Revised AUS6 Model: Significant Changes & Approaches to the Seismotectonic Model

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Abstract

An improved version of the AUS6 seismotectonic model is outlined for contribution to the National Seismic Hazard Assessment (NSHA 18) Project, that aims to revise the existing seismic hazard map (AS1170.4:2007) for Australia. Significant seismological changes are made to the AUS6 seismotectonic model for earthquake hazard studies. Previous unresolved issues in the AUS5 model's approach of handling seismicity are now overcome in the new and improved AUS6 seismotectonic model where background area sources are now made redundant. AUS6 treats area zone seismicity together with active neotectonic faults independently in the seismotectonic model. Fault source parameters are based on mechanism, observed fault length (or mappable surface trace) assumed slip rate and magnitude range for each feature. Other significant changes to AUS6 is the treatment of the assumed maximum magnitude to both area and fault sources. The b-value of each fault is assumed to be the same as the area source. These and other changes have led to improved estimates for earthquake hazard studies using the AUS6 model, which now supersedes all previous versions.

Keywords: seismotectonics, seismic hazard, PSHA, seismogenic sources, NSHA, Australia

1. INTRODUCTION:

The National Seismic Hazard Assessment Project (NSHA 18) is a collective approach in developing a new and improved version of the existing Australian Seismic Hazard Map (AS1170.4:2007). As part of this initiative, the AUS6 seismotectonic model is reviewed and improved in methodological terms for this purpose. Some of these improvements include the manner in which area zones and fault sources are treated and how their input parameters are now determined. A completely different set of rules and assumptions are applied to AUS6, as compared to the superseded AUS5 model, first introduced by Brown & Gibson (2004).

2. SEISMOTECTONIC MODEL:

2.1 Extent of AUS6 Seismotectonic Model:

AUS6 is defined as a uniform area zone based seismotectonic model for inclusion in the NSHA 18 project. It builds on earlier work of Brown & Gibson (2004) whom first introduced the AUS5 methodology as an iterative process that is continually refined for each Probabilistic Seismic Hazard Assessment (PSHA) conducted. Like AUS5, the revised and improved version of AUS6 presented here, is continually evolving with respect to zone boundaries and incorporating more seismic data collected.

AUS6 consists of 124 area sources with zone boundaries corrected for gaps and overlaps, see Figure 1 (whole model), Figure 2 (SA model), Figure 3 (VIC-Southern NSW model) and Figure 4 (SE QLD-NE NSW). Eucumbene zone is omitted for this iteration as it conflicts with the NSHA 18 guidelines of not containing any doughnut shaped polygons, or a polygon within another polygon. Most changes to zone boundaries are dominantly in more active zones (i.e. on non-cratonic regions of Australia) as the added seismicity recorded over time has helped to reshape the area zone boundaries with each iteration.

The model extends to the continental shelf and beyond to some offshore basins surrounding Australia, but no improvements to these outer zones is made. The model was originally intended to be a standalone model for exclusive use of PSHA studies within Australia. AUS6 is unlike the DIM-AUS model (Dimas & Venkatesan, 2016) that seamlessly integrates with plate boundaries to the north of Australia, where careful thought has been given to hazard at this intersection. Recent revisions along the continental shelf boundary on the east coast of Australia are made in the AUS6 model, particularly between Brisbane and Gladstone, with an additional zone labelled 'Seamound' west of the Lord Howe Rise (ID#120 in Figure 1), incorporates the volcanic chain. Other improvements include the South Australian region with modifications to zone boundaries along the Flinders and Mt Lofty Ranges.

Zone boundary size varies greatly within the AUS6 model. This is due to the extensive seismic catalogue collected, particularly in southeast Australia, over forty years that has contributed to better resolution of seismic patterns and hence more detailed area zones. In less active regions such as remote Australia, source zones remain larger in order to capture a sufficient level of seismicity to determine activity rates and b-values for statistical purposes.

For the NSHA 18 project, each source zone is re-modelled using the latest supplied catalogue provided by Gary Gibson (GGcat events until 2016-06-30 version). The processing of the earthquake magnitude recurrence (EMR) data is currently underway and will be made available early 2017 for the final version of the model.

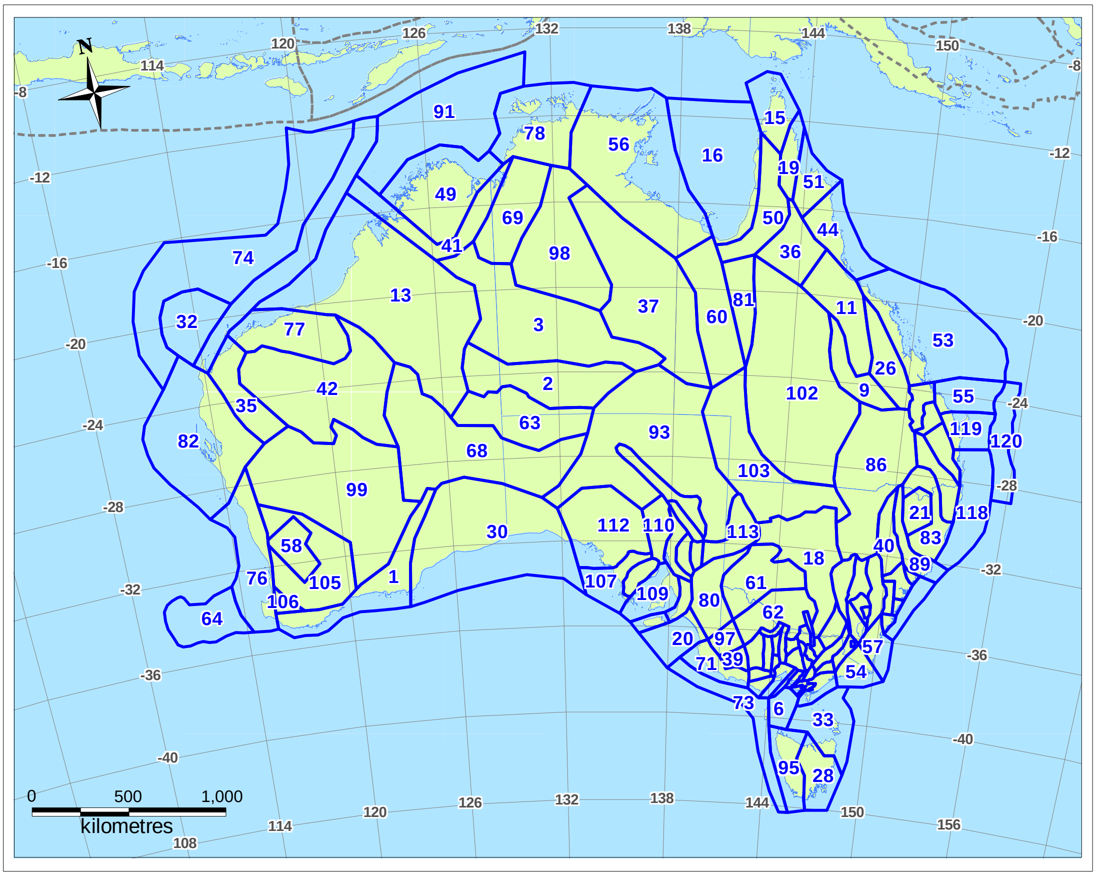

Figure 1: AUS6 seismotectonic source model (whole model)

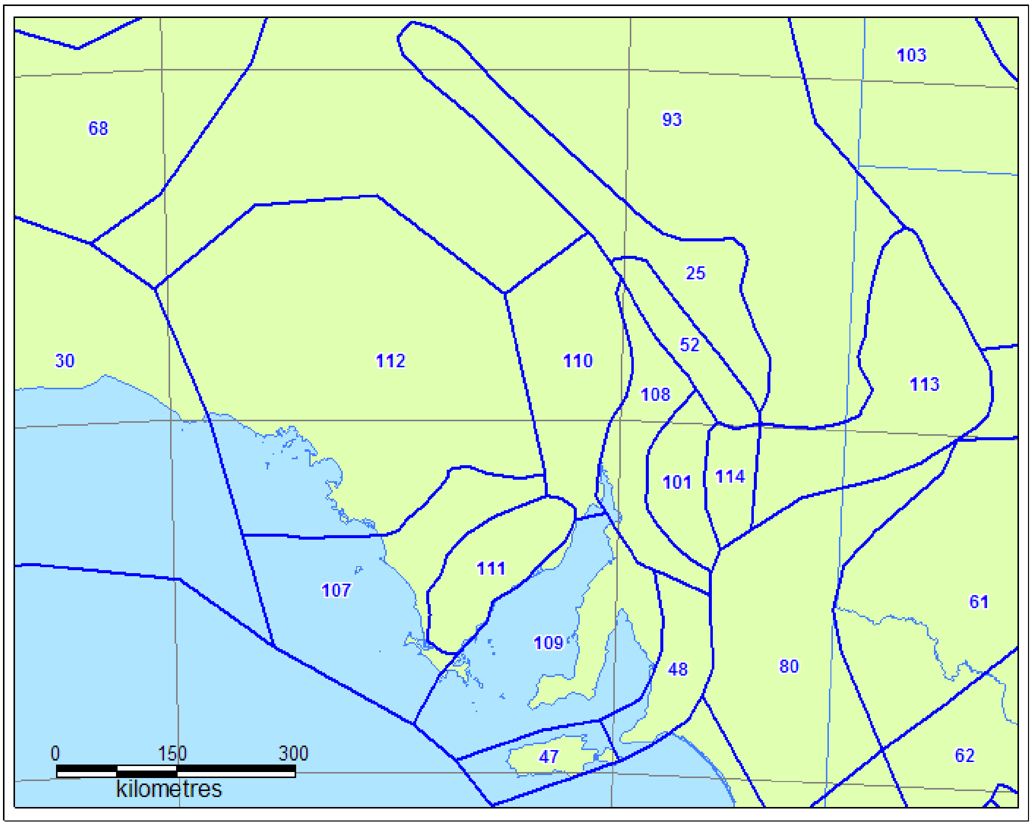

Figure 2: AUS6 seismotectonic source model (SA model)

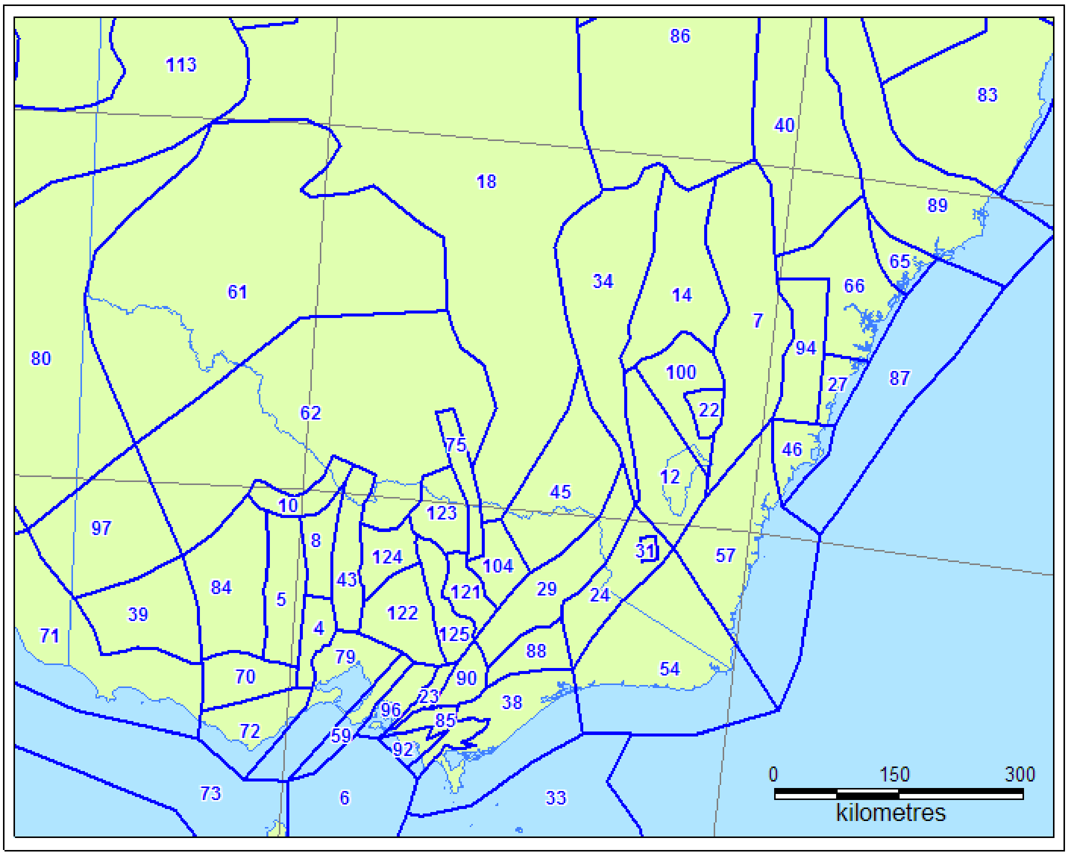

Figure 3: AUS6 seismotectonic source model (VIC-Southern NSW model)

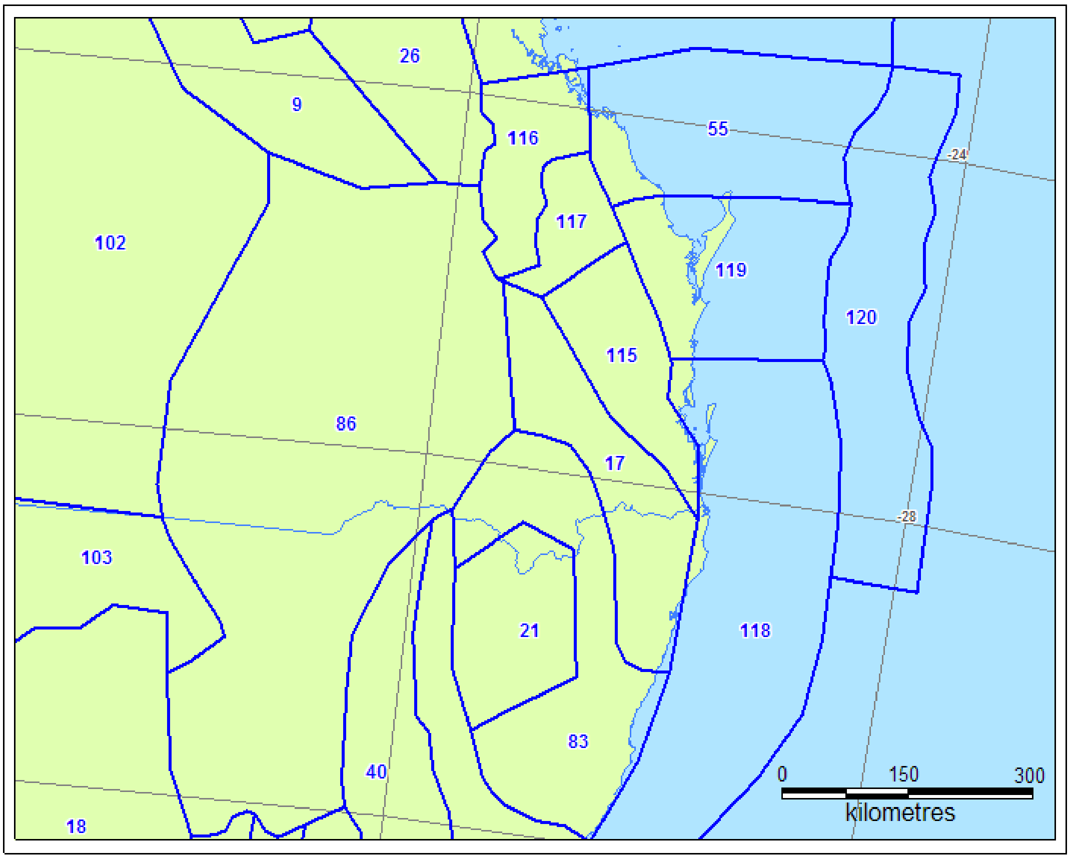

Figure 4: AUS6 seismotectonic source model (SE QLD-NE NSW model)

2.2 Area Sources in AUS6 model:

In the final release of AUS6, parameters for the area sources will be provided for activity rate, b-value, depth range of seismogenic source, fault mechanism and magnitude range. The seismogenic source is assigned a default 2 to 20 kilometre depth range for all sources in the AUS6 model. Previously a select few zones were assigned variations to this depth range, but now the AUS6 model incorporates a standard depth range. The EMR for each zone assumes an exponential Gutenberg-Richter (G-R) relationship of small to large events in determining the b-value and activity rate (Gutenberg & Richter, 1944; 1956). Although the EMR approach remains similar to that applied to more recent versions of AUS5, the maximum magnitude for each zone has been reviewed and a new schema applied.

Previously the maximum magnitude (Mmax) of 7.5 was assumed throughout the model. A schema with three pre-selected Mmax values is now applied to all area zones. The choice of Mmax is made by considering the number of identified active neotectonic faults within that area zone and how active these are (considering the assumed slip rate of the collective faults within the zone). Mmax of 6.4 is assigned to an area we assume to have identified all (or most) of the active neotectonic faults. Lowering the Mmax from a standard 7.5 to 6.4 allows seismicity to be attributed to the larger faults, which considers a more realistic approach. Examples of this schema are the Strzelecki (VIC) and Mt Lofty (SA) Ranges were many active faults are distributed throughout these zones and thus seismicity is assumed to be well understood. Mmax of 6.8 is assigned to zones with some active faults throughout. Based on the seismicity within these zones we assume there could be other blind faults not yet discovered/identified within the zone, with examples of this schema are the Port Phillip or Stawell zones in Victoria. The final choice of Mmax 7.3 is assigned to all other zones, typically with no active neotectonic faults or none identified. Examples of this schema are the Mallacoota (VIC) and Newcastle (NSW) zones.

All area sources are assumed to have a reverse fault mechanism, as the Australian Plate is under compressive stress in the current stress regime (Hilis & Reynolds, 2000; Sandiford & Coblentz, 1994). G-R relationships are assumed throughout the continent, with the same exponential relationships also applied to the active neotectonic faults within this model. Our experience in preparing the Newcastle EMR, showed larger recorded events those with a magnitude 5.0+ followed a similar exponential relationship (Gibson & Dimas, 2014). Due to lack of further evidence we believe the blind fault(s) within this zone exhibit exponential relationships, as opposed to characteristic relationships typically observed in Parkfield, California (Bakun, 2005).

2.3 Fault Sources of AUS6 Model:

Currently only the active neotectonic faults identified through combined methods have been incorporated into the AUS6 model, rather than the fully revised Australian Neotectonic Features Database (ANFD, Clark et al, 2011 & 2012) supplied by Geoscience Australia. In order to properly incorporate these into the seismic hazard software (EZ-Frisk^{TM}) a series of input parameters are required, such as slip rates, b-values, Mmin, Mmax, geometry, fault mechanism etc. Until these are quantified for each ANFD feature, currently being investigated by Geoscience Australia as part of their contribution to NSHA, this task is beyond the scope of our model and is thus excluded for now. It is anticipated once these parameters are established, they too can be considered within the AUS6 model and have seismicity attributed to them.

The methods used to date in identifying if a neotectonic feature/fault is active for inclusion in the AUS6 fault source model is to consider if the feature is active in the current stress regime. Methods applied for determining this process is to assess information from topography maps, DEMs, geology maps or a combination of these methods. Topography maps may help in identifying a clear expression of sudden change in elevation that may be attributed to recent neotectonic activity. Note that this may also be evidence of weathering and erosion, rather than possible recent earthquake activity on an identifiable or blind fault. So this method is typically combined with fly-throughs from a DEM (Google Earth™) together with information from geology maps. Where available 1:100,000 or 1:250,000 scale geology maps are explored to identify any evidence of Quaternary alluvial deposits observed on either side of a fault (whether it is mapped or assumed from regional tectonics) and thus providing some evidence of possible movement in recent geological time (Clark & Leonard, 2015).

The existing faults in the AUS6 model have been dominantly identified in eastern Australia where review has allowed their incorporation, due to most PSHA studies that have been undertaken in this region. In the absence of other significant evidence to support an alternative assumption, the b-value of the fault is assumed to be the same as that of the area zone. We use an alternative assumption to that of Dimas & Venkatesan (2016), where their b-values are determined based on a regionalisation (or grouping of like zones) of area zones. In the DIM-AUS model, it is assumed the regional tectonics is similar throughout the entire craton or fold-belt being investigated, thus the need for a differing b-value is not required. In contrast, the AUS6 model assumes that all faults in the model behave similarly to that of the area zone, in which they are located within.

The slip rate applied to each fault in the AUS6 model is an estimation from the deformation rate (Youngs & Coppersmith, 1985). This is assigned a rate in meters per million years (m/Myr) which either refers to the vertical offset rate or the horizontal offset rate. Slip rate values applied to each fault are considered relative to other nearby faults. We apply the largest slip rate value to the largest most dominant fault, with other surrounding faults assigned lower slip rate values. We assume that field measured geological slip rates (Sandiford, 2003) are too high according to the seismic record and thus apply a relative slip rate value to each fault in our model. At this stage uncertainties for each fault source are not incorporated in the model, instead this will be revised following further discussions and workshops on how to handle epistemic uncertainty for this branch of the logic-tree.

The fault Mmax is determined on surface fault traces from 1:250,000 scale geological maps, but is limited to 7.5 as a cut-off. An improvement of the AUS6 model is how the Mmax and Mmin are determined. The fault Mmax is determined by calculating the $\log10_l$ minus the $Area_l$ divided by the b_l (where 'l' is length) and then applying a width correction depending on what fault mechanism the fault is assigned. The Mmin is then determined using information in Table 1 which deducts the Mmax by a certain amount of magnitude units for each Mmax range. The rupture length sigma is applied in the software automatically, given the above inputs.

Table 1: Method for calculating the assigned Mmin to fault sources

Mmax	Deduct Mmax by X Magnitude Units	Mmin
7.5+	2.0	5.5
6.5 – 7.4	1.5	5.0 – 5.9
5.8 – 6.4	1.0	4.8 – 5.4
5.0 – 5.7	0.5	4.5 – 5.2
< 4.9	0.5	4.5

The fault sources within AUS6 are important given Australian faults are prone to episodic rupture behaviour (Clark & Leonard, 2015; Clark & Leonard, 2014). Further careful consideration of additional features/faults from the ANFD will form an integral part of a consolidated and comprehensive collection of sources that properly account for the episodic nature of seismic activity in a SCR such as Australia. It is anticipated that further workshops for NSHA will assist in determining these details and will be implemented in future revisions of NSHA.

2.4 Completeness Periods and Declustering:

Initial iterations of completeness periods for the AUS6 model are based on set time-magnitude periods (see Table 2) that are subsequently improved by also considering the seismic network throughout time and space as presented by Cuthbertson (2016). In south-eastern Australia with long-term seismic monitoring, completeness periods are often improved, thus allowing smaller events to be incorporated in the seismicity rates for these area zones. Uncertainties of b-values are provided in zone EMR plots, although not fully incorporated in the seismotectonic model at this stage. A total annualised moment release for the model will also be prepared using the Kostrov summation method to ensure total seismicity rates are not greater than Geoscience Australia's national geodetic network strain rate of 0.1 (+/- 0.2) mm/yr (M. Leonard, 2016, pers. comm).

Table 2: Generic completeness periods

Start Year	End Year	Complete above Magnitude
1890	1900	6.0
1900	1965	4.5
1965	2000	3.5
2000	2016	3.0

The declustering has been prepared by Gary (G. Gibson, 2016 pers. comm) in his GGcat provided to all in preparation of a seismotectonic model, following earlier detailed work done (Allen, 2012; Burbidge, 2012; Leonard, 2008 & 2013). The AUS6 preference for declustering an earthquake catalogue is that it be done at the continent scale firstly, and then processed individually for each area zone as the EMR parameters are determined. This is the most comprehensive approach used in the AUS6 methodology where declustering is identified on multiple levels to remove neighbouring dependent events.

2.5 Parameters of AUS6 model:

Parameters calculated to date are included in Table 3 (area sources) and Table 4 (fault sources). At this stage full parameter details for the area sources are not provided as these are still being computed. Area sources are listed by zone name as these have been listed in Figure 1 by their unique identifier (referred to as ‘No’ in the table). Fault sources are listed by zone name and then by fault name for ease of identification of which zones have any faults. Most required parameters for the fault sources are included, except b-values, as these are reliant on zone values. The fault slip rates provided are the total slip rate in m/Myr determined by calculating either the vertical or strike slip of each. These will all be made available for the final release of the AUS6 seismotectonic model once prepared.

3. DIFFERENCES BETWEEN AUS5 AND AUS6:

The fundamental approach of the AUS5 seismotectonic model is that area sources are exclusively used in regions where no identified active neotectonic faults are incorporated into the model. Where faults are incorporated, these were subtracted from the overall area zone’s activity to produce a background area which was then included together with the fault sources. The AUS6 model no longer uses this subtraction approach, but rather restricts the area zone seismicity to a specified Mmax, with the higher Mmax values are placed on the fault sources instead. AUS5 incorporated a uniform Mmax of 7.5 for all area and fault sources, whilst AUS6 has a tiered approach to Mmax and Mmin for area and fault sources.

In the AUS5 model, activity rates were determined for both area and fault sources, but in the AUS6 model this was subsequently developed to include slip rates for the fault sources. This now allows the software to make the conversion using Youngs & Coppersmith (1985) relationships. The AUS5 model used the subtraction method for tallying the fault seismicity with the area seismicity by way of producing a background source, if faults were included in that zone. As this occasionally resulted in negative seismicity of a background area zone, the AUS6 model now overcomes this by treating area and fault sources independently to the zone.

4. CONCLUSION:

The AUS6 seismotectonic model consists of 124 area sources and an individual set of fault sources collected and included over many revisions that differs to the ANFD. It supersedes earlier versions of AUS5 and overcomes some of the shortcomings of the methodology used in that model by now independently incorporating area and fault sources, with no further need for background sources. Significant changes include area sources being assigned one of three Mmax values of 6.4 (where many active neotectonic faults are identified in the zone), 6.8 (where a moderate amount of active neotectonic faults are identified in the zone) and 7.3 (where no known active neotectonic faults are identified). In area zones with numerous faults, this allows the larger events to occur on the faults instead of being accounted within the area zone. All b-values for both area and fault sources are determined using the exponential Gutenberg-Richter relationships, with fault sources remaining the same as the area source they lie within. Most area and fault sources are considered to have a reverse fault mechanism, with only a couple of older and less active faults still being assigned a strike-slip mechanism. The surface traced fault length controls the Mmax that is assigned, and this in turn is used to restrict the Mmin for each fault source. Activity rates for faults are no longer calculated, instead assumed slip rates based on either vertical or horizontal offset rates are incorporated, with the software making the conversion to activity rates for fault sources. The AUS6 model is now considered to be the preferred model for inclusion in any future PSHA studies, whether it be incorporated solely or as part of a logic-tree branch.

Table 3: Parameters of AUS6 seismotectonic model (area sources, work to date)

No.	Zone Name	Region	Area (km²)	No.	Zone Name	Region	Area (km²)
1	Albany-Fraser	Western AUS	133,256	64	Naturaliste Plateau	Western AUS	85,959
2	Amadeus Basin	Western AUS	167,658	65	Newcastle	NSW	3,476
3	Arunta Block	Western AUS	321,638	66	North Sydney Basin	NSW	14,773
4	Ballan	VIC	3,198	67	North West Shelf	Western AUS	165,509
5	Ballarat	VIC	7,934	68	Officer Basin	Western AUS	337,628
6	Bass Strait	TAS	23,527	69	Ord	Northern AUS	120,094
7	Bathurst	NSW	26,238	70	Otway Basin East	VIC	5,653
8	Bendigo	VIC	3,865	71	Otway Basin West	VIC	38,785
9	Bowen	QLD	57,689	72	Otway Ranges	VIC	7,934
10	Bunnaloo	VIC	3,909	73	Otway Shelf	VIC	73,853
11	Burdekin	QLD	106,776	74	Outer Northwest Shelf	Western AUS	384,728
12	Canberra	NSW	11,703	75	Ovens Valley Graben	VIC	3,602
13	Canning	Western AUS	562,866	76	Perth Basin	Western AUS	142,406
14	Canowindra	NSW	17,105	77	Pilbara	Western AUS	126,648
15	Cape York	Northern AUS	64,381	78	Pine Creek	Northern AUS	160,745
16	Carpenteria	Northern AUS	262,513	79	Port Phillip	VIC	11,548
17	Clarence-Moreton	QLD	40,443	80	Renmark	SA	67,339
18	Cobar	NSW	138,137	81	Richmond	QLD	58,206
19	Coen Block	QLD	33,803	82	Shark Bay	Western AUS	301,497
20	Coorong	SA	52,010	83	Southern New England	NSW	58,377
21	Copeton	NSW	29,143	84	Stawell	VIC	14,144
22	Dalton	NSW	1,958	85	Strzelecki	VIC	3,730
23	Darnum	VIC	1,361	86	Surat Basin	QLD	228,849
24	Deddick	VIC	9,137	87	Sydney Coast	NSW	25,669
25	Denison	SA	39,132	88	Tabberabbera	VIC	4,270
26	Drummond	QLD	65,391	89	Tamworth	NSW	38,152
27	East Sydney Basin	NSW	3,303	90	Thomson	VIC	2,799
28	East Tasmania	TAS	53,833	91	Timor Sea	Northern AUS	264,375
29	Eastern Highlands	VIC	12,044	92	Venus Bay	VIC	1,823
30	Eucla	Western AUS	406,045	93	Warburton	SA	436,471
31*	Eucumbene	NSW	523	94	West Sydney Basin	NSW	8,245
32	Exmouth Plateau	Western AUS	89,545	95	West Tasmania	TAS	55,466
33	Flinders Island	TAS	78,064	96	Western Port	VIC	3,339
34	Forbes-Tumut	NSW	24,827	97	Wimmera	VIC	19,089
35	Gascoyne	Western AUS	82,248	98	Wiso Basin	Northern AUS	216,534
36	Georgetown Block	QLD	73,594	99	Yilgarn	Western AUS	409,509
37	Georgina Basin	Northern AUS	334,674	100	Young	NSW	7,814
38	Gippsland	VIC	18,752	101	Peterborough	SA	13,169
39	Grampians	VIC	12,089	102	Eromanga	QLD	464,276
40	Gunnedah	NSW	36,251	103	Cooper	QLD	221,757
41	Halls Creek	Northern AUS	98,678	104	Mt Buffalo	VIC	4,269
42	Hamersley	Western AUS	315,674	105	Kalgoorlie	Western AUS	140,620
43	Heathcote	VIC	6,444	106	Yilgarn Extra	Western AUS	9,939
44	Hodgkinson	QLD	86,908	107	Eyre Peninsula	SA	51,590
45	Hume	VIC	16,975	108	Flinders Ranges	SA	21,115
46	Illawarra	NSW	4,851	109	Spencer Gulf	SA	54,546
47	Kangaroo Island	SA	11,733	110	Stuart Shelf	SA	35,895
48	Mt Lofty Ranges	SA	15,119	111	Whyalla	SA	18,065
49	Kimberley	Northern AUS	180,966	112	Gawler	SA	149,205
50	Korumba Basin	Northern AUS	86,459	113	Broken Hill	SA	47,961
51	Laura Basin	QLD	48,855	114	Yunta	SA	8,632
52	Leigh Creek	SA	12,015	115	Central New England	QLD	25,988
53	Mackay	QLD	279,179	116	Northern New England	QLD	22,027
54	Mallacoota	VIC	32,945	117	Gayndah	QLD	13,012
55	Gladstone	QLD	57,266	118	New England Coast	NSW	104,414
56	McArthur	Northern AUS	381,487	119	Maryborough	QLD	45,711
57	Merimbula	NSW	30,435	120	Seamound	Northern AUS	66,197
58	Merredin	Western AUS	47,325	121	Mt Buller	VIC	3,386
59	Mornington	VIC	3,837	122	Yea	VIC	7,695
60	Mt Isa	QLD	138,486	123	Yarrawonga	VIC	5,291
61	Murray Darling	NSW	94,319	124	Shepparton	VIC	4,317
62	Murray Shelf	VIC	73,435	125	Eildon	VIC	4,525
63	Musgrave Block	Western AUS	141,682	** removed from AUS6 version (remnant of AUS5 model)*			

Table 4: Parameters of AUS6 seismotectonic model (fault sources, work to date)

Fault	Mech	Zone	Len	Slip Rate	Mmin	Mmax
Coimadai	REV	Ballan	31	1.7	5.1	6.6
Djerriwarrh	REV	Ballan	22	1.7	4.8	6.3
Greendale	REV	Ballan	16	1.7	4.6	6.1
Lovely Banks	REV	Ballan	29	17.4	4.6	6.6
Mt William	REV	Ballan	45	8.7	5.4	6.9
Rowsley	REV	Ballan	62	26.2	5.4	7.2
Rowsley Central	REV	Ballan	24	26.2	4.9	6.4
Spring Creek	REV	Ballan	21	1.7	4.8	6.3
Bet Bet	REV	Ballarat	15	1.7	4.6	6.1
Campbelltown	REV	Ballarat	15	3.5	5.0	6.0
Enfiled	REV	Ballarat	48	1.7	5.5	7.0
Muckleford-Leichardt	REV	Ballarat	111	8.7	5.6	7.6
Spring Hill	REV	Ballarat	20	8.7	4.8	6.3
Williamson Creek	REV	Ballarat	24	1.7	4.9	6.4
Crookwell Scarp	REV	Bathurst	56	8.7	5.1	7.1
Ilgingerry	REV	Bathurst	53	8.7	5.5	7.0
Mudgee	REV	Bathurst	100	8.7	5.5	7.5
Mulwarre	REV	Bathurst	174	8.7	5.5	7.5
Native Dog	REV	Bathurst	45	8.7	5.4	6.9
Nindethana	REV	Bathurst	89	8.7	5.4	7.4
Sawmill Hill	REV	Bathurst	43	8.7	5.4	6.9
Shoalhaven	REV	Bathurst	85	26.2	5.4	7.4
Wiagdon	REV	Bathurst	75	8.7	5.3	7.3
Yarralaw	REV	Bathurst	109	8.7	5.6	7.6
Sebastian	REV	Bendigo	71	3.5	5.3	7.3
Whitelaw	REV	Bendigo	52	3.5	5.5	7.0
Farmcote	REV	Broken Hill	15	8.7	5.0	6.0
Globe Vauxall	REV	Broken Hill	11	8.7	4.8	5.8
Mundi Mundi	REV	Broken Hill	160	28.3	5.6	7.6
Northern Nundooka	REV	Broken Hill	32	8.7	5.1	6.6
Nundooka	REV	Broken Hill	79	8.7	5.4	7.4
Olary Creek Scarp 1	REV	Broken Hill	133	3.5	5.5	7.5
Olary Creek Scarp 2	REV	Broken Hill	97	3.5	5.5	7.5
Olary Creek Scarp 3	REV	Broken Hill	30	3.5	5.1	6.6
Scopes Range	REV	Broken Hill	26	8.7	5.0	6.5
Leaghur	REV	Bunnaloo	82	17.4	5.4	7.4
Coodradigbee	REV	Canberra	70	8.7	5.3	7.3
Cotter	REV	Canberra	104	8.7	5.6	7.6
Mooney Mooney	REV	Canberra	109	8.7	5.6	7.6
Murrumbidgee	REV	Canberra	122	8.7	5.5	7.5
Carcoar	REV	Canowindra	32	8.7	5.1	6.6
Copperhannia	REV	Canowindra	48	3.5	5.5	7.0
Cudal	REV	Canowindra	116	8.7	5.5	7.5
Manildra	REV	Canowindra	108	8.7	5.5	7.5
Nurea	REV	Canowindra	63	8.7	5.2	7.2
Wyangala	REV	Canowindra	31	8.7	5.1	6.6
Beenleigh	REV	Central New England	74	2.0	5.3	7.3
Beenleigh	REV	Central New England	74	20.1	5.3	7.3
Brisbane	REV	Central New England	53	3.5	5.5	7.0
Brisbane	REV	Central New England	53	17.4	5.5	7.0
Esk	REV	Central New England	30	3.5	5.1	6.6
Esk	REV	Central New England	30	17.4	5.1	6.6
North Pine Inner Nth	REV	Central New England	61	4.0	5.1	7.1
North Pine Inner Nth	REV	Central New England	61	20.1	5.1	7.1
North Pine Inner Sth	REV	Central New England	27	2.0	5.0	6.5
North Pine Inner Sth	REV	Central New England	27	20.1	5.0	6.5
North Pine Outer Nth	REV	Central New England	102	4.0	5.6	7.6
North Pine Outer Nth	REV	Central New England	102	20.1	5.6	7.6
North Pine Outer Sth	REV	Central New England	51	2.0	5.5	7.0
North Pine Outer Sth	REV	Central New England	51	20.1	5.5	7.0
North Tarong	REV	Central New England	21	2.0	4.8	6.3
North Tarong	REV	Central New England	21	20.1	4.8	6.3
Somerset	REV	Central New England	7	1.7	4.4	5.4
Somerset	REV	Central New England	7	17.4	4.4	5.4
Tarong	REV	Central New England	34	1.7	5.2	6.7
Tarong	REV	Central New England	34	17.4	5.2	6.7
Tingoora	REV	Central New England	45	2.0	5.4	6.9
Tingoora	REV	Central New England	45	20.1	5.4	6.9
Western Ipswich Inner Nth	REV	Central New England	17	3.5	4.6	6.1
Western Ipswich Inner Nth	REV	Central New England	17	17.4	4.6	6.1
Western Ipswich Inner Sth	REV	Central New England	48	3.5	5.5	7.0
Western Ipswich Inner Sth	REV	Central New England	48	17.4	5.5	7.0
Western Ipswich Outer Nth	REV	Central New England	19	3.5	4.7	6.2
Western Ipswich Outer Nth	REV	Central New England	19	17.4	4.7	6.2

Western Ipswich Outer Sth	REV	Central New England	35	3.5	5.2	6.7
Western Ipswich Outer Sth	REV	Central New England	35	17.4	5.2	6.7
Yarraman	REV	Central New England	46	2.0	5.4	6.9
Yarraman	REV	Central New England	46	20.1	5.4	6.9
Boonah	REV	Clarence Moreton	41	2.0	5.3	6.8
Boonah	REV	Clarence Moreton	41	20.1	5.3	6.8
Bunya	REV	Clarence Moreton	27	1.7	5.0	6.5
Bunya	REV	Clarence Moreton	27	17.4	5.0	6.5
Condamine	REV	Clarence Moreton	71	1.7	5.3	7.3
Condamine	REV	Clarence Moreton	71	17.4	5.3	7.3
Kumbia	REV	Clarence Moreton	34	1.7	5.2	6.7
Kumbia	REV	Clarence Moreton	34	17.4	5.2	6.7
Kumbia Branch	REV	Clarence Moreton	15	1.7	4.6	6.1
Kumbia Branch	REV	Clarence Moreton	15	17.4	4.6	6.1
Mount Lindsay	REV	Clarence Moreton	39	1.7	5.3	6.8
Mount Lindsay	REV	Clarence Moreton	39	17.4	5.3	6.8
Mount Lindsay Branch	REV	Clarence Moreton	14	1.7	5.0	6.0
Mount Lindsay Branch	REV	Clarence Moreton	14	17.4	5.0	6.0
Mt Alexander	REV	Clarence Moreton	25	1.7	4.9	6.4
Mt Alexander	REV	Clarence Moreton	25	17.4	4.9	6.4
Mt Perseverance	REV	Clarence Moreton	32	1.7	5.1	6.6
Mt Perseverance	REV	Clarence Moreton	32	17.4	5.1	6.6
Sugarloaf	REV	Clarence Moreton	33	1.7	5.2	6.7
Sugarloaf	REV	Clarence Moreton	33	17.4	5.2	6.7
Upper Pilton	REV	Clarence Moreton	25	1.7	4.9	6.4
Upper Pilton	REV	Clarence Moreton	25	17.4	4.9	6.4
Wild Horse	REV	Clarence Moreton	32	1.7	5.1	6.6
Wild Horse	REV	Clarence Moreton	32	17.4	5.1	6.6
Koonenberry	REV	Cooper	301	8.7	5.5	7.5
Lawrence	REV	Cooper	215	8.7	5.5	7.5
Olepoloko	REV	Cooper	146	8.7	5.5	7.5
Frogmore Middle	REV	Dalton	58	17.4	5.1	7.1
Lake George Middle	REV	Dalton	59	26.2	5.1	7.1
Darnum	REV	Darnum	26	7.0	5.0	6.5
Heath Hill	REV	Darnum	40	13.9	5.3	6.8
Barneys Range	REV	Deddick	44	3.5	5.4	6.9
Berridale	SS	Deddick	58	5.0	5.3	6.8
Berridale Branch	REV	Deddick	13	3.5	4.9	5.9
Crackenback	REV	Deddick	39	8.7	5.3	6.8
Indi	REV	Deddick	76	8.7	5.3	7.3
Jindabyne	REV	Deddick	92	8.7	5.5	7.5
Long Plain	REV	Deddick	112	8.7	5.5	7.5
Morass Creek	REV	Deddick	4	3.5	4.1	5.1
Lake Echo Scarp	REV	East Tasmania	40	3.5	5.3	6.8
Poatina Scarp	REV	East Tasmania	24	3.5	4.9	6.4
Richmond	REV	East Tasmania	3	3.5	4.3	4.8
Bogong	REV	Eastern Highlands	15	3.5	5.0	6.0
Buenba	REV	Eastern Highlands	68	34.0	5.2	7.2
Gibbo River	REV	Eastern Highlands	34	24.0	5.2	6.7
Khancoban	REV	Eastern Highlands	8	3.5	4.5	5.5
Livingstone Creek	REV	Eastern Highlands	44	17.4	5.4	6.9
Murtagh	REV	Eastern Highlands	13	8.7	4.9	5.9
Tawonga	REV	Eastern Highlands	53	34.9	5.5	7.0
Barjarg	REV	Euroa	8	3.5	4.6	5.6
Burra East	REV	Flinders Ranges	56	26.2	5.1	7.1
Burra West	REV	Flinders Ranges	40	17.4	5.3	6.8
Crystal Brook (Baroota-Wilkatana)	REV	Flinders Ranges	83	156.9	5.4	7.4
Nectar Brook	REV	Flinders Ranges	57	130.8	5.1	7.1
Northern Flinders	REV	Flinders Ranges	100	69.7	5.5	7.5
Wilkatana	REV	Flinders Ranges	77	156.9	5.3	7.3
Cootamundra	REV	Forbes-Tumut	92	8.7	5.5	7.5
Balook North	REV	Gippsland	8	3.5	4.5	5.5
Budgeree Splay	REV	Gippsland	18	8.7	4.7	6.2
Darriman Monocline	REV	Gippsland	33	1.7	5.3	6.7
Morwell North	REV	Gippsland	18	8.7	4.7	6.2
Napier Monocline	REV	Gippsland	10	1.7	4.8	5.8
Rosedale	REV	Gippsland	62	13.9	5.2	7.2
Snake Ridge Monocline	REV	Gippsland	37	1.7	5.3	6.7
Wonwron	REV	Gippsland	55	3.5	5.1	7.1
Cadell Scarp	REV	Heathcote	55	5.2	5.1	7.1
Echuca South Scarp	REV	Heathcote	11	1.7	4.8	5.8
Heathcote	REV	Heathcote	28	17.4	5.0	6.5
Meadow Valley	REV	Heathcote	60	1.7	5.1	7.1
Moormbool	REV	Heathcote	53	8.7	5.5	7.0
Mt Ida	REV	Heathcote	44	17.4	5.4	6.9
Beechworth Ext	REV	Hume	49	15.1	5.5	7.0
Cudgewa	REV	Hume	87	17.4	5.4	7.4

Talgarno Spring Creek	REV	Hume	27	18.9	5.0	6.5
Tallangatta Creek	SS	Hume	59	2.0	5.3	6.8
Dee Range	REV	Mackay	29	3.5	4.6	6.6
Fitzroy River	REV	Mackay	32	1.7	4.6	6.6
Burragate	SS	Mallacoota	46	2.0	5.1	6.6
Irondoon	REV	Mallacoota	31	3.5	5.1	6.6
Thurra	SS	Mallacoota	73	2.0	5.5	7.0
Woodglen	REV	Mallacoota	66	8.7	5.2	7.2
Brogo	REV	Merimbula	26	3.5	5.0	6.5
Budawang East	REV	Merimbula	30	3.5	5.1	6.6
Budawang West	REV	Merimbula	49	3.5	5.5	7.0
Tantawangalo	SS	Merimbula	62	2.0	5.4	6.9
Balcombe	REV	Mornington	33	1.7	5.2	6.7
Devilbend	REV	Mornington	22	1.7	4.8	6.3
Selwyn	REV	Mornington	96	13.9	5.5	7.5
Tyabb	REV	Mornington	55	3.5	5.1	7.1
Beechworth	REV	Mt Buffalo	24	9.4	4.9	6.4
Ovens Valley East	REV	Mt Buffalo	55	8.7	5.1	7.1
West Kiewa-Sawpit Gully	SS	Mt Buffalo	55	3.0	5.3	6.8
Cloncurry	REV	Mt Isa	117	1.7	5.7	7.7
Coolullah	REV	Mt Isa	136	1.7	5.5	7.5
Dugald River	REV	Mt Isa	81	1.7	5.4	7.4
Fountain Range	REV	Mt Isa	135	1.7	5.5	7.5
George Creek	REV	Mt Isa	182	1.7	5.5	7.5
Mahaffy Creek	REV	Mt Isa	10	1.7	4.7	5.7
Mount Gordon	REV	Mt Isa	164	1.7	5.5	7.5
Mt Dore	REV	Mt Isa	111	1.7	5.6	7.6
Mt Isa	REV	Mt Isa	146	1.7	5.5	7.5
Phosphate Hill	REV	Mt Isa	6	1.7	4.3	5.3
Pilgrim	REV	Mt Isa	78	1.7	5.3	7.3
Russell's	REV	Mt Isa	2	1.7	3.9	4.4
Alma	REV	Mt Lofty Ranges	122	13.9	5.7	7.7
Bremer	REV	Mt Lofty Ranges	125	13.9	5.7	7.7
Clarendon	REV	Mt Lofty Ranges	45	8.7	5.4	6.9
Clarendon Central	REV	Mt Lofty Ranges	19	8.7	4.7	6.2
Eden-Burnside	REV	Mt Lofty Ranges	46	8.7	5.4	6.9
Eden-Burnside Central	REV	Mt Lofty Ranges	28	13.9	5.0	6.5
Encounter Bay	REV	Mt Lofty Ranges	34	8.7	5.2	6.7
Meadows	REV	Mt Lofty Ranges	52	5.2	5.5	7.0
Palmer	REV	Mt Lofty Ranges	99	13.9	5.5	7.5
Para	REV	Mt Lofty Ranges	54	7.0	5.5	7.0
Para Central	REV	Mt Lofty Ranges	27	8.7	5.0	6.5
Tarlee	REV	Mt Lofty Ranges	35	5.2	5.2	6.7
Williamstown	REV	Mt Lofty Ranges	42	5.2	5.4	6.9
Willunga	REV	Mt Lofty Ranges	82	7.0	5.4	7.4
Willunga Central	REV	Mt Lofty Ranges	35	8.7	5.2	6.7
Iona Ridge	REV	Murrary Darling	73	3.5	5.3	7.3
Neckarboo Ridge	REV	Murrary Darling	122	3.5	5.5	7.5
Maitland	REV	Newcastle	25	3.5	5.0	6.5
Kooree Creek Lineament	REV	North Sydney Basin	22	3.5	4.8	6.3
Bracewell	REV	Northern New England	35	3.5	5.2	6.7
Mt Larcom	REV	Northern New England	56	3.5	5.1	7.1
Queenslander	REV	Northern New England	37	5.2	5.2	6.7
The Narrows	REV	Northern New England	40	3.5	5.3	6.8
Western Basin	REV	Northern New England	56	3.5	5.1	7.1
Woolsthorpe Scarp	REV	Otway Basin West	26	1.7	5.1	6.5
Bambra	REV	Otway Ranges	57	3.5	5.1	7.1
Barrabool	REV	Otway Ranges	19	7.0	4.7	6.2
Castle Cove	REV	Otway Ranges	25	1.7	5.0	6.4
Chapplevale	REV	Otway Ranges	43	3.5	5.4	6.9
Colac Monocline	REV	Otway Ranges	75	1.7	5.3	7.3
Cooriejong Monocline	REV	Otway Ranges	10	1.7	4.8	5.7
Coradjil Anticline	REV	Otway Ranges	19	1.7	4.8	6.2
Curdie Monocline	REV	Otway Ranges	23	1.7	5.0	6.4
Ferguson Hill Anticline	REV	Otway Ranges	33	3.5	5.2	6.7
Johanna	REV	Otway Ranges	50	3.5	5.1	7.0
Love Creek Monocline	REV	Otway Ranges	21	1.7	4.9	6.3
Pirron Yallock Monocline	REV	Otway Ranges	35	1.7	5.3	6.7
Simpson Anticline	REV	Otway Ranges	21	1.7	4.9	6.3
Torquay	REV	Otway Ranges	110	10.5	5.6	7.6
Winchelsea Scarp	REV	Otway Ranges	11	3.5	4.8	5.8
Avalon Scarp	REV	Port Phillip	20	1.7	4.9	6.3
Beaumaris	REV	Port Phillip	19	5.2	4.7	6.2
Bellarine	REV	Port Phillip	23	5.2	4.9	6.4
Coonewarre	REV	Port Phillip	10	3.5	4.8	5.8
Curlewis	REV	Port Phillip	15	1.7	4.6	6.1
Melbourne Warp	REV	Port Phillip	21	0.0	4.8	6.3

Yarra	REV	Port Phillip	21	7.0	4.8	6.3
Kinchega Scarp	REV	Renmark	23	3.5	4.9	6.4
Pine Creek Scarp 1	REV	Renmark	60	3.5	5.1	7.1
Pine Creek Scarp 2	REV	Renmark	60	3.5	5.1	7.1
Ovens Valley West	REV	Shepparton	56	8.7	5.1	7.1
Tatura	REV	Shepparton	10	1.7	4.7	5.7
Demon Fault Zone	SS	Southern New England	160	10.0	5.6	7.6
Coobowie Scarp	REV	Spencer Gulf	14	8.7	5.0	6.0
Owen	REV	Spencer Gulf	30	17.4	5.1	6.6
Pine Point	REV	Spencer Gulf	73	17.4	5.3	7.3
Yorketown Scarp	REV	Spencer Gulf	25	17.4	4.9	6.4
Avoca	REV	Stawell	160	1.7	5.5	7.5
Allambee South	REV	Strzelecki	10	8.7	4.7	5.7
Balook South	REV	Strzelecki	14	20.9	5.0	6.0
Bass East	REV	Strzelecki	47	34.9	5.4	6.9
Bass West	REV	Strzelecki	10	17.4	4.7	5.7
Boolarra	REV	Strzelecki	9	17.4	4.6	5.6
Budgeree	REV	Strzelecki	34	69.7	5.2	6.7
Carrajung	REV	Strzelecki	18	17.4	4.7	6.2
Doomburrin	REV	Strzelecki	33	29.6	5.2	6.7
Fish Creek	REV	Strzelecki	25	26.2	4.9	6.4
Geliondale	REV	Strzelecki	36	34.9	5.2	6.7
Hallston	REV	Strzelecki	15	8.7	5.0	6.0
Haunted Hills South	REV	Strzelecki	6	10.5	4.3	5.3
Kongwak	REV	Strzelecki	48	19.2	5.4	6.9
Koorooman	REV	Strzelecki	18	3.5	4.7	6.2
Mirboo	REV	Strzelecki	23	17.4	4.9	6.4
Morwell South	REV	Strzelecki	20	34.9	4.8	6.3
Tanjil South	REV	Strzelecki	7	8.7	4.4	5.4
Tap Tap	REV	Strzelecki	14	8.7	5.0	6.0
Tarwin East	REV	Strzelecki	34	26.2	5.2	6.7
Toora	REV	Strzelecki	14	3.5	5.0	6.0
Waratah Branch	REV	Strzelecki	12	26.2	4.9	5.9
Waratah North	REV	Strzelecki	21	27.9	4.8	6.3
Waratah South	REV	Strzelecki	17	34.9	4.6	6.1
Yarragon	REV	Strzelecki	33	69.7	5.2	6.7
Yarram	REV	Strzelecki	52	69.7	5.5	7.0
Forestvale	REV	Surat	42	1.7	4.9	6.9
Walgett Scarp	REV	Surat	34	1.7	5.2	6.7
Newcastle Offshore	REV	Sydney Coast	34	8.7	5.2	6.7
Attunga	REV	Tamworth Terrane	54	1.7	5.5	7.0
Baldwin	REV	Tamworth Terrane	53	1.7	5.5	7.0
Brownmore	REV	Tamworth Terrane	10	1.7	4.7	5.7
Campo Santo	REV	Tamworth Terrane	74	1.7	5.3	7.3
Crawford River No 1	REV	Tamworth Terrane	32	3.5	5.1	6.6
Crawford River No 2	REV	Tamworth Terrane	30	3.5	5.1	6.6
Elcombe	REV	Tamworth Terrane	43	1.7	5.4	6.9
Goorangoola	REV	Tamworth Terrane	48	3.5	5.5	7.0
Horton	REV	Tamworth Terrane	37	1.7	5.3	6.8
Hunter	REV	Tamworth Terrane	142	3.5	5.6	7.6
Karrakurra	REV	Tamworth Terrane	36	1.7	5.2	6.7
Kelvin	REV	Tamworth Terrane	77	1.3	5.3	7.3
Majors Creek	REV	Tamworth Terrane	37	3.5	5.2	6.7
Manning River	REV	Tamworth Terrane	128	1.7	5.5	7.5
Mooki	REV	Tamworth Terrane	364	3.5	5.6	7.6
Namoi	REV	Tamworth Terrane	125	1.7	5.5	7.5
Peel	REV	Tamworth Terrane	219	3.5	5.6	7.6
Targan	REV	Tamworth Terrane	38	3.5	5.3	6.8
Unnamed Tamworth 1	REV	Tamworth Terrane	34	1.7	5.2	6.7
Unnamed Tamworth 2	REV	Tamworth Terrane	52	1.7	5.5	7.0
Unnamed Tamworth 3	REV	Tamworth Terrane	36	1.7	5.2	6.7
Webbers	REV	Tamworth Terrane	30	1.7	5.1	6.6
Williams River	REV	Tamworth Terrane	57	1.7	5.1	7.1
Haunted Hills North	REV	Thomson	6	12.2	4.4	5.4
Tanjil North	REV	Thomson	13	5.2	4.9	5.9
Yallourn	REV	Thomson	66	55.8	5.2	7.2
Tarwin West	REV	Venus Bay	45	8.7	5.4	6.9
Kantappa	REV	Warburton	92	8.7	5.5	7.5
Kurrajong	REV	West Sydney Basin	36	8.7	5.2	6.7
Lapstone	REV	West Sydney Basin	94	52.3	5.5	7.5
D'Aguilar Ranges	REV	West Tasmania	45	3.5	5.4	6.9
Gell River	REV	West Tasmania	10	3.5	4.7	5.7
Lake Edgar	REV	West Tasmania	28	3.5	5.0	6.5
Brella	REV	Western Port	14	5.2	5.0	6.0
Corinella	REV	Western Port	14	3.5	5.0	6.0
Koo Wee Rup	REV	Western Port	18	1.7	4.7	6.2
Lang Lang	REV	Western Port	19	3.5	4.7	6.2

Tankerton	REV	Western Port	38	5.2	5.3	6.8
Wellington	REV	Western Port	12	7.0	4.9	5.9
Ash Reef	REV	Whyalla	24	1.7	4.9	6.4
Charleston	REV	Whyalla	17	8.7	4.6	6.1
Moonabie	REV	Whyalla	28	17.4	5.0	6.5
Murminnie	REV	Whyalla	14	13.9	5.0	6.0
Nonowie	REV	Whyalla	23	1.7	4.9	6.4
Poynton	REV	Whyalla	7	13.9	4.5	5.5
Randell	REV	Whyalla	34	8.7	5.2	6.7
Roopena	REV	Whyalla	29	1.7	5.1	6.6
Frogmore North	REV	Young	66	8.7	5.2	7.2
Frogmore South	REV	Young	15	8.7	5.0	6.0
Lake George North	REV	Young	59	17.4	5.1	7.1
Lake George South	REV	Young	51	8.7	5.5	7.0
Queanbeyan	REV	Young	30	8.7	5.1	6.6
Reids Flat Thrust	REV	Young	35	8.7	5.2	6.7

*Mech – fault mechanism; REV – reverse; SS – strike-slip; Len – length in km; Slip Rate – total slip in m/Myr

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