

2020 Eromanga Basin seismic structural surfaces mapping project

Extension and update for the Far North Prescribed Wells Area

Report Book
2020/00014

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Government
of South Australia
Department for
Energy and Mining

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structural surfaces mapping project
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Prescribed Wells Area**

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June 2020

Report Book 2020/00014

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Preferred way to cite this publication

Novak M 2020. *2020 Eromanga Basin seismic structural surfaces mapping project – Extension and update for the Far North Prescribed Wells Area*, Report Book 2020/00014. Department for Energy and Mining, South Australia, Adelaide.

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2020 Eromanga Basin seismic structural surfaces mapping project – Extension and update for the Far North Prescribed Wells Area

Martin Novak

INTRODUCTION

In December 2018, the South Australian Department for Energy and Mining (DEM) contracted AusGeos Pty Ltd to consolidate/validate geophysical and geological datasets and produce a series of depth structure maps of key aquifers and aquitards that would be incorporated into a transient groundwater model of the South Australian portion of the Great Artesian Basin (GAB) that is being developed by the South Australian Department for Environment and Water (DEW) in conjunction with DEM.

This report provides an overview of the methodology adopted for the project, data sources, limitations, assumptions and conclusions. Importantly, it provides a dataflow and directory of data-files and should be used in conjunction with *Far North Prescribed Wells Area Groundwater Model project* (Department for Environment and Water 2020), as a first point of reference for future groundwater models.

PROJECT OVERVIEW

In early 2018 the South Australian Department for Environment and Water and the South Australian Department for Energy and Mining formed a steering committee with representation from Santos, Beach Energy and Senex Energy to oversee the development of a new transient groundwater model to inform future water allocation decisions for the Far North Prescribed Wells Area (FNPWA).

This new numerical model aims to address gaps identified in the pre-existing models and to provide confidence to decision makers regarding the management of water in the FNPWA.

The model domain encompasses the limits of the GAB within South Australia, Northern Territory and a buffer zone extending up to 300 km in places across the border in Queensland to include important spring sites, covering a total area of 725,000 km² (Fig. 1).

A major component of this new groundwater model is the provision of updated stratigraphic surfaces for key geological units, incorporating key seismic horizons and stratigraphic surfaces last mapped by DEW and Geoscience Australia (GA) in the 2012 Geoscience Australia Great Artesian Basin Water Resource Assessment (GABWRA) project (Ransley and Smerdon 2012) and updated by Ransley et.al. (2015).

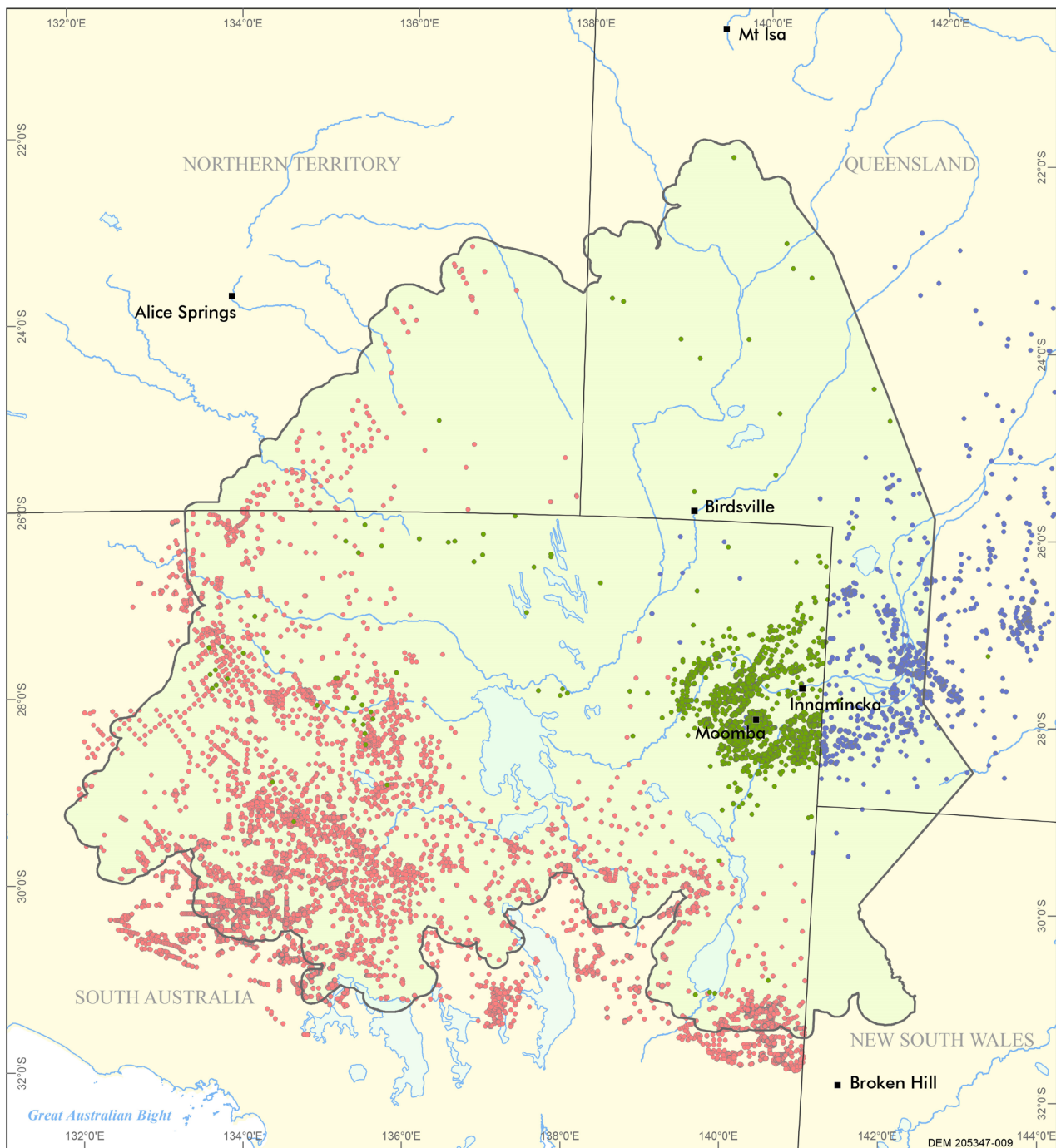


- Model boundary
- Locality
- Lake Eyre Basin
- Eromanga Basin (GAB)
- Permian basins

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LOCATION MAP
BASIN OUTLINES and MODEL DOMAIN

Figure 1. Regional location map for this study showing basin outlines and model domain.

This report details the merging of the pre-existing GABWRA stratigraphic surfaces, company seismic horizon and well data from South Australia, Queensland and Northern Territory and water bore data to develop 7 key horizons that represent major aquifers and aquitards of the basin (Fig. 2).



- DEM well
- DEW well
- Santos well
- Model boundary
- Locality
- Drainage
- Waterbodies

0 250 km
GDA 2020 : Lamberts

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**WELL COVERAGE and
TOP CADNA-OWIE COVER**

Figure 3. Location of wells (at Top Cadna-owie horizon) used for developing surfaces.

DEW

Well data compiled by DEW contributed the largest collection of wells. The DEW dataset comprised mineral wells, water bores, some exploration wells and all wells located in Northern Territory.

Exploration wells contained in the DEW dataset were superseded by more recent data extracted from the PEPS database and by data received from industry.

All well data with well header (name and location) and formation data (formation tops and depths) were provided by DEW in spreadsheet form.

DEM

Well data stored in PEPS contributed a significant dataset to the WAP project. Extraction filters excluded wells with an inclination greater than 10 degrees. Stored formation tops for Cadna-Owie and Hutton and their sub-sea depths in metres were extracted for each well, with well name, top-hole X,Y and KB elevation, and written to Excel spreadsheets.

Relevant formation tops, listed in Table 1, from base Cadna-owie Formation to base Poolowanna Formation / Base Eromanga Basin were extracted from PEPS, and combined with equivalent data from the Santos dataset and the QPED online database using Excel spreadsheets.

Santos

A number of South Australian operators provided well datasets for this project. The Santos dataset was the most extensive with over 4,000 wells. The datasets contained both well identifying information and formation tops and depths. The Santos datasets were received in spreadsheet format between 18th January and 22nd January 2019 defining their currency to some date before those dates. The dataset contained a number of blank entries representing either missing or redacted data.

QLD

Queensland well data were extracted from the QPED database during the well compilation stage of the project around March/April 2019 and saved in Excel spreadsheets.

Deviation data

Well formation top data in the PEPS database contained deviation labels but did not contain deviation corrections. Filters were used to extract only vertical and 'slightly deviated' wells, meaning those generally having inclinations less than 10 degrees.

A few deviated South Australian wells were included in the study where they had deviation data loaded from previous work.

Santos' well dataset was assessed to contain TVD depth data corrected for deviation (applying deviation surveys), but without additional location data for tops in deviated wells. This location error while present in the data was deemed minor.

Additional well formation top data in the QPED database also did not contain deviation corrections. All these wells included in the study were considered to be close to vertical.

No deviation data had been used within the DEW dataset. Consequently many exploration wells within the DEW dataset were replaced by correctly deviated wells from the industry dataset.

Data sources – outcrops

Outcrop points were supplied by DEW. The datasets comprised field data of first occurrence of basement outcrop and a further outcrop point 500 m beyond the first outcrop for grid stabilisation purposes. 465,614 points in SA and NT and 38,892 points in NSW were loaded. Outcrop data were treated as well data in the gridding and contouring processes.

Data sources – springs

Location data of 5152 known spring locations were provided by DEW and loaded into the project database (Fig. 4). Ground spring data were used to verify the mapped extents of aquifers.

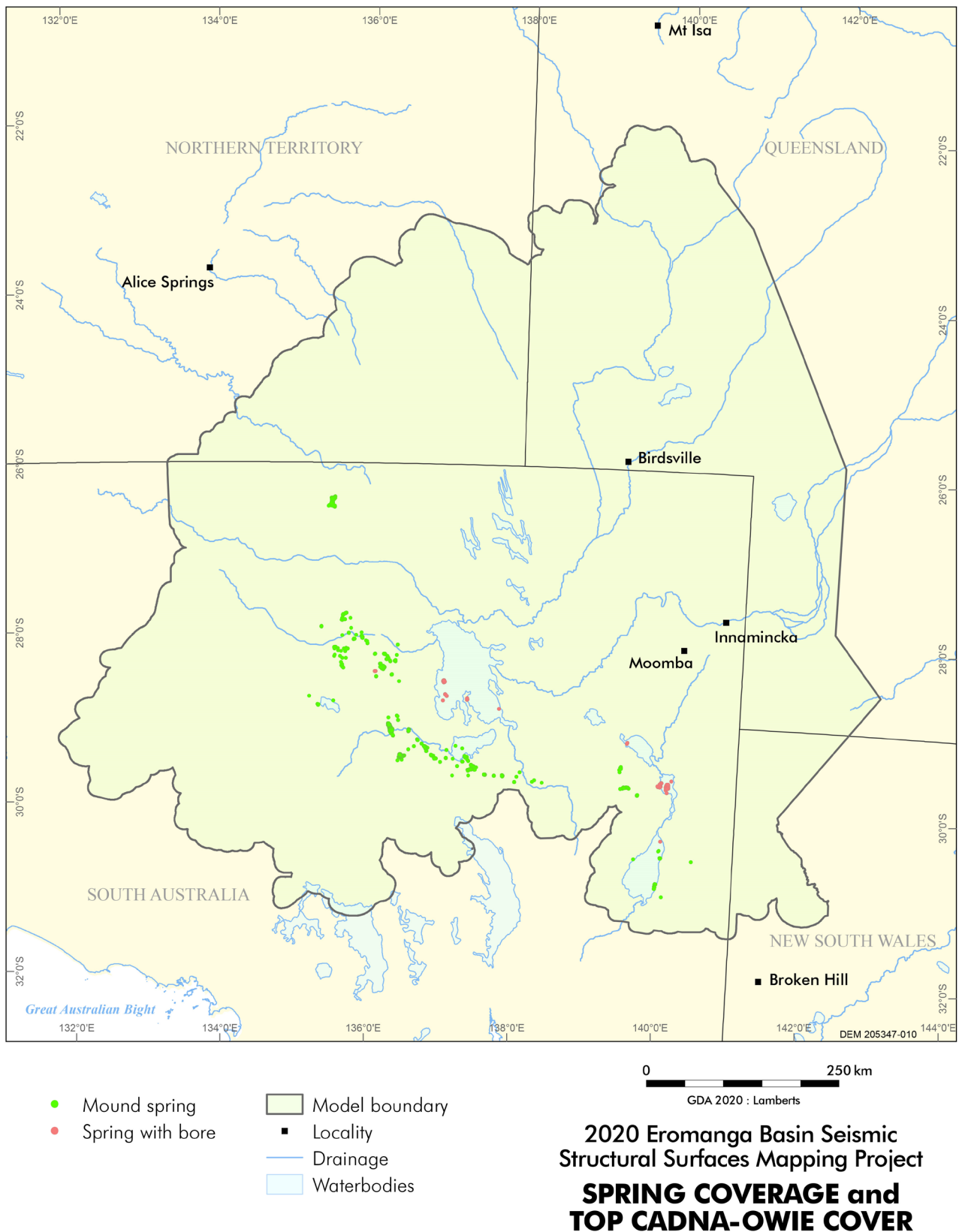


Figure 4. Location of springs used in model.

Data sources – depth surfaces

Geoscience Australia (GA)

Four depth surfaces were obtained from the 2012 GABWRA project for use in this project (Ransley and Smerdon 2012).

- i. Layer 01 - 3-second Digital Elevation Model surface
- ii. Layer 04 - Base of Rolling Downs Group surface
- iii. Layer 06 - Base of Injune Creek Group surface
- iv. Layer 10 - Base of Jurassic-Cretaceous sequence surface

Layers 04, 06 and 10 were used to provide data in areas not covered by the other data sources.

Santos

Santos provided a number of surfaces in time and depth. The following three surfaces in depth were used for the construction of the appropriate depth grids:

- i. Near_Top_Cadna-owie_DEPTH_SS_Tied_ReferenceWells
- ii. Near_Top_Hutton_DEPTH_SS_Tied_RefWells
- iii. Near_Base_Eromanga_DEPTH_SS_Tied_RefWells

Senex

Senex Energy provided 11 surfaces. After detailed analysis much of the extent of the Senex grids was also covered by the Santos grids. The western parts of the Senex grids were found to be at odds with the WAP2012 grids and it was decided not to use the Senex grids in the construction of the appropriate depth grids.

Beach

Beach Energy provided a limited number of depth grids. These were split by historical permits and, for data originating from 3D interpretations, the grids were confined to the extents of their 3D data. Consequently the Beach data offered a number of small patches of depth data which restricted their value for a large regional study. In addition the Beach data covered similar areas to the Santos data which was more extensive and continuous. The Beach depth surfaces were assessed to provide minimal additional information over the Santos datasets and it was decided not to use the Beach grids in the construction of the appropriate depth grids.

Methodology – wells

Data loading

Header data for wells including well name, location, KB elevation and other support information were loaded to Petrosys. For each well, depth information converted to subsea (negative below MSL, positive above MSL) was loaded for the each surface in the study.

Data QC/QA

Well data were extensively quality controlled using a number of methods.

Where multiple sources for the same data were available, depth and location data were cross-checked to identify differences. Large differences were followed up to seek an explanation and to identify the correct data. Where a confident reason for differences was found the correct result was used.

This data QC effort identified a number of wells which had incorrect depth or location data either due to keying in errors or due to other causes such as metric/imperial unit errors.

In some cases depth differences stemmed from different log interpretations. These were reviewed by experienced staff within DEW and DEM and corrected if necessary.

Differences in depth of less than 8 m were generally acceptable.

Deviated wells

Deviated wells were identified and a determination was made as follows:

- Wells with inclinations less than 10 degrees were used uncorrected (without correction for well deviation).
- Wells deviated >10 degrees with the correct deviation applied to depth (regardless of corrections to sub-surface location) were used.
- Deviated wells >10 degrees that had not been corrected for depth were generally removed. This applied mainly to recently drilled development wells in areas with adequate well density.
- In a number of cases where a well was deemed valuable but had not been corrected for deviation, and a deviation survey existed, rather than discard such wells, the depth and location data were re-calculated from the deviation survey.

Inconsistent names

Some effort was required to reconcile various well naming styles adopted by the different providers of data. Examples included different numbering systems such as WellName 001 vs. WellName 1, different applications of hyphens and spaces in well names; use of different side-track abbreviations such as ST1 and DW1; and so on.

Parked wells

Errors in well data that could not be adequately resolved led to wells being separated from the live dataset into a 'parked' category. Over time some of these wells could be resolved and returned to the live dataset. A small collection of wells remained 'parked' and these wells were not used to construct the final surfaces.

Methods – surfaces

Data loading

At the start of the project 400 m by 400 m gridding was chosen as the working and final grid spacing for all surfaces. All incoming surfaces were resampled to this grid spacing using Petrosys.

A Datum / Projection CRS of GDA94 / SA Lambert was chosen for this project and all incoming surfaces were converted to this Datum / Projection using Petrosys.

A project AOI was established and surfaces extending beyond this area were clipped/constrained to this AOI also within Petrosys.

Data QC/QA

A considerable effort was dedicated to quality control of all surfaces throughout the project. Incoming surfaces were checked upon loading to Petrosys. Surfaces were checked after tying to wells which provided a powerful means of checking the well data and resolving the most visible errors. The surfaces were also checked relative to faults, visually against seismic data, relative to outcrops and springs. The surfaces were investigated for interaction (crossing and excessive thinning) with other surfaces using isopachs constructed between adjacent surfaces. Isopachs were constructed and used to QC the surfaces at various stages of completion. Final checks were performed after the final well tie, before the implementation of dummy wells. Further surface checks were performed after the final tie to all wells, including dummy wells, and in ArcGIS after export from Petrosys and prior to handover to the modelling part of the project.

Input surface problems and resolution

Various concerns were noted with some of the input surface, and were resolved as follows:

Original surfaces from the GABWRA website were found to contain an artificial 'mesh' type pattern. This was resolved by the GA team and a new set of corrected surfaces were provided for this project.

In a few cases, surfaces received from the operators deviated along their periphery from other corresponding surfaces in the project. As would be expected, surfaces received from the operators were consistently more detailed than either the WAP2012 or the GA surfaces. However in some parts outside the operators' core exploration and development areas, larger differences were noted. Surfaces in these areas were observed to be unconstrained by wells, assumed to be extrapolated from the operators' core areas, and of lower importance. These discrepancies were resolved by incorporating dummy wells along the margin of those surfaces provided by Santos to minimise the deviations prior to the merge of the surfaces.

Surfaces provided by Senex were noted to contain surface irregularities along their western edge. As the Santos grids largely overlaid the Senex grids, Senex grids were not used in the construction of the final surfaces.

Input surface priorities

Once the input depth grids were selected, for a number of the required surfaces multiple input surfaces were available, each with a different spatial extent. Because of the higher detail/resolution of the surface provided by industry it was necessary to merge individual surfaces in a way that retained the highest level of detail in the final product. To do this, priorities - based on the quality and detail of each surface – were defined as follows:

- The highest priority was given to the Santos surfaces. Where a Santos surface was available it was used.
- The second priority was given to the WAP2012 surfaces. Where the WAP surface existed outside the Santos surface it was used.
- The lowest priority was assigned to the GABWRA surfaces. These surfaces were used to fill in all missing areas within the AOI.

Only these three sources provided input into the construction of the final surfaces.

Tie to wells

All surfaces were tied to wells before proceeding with further steps.

Surface merging

Where grids from multiple sources were available and needed to be merged, such grids, once approved, were merged according to the above priority sequence. Typically a 'Feathering Distance' of 15 km was used to blend surfaces at their join to reduce undesirable edge features.

In some cases, control (dummy) wells were added to constrain surfaces beyond the feathering distance to reduce edge effects further. These locations were generally characterised by very sparse well densities.

Re-tie to wells

A further tie to wells was performed before checking for crossing and closely approaching surfaces. Isopachs were found most expedient for locating crossing and closely approaching surfaces.

Isopachs

Throughout the construction process isopachs were used to check the integrity of surfaces. The Cadna-owie (C) to Base Eromanga (J) isopach was essential in defining the key Western edge of the GAB, but also along the Northern and Southern margins, and around the various known outcrops. Isopachs were also used to QC the surfaces in known spring locations.

Outcrop data

A detailed outcrop dataset representing the line of first occurrence of outcropped basement, comprising X, Y location and elevation above MSL data, was supplied by DEW. Cadna-owie and Base Eromanga surfaces were tied to this elevation data during the same well tie process as the verified well data.

In addition X, Y, and elevation data of points 500 m inboard of the first line of outcrops were provided by DEW. The objective was that the basement surface would attain a slope more closely corresponding to the assumed basement form near the outcrop edge of the GAB by concurrently tying to both outcrop datasets. Inspection of the results showed that these two surfaces honoured the provided outcrop data within the capability of the selected gridding parameters and the gridding algorithm.

Faults

Surfaces provided by Santos and the WAP2012 contained large interpreted faults. Additional fault interpretation was not specified in the scope of this work. All provided (prior interpreted) faults were kept. Many faults were checked against seismic data. In a few cases, where faulting was required to stabilise surfaces or insert a clearly missed fault, such faults were added.

Control features (faults)

In some complex areas, typically near steeply rising basement, where stabilising original C and J surfaces was particularly challenging and where these surfaces crossed, removing substantial areas of the GAB section needed for this study, 'control faults' were added to correct this problem. One such location was the structurally complex area west of Lake Frome.

Extent of surfaces

The final extent of surfaces was determined according to the following methodologies.

LITHOSTRATIGRAPHY

The generalised lithostratigraphy of the Cooper/Eromanga Basin is shown in Figure 2.

All surfaces selected for this study and for input to modelling, are labelled in Figure 2 and listed in Table 1. The surface abbreviations and any equivalent formation names are also listed in Table 1.

Table 1. Surfaces selected for this study with abbreviations, names and equivalent formation names.

Surface abbreviation	Surface name	Equivalent formations
C	Top Cadna-owie Fm.	
DM	Top Murta Fm	
McK	Top McKinlay Mbr.	
Dn	Top Namur Sst.	Algebuckina Sst., Longsight Sst., Hooray Sst., De Souza Sst.
E	Top Birkhead Fm.	
H	Top Hutton Sst.	
J	Base Eromanga Basin	

SEQUENCE AND METHOD OF SURFACE CONSTRUCTION

Surfaces were constructed in the following sequence:

1. Cadna-owie
2. Base Eromanga
3. Hutton
4. Birkhead
5. Namur
6. Murta
7. McKinlay

The general method used for construction of each surface is listed below.

- The Cadna-owie surface was constructed by merging available Santos, WAP2012 and GABWRA Cadna-owie surfaces into one surface and tying to available well and outcrop data. Cadna-owie was the uppermost surface in the sequence and thus formed the top envelope for all other surfaces.
- The Base Eromanga surface was constructed by merging available Santos, WAP2012 and GABWRA Base Eromanga surfaces into one surface and tying to available well and outcrop data. Base Eromanga was the lowermost surface in the sequence and it formed the base envelope for all other surfaces.
- The Hutton surface was constructed by merging available Santos, WAP2012 and GABWRA Hutton surfaces into one surface and tying to available well and outcrop data.
- The Birkhead surface was constructed from the Hutton surface by phantoming from the Hutton surface and tying to all Birkhead wells. Amount of shift was calculated by gridding of the Birkhead thickness at wells. Or put another way, the Hutton surface was bulk-shifted by the calculated Birkhead-to-Hutton well isopach and tied to every Top Birkhead Fm depth in the well dataset.
- The Namur surface was constructed from the Cadna-owie surface by phantoming down from the Cadna-owie surface and tying to all Namur wells. Amount of shift was calculated by gridding of the Cadna-owie to Namur well isopach.
- The Murta surface was calculated as the mid-point of the Cadna-owie and Namur surfaces and tying to all Murta wells. The midpoint was derived using the equation $(\text{Cadna-owie} + \text{Namur})/2$.
- The McKinlay surface was calculated as a midpoint of the Namur and Murta surfaces and tying to all McKinlay wells. The midpoint was derived using the equation $(\text{Murta} + \text{Namur})/2$.

CLIPPING BY OTHER SURFACES

The spatial extent of all surfaces was defined in three ways. Primarily the extent of surfaces was set by their juxtaposition to other surfaces. Truncation of surfaces conformed to a sequence stratigraphic framework defined below.

Stratigraphic framework

- Top Cadna-owie formation surface (C) terminates against Base Eromanga surface (J). The clipping of the C surface by the J surfaces was however not performed in Petrosys. Both surfaces were provided to the modelling team together with the locus of the intersection of the two surfaces (zero thickness of the C-J isopach). The DEW modelling team were able to define the exact GAB termination point using the implied intersection of the C and J surfaces and the team's detailed geologic knowledge from maps, satellite data and field work.
- Top Cadna-owie formation surface also terminates against top Algebuckina where Algebuckina sandstone is present.
- Top Algebuckina Sandstone terminates against Base Eromanga surface. Similarly for the Longsight, Hooray and De Souza sandstones which are equivalent to Algebuckina.
- Top Murta surface does not terminate against any other surfaces but undergoes a facies change to the Algebuckina Sandstone west of the Birdsville Track Ridge.

- Top McKinlay surface does not terminate against any other surfaces but the upper boundary intertongues with the Murta Formation.
- Top Hutton surface truncates against Base Eromanga, or passes laterally into the Algebuckina Sandstone when the Birkhead Formation is absent.
- Top Birkhead surface truncates against Base Eromanga, or undergoes a facies change to Algebuckina Sandstone at the same point as the Hutton Sandstone to the west of the Birdsville Track Ridge.
- Top Namur surface does not terminate against any other surfaces but is a lateral equivalent of the Algebuckina Sandstone.

CLIPPING TO OUTLINES

In addition to stratigraphic truncation of surfaces as described above, the extent of surfaces was also defined by stratigraphic information from wells. Outlines were defined by inspection of well data to ensure that surfaces correctly honoured well data. This process naturally relied on the lithological interpretation provided in the Well Completions Reports. Where units became very thin the interpretation can be subjective. A number of wells were analysed in detail including log re-interpretation as a form of QC and to maintain consistency of interpretation. Naturally some uncertainty remained in the exact definition of these clipping outlines.

MANUAL CLIPPING

In a few locations methods above were supplemented by manual intervention to improve how well data were honoured or how surfaces terminated where surfaces were poorly constrained by wells or by other surfaces.

Dummy wells

Dummy wells were used to adjust surfaces to achieve the following three outcomes:

1. To separate grids to prevent grids crossing. Undesirable crossing of grids, or exceptionally thin isopachs between grids might occur where:
 - wells in close proximity with sufficiently different depth values created a 'dipole flex' which caused the surface to interact with one or more of the other surfaces;
 - some supplied surfaces had faults interpreted while others did not, creating 'overshoot' structures which in some cases caused undesirable interaction between surfaces;
 - grids extrapolated into areas with no well data might create large areas of crossing surfaces simply due to the difference in depth between the last two known well data points.
2. Improved merging of grids corresponding to the same geologic interface. Where grids from different sources had unacceptably different values, sometimes of the order of 100+m, were corrected to improve the merging of grids. Generally the grid having lower confidence would be adjusted, but if a measure of confidence could not be assigned to grids in these problematic areas both grids would be adjusted either equally or in some weighted proportion.
3. To adjust grids to more closely honour springs data. Presence of known springs required for aquifers to be present in the vicinity. While other scenarios were possible to cause surface springs, such as small, unmapped faults, it was considered more likely that the uncertainty of the surfaces – particularly when dealing with aquifer thicknesses of less than 10 m – was responsible for the observed discrepancies with surface springs.

The decision to use dummy wells was taken after careful consideration of available options and their impact on the quality and usability of the produced surfaces. Approximately 100 dummy wells were used to accomplish these adjustments.

Final re-tie to wells

All surfaces were re-tied to all well, dummy and outcrop data prior to clipping and export from Petrosys.

LIMITATIONS

Wells

Well location data, well names, KB elevations, deviations and formation depths, as well as all calculations were subject to extensive testing and quality assurance. Wherever errors were found they were corrected. If discrepancies could not be satisfactorily resolved such data were taken out of the respective datasets. Despite the large QC/QA effort numerous known, as well as possible unknown, errors and uncertainties remain as described below.

Deviated wells

Most deviated wells (inclination >10 degrees) have been removed, or depths and locations have been recalculated from the deviation survey. Where deviations are less than 10 degrees no adjustment for depth or location have been made. These differences are likely to be up to 40 m in depth and up to 475 m in location for the J surface at the deepest part of the basin. The differences would be reduced to approximately 30 m depth and 330 m in location for the C surface at the deepest part of the basin.

Errors (various)

Location errors were generally easy to locate and remove, however location errors less than 20 m were generally not subject to correction.

Depth differences between well data from different sources were investigated with the aim of reducing, or limiting known depth errors (differences) to 8 m. The number of wells with depth differences less than 20 m was large and the number with differences less than 8 m was very large. Due to the large number of wells with differences in the 8–20 m range the cut off for investigating sources of error was raised to 20 m. Since depths are averaged in the gridding process, 20 m depth differences at well locations are averaged. We estimate that the maximum likely surface depth error at known wells from this source is approximately 10 m.

Different interpretations

In some cases a depth difference was not designated as an error, but a legitimate interpretation difference. In general these interpretation differences were not greater than 20 m. Reinterpretation of logs to reconcile different interpretations was not within the scope of this work. Where interpretations were greater than 20 m the wells were removed, and where the difference was 20 m or less the wells were retained. Due to the averaging of well data during gridding the error from different interpretations was of the same order of magnitude as other differences described in the above section.

Final estimated well depth and location error

For the intervals of most interest located within the gross interval containing the Cadna-owie to Hutton formations, we estimate an approximate maximum depth uncertainty of the order of +/- 30 m but generally less than +/- 20 m.

The equivalent location uncertainty would be largest at uncorrected deviated wells perhaps of the order of 330 m, while for the majority of wells the location uncertainty would be less than 30 m.

Surfaces

While supplied input surfaces were assumed to be correct, numerous quality checks were performed. Obvious visible errors were identified and where possible corrected. If input surfaces could not be corrected they were excluded from the dataset as described earlier. QC of surfaces identified discrepancies between surfaces and well data, and between surfaces pertaining to the same stratigraphy. If no errors were found in the well data (and the well was retained), surfaces

were corrected to tie wells. Correction surfaces were generated at various stages and retained within the project.

Absolute measures of error within each surface were difficult to estimate and to present. Work required to obtain such estimates would have required use of blind wells and a detailed analysis across the area of the study, which was not identified as a requirement.

In summary:

- all surfaces match all wells contained within the project, as well as other spatial data such as outcrops (within the capability of the gridding algorithm);
- in high well density areas the surfaces are likely to be more accurate;
- in low well density areas, and particularly where wells are absent, the surfaces will have greater error;
- using dummy wells to make manual adjustments to the grids to provide geologic integrity was expected to improve the overall accuracy of the final surfaces.

It is worth noting that in some places where geologic units were mapped as very thin, a relatively small depth error — of a few tens of metres — would have a substantial impact on the relative thickness of a layer. These thin areas were most likely to occur on the margins of the GAB, particularly to the west and south, and in areas where faulting, or basement highs thinned overlying units.

Dummy wells

Adjustments to surfaces for the purposes of grid merging and avoiding surface cross-overs, or for legitimate geological reasons, by use of dummy wells, are estimated to be mostly in the range 0–100 m. A small number of adjustment were greater than 100 m with one or more exceptional cases, such as near major faults, or in areas with poor well control, where dummy wells required adjustment in the 100–200 m range.

Gridding algorithm

The gridding method used within Petrosys was the Standard gridding operation, Minimum-Curvature Gridding algorithm with Slope type Estimation, and Bicubic Interpolation method. These parameters were recommended within the Petrosys suite as suitable for most standard gridding operations. More specialised gridding approaches were considered and some were examined, however the standard, recommended methods were deemed most appropriate for the specific data requirements, with minimal limitations and generally producing the most accurate results.

Final estimated depth error

We estimate that the depth surfaces are accurate in the most part to +/- 50 m across the area of interest with errors reducing to perhaps half (~+/- 25 m) in high well density areas, but increasing to perhaps the range 50–200 m in low well density areas.

RESULTS

Final mapped surfaces are displayed in Figures 5–11 inclusive and a representative east-west cross-section demonstrating facies change of aquitards on the western margins of the basin is shown in Figure 12.

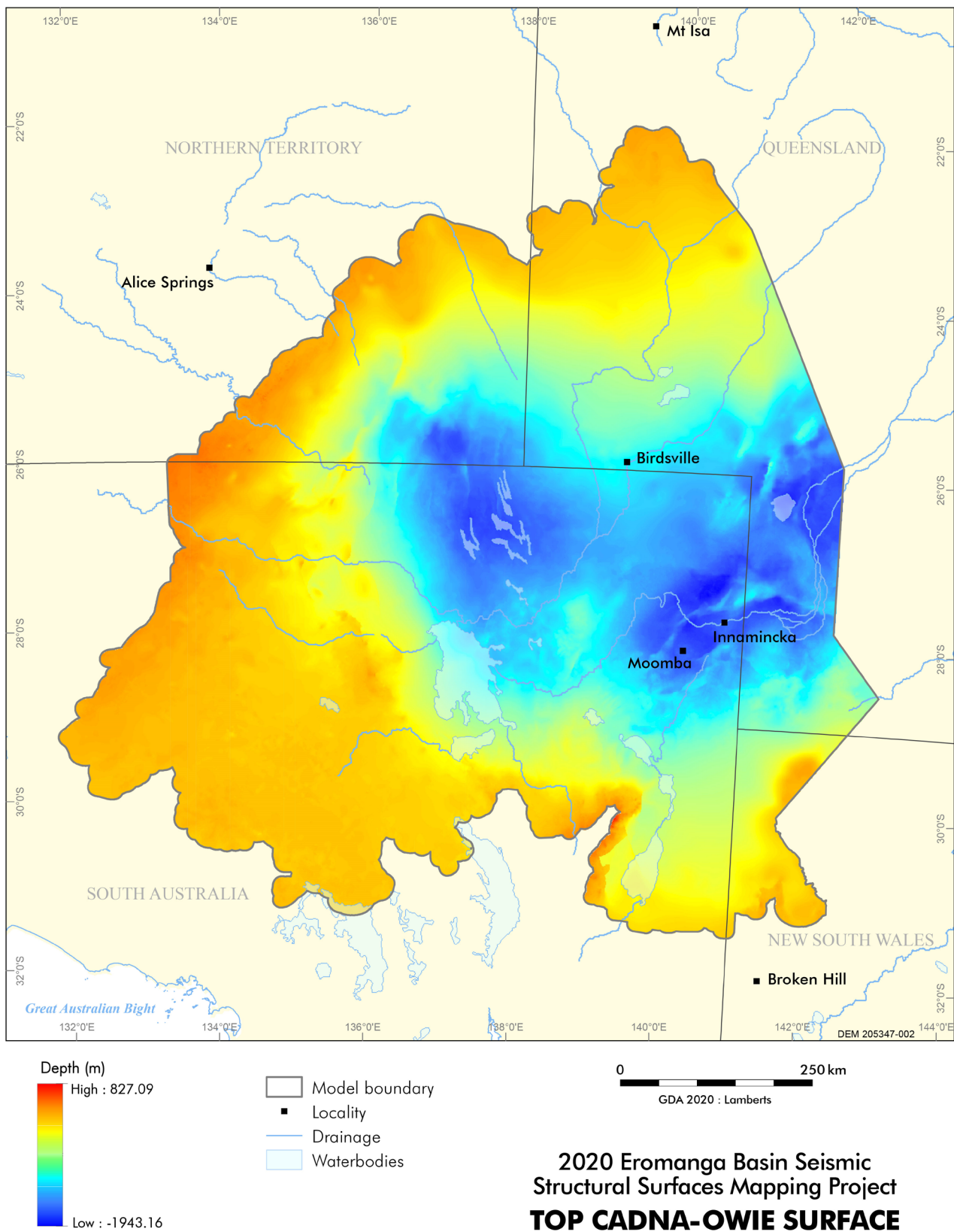
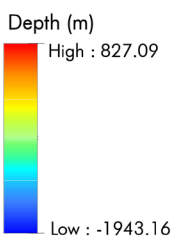
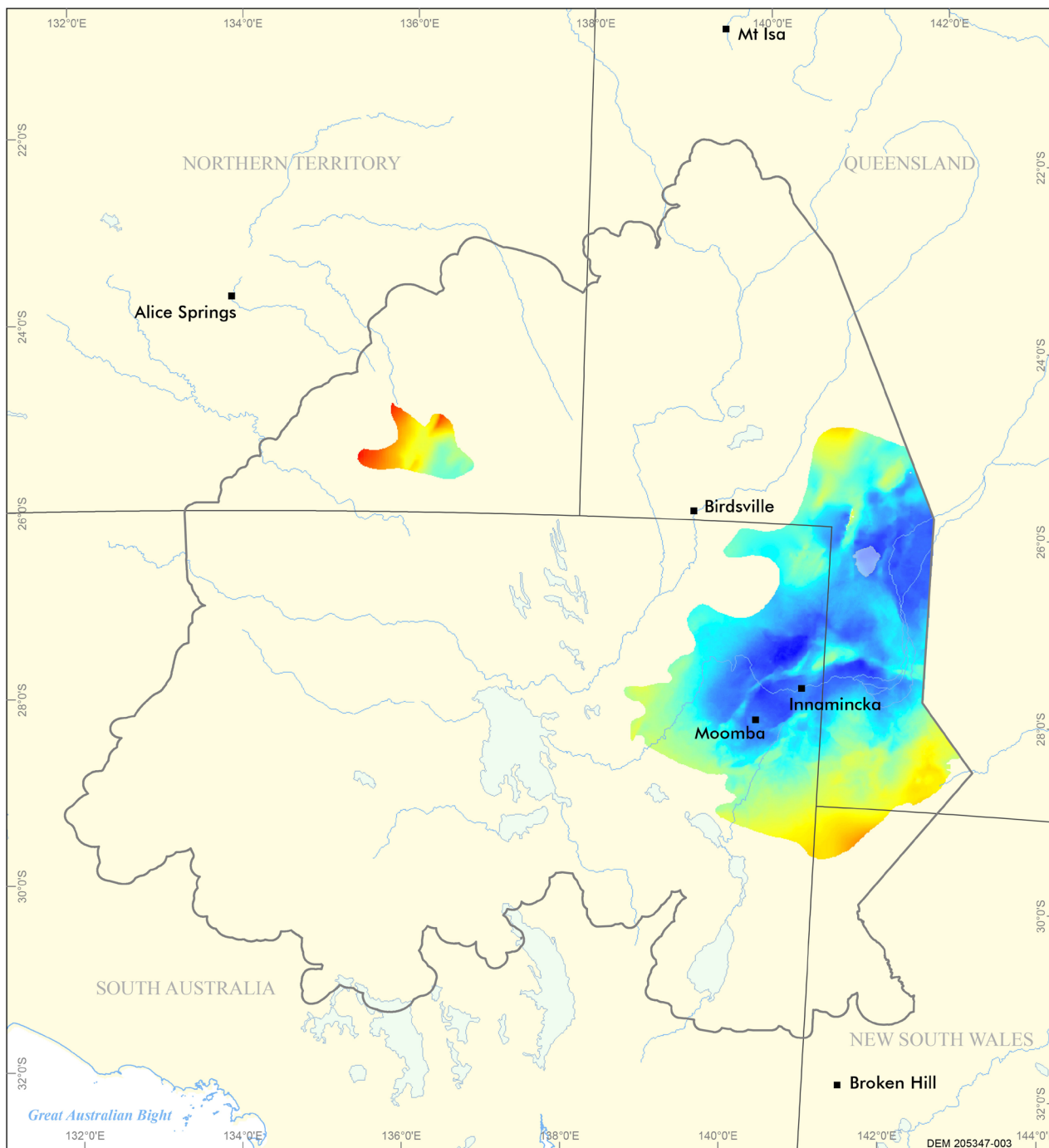


Figure 5. Top Cadna-owie surface.

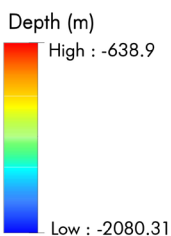
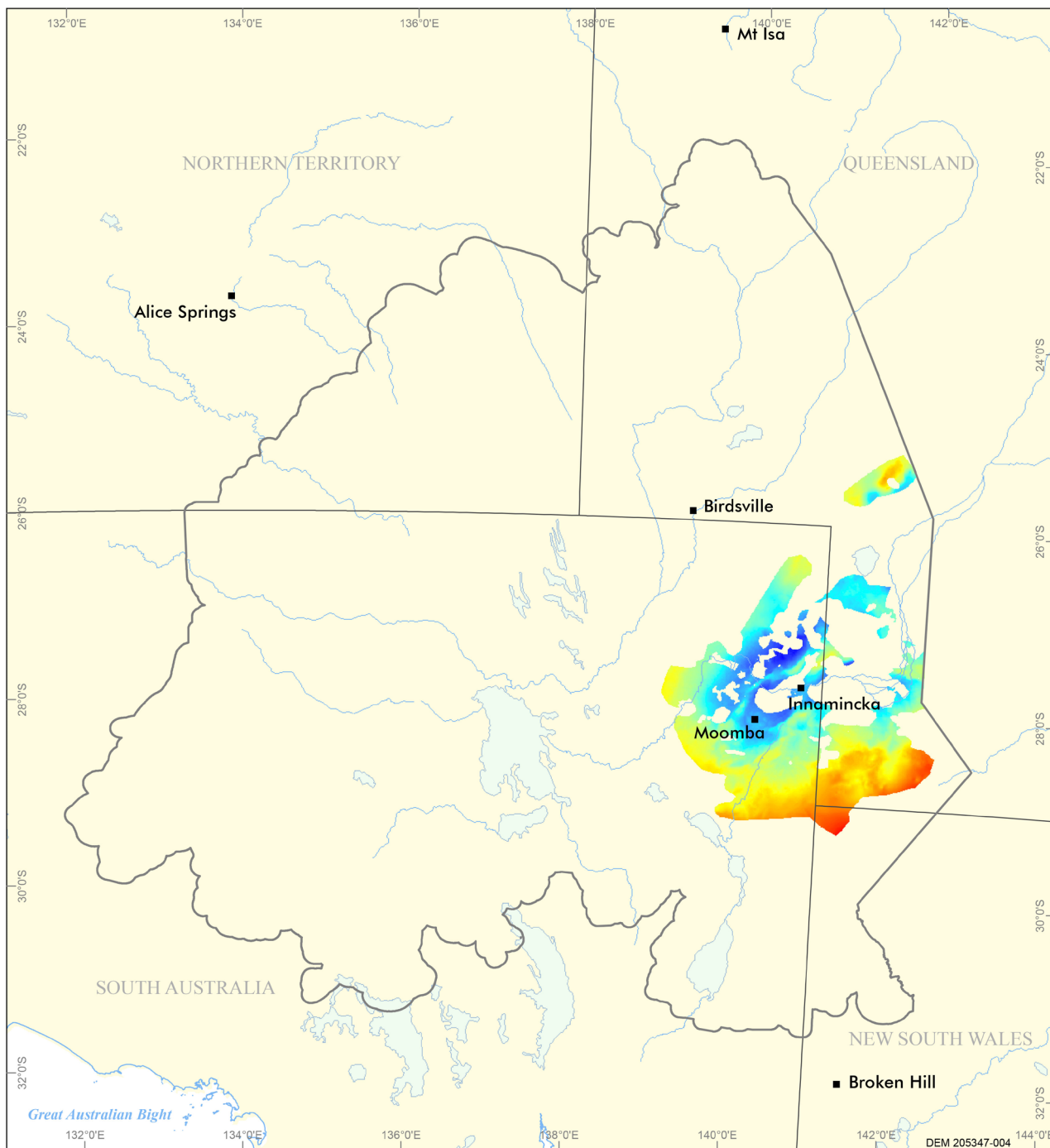


- Model boundary
- Locality
- Drainage
- Waterbodies



**2020 Eromanga Basin Seismic
Structural Surfaces Mapping Project
TOP MURTA SURFACE**

Figure 6. Top Murta surface.

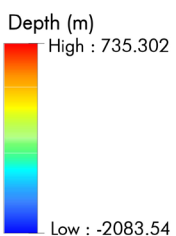
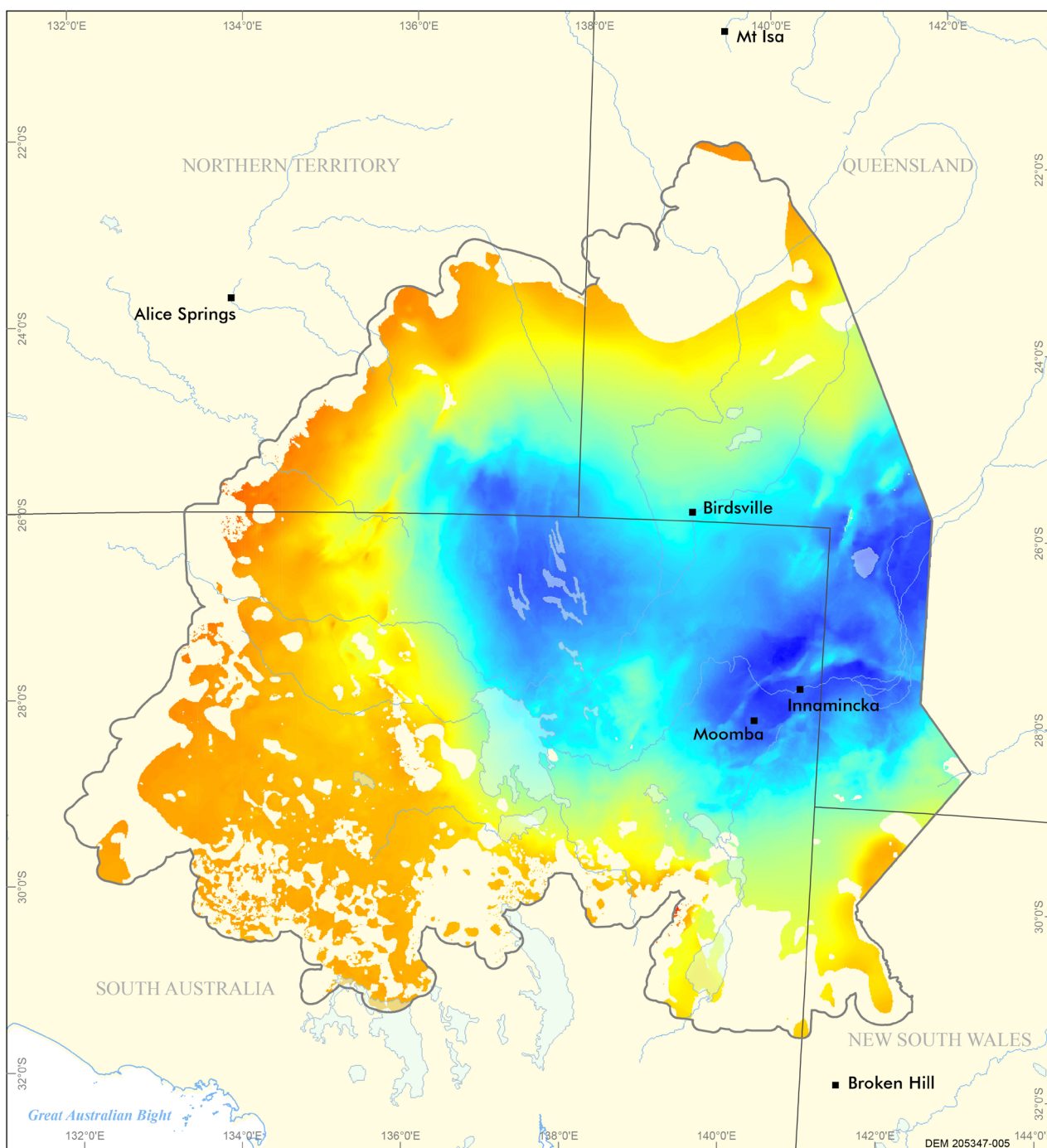


- Model boundary
- Locality
- Drainage
- Waterbodies



2020 Eromanga Basin Seismic
Structural Surfaces Mapping Project
TOP MCKINLAY SURFACE

Figure 7. Top McKinlay surface.

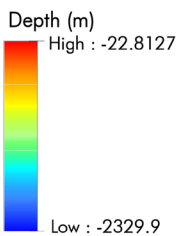
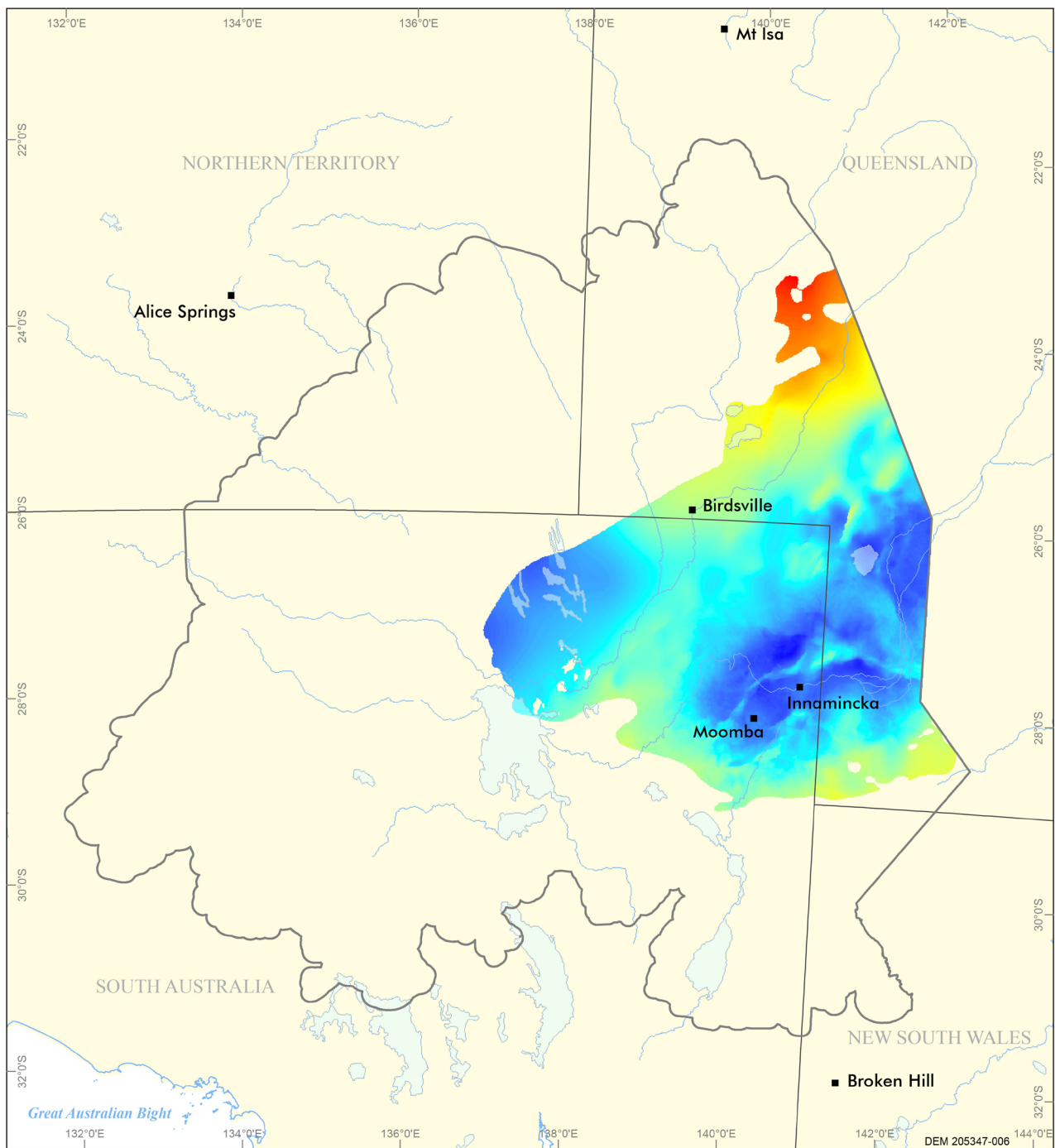


- Model boundary
- Locality
- Drainage
- Waterbodies

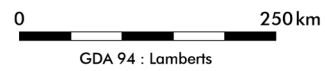


2020 Eromanga Basin Seismic
 Structural Surfaces Mapping Project
TOP NAMUR SURFACE

Figure 8. Top Namur surface.

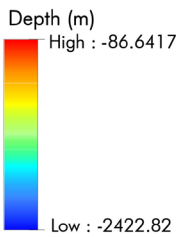
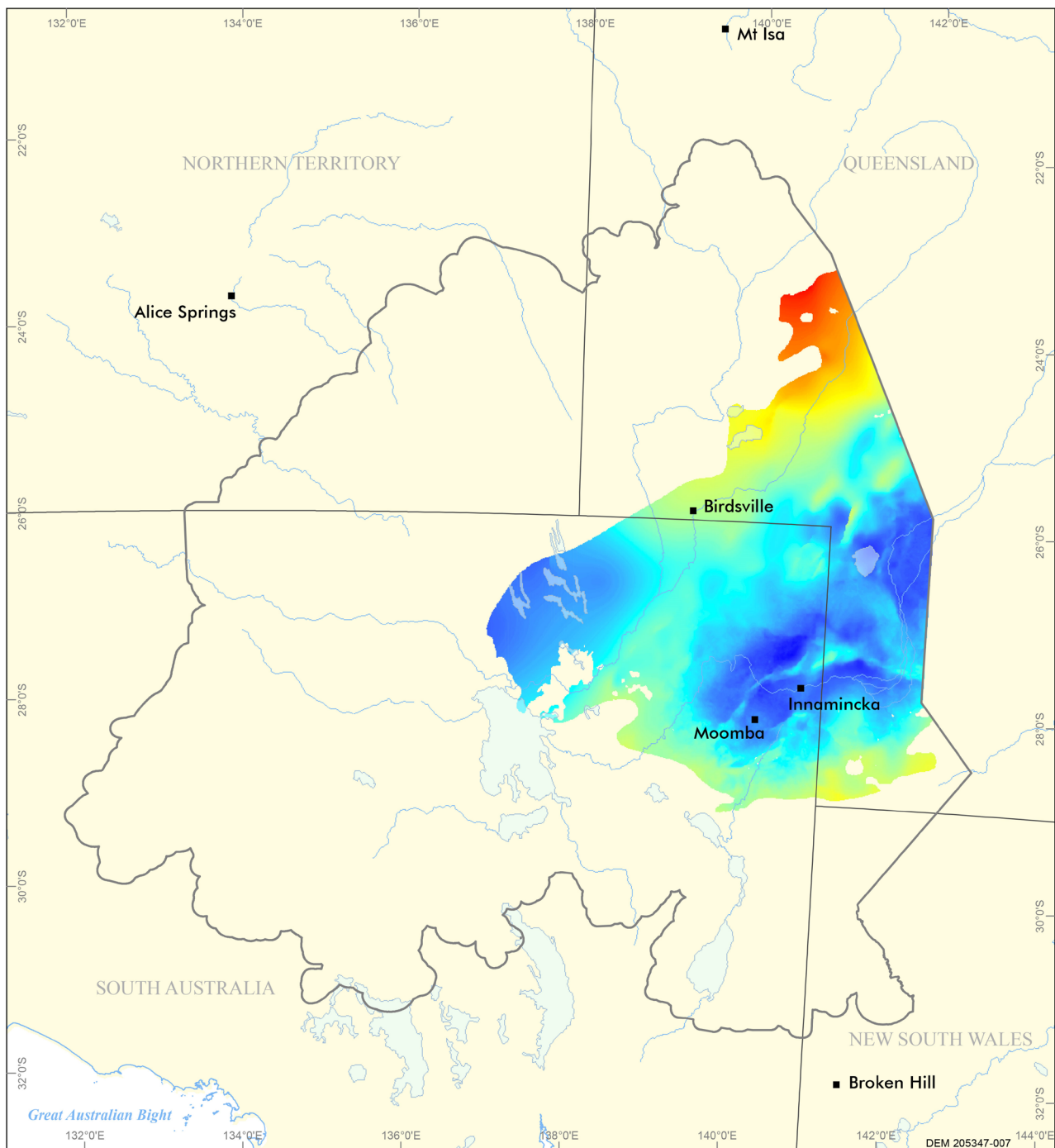


- Model boundary
- Locality
- Drainage
- Waterbodies



2020 Eromanga Basin Seismic
 Structural Surfaces Mapping Project
TOP BIRKHEAD SURFACE

Figure 9. Top Birkhead surface.

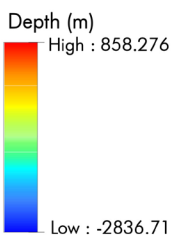
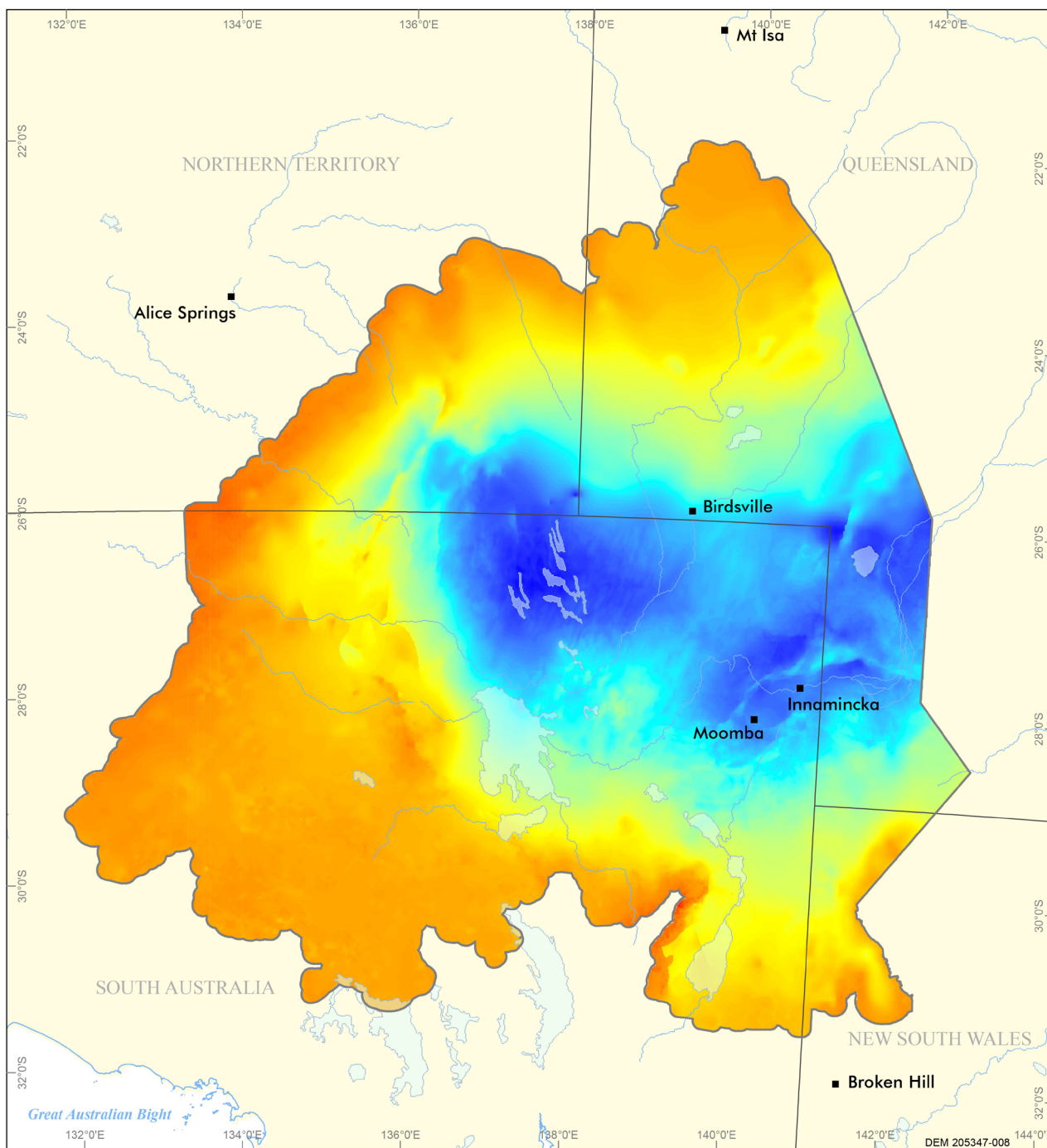


- Model boundary
- Locality
- Drainage
- Waterbodies

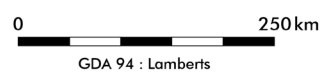


2020 Eromanga Basin Seismic Structural Surfaces Mapping Project
TOP HUTTON SURFACE

Figure 10. Top Hutton surface.



- Model boundary
- Locality
- Drainage
- Waterbodies



2020 Eromanga Basin Seismic
Structural Surfaces Mapping Project
BASE EROMANGA SURFACE

Figure 11. Base Eromanga surface.

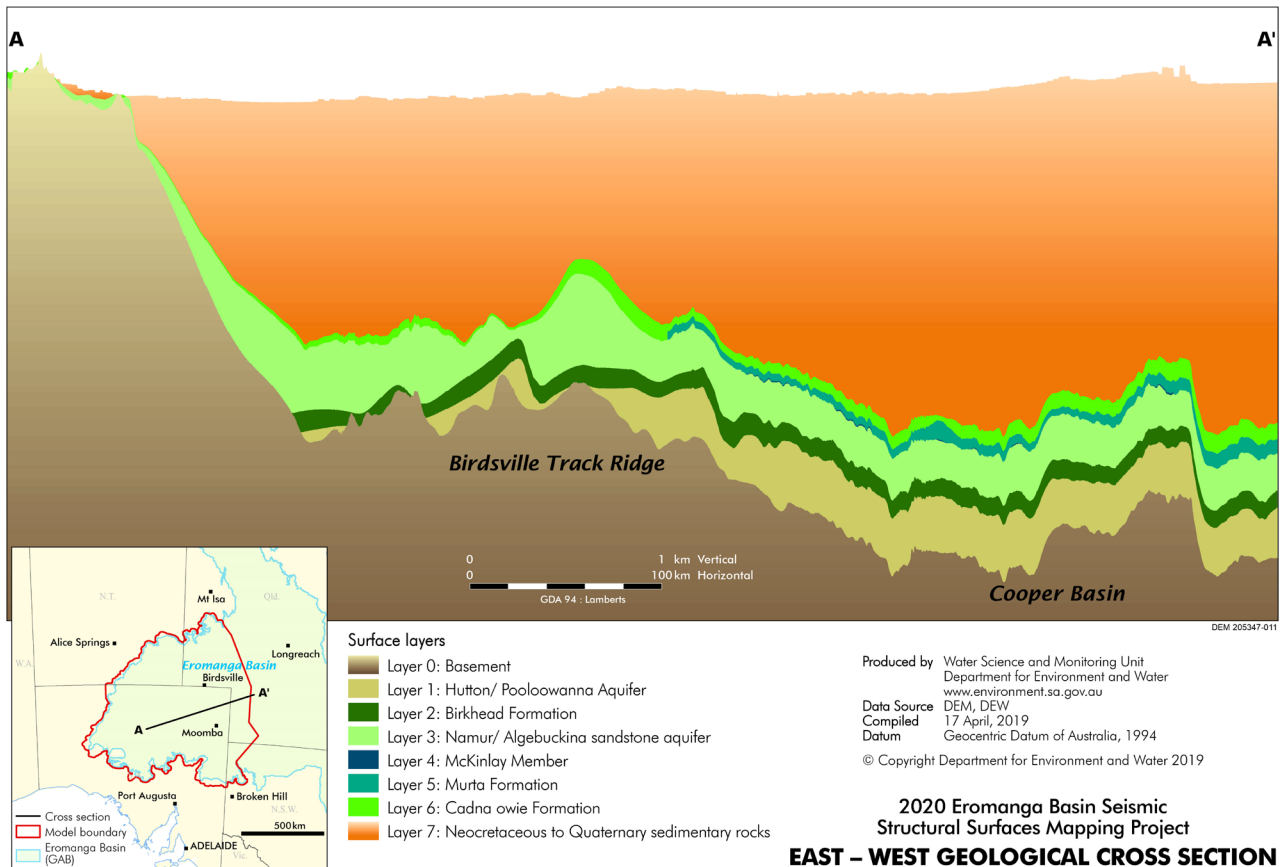


Figure 12. East-West cross-section displaying facies changes on the western margins of the Eromanga Basin.

CONCLUSIONS AND LESSONS

Conclusions

Seismic structural surfaces required for the construction of a 3-dimensional static and dynamic model were successfully created using a combination of industry and government data. In the course of this project numerous errors were corrected both in publicly-available grid and well data, and in data provided by industry. This step improved the quality of data in the public domain.

The results from this project were made available to the modelling stage of the Far North Prescribed Wells Area project, and subject to the appropriate authorities' permissions the results can be made available to the public.

The results, working projects, reports and adjunct data involved in this project have been saved and archived by DEW for future use. It is recommended that the DEW Far North Prescribed Wells Area Groundwater Model project (DEW 2020) and this report are used as reference guides for future updates and extensions to the FNPWAP dataset.

Lessons

Major projects in particular, provide opportunities for improvements of data and methods. In this project, in addition to the main purpose of improving the FNWAP transient model, there were some unexpected opportunities to improve existing data and to highlight possible improvements to methods and processes.

To ensure that input data were of the highest data quality prior to input into this project an extensive phase of well data QC of data stored in PEPS SA was carried out in the early stages of the project highlighted. This stage required more time than estimated and highlighted the need for periodic QA of the PEPS database, or for more robust methods of QA during data entry.

A program of correcting tops data in deviated wells using the well deviation survey would add value to the PEPS database and should be considered for future implementation.

A further benefit in the PEPS database would be to allow base formation depths to be extracted. An entry for base Eromanga for example would have been time-saving and extremely useful.

Our work with GABWRA surfaces downloaded from the GA website highlighted undesirable patterns contained within the publically-available data. Our work led to the removal of these patterns in the publically available grids.

Differences in exploration data in the DEW database and in the PEPS database showed how these two databases had become disconnected, and highlighted the need for the two databases to be linked, in particular for the DEW database to be dynamically updated from the PEPS database on a regular, perhaps weekly basis.

Due to the large spatial extent of the study area and the large number of grid nodes involved (up to 55.6 million in imported grids), initial computations on a small laptop were lengthy, taking up to 6 hours for more complex functions on the largest grids. Through various trials, these processes were optimised reducing the computational time to about 30 minutes. Final exported grids had 400 x 400 m cells and roughly 8.8 million nodes. With a new and more powerful computer processing times were further reduced by half.

The project was originally conceived as an extension, improvement and refinement of the previous WAP2012 grids by incorporating and interpreting seismic data. The sheer volume and, in many cases poor quality of the seismic data, prevented this approach from being implemented. Furthermore time interpretations would have required a large additional component — the velocity field — to translate the time grids into depth. Both steps were considered too large for the time and cost constraints of the project. Consequently, seismic data, loaded at the start of the project were used for reference and for QA of depth grids, for example confirmation of broad structural features and major faults.

A number of key staff with historical knowledge, geological, interpretive and general logistical skills were on hand to assist with the project. These and the excellent help from IT staff were essential in expediting the project. Additionally, personal knowledge of staff in DEM, contractors, staff in DEW and in other organisations such as GA, and operators (Santos, Senex, Beach) added value during the data collection stage of the project.

DATA DISBURSEMENT

The following files were delivered to DEW on 31st January 2020.

Table 2. Listing of final structural surfaces ESRI BIL files.

C_CadnaOwie_20200131.bil.aux.xml
C_CadnaOwie_20200131.bil.ovr
C_CadnaOwie_20200131.hdr
C_CadnaOwie_20200131.bil
C_CadnaOwie_20200131.prj
C_CadnaOwie_20200131.stx

J_BaseEromanga_20200131.bil.aux.xml
J_BaseEromanga_20200131.bil.ovr
J_BaseEromanga_20200131.hdr
J_BaseEromanga_20200131.bil
J_BaseEromanga_20200131.prj
J_BaseEromanga_20200131.stx

H_Hutton_20200131.bil.aux.xml
H_Hutton_20200131.bil.ovr
H_Hutton_20200131.hdr
H_Hutton_20200131.bil
H_Hutton_20200131.prj
H_Hutton_20200131.stx

E_Birkhead_20200131.bil.aux.xml
E_Birkhead_20200131.bil.ovr
E_Birkhead_20200131.hdr
E_Birkhead_20200131.bil
E_Birkhead_20200131.prj
E_Birkhead_20200131.stx

DM_Murta_20200131.bil.aux.xml
DM_Murta_20200131.bil.ovr
DM_Murta_20200131.hdr
DM_Murta_20200131.bil
DM_Murta_20200131.prj
DM_Murta_20200131.stx

Dn_Namur_20200131.bil.aux.xml
Dn_Namur_20200131.bil.ovr
Dn_Namur_20200131.hdr
Dn_Namur_20200131.bil
Dn_Namur_20200131.prj
Dn_Namur_20200131.stx

McK_McKinlay_20200131.bil.aux.xml
McK_McKinlay_20200131.bil.ovr
McK_McKinlay_20200131.hdr
McK_McKinlay_20200131.bil
McK_McKinlay_20200131.prj
McK_McKinlay_20200131.stx

All project data, including progress reports, emails and images were provided to DEM on a 1 TB portable USB drive for archive.

A short internal report detailing the well and surface data structures and flows within Petrosys was provided to DEM under the name: FNWAP 2019-2020 – Project Configuration and Use.

ABBREVIATIONS

AOI	Area of interest
C	Cadna-owie
CRS	Coordinate Reference System
DEW	Department for Environment and Water
DM	Murta
Dn	Namur
E	Birkhead
FNPWA	Far North Prescribed Wells Area
FNWAP	Far North Water Allocation Plan
H	Hutton
GA	Geoscience Australia
GAB	Great Artesian Basin
GABWRA	Great Artesian Basin Water Resource Assessment
J	Base Eromanga
McK	McKinlay
MSL	Mean sea level
m	metres
PEPS	Petroleum Exploration and Production System
QC/QA	Quality Control/Quality Assurance
QPED	Queensland Petroleum Exploration Data
TB	Terabyte
WAP/WAP2012	Water Allocation Plan (2012)

ACKNOWLEDGEMENTS

This report was prepared by AusGeos for the Energy Resources Division of the South Australian Department for Energy and Mining as part of the Far North Prescribed Wells Area Transient Groundwater Model Project, April 2020.

Funding of this project was provided by the Energy resources Division of the South Australian Department for Energy and Mining with technical input from Tony Hill (DEM), Lloyd Sampson and Dr Mark Keppel (DEW) and contributions from Alan Sansome, Iain Campbell (DEM) and Katie Norton (consultant). Santos, Beach Energy and Senex Energy provided key well and seismic datasets. Drafting and desktop publishing services were provided by Carice Holland and Rachel Froud (DEM).

REFERENCES

- Department for Environment and Water 2020. *Far North Prescribed Wells Area Groundwater Model project*, DEW Technical report. Department for Environment and Water, South Australia, Adelaide (in press).
- Ransley TR and Smerdon BD (eds) 2012. [*Hydrostratigraphy, hydrogeology and system conceptualisation of the Great Artesian Basin. A technical report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment*](#). CSIRO Water for a Healthy Country Flagship, Australia.
- Ransley TR, Radke BM, Feitz AJ, Kellett JR, Owens R, Bell J, Stewart G and Carey H 2015. *Hydrogeological Atlas of the Great Artesian Basin*. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/9781925124668>.