Petroleum Legislation Amendment Bill 2020 passed the Victorian Parliament on 16 June 2020.

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