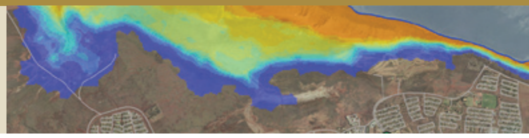
Australian Government
Geoscience Australia

AUSGEO news
ISSUE 93 Mar 2009

Scientific expertise and emergency management

Successful collaboration for safer communities



Jane Sexton, Ole Nielsen, David Burbidge and Trevor Dhu

Geoscience Australia's Risk and Impact Analysis Group has been working together with state and Australian Government emergency management agencies in recent years to help build safer communities in Australia by developing tools and information to underpin our planning and preparation for tsunamis.

"The effective collaborations with state and Australian Government emergency management agencies have been underpinned by quality science."

Science and emergency management

Effective emergency management for natural disasters comprises four key processes: planning, preparation, response and recovery. The planning and preparation components are typically applied before a natural hazard event occurs whilst the response and recovery components are applied during and after an event. The two main actions during the planning and preparation phases are:

- development of mitigation strategies
- education to create community awareness of the risks associated with natural disasters.

The response and recovery phases involve community action such as evacuation and post-disaster clean-up operations, as well as rebuilding of infrastructure and social networks.

Geoscience Australia plays an important role in supporting effective emergency management in the planning and preparation stages. The key activity underpinning the development of mitigation strategies is the assessment of risk from natural hazards. Currently, the agency has a program to monitor and assess earth-surface processes which pose a risk to Australia and to develop and apply methodologies for risk modelling.

Geoscience Australia has adopted a quantitative 'all-hazards' approach to understanding impact and risk from natural hazards. This approach aligns with current Australian emergency management practices where plans are also developed in an 'all-hazards' context. Consequently, the processes described here for tsunami planning and preparation apply to other hazards as well.

Partnership to understand risk and raise awareness

The tragic events of the Indian Ocean tsunami on 26 December 2004 highlighted shortcomings in the alert and response systems for tsunami threats to Western Australia's (WA) coastal communities. To improve community awareness and understanding of tsunami hazard and potential impact for Western Australia, the Fire and Emergency Services Authority of WA (FESA) established a collaborative partnership with Geoscience Australia in which scientific knowledge and emergency management expertise was applied to identified communities.

This partnership relied on effective communication between scientists, emergency managers, data custodians and the community as well as the development and implementation of a best practice methodology. As a result of this, tsunami preparation and emergency response plans have been formulated following community engagement workshops which increased stakeholder awareness of the science involved as well as the risk of tsunami.

Scientific process and the big questions

The scientific process was driven by the information requirements of emergency managers and local land-use managers which had been identified during workshops across the state. Their specific questions included:

- the maximum credible tsunami
- the likelihood of large tsunami
- the time between the earthquake event and arrival at the coast
- the extent of inundation from a tsunami impact
- the likely damage
- the likely differences if the tsunami arrives at the location at different tide levels.

It is not currently possible to determine the extent of inundation for the entire length of the Western Australian coastline because of the time required to collect all the necessary bathymetry data and run the numerical models for the selected tsunami events. As a result, a prioritisation process was necessary to decide which locations would be selected to determine in detail the inundation extent and impact. Each tsunami scenario consists of a tsunami event, a tide level and a community.

FESA worked with Geoscience Australia to develop a systematic prioritisation process based on best available evidence of potential tsunami threats. A key input was provided by Geoscience Australia through the development of the Western Australian Tsunami Hazard Map that identified regions where the offshore hazard (defined as minimum wave height for a given probability of exceedance) was highest (Burbidge et al 2008: see link below). In conjunction with a community profiling process undertaken by FESA, a number of communities were then prioritised for detailed assessments.

The tsunami hazard map not only served as an input to the prioritisation process, it also allowed the selection of possible tsunami events for each community. Once a number of 'worst-case' scenario events were chosen, the remaining questions could then be addressed for the identified locations (Stevens, Hall and Sexton 2008). This was mainly through using inundation maps (see example in figure 1). The assessment also included an additional output from the modelling which was based on maps showing maximum flow speed from the tsunami scenarios. While initial attention had focused on the onshore impact of tsunamis on communities,

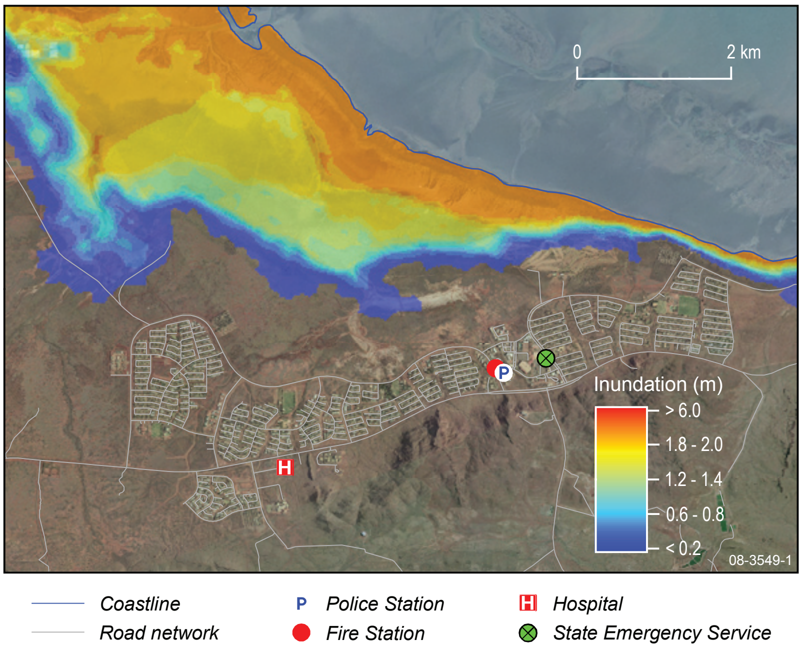


Figure 1. Maximum inundation map at Highest Astronomical Tide. Image courtesy of Landgate.

the noticeable offshore threat resulting from strong currents generated by tsunamis were also taken into account.

With modelled results in hand, FESA and Geoscience Australia conducted stakeholder workshops to discuss the best approach, identify key areas of interest and seek feedback on the credibility of the results, to determine if the inundation results were believable. This is vital as the community itself has a more detailed understanding of their local area than central agencies. Another key aspect of the workshops was to ensure that the results were understood in context. That is, the results were produced for selected events only, and did not necessarily represent all possible scenarios in which a tsunami event occurs. The results were indicative only and were only one component in any decision-making process.

Community awareness and education

Emergency Management Australia (EMA), an agency of the Australian Government, is charged with the development of community awareness and education products at a national level. This supports the capability of the state and territory agencies in planning and preparing for tsunami risk. As a result of collaboration between EMA, the Bureau of Meteorology and Geoscience Australia, the Introduction to Tsunami for Emergency Managers workshop (ITEM) was developed. ITEM provides information on the detection, alert and warning processes, the tsunami science, the risk modelling methodology as well as emergency management arrangements. The underlying intent of ITEM is to 'train the trainers', whereby

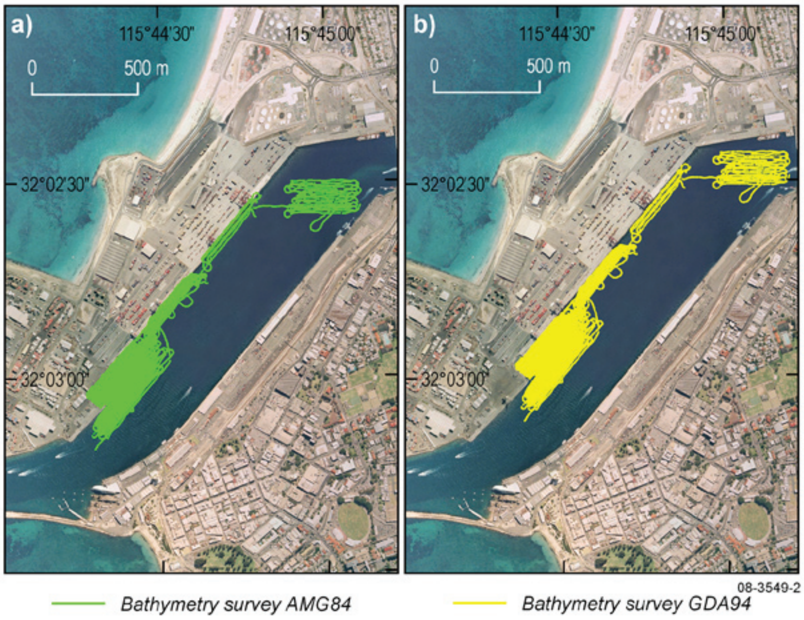


Figure 2. Data errors: datum issues in bathymetry (a) AMG84 and (b) GDA94. Image courtesy of Landgate. Bathymetry supplied by Department for Planning and Infrastructure, Western Australia.

the relevant state and territory agencies can then further provide tsunami awareness and education within their communities.

Geoscience Australia also assisted in raising community awareness and strengthening ties with local emergency services in partnership with FESA through a recent graduate project in Onslow, Western Australia, (*AusGeo News* 89). A community-specific tsunami awareness brochure produced by the Geoscience Australia graduates was distributed to key community and emergency personnel during information-sharing presentations at community meetings.

The run-up survey conducted by Geoscience Australia after the 17 July 2006 tsunami impact at Shark Bay in Western Australia also assisted FESA's community awareness and education activities by providing the first fully documented tsunami impact on Australia. The tsunami destroyed several campsites, inundated up to 200 metres inland and transported a 4WD vehicle ten metres. The survey found widespread erosion of roads and sand dunes, deposition of fish, starfish, corals and sea urchins well above the regular high-tide mark, as well as extensive vegetation damage indicating a run-up height exceeding seven metres. This event has 'made it real' for emergency managers and provided a local example to illustrate the difference between wave height (the amplitude of the approaching wave) and run-up height (the highest point on shore that was inundated). Typically, the latter is much greater than the former. This activity also demonstrated the role of tsunami geology in understanding tsunami hazard and risk.

Underpinning science

The effective collaborations with state and Australian Government emergency management agencies have been underpinned by quality science. The tsunami risk modelling methodology has undergone continuous development since 2005 (Nielsen et al 2006) and relies on understanding the sources that generate tsunamis, the propagation of tsunamis through the ocean, as well as their behaviour as they reach the coast and flow onshore. This knowledge is then combined with information about particular communities (Nadimpalli 2007) to assess the potential impact of an event. This methodology can be described in five key steps:

1. ***Define a source model.*** The first step involves identifying potential tsunami sources —earthquake, landslide, volcano or meteorite—and modelling the magnitude and frequency of tsunami they generate.
2. ***Simulate the tsunami using a deep-water propagation model.*** Once a tsunami is generated it often has to travel across an expanse of ocean to reach the coastline of interest. This process is modelled by a deep-water propagation model, which simulates the tsunami from the source to the shallow water off the coast of interest, typically 100 metre water depth. If the tsunami source is very close to the community of interest, this step may be omitted.
3. ***Simulate the tsunami in shallow-water and onshore using an inundation model.*** Once the tsunami enters shallow water, typically defined as a depth of 100 metres or less, an inundation model is used to simulate the tsunami as it approaches land and flows onshore. Inundation models use a more sophisticated numerical technique than deep-water propagation models, reflecting the more complex flow patterns observed as tsunamis are affected by local bathymetry and topography or even buildings.
4. ***Define structural vulnerability models.*** Vulnerability is a broad measure of the susceptibility to suffer loss or damage. Structural vulnerability models describe the type and amount of damage that a particular type of structure may experience from a given tsunami.
5. ***Combine with an exposure database for the area of interest.*** To understand the impact a tsunami may have on a community, it is necessary to know which buildings and infrastructure are potentially exposed to the tsunami. This information is held in an exposure database (Nadimpalli 2007).

In summary, the tsunami risk assessment process combines the results of the hazard modelling (which areas of the community would get wet, how deep the water would get and how fast it would move) together with vulnerability models (how buildings and people will respond to the water level and flow) with the exposure database (where buildings are located as well as their characteristics) to allow us to estimate the number of people and buildings affected by a given tsunami.

Limitations of the risk assessment approach

In communicating model outputs it is important to stress that 'models are only a representation of what may happen'. From the mathematical description of the model to its computational implementation and further to the model's inputs, a series of assumptions have been made. The methodology itself is underpinned by an evolving science of tsunami modelling and Geoscience Australia has made efforts to validate the individual components of the methodology using wave tank experiments (Nielsen et al 2005) and tide gauge data where available. A recent model of the 2004 Indian Ocean tsunami impact at Patong Beach has also validated the modelling methodology using an historic event. As data becomes available, further validation tests will be conducted.

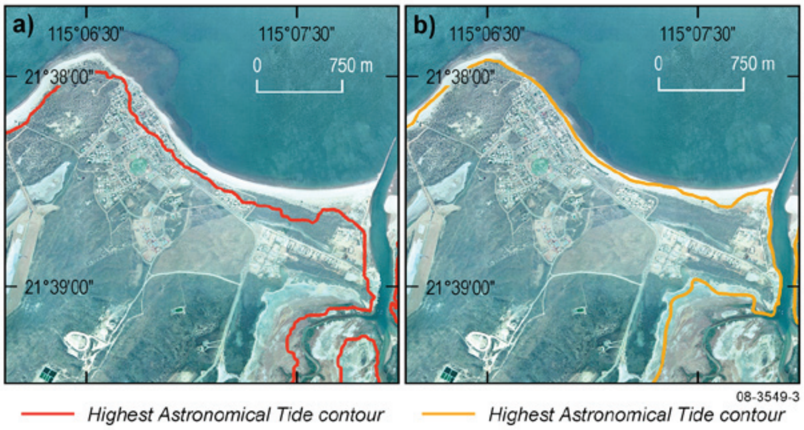


Figure 3. Data errors: accuracy in topography. Image shows highest astronomical tide contour for two data sets (a) 30 metre Digitial Terrain Elevation Data Level 2 and (b) Landgate 20 metre Orthophoto Digital Elevation Model. Image courtesy of Landgate.

The FESA-Geoscience Australia partnership has played a crucial role in highlighting the importance of high quality bathymetric and topographic elevation data when it comes to estimating tsunami impact at the community level. FESA's networks within state and local government have proved crucial in sourcing the best available data and supporting metadata. However, some of the data has gaps and verification of its quality has not always been easy or possible (figures 2a, b and 3a and b).

Summary

Geoscience Australia has worked in partnership with state and Australian Government emergency management agencies to manage tsunami risk in Australia. In particular, the FESA and Geoscience Australia partnership has improved community safety in WA by raising community awareness and providing a solid platform of knowledge, on which emergency managers can base their planning. These plans are therefore based on a realistic and quantitative understanding of the likely consequences of a tsunami. The project has also served to emphasise and highlight phenomena associated with tsunami that must be managed for an effective response, such as, large currents and localised extreme run-ups. In order for Geoscience Australia to effectively collaborate in this way, the underpinning science has to be continually tested for its quality.

For more information

phone Jane Sexton on +61 2 6249 9841
email jane.sexton@ga.gov.au

The author

Jane Sexton was a Distinguished Geoscience Australia Lecturer (DGAL) for 2008, and this article is based on her DGAL presentation.

References

Burbidge D, Cummins PR, Mleckzo R & Thio HK. 2008. A probabilistic tsunami hazard assessment for Western Australia, Pure and Applied Geophysics, 165:2059–2088. DOI 10.1007/s00024-008-0421-x.

www.springerlink.com

Graduate project strengthens community ties. 2008. AusGeo News 89.

www.ga.gov.au/ausgeonews/ausgeonews200803/inbrief.jsp#inbrief1

Nielsen O, Sexton J, Gray D & Bartzis N. 2006. Modelling answers tsunami questions. AusGeo News 83.

www.ga.gov.au/ausgeonews/ausgeonews200609/modelling.jsp

Nadimpalli, K. 2007. Safeguarding Australia. AusGeo News 88.

www.ga.gov.au/ausgeonews/ausgeonews200712/nexis.jsp

Nielsen O, Roberts S, Gray D, McPherson A, & Hitchman A. 2005. Hydrodynamic modelling of coastal inundation. MODSIM 2005, International Congress on Modelling and Simulation. Modelling and Simulation Society of Australian and New Zealand. 518-523.

www.mssanz.org.au/modsim05/papers/nielsen.pdf

Stevens R, Hall G & Sexton J. 2008. Tsunami planning and preparation in Western Australia: application of scientific modelling and community engagement. Australian Journal of Emergency Management. 23, 4:30–36.

www.ema.gov.au

Related articles/websites:

Shark Bay tsunami impact, 17 July 2006.

www.ga.gov.au/image_cache/GA10828.pdf

Tsunami threat map (Fire and Emergency Services, Western Australia)

www.fesa.wa.gov.au/internet/default.aspx?MenuID=372