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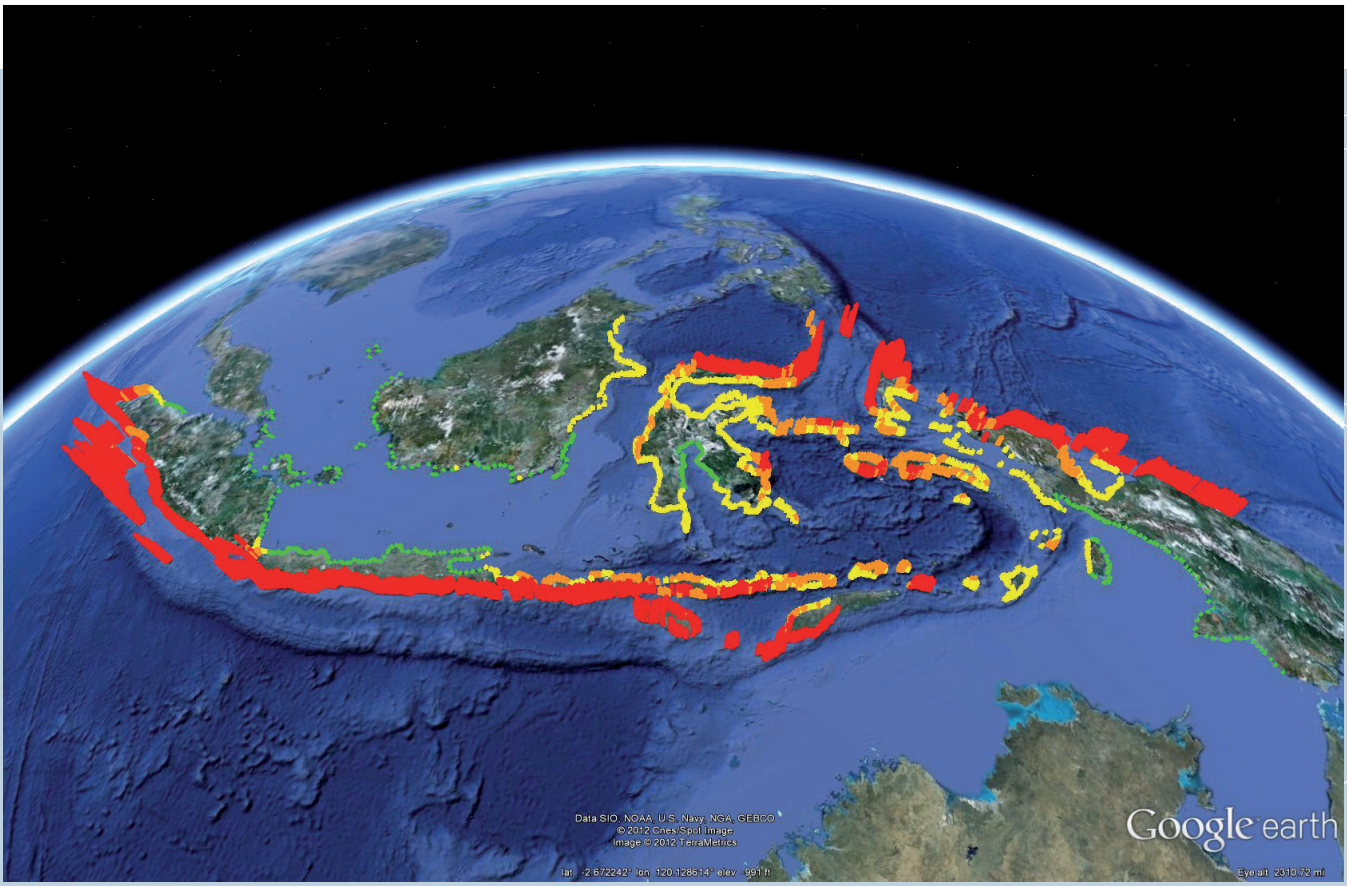

A National Tsunami Hazard Assessment for Indonesia

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A National Tsunami Hazard Assessment for Indonesia

Summary

This document presents the findings of a National Tsunami Hazard Assessment for Indonesia. The assessment was supported by the Indonesian National Disaster Management Agency (BNPB) and the Australian Agency for International Development (AusAID) through the Australia-Indonesia Facility for Disaster Reduction (AIFDR). It represents Indonesia's most advanced and rigorous assessment of tsunami hazard and was developed as a collaborative effort between Indonesian and Australian scientists representing Institut Teknologi Bandung (ITB), the Indonesian Institute of Science (LIPI), the Agency for the Assessment and Application of Technology (BPPT), the Geological Agency, the Meteorology, Climatology and Geophysics Agency (BMKG), the Tsunami and Disaster Mitigation Research Centre at Syiah Kuala University (TDMRC) and Geoscience Australia (GA). The tsunami hazard maps are based on a probabilistic tsunami hazard assessment methodology, which allows the chance of tsunami of different heights to be estimated.

The series of maps produced will allow BNPB and BPBDs to:

- Rank the tsunami potential for each district in Indonesia and prioritise communities for further tsunami mitigation activities and detailed hazard and risk assessments;
- Assess the tsunami potential for each district to plan tsunami mitigation activities;
- Understand the chance of a tsunami reaching the coastline that would trigger a *"tsunami warning with an orange level"* (tsunami height between 0.5 – 3.0 m) or *"major tsunami warning with a red level"* (tsunami height over 3.0 m) from the Indonesian Tsunami Early Warning System (InaTEWS);
- Understand the maximum tsunami height over different return periods; and
- Determine the earthquake fault lines that may have an impact on each district.

The key findings from the tsunami hazard assessment are:

- The regions with the highest chance of experiencing a major tsunami warning (tsunami over 3 m) in any one year are Lampung Barat, the Mentawai Islands and Nias. This is followed by the south coast of Java, the south-west coast of Sumatra and some parts of Bali and Nusa Tenggara Barat, which all have a 2-10% chance.
- There is a greater than 10% chance that somewhere in Indonesia will experience a major tsunami warning (tsunami over 3 m) in any one year. This would warrant a *"major tsunami warning with a red level"* according to the InaTEWS scale;
- For most regions of Indonesia there is a greater than 10% chance of experiencing a tsunami warning (tsunami between 0.5 – 3.0 m) in any one year. This would warrant a *"tsunami warning with an orange level"* according to the InaTEWS scale;
- The locations with the highest chance (> 10%) of experiencing an orange warning are the west coast of Sumatra, south coast of Java, Nusa Tenggara Barat and Nusa Tenggara Timur. The locations with a lesser chance (2-10%) are most locations in eastern Indonesia, including Sulawesi, north Papua and Maluku; and
- Regions with low tsunami hazard are the north coast of Java, east coast of Sumatra, the west and south coasts of Kalimantan and the south coast of Papua.

1 Interestingly, the central-west coast of Sumatra has a lower chance of experiencing a major tsunami warning, which is due in part to the presence of the Mentawai Islands that act as a barrier to tsunami propagation and also cause less water to be displaced during large earthquakes on this section of the Sumatra Subduction Zone.

These findings highlight that the west coast of Sumatra, south coast of Java and Nusa Tenggara Barat and Timur have the highest tsunami hazard in Indonesia. However many parts of eastern Indonesia, including the north coast of Papua, Sulawesi, Maluku and North Maluku have a high tsunami hazard and have the potential to experience large and devastating tsunami. These regions in eastern Indonesia have received less attention and tsunami models are not included in the InaTEWS system, but the findings from this study show that the tsunami hazard here is high and warrants further work.

National Tsunami Hazard Assessment Results

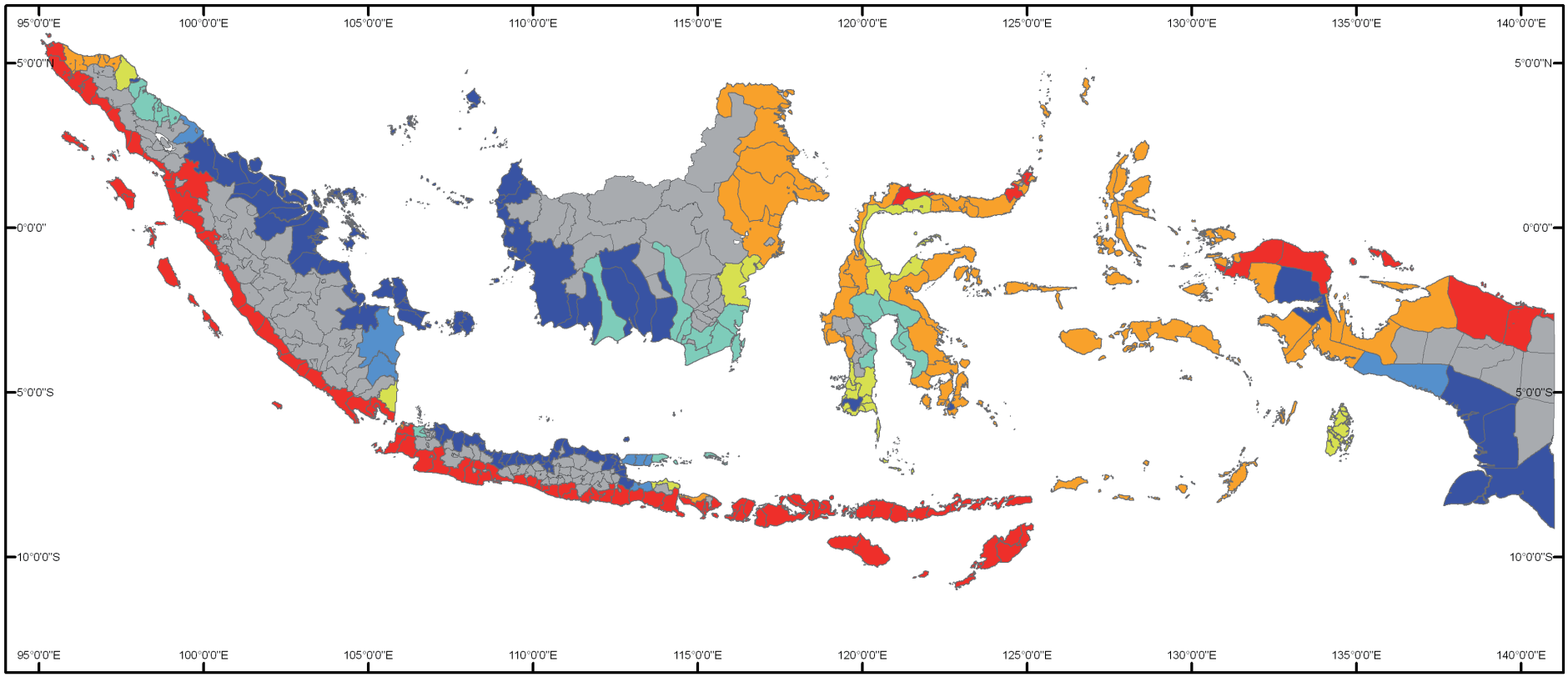
This assessment aims to quantify the tsunami hazard at the coast for Indonesia. This hazard is expressed as maps showing the chance of exceeding a tsunami height at the coast in a given year, which in the results above is in relation to the tsunami heights that are used for different warning levels from InaTEWS. An alternative way of expressing the chance of a tsunami is through return period maps. These maps show the minimum tsunami height that is expected to be experienced during a given time interval (e.g. 100, 500, 2500 years). These maps show the areas in Indonesia that are most likely to have a tsunami that would trigger a tsunami warning, and they also show the tsunami exceedence height for a given return period to understand how high the tsunami may be at a given location.

The maps show:

- Chance of experiencing a tsunami greater than 0.5 m in a given year, which would trigger a "tsunami warning – orange level";
- Chance of experiencing a tsunami greater than 3 m in a given year, which would trigger a "major tsunami warning – red level";
- Tsunami height at the coast expected over a 100-year return period;
- Tsunami height at the coast expected over a 500-year return period;
- Tsunami height at the coast expected over a 2500-year return period; and
- The provincial capital cities that are most likely to experience an inundating tsunami.

From these maps the following conclusions can be made:

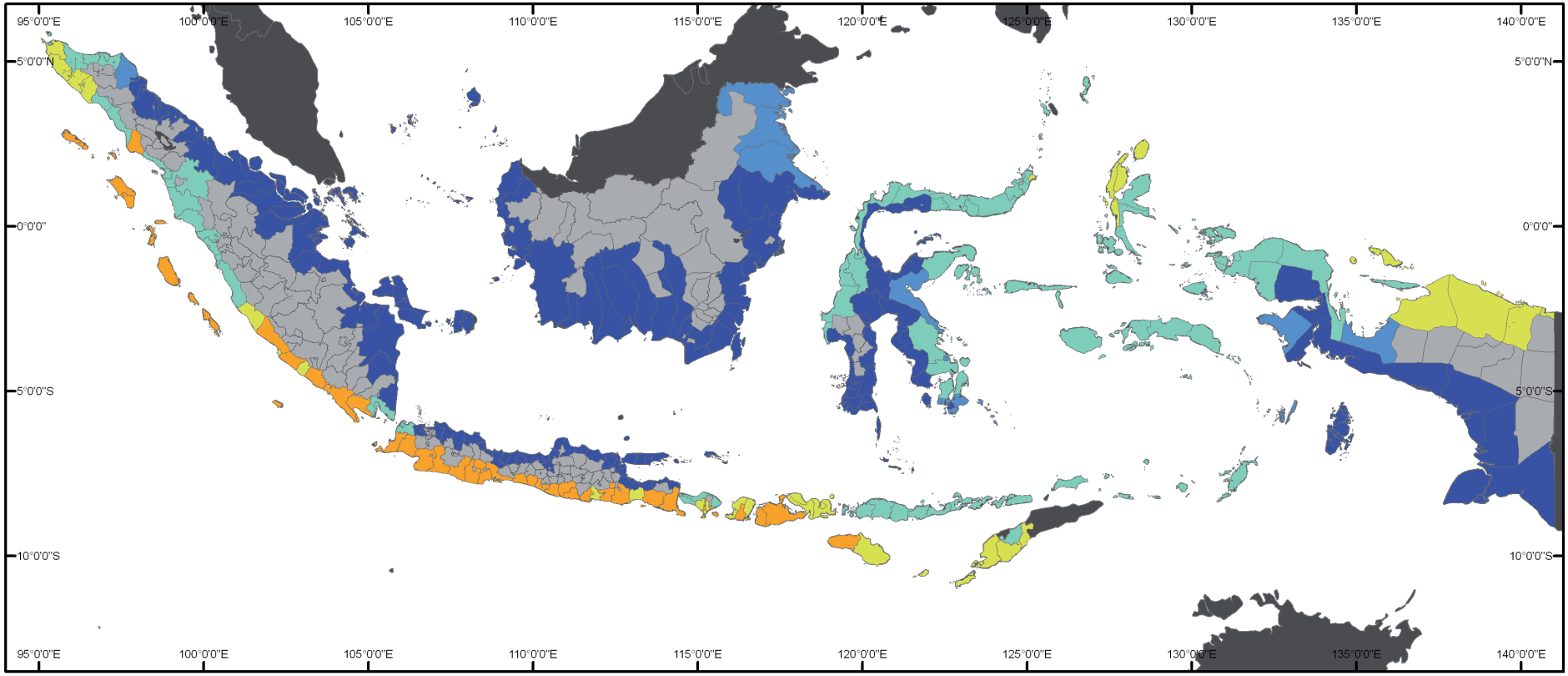
- The west coast of Sumatra, south coast of Java and Nusa Tenggara Barat have the highest tsunami hazard for a 100-year return period and would expect tsunami with a height between 5-10 m over this time period. Eastern Indonesia has a slightly lower tsunami hazard and can expect to have tsunami with heights between 2-3 m over a 100-year period;
- At the 500-year return period some districts in Sumatra have a higher hazard than other areas, including the Mentawai Islands. The south coast of Java has a higher tsunami hazard than Nusa Tenggara Barat for a 500-year return period. Parts of Eastern Indonesia, such as North Papua, north-west coast of Sulawesi, North Maluku and South Maluku, have equivalent tsunami hazard to the south coast of Java for this return period.
- The difference in tsunami hazard patterns between different return periods reflect the increasing contribution from earthquake sources that have lower frequency of occurrence in the short term (100 years), but over longer time periods they can cause large tsunami, particularly in eastern Indonesia.
- The provincial capital cities most likely to experience tsunami are (in order of highest to lowest) Denpasar, Jayapura, Bengkulu, Ternate, Manado, Banda Aceh, Manokwari, Padang, Ambon and Mataram.



Probability of experiencing a tsunami with an orange warning level (0.5 - 3.0 m tsunami) in a year

- less than 1/1000
- 1/1000 to 1/500
- 1/500 to 1/100
- 1/100 to 1/50
- 1/50 to 1/10
- greater than 1/10

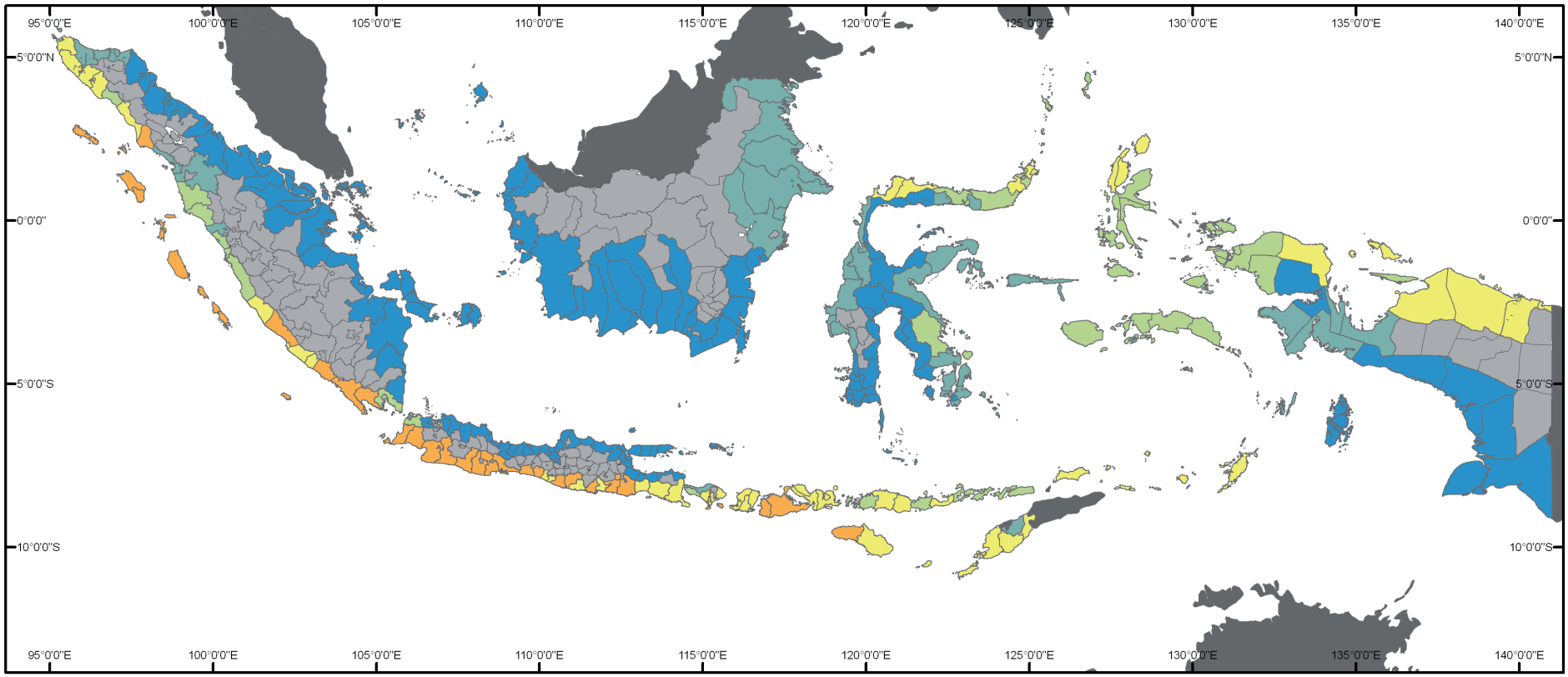
0 500 1,000
Kilometers



Probability of experiencing a tsunami with a red warning level (> 3 m tsunami) in a year

- less than 1/1000
- 1/1000 to 1/500
- 1/500 to 1/100
- 1/100 to 1/50
- 1/50 to 1/10
- greater than 1/10

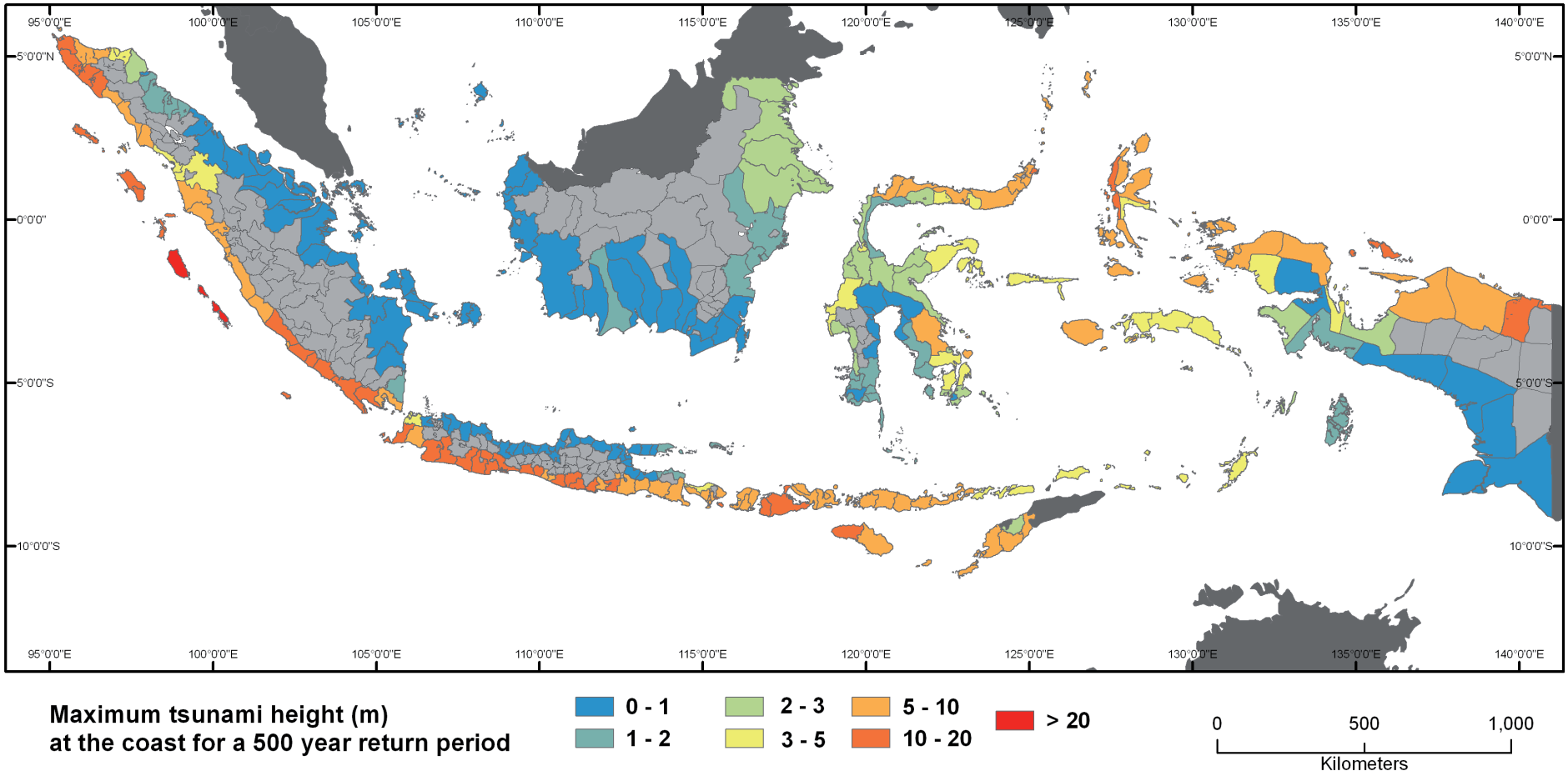
0 500 1,000
Kilometers

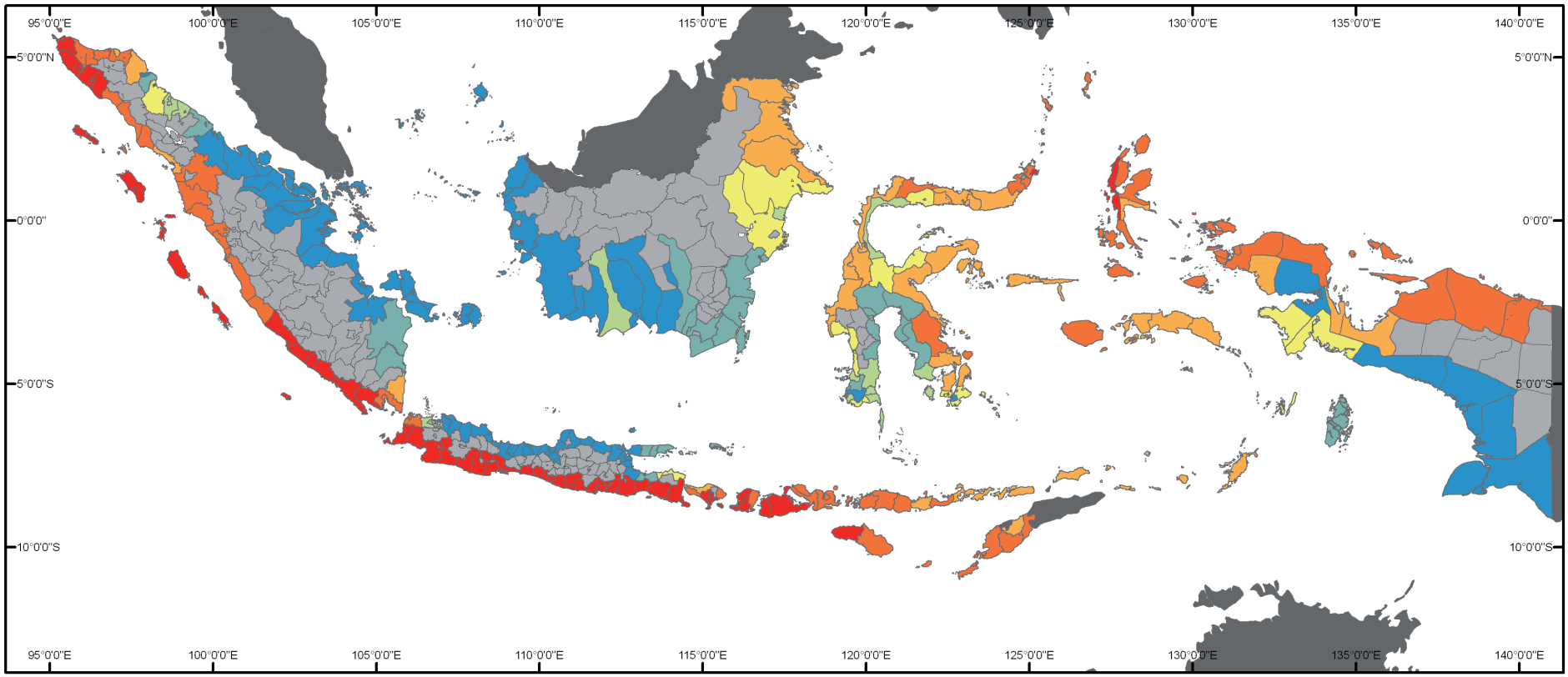


Maximum tsunami height (m)
at the coast for a 100 year return period

0 - 1
1 - 2
2 - 3
3 - 5
5 - 10
10 - 20
> 20

0 500 1,000
Kilometers

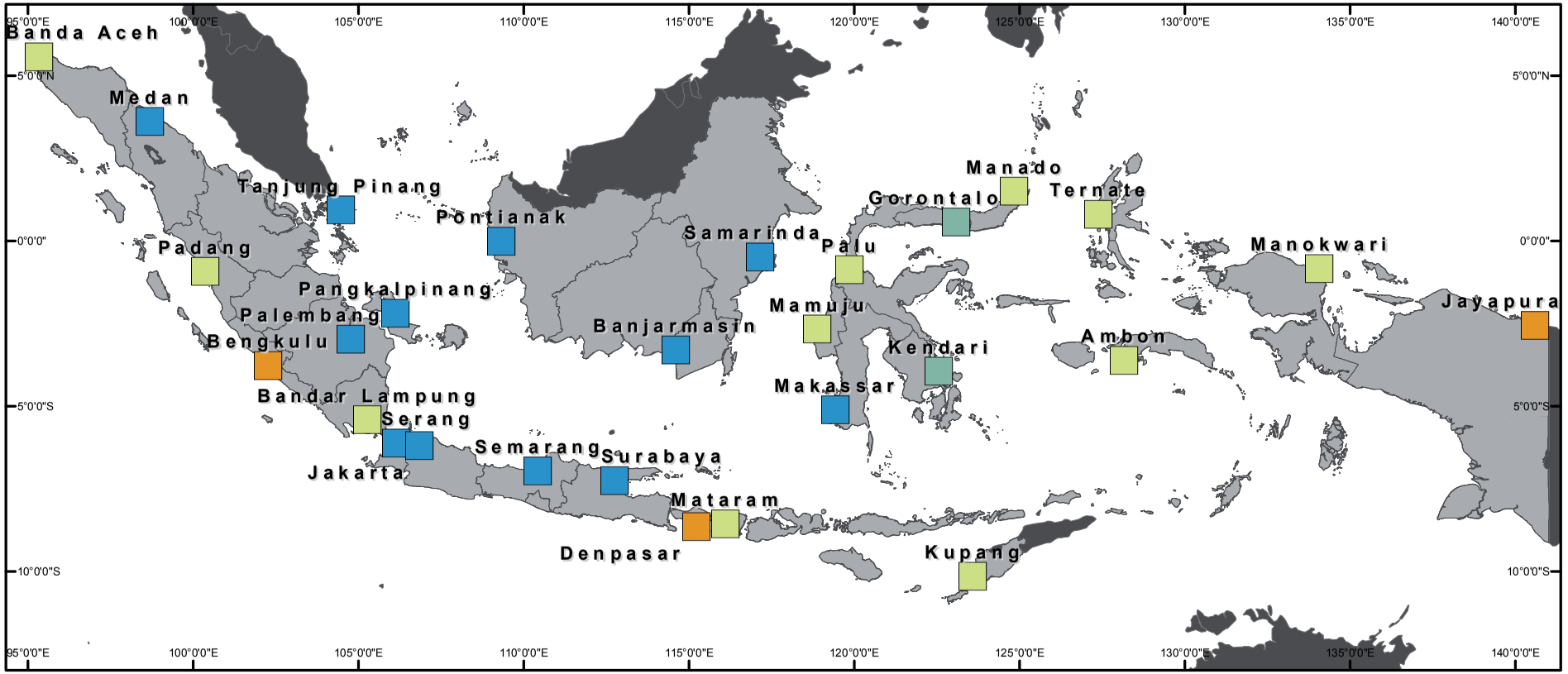

95°0'0"E
100°0'0"E
105°0'0"E
110°0'0"E
115°0'0"E
120°0'0"E
125°0'0"E
130°0'0"E
135°0'0"E
140°0'0"E
5°0'0"N
0°0'0"
5°0'0"S
10°0'0"S
Maximum tsunami height (m)
at the coast for a 500 year return period
0 - 1
1 - 2
2 - 3
3 - 5
5 - 10
10 - 20
> 20
0
500
1,000
Kilometers



Maximum tsunami height (m)
at the coast for a 2500 year return period

0 - 1
1 - 2
2 - 3
3 - 5
5 - 10
10 - 20
> 20

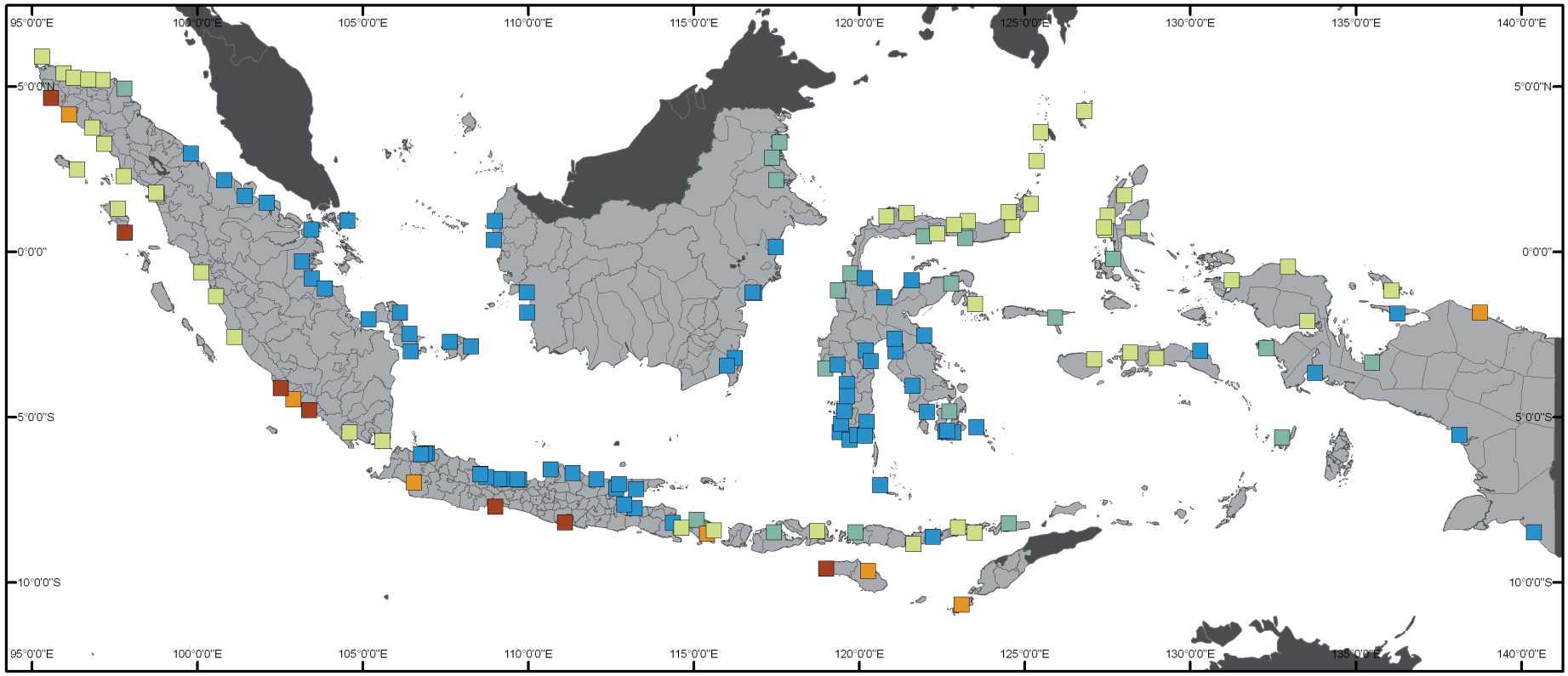
0 500 1,000
Kilometers



Capital cities of provinces showing the probability of experiencing a tsunami with a height at the coast of > 3m in any given year

less than 1/1000 | 1/500 to 1/100 | 1/100 to 1/50
1/1000 to 1/500 | 1/50 to 1/10 | greater than 1/10

0 500 1,000
Kilometers



Locations of towns and cities showing the probability of experiencing a tsunami with a height at the coast of > 3m in any given year

less than 1/1000
1/1000 to 1/500
1/500 to 1/100
1/50 to 1/10
1/100 to 1/50
greater than 1/10

0 500 1,000
Kilometers

Scope

This assessment considers the tsunami hazard posed to Indonesia from tsunami generated by local earthquakes in the Indonesia region, and by distant earthquakes in the Indian Ocean and the Pacific Ocean. The focus on earthquake generated tsunami is justified since over 85% of tsunami recorded in Indonesia have been generated by submarine earthquakes. This assessment does not consider tsunami generated by submarine landslides, volcanoes or asteroids. It should be noted that tsunami caused by these sources have been responsible for considerable loss of life in the past, including the 1883 Krakatau eruption. In addition, earthquakes may trigger submarine landslides leading to locally larger tsunami. Future studies should develop a more complete methodology to include non-earthquake tsunami sources.

It is important to note the tsunami hazard maps are defined at the coastline and cannot be used to directly infer inundation extents, run-ups, damage or other onshore phenomena. To estimate onshore impacts detailed tsunami inundation simulations must be conducted. These simulations require detailed topography in the region of interest

Methodology

Probabilistic tsunami hazard assessments (PTHA) are analogous to probabilistic seismic hazard assessment (PSHA) which is the global standard for defining ground shaking levels for building codes and carrying out earthquake risk assessments. The PTHA method can be summarised as:

1. Determine the earthquake source zones (fault lines) to be included in the study;
2. For each earthquake fault, determine the characteristics (e.g. maximum magnitude, geometry etc.) of the earthquakes that could occur on the fault and the probability of such earthquakes;
3. Simulate all possible earthquakes for each fault and the resulting tsunami. For each coastal location calculate the tsunami waveheight that would result from the tsunami generated by each earthquake;
4. Combine these results to relate the maximum tsunami amplitude at the coast with a probability that they might occur.

The characteristics of each fault were determined using the highest quality data available to the assessment team. This included historical catalogues of earthquakes and tsunami, physical laws on earthquake size, assessments made during the 2010 revision of Indonesia's seismic hazard map, and expert scientific judgement by the assessment team.

Numerical computations were performed to simulate the propagation of tsunami waves from the earthquake fault to the coast. In total, 100,000 synthetic tsunami were simulated and included in the assessment from a total of thirty earthquake faults. Twenty one faults were from around Indonesia and nine were from regional and distant sources in the Indian and Pacific Oceans (see Figures 1 & 2). Results of the simulations were used to estimate the maximum tsunami waveheight at each coastal location around Indonesia for each earthquake. This information is then used to calculate the tsunami hazard for each district.

Limitations

It must be reiterated that this assessment does not provide information on what will happen to the tsunami once it travels onshore, including estimating maximum run-up, inundation extent, damage or other onshore phenomena. To understand the onshore impacts detailed tsunami inundation simulations must be conducted that use high-resolution bathymetry and topography data. This type of simulation can be carried out using tsunami inundation modelling software.

Tsunami simulations are very sensitive to a number of input parameters. These include: the quality and resolution of the nearshore bathymetry, the geometry of the earthquake fault sources, and the earthquake recurrence information. The best available data was used for this assessment, however it must be noted that in general, these parameters are better constrained in western Indonesia (west of Bali) than in eastern Indonesia. It is recommended that future work involve trying to better constrain the geometry of fault sources in East Indonesia and to improve models of earthquake recurrence. There are numerous studies currently underway by Indonesia's earth science research community and as new data is made available the national tsunami hazard assessment should be updated to include this new data. Although estimates of maximum earthquake magnitude used in this study are conservative, lessons from recent tsunami such as the 2011 Tohoku, Japan, tsunami which was larger than expected will also need to be incorporated in future assessments. This will ensure that the national tsunami hazard is based on the best available science information.

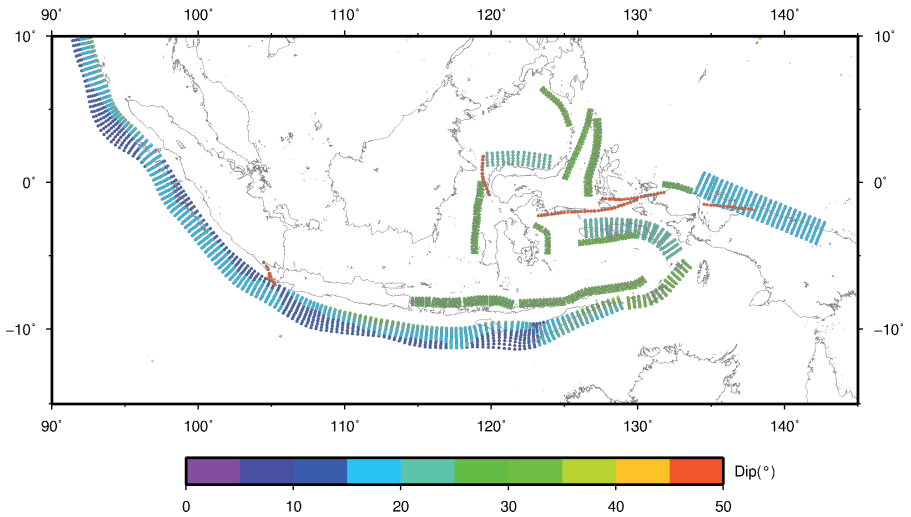


Figure 1. Location of local faults that were used in the PTHA. The colour shows the dip (measured from horizontal) of the fault. High dip angles mean a steep, near vertical fault. Low dip angles mean shallow sloping faults. Typically, the shallower the dip, the larger the potential tsunami.

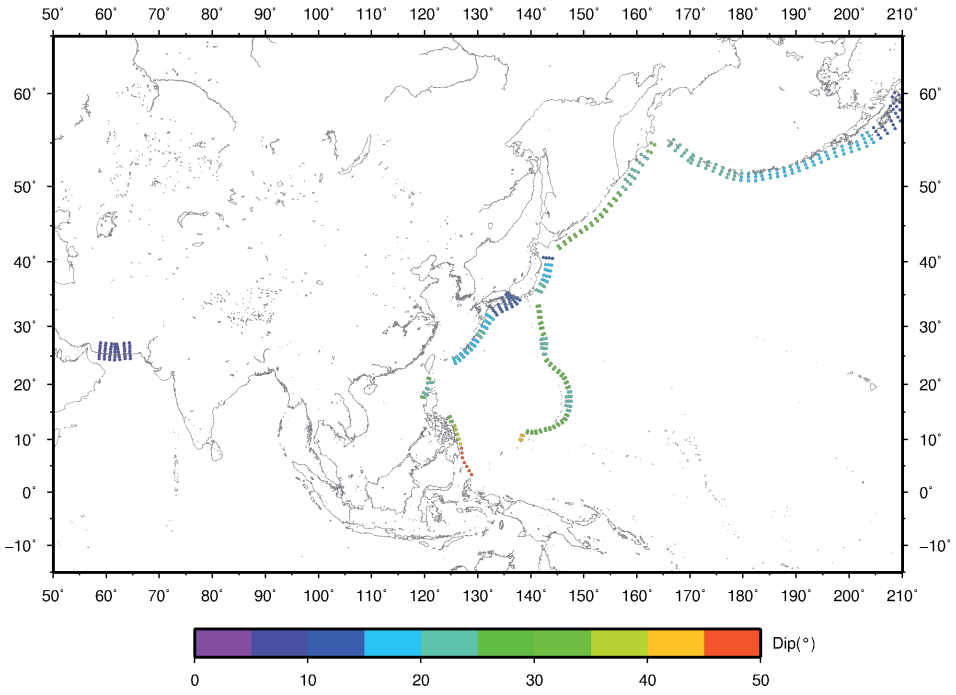


Figure 2. Location of regional and distant fault sources used in the PTHA. The colour of the fault is the angle of the fault dip (see Figure 1 for explanation).

Conclusions

A National Tsunami Hazard Assessment has been completed for Indonesia. The key findings of this assessment are:

- At short return periods the west coast of Sumatra, south coast of Java and Nusa Tenggara Barat have the highest tsunami hazard and can expect tsunami with a height between 5-10 m at least once every 100 years. Eastern Indonesia has a slightly lower tsunami hazard and can expect to have tsunami with heights between 2-3 m over a 100-year period.
- At longer return periods of 500 years parts of Sumatra, including the Mentawai Islands, have the highest tsunami hazard. For this return period there is also very high hazard for southern Java, Bali, Nusa Tenggara, north cost of Papua, northern Sulawesi and Maluku.
- The provincial capital cities most likely to experience tsunami are (in order of highest to lowest) Denpasar, Jayapura, Bengkulu, Ternate, Manado, Banda Aceh, Manokwari, Padang, Ambon and Mataram.
- The regions with the highest chance of experiencing a major tsunami warning (tsunami over 3 m) in any one year are Lampung Barat, the Mentawai Islands and Nias. This is followed by the south coast of Java, the south-west coast of Sumatra and some parts of Bali and Nusa Tenggara Barat, which all have a 2-10% chance.
- There is a greater than 10% chance that somewhere in Indonesia will experience a major tsunami warning (tsunami over 3 m) in any one year. This would warrant a *"major tsunami warning with a red level"* according to the InaTEWS scale;
- For most regions of Indonesia there is a greater than 10% chance of experiencing a tsunami warning (tsunami between 0.5 – 3.0 m) in any one year. This would warrant a *"tsunami warning with an orange level"* according to the InaTEWS scale;
- The locations with the highest chance of experiencing (> 10%) an orange warning are the west coast of Sumatra, south coast of Java, Nusa Tenggara Barat and Nusa Tenggara Timur. The locations with a lesser chance (2-10%) are most locations in eastern Indonesia, including Sulawesi, north Papua and Maluku; and
- Regions with low tsunami hazard are the north coast of Java, east coast of Sumatra, the west and south coasts of Kalimantan and the south coast of Papua.

Key definitions

InaTEWS: Indonesian Tsunami Early Warning System, operated by BMKG. http://inatews.bmkg.go.id

Major tsunami warning (Awas) with red level: Warning issued from the InaTEWS system for regions that can expect a tsunami greater than 3.0 m high at the coast. Province, district and city governments are expected to immediately guide their communities for full evacuation.

Tsunami warning (Siaga) with orange level: Warning issued from the InaTEWS system for regions that can expect a tsunami between 0.5 – 3.0 m high at the coast. Province, district and city governments are expected to immediately guide their communities for evacuation.

Tsunami height at the coast: This assessment is based on tsunami height at the coast. This is defined as the maximum height of the tsunami above mean sea level. Tsunami height is modelled to approximately 200 m water depth and then a scaling relationship (Greens Law) is used to estimate tsunami height at the coast. Actual run-up heights reached by tsunami on land may be higher than tsunami height at the coast.

Run-up height: Maximum height above mean sea level that a tsunami reaches on land. May be higher than tsunami height at the coast. Note that the results of this study cannot be used to directly infer run-up heights.

Appendix One:

Ranking of district by chance of experiencing a "major tsunami" (>3m).

This table shows the chance (%) that each district will experience a major tsunami warning (tsunami > 3 m) in any given year. This can be used to identify the districts most likely to have a major tsunami. Columns 4-6 show the expected tsunami height over 100, 500 and 2,500 year return periods.

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
1	LAMPUNG BARAT	LAMPUNG	7.3%	6.9	15.8	37.1
2	KEPULAUAN MENTAWAI	SUMATERA BARAT	6.9%	7.5	20.6	42.3
3	NIAS	SUMATERA UTARA	5.8%	6.4	11.7	23.7
4	BENGKULU UTARA	BENGKULU	5.2%	5.7	14.4	32.9
5	GARUT	JAWA BARAT	4.9%	6.3	11.5	30.8
6	CIANJUR	JAWA BARAT	4.7%	6.2	11.5	30.0
7	NIAS SELATAN	SUMATERA UTARA	4.1%	5.7	15.9	33.0
8	GUNUNG KIDUL	DAERAH ISTIMEWA YOGYAKARTA	4.1%	6.1	11.1	32.1
9	CIAMIS	JAWA BARAT	3.8%	6.0	11.6	28.2
10	PURWOREJO	JAWA TENGAH	3.8%	6.0	10.9	30.3
11	TASIKMALAYA	JAWA BARAT	3.7%	6.0	11.7	29.4
12	WONOGIRI	JAWA TENGAH	3.5%	5.8	10.8	33.5
13	KAB. BLITAR	JAWA TIMUR	3.5%	6.0	10.9	28.1
14	PANDEGLANG	BANTEN	3.4%	6.3	11.7	26.7
15	SIMEULUE	NANGGROE ACEH DARUSSALAM	3.4%	5.5	11.9	24.3
16	KAUR	BENGKULU	3.3%	5.9	13.0	30.8
17	SUKABUMI	JAWA BARAT	3.3%	5.8	10.6	28.0
18	KEBUMEN	JAWA TENGAH	3.3%	5.6	10.9	31.6
19	SUMBAWA BARAT	NUSA TENGGARA BARAT	3.2%	6.4	12.0	28.3
20	TRENGGALEK	JAWA TIMUR	3.2%	5.8	10.7	28.6
21	TANGGAMUS	LAMPUNG	3.2%	4.1	11.5	30.9
22	SUMBAWA	NUSA TENGGARA BARAT	3.1%	6.1	12.0	29.2
23	CILACAP	JAWA TENGAH	3.1%	5.4	10.6	29.1
24	KULON PROGO	DAERAH ISTIMEWA YOGYAKARTA	3.0%	4.9	9.9	28.6
25	ACEH SINGKIL	NANGGROE ACEH DARUSSALAM	2.8%	4.9	9.2	19.9
26	BADUNG	BALI	2.7%	5.1	9.7	23.8
27	LEBAK	BANTEN	2.7%	5.5	9.9	25.5
28	SUMBA BARAT	NUSA TENGGARA TIMUR	2.7%	5.3	10.4	24.4
29	KLUNGKUNG	BALI	2.6%	5.2	11.4	31.1
30	SELUMA	BENGKULU	2.6%	4.8	10.7	25.1
31	KAB. MALANG	JAWA TIMUR	2.5%	4.7	9.1	25.8
32	PACITAN	JAWA TIMUR	2.5%	4.7	10.1	29.2
33	LOMBOK TENGAH	NUSA TENGGARA BARAT	2.4%	4.7	9.7	24.5

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
34	BANTUL	DAERAH ISTIMEWA YOGYAKARTA	2.1%	4.2	9.5	28.3
35	JEMBER	JAWA TIMUR	2.1%	4.4	9.2	25.9
36	BANYUWANGI	JAWA TIMUR	2.0%	4.3	9.8	27.8
37	BENGKULU SELATAN	BENGKULU	2.0%	4.7	10.4	24.2
38	TULUNGAGUNG	JAWA TIMUR	1.9%	4.2	9.3	26.4
39	DOMPU	NUSA TENGGARA BARAT	1.7%	3.9	8.3	18.6
40	BIAK NUMFOR	PAPUA	1.6%	4.1	10.6	18.7
41	KOTA JAYAPURA	PAPUA	1.6%	4.2	10.0	17.6
42	SUPIORI	PAPUA	1.6%	4.1	10.1	18.1
43	ACEH JAYA	NANGGROE ACEH DARUSSALAM	1.6%	4.0	14.3	31.7
44	ACEH BARAT	NANGGROE ACEH DARUSSALAM	1.5%	4.1	13.7	30.2
45	BENGKULU	BENGKULU	1.5%	4.0	9.3	21.6
46	SUMBA TIMUR	NUSA TENGGARA TIMUR	1.5%	3.8	8.3	18.9
47	SARMI	PAPUA	1.5%	3.8	9.6	16.4
48	TIMOR TENGAH SELATAN	NUSA TENGGARA TIMUR	1.5%	3.8	8.8	16.1
49	BELU	NUSA TENGGARA TIMUR	1.5%	3.8	8.2	14.4
50	KUPANG	NUSA TENGGARA TIMUR	1.4%	3.6	7.7	15.2
51	KUPANG	NUSA TENGGARA TIMUR	1.4%	3.6	7.7	15.2
52	DENPASAR	BALI	1.4%	4.0	8.6	22.7
53	JAYAPURA	PAPUA	1.4%	3.5	10.2	18.2
54	LOMBOK BARAT	NUSA TENGGARA BARAT	1.3%	4.5	9.3	25.1
55	LUMAJANG	JAWA TIMUR	1.3%	3.4	7.5	25.4
56	LOMBOK TIMUR	NUSA TENGGARA BARAT	1.3%	3.1	6.7	18.3
57	ROTE NDA	NUSA TENGGARA TIMUR	1.2%	3.3	7.3	14.4
58	BIMA	NUSA TENGGARA BARAT	1.2%	3.1	7.0	16.6
59	BIMA	NUSA TENGGARA BARAT	1.2%	3.1	7.0	16.6
60	NAGAN RAYA	NANGGROE ACEH DARUSSALAM	1.2%	3.5	12.7	28.6
61	MUKOMUKO	BENGKULU	1.2%	3.3	7.9	16.7
62	HALMAHERA BARAT	MALUKU UTARA	1.2%	3.4	12.2	24.6
63	KOTA BITUNG	SULAWESI UTARA	1.1%	3.2	10.8	21.5
64	HALMAHERA UTARA	MALUKU UTARA	1.1%	3.2	9.4	17.3
65	TABANAN	BALI	1.0%	3.0	7.7	22.3
66	GIANYAR	BALI	1.0%	3.0	7.2	24.3
67	WAROPEN	PAPUA	1.0%	3.1	8.0	13.7
68	KOTA TIDORE KEPULAUAN	MALUKU UTARA	1.0%	3.0	11.9	24.9
69	KOTA TERNATE	MALUKU UTARA	1.0%	3.0	12.3	25.5
70	ACEH BESAR	NANGGROE ACEH DARUSSALAM	1.0%	2.9	16.7	40.5
71	MANOKWARI	IRIAN JAYA BARAT	1.0%	2.9	7.6	13.0
72	KEPULAUAN SANGIHE	SULAWESI UTARA	1.0%	2.9	9.9	17.9
73	MINAHASA UTARA	SULAWESI UTARA	1.0%	2.9	9.0	17.0

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
74	KEPULAUAN TALAUD	SULAWESI UTARA	0.9%	2.8	9.3	18.7
75	SIKKA	NUSA TENGGARA TIMUR	0.9%	2.8	6.5	10.9
76	SORONG	IRIAN JAYA BARAT	0.9%	2.9	7.6	13.7
77	KOTA MANADO	SULAWESI UTARA	0.9%	2.7	7.5	12.3
78	YAPEN WAROPEN	PAPUA	0.9%	2.7	6.9	11.3
79	BUOL	SULAWESI TENGAH	0.9%	2.7	6.7	10.4
80	BANDA ACEH	NANGGROE ACEH DARUSSALAM	0.9%	2.3	14.8	36.8
81	MINAHASA SELATAN	SULAWESI UTARA	0.8%	2.7	7.1	12.0
82	ACEH SELATAN	NANGGROE ACEH DARUSSALAM	0.8%	2.5	6.7	14.9
83	ACEH BARAT DAYA	NANGGROE ACEH DARUSSALAM	0.8%	2.3	7.9	19.1
84	MINAHASA	SULAWESI UTARA	0.8%	2.5	7.6	13.9
85	MANDAILING NATAL	SUMATERA UTARA	0.8%	2.4	6.3	15.0
86	HALMAHERA TIMUR	MALUKU UTARA	0.8%	2.5	6.8	12.2
87	KARANG ASEM	BALI	0.7%	2.5	6.4	18.0
88	ENDE	NUSA TENGGARA TIMUR	0.7%	2.5	5.0	9.9
89	GORONTALO	GORONTALO	0.7%	2.4	6.0	9.6
90	GORONTALO	GORONTALO	0.7%	2.4	6.0	9.6
91	PADANG	SUMATERA BARAT	0.7%	2.4	6.1	11.7
92	SABANG	NANGGROE ACEH DARUSSALAM	0.7%	2.0	9.8	21.8
93	NGADA	NUSA TENGGARA TIMUR	0.7%	2.4	5.1	10.0
94	TOLI-TOLI	SULAWESI TENGAH	0.7%	2.4	5.7	9.5
95	MANGGARAI	NUSA TENGGARA TIMUR	0.6%	2.4	5.5	11.7
96	PESISIR SELATAN	SUMATERA BARAT	0.6%	2.3	6.0	12.3
97	LAMPUNG SELATAN	LAMPUNG	0.6%	2.2	6.3	16.1
98	FLORES TIMUR	NUSA TENGGARA TIMUR	0.6%	2.3	5.1	9.7
99	PADANG PARIAMAN	SUMATERA BARAT	0.6%	2.2	6.1	12.2
100	JEMBRANA	BALI	0.6%	2.3	6.5	19.3
101	AGAM	SUMATERA BARAT	0.6%	1.9	6.1	13.0
102	MALUKU TENGGARA BARAT	MALUKU	0.6%	2.3	4.6	8.4
103	PASAMAN BARAT	SUMATERA BARAT	0.6%	1.9	6.1	13.8
104	BURU	MALUKU	0.5%	2.3	5.2	10.6
105	MANGGARAI BARAT	NUSA TENGGARA TIMUR	0.5%	2.3	5.8	14.8
106	BOLAANG MENGONDOW	SULAWESI UTARA	0.5%	2.1	5.5	9.7
107	KOTA BANDAR LAMPUNG	LAMPUNG	0.5%	2.2	6.2	15.3
108	KONAWE	SULAWESI TENGGARA	0.5%	1.9	5.8	10.9
109	SERANG	BANTEN	0.5%	1.7	4.5	12.6
110	AMBON	MALUKU	0.5%	1.9	5.7	11.7
111	KOTA SORONG	IRIAN JAYA BARAT	0.5%	2.5	5.1	10.2
112	TAPANULI SELATAN	SUMATERA UTARA	0.5%	1.9	4.6	10.3

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
113	PARIAMAN	SUMATERA BARAT	0.5%	1.9	5.4	9.9
114	HALMAHERA TENGAH	MALUKU UTARA	0.5%	2.0	4.2	8.2
115	LEMBATA	NUSA TENGGARA TIMUR	0.4%	2.3	4.1	9.1
116	MATARAM	NUSA TENGGARA BARAT	0.4%	2.1	4.6	12.9
117	PIDIE	NANGGROE ACEH DARUSSALAM	0.4%	1.3	6.4	13.0
118	SORONG SELATAN	IRIAN JAYA BARAT	0.4%	2.1	4.3	8.9
119	HALMAHERA SELATAN	MALUKU	0.4%	1.9	5.3	11.0
120	RAJA AMPAT	IRIAN JAYA BARAT	0.4%	2.5	6.4	11.6
121	KOTA SIBOLGA	SUMATERA UTARA	0.4%	1.7	4.4	9.6
122	BIREUEN	NANGGROE ACEH DARUSSALAM	0.4%	1.3	5.7	12.4
123	TAPANULI TENGAH	SUMATERA UTARA	0.4%	1.7	4.2	9.3
124	MALUKU TENGAH	MALUKU	0.4%	1.9	4.2	8.8
125	MALUKU TENGAH	MALUKU	0.4%	1.9	4.2	8.8
126	MALUKU TENGAH	MALUKU	0.4%	1.9	4.2	8.8
127	KEPULAUAN SULA	MALUKU UTARA	0.4%	1.8	4.3	8.1
128	ACEH UTARA	NANGGROE ACEH DARUSSALAM	0.4%	1.0	4.9	10.4
129	ALOR	NUSA TENGGARA TIMUR	0.4%	2.1	3.7	8.7
130	LHOKSEUMAWE	NANGGROE ACEH DARUSSALAM	0.3%	1.0	4.7	9.8
131	TELUK WONDAMA	IRIAN JAYA BARAT	0.3%	1.8	3.5	7.2
132	MUNA	SULAWESI TENGGARA	0.3%	1.8	3.4	7.5
133	BANGGAI KEPULAUAN	SULAWESI TENGAH	0.3%	1.5	3.5	7.2
134	BULELENG	BALI	0.3%	1.0	3.4	8.1
135	MAJENE	SULAWESI BARAT	0.3%	1.2	3.4	7.4
136	CILEGON	BANTEN	0.3%	1.2	3.6	10.2
137	MAMUJU	SULAWESI BARAT	0.2%	1.6	3.2	7.2
138	KONAWE SELATAN	SULAWESI TENGGARA	0.2%	1.5	3.2	6.9
139	BANGGAI	SULAWESI TENGAH	0.2%	1.3	3.2	6.5
140	PALU	SULAWESI TENGAH	0.2%	1.7	3.0	5.9
141	BOALEMO	GORONTALO	0.2%	1.0	3.1	7.0
142	BONE BOLANGO	GORONTALO	0.2%	1.1	3.1	7.1
143	DONGGALA	SULAWESI TENGAH	0.2%	1.7	3.0	6.0
144	MAMUJU UTARA	SULAWESI BARAT	0.2%	1.6	3.0	6.1
145	TIMOR TENGAH UTARA	NUSA TENGGARA TIMUR	0.2%	1.8	2.9	7.9
146	KOTA KENDARI	SULAWESI TENGGARA	0.2%	1.4	2.9	6.5
147	MOROWALI	SULAWESI TENGAH	0.2%	1.3	2.8	5.7
148	NUNUKAN	KALIMANTAN TIMUR	0.2%	1.5	2.8	6.7
149	ACEH TIMUR	NANGGROE ACEH DARUSSALAM	0.2%	0.5	2.6	6.1
150	BULUNGAN	KALIMANTAN TIMUR	0.2%	1.5	2.7	6.4
151	WAKATOBI	SULAWESI TENGGARA	0.2%	1.6	2.8	5.0
152	MALUKU TENGGARA	MALUKU	0.2%	1.1	2.7	4.3

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
153	NABIRE	PAPUA	0.1%	1.5	2.7	5.2
154	BUTON	SULAWESI TENGGARA	0.1%	1.3	2.5	4.6
155	BERAU	KALIMANTAN TIMUR	0.1%	1.5	2.5	5.2
156	TARAKAN	KALIMANTAN TIMUR	0.1%	1.3	2.4	5.5
157	FAK-FAK	IRIAN JAYA BARAT	0.1%	1.4	2.4	4.5
158	POLMAS	SULAWESI BARAT	0.1%	1.0	2.3	4.0
159	LAMPUNG TIMUR	LAMPUNG	0.1%	0.7	1.5	5.5
160	KUTAI TIMUR	KALIMANTAN TIMUR	0.1%	1.5	2.3	4.1
161	PAHUWATO	GORONTALO	0.1%	0.8	2.2	4.1
162	PINRANG	SULAWESI SELATAN	0.1%	1.0	2.2	4.0
163	KAIMANA	IRIAN JAYA BARAT	0.1%	0.9	1.9	3.1
164	TOJO UNA-UNA	SULAWESI TENGAH	0.1%	0.7	2.0	3.7
165	KUTAI	KALIMANTAN TIMUR	0.1%	1.1	1.9	3.8
166	POSO	SULAWESI TENGAH	0.1%	0.7	2.1	3.6
167	BARRU	SULAWESI SELATAN	0.1%	0.8	2.0	3.3
168	BANTAENG	SULAWESI SELATAN	< 0.1%	0.7	1.7	3.2
169	SITUBONDO	JAWA TIMUR	< 0.1%	0.6	1.7	3.1
170	JENEPONTO	SULAWESI SELATAN	< 0.1%	0.7	1.8	3.1
171	LANGKAT	SUMATERA UTARA	< 0.1%	0.2	1.3	3.1
172	PARIGI MOUTONG	SULAWESI TENGAH	< 0.1%	0.6	1.8	2.9
173	PARE-PARE	SULAWESI SELATAN	< 0.1%	0.8	2.0	3.2
174	SERUYAN	KALIMANTAN TENGAH	< 0.1%	0.4	1.1	2.3
175	BOMBANA	SULAWESI TENGGARA	< 0.1%	0.8	1.7	2.7
176	TANGERANG	BANTEN	< 0.1%	0.2	0.7	2.6
177	TANGERANG	BANTEN	< 0.1%	0.2	0.7	2.6
178	JAKARTA UTARA	DKI JAKARTA	< 0.1%	0.1	0.3	0.8
179	KEPULAUAN SERIBU	DKI JAKARTA	< 0.1%	0.2	0.4	1.4
180	TANJUNG JABUNG T	JAMBI	< 0.1%	0.0	0.0	0.0
181	BEKASI	JAWA BARAT	< 0.1%	0.1	0.2	0.8
182	CIREBON	JAWA BARAT	< 0.1%	0.0	0.0	0.0
183	INDRAMAYU	JAWA BARAT	< 0.1%	0.0	0.1	0.2
184	KARAWANG	JAWA BARAT	< 0.1%	0.1	0.2	0.6
185	KOTA CIREBON	JAWA BARAT	< 0.1%	0.0	0.0	0.0
186	SUBANG	JAWA BARAT	< 0.1%	0.0	0.1	0.4
187	BATANG	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
188	BREBES	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
189	DEMAK	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
190	JEPARA	JAWA TENGAH	< 0.1%	0.0	0.0	0.1
191	KENDAL	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
192	PATI	JAWA TENGAH	< 0.1%	0.0	0.1	0.2
193	PEKALONGAN	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
194	PEKALONGAN	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
195	PEMALANG	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
196	REMBANG	JAWA TENGAH	< 0.1%	0.0	0.1	0.2

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
197	SEMARANG	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
198	SEMARANG	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
199	TEGAL	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
200	TEGAL	JAWA TENGAH	< 0.1%	0.0	0.0	0.0
201	BANGKALAN	JAWA TIMUR	< 0.1%	0.2	0.4	0.9
202	GRESIK	JAWA TIMUR	< 0.1%	0.1	0.3	0.5
203	KAB. PASURUAN	JAWA TIMUR	< 0.1%	0.1	0.4	0.9
204	KAB. PROBOLINGGO	JAWA TIMUR	< 0.1%	0.2	0.5	1.1
205	KOTA PASURUAN	JAWA TIMUR	< 0.1%	0.1	0.4	0.8
206	KOTA PROBOLINGGO	JAWA TIMUR	< 0.1%	0.1	0.4	0.7
207	LAMONGAN	JAWA TIMUR	< 0.1%	0.1	0.2	0.4
208	PAMEKASAN	JAWA TIMUR	< 0.1%	0.2	0.5	1.1
209	SAMPANG	JAWA TIMUR	< 0.1%	0.2	0.4	1.1
210	SIDOARJO	JAWA TIMUR	< 0.1%	0.1	0.4	0.8
211	SUMENEP	JAWA TIMUR	< 0.1%	0.4	1.1	1.9
212	SURABAYA	JAWA TIMUR	< 0.1%	0.1	0.4	0.8
213	TUBAN	JAWA TIMUR	< 0.1%	0.1	0.1	0.3
214	BENGKAYANG	KALIMANTAN BARAT	< 0.1%	0.0	0.1	0.1
215	KETAPANG	KALIMANTAN BARAT	< 0.1%	0.0	0.0	0.0
216	KOTA SINGKAWANG	KALIMANTAN BARAT	< 0.1%	0.0	0.1	0.1
217	PONTIANAK	KALIMANTAN BARAT	< 0.1%	0.0	0.0	0.1
218	SAMBAS	KALIMANTAN BARAT	< 0.1%	0.1	0.1	0.3
219	BANJAR	KALIMANTAN SELATAN	< 0.1%	0.2	0.6	1.1
220	BARITO KUALA	KALIMANTAN SELATAN	< 0.1%	0.2	0.6	1.1
221	KOTA BARU	KALIMANTAN SELATAN	< 0.1%	0.4	0.9	1.1
222	TANAH BUMBU	KALIMANTAN SELATAN	< 0.1%	0.3	0.6	1.1
223	TANAH LAUT	KALIMANTAN SELATAN	< 0.1%	0.3	0.9	1.5
224	KAPUAS	KALIMANTAN TENGAH	< 0.1%	0.2	0.6	1.1
225	KATINGAN	KALIMANTAN TENGAH	< 0.1%	0.1	0.2	0.4
226	KOTAWARINGIN BARAT	KALIMANTAN TENGAH	< 0.1%	0.0	0.0	0.0
227	KOTAWARINGIN TIMUR	KALIMANTAN TENGAH	< 0.1%	0.1	0.2	0.4
228	PULANG PISAU	KALIMANTAN TENGAH	< 0.1%	0.1	0.2	0.4
229	SUKAMARA	KALIMANTAN TENGAH	< 0.1%	0.0	0.0	0.0
230	BALIKPAPAN	KALIMANTAN TIMUR	< 0.1%	0.8	1.3	2.0
231	BONTANG	KALIMANTAN TIMUR	< 0.1%	1.1	1.9	2.8
232	PASIR	KALIMANTAN TIMUR	< 0.1%	0.5	1.1	1.6
233	PENAJAM PASER UT	KALIMANTAN TIMUR	< 0.1%	0.6	1.1	1.6
234	BANGKA	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0
235	BANGKA BARAT	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0
236	BANGKA SELATAN	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0
237	BANGKA TENGAH	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0

Rank	District	Province	Probability of a tsunami with a height at the coast > 3m in a given year	Max tsunami height at the coast for a:		
				100 year return period	500 year return period	2500 year return period
238	BELITUNG	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0
239	BELITUNG TIMUR	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0
240	PANGKAL PINANG	KEPULAUAN BANGKA BELITUNG	< 0.1%	0.0	0.0	0.0
241	KEPULAUAN RIAU	KEPULAUAN RIAU	< 0.1%	0.0	0.0	0.1
242	KOTA BATAM	KEPULAUAN RIAU	< 0.1%	0.0	0.0	0.1
243	LINGGA	KEPULAUAN RIAU	< 0.1%	0.0	0.0	0.1
244	NATUNA	KEPULAUAN RIAU	< 0.1%	0.1	0.2	0.4
245	TULANGBAWANG	LAMPUNG	< 0.1%	0.2	0.4	1.5
246	KEPULAUAN ARU	MALUKU	< 0.1%	0.5	1.2	1.8
247	ACEH TAMIANG	NANGGROE ACEH DARUSSALAM	< 0.1%	0.2	1.0	2.0
248	ASMAT	PAPUA	< 0.1%	0.1	0.1	0.2
249	MAPPI	PAPUA	< 0.1%	0.1	0.1	0.1
250	MERAUKE	PAPUA	< 0.1%	0.0	0.1	0.1
251	MIMIKA	PAPUA	< 0.1%	0.2	0.5	1.0
252	BONE	SULAWESI SELATAN	< 0.1%	0.6	1.4	2.1
253	BULUKUMBA	SULAWESI SELATAN	< 0.1%	0.7	1.7	2.5
254	LUWU	SULAWESI SELATAN	< 0.1%	0.3	0.6	1.3
255	LUWU TIMUR	SULAWESI SELATAN	< 0.1%	0.2	0.5	1.2
256	LUWU UTARA	SULAWESI SELATAN	< 0.1%	0.2	0.5	1.3
257	MAROS	SULAWESI SELATAN	< 0.1%	0.6	1.3	1.8
258	PALOPO	SULAWESI SELATAN	< 0.1%	0.2	0.5	1.1
259	PANGKAJENE KEPULAUAN	SULAWESI SELATAN	< 0.1%	0.6	1.6	2.4
260	SELAYAR	SULAWESI SELATAN	< 0.1%	0.6	1.5	2.8
261	SINJAI	SULAWESI SELATAN	< 0.1%	0.7	1.6	2.4
262	TAKALAR	SULAWESI SELATAN	< 0.1%	0.6	1.6	2.6
263	UJUNG PANDANG	SULAWESI SELATAN	< 0.1%	0.6	1.1	1.9
264	WAJO	SULAWESI SELATAN	< 0.1%	0.3	0.6	1.3
265	KOLAKA	SULAWESI TENGGARA	< 0.1%	0.4	1.0	1.6
266	KOLAKA UTARA	SULAWESI TENGGARA	< 0.1%	0.3	0.6	1.4
267	BANYU ASIN	SUMATERA SELATAN	< 0.1%	0.0	0.0	0.0
268	OGAN KOMERING ILIR	SUMATERA SELATAN	< 0.1%	0.2	0.4	1.5
269	ASAHAN	SUMATERA UTARA	< 0.1%	0.1	0.4	1.1
270	DELI SERDANG	SUMATERA UTARA	< 0.1%	0.2	1.0	2.1
271	DELI SERDANG	SUMATERA UTARA	< 0.1%	0.2	1.0	2.1
272	KOTA MEDAN	SUMATERA UTARA	< 0.1%	0.2	1.1	2.1
273	LABUHAN BATU	SUMATERA UTARA	< 0.1%	0.0	0.1	0.2
196	REMBANG	JAWA TENGAH	< 0.1%	0.0	0.1	0.2

Appendix Two:

Ranking of Capital Cities of Provinces by chance of experiencing a "major tsunami" (>3m at the coast).

This table shows the chance (%) that each provincial capital located within 5km of the coast will experience a major tsunami warning (tsunami > 3 m) in any givenyear. This can be used to identify the cities most likely to have a major tsunami. Columns 5-7 show the expected tsunami height over 100, 500 and 2,500 year return periods.

Rank	City	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
					100 year return period	500 year return period	2500 year return period
1	Denpasar	Bali	1.40%	71	3.1	6	10.8
2	Jayapura	Papua	1.27%	79	3.5	9.9	17.0
3	Bengkulu	Bengkulu	1.20%	82	2.7	5.6	11.6
4	Ternate	Maluku Utara	0.90%	105	2.2	6.8	12.6
5	Manado	Sulawesi Selatan	0.90%	109	2.2	5.3	8.3
6	Banda Aceh	Nanggroe Aceh Darussalam	0.80%	121	1.8	7.2	18.9
7	Manokwari	Papua Barat	0.70%	154	1.9	3.9	7.1
8	Padang	Sumatra Barat	0.60%	174	1.9	4	6.7
9	Kupang	Nusa Tenggara Timur	0.50%	182	2	3.4	6.4
10	Bandar Lampung	Bandar Lampung	0.50%	189	1.8	3.5	7.4
11	Ambon	Maluku	0.50%	202	1.7	3.4	7.3
12	Mataram	Nusa Tenggara Barat	0.40%	226	2	3.2	6.9
13	Palu	Sulawesi Tengah	0.30%	387	1.6	2.5	3.6
14	Mamuju	Sulawesi Barat	0.20%	490	0.9	2.1	3.6
15	Kendari	Sulawesi Tenggara	0.20%	522	1.3	2.1	3.5
16	Gorontalo	Gorontalo	0.20%	544	0.8	2.2	3.5
17	Serang	Banten	0.1%	1420	0.4	1.1	4.5
18	Belawan (Medan)	Sumatra Utara	<0.1%	>2500	0.2	1.1	2.1
19	Samarinda	Kalimantan Timur	<0.1%	>2500	0.9	1.2	1.7
20	Makassar	Sulawesi Selatan	<0.1%	>2500	0.4	0.8	1.4
21	Banjarmasin	Kalimantan Selatan	<0.1%	>2500	0.2	0.4	0.8
22	Jakarta	DKI Jakarta Raya	<0.1%	>2500	0.1	0.3	0.8
23	Surabaya	Jawa Timur	<0.1%	>2500	0.1	0.2	0.4
24	Palembang	Sumatra Selatan	<0.1%	>2500	< 0.01	< 0.01	< 0.01
25	Pangkalpinang	Kepulauan Bangka Belitung	<0.1%	>2500	< 0.01	< 0.01	< 0.01
26	Semarang	Jawa Tengah	<0.1%	>2500	< 0.01	< 0.01	< 0.01
27	Pontianak	Kalimantan Barat	<0.1%	>2500	< 0.01	< 0.01	< 0.01
28	Tanjung Pinang	Kepulauan Riau	<0.1%	>2500	< 0.01	< 0.01	< 0.01

Appendix Three:

Ranking of Towns and Cities by chance of experiencing a "major tsunami" (>3m at the coast).

This table shows the chance (%) that each town or city located within 5km of the coast will experience a major tsunami warning (tsunami > 3 m) in any given year. This can be used to identify the cities most likely to have a major tsunami. Columns 5-7 show the expected tsunami height over 100, 500 and 2,500 year return periods.

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
1	Telukdalam	Nias Selatan	Sumatera Utara	6.6%	15	6.42	13.15	26.22
2	Bondowatu	Sumba Barat Daya	Nusa Tenggara Timur	3.0%	33	5.71	10.99	26.19
3	Kaur	Kaur	Bengkulu	2.9%	34	5.56	11.76	27.76
4	Seluma	Seluma	Bengkulu	2.8%	35	4.71	10.17	24.13
5	Cilacap	Cilacap	Jawa Tengah	2.4%	41	4.78	9.59	24.87
6	Pacitan	Pacitan	Jawa Timur	2.2%	46	4.25	9.83	29.71
7	Calang	Aceh Jaya	Nanggroe Aceh Darussalam	2.0%	50	4.32	12.45	26.95
8	Meulaboh	Aceh Barat	Nanggroe Aceh Darussalam	1.5%	67	3.98	12.49	27.07
9	Pelabuhanratu	Sukabumi	Jawa Barat	1.4%	73	3.47	9.66	29.51
10	Baa	Rote Ndao	Nusa Tenggara Timur	1.3%	75	3.32	6.53	14.27
11	Manna	Bengkulu Selatan	Bengkulu	1.3%	76	3.33	9.57	22.15
12	Sarmi	Sarmi	Papua	1.3%	78	3.54	8.74	15.07
13	Waingapu	Sumba Timur	Nusa Tenggara Timur	1.2%	83	3.27	7.05	15.68
14	Klungkung	Klungkung	Bali	1.2%	85	3.2	8.55	26.28
15	Soasiu	Halmahera Tengah	Maluku Utara	1.0%	100	2.98	11.55	24.48
16	Singkil	Aceh Singkil	Nanggroe Aceh Darussalam	1.0%	104	2.91	5.17	10.97
17	Jailolo	Halmahera Barat	Maluku Utara	1.0%	104	2.84	11.38	22.47
18	Bitung	Kota Bitung	Sulawesi Utara	1.0%	105	2.84	8.57	15.95
19	Tidore	Kota Tidore	Halmahera Utara	0.9%	105	2.82	10.12	20.23
20	Sinabang	Simeuleu	Nanggroe Aceh Darussalam	0.9%	110	2.79	7.68	15.98
21	Talaud	Kepulauan Talaud	Sulawesi Utara	0.9%	110	2.75	8.96	17.78
22	Larantuka	Flores Timur	Nusa Tenggara Timur	0.9%	111	2.85	6.52	11.39
23	Sunkris	Sorong	Irian Jaya Barat	0.9%	114	2.75	7.07	12.35
24	Ende	Ende	Nusa Tenggara Timur	0.8%	119	2.8	5.37	11.35
25	Buol	Buol	Sulawesi Tengah	0.8%	123	2.64	6.54	10.49

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
26	Blangpidie	Aceh Barat Daya	Nanggroe Aceh Darussalam	0.8%	124	2.27	7.74	17.79
27	Kwandang	Gorontalo Utara	Gorontalo	0.8%	129	2.56	6.57	10.5
28	Biak	Biak Numfor	Papua	0.7%	140	2.52	6.44	10.53
29	Belang	Minahasa Selatan	Sulawesi Utara	0.7%	142	2.49	6.45	10.75
30	Kota Agung	Tanggamus	Lampung	0.7%	148	2.51	7.47	25.19
31	Painan	Pesisir Selatan	Sumatera Barat	0.6%	160	2.25	5.7	11.6
32	Mukomuko	Muko-muko	Bengkulu	0.6%	161	2.24	5.68	12.24
33	Amlapura	Karang Asem	Bali	0.6%	161	2.52	6.18	14.1
34	Boroko	Bolaang Mongondow Utara	Sulawesi Utara	0.6%	167	2.19	5.72	8.79
35	Tobelo	Halmahera Utara	Maluku Utara	0.6%	171	2.52	4.86	10.32
36	Negara	Jembrana	Bali	0.6%	178	2.35	6.16	18.42
37	Sabang	Kota Sabang	Nanggroe Aceh Darussalam	0.6%	181	1.63	7.36	15.02
38	Kotabunan	Minahasa Tenggara	Sulawesi Utara	0.5%	190	1.96	5.69	9.66
39	Ondong	Kepulauan Sitaro	Sulawesi Utara	0.5%	202	2.18	5.11	10.76
40	Gunungsitoli	Nias	Sumatera Utara	0.5%	203	2.11	4.93	9.93
41	Tapaktuan	Aceh Selatan	Nanggroe Aceh Darussalam	0.5%	214	1.76	5.17	11.4
42	Pariaman	Kota Pariaman	Sumatera Barat	0.4%	224	1.85	5.37	9.79
43	Namlea	Buru	Maluku	0.4%	224	2.12	3.97	7.65
44	Sorong	Kota Sorong	Irian Jaya Barat	0.4%	227	1.82	5.32	10.2
45	Tahuna	Kepulauan Sangihe	Sulawesi Utara	0.4%	254	2.01	4.23	9.48
46	Maba	Halmahera Timur	Maluku Utara	0.4%	263	1.84	4.13	7.94
47	Kalianda	Lampung Selatan	Lampung	0.4%	271	1.59	4.81	13.94
48	Bima	Kota Bima	Nusa Tenggara Barat	0.4%	271	1.61	4.27	8.83
49	Sigli	Pidie	Nanggroe Aceh Darussalam	0.4%	273	1.16	4.95	10.36
50	Meureudu	Pidie Jaya	Nanggroe Aceh Darussalam	0.4%	273	1.16	4.95	10.36

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
51	Tolitoli	Toli Toli	Sulawesi Tengah	0.4%	274	1.87	3.78	7.36
52	Bireuen	Bireun	Nanggroe Aceh Darussalam	0.4%	275	1.07	5.15	11.2
53	Bintuni	Teluk Bintuni	Irian Jaya Barat	0.3%	291	1.82	3.65	7.2
54	Lhokseumawe	Kota Lhoksumawe	Nanggroe Aceh Darussalam	0.3%	297	1.02	4.47	9.47
55	Piru	Seram Bagian Barat	Maluku	0.3%	298	1.94	3.51	7.08
56	Lewoleba	Lembata	Nusa Tenggara Timur	0.3%	346	2.06	3.37	8
57	Tilamuta	Boalemo	Gorontalo	0.3%	365	1.08	3.34	7.88
58	Banggai	Banggai Kepulauan	Sulawesi Tengah	0.3%	382	1.52	3.29	6.94
59	Sibolga	Tapanuli Tengah	Sumatera Utara	0.2%	402	1.47	3.29	7.14
60	Sibolga	Kota Sibolga	Sumatera Utara	0.2%	402	1.47	3.29	7.14
61	Masohi	Maluku Tengah	Maluku	0.2%	463	1.68	3.07	6.02
62	Kalabahi	Alor	Nusa Tenggara Timur	0.2%	519	1.5	2.93	6.89
63	Labuhan Bajo	Manggarai Barat	Nusa Tenggara Timur	0.2%	530	1.27	2.84	5.63
64	Donggala	Donggala	Sulawesi Tengah	0.2%	534	1.7	2.91	5.94
65	Raha	Muna	Sulawesi Tenggara	0.2%	551	1.68	2.89	5.72
66	Labuha	Halmahera Selatan	Maluku Utara	0.2%	553	1.47	2.82	6.48
67	Sumbawa Besar	Sumbawa	Nusa Tenggara Barat	0.2%	603	1.13	2.77	6.16
68	Singaraja	Buleleng	Bali	0.2%	633	0.74	2.61	6.35
69	Tanjung Selor	Bulungan	Kalimantan Timur	0.2%	642	1.46	2.67	6.09
70	Tarakan	Bulungan	Kalimantan Timur	0.2%	642	1.46	2.67	6.09
71	Nabire	Nabire	Papua	0.1%	693	1.45	2.7	5.53
72	Luwuk	Banggai	Sulawesi Tengah	0.1%	759	1.19	2.45	4.54
73	Suwawa	Bone Bolango	Gorontalo	0.1%	776	0.91	2.52	4.7
74	Tanjungredeb	Berau	Kalimantan Timur	0.1%	778	1.47	2.57	5.67
75	Sanana	Kepulauan Sula	Maluku Utara	0.1%	799	1.74	2.63	4.07

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
76	Fak-Fak	Fak Fak	Irian Jaya Barat	0.1%	808	1.38	2.54	5.19
77	Tual	Maluku Tenggara	Maluku	0.1%	842	1.03	2.72	4.26
78	Malinau	Malinau	Kalimantan Timur	0.1%	859	1.3	2.41	5.48
79	Pasangkayu	Mamuju Utara	Sulawesi Barat	0.1%	922	1.41	2.46	4.64
80	Idi Rayeuk	Aceh Timur	Nanggroe Aceh Darussalam	0.1%	940	0.37	1.91	4.82
81	Marisa	Pohuwato	Gorontalo	0.1%	950	0.85	2.32	4.2
82	Majene	Majene	Sulawesi Barat	0.1%	953	0.91	2.33	3.88
83	Banyuwangi	Banyuwangi	Jawa Timur	0.1%	1081	0.74	2	4.68
84	Serui	Yapen	Papua	0.1%	1229	1.1	2.09	3.76
85	Hoti	Seram Bagian Timur	Maluku	0.1%	1287	1.38	2.17	3.65
86	Poso	Poso	Sulawesi Tengah	0.1%	1464	0.68	2.06	3.56
87	Pasarwajo	Buton	Sulawesi Tenggara	0.1%	1672	0.92	2.16	3.29
88	Wangi-wangi	Wakatobi	Sulawesi Tenggara	0.1%	1675	1.1	2.13	3.23
89	Bonthain	Bantaeng	Sulawesi Selatan	0.1%	1931	0.69	1.74	3.28
90	Maumere	Sikka	Nusa Tenggara Timur	< 0.1 %	2012	0.83	1.98	3.13
91	Pare-pare	Kota Pare-Pare	Sulawesi Selatan	< 0.1 %	2217	0.74	1.85	3.15
92	Pemalang	Pemalang	Jawa Tengah	< 0.1 %	> 2500	0.66	1.78	2.97
93	Tegal	Kota Tegal	Jawa Tengah	< 0.1 %	> 2500	0.73	1.87	2.88
94	Cirebon	Cirebon	ss	< 0.1 %	> 2500	0.73	1.76	2.86
95	Tanjung Balai	Kota Tanjung Balai	Sumatera Utara	< 0.1 %	> 2500	0.73	1.76	2.86
96	Kuala Tungkal	Tanjung Jabung Barat	Jambi	< 0.1 %	> 2500	0.49	1.73	2.68
97	Sungai Gerong	Banyuasin	Sumatera Selatan	< 0.1 %	> 2500	1.1	1.73	2.63
98	Toboali	Bangka Selatan	Bangka Belitung	< 0.1 %	> 2500	0.6	1.53	2.47
99	Sungai Liat	Bangka	Bangka Belitung	< 0.1 %	> 2500	0.41	1.49	2.4
100	Tanjungpandan	Belitung	Bangka Belitung	< 0.1 %	> 2500	0.6	1.56	2.36

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
101	Tuban	Tuban	Jawa Timur	< 0.1 %	> 2500	0.66	1.6	2.35
102	Rembang	Rembang	Jawa Tengah	< 0.1 %	> 2500	0.73	1.79	2.33
103	Probolinggo	Kodya Probolinggo	Jawa Timur	< 0.1 %	> 2500	0.63	1.5	2.27
104	Pasuruan	Kodya Pasuruan	Jawa Timur	< 0.1 %	> 2500	0.64	1.52	2.15
105	Gresik	Gresik	Jawa Timur	< 0.1 %	> 2500	0.58	1.55	2.03
106	Sampang	Sampang	Jawa Timur	< 0.1 %	> 2500	0.63	1.51	2.03
107	Bangkalan	Bangkalan	Jawa Timur	< 0.1 %	> 2500	0.56	1.1	1.92
108	Batang	Batang	Jawa Tengah	< 0.1 %	> 2500	0.29	0.64	1.4
109	Pekalongan	Kota Pekalongan	Jawa Tengah	< 0.1 %	> 2500	0.46	1.06	1.39
110	Jepara	Jepara	Jawa Tengah	< 0.1 %	> 2500	0.46	1.06	1.39
111	Merauke	Merauke	Papua	< 0.1 %	> 2500	0.33	0.67	1.36
112	Tembilahan	Indragiri Hil	Riau	< 0.1 %	> 2500	0.23	0.52	1.31
113	Dumai	Kota Dumai	Riau	< 0.1 %	> 2500	0.24	0.55	1.29
114	Bagasiapiapi	Rokan Hilir	Riau	< 0.1 %	> 2500	0.4	0.9	1.14
115	Bengkalis	Bengkalis	Riau	< 0.1 %	> 2500	0.23	0.5	1.13
116	Sumber	Cirebon	Jawa Barat	< 0.1 %	> 2500	0.22	0.48	1.12
117	Muara Sabak	Tanjung Jabung Timur	Jambi	< 0.1 %	> 2500	0.37	0.78	1.12
118	Tanjung Pinang	Bintan	Kepulauan Riau	< 0.1 %	> 2500	0.17	0.44	1.06
119	Koba	Bangka Tengah	Bangka Belitung	< 0.1 %	> 2500	0.14	0.38	0.84
120	Muntok	Bangka Barat	Bangka Belitung	< 0.1 %	> 2500	0.11	0.25	0.84
121	Manggar	Belitung Timur	Bangka Belitung	< 0.1 %	> 2500	0.11	0.25	0.84
122	Cilincing	Kota Jakarta Utara	DKI Jakarta	< 0.1 %	> 2500	0.11	0.25	0.84
123	Tanjungpriok	Kota Jakarta Utara	DKI Jakarta	< 0.1 %	> 2500	0.13	0.37	0.83
124	Kapuk	Kota Jakarta Utara	DKI Jakarta	< 0.1 %	> 2500	0.13	0.36	0.74
125	Kaimana	Kaimana	Irian Jaya Barat	< 0.1 %	> 2500	0.11	0.26	0.46

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
126	Agats	Merauke	Papua	< 0.1 %	> 2500	0.03	0.17	0.44
127	Tanjung Balai Karimun	Karimun	Kepulauan Riau	< 0.1 %	> 2500	0.08	0.2	0.44
128	Takalar	Takalar	Sulawesi Selatan	< 0.1 %	> 2500	0.06	0.15	0.34
129	Jene Ponto	Jeneponto	Sulawesi Selatan	< 0.1 %	> 2500	0.04	0.1	0.17
130	Sungguminasa	Gowa	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.08	0.16
131	Palopo	Kota Palopo	Sulawesi Selatan	< 0.1 %	> 2500	0.03	0.04	0.14
132	Baubau	Kota Baubau	Sulawesi Tenggara	< 0.1 %	> 2500	0.03	0.04	0.14
133	Pangkajene	Pangkajene Kepulauan	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.03	0.11
134	Polewali Mandar	Polewali Mandar	Sulawesi Barat	< 0.1 %	> 2500	0.02	0.03	0.1
135	Sinjai	Sinjai	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.03	0.1
136	Bulukumba	Bulukumba	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.03	0.1
137	Barru	Barru	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.02	0.04
138	Kolaka	Kolaka	Sulawesi Tenggara	< 0.1 %	> 2500	0.02	0.02	0.04
139	Benteng	Selayar	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.02	0.02
140	Belopa	Luwu	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.02	0.02
141	Kolaka Utara	Kolaka Utara	Sulawesi Tenggara	< 0.1 %	> 2500	0.02	0.02	0.02
142	Malili	Luwu Timur	Sulawesi Selatan	< 0.1 %	> 2500	0.02	0.02	0.02
143	Parigi	Parigi Moutong	Sulawesi Tengah	< 0.1 %	> 2500	0.02	0.02	0.02
144	Baubau	Kota Baubau	Sulawesi Tenggara	< 0.1 %	> 2500	0.02	0.02	0.02
145	Bonegunu	Buton Utara	Sulawesi Tenggara	< 0.1 %	> 2500	0.02	0.02	0.02
146	Bungku	Morowali	Sulawesi Tengah	< 0.1 %	> 2500	0.02	0.02	0.02
147	Ampana	Toja Una-Una	Sulawesi Tengah	< 0.1 %	> 2500	0.02	0.02	0.02
148	Cirebon	Kota Cirebon	Jawa Barat	< 0.1 %	> 2500	0.02	0.02	0.02
149	Singkawang	Kota Singkawang	Kalimantan Barat	< 0.1 %	> 2500	0	0.01	0.02
150	Ketapang	Ketapang	Kalimantan Barat	< 0.1 %	> 2500	0.02	0.02	0.02

Rank	City	Kabupaten	Province	Probability of a tsunami with a height at the coast of > 3m in a given year	Average return period (years) of a tsunami at the coast of > 3m	Tsunami height (m) at the coast for a		
						100 year return period	500 year return period	2500 year return period
151	Kualakapuas	Kapuas	Kalimantan Tengah	< 0.1 %	> 2500	0.01	0.02	0.02
152	Kotabaru	Kota Baru	Kalimantan Selatan	< 0.1 %	> 2500	0.02	0.02	0.02
153	Balikpapan	Kota Balikpapan	Kalimantan Timur	< 0.1 %	> 2500	0.02	0.02	0.02
154	Mempawah	Pontianak	Kalimantan Barat	< 0.1 %	> 2500	0.02	0.02	0.02
155	Sukadana	Kayong Utara	Kalimantan Barat	< 0.1 %	> 2500	0	0.01	0.02
156	Batulicin	Tanah Bumbu	Kalimantan Selatan	< 0.1 %	> 2500	0.02	0.02	0.02
157	Panajam	Penajam Paser Utara	Kalimantan Timur	< 0.1 %	> 2500	0.02	0.02	0.02
158	Bontang	Kota Bontang	Kalimantan Timur	< 0.1 %	> 2500	0.02	0.02	0.02

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