Meeting of the HB Civil Defence Emergency Management Group Joint Committee

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Hawke's Bay Regional Council
159 Dalton Street
NAPIER

Attachments excluded from Agenda

Strengthening Civil Defence Emergency Management in Hawke's Bay

Review of Civil Defence Emergency Management in Hawke's Bay based on Events and Lessons from 2020

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*Contextus*Solutions thanks and is very grateful to all of those personnel from emergency service, council, CDEM, iwi Māori and community organisations that provided their time, expertise and input to this Review. The Review would not have been possible without them.

Contents

Glossary of Abbreviations

BAU	Business as Usual
BCP	Business Continuity Plan
CDEM	Civil Defence Emergency Management
CEG	Coordinating Executive Group
CHBDC	Central Hawke's Bay District Council
CIMS	Coordinated Incident Management System
EOC	Emergency Operations Centre
FENZ	Fire and Emergency New Zealand
GECC	Group Emergency Coordination Centre
HBDHB	Hawke's Bay District Health Board
HBRC	Hawke's Bay Regional Council
HDC	Hastings District Council
ICT	Information and Communication Technology
IMT	Incident Management Team
NCC	Napier City Council
NEMA	National Emergency Management Agency
NKII	Ngāti Kahungunu Iwi Incorporated
RAG	Rural Advisory Group
WAG	Welfare Advisory Group
WDC	Wairoa District Council

Strengthening Civil Defence Emergency Management in Hawke's Bay: Review of Civil Defence Emergency Management in Hawke's Bay based on Events and Lessons from 2020

Executive Summary

Viewed as a whole, the Hawke's Bay CDEM system and collective capability has real strengths. Key outcomes were delivered for the community during the events of 2020. However, these events also highlighted a number of opportunities to further strengthen the Hawke's Bay CDEM system.

Relationships are generally strong and constructive between CDEM Partner Agencies and participants. An Emergency Services Coordinating Committee provides for strong working relationships across agencies, and constructive working relationships are in place at governance and management levels and among Group and Local Controllers.

However, there are opportunities to develop relationships further and strengthen support mechanisms for CDEM leaders and community welfare networks. Recommendations are made in this Review to undertake work in these critical areas. Recommendations are divided into ***priority recommendations*** and ***other recommendations***; all of the recommendations are regarded as important improvement opportunities however the Review regards the ***priority recommendations*** as being of first order importance. These should be addressed with urgency.

CDEM arrangements and capability can be strengthened through the introduction of a Common Operating Platform to facilitate inter-agency communication and the management of information. This is currently a missing link.

A reset of the Response structure, and roles and responsibilities to better reflect the organisational and operating context in Hawke's Bay will also lead to strengthened capability. The current operating framework and structure has become too centralised, particularly with respect to the Napier and Hastings Council areas. Resetting this framework and structure to provide for local level response management working under a Group Emergency Coordination Centre (GECC) will better reflect the organisational context and community expectations that currently exist.

The Review suggests that the CDEM work programme should be rebalanced to place greater emphasis on operational readiness in Response and Recovery activities. The CDEM Group Office has, since its effective formation in 2011, delivered an approved work programme to address the 4Rs of emergency management (Reduction, Readiness, Response and Recovery) and enhance the technical knowledge and capacity of the collective CDEM enterprise. This has seen some very high-quality work done in line with Government guidelines and requirements. It is timely now however, to place greater relative emphasis on strengthening operational readiness in the Response and Recovery spheres. Steps to achieve this are set out below.

Ensuring that the resourcing of Response and Recovery activities is adequate after a period of multiple activations is a key step that can be taken as part of good operational Readiness planning. The CDEM resourcing model is based on staff being drawn from across councils to fill Response and Recovery roles in an emergency event. Staff training and ensuring the availability of staff are issues that need ongoing attention.

Within Response arrangements, greater focus should be given to the issues of when Recovery work should commence. Guidance for this issue should be developed and Recovery planning work updated. Greater attention and emphasis should also be given to Recovery planning and activity overall. Coordination with Lifeline utilities during emergency activations should also be an area of focus.

Welfare arrangements should also be reset to ensure Hawke's Bay makes best use of its community and Council welfare capability while providing strong regional coordination and support. The work of the Rural Advisory Group and the Tihei Mauri Ora Network and Taiwhenua were real success stories during 2020, but better support mechanisms for these networks can be put in place. The demanding *Needs Assessment* process also needs to be appropriately resourced and coordinated.

Formalised relationship and representation arrangements with iwi/Māori in Hawke's Bay would also strengthen CDEM capabilities. Steps to consider these arrangements are recommended.

It is recommended that CEG and the Joint Committee put in place a change programme to drive and coordinate the improvement opportunities identified. This change programme should be adequately resourced and worked through with key stakeholders. It would be neither fair nor effective to expect the Group Office to manage the initiatives identified as part of 'business as usual'.

Overall, the current and planned resourcing of the collective Hawke's Bay CDEM 'enterprise' (i.e., the Group Office) may be sufficient if the reset and rebalancing work recommended takes place and the councils ensure that resourcing commitments are honoured. However, the quantum of resourcing required against what is currently allocated should be assessed as the change programme is worked through. Additional resourcing will be required to enact the change programme so as not to negatively impact response capability.

It is noted that the Government is conducting a review of CDEM. The Change Programme arising out of this review should be revisited once the outcomes of the Government review are known.

Hawke's Bay's CDEM arrangements functioned adequately for the community during the events of 2020. However, in every emergency event there are opportunities for improvement. The CDEM Partner agencies have a good opportunity to learn from the events of the previous year and strengthen their capabilities, and Response and Recovery arrangements, for the benefit of the communities of Hawke's Bay. The recommendations below and the detailed commentary, observations and advice set out in this report are designed to enable them to seize that opportunity.

Recommendations

[Recommendations should be read in the context of the commentary contained in the body of the report]

Priority Recommendations

1. **That the Coordinating Executive Group commission a reset of the Operating Framework and the Response Structure, Roles and Responsibility to provide for a Group Emergency Coordinating Centre, and a Local Emergency Operations Centre/Incident Management Team in each Council area. These arrangements will better reflect the context that Civil Defence Emergency Management is operating within in Hawke's Bay. This reset should specifically address and take account of:**
    a. **community expectations of Council assistance and response,**
    b. **effective support for Mayoral leadership and spokesperson roles,**
    c. **council capabilities including (but not limited to) welfare, lifeline utility and building inspections,**
    d. **the need for effective regional coordination, and**
    e. **the efficiency and coordination benefits for Emergency Service organisations in having a high-functioning Group Emergency Coordination Centre.**

2. **That the Coordinating Executive Group initiate an urgent 'rebalancing exercise' on the Group Work Programme with a view to presenting a new programme to the Coordinating Executive Group and the CDEM Group Joint Committee. The Rebalancing Exercise should place greater emphasis on Operational Readiness, Response and Recovery Activities including:**
    a. **Development of a shared Common Operating Platform and ICT system (see 3 below)**
    b. **The Operating Framework and structure, roles and responsibilities reset recommended in 1 above**
    c. **Revision of training and capability development programmes**
    d. **A review of resourcing and staffing as recommended in 4 below**
    e. **Staff recruitment, rostering, training and relationship development for Response and Recovery**
    f. **Readiness monitoring**
    g. **Response and Recovery support systems, including facility capacity and resilience, and back up options**
    h. **Recovery planning and establishment.**

3. That as a component of the rebalanced CDEM work programme, the Coordinating Executive Group initiate the development, with partner agencies, of a Common Operating Platform for CDEM Response. This should be based on CIMS and include an appropriate ICT system or systems and agreed processes for issues such as building inspection.
4. That the Coordinating Executive Group commission an urgent review of staffing and resourcing arrangements for the Group Emergency Coordination Centre and Council Incident Management Teams/Emergency Operations Centres to ensure sufficient resourcing is in place to support both Response and Recovery activities in an emergency event.
5. That Council Chief Executives provide concerted leadership focus within their Council organisations to ensure that agreements made at the CDEM Group Joint Committee and the Coordinating Executive Group, particularly in relation to resourcing commitments and Response structures, roles and responsibilities, are honoured and given effect to.
6. That, in order to give effect to the above and other recommendations, the Coordinating Executive Group put in place a change programme to drive and coordinate the improvement opportunities recommended here and identified in this report. The change programme should be sufficiently resourced to support the changes identified and ensure that the programme does not impact upon the need to maintain operational readiness. The change programme should be agreed with and regularly reported on to the CDEM Joint Committee.

Other Recommendations

7. That a reset of Welfare arrangements be carried out in order to strengthen Welfare coordination and delivery. This reset should make changes that enable the following:
    a. Optimal use of relationships with and support for community welfare networks (e.g., Taiwhenua, Rural Advisory Group)
    b. Local authority welfare delivery
    c. Effective regional coordination of welfare activities and resourcing, including coordination with NEMA and national welfare agencies
    d. Appropriate Group led delivery of Needs Assessment work.
8. That as a component of the rebalanced CDEM work programme, CDEM Group Staff in conjunction with appropriate council staff, commence work to enhance relationships and develop support protocols with welfare response agencies including the Tihei Mauri Ora Network and the Taiwhenua, and the Rural Advisory Group. Staff support for the Rural Advisory Group during activations should be considered as part of this work.

9. That as a component of the rebalanced CDEM work programme, training, exercising and relationship development programmes be reviewed to ensure they are fit-for-purpose, appropriately targeted and not imposing too great a burden on participating agencies.
10. That CDEM Group staff programme further opportunities for developing effective working relationships, job familiarity and support mechanisms for senior leaders within Hawke's Bay CDEM. This should include the Mayors and Regional Council Chair, Controllers and senior Response personnel, and senior Emergency Service personnel. Greater levels of support for Mayor and the Regional Council Chair as lead spokespersons and community leaders are essential.
11. That CDEM Group Staff develop guidance for Controllers and schedule discussions in Controller meetings so that a greater focus on Recovery is provided for within event responses.
12. That the Coordinating Executive Group initiate programmes of work to enhance capability, planning, readiness and relationships in the areas of Recovery and Lifeline Utility Response coordination. The new resource budgeted for in 2021/22 will greatly assist with this however consideration should be given to ensuring the appropriate 'level' of resourcing is engaged in the work in its 'establishment phase'.
13. That the Coordinating Executive Group commission a project to establish a common approach and processes for assessing buildings during an emergency event as to whether they are inhabitable or not. This project should include developing a common platform, approach and system for this area of work. Parties involved in the project need to include the four territorial authority councils, FENZ, HBDHB/Public Health and the CDEM Group. The approach should be based on standard practice within New Zealand unless there are compelling reasons to depart from this.
14. That the CDEM Group Joint Committee and the Coordinating Executive Group seek advice and consider the appointment of appropriate iwi representation on the Joint Committee and the Coordinating Executive Group.
15. That the CDEM Group Joint Committee and the Coordinating Executive Group consider further action in relation to this review once the outcomes of the Government CDEM Review are known.
16. That consideration be given within the Public Information work programme to developing a resource library for use in emergency events.
17. That consideration be given to inviting the Hawke's Bay District Health Board to explore with CEG how public health perspectives might be utilised to strengthen CDEM arrangements.

Strengthening Civil Defence Emergency Management in Hawke's Bay: Review of Civil Defence Emergency Management in Hawke's Bay based on Events and Lessons from 2020

Introduction

The year 2020 was unprecedented in the history of emergency management in Hawke's Bay, and indeed New Zealand. Against the background of an international pandemic, increasing natural hazard events and a changing climate, the emergency management system has come under more pressure than ever before. The system operates within a changing society grappling with broader issues including inequality, housing shortage, mental health issues, drug use and more, all of which can make emergency management efforts more challenging. The levels of complexity the system is dealing with and the complexity of the system itself have risen significantly. And public and political expectations of what the system will deliver increase after each response event.

These factors make emergency management a vitally important function in a rapidly evolving environment. Following a series of emergency events that affected Hawke's Bay in 2020, the Chief Executives of the five Hawke's Bay Councils commissioned a review (the Review) of Civil Defence Emergency Management (CDEM) in the Hawke's Bay Region. The purpose of the Review is to ensure that this important part of the public sector can continue to operate effectively for the communities it serves within the changing context it faces. The objective is to enhance the capability of the emergency management system and build a higher performance operating model and systems.

Brief and Methodology

Brief/Terms of Reference

The purpose, problem definition and scope for the Review are set out in the Terms of Reference which is attached as appendix one. Key elements are listed here for clarity.

The Review is to "*provide advice to the Chief Executives ... on operational mechanisms to support effective responses to natural disasters and other emergencies in Hawke's Bay.*" Further, the purpose of the review is to "*ensure that our emergency response framework and system is well placed to respond to current and future emergencies.*" The existing system is being reviewed in order to "*further enhance and strengthen the current system and processes across the whole* [CDEM] *Group emergency management response system.*"

The problem definition states that "*the purpose of the review is to ensure that Hawke's Bay's CDEM operational response framework, and Council's roles & responsibilities in responding to events are; fit-for-purpose; an adaptive and rapid learning system; and are well placed to meet future challenges including concurrent emergencies.*" "*The current structures, processes and* *roles need to align with the expectations for system performance." … "The system must be flexible enough to adjust during the response phase and transition seamlessly into a recovery phase. Relationships and clarity of roles and responsibilities is critical."*

The scope of the Review is set out in the Terms of Reference as follows:

"The work will examine:

- *The current statutory model and operational response framework of lead and support agencies to manage response and recovery to emergencies.*
- *The roles and responsibilities between responding organisations, including interdependencies between national, regional, and local entities.*
- *The accountability and reporting pathways for executive management and governance structures.*
- *Decision making, chain of command, communication and handover processes including:*
  - *Activation of staff and mobilisation of regional response structures*
  - *Resourcing and sustaining emergency response*
  - *Clarity of the chain of command and its appropriateness*
  - *Preparedness and training of staff*
  - *Response & Recovery capability and capacity*
  - *Barriers to effective command and control, coordination, and communication*
- *Problems and issues encountered and identified through the COVID-19 pandemic, drought and flood events*
- *System capacity and resourcing to effect the leanings and opportunities from 'event reviews' back into the system in a timely manner. We expect this to include training of staff/keeping abreast of changing staff and council turnover rates*
- *An assessment of ICT systems to ensure that Hawke's Bay is utilising the best systems and technology where possible. This includes information, capacity of systems, resiliency, redundancy and toolsets*
- *General assessment of other risks including: appropriate buildings for all levels of response; vertical evacuation options*
- *Review of the formation of an IMT when group are forming at the same time"*

Methodology and Programme Outline

The Review was undertaken utilising the following methodology:

a. Documentation Review

A review of the existing operating frameworks and statutory documentation was carried out to establish the baseline expectations CDEM is operating under and the arrangements and resourcing in place. Discussions were held with the CDEM Group Controller/Manager to better understand existing arrangements.

b. Review of 2020 Event Debrief/Review Reports

Post-event reviews from 2020 were reviewed and analysed in order to identify the lessons learnt and improvement opportunities identified.

c. Engagement with Key/Nominated council and CDEM Personnel and Key Stakeholders

Engagement sessions were held with personnel from CDEM Partner agencies and stakeholders to elicit feedback on system performance and opportunities for improvement. An engagement framework was developed to underpin this exercise. Engagement sessions were held with the following Groups/senior personnel from the following organisations:

- CDEM Joint Committee Members (Regional Council Chair and Mayors)
- CDEM Group Staff
- Central Hawke's Bay District Council
- Coordinating Executive Group
- Fire and Emergency New Zealand
- Hastings District Council
- Hawke's Bay District Health Board
- Hawke's Bay Regional Council
- Napier City Council
- National Emergency Management Agency
- New Zealand Police
- Rural Advisory Group
- Te Taiwhenua o Heretaunga
- Te Taiwhenua o Tamatea
- Te Taiwhenua o Te Whanganui ā Orotū
- Te Taiwhenua o Wairoa
- Wairoa District Council

Input was also sought from Ngāti Kahungunu Iwi Incorporated.

d. Analysis of Engagement Feedback

Qualitative analysis work was carried out on the information gathered through the engagement process document review. Key themes were identified to underpin recommendations and commentary on opportunities to strengthen the CDEM system.

e. Assessment of the Adequacy and Robustness of CDEM ICT Systems

As part of the terms of reference, an assessment of the suitability of ICT systems in use was requested. Discussion prompts on this review topic were incorporated into the Engagement Framework and prompted useful feedback from participants on ICT systems and the need for a common operating platform.

f. Commentary and Recommendations

Based on the analysis and assessment of post-event reviews and discussions with key participants, partners and stakeholders, observations, conclusions and recommendations have been arrived at. Observations and recommendations are presented that will allow the Coordinating Executive Group and CDEM network participants to strengthen response and recovery arrangements and address any areas of relative vulnerability that have emerged through recent emergency events.

Themes Emerging from the Engagement Process and Post Event Reviews

This section of the report identifies and discusses the main themes that emerged from the Review. Themes that emerged strongly through the analysis of documentation, post-event reviews and engagement form the main part of the discussion. However, useful observations that may be incidental to the main themes of the report are also highlighted where it is considered they can add value.

This report has not repeated all of the findings and recommendations of the post-event review reports. The HBCDEM Group, and its constituent partner agencies, should review and act upon the various detailed recommendations emerging from these reports. It is noted that the Group has already put in place review and improvement initiatives in relation to a number of the recommendations included in post-event reviews.

This report focuses on what it sees as critical key themes that have emerged from the engagement and analysis carried out. These have been grouped together in a manner that is hopefully logical and useful to the intended audience.

Themes

1. Relationships are King…and need to be further developed and maintained

One of the recurring themes to emerge from the Review is the importance of relationships in enabling successful response and recovery operations to be carried out.

Overall, important relationships within Hawke's Bay CDEM are very strong. This was highlighted in a number of engagement sessions and reinforced in some of the post-event reviews. Multiple engagement participants pointed to the role played by the Emergency Services Coordinating Committee in building strong, face-to-face, high-trust, collaborative relationships between key personnel across emergency service organisations including CDEM. These relationships have proved vital in building effective responses to the emergency events of 2020, particularly in the early stages of events when information can be sketchy and things, by the very nature of most emergencies, can be chaotic.

Relationships at CDEMG Joint Committee and CEG level are constructive and collaborative, and increasingly focused on homing in on opportunities for developing community resilience and the effectiveness of Response and Recovery arrangements. This Review in itself is an example of that focus.

The work led by Group staff in building relationships between Group and Local Controllers by meeting together regularly has also contributed significantly to common approaches, increased inter-operability and ability for personnel from different councils to support communities and councils outside of their own patch.

Another area where strong relationships were particularly evident was the Pandemic response arrangements within Wairoa and Central Hawke's Bay. The existing relationships between the respective councils and with their local NGOs, particularly the respective

Taiwhenua organisations, and the local knowledge and relationships these organisations had with their communities, really was a case of "small being beautiful". These Taiwhenua community networks existed in the larger local authority areas as well. Opportunities for strengthening these relationships are commented on below.

While these examples are among the success stories, there is also scope to strengthen Response and Recovery arrangements by developing relationships further.

Working relationships between Controllers, key Emergency Service personnel and Mayors and the Regional Council Chair should be a focus of greater attention. While these relationships are acceptable currently, the roles of the Mayors and the Chair, as spokespeople and community leaders during a response, need to be given greater levels of support. This needs to happen both prior to and during emergency events. Mayors and the Chair should be involved in preparing for Response activities through exercises and regular interactions with Controllers and other key personnel. It is vital that key response leaders have a working familiarity with their roles and with each other, and have confidence to communicate with each other openly and frankly. Contact to build these relationships should be deliberately programmed. The Group Controller/CDEM Manager, assisted by the CEG Chair and CDEM Group Joint Committee Chair, needs to play a strong and proactive leadership role in this relationship development work.

Building relationships and coordination and support mechanisms between CDEM and Council staff and community welfare organisations should also be an area for focus. This is commented on further below.

Relationships between Controllers can likewise be further strengthened. The regular meetings of Controllers occurring currently are very good. However, all personnel that may end up filling Controller roles need to be involved regularly. The involvement of Alternate Controllers is essential – while they are currently invited, their attendance and involvement would help strengthen the depth of the region's capability. 'Churn' among controllers should also be minimised as much as possible.

A targeted approach to improving training and exercising will also help in building effective working relationships among CDEM staff from different Partner organisations.

2. Collective Responsibility for CDEM Needs Reinforcement

Engagement sessions held during the Review often included comments or language that pointed to a perception of the Group or CDEM being a standalone organisation or entity with accountabilities separate to the councils and other CDEM partners. These comments were reinforced by issues and patterns of behaviour on the part of council personnel that were captured in some of the post-event reviews.

CDEM activity is a shared and collective responsibility. The principal body responsible for CDEM in Hawke's Bay under the Act is the CDEMG Joint Committee. This is a Joint Committee of all five local authorities in the region. It has a responsibility for collective governance. While the Hawke's Bay Regional Council plays the role of administering authority, employer of CDEM

Group staff and provides resourcing for Group operations, each council has an equal, shared and collective responsibility for ensuring CDEM arrangements function effectively and are adequately resourced (particularly via staffing during and following an emergency event). Alongside the councils, Emergency Service organisations also have obligations to contribute to the effective functioning of CDEM arrangements.

Roles and responsibilities for CDEM are, by design, shared across the central Group 'organisation' and the local authorities and other 'partner' agencies that make up or are affiliated to the Group. This sharing is central to the CDEM Act 2002 and is carried through to Hawke's Bay CDEM Group Plan and subsidiary documents.

The post-event reviews and engagement show that Hawke's Bay Communities were generally served well by the CDEM response. However, in every emergency response there are always opportunities for improvement. The events of 2020 highlight an opportunity for the collective responsibility for CDEM activity to be reinforced through the agencies involved, particularly within the five councils.

The CDEMG Joint Committee and the Coordinating Executive Group appear to understand well the collective nature of the responsibility for CDEM activities. They appear to operate effectively and discharge their responsibilities under the Act well. From the engagement and information review that formed part of this review, good relationships are evident between the individuals and organisations operating at these governance and management levels. Collective and District/Regional responsibilities appear to be understood and well balanced.

Two particular areas of focus emerge where the governance and management layers of CDEM can act to strengthen the effectiveness of CDEM arrangements in Hawke's Bay. These are firstly, the priorities of the CDEM work programme, and secondly, ensuring that decisions, priorities and resourcing expectations agreed at the Joint Committee or CEG flow through to, and are honoured within their respective organisations.

A suggested basis for realignment the CDEM work programme is addressed in detail in a separate section of the report below.

Ensuring that decisions, priorities and resourcing expectations agreed at the Joint Committee or at CEG are understood and committed to within their organisations needs to be a key focus area for Joint Committee and CEG members. This is particularly important in respect of the councils, which are not *disciplined* organisations in contrast to Emergency Service organisations.

There were instances during some of the 2020 events where collective decisions were not fully implemented or accorded priority. These instances relate to roles and responsibilities, the command-and-control structure and resource availability, and are highlighted in some of the post-event reviews examined.

Resource availability is key in ensuring CDEM can operate effectively in an emergency. The Napier Flood Event highlighted difficulties in obtaining staff to operate both the Group ECC and the Napier IMT. Staff identified for GECC duties, could not be reached, declined to attend, or were not released from BAU duties. This impacted upon the scope of work and the support to Napier City Council and emergency services that the GECC could provide. It also meant that Police staff ended up covering Intelligence roles in the GECC that should have been filled by staff from councils. Napier City Council also reported that GECC resourcing requirements had an impact on their ability to meet there own BCP requirements, lifeline and welfare requirements.

Staff availability for training and exercising is another area where agreed collective priorities are sometimes not reflected in day-to-day, line management decision-making. It is vital that organisational decision-making is consistent with agreed CEG and CDEMG priorities. Group staff advise that staff who respond to GECC activations consistently state that they have not received enough training, however when training is provided many staff fail to attend or are not released from BAU duties.

Emergency management, particularly in the context of an emergency event, is a statutory and essential function of local government. It is a critical activity that councils contribute to in order to ensure the safety and welfare of their residents and the protection of property. Prioritisation and the allocation of resourcing in both peacetime and during an activation should reflect this. For the most part it does in Hawke's Bay, however, there are opportunities for the implementation of priorities to be reinforced within organisations. This needs to be a leadership priority. Aligning roles and responsibilities to better reflect the operating context for CDEM with Hawke's Bay will also assist organisational leaders in achieving this.

3. Response Framework and Roles and Responsibilities should be better aligned with Hawke's Bay's Operating Context

Hawke's Bay has evolved its Roles and Responsibilities model, Response Framework and operating approach under the Act to a more centralised model than previously. It is among the most centralised when compared with other CDEM Groups. The approach outlined in the Roles and Responsibilities document and the Response Framework (2019) sees a move away from Local EOCs in Napier and Hastings Council areas, with response functions including welfare coordination and delivery, response management, public information, volunteer management assigned to the GECC. The Councils take on more of a business continuity focus. Recognising the relative distance and isolation of Wairoa and Central Hawke's Bay, Local Emergency Operations Centres/Incident Management Teams are retained for those Districts, with the Group playing coordinating and support roles rather than organising the on-the ground emergency response.

The experience in the region in 2020 suggests there is a need to revisit the Response Framework and the structure and roles and responsibilities therein. This is a formal recommendation of one of the Napier Flood post-event Reviews and was touched on either directly or indirectly by a majority of engagement participants.

While the more centralised structure and framework has been approved by CDEMG and CEG, it is evident that this structure is not understood, supported or bought into by all participants at operational levels. IMTs have operated at Napier and Hastings Councils in recent events despite not being a formal part of the approved CDEM operating model. Departures from adopted structure do not aid a coordinated approach between the GECC and councils, and can drive a tendency toward duplication of response efforts and inefficient use of resources.

It is also apparent that the adopted structure is not well understood in the community.

The context that partner organisations are operating in is important when considering structure, roles and responsibility. There are currently four territorial authorities and one regional council in Hawke's Bay. The populations in each of the territorial authorities look to their councils and Mayors to provide support and leadership in an emergency event. The Councils have capabilities in welfare, building assessment and public works that can be very useful in an emergency event. The current structure, with a centralised operating model in respect of Napier and Hastings, is not necessarily best suited to the reality of this organisational and community context.

The drivers from those contextual factors also need to be balanced with considerations of efficient resource allocation and regional and national coordination. A Group Response plays a key role in addressing these considerations. Emergency Service organisations are clear that they do not have the resource capacity to provide liaison resources across the GECC and four Local EOCs as well as fulfill their own organisational Response and BAU requirements. A Group Response facility provides a necessary and central point of liaison for those organisations.

For emergency events that span more than one territorial authority, regional prioritisation and coordination of resources can be an essential function. Some welfare resources are best liaised with and directed regionally. Likewise, coordination with NEMA and the National Crisis Management Centre is a vital role for the Group, particularly where more than one council area is affected by an emergency event.

Given this context, the Region's structure, roles and responsibilities for Response should be reset to better align with the community expectations and organisational realities that CDEM operates within. Specifically, Local Emergency Operations Centres/Incident Management Teams should be reintroduced for Napier and Hastings (alongside those existing in Wairoa and Central Hawke's Bay). These Local EOCs will undertake delivery and coordination of local response functions and report to the GECC. The GECC will provide regional coordination and undertake those functions best delivered at a regional level. This reset needs to balance the community expectation for local assistance and leadership with the requirements for regional prioritisation and efficient coordination and the ability for personnel to be able to operate across different parts of the system as exigencies demand (interoperability).

If this model is pursued, ensuring there is adequate resourcing allocated to it will be vital. Assisting in emergency response and recovery needs to be made a fundamental part of the roles of all council staff. When staff are responding to an activation, they need to be freed up from BAU duties. There were reports of instances during the pandemic and flood responses where staff finished an GECC/IMT shift only to return to their BAU work. This places unfair pressure on staff, can create significant fatigue risks and mean that response and recovery activities will not necessarily get the focus they require.

4. A greater focus should be placed on Capability Development, Coverage and Training

Depth of capability and coverage can be issues for most organisations. How do you fill a hole created when a critical person is away or leaves the organisation? How do you ensure critical knowledge and expertise is held across an organisation or group of organisations rather than by individuals?

Putting in place and delivering training and collaboration mechanisms to build greater depth in resourcing and share knowledge across CDEM emerged as a theme throughout the engagement process. Changes in personnel, absences of key staff, and not having all cover personnel fully trained can hamper Response efforts. As an example, the absence of the experienced Local Controller during the Napier Flood Event did not aid the establishment and management of response efforts or coordination between Group and Local Response teams. The alternate Local Controller was recently appointed and not fully trained. The experience and relationships of the primary Controller would have assisted significantly.

Parallels to this specific example can be seen across CDEM staffing arrangements. From time to time, staff experienced in CDEM leave their organisations. Events can occur before the Training and Exercise system has caught up with their replacement. This can mean lesser experienced and/or untrained staff being asked to perform roles in the GECC or other facilities.

Despite this reality, greater emphasis should be placed on the recruitment and training of GECC and IMT staff to build capability and coverage. There is a Training programme in place. However, delivery can sometimes be held up and commitment to attendance by council staff (or their managers) is not always strong. Training should be reviewed to make sure it is fit-for-purpose and timely but involves as small a time commitment as possible to achieve the results desired. Regular refresher sessions and mini-exercises should be scheduled. The Mayors, Regional Council Chair and other key elected members should be involved in training and exercising with respect to their declaration, spokesperson and leadership roles. This will build their familiarity with Controllers and senior personnel. Alongside this, organisational leaders need to ensure staff are available for training and exercises. This availability needs to be built into BAU work programmes. Staff opting to avoid training (and activations) or being withheld by line managers has been commonly cited as a problem during the Review. This situation cannot be permitted to continue given the priority of effective Response and Recovery activities in an emergency event.

5. Inter-agency coordination and communication during a Response is Vital...

Inter-agency relationships and collaboration can generally be rated as strong in Hawke's Bay. The Emergency Services Coordinating Committee works effectively in maintaining relationships, Controller 'get-togethers' are in place, CEG and CDEMG operate collaboratively, and the Welfare Coordination Group and the 'Network of Networks' enable coordination across and between organisations and less formal groups.

Steps can be taken though to improve communication, particularly during a response. Improving coordination between the Group and Councils is an area highlighted for attention in one of the Napier Flood reviews. The need for a Common Operating Platform is addressed elsewhere in this report but is vital. Focus should also turn to ensuring alternate office holder in key roles are fully trained and brought into the appropriate relationship building fora.

Once the structure and roles and responsibilities have been revised as outlined above, CEG need to ensure that all partners understand the lead agency concept. This includes understanding the sorts of events different agencies will be lead agency for and the role of CDEM and other emergency services in providing welfare activity and other powers, resourcing and support to the community and in support of the lead agency.

As an example, the pandemic response saw Health as the clinical response lead in terms of providing healthcare and public health advice and regulation. When a state of emergency was declared, CDEM assumed lead agency status for the wider emergency. Regulatory enforcement and welfare support were provided by the Police and networks and agencies under CDEM respectively. Coordination between the parties, for instance on the status of regulatory powers or the official authorisation of community networks, is vital for ensuring partner agencies have the confidence and legal surety to act.

6. …Meaning the Lack of a Common Operating Platform is a Key Gap

The development of a Common Operating Platform using an appropriate and agreed ICT system has emerged during this review as a high-priority area of focus. The lack of a shared system impedes optimal information sharing and communication. The issue is addressed in the 'ICT System Needs and a Common Operating Platform' section of the report below.

7. The Group Work Programme should be Rebalanced

Over the last decade, CDEM in Hawke's Bay has worked methodically to improve community resilience, reduce hazards and build capability. The Group Plan and specific strategies have been developed and adopted. Work programmes have been prepared by the Group Office in consultation with partner agencies, and shaped and approved by CEG and the CDEM Group Joint Committee. National direction and requirements from MCDEM/NEMA have been incorporated into plans and programmes. Group staff appear to have worked diligently and effectively to put agreed priorities and work programmes into effect.

Some very good readiness planning work has been done as part of this programme. However, the demands on the Group arising out of Group Plan priorities and national/legislative requirements have tended to drive emphasis toward some of the more technical and planning dimensions of the Group's work.

After analysis of the post-event reviews and engagement sessions, this review concludes that a rebalancing of the Group work programme would be beneficial to Response and Recovery operations in Hawke's Bay CDEM. While planning and technical work remains important and should be factored into the work programme, there needs to be a period of greater relative focus on enhancing wider Group capability in the Readiness, Response and Recovery spheres. This work needs to include:

- Development of an agreed and shared common operating platform for all CDEM partner agencies to use, including an ICT system for sharing information and coordinating action across agencies.
- A review of CDEM structure, roles and responsibilities so that these are optimally aligned with the context provided by the five council local government structure in Hawke's Bay, community expectations and the need for regional coordination and efficiency in the allocation of Emergency Service and other resources. (The structure that is agreed must be communicated clearly and adhered to by and within all partner organisations).
- Revision of training and capability development programmes, exercise programmes and capability maintenance programmes to ensure these are short, sharp and fit-for-purpose and do not place time burdens on individuals or organisations that cause staff to "drop-out" or avoid participation.
- An exercise on resource balancing to ensure resource requirements of the GECC and council EOCs/IMTs are understood, and the sources of resourcing and expectations on councils and partner organisations are agreed.
- A sustained focus on staff recruitment, rostering, training and relationship development to meet the Response and Recovery needs of the Group and each Council. Specialisations such as logistics and intelligence are important within this work.
- A regime of readiness monitoring should be introduced or upgraded. Regular "check-ins" with staff should be carried out in peacetime to confirm contact details (and check that they still work in their organisation), check on barriers to availability, check on how prepared they feel to assist in a response and discuss upcoming training, development and networking requirements and opportunities.
- Systems to sustain and support Response and Recovery Efforts need to be revisited to ensure they are fit-for-purpose. While a Common Operating Platform will help address information flows, effective shift handover and induction systems, staff welfare checks and resourcing of 'Response management' will help establish and sustain an effective response. If the current 'Response Manager' role is too stretched to deal with all aspects of this area of work, a GECC Manager/Facility Manager/Chief of Staff role should be identified to ensure focus on these activities. The capacity and suitability of primary and back-up/overflow GECC and local Response building facilities, and back up ICT and other equipment, needs to be a key part of operational Readiness planning.
- As noted below, practical resource planning for Recovery operations should also be carried out at both Group and Local level. Who will be called on during the response, during the transition from Response to Recovery, and then for the Recovery thereafter? How will these roles be resourced? It is not clear that the answers to these questions are known. These questions should be answered in the near future, and a shared understanding developed. A framework and establishment guidelines for

Recovery should also be developed to guide Controllers and Recovery Managers in ensuring Recovery is addressed in a timely fashion during the Response phase.

This list is not intended as exhaustive. There will be other components of work that arise. However, the work identified above requires a sustained focus to address gaps highlighted through the 2020 events, with sufficient resourcing allocated to it within the work programme of both Group staff and Council organisations (and other partners where necessary e.g., Common Operating Platform). When CEG is satisfied that response and recovery ICT platforms, resourcing, staffing, training and inter-operability have been enhanced to the desired level, sufficient resource and focus should be applied (within the work programme) to maintaining those levels of readiness on an ongoing basis.

This work is not glamorous or high-profile. However, it helps maintain the fundamental foundations for an effective response. Some of this work will be happening already, but after a year of significant operational activity, 'maintenance' work of this nature can tend to take a lesser priority to other activities. Placing greater focus on these practical readiness activities will pay dividends when a Response is needed.

The allocation of Group staff is also an issue to be considered. Group Emergency Management Advisors are highly valued by Councils, particularly during emergency events. They can also have roles within the GECC, particularly when there are not sufficient Council staff available, and during the pandemic response, and Advisors were also deployed to other agencies and community organisations for periods of time. For coordination purposes, having an advisor at each Council EOC/IMT is the ideal. Having multiple demands on individual advisors is not ideal. This makes staff availability to the GECC vital and means that Group staffing arrangements and allocation should be carefully planned.

8. Recovery and Lifelines need Greater Focus - during Readiness Planning and Response and more broadly

Several persons and organisations engaged with during the review commented on the need to place a focus on recovery and commence recovery activities earlier in (from the outset of) emergency responses. One of the post-event reviews of the Napier Flood Event found evidence that the transition to Recovery was not considered or enacted early enough. Recent work carried out within the Group's Recovery work programme has highlighted a need for a greater focus on recovery planning and resourcing more broadly. This work was recently reported to CEG and consideration of it alongside this review is timely.

Recovery planning in Hawke's Bay has been well served in Hawke's Bay in recent years by a part time Group Recovery Manager working alongside Local Recovery Managers, who usually fill their roles in addition to their BAU responsibilities. However, this resourcing approach has meant that there hasn't been the same level of focus on Recovery as there has been on Response planning and Readiness, or some of the hazard reduction activities. NEMA personnel commented that Recovery did not appear as well-resourced as other areas of activity, and that this could be a gap that the Group needs to consider.

Staff working in response and recovery do not appear to have a clear, shared understanding of the respective roles of Group and Local Recovery Managers. There also appears to be a lack of clarity among some staff in CDEM roles about when Recovery activities should start, when

Response activities draw to a close, and whether/how Recovery related expenditure is to be funded. While there is a high-level management structure for Recovery set out within the Group Recovery Strategy, this is not regarded as providing a detailed level of guidance to enable recovery managers at either Group of Local level to immediately commence Recovery activities during or post an event. This lack of a clear, shared understanding about Recovery arrangements may have contributed to a delay in considering and enacting Recovery arrangements in relation to the Napier Flood event. It may also create financial incentives for the onset of Recovery action to be deferred if some Council staff believe activity labelled Response has a greater chance of drawing central Government funding.

Establishing (or better promoting) clear guidelines on commencing the Recovery process as part of Response efforts would help address this lack of clarity.

The Recovery work done in recent times also suggests that a Recovery lens may not be sufficiently embedded within local authority planning, and that more attention to, and greater resourcing of, Recovery arrangements overall may be desirable. In terms of strategic planning for Recovery, it is important to see recovery as being about renewal and opportunity as much as replacement. Definition of desired outcomes is important in Recovery planning. There has been some good regional thinking that could form a basis for Recovery outcomes following a major event (for instance within the Heretaunga Plains Urban Development Strategy, the Regional Land Transport Strategy and the Regional Coastal Strategy), however there is scope for further embedding of this thinking within local authority planning. CEG and the local authority Chief Executives should give further consideration to how this might be approached. As part of this planning work, consideration should also be given to how recovery activities will be funded post-event. The advice from the Group's recovery personnel is that the more consideration that is given to these sorts of (planning and funding) issues prior to a catastrophic event, the easier and quicker such decisions will be able to be made post-event.

In respect of resourcing, the current situation of a Group Recovery Manager leading recovery planning on a part time basis supported by local authority staff accommodating the responsibility within their other roles should be reviewed as a part of the Recovery recommendations before CEG. The current approach may be acceptable in peacetime if sufficient time is allocated by those personnel involved and greater resourcing is provided, within the Group work programme and within local authorities for strategic planning. However, in the event of an emergency, sufficient and sufficiently skilled and experienced resource will need to be freed up to focus on Recovery. The ability to deal with senior government leaders and officials, business and iwi leaders, elected members and other key stakeholders will be a key part of Recovery activities. It is also possible that there may be different skill sets required depending on the emergency event that occurs (e.g. one causing significant physical damage (earthquake) versus one causing social and economic disruption (pandemic)). It will not be possible for senior personnel (who may be the right people) to provide the level of leadership and focus necessary if they are still fulfilling BAU expectations in addition to Recovery roles.

It seems timely, given the experiences of 2020 and the recent work done by the Group's Recovery team, that a review of the Group Recovery Strategy for Hawke's Bay and the associated resourcing arrangements should be undertaken. This should focus on establishing clear and common Recovery related guidance for persons in both Recovery and Response roles, and ensuring those persons are trained and familiar with the strategy, guidelines and key working relationships. Although establishing arrangements for transitioning from Response to Recovery is seen as a responsibility of the Group Recovery Manager during the Response phase, a prior framework for this process and knowledge of it among Group and Local Response, Recovery and Welfare participants would likely add value in the transition. Strategic planning for Recovery and resourcing should also be areas of focus.

Some concerns have also emerged in relation to coordination with Lifeline Utilities during emergency events and related readiness planning. Each utility has its own responsibility for, and focus on, its own business continuity and service restoration. However, recovery dependencies and priorities, and links to CDEM, require planning and coordination across and between the various Lifeline Utility organisations involved. There is a Lifelines Group operating in Hawke's Bay, however the leadership, coordination and membership of this has tended to be undertaken on a largely 'voluntary' basis, on top of the BAU duties of already busy management personnel within Lifeline organisations. Those involved in Group Lifeline coordination work report that it is sometimes difficult to get timely responses from council asset managers due to workload issues.

It is apparent from the review process, that there is a need to lift the level of readiness and capability applied to initiating Recovery activities in an event, and to Recovery activity more broadly. It also seems desirable to provide greater focus on Lifeline coordination and planning and the ability to provide a coordination between CDEM and Lifeline Utilities when the region is on a Response footing.

Steps in the right direction are in train. CDEM Group staff advised that an additional advisor role had been provided for in the 2021/22 (HBRC) budget and work programme to focus on Recovery and Lifelines. This is a sensible addition of resourcing to address areas of CDEM activity that have not received the same focus as other areas of activity. It may be however, that rather than starting with an advisor level role, a more senior resource with strong networks and credibility across the organisations involved might provide greater initial impetus to the system and capability building work required. CEG should consider this in conjunction with the CDEM Group Manager and the Regional Council Chief Executive.

9. A Reset of Welfare Arrangements is Timely

At a headline level, Welfare is a real success story for the Partners involved in Hawke's Bay CDEM. During 2020, essential Welfare support was provided to significant numbers of people that needed it in the face of the Covid pandemic, the Napier Floods and severe drought conditions. This was achieved through a combination of established and newly linked local, regional and national Welfare agencies and capabilities, and with Council, Group and community led and coordinated initiatives. The Welfare Coordination Group, the mandated regional structure for welfare planning and coordination, worked well in providing a base for coordination and interoperability. In particular, the Tihei Mauri Ora Network Emergency Response Centre working with the various Taiwhenua during Covid, the work of the Rural Advisory Group through the drought and the Network of Networks supporting priority populations during and since Covid, demonstrated the power of local networks, knowledge and connections in effectively targeting Welfare assistance and support. All of those involved should take real pride in their efforts.

As with any event, the experiences of 2020 have also highlighted improvements and enhancements that can made to CDEM Welfare arrangements. As with the Response Framework overall, Welfare is an area of activity where the allocation of roles and responsibilities should be revised.

Welfare is an area of activity where the CDEM Group had taken on a more centralised leadership, management and delivery role. The events of 2020 highlighted a number of areas where the Group is best placed to lead, but others where local and community level leadership is likely best placed to operate effective welfare activities.

Territorial Authorities in the region have a number of facilities and personnel that can be used to support evacuation and welfare responses. The use of Kennedy Park Holiday Park in the Napier Floods is a perfect example of this. This capability should be formally recognised and mandated within Welfare response arrangements. While these sorts of resources are available under current arrangements, their status and availability and who operates them is not altogether clear.

The role played by the Tihei Mauri Ora Network Emergency Response Centre and the Taiwhenua in the pandemic response is canvassed in detail elsewhere in this report. Also outlined is the role of the Rural Advisory Group in providing Welfare support to the rural sector in the drought and pandemic period. The 12 networks in the Network of Networks supporting and coordinating needs and information for priority populations is also a success story. Common to all of these welfare efforts is the knowledge of people in the community, a strong level of trust with their respective communities, and the ability to reach them. Several organisations and persons engaged with in the Review commented on the real strengths available in grass-roots organisations operating in communities supported by CDEM and Council resourcing and administrative capacity.

The structure, roles and responsibilities for Welfare should be such that they explicitly provide for and support local and community delivery of Welfare activities such as the examples given above. But they also need to provide a level of regional coordination so that there is a clear picture of what is being delivered and where there are gaps and a need for additional support. Providing that relationships are fostered, and a shared understanding of the capability of community and council organisations and collaborative working arrangements is developed in 'peacetime', support and resourcing will be able to be directed to welfare efforts effectively and efficiently during a response. This 'operational level' Welfare Readiness planning is where more focus needs to be placed. It is noted that work on building relationships across the network of community welfare organisations has been commenced within the Group work programme following the appointment of a new Group Welfare Manager.

Relationship development and the establishment of agreed working and support processes should be a focus for Group Welfare Readiness planning. Each of the councils that wishes to play a Welfare delivery role should also have a focus on key relationships within its community networks. This work is already a focus within the CHB and Wairoa councils. Councils taking on a welfare delivery role also need to ensure they are fully engaged in Welfare Coordination Group arrangements.

The Group Welfare team should also focus on its role in coordinating and channelling Government support, and on some of the more specialist and complex aspects of the Welfare function. The Needs Assessments function for instance has become more complex and demanding in recent years. While a Needs Assessment tool, *Awhina*, has been developed, there are concerns over privacy and security associated with a wide scale roll out, and a lack of agreement nationally over its use. This has led to the Group developing its own needs assessment tool within the Office 365 suite. In the short term, the CDEM group needs to assure itself that this tool can effectively manage the needs assessment process and task allocations coming out of it. Maintaining and, where needed, developing the capability to conduct Needs Assessment work across the region should be a priority in the Welfare area. Given the increasing complexity and the demands on staff doing this work, the Group may wish to consider contracting specialist providers to carry out this work. Some outsourcing occurred during the Pandemic Response.

It is puzzling however that the Group is having to create systems for tasks that are common across the CDEM sector nationally. It may be considered appropriate for the Joint Committee and CEG to advocate for solutions for common system requirements (such as welfare needs assessment) to be put in place nationally.

10. Kaupapa Māori Organisations are a proven Welfare Network – and can be Strengthened Further

The response to the Covid Pandemic demonstrated the strength and utility of kaupapa Māori organisations as welfare organisations. The four Taiwhenua organisations covering Hawke's Bay (Te Taiwhenua o Wairoa, Te Taiwhenua o Te Whanganui a Orotū, Te Taiwhenua o Heretaunga, Te Taiwhenua o Tamatea), supported by Ngāti Kahungunu Iwi Incorporated and the HBDHB, utilised their existing organisational capability, networks and knowledge of their communities to stand up and operate effective welfare services to those in need. The detailed knowledge held by the Taiwhenua and their networks on who was vulnerable and likely to be in need was of significant value to those receiving assistance and in the overall welfare response.

This working relationship with is one of the success stories of the Pandemic Response. It would be a major opportunity lost were the capability and linkages to CDEM that developed during the pandemic not solidified and capitalised on for the future.

There are however a number of lessons that can be learned and improvements that can be made in how kaupapa Māori/Taiwhenua organisations are supported, and how the relationships and linkages between CDEM organisations and the Māori network of organisations operate. Discussions held during the review indicate that there may also be other Māori organisations that could play a role in CDEM/welfare activities that should be engaged with (e.g., post-settlement entities).

While all of the Taiwhenua had existing Welfare capabilities, their experiences in relating to and working with CDEM differed to some extent during the Pandemic Response. This appears to have been influenced to some degree by the closeness of their relationship to their local council and the extent to which their local council was involved in Response and Welfare operations. This links back to the operating model in place for HBCDEM and the difference in approach applied in Central Hawke's Bay and Wairoa as compared to Napier and Hastings.

Wairoa and Central Hawke's Bay District councils both had formal mandated roles in leading local response operations in an emergency. Taiwhenua in these areas had strong pre-existing relationships with their respective councils before taking on operational welfare functions during the pandemic. In Wairoa, agencies had commenced welfare focused activities ten days to a fortnight ahead of the pandemic lockdown in response to job layoffs in the forestry sector. This meant they were already operating in a coordinated fashion when the need to scale up activities in the face of the lockdown occurred. Strong relationships meant that start up and coordination challenges could be overcome quickly. In Central Hawke's Bay, the existing relationships meant that the Taiwhenua rapidly became part of the formal CDEM local response as the Māori Response Unit. The Council acted quickly to provide communications resources to support Taiwhenua welfare operations.

In contrast, the CDEM operating framework mandates the CDEM Group as the mandated lead for Response operation in Napier and Hastings. This meant that while there were some good relationships in place between Taiwhenua and councils, these did not necessarily always extend to the CDEM Group to the same degree. The support provided by the CDEM Group in seconding two staff to Tihei Mauri Ora was a valuable initiative. However, while overall the role played by the network of Māori organisations was a success, clearer linkages to the CDEM operating and Welfare structures could help ensure a more streamlined and coordinated response from early in the Response phase.

Engagement with kaupapa Māori organisations points to a number of areas where processes can be improved, and changes made to further strengthen the ability of these organisations to operate and deliver for their communities in a Welfare Response. These include clarity for resourcing and reimbursement arrangements, communication linkages between Taiwhenua and CDEM response arrangements, official recognition of their role and work, and training of personnel. Some of these matters relate to the clarification of the broader CDEM structure and how roles and responsibilities are allocated within it.

In terms of resourcing, funding and reimbursement arrangements were not necessarily clearly understood by Taiwhenua at the outset of the response effort. Organisations expended significant resources upfront on Welfare prior to reimbursement being confirmed and then paid. For smaller organisations this can place stresses on financial capacity. Organisations highlighted that having emergency reserve funds to be able to call on for Welfare expenditure before reimbursement was available would be of great assistance in sustaining Welfare efforts. Similarly, resourcing for personnel applied to Welfare activities is something that could be given consideration, particularly if people without employment were making their time available to assist the Response.

The CDEM Group is constrained to a large degree here by the rules and processes in place around resourcing of welfare. NEMA is responsible for reimbursement of welfare costs and there is no ability for the CDEM Group to 'pre-pay'. Personnel costs are also generally not reimbursed. These may be issues that the Joint Committee and CEG wish to consider advocating on. The Joint Committee could also consider whether a regional emergency reserve fund to assist with immediate welfare activity might be of use, although care would need to be taken to ensure the activity would still qualify for eventual reimbursement under such an approach.

The utility of the pre-existing relationships in Wairoa and CHB again highlighted the value of strong relationships in Response and Welfare operations. While these close relationships are not as easy to achieve in larger communities as they are in smaller, closer-knit communities, focus needs to be given to developing relationships that will be needed in times of activation and Response. Targeted familiarisation visits, training and exercising (particularly in issues such as volunteer management), 'peace-time' projects of mutual interest and regular meetings or forums are all initiatives that could be used to develop essential and functional relationships. Some of these initiatives are likely to need an appropriate level of resourcing to support them. Relationships that should be prioritized include those between key personnel and volunteers associated with Taiwhenua and other relevant kaupapa Māori organisations, and Controllers and key welfare and response personnel with the CDEM Group and the councils (particularly HBRC, Napier and Hastings). Wairoa and CHB councils and respective Taiwhenua have demonstrated what can be achieved. While the close-knit and even whānau relationships in Wairoa cannot be replicated everywhere, CHBDC and Te Taiwhenua o Tamatea (as an example) have demonstrated what can be achieved in building strong working relationships in the emergency management field.

Some formalisation of mutual expectations and linkages will help in developing relationships. Formalisation will also assist within emergency events as Taiwhenua (and other organisations) and their personnel and networks can be more readily accredited as an official part of the response. This emerged as an issue during the pandemic lockdown when only authorised activity and personnel were permitted to be operating. Essential worker status had to be arranged for those working in Welfare roles for Taiwhenua.

It is important that what was learned in the successes and lessons of the pandemic is captured and utilised for future events. It was reported that the linkages that developed during the pandemic response were not as evident during the subsequent response to the Napier Flood event. While the events were different in scale and nature (one was part of a national/regional response with the Tihei Mauri Ora operation in place, the other a more local event), further development and then maintenance of relationships between Taiwhenua, NKII, and the wider network of Māori organisations, and the larger councils and the CDEM Group staff will likely ensure there are fewer teething problems in coordinating Response, Welfare and Recovery activities in the face of an event.

This work should be incorporated into the CDEM work programme as a priority. Resourcing should be allocated, particularly in the Welfare/Readiness area, to undertake regular liaison and readiness and response planning with Taiwhenua and other appropriate Māori organisations. While recognising the good work already in place in partnership with Te Puni Kōkiri, planning and resourcing to use Marae as Welfare centres in emergency events could be further developed, including resourcing for Marae being on 'stand-by'. More communication across the network of Māori organisations providing welfare assistance, so that there is a clearer picture of who is doing what, could also be considered. Authorisation and resourcing arrangements to enable Taiwhenua to operate as official Welfare providers in an emergency should be considered, aligned with the wider project to establish a Common Operating Platform and processes.

11. Iwi/Māori involvement in CDEM should be Strengthened

The experience of the Pandemic Response in particular highlights the benefits, opportunities and need to strengthen relationships between CDEM agencies and kaupapa Māori organisations in Hawke's Bay. As highlighted above, the Tihei Mauri Ora Network was instrumental in successfully delivering support and welfare to Māori communities (and others) across Hawke's Bay. Sitting alongside this experience, other emergency events around New Zealand have demonstrated the value and functionality of Marae in providing Welfare support to both Māori and non-Māori alike.

The links in place between CDEM and Māori are not based on any CDEM specific legislative provisions or existing governance arrangements. While each of the member Councils of the CDEM Group has obligations to Māori under the Local Government Act and the Treaty of Waitangi, the CDEM Act is silent on connections between Maori and CDEM Groups. There is no specific provision for iwi/Māori representation on the CDEM Group Committee and no representation required at CEG level. While there are a number of strong and developing relationships in place between iwi/Māori organisations and councils, and iwi/Māori organisations and Emergency Services (e.g. the links via Police Iwi Liaison Officers), and some links into CDEM, there are gaps in direct connections between the region's CDEM arrangements and iwi organisations.

After reviewing the engagement during this Review, it is considered there would be considerable value in providing for formalised iwi/Māori involvement in CDEM. While there is no specific provision for iwi/Māori representation on the CDEM Group Committee, there appears to be no explicit prohibition under the Act. The Committee is constituted as a joint Committee of the councils under the Local Government Act 2002, and councils have the power to appoint non-council members onto Joint Committees. However, it is noted that in response in 2018 to recommendations of the Technical Advisory Group, the Government did not favour iwi membership of Groups. NEMA staff advise that some regions have included some form of iwi representation as part of their Joint Committees, and that the issue of iwi involvement is currently being considered as part of the current national review of CDEM arrangements. It is recommended that the councils should consult further with Ngāti Kahungunu Iwi Incorporated, NEMA and any other appropriate parties as to their views on this matter. Subject to feedback from this consultation (including on whether participation is a priority for iwi), the appointment of appropriate representation onto the CDEM Group Committee, in a legally permissible form, is recommended. It is considered that such representation would provide a strong Māori perspective into governance and policy decision-making in CDEM, strengthening the effectiveness of priority setting, capability development and policy formulation, particularly in areas such welfare, hazard identification and reduction and public engagement.

Likewise with respect to CEG, it is considered that appropriate executive level presence would add perspective to decision-making and oversight that would improve decision-making, prioritisation and the ability to shape and steer work programmes. This would help ensure that the needs of Māori communities were better understood and accounted for, and the capabilities of Māori organisations incorporated into planning.

Post-event reviews carried out have highlighted the valuable role that iwi/Māori organisations played during emergency events in 2020. Some of these have also highlighted that the Group could consider instituting iwi representation within CDEM arrangements on an ongoing basis, and that these would pay dividends during future emergencies. It is clear that this representation would be valuable at each of Governance, CEG and operational levels.

12. There are Effective Links with Rural Welfare Networks – but these Networks need Ongoing Support

The Drought experienced in 2020 was a key event that affected the rural sector. As the drought became worse, the Covid-19 Pandemic added extra stress and complexity for those already suffering from the effect of the drought.

The Rural Advisory Group was a key community mechanism for providing Welfare support to rural communities. Working with the Rural Support Trust, it was able to contact farmers to get data on water levels, feed availability and need, animal welfare, mental health and other key factors. Staffing support from the Regional Council allowed the RAG to operate a Welfare logistics operation in support of the rural sector.

The RAG had established relationships with CDEM through the former Group Welfare Manager. However, during the pandemic, CDEM was stretched and could not place significant focus on rural issues and the RAG. At this stage, a strong relationship with the Regional Council and the staffing support they provided, allowed the RAG to function effectively and provide Welfare support where it was needed. Without that staffing support, the RAG would not have been able to function effectively. The RAG Chairman was effusive in this praise of the support provided by the Council.

The RAG has become a vital part of the Welfare network. However, it will not operate effectively in a Response without resourcing assistance. CEG needs to consider how this support will be provided – will the Regional Council be able to assist again in the future or does this need to be factored into to the wider Welfare resourcing equation? The role of other agencies (Ministry for Primary Industries for animal welfare, the HBDHB for mental health and

MSD for financial assistance) would also need to be taken into consideration in any consideration of this wider Welfare resourcing equation.

13. Sustaining a Large-scale or Prolonged Response could place pressure on Facilities and Resourcing

CDEM in Hawke's Bay has access to good capability and capacity to assist the community to deal with emergency events. However, major events, multiple events at once and prolonged events can test any region's capacity to Respond to events and then sustain Recovery operations.

Access to sufficient and adequately trained staff resourcing is a fundamental requirement in sustaining Response and Recovery operations. The events of 2020 demonstrated that successive events, some of them of reasonably significant duration, can contribute to staffing shortages and unavailability. Staff availability was a negatively impacting factor on the Response during the Napier Floods. Staff not being fully trained due to churn or gaps between new systems coming online and training, can also impair capability.

This vulnerability reinforces the need for a focus on prioritising staff availability, identifying sufficient staff to cover required roles and shifts, timely staff training, and a greater focus on operational readiness work as discussed above. It also highlights the need for strong relationships with NEMA and neighbouring Groups so that local resourcing can be supplemented by externally resource where appropriate. 'Surge capacity' for longer duration events needs to be considered within response planning.

The recent investment in the GECC facility in Hastings has provided a well-equipped and resilient facility for the Group that meets required Building Standards. The provision of space for Police within the facility has also provided additional redundancy and back-up for emergency service operations. However, the facility does not have unlimited physical capacity. More than one person engaged with queried whether the primary GECC facility would be able to accommodate a large-scale event or multiple events at once. One engagement participant also commented that development adjacent to the facility has limited the ability for onsite expansion/temporary facilities.

It seems clear that the facility will play a valuable and sufficient role in most emergency events. But the concerns raised highlight the need for operational readiness planning to identify alternative facilities in case primary facilities are affected in an emergency, and to identify suitable back-up capacity should event contingencies make them necessary. Council chamber facilities, meeting rooms and community buildings can be useful and have been used in the past. Utilising additional 'virtual' capacity via technology also should also be considered. However, there need to be suitability checks carried out, usage arrangements in place, and back-up ICT and other essential equipment available. Facility replacement and augmentation arrangements such as this also add impetus to the need for a Common Operating Platform to enable agencies to share information and achieve inter-operability regardless of location.

This facility capacity and resilience component of operational readiness should also extend to facilities to be used by council and other agency IMTs.

In terms of participant comments regarding the need for a larger primary facility, relevant organisations represented on CEG (CDEM, Police, FENZ, Health) should commence consideration of this issue. Developing a larger GECC facility/ emergency management hub would likely require multi-agency buy-in and a significant lead time. The CDEM Group and CEG may wish to consider whether a Ten-Year Facility Development and Replacement strategy and programme may be a useful approach.

14. Pre-planning for Public Information could aid Response Efficiency

One theme that arose during the Review was the tendency for there to be a scramble to assemble Welfare and public health information during an emergency event. This places pressure on often stressed welfare, public health and PIM resources when in reality, much of the information could be pre-prepared and held as resources to be used. Consideration should be given to the PIM team working with welfare and public health personnel in peacetime to develop and maintain resource libraries for use in emergency events.

15. Greater consideration could be given to the Public Health implications of Emergency Events

DHB representatives expressed a view that there could be a much stronger public health lens applied in Resillience, and in Readiness, Recovery and Response planning. Response activities always have public health implications and the Welfare responses during the events of 2020 opened a window on a number of underlying health issues affecting communities.

While it is difficult to explore the wider public health dimensions of CDEM within the context of this Review, it is clear that there could be significant benefits to applying a stronger public health lens to CDEM planning and decision-making. From initiatives such as using DHB Health Protection staff and Council Environmental Health Officers in a greater 'Health Response team', to DHB input into the basis for carrying out building inspections in an emergency event, and using public health criteria when agreeing funding and work programme priorities, it is considered that more significant public health input into CDEM related activity could have potential to further strengthen response capability and resilience.

It is recommended that CEG formally invite DHB representatives to explore with CEG how CDEM arrangements might be strengthened by greater consideration of public health initiatives.

ICT System Needs and Common Operating Platform

Significant frustrations emerged during some of the 2020 Emergency Events due to the lack of an appropriate Common Operating Platform. Information sharing was hindered during the Napier Flood, with Emergency Services being unable to access information held on Group systems.

ICT systems to support CDEM Response activity is an area that has been somewhat fraught with difficulty. The nationally developed EMIS system has been discontinued. NEMA has sought to replace this with a new system, EMI, although this has not had widespread adoption. Different solutions are being pursued by different Groups across the country. There is unlikely to be a nationally agreed system in the near future.

Establishing an agreed Common Operating System that could be used by all CDEM Partners in an emergency event would significantly strengthen CDEM response capability in Hawke's Bay. Providing the ability for agencies, IMTs and different shifts to share information and build a 'single source of truth' would aid decision-making, coordination and overall emergency management effectiveness greatly.

The system requirements for sharing information, communicating and managing resources during an emergency event are not particularly special or unique. There are a number of common programmes (e.g., Sharepoint/Teams) that could be used as a base for meeting the Group's needs. This could be augmented by the use of GIS systems for spatial mapping (the councils may need to provide these tools to Emergency Service Partner agencies). The key requirement is for Group Partners (including the Emergency Services) to identify needs, agree on and commit to a system that everyone can access and will use, and then commission a team to set up that system to operate effectively for the Group and its partners.

It is recommended that this piece of work be incorporated as an urgent priority within the Group Work Programme.

As part of wider system needs, the CDEM group needs to assure itself (as covered is section 9 above) that the tool it has developed for welfare needs assessment can effectively manage the needs assessment process and task allocations coming out of it. As part of improvement work on Welfare arrangements also covered in section 9, it is recommended that the Group establish a capability to conduct Needs Assessment work across the region.

The HB Emergency website is a key information source for the public in an emergency event. It is hosted for the CDEM Group by one of the partner councils. During the 2021 Tsunami warning, the website stopped working after it was inundated with visits. The site was restored with extra capacity added, however this still represented a temporary and critical system failure.

Priority should be given to ensuring that key information systems such as the public-facing website are robust and fit-for-purpose, and have the capacity to deal with vast volumes of traffic in a short time period. While there is nothing wrong *per se* in having infrastructure provided by one of the councils, the Group needs to be satisfied that what is provided can withstand likely traffic volumes. Noting that some work has been done already, resilience to cyber-attacks and other ICT risks are also matters that should be examined periodically and reported to CEG. Consideration should be given to comparing the existing approach to ICT services and support with the use of specialist third-party providers with specialist resilience capability.

A Common Operating Platform does not refer solely to ICT systems. Processes, protocols and management systems can also be critical in enabling agencies to operate effectively together. CIMS is the widely accepted system for managing emergency events. It is used by Emergency Services in New Zealand and is the backbone of CDEM Response. As HBCDEM looks at its structure and roles and responsibilities as discussed above, it should ensure that CIMS is used at the centre of the model. Ensuring personnel are trained in CIMS will also be important as part of the training and capability development and maintenance programme.

Within the CIMs model, the Intelligence function is focused on the gathering, analysis and interpretation of information for use in Response and Recovery decision making. One theme emerging from engagement sessions was the need to ensure there was shared understanding of what the Intelligence role was and that it was sufficiently resourced with appropriately trained personnel. Currently, different agencies have different approaches to intelligence – some agencies are GIS/mapping focused while others focus on information for decision-making. It was also noted that GECC resourcing shortages during the Napier Floods meant that Police personnel ended up resourcing the Intelligence function, which will not usually be possible. Resourcing, establishing an agreed approach, and training are all matters that should be addressed in respect of the Intelligence function.

The Intelligence function is central to accurate, timely and efficient decision making and information flows. It underpins communication across agencies, between local, Group and National Response activities and for public information purposes. An agreed understanding of the Intelligence function, adequate resourcing of it and an agreed and effective Common Operating Platform are all essential components of a high-functioning response capability. These should be prioritized in the increased focus on Operational Readiness and a Common Operating Platform.

An issue that arose during the Napier Floods was different approaches and interpretations, and different systems for assessing buildings as to whether they were inhabitable or not. Different information was being held by different agencies which created some confusion as to who needed assistance and who did not, among other issues.

A common platform, approach and system for this area of work needs to be agreed upon and implemented between the councils, HBDHB, FENZ and any other agencies involved as a priority. CDEM should facilitate this work. The approach should be based on standard practice within New Zealand unless there are compelling reasons to depart from this. More generally, consideration should be given to regular auditing of shared systems of this nature that CDEM relies upon to ensure there are agreed and robust systems and processes in place.

Overall Assessment and Recommendations

Viewed as a whole, the Hawke's Bay CDEM system and collective capability has real strengths. Key outcomes were delivered for the community during the events of 2020. However, these events also highlighted a number of opportunities to further strengthen the Hawke's Bay CDEM system.

The preceding analysis outlines some of the experiences from 2020 and opportunities for improvement. These span structure, roles and responsibilities, relationships, Welfare, Recovery and lifelines arrangements, resourcing and a Common Operating Platform. Links to iwi/Māori are also canvassed.

Hawke's Bay's CDEM arrangements functioned adequately for the community during the tests of 2020. However, in every emergency event there are opportunities for improvement. The CDEM Partner Agencies have a good opportunity to learn from the events of the previous year and strengthen their capabilities, Response and Recovery arrangements for the benefit of the communities of Hawke's Bay. The recommendations below and the detailed commentary and advice set out in this report are designed to enable them to do that. Key elements are a reset of the Response structure, and roles and responsibilities, a rebalancing of the CDEM work programme to emphasise Operational Readiness and Response and Recovery planning, and a reset of Welfare arrangements.

In order to capture the improvement opportunities available, a change programme should be put in place. This change programme should be adequately resourced and work with key stakeholders. It would be neither fair nor effective to expect the Group Office to manage the initiatives identified as part of 'business as usual', and could impact negatively on operational readiness.

It is noted that the Government is conducting a review of CDEM. The Change programme arising out of this review should be revisited once the outcomes of the Government review are known.

Recommendations

[Recommendations should be read in the context of the commentary contained in the body of the report]

Priority Recommendations

1. **That the Coordinating Executive Group commission a reset of the Operating Framework and the Response Structure, Roles and Responsibility to provide for a Group Emergency Coordinating Centre, and a Local Emergency Operations Centre/Incident Management Team in each Council area. These arrangements will better reflect the context that Civil Defence Emergency Management is operating within in Hawke's Bay. This reset should specifically address and take account of:**
    a. **community expectations of Council assistance and response,**
    b. **effective support for Mayoral leadership and spokesperson roles,**
    c. **council capabilities including (but not limited to) welfare, lifeline utility and building inspections,**
    d. **the need for effective regional coordination, and**
    e. **the efficiency and coordination benefits for Emergency Service organisations in having a high-functioning Group Emergency Coordination Centre.**

2. **That the Coordinating Executive Group initiate an urgent 'rebalancing exercise' on the Group Work Programme with a view to presenting a new programme to the Coordinating Executive Group and the CDEM Group Joint Committee. The Rebalancing Exercise should place greater emphasis on Operational Readiness, Response and Recovery Activities including:**
    a. **Development of a shared Common Operating Platform and ICT system (see 3 below)**
    b. **The Operating Framework and structure, roles and responsibilities reset recommended in 1 above**
    c. **Revision of training and capability development programmes**
    d. **A review of resourcing and staffing as recommended in 4 below**
    e. **Staff recruitment, rostering, training and relationship development for Response and Recovery**
    f. **Readiness monitoring**
    g. **Response and Recovery support systems, including facility capacity and resilience, and back up options**
    h. **Recovery planning and establishment.**

3. That as a component of the rebalanced CDEM work programme, the Coordinating Executive Group initiate the development, with partner agencies, of a Common Operating Platform for CDEM Response. This should be based on CIMS and include an appropriate ICT system or systems and agreed processes for issues such as building inspection.
4. That the Coordinating Executive Group commission an urgent review of staffing and resourcing arrangements for the Group Emergency Coordination Centre and Council Incident Management Teams/Emergency Operations Centres to ensure sufficient resourcing is in place to support both Response and Recovery activities in an emergency event.
5. That Council Chief Executives provide concerted leadership focus within their Council organisations to ensure that agreements made at the CDEM Group Joint Committee and the Coordinating Executive Group, particularly in relation to resourcing commitments and Response structures, roles and responsibilities, are honoured and given effect to.
6. That, in order to give effect to the above and other recommendations, the Coordinating Executive Group put in place a change programme to drive and coordinate the improvement opportunities recommended here and identified in this report. The change programme should be sufficiently resourced to support the changes identified and ensure that the programme does not impact upon the need to maintain operational readiness. The change programme should be agreed with and regularly reported on to the CDEM Joint Committee.

Other Recommendations

7. That a reset of Welfare arrangements be carried out in order to strengthen Welfare coordination and delivery. This reset should make changes that enable the following:
    a. Optimal use of relationships with and support for community welfare networks (e.g., Taiwhenua, Rural Advisory Group)
    b. Local authority welfare delivery
    c. Effective regional coordination of welfare activities and resourcing, including coordination with NEMA and national welfare agencies
    d. Appropriate Group led delivery of Needs Assessment work.
8. That as a component of the rebalanced CDEM work programme, CDEM Group Staff in conjunction with appropriate council staff, commence work to enhance relationships and develop support protocols with welfare response agencies including the Tihei Mauri Ora Network and the Taiwhenua, and the Rural Advisory Group. Staff support for the Rural Advisory Group during activations should be considered as part of this work.

9. That as a component of the rebalanced CDEM work programme, training, exercising and relationship development programmes be reviewed to ensure they are fit-for-purpose, appropriately targeted and not imposing too great a burden on participating agencies.
10. That CDEM Group staff programme further opportunities for developing effective working relationships, job familiarity and support mechanisms for senior leaders within Hawke's Bay CDEM. This should include the Mayors and Regional Council Chair, Controllers and senior Response personnel, and senior Emergency Service personnel. Greater levels of support for Mayor and the Regional Council Chair as lead spokespersons and community leaders are essential.
11. That CDEM Group Staff develop guidance for Controllers and schedule discussions in Controller meetings so that a greater focus on Recovery is provided for within event responses.
12. That the Coordinating Executive Group initiate programmes of work to enhance capability, planning, readiness and relationships in the areas of Recovery and Lifeline Utility Response coordination. The new resource budgeted for in 2021/22 will greatly assist with this however consideration should be given to ensuring the appropriate 'level' of resourcing is engaged in the work in its 'establishment phase'.
13. That the Coordinating Executive Group commission a project to establish a common approach and processes for assessing buildings during an emergency event as to whether they are inhabitable or not. This project should include developing a common platform, approach and system for this area of work. Parties involved in the project need to include the four territorial authority councils, FENZ, HBDHB/Public Health and the CDEM Group. The approach should be based on standard practice within New Zealand unless there are compelling reasons to depart from this.
14. That the CDEM Group Joint Committee and the Coordinating Executive Group seek advice and consider the appointment of appropriate iwi representation on the Joint Committee and the Coordinating Executive Group.
15. That the CDEM Group Joint Committee and the Coordinating Executive Group consider further action in relation to this review once the outcomes of the Government CDEM Review are known.
16. That consideration be given within the Public Information work programme to developing a resource library for use in emergency events.
17. That consideration be given to inviting the Hawke's Bay District Health Board to explore with CEG how public health perspectives might be utilised to strengthen CDEM arrangements.

Appendix – Terms of Reference

Terms of Reference

Events and Learnings of 2020: Hawke's Bay Review of CDEM

Purpose

This review will provide advice to the Chief Executives of the five Hawke's Bay Councils on operational mechanisms to support effective responses to natural disasters and other emergencies in Hawke's Bay.

The purpose is to ensure that our emergency response framework and system is well placed to respond to current and future emergencies. In light of the events and lasting effects of 2020, including the COVID-19 pandemic, drought, fire and the Napier flood it is appropriate to review the performance of the system so that we can further enhance and strengthen the current system and processes across the whole Group emergency management response system.

2. Context

The Hawke's Bay CDEM Group is a statutory construct under the CDEM Act 2002. Its membership consists of the four Hawke's Bay TLAs and the Hawke's Bay Regional Council. HBRC is the mandated administrating authority and in the role administers the CDEM targeted rate and employs the CDEM Group office staff. The Group operated in a "shared service" arrangement.

The CDEM Group works across the four Rs of emergency management – Reduction, Readiness, Response, and Recovery. This review will only be focussing on the response and recovery environments, a relatively small but important part of the wider emergency management system. It should be noted that the Government is currently undertaking emergency management system reforms and reviewing the roles and responsibilities within the system of CDEM Groups and local councils.

The series of recent events and emergencies in Hawke's Bay has resulted in reflection on whether the current Group operational framework for responding to natural disasters and other emergencies are fit for purpose. Moreover, communities are continually expecting an ever-increasing level of service from official organisations in response to emergency events.

Many opportunities for improvement have been identified from the COVID-19 pandemic, Hawke's Bay drought, various large rural fires, and the Napier rain events, and we now need to ensure that they are successfully embedded into the operation of the CDEM Group and Council member systems.

An emergency event is a complex adaptive human system - with many interrelated, changing parts subject to people's interactions. It is timely to take a wide look at how the sum of those parts work together. In particular, to consider whether any changes could optimise the civil defence emergency management and council system's performance in the response & recovery phase of in relation to responding to an emergency; and therefore the outcomes that we can deliver to communities.

3. Project Definition

The problem

The purpose of the review is to ensure that Hawke's Bay's CDEM operational response framework, and Council's roles & responsibilities in responding to events are; fit-for-purpose; an adaptive and rapid learning system; and are well placed to meet future challenges including concurrent emergencies.

The current structures, processes and roles need to align with the expectations for system performance.

Recent events tested our response and recovery framework, and its effectiveness in supporting decision making, information sharing and operational capability. By definition, managing an emergency is a complex and demanding process. Often decisions need to be made quickly with incomplete information. The system must be flexible enough to adjust during the response phase and transition seemlessly into a recovery phase. Relationships and clarity of roles and responsibilities is critical.

In reviewing recent events in particular, it has been noted that emergencies often have characteristics such as:

- Competing resources: Councils and Volunteers may not be adequately resourced or supported.
- Imperfect information: Information is not always readily available to decision makers on the scale, complexity and evolving nature of the emergency, to determine the capacity and capabilities required for the response effort.
- Lack of clarity for Roles and Responsibilities: misunderstandings or confusion relating to roles, responsibilities, process handoffs and/or action plans.
- There is increasing need for:
    - Providing information and briefings to governance
    - Consistent and accurate communications to the public including warnings.
    - Response capabilities to be deployed as promptly and seamlessly as possible.
    - Learnings from previous events to be embedded into cross system processes.

In summary, we want to review the Group operational response framework, processes and structures across the system in the context of the events and impacts of 2020, to identify if it is performing optimally to meet current and future needs.

Scope

The work will examine:

- The current statutory model and operational response framework of lead and support agencies to manage response and recovery to emergencies.
- The roles and responsibilities between responding organisations, including interdependencies between national, regional, and local entities.
- The accountability and reporting pathways for executive management and governance structures.
- Decision making, chain of command, communication and handover processes including:
  - Activation of staff and mobilisation of regional response structures
  - Resourcing and sustaining emergency response
  - Clarity of the chain of command and its appropriateness
  - Preparedness and training of staff
  - Response & Recovery capability and capacity
  - Barriers to effective command and control, coordination, and communication
- Problems and issues encountered and identified through the COVID-19 pandemic, drought and flood events
- System capacity and resourcing to effect the leanings and opportunities from 'events reviews' back into the system in a timely manner. We expect this to include training of staff/keeping abreast of changing staff and council turnover rates
- An assessment of ICT systems to ensure that Hawke's Bay is utilising the best systems and technology where possible. This includes information, capacity of systems, resiliency, redundancy and toolsets.
- General assessment of other risks including: buildings have appropriate buildings for all levels of response; vertical evacuation options
- Review of the formation of an IMT when group are forming at the same time

Outcomes Sought

1. The Hawke's Bay operational response system is fit for purpose and aligns with stakeholder needs and statutory requirements.
2. A system that is flexible and reactive to the changing nature of responding to an emergency or concurrent emergencies.
3. Hawke's Bay response and recovery system has appropriately skilled and responsive resourcing, regardless of the location, complexity and scale of the emergency.
4. Appropriate processes and protocols exist to enable supporting agencies to respond efficiently and effectively in support of a CDEM emergency.
5. The chain of command and control, coordination, and decision making during an emergency is effective and appropriate.
6. There is a clear operating model and chain of command and control and coordination during response and recovery including the recognition of mandated lead and support agencies.

7. All participants in the system understand the operating framework and their respective roles and responsibilities, including how these might change over the course of the response or as the event unfolds.
8. Information flows into, across, and out of the system effectively, allowing timely and accurate communication to Ministers; agencies; officials; stakeholders with particular interests; and to the public during emergencies.
   - Recognition of the modern news cycle – immediacy of social media and power of factual decisive information delivered as speedily as possible
   - Stakeholder needs are understood (what information is required; where and how to gather the information, providing it at the right time and in the right format).
   - Official information maintains pace with media dialogue and social media activity.

Budget & Timeframe

[Please advise]
Two months from commencement – but will take advice from the respondents

Deliverable

A report using the context of the 2020 emergency events (COVID-19 pandemic, drought, fire and flood), to analyse the opportunities, problems and issues encountered and make recommendations so that we can further enhance and strengthen the current system and processes across the region.

Recommendations that allow for the development of an operational framework which provides for clarity of roles and responsibilities between the Group and partners while providing for efficient and effective emergency management outcomes for the Hawke's Bay Community.

Governance

Sponsor: Monique Davidson
Steering Group: James Palmer, Steph Rotarangi, Kitea Tipuna, Nigel Bickle, Monique Davidson
Programme Manager: Toni Goodlass

Stakeholder Engagement

CDEM Group office staff
Council Officers
Emergency Services
NEMA
Welfare Coordination Group
CDEM Joint Committee

Level 3 Tsunami Modelling in Hawke's Bay
Final Report

DR Burbidge JH Roger X Wang
B Lukovic WL Power

GNS Science Consultancy Report 2022/58
June 2022

BIBLIOGRAPHIC REFERENCE

Burbidge DR, Roger JH, Wang X, Lukovic B, Power WL. 2022. Level 3 tsunami modelling in Hawke's Bay final report. Lower Hutt (NZ): GNS Science. 52 p. Consultancy Report 2022/58.

Project Number 900W2115

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FIGURES

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EXECUTIVE SUMMARY

In November 2021, Hawke's Bay Regional Council (HBRC) commissioned GNS Science to provide them with tsunami hazard maps for Napier and surrounding areas that are appropriate for them to use for land-use planning in the region. To create maps suitable for this purpose, HBRC has requested that GNS Science conduct a study to create probabilistic tsunami inundation hazard maps to a Level 3 standard for the Napier/Hastings Coastal Hazard Zone. This is Zone 73 in the National Tsunami Hazard Model (NTHM; see Power et al. 2022). HBRC also requested that the area to be mapped is extended beyond the zone out to the neighbouring Cape Kidnappers Hazard Zone (Zone 74 in the NTHM) if that was appropriate. Maps were to cover four return periods: 100, 500, 1000 and 2500 years, and the latter return period needed to be consistent with the 'Maximum Considered Tsunami' as defined in the Ministry of Business, Innovation & Employment (MBIE) guidelines. Hazard maps were also required for four different sea-level heights: the present-day level at Mean High Water Springs (MHWS) and the MHWS level plus 0.65 m, 1.0 m and 1.99 m of sea-level rise. In total, 16 different hazard maps were requested for the area of interest for each coastal zone.

To produce these maps, GNS Science used the latest update to the NTHM (Power et al. 2022) to select scenarios appropriate for each return period for both Zone 73 and 74. The NTHM estimates the offshore tsunami height at a range of return periods, including those needed in this project. For all of the return periods investigated here, an earthquake on the Hikurangi Subduction Zone was the largest contributor to the tsunami hazard for both coastal zones. At the 100-year return period, the majority of the tsunami hazard for this return period comes from a Hikurangi earthquake with an effective moment magnitude (M_W) 8.3 megathrust earthquake. At the 2500-year return period, the majority of the hazard comes from an effective M_W 9.0 megathrust earthquake on the Hikurangi interface. Earthquake magnitudes in the NTHM are 'effective', rather than the actual seismic magnitude, as they also include a component to capture the effect of non-uniform slip on the resulting tsunami (see Power 2013 and Power et al. 2022).

However, the Hikurangi interface is not the only source of tsunami hazard for this area at these return periods. For the 100-year return period, most of the rest of the hazard to both coastal zones comes from regional and distant subduction zone earthquakes on subduction zones such as Peru, Chile, Kermadec and the Kuriles. At the 500-year return period, most of the rest of the hazard comes from a combination of earthquakes on local crust faults lying offshore New Zealand (such as the Lachlan Fault), the outer-rise faults and earthquakes on the Kermadec or Peru Subduction Zone interfaces. At the 2500-year return period, the top six sources of the hazard are all local sources, mostly from earthquakes on the Hikurangi interface but with a significant additional contribution from earthquakes on local crustal faults and local outer-rise faults as well.

GNS Science then combined LiDAR provided by HBRC with their existing bathymetry and topography to produce a Digital Elevation Model suitable for tsunami inundation modelling for the area of interest. Also, a grid of roughness values has been built in agreement with the actual land-cover data for Napier. This grid, and the scenarios described above, were then used to simulate the inundation expected from these scenarios in the region at each of the required sea levels. These were then combined using a weighted median approach to create probabilistic tsunami inundation maps for each return period and sea-level height combination. As expected, at the 100-year return period (i.e. the map showing the flow depths with a 1-in-100 chance of being exceeded each year, aka the 1:100-year map) the extent of inundation is small at the current MHWS, restrained to the low-lying area around Hawke's Bay Airport and the immediate

neighbourhood of rivers. However, at the 1000- and 2500-year return periods, the inundation extents are much larger, with most of the inundation occurring in Napier's coastal suburbs of Ahuriri and Awatoto, the low-lying area around the Hawke's Bay Airport, Napier Port and small towns south of the Tutaekuri river (i.e. Clive, Haumoana and Te Awanga). The effect of adding 0.65 m, 1 m or 1.99 m of sea-level rise projections is to increase the area inundated. The increase in area is substantial once 1.99 m is added to the current MHWS. This has the effect of increasing the frequency of a given area of inundation. For example, adding 1.99 m of sea-level rise to the model increases the area inundated by the 1:100-year tsunami (Figure 5.4) beyond that inundated by the 1:2500 event at the current MHWS (Figure 5.13). Increasing the sea level by these large amounts has a greater impact on the area inundated than increasing the return period within the ranges considered in this study.

1.0 INTRODUCTION

Hawke's Bay Regional Council (HBRC) commissioned GNS Science to provide them with tsunami models for Hawke's Bay that are appropriate to use for land-use planning in the region. HBRC anticipates that, during preparation of the Kotahi Plan, a risk management approach to assessing hazard risks is likely to be taken and the risk then managed according to accepted thresholds. The available tsunami computer modelling completed to date for the area is deterministic (i.e. based on particular scenarios) and has not taken the probabilistic method now recommended for land-use planning. The National Emergency Management Agency (NEMA; formerly MCDEM) Director's Guidelines for Tsunami Evacuation Zones recommends the use of 'Level 3 or 4' probabilistic mapping to provide results with sufficient accuracy for land-use planning purposes. Level 3 modelling "uses a physics-based computer simulation of the process by which water inundates across land" from a tsunami to estimate the evacuation zones (MCDEM 2016). 'Level 4' modelling for evacuation zone design "is the most comprehensive approach, based on drawing an envelope around all inundations from many well-tested hydrodynamic computer models run from source through to inundation". These types of tsunami hazard map have been previously completed by GNS Science for Porirua, Wellington and Hutt City Councils primarily for land-use planning (Gusman et al. 2019a; Burbidge et al. 2021a; 2021b) and for Environment Canterbury for evacuation zone design (Mueller et al. 2019, 2020).

To create maps suitable for land-use planning, HBRC has requested that GNS Science conduct a study to create probabilistic tsunami hazard mapping to a Level 3 standard for the Napier/Hastings coastal zone (Zone 73 in Power [2013] and Power et al. [2022]). This zone is labelled as 'Napier' in Figure 1.1. HBRC also requested that the area to be modelled be extended beyond the zone out to Point 1 (location shown in Figure 1.1) in the Cape Kidnappers Zone (Zone 74), if that was feasible. Maps were to cover four return periods: 100, 500, 1000 and 2500 years, and the latter needed to be consistent with the 'Maximum Considered Tsunami' as defined in NEMA's Director's Guidelines for Tsunami Evacuation Zones (MCDEM 2016). The last set of maps are thus also suitable for informing the design of evacuation zones, primarily the Yellow Zone. On the other hand, the first set of maps for the 100-, 500- and 1000-year return periods are primarily designed for use in land-use planning.

Hazard maps were also required for four different sea-level heights: the present-day level at Mean High Water Springs (MHWS; which is 0.92 m above mean sea level [MSL] in this study for this area) and the MHWS level plus the 0.65 m, 1.0 m and 1.99 m of sea-level rise as requested by HBRC. This resulted in a total of 16 different hazard maps covering each coastal zone in the area of interest. The maps were required to show both the extents and depths of inundation (i.e. flow depths) at these return periods and sea-level assumptions. The maps were to be accompanied by a methodology report (this document). The methodology GNS Science has decided to use for this project is based on the ones used in previous similar studies completed for Porirua City Council (Gusman et al. 2019a) and then further developed in Burbidge et al. (2021a, 2021b) for Wellington and Hutt City Councils.

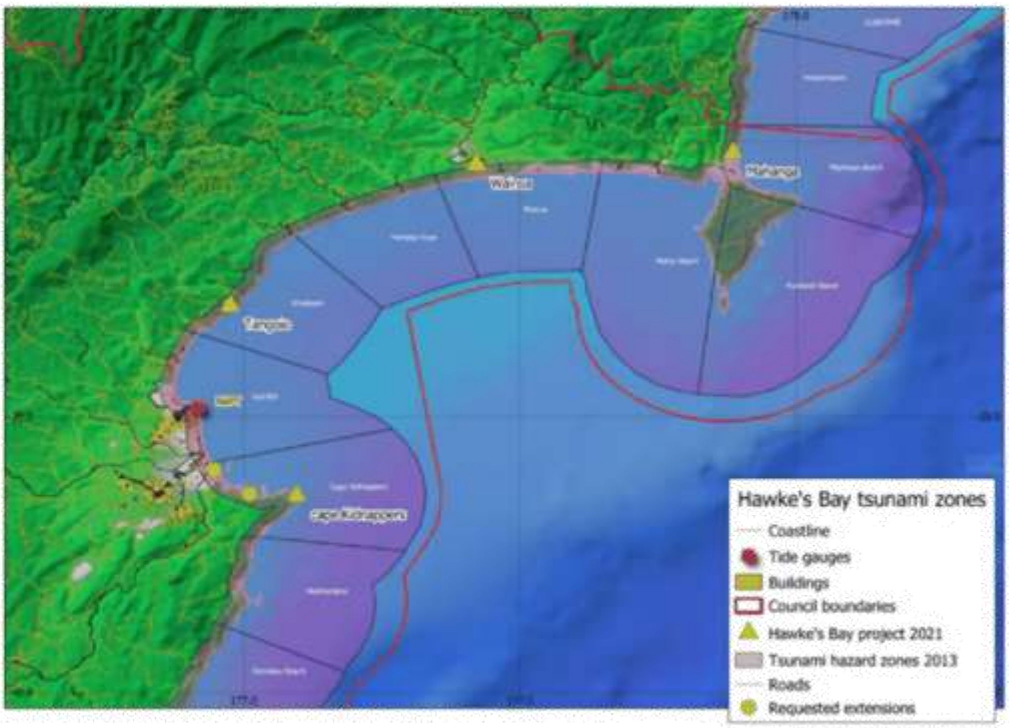

Figure 1.1 Tsunami coastal zones offshore the Hawke's Bay region. This project is limited to the area of LiDAR data provided by HBRC within the 'Napier' Hazard Zone extending out to Point '1', which is within the neighbouring Cape Kidnappers Tsunami Hazard Zone. The yellow triangles indicate the initial area of the study and thus the long-term requirements of HBRC.

The Earthquake Commission (EQC) are funding part of the cost of this project, and they require that the project also:

1. Demonstrate alignment with the three-year tsunami loss modelling project that EQC have commissioned GNS Science to complete.
2. Provide a pilot for the National Tsunami Hazard (or Risk) Model (NTHRM). The proposed NTHRM will provide New Zealand with a national, consistent tsunami hazard and risk model that is suitable for purposes such as land-use planning. This project will test the feasibility of this on a smaller spatial scale than is planned for the NTHRM and will produce a limited set of probabilistic tsunami inundation maps only (i.e. just the hazard, not the risk). Lessons learned from this study will be used to inform GNS Science on the issues and complexities of producing probabilistic tsunami inundation maps for a single coastal zone. This will then be used to inform GNS Science on what will need to be done to complete the much larger-scale NTHRM at a later date, if that project is funded.

1.1 Project Design

The project was structured into the following stages.

1.1.1 Stage 1: Scenario Selection

For each return period, the hazard in the Napier Zone (Zone 73) in the new NTHM model (NTHM2021; Power et al. 2022) was deaggregated, and six scenarios were selected for each return period that encompass the range of tsunamigenic earthquake sources that contribute to the hazard at that return period for the Napier Zone. For the 100-, 500- and 1000-year return periods, the median (50th percentile) hazard value for the zone was selected as the target, while the 84th percentile was used for the 2500-year period map. The 2500-year period map uses the 84th percentile (i.e. confidence level) rather than the 50th percentile to ensure that it meets the Ministry of Business, Innovation & Employment (MBIE) guidelines for the 'Maximum Considered Tsunami' as requested by HBRC (MCDEM 2016).

Since HBRC would like to extend the maps out beyond the Napier Zone (to Point 1 in Figure 1.1), we also need to determine whether any additional scenarios are required. To determine what the additional scenarios might be, we also deaggregated the hazard in the nearby Cape Kidnappers zone (Zone 74, see Figure 2.1) in the NTHM2021 to determine whether there are any scenarios in that deaggregation that are significantly different from those in the Napier zone. For the purposes of this study, an event is significantly different if it comes from a different source (i.e. fault) or from the same source but differs by more than 0.1 magnitude units or differs in location by more than a fault length. These additional scenarios were then included in the inundation modelling stage below. The results from the deaggregation of the NTHM2021 for Zones 73 and 74 are provided in Section 2.

1.1.2 Stage 2: Digital Elevation Model Creation

For the purpose of the tsunami inundation modelling, GNS Science created a 5 m resolution Digital Elevation Model (DEM) of the Napier region by combining existing topographic and bathymetric data. This DEM extent is shown on Figure 1.2 (red rectangle). Bathymetric data came from the extraction of nautical chart information and/or GNS Science's existing bathymetric survey datasets (see Section 3). Topographic data came from GNS Science's existing topographic datasets, as well as the LiDAR dataset provided by HBRC (pink polygon on Figure 1.2). GNS Science then integrated this topographic and bathymetry data into a single 5 m elevation grid and then down sampled it to about 11 m to produce a final grid to be used in the modelling stage. An 11 m grid was used to keep the computations tractable within the time available to complete this project. This grid was then tested to ensure modelling stability and to ensure that features such as stop banks were properly incorporated. Note that this grid has been designed solely for the purposes of producing tsunami models for the area and may not be suitable for other purposes (e.g. navigation). The resulting grid is provided as one of the deliverables and described further in Section 3.

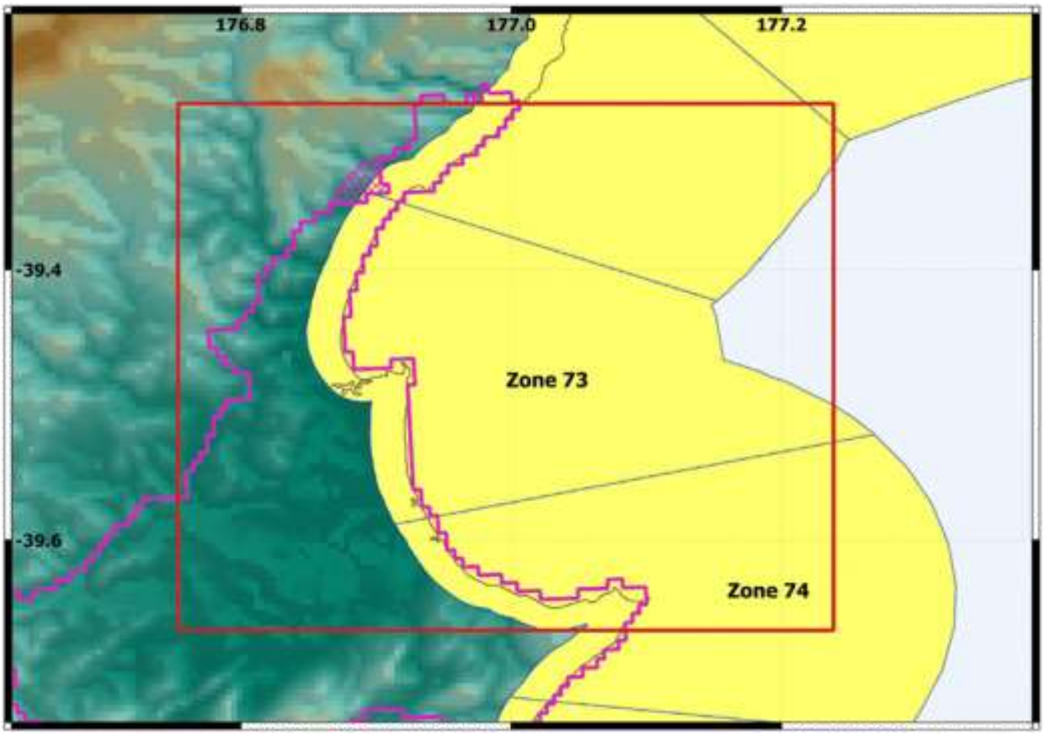

Figure 1.2 The area of interest for the project (red rectangle). HBRC's high-resolution LiDAR is shown by the pink polygon. The hatched pink polygon represents the zone where GNS Science asked HBRC for more LiDAR data. The current tsunami evacuation Yellow Zone is represented by the yellow-filled polygon.

1.1.3 Stage 3: Tsunami Inundation Modelling

After testing the stability of the new grids, each of the scenarios identified in Stage 1 were then modelled through to inundation in the area of interest. To do this, the models were run on either the High-Performance Computing Facility (HPCF) hosted within New Zealand's eScience Infrastructure (NeSI) or on GNS Science's own HPC system. At the end of this stage, we then had a set of scenarios with both the inundation extent and flow depths for each of them. These were run four times at each required sea-level value. In total, 134 tsunami models were completed through to inundation for the area of interest, all described further in Section 4.

1.1.4 Stage 4: Hazard Maps

Finally, from the set of scenarios calculated in Stage 3, GNS Science then created a series of tsunami hazard maps showing the median or 84th percentile inundation extent and flow depths region at each of the return periods and sea-level rise values specified. One set of maps were created for the scenarios used for Zone 73 and another for the scenarios appropriate for Zone 74. Since four return periods are required for four different sea-level rise values, a total of 32 maps are provided (16 for each coastal zone). Note also that the maps at the first three return periods (100, 500 and 1000 years) have been produced primarily to inform land-use planning in each coastal zone rather than to replace the existing evacuation zones maps. The maps have been provided to HBRC along with this report. The hazard map creation is described further in Section 5.

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2.0 SCENARIO SELECTION

2.1 Deaggregating the National Tsunami Hazard Model

As stated earlier, we have based the scenarios for inundation modelling on the latest version of the NTHM2021. This new model has a variety of improvements; the main one relevant for this project being improved modelling of the tsunami from local sources. To achieve this improvement in the treating of local sources, we modelled tsunami caused by 248 local faults from around New Zealand based on estimates of fault geometry and plausible magnitudes of the earthquakes that could occur on each fault (Stirling et al. 2012; Power 2013). We also updated data and methods used in calculating tsunami heights from local-, regional- and distant-source subduction zones. This is further detailed in Power et al. (2022).

Figure 2.1a shows the updated hazard curves for Zone 73 (Napier) in the NTHM2021. For comparison, the hazard curves from the 2013 version of the NTHM (NTHM2013; Power 2013) are also shown (Figure 2.1b). The solid black line is the median hazard (as defined by the maximum offshore amplitude, i.e. tsunami height) as a function of the return period, while dashed lines show the 16% and 84% confidence intervals. The 16% and 84% confidence curves give an indication of the level of uncertainty in the hazard values for a given return period. Statistically, there is a 16% chance that the hazard will be below the lower dotted line and an 84% chance that it will be below the higher dotted line (and thus a 16% chance that it will be above it).

In the case shown here, the revised hazard estimated for Tsunami Hazard Zone 73 has gone up slightly. This appears to be mostly due to a larger contribution to the estimated hazard from outer-rise faults in the Hawke's Bay region, which more than compensates for a reduced contribution from South American distant sources, both of which are modelled using more accurate methods in the revised NTHM2021 than in the earlier NTHM2013.

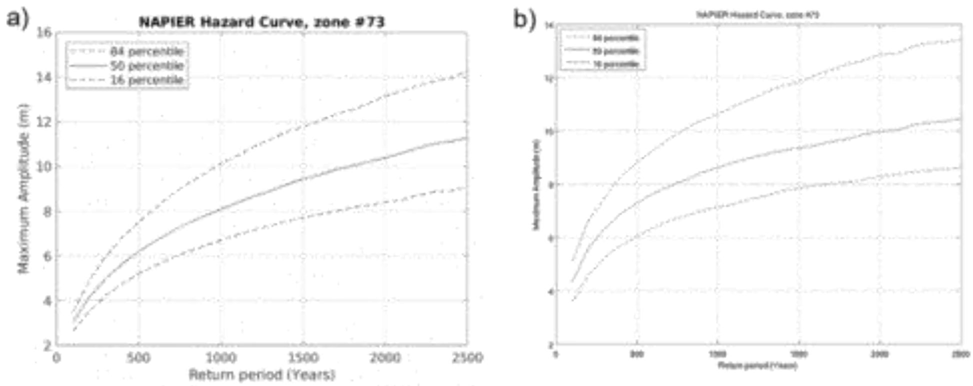


Figure 2.1 Tsunami hazard curves for Zone 73 in (left) NHTM2021 and (right) NTHM2013. The offshore tsunami height (i.e. amplitude in the figure) above mean sea level is a function of the return period.

The hazard at any particular return period usually comes from a range of different earthquake sources. To determine this, we use a process known as 'deaggregation' to determine which sources from a database of scenarios contribute most of the hazard for a specific zone at a given return period. Tables 2.1 and 2.2 show the top six hazard source scenarios at each of the four return periods for Zone 73 and 74, respectively. These sources encompass the majority of the hazard for that particular return period in these zones. The locations of the earthquake sources referred to in the tables are shown in Figure 2.2.

Table 2.1 The top six scenarios and their effective magnitudes for Zone 73 (Napier) determined by deaggregating NTHM2021 (Power et al. 2022) at four return periods: 100, 500, 1000 and 2500 years. Effective magnitude is described in detail in Power (2013). 'SZ' is short for subduction zone. The other sources are crustal faults. The first three deaggregations (return periods 100, 500 and 1000 years) were calculated at the median (50th percentile) hazard value in Zone 73, while the 2500-year one was calculated at the 84th percentile. 'Tsunami Height' is the maximum amplitude of the tsunami in Zone 73 at the corresponding return period and confidence level. 'Weight' is the percentage that this subduction zone or fault contributes to this particular hazard value. Note that only the top six sources are shown, so weights do not add to 100%.

	Return Period (Years)	100	500	1000	2500
	Confidence Level (Percentile)	50	50	50	84
	Tsunami Height in NTHM2021 (m)	3.0	6.2	8.1	14.2
Scenario 1	**SZ Name and Weight**	Hikurangi SZ 32.2%	Hikurangi SZ 42.2%	Hikurangi SZ 42.9%	Hikurangi SZ 34.4%
	Magnitude Range and Median (Effective M_W)	8.0–8.7, with median of 8.3	8.3–8.9, with median of 8.6	8.5–9.0, with median of 8.7	8.5–9.2, with median of 9.0
Scenario 2	**SZ or Fault Name and Weight**	Peru SZ 11.5%	Hawkes Bay Outer Rise Fault 6.9%	Hawkes Bay Outer Rise Fault 10.8%	Hawkes Bay Outer Rise Fault 20.8%
	Magnitude Range and Median (Effective M_W)	9.1–9.5, with median of 9.3	8.1–8.1, with median of 8.1	8.2–8.3, with median of 8.2	8.2–8.6, with median of 8.5
Scenario 3	**SZ or Fault Name and Weight**	North Chile SZ 9.6%	Lachlan Fault 6.8%	North Wairarapa Outer Rise Fault 9.7%	North Wairarapa Outer Rise Fault 16.8%
	Magnitude Range and Median (Effective M_W)	9.0–9.4, with median of 9.2	7.7–7.8, with median of 7.8	8.2–8.3, with median of 8.3	8.2–8.6, with median of 8.5
Scenario 4	**SZ or Fault Name and Weight**	Kermadec SZ 8.0%	Kermadec SZ 6.6%	Lachlan Fault 7.9%	Lachlan Fault 9.1%
	Magnitude Range and Median (Effective M_W)	8.6–9.3, with median of 8.8	9.0–9.7, with median of 9.3	7.9–7.9, with median of 7.9	7.9–8.2, with median of 8.2
Scenario 5	**SZ or Fault Name and Weight**	Central Chile SZ 7.3%	North Wairarapa Outer Rise Fault 6.3%	South Wairarapa Outer Rise Fault 5.1%	South Wairarapa Outer Rise Fault = 5.7%
	Magnitude Range and Median (Effective M_W)	9.3–9.7, with median of 9.5	8.1–8.2, with median of 8.1	8.4–8.5, with median of 8.4	8.5–8.8, with median of 8.7
Scenario 6	**SZ or Fault Name and Weight**	Kuriles-Kamchatka SZ 4.0%	Peru SZ 6.3%	Peru SZ 4.0%	Napier_1931 Fault 2.9%
	Magnitude Range and Median (Effective M_W)	9.3–9.6, with median of 9.4	9.5–9.8, with median of 9.6	9.6–9.9, with median of 9.7	7.9–8.3, with median of 8.2

Table 2.2 The top six scenarios and their effective magnitudes for Zone 74 (Cape Kidnappers) determined by deaggregating NTHM2021 (Power et al. 2022) at four return periods: 100, 500, 1000 and 2500 years. Effective magnitude is described in detail in Power (2013). 'SZ' is short for subduction zone. The other sources are crustal faults. The first three deaggregations (return periods 100, 500 and 1000 years) were calculated at the median hazard value (50th percentile) in Zone 74, while the 2500-year one was calculated at the 84th percentile. 'Tsunami Height' is the maximum amplitude of the tsunami in Zone 74 at the corresponding return period and confidence level. 'Weight' is the percentage that this subduction zone contributes to this particular hazard value. Note that only the top six sources are shown, so weights do not add to 100%.

	Return Period (Years)	100	500	1000	2500
	Confidence Level (Percentile)	50	50	50	84
	Tsunami Height in NTHM 2021 (m)	3.3	6.8	8.9	15.1
Scenario 1	**SZ Name and Weight**	Hikurangi SZ 38.2%	Hikurangi SZ 39.3%	Hikurangi SZ 42.3%	Hikurangi SZ 33.3%
	Magnitude Range and Median (Effective M_W)	7.9 to 8.7, with median of 8.3	8.4 to 8.9, with median of 8.6	8.5 to 9.0, with median of 8.7	8.6 to 9.2, with median of 9.0
Scenario 2	**SZ or Fault Name and Weight**	Peru SZ 12.7%	Peru SZ 7.9%	North Wairarapa Outer Rise Fault 9.8%	North Wairarapa Outer Rise Fault 20.5%
	Magnitude Range and Median (Effective M_W)	9.2 to 9.5, with median of 9.3	9.4 to 9.8, with median of 9.5	8.2 to 8.2, with median of 8.2	8.2 to 8.5, with median of 8.4
Scenario 3	**SZ or Fault Name and Weight**	Central Chile SZ 7.1%	North Wairarapa Outer Rise Fault 6.9%	Hawkes Bay Outer Rise Fault 9.3%	Hawkes Bay Outer Rise Fault 16.6%
	Magnitude Range and Median (Effective M_W)	9.3 to 9.7, with median of 9.4	8.1 to 8.1, with median of 8.1	8.3 to 8.4, with median of 8.3	8.4 to 8.6, with median of 8.6
Scenario 4	**SZ or Fault Name and Weight**	North Chile SZ 6.5%	Hawkes Bay Outer Rise Fault 6.8%	Lachlan Fault 6.3%	Lachlan Fault 6.9%
	Magnitude Range and Median (Effective M_W)	9.0 to 9.5, with median of 9.2	8.2 to 8.2, with median of 8.2	7.9 to 8.0, with median of 8.0	8.0 to 8.3, with median of 8.2
Scenario 5	**SZ or Fault Name and Weight**	Kermadec SZ 5.1%	Lachlan Fault 6.3%	Peru SZ 5.3%	South Wairarapa Outer Rise Fault 6.2%
	Magnitude Range and Median (Effective M_W)	8.7 to 9.4, with median of 9.0	7.8 to 7.9, with median of 7.9	9.5 to 9.9, with median of 9.6	8.5 to 8.8, with median of 8.7
Scenario 6	**SZ or Fault Name and Weight**	Kuriles-Kamchatka SZ 3.5%	Kermadec SZ 4.7%	South Wairarapa Outer Rise Fault 4.7%	Motuokura Fault 4.7%
	Magnitude Range and Median (Effective M_W)	9.3 to 9.6, with median of 9.4	9.1 to 9.7, with median of 9.3	8.4 to 8.5, with median of 8.4	7.9 to 8.2, with median of 8.1

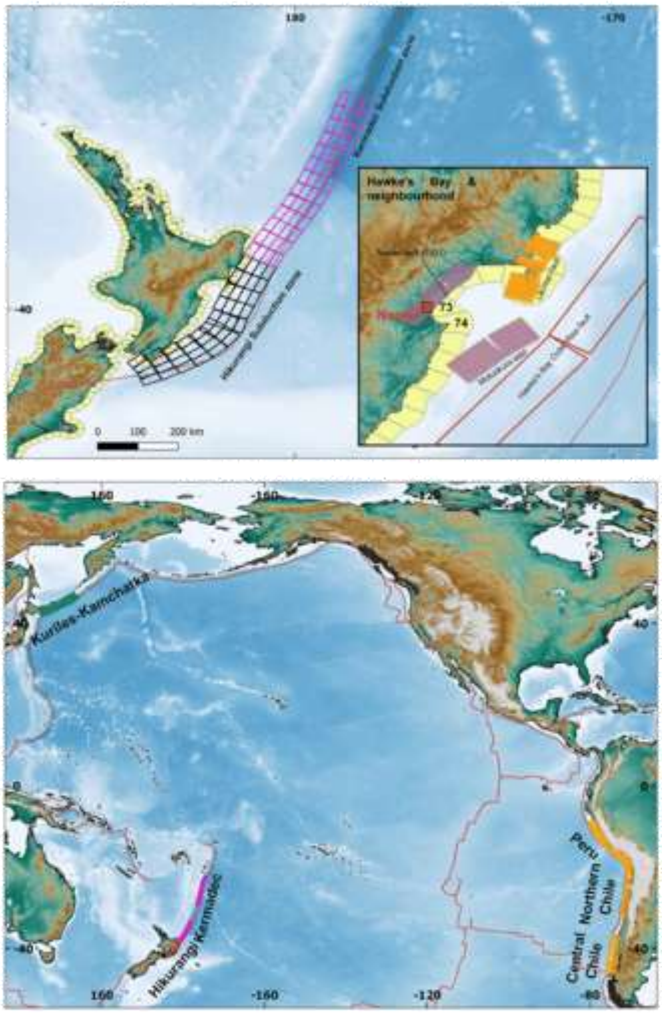


Figure 2.2 Maps showing the location of the faults for each of the scenarios listed in Tables 2.1 and 2.2. Top: the local faults and tsunami zones 73 (Napier) and 74 (Cape Kidnappers). The black and pink squares show the unit sources on each subduction zone. The earthquake used in the simulations was constructed by adding together the deformation from each of these smaller unit sources. Bottom: the distant and regional sources used in this study. The green and orange squares show the unit sources used for the Kurils and South American subduction zone sources, respectively. In addition to the faults shown here, tsunami from the North and South Wairarapa Outer Rise Faults were also simulated. These faults extend from the 'Hawkes Bay Outer Rise Fault' shown in the top figure down to approximately Cook Strait and run roughly parallel to the Hikurangi subduction zone. They are not shown in regional scale figure to avoid obscuring the Hikurangi Interface unit sources (i.e. the black squares).

As can be seen from Tables 2.1 and 2.2, the tsunami hazard in the two zones is quite similar in terms of tsunami height and the main subduction zones and faults that contribute to it. This means that we can extend the hazard into part of Zone 74 with only a small number of additional scenarios. The scenarios needed for the probabilistic modelling are listed in Table 2.3. This table was compiled by comparing the scenarios in Tables 2.1 and 2.2 and the locations of the specific scenarios. If the median magnitude of the scenario for Zone 73 is within 0.1 magnitude unit of that for the corresponding Zone 74 scenario, and the location of the closest scenario to the target is within a fault length, then we assume that the same scenario can reasonably be used for both coastal zones. The process of selecting the exact location for each scenario along its source is described in detail in Section 2.2. As most of the area of interest is in Zone 73, the magnitude used for the scenario in the modelling stage described in Section 4 will be the median magnitude for Zone 73. If the median of the corresponding scenario is 0.2 magnitude units or more different, or if there is no corresponding scenario for the other coastal zone set or if the closest scenario is more than one fault length away, then we need to model both scenarios. In all, 31 different scenarios need to be modelled through to inundation in Stage 3.

Table 2.3 The 31 scenarios, their effective magnitudes and the return periods used in this study. The final column indicates whether the scenario will be used for both coastal zones or just one. Note that the final hazard maps will not cover the whole of Zone 74, just up to point 2 indicated in Figure 1.1.

Subduction Zone or Fault Name	Effective Magnitude	Return Period (Years)	Used for Coastal Zones:
Hikurangi subduction zone	8.3	100	73
Hikurangi subduction zone	8.3	100	74
Hikurangi subduction zone	8.6	500	73, 74
Hikurangi subduction zone	8.7	1000	73, 74
Hikurangi subduction zone	9.0	2500	73
Hikurangi subduction zone	9.0	2500	74
Peru subduction zone	9.3	100	73
Peru subduction zone	9.3	100	74
Peru subduction zone	9.6	500	73, 74
Peru subduction zone	9.7	1000	73
Peru subduction zone	9.6	1000	74
Central Chile subduction zone	9.5	100	73, 74
North Chile subduction zone	9.2	100	73
North Chile subduction zone	9.2	100	74
Kermadec subduction zone	8.9	100	73, 74
Kermadec subduction zone	9.3	500	73
Kermadec subduction zone	9.3	500	74
Kuriles-Kamchatka	9.4	100	73, 74
Hawkes Bay Outer Rise Fault	8.1	500	73, 74
Hawkes Bay Outer Rise Fault	8.2	1000	73, 74
Hawkes Bay Outer Rise Fault	8.5	2500	73, 74
Lachlan Fault	7.8	500	73, 74
Lachlan Fault	7.9	1000	73, 74
Lachlan Fault	8.2	2500	73, 74
North Wairarapa Outer Rise Fault	8.1	500	73, 74
North Wairarapa Outer Rise Fault	8.3	1000	73, 74
North Wairarapa Outer Rise Fault	8.5	2500	73, 74
South Wairarapa Outer Rise Fault	8.4	1000	73, 74
South Wairarapa Outer Rise Fault	8.7	2500	73, 74
Napier_1931	8.2	2500	73
Motuokura East	8.1	2500	74

2.2 Determining the Earthquake Source Parameters

In order to determine the exact earthquake source parameters (e.g. the exact location of the earthquake along the interface) of each of the scenarios selected for the tsunami inundation modelling, we first found a scenario in the Tsunami Threat Map database (Gusman et al. 2019b) that produced a tsunami height in Tsunami Hazard Zone 73 or 74 closest to the tsunami height (target height) of a given return period and that had a magnitude similar to the deaggregated scenario. We then scaled the slip amount based on the tsunami heights of the selected scenario (initial height) and target height. The target height, initial slip amount and re-scaled slip and resulting moment magnitudes for each of four return periods are shown in the following tables (Zone 73: Tables 2.4, 2.5, 2.6, 2.7; 74: Tables 2.8, 2.9, 2.10, 2.11). To calculate the re-scaled slip amount, we multiplied the initial slip amount with the ratio between the target and initial height. The re-scaled slip amount can be used to calculate the re-scaled moment magnitude (M_W) by first re-calculating the scalar seismic moment (mo) while keeping the rigidity and fault area the same as the initial model values, using Equations 2.1 and 2.2.

$$mo = \mu SA \qquad \text{Equation 2.1}$$

$$M_W = \frac{2}{3}(log(mo) - 9.1) \qquad \text{Equation 2.2}$$

The assumed rigidity (μ) is 40 GPa for interplate and outer-rise earthquakes and 34.3 GPa for crustal fault earthquakes, while A is the fault area. These values were chosen to be consistent with values used in other studies, such as Gusman et al. (2019b) and Power et al. (2022). The re-scaled slip and magnitudes for all of the deaggregated scenarios are presented in the following tables for each return period. Note that the effective moment magnitudes indicated in each table are median values.

Table 2.4 Deaggregated source scenarios and the re-scaled slip and magnitude amount used in the inundation modelling for the 100-year return period hazard maps for Zone 73. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	3.03	8.28	3.55	3.47	2.96	8.25
Peru	3.03	9.30	3.32	19.59	17.89	9.27
Northern Chile	3.03	9.17	2.90	19.96	20.85	9.11
Kermadec	3.03	8.84	2.82	13.86	14.93	8.92
Center Chile	3.03	9.46	2.64	28.37	32.55	9.54
Kuril-Kamchatka	3.03	9.43	2.57	15.24	18.02	9.35

Table 2.5 Deaggregated source scenarios and the re-scaled slip and magnitude amount used in the inundation modelling for the 500-year return period hazard maps for Zone 73. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	6.20	8.56	6.02	5.83	6.00	8.51
Hawkes Bay Outer rise_1002	6.20	8.123	5.78	10.47	11.23	8.22
Lachlan3_231	6.20	7.80	5.19	4.57	5.46	7.75
Kermadec	6.20	9.27	5.03	21.5	26.51	9.16
North Wairarapa Outer rise	6.20	8.14	7.15	10.47	9.08	8.16
Peru	6.20	9.57	5.88	34.58	36.49	9.52

Table 2.6 Deaggregated source scenarios and the rescaled slip and magnitude amount used in the inundation modelling for the 1000-year return period hazard maps for Zone 73. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	8.09	8.69	8.27	8.82	8.63	8.69
Hawkes Bay Outer rise_1002	8.09	8.24	5.78	10.47	14.66	8.30
North Wairarapa Outer rise_1003	8.09	8.26	7.15	10.47	11.86	8.24
Lachlan3_231	8.09	7.91	5.19	4.57	7.13	7.83
South Wairarapa Outer rise_1004	8.09	8.44	4.66	10.47	18.16	8.36
Peru	8.09	9.68	5.88	34.58	47.63	9.59

Table 2.7 Deaggregated source scenarios and the rescaled slip and magnitude amount used in the inundation modelling for the 2500-year return period hazard map for Zone 73. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	14.28	8.97	14.27	13.86	13.87	8.90
Hawkes Bay Outer rise_1002	14.278	8.49	5.77	10.47	25.87	8.46
North Wairarapa Outer rise_1003	14.28	8.50	7.15	10.47	20.92	8.40
Lachlan3_231	14.28	8.15	5.19	4.57	12.57	7.99
South Wairarapa Outer rise_1004	14.28	8.68	4.67	10.47	32.04	8.52
Napier 1931_242	14.28	8.21	3.95	4.58	16.55	8.07

Table 2.8 Deaggregated source scenarios and the re-scaled slip and magnitude amount used in the inundation modelling for the 100-year return period hazard maps for Zone 74. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	3.37	8.26	3.74	3.47	3.13	8.27
Peru	3.37	9.29	3.35	16.63	16.72	9.30
Centre Chile	3.37	9.41	3.97	30.74	26.14	9.45
Northern Chile	3.37	9.18	4.06	30.48	25.32	9.25
Kermadec	3.37	8.99	2.70	13.86	17.29	8.96
Kuril-Kamchatka	3.37	9.41	2.95	15.24	17.42	9.34

Table 2.9 Deaggregated source scenarios and the re-scaled slip and magnitude amount used in the inundation modelling for the 500-year return period hazard maps for Zone 74. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	6.80	8.59	6.24	5.83	6.35	8.52
Peru	6.80	9.53	5.88	34.58	40.01	9.54
North Wairarapa Outer rise	6.80	8.10	9.60	10.47	7.41	8.10
Hawkes Bay Outer rise_1002	6.80	8.19	5.80	10.47	12.26	8.25
Lachlan3_231	6.80	7.85	4.57	4.57	6.80	7.81
Kermadec	6.80	9.30	4.98	32.27	44.08	9.39

Table 2.10 Deaggregated source scenarios and the re-scaled slip and magnitude amount used in the inundation modelling for the 1000-year return period hazard maps for Zone 74. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	8.86	8.70	8.97	8.82	8.70	8.70
North Wairarapa Outer rise_1003	8.86	8.21	9.60	10.47	9.65	8.18
Hawkes Bay Outer rise_1002	8.86	8.30	5.80	10.47	15.97	8.32
Lachlan3_231	8.86	7.96	4.57	4.57	8.86	7.89
Peru	8.86	9.63	7.30	31.62	38.37	9.56
South Wairarapa Outer rise_1004	8.86	8.44	4.79	10.47	19.34	8.38

Table 2.11 Deaggregated source scenarios and the re-scaled slip and magnitude amount used in the inundation modelling for the 2500-year return period hazard maps for Zone 74. The target heights and magnitude come from the deaggregation of the NTHM for this return period. The initial height and slip amount were found from the closest scenario in the database to the target magnitude and height. The final slip amount and final moment magnitude after re-scaling are shown in the last two columns. These are the values used in the tsunami simulations later in the project.

Source Name	Target Height (m)	Target Effective Moment Magnitude	Initial Height (m)	Initial Slip Amount (m)	Re-Scaled Slip Amount (m)	Re-Scaled Moment Magnitude
Hikurangi	15.06	8.98	14.53	17.32	17.95	8.91
North Wairarapa Outer rise_1003	15.06	8.44	9.60	10.47	16.41	8.33
Hawkes Bay Outer rise_1002	15.06	8.53	5.80	10.47	27.16	8.48
Lachlan3_231	15.06	8.18	4.57	4.57	15.06	8.05
South Wairarapa Outer rise_1004	15.06	8.66	4.79	10.47	32.88	8.53
MotuokuraE_293	15.06	8.11	4.57	4.57	15.06	8.05

3.0 DIGITAL ELEVATION MODEL CREATION

Three sets of DEM data have been used in this study to meet spatial accuracy and coverage requirements for the simulation of tsunami originating from their sources, travelling through open sea and interacting with the coasts of Hawke's Bay and its surrounding areas.

These DEM datasets are:

- Global DEM data
- New Zealand DEM data, and
- Hawke's Bay DEM data.

These DEM datasets provide elevation information at numerical modelling grids used for the tsunami simulations (see Section 4).

3.1 Global Digital Elevation Model

Global DEM data was developed at a spatial resolution of 2 arc-minutes (~3600 m on the equator and ~2780 m in Napier) using ETOPO2v2 (https://www.ngdc.noaa.gov/mgg/global/etopo2.html) as a base model, together with other data. ETOPO2v2 is a 2 arc-minute global relief model of Earth's surface that integrates land topography and ocean bathymetry and is available from the National Centers for Environmental Information of NOAA (National Oceanic and Atmospheric Administration). In addition to this dataset, the New Zealand DEM data was used to update the New Zealand region in the original ETOPO2v2 data for improved data accuracy.

3.2 New Zealand Digital Elevation Model

The New Zealand DEM data was derived from LINZ charts, the Seabed Mapping CMAP, GEBCO 08 (https://www.gebco.net/news_and_media/updated_gebco_08_release.html) and LINZ 8 m elevation datasets. This DEM dataset covers the main islands of New Zealand and their offshore regions at a grid spacing of 10 arc-seconds (~200–250 m in New Zealand).

3.3 Hawke's Bay Digital Elevation Model

For the scope of the project, we have combined the LiDAR data provided to us by HBRC (Jose Beya, pers. comm.) with our existing bathymetry and elevation data to create a new DEM grid for the region suitable for inundation modelling. The DEM vertical reference is set to MSL, which has zero-elevation. Heights in terms of New Zealand Vertical Datum 2016 (NZVD2016) from the original LiDAR DEM obtained from HBRC were related to the local vertical datum Napier 1962 (MSL), using LINZ conversion file: https://data.linz.govt.nz/layer/53436-napier-1962-to-nzvd2016-conversion/. Additional digitisation of georeferenced nautical charts in shallow waters offshore Napier, including Napier Port (i.e. chart NZ 5612 Napier Road[1]), has been necessary to increase the resolution of the bathymetry near the coast and inside the port (Figure 3.1). LiDAR data provided by the council covers the stopbanks of the rivers but not the river bathymetry itself. Manual work, using both river cross-sections provided by the council and aerial images, was used to construct the river bathymetry. For this project, we have put together a 5 m resolution DEM grid that covers the area of interest by combining the different irregular datasets using a GIS software (Global Mapper, Blue Marble Geographics®). In order to produce

1 https://data.linz.govt.nz/layer/51406-chart-nz-5612-napier-roads/ and https://data.linz.govt.nz/layer/51550-chart-nz-5612-napier-roads/

a regular 10 m resolution grid suitable for further tsunami simulations, we interpolated the 5 m grid using the kriging methodology in the Surfer® software. Note that kriging is a robust and widely used geostatistical interpolation methodology providing generally better results than more traditional techniques (e.g. linear regression, nearest neighbour, inverse distance weighted, etc.) as long as there is a good spatial correlation between the data points; it uses this spatial correlation between the points (i.e. the spatial distribution) to interpolate the values in space using a variogram (e.g. Arun 2013; Ikechukwu et al. 2017).

We then ran some grid-quality test models to ensure that the resulting 10 m resolution modelling grid does not have any strange bathymetric or topographic points leading to instabilities of the model and that the stop banks were suitably contiguous to inhibit tsunami flow appropriately (see Section 4.8). The final 5 m DEM is shown in Figure 3.2. This DEM is provided with the report.

Figure 3.1 Details of the nearshore bathymetry of the digital elevation model (DEM), including Napier Port and the Ahuriri Estuary revealed with slope shading imaging. The figure shows the local slope in degrees. This method of visualising the DEM highlights the parts of the region with steep slope that are most likely to stop or inhibit the tsunami inundation (e.g. Bluff Hill).

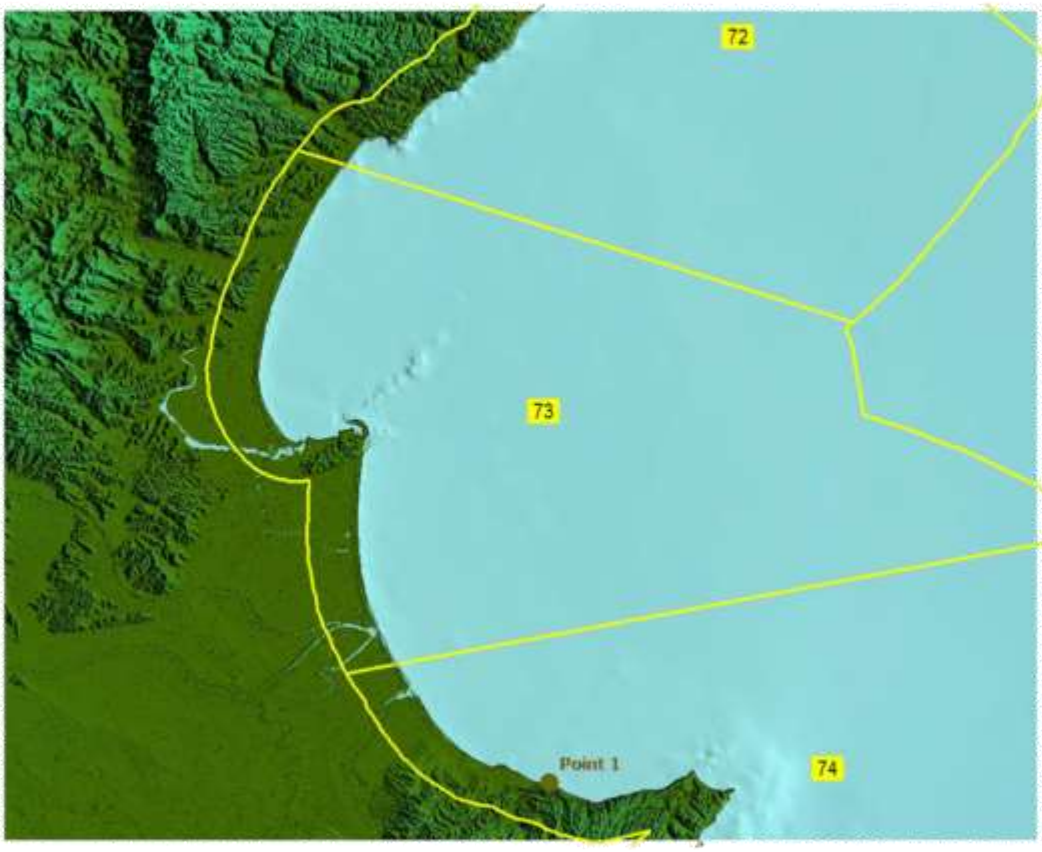


Figure 3.2 The high-resolution (~5 m) DEM created to model the inundation in Zones 73 and part of Zone 74. The yellow lines outline the extents of the tsunami coastal zones; the red dot shows the location of Point 1 as defined in the contract.

4.0 TSUNAMI INUNDATION MODELLING

4.1 Simulation Software: COMCOT

The numerical simulation model, COMCOT (Cornell Multi-grid Coupled Tsunami), was adopted to simulate tsunami generation and propagation from their sources to Hawke's Bay, calculate tsunami evolution inside the bay and model detailed tsunami inundations in its coastal areas. The model was originally developed at Cornell University, USA, in the 1990s (Liu et al. 1998; Wang 2008) and, since 2009, it has been under development at GNS Science, New Zealand (for example, see Wang and Power 2011). Multiple source mechanisms have been integrated in this simulation tool, such as earthquakes with time-dependent rupture, variable slip distributions or landslides.

This model has been widely benchmarked and used by researchers worldwide to study various aspects of tsunami, including tsunami-generation mechanisms, transoceanic propagation, run-up and coastal inundation. In recent years, it has been further developed and is increasingly used to investigate storm surges; wave-structure interactions; effects of rivers, tides and sea-level rise on tsunami hazards; landslides in reservoirs/lakes; and downstream flooding (Wang and Liu 2006; Wijetunge et al. 2008; Beavan et al. 2010; Wang 2008, Wang and Power 2011; Mueller et al. 2015a, 2015b; Wang et al. 2017a, 2017b; Mountjoy et al. 2019; Liu et al. 2018; Li et al. 2018; Mueller et al. 2019; Power et al. 2019; Gusman et al. 2020; Roger et al. 2020; Wang et al. 2020a, 2020b). The latest version of this model was used in this study.

COMCOT uses a modified staggered finite difference scheme to solve linear and non-linear shallow water equations that typically govern tsunami, floods and river flows with shock[2] capturing up-wind schemes, together with ad-hoc wave breaking algorithms (Kennedy et al. 2000; Lynett 2002; Wang and Power 2011) for improved stability and to account for the energy dissipation effects during run-up and inundation. Both spherical and Cartesian coordinate systems are supported, providing flexibility to tsunami hazard investigations over large transoceanic coverages and small local areas. A two-way nested grid configuration is implemented in the model to balance computational efficiency and numerical accuracy (Wang 2008; Wang and Power 2011). The model uses a relatively large grid spacing to efficiently simulate the propagation of tsunami in the deep ocean and switches to refined grid spacings in near-shore and coastal regions to account for the shortening of tsunami wavelength due to the shallowness of water depth and to achieve sufficient numerical accuracy in the areas of interest (Fraser 2014; Fraser et al. 2014).

4.2 Reference Level and Terminologies

COMCOT uses a universal reference level (zero-elevation level), locally in coincidence with MSL, to interpret input data for elevation information in the DEM and create output data such as tsunami elevations. This reference level is fixed in a virtual space, does not change throughout a numerical simulation and, particularly, is not affected by any potential co-seismic displacements (e.g. uplift or subsidence) in a local earthquake event. During a simulation and

2 This is a modelling method to deal with shock waves in inviscid fluids (common assumption for water for gravity-dominated wave dynamics modelling). Shock waves will lead to a sharp of fluid motions and cause discontinuities of flow variables, a major source of instability. COMCOT uses a conservative form of governing equations so that shock waves become a natural part of the solution. Accuracy and stability are further enhanced by specially designed up-wind finite difference schemes in which no information in front of a shock ('unknown zone') will be used to evaluate derivatives, based on velocity directions.

in output data, 'tsunami elevation' is defined as the tsunami water surface level above the universal reference level (e.g. MSL) and 'tsunami flow depth' refers to the vertical water layer thickness between the water surface and topographical surface (ground or seafloor surface) as defined in the DEM (Figure 3.1). Elevation data is positive if above the universal reference level (in this case, tsunami elevation is often called tsunami height) and negative if below it. Note that flow depth values are independent of reference levels.

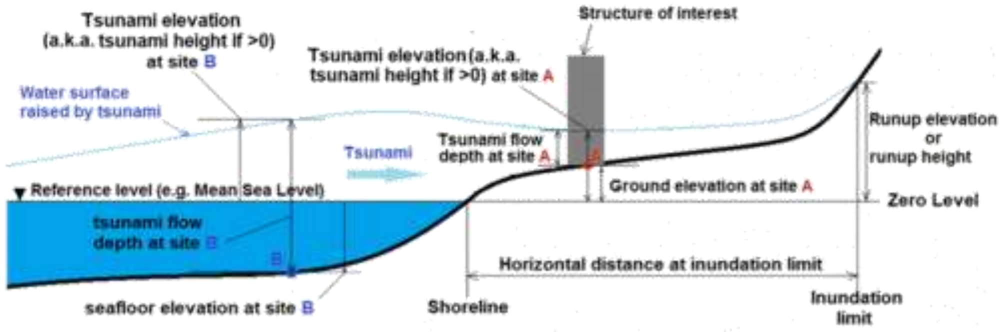


Figure 4.1 Illustration of some definitions used in tsunami modelling, for example, water surface level / tsunami elevation (i.e. tsunami height), tsunami flow depth / inundation depth and ground elevation at site location A on land and B in water.

4.3 Modelling Grid Set-Up

COMCOT uses a series of nested numerical modelling grids at cascading spatial resolutions to account for spatial resolution requirements by a tsunami travelling in different regions, e.g. from deep ocean basin to shallow coastal areas (Wang and Power 2011). In this study, four levels of numerical grid with different spacing refinement were used to simulate tsunami generation, transoceanic propagation, coastal run-up and inundation. This nested grid set-up is able to telescope spatial resolutions from 2 arc-minutes (~3600 m on the Equator), covering the entire Pacific, to 0.5 arc-seconds (about 11 metres) covering the Hawke's Bay and its surrounding areas.

The first grid level (grid 01) covers the whole Pacific Ocean to simulate tsunami generations and propagations from a variety of sources at a spatial resolution of 2 arc-minutes (~3900 m on the Equator and ~2850 m in Napier, see Figure 4.2). The elevation data of grid 01 was interpolated from the Global DEM data described in Section 3.1.

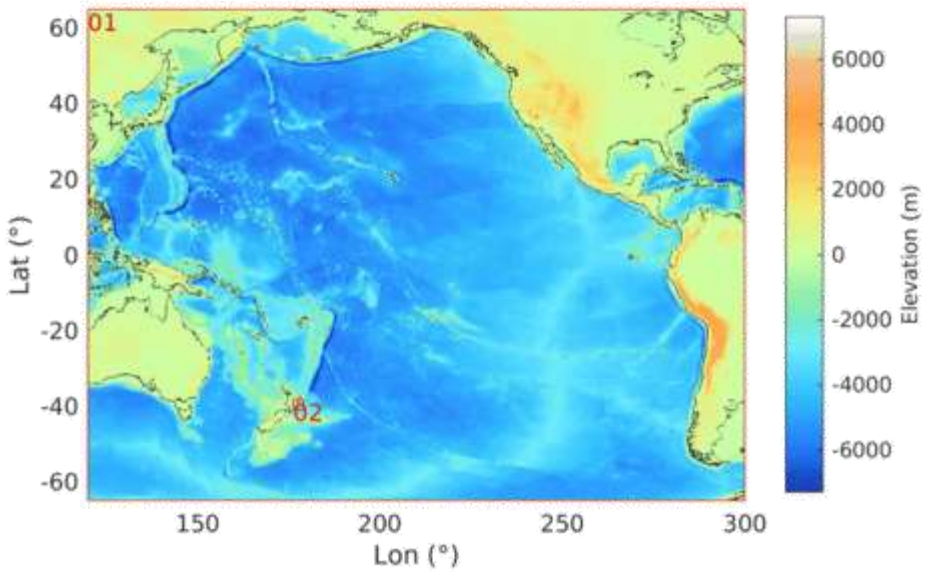


Figure 4.2 Coverage of modelling grid 01 for the Hawke's Bay modelling. Red box outlines the coverage of grid 02. Elevation (relative to MSL) is colour-coded in metres. Data is from the global DEM grids with a spatial resolution of 2 arc-minutes.

The second grid level (grid 02) covers part of New Zealand's North Island east coast at 15 arc-seconds (~310–380 m in New Zealand and ~360 m in Hawke's Bay, see Figures 4.2 and 4.3). The third grid level (grid 03) covers the Hawke's Bay region at a spatial resolution of 1.875 arc-seconds (~45 m in Napier), shown in Figure 4.3. The elevation data of grids 02 and 03 were all interpolated from the 10 arc-second New Zealand DEM data described in Section 3.2.

The fourth and last grid level (grid 04) covers part of the Hawke's Bay region around Napier and its surrounding suburbs and the sea in front of it at a spatial resolution of ~0.47 arc-seconds, which is about 11 m at Napier's latitude (Figure 4.4). Its elevation data was interpolated from the 5 m Hawke's Bay DEM described in Section 3.3. This DEM is also provided with the report.

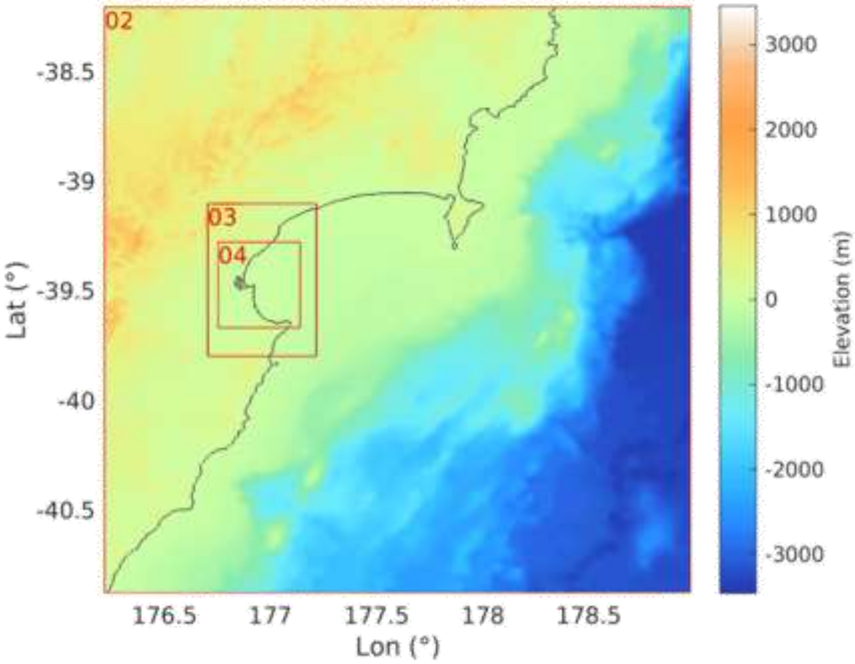


Figure 4.3 Coverage of modelling grid 02. Red boxes show the location of grids 03 and 04. Elevation (relative to MSL) is colour-coded in metres.

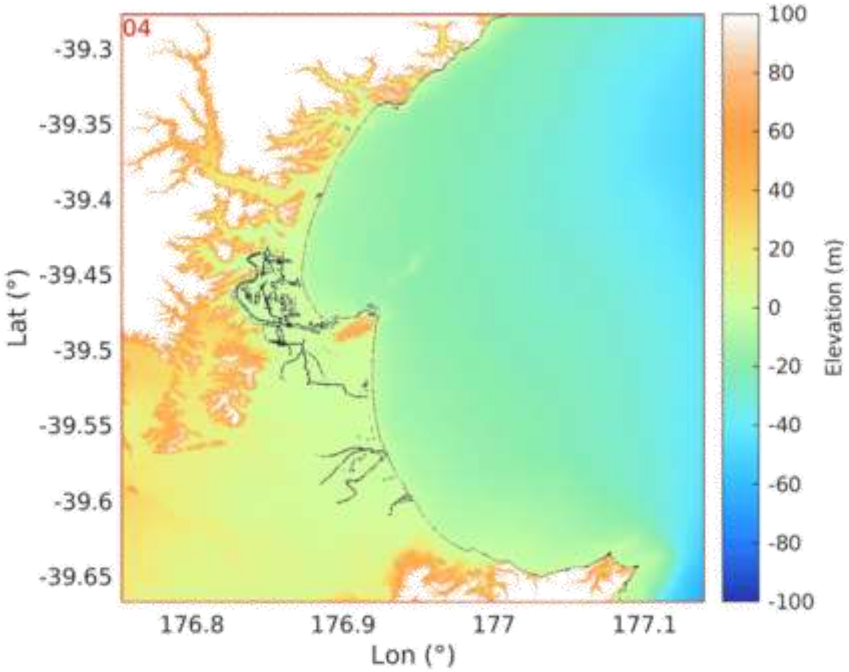


Figure 4.4 Coverage of modelling grid 04, which has the highest level of detail (~11 m) used for the modelling of tsunami inundation in the Hawke's Bay region. Elevation (relative to MSL) is colour-coded in metres. The black contour shows the 0 m contour at MSL.

Table 4.1 summarises the nested grid set-up and modelling settings used for this study.

Table 4.1 Nested grid set-up for tsunami simulations. The grid sizes are indicative and only accurate along parallels of latitude; refer to Section 4.6 for further detail about grid sizes.

Grid	Grid Coverage	Grid Size (Arc-Second)	Time Step (Second)	Tsunami Model	Boundary Condition
01	120.0~300.0E, -65.0~65.0N	120.00 (~2700 m)	3.0885	Linear	Absorbing
02	176.2~179.0, -40.9~-38.2	15.00 (~360 m)	1.0295	Linear	2-way nested
03	176.7~177.22, -39.8~-39.1	1.86 (~45 m)	0.5147	Linear	2-way nested
04	176.7535~177.14, -39.6670~-39.2770	0.47 (~11 m)	0.1715	Non-linear	2-way nested

4.4 Roughness Model

In tsunami inundation modelling, a commonly adopted approach is that land-cover features, such as buildings, are deliberately removed from DEM data and replaced with corresponding equivalent roughness values for different types of land covers to simplify the computation (see Wang et al. 2017a and references therein). It is also preferable that a range of roughness values are used for different land-cover types in an inundation simulation in order to account for the spatial variation of their resistance effects on tsunami flow dynamics.

In this study, we used a set of roughness values (i.e., Manning's roughness coefficient, n; Manning 1891) for a relatively simplified set of land-cover groups proposed in Wang et al. (2017a). The land-coverage groups and their roughness values are given in Table 4.2. These values were derived by comparing roughness values found in the literature, grouping and averaging roughness values for similar land-cover types (Arcement and Schneider 1984; Fujima 2001; Imamura et al. 2006; Wang and Liu 2007; Wang et al. 2009; Gayer et al. 2010; Kaiser et al. 2011; Fraser et al. 2014; Bricker et al. 2015) but leaning slightly toward the lower end of the value ranges.

Table 4.2 Roughness values for different land-cover groups for the tsunami modelling.

Land-Cover Group	Manning's n (Roughness Coefficient)
Built-up area (e.g. urban / residential / industrial / Central Business District)	0.060
Tall vegetation (e.g. forest)	0.040
Scrub (e.g. low trees / bushes)	0.040
Low vegetation (e.g. grass)	0.030
Urban open area (e.g. paved/smoothed)	0.025
Bare land (e.g. farmland)	0.025
Water area (e.g. riverbed/seabed)	0.011

Figure 4.5 shows the spatial distribution of roughness values (Manning's n) for different land-cover groups in the Hawke's Bay and its surrounding areas. The roughness grid was developed using the land cover data obtained from the LRIS portal (https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/). The land cover types were grouped into five categories, each was assigned the Manning coefficient n (see Figure 4.5) and the resulting polygons were turned into a grid within ArcGIS software.

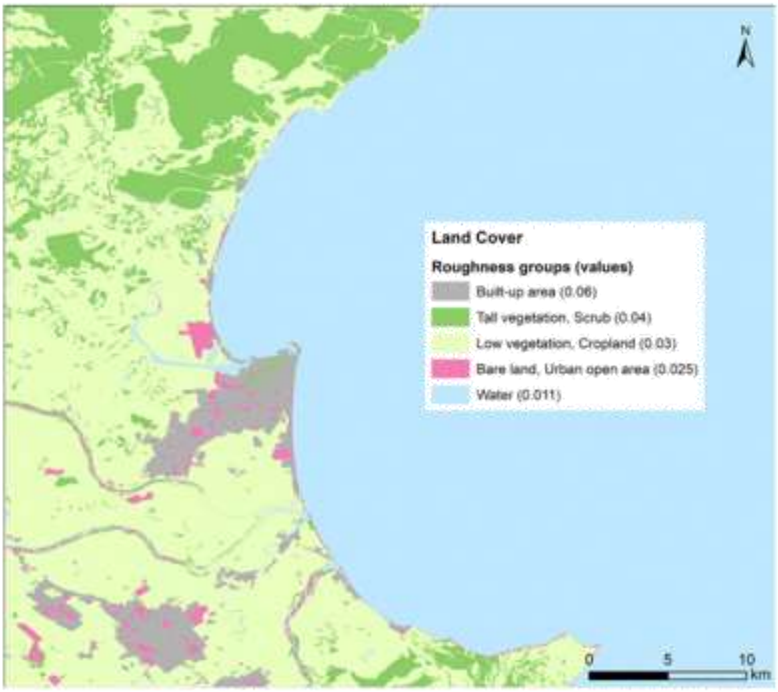


Figure 4.5 Spatial distribution of equivalent surface roughness values, i.e. Manning's n, in Hawke's Bay (grid 04) for tsunami inundation modelling.

4.5 Special Treatment with Low-Lying Dry Land

Special consideration has been made to deal with low-lying areas around the Hawke's Bay airport and to the south of Ahuriri Estuary, as shown in Figure 4.6. These low-lying areas are below MSL, but are actually dry land, not connected to the open sea at MSL. Without special treatment, these areas would appear as 'water' and be modelled as such in numerical simulations of tsunami.

In this modelling, a special algorithm in COMCOT was applied to completely 'drain' the artificial water in these areas. This was achieved by setting initial values of flow depth at numerical grids within these low-lying dry areas to zero before a tsunami simulation starts.

Figure 4.6 Yellow polygons outline low-lying land areas around Hawke's Bay Airport and south of Ahuriri Estuary. These dry land areas are below MSL.

4.6 Effects of Earth Curvature, Rotation and High Latitude

This study adopts tsunami-governing equations in a Spherical Coordinate System to simulate tsunami from selected sources to the Hawke's Bay region. This is necessary for tsunami simulations over a very large area that need to consider the curvature of the Earth's surface. The effect of the Earth's rotation was also evaluated through the inclusion of the Coriolis force in both linear and non-linear tsunami models in COMCOT (Wang and Power 2011).

In high-latitude regions, the commonly used approach of using 'square' grids in spherical coordinates, i.e. equal cell edges in arc-degrees, leads to grid cells that are highly elongated when measured in metres. For example, for this type of grid in Hawke's Bay, the S–N edge of a grid cell will be over 30% longer than its W–E edge. This will not only affect the stability of tsunami simulations but also lead to inconsistent accuracies of modelling results in different directions.

To overcome these issues, the size of a numerical grid cell in COMCOT varies along its meridian (i.e. lines of longitude) and is self-adjusted according to its latitude so that its edge length along the parallel (i.e. circles of latitude) and meridian are equal in metres. This ensures that 'square' grids (in metre terms) are created for numerical calculations and thus maintains the same accuracies in different directions. As a result, the grid sizes given in Table 4.1 are nominal and are only true along the parallels.

4.7 Other Simulation Settings

In the tsunami simulations, co-seismic ground surface and seafloor displacement in an earthquake event is calculated using the widely used elastic finite fault theory of Okada (1985) and is introduced in the model as the initial condition of tsunami generation.

In local earthquake events, the co-seismic uplift or subsidence may also change the ground and seafloor elevation as defined in the input DEM (i.e. current-day or pre-event DEM). When this happens, the COMCOT model firstly adjusts the input DEM with the computed co-seismic uplift/subsidence and then simulates the subsequent tsunami to calculate hazard parameters, e.g. tsunami elevation, flow depth, flow velocity and flow acceleration, over the adjusted DEM (i.e. post-event DEM).

In the numerical simulations, tsunami propagation was simulated for 30 hours for distant scenarios (e.g. South America), 15 hours for regional scenarios (e.g. Kermadec) and 10 for local earthquake scenarios (e.g. Hikurangi and New Zealand crustal faults) from their generation in the sources to ensure that the maximum tsunami hazard parameters were obtained in the Hawke's Bay region. Detailed examinations of selected scenarios revealed that the maximum tsunami inundation extents had clearly been reached in less than 10 hours after first arrivals, assuring that these run times were long enough. All of the simulations assume that tsunami occurs at MHWS or at MHWS plus the appropriate sea-level rise. MHWS was modelled as a static level above the local MSL, not changing over time with the tidal fluctuations.

4.8 Test Runs

To ensure that the DEMs were constructed correctly and that features such as the stopbanks were included correctly, we ran multiple test scenarios using the grid set-up described above. For testing purposes, we used both local and distant earthquake scenarios with uniform and non-uniform slip distributions. One example is shown in Figure 4.6. The stop banks performed as expected across the tests and inhibited the water entering the low-lying areas, including the tsunami flow. This is particularly important to verify at the beginning of the simulation process when we add the sea-level rise value to the actual MSL (Figure 4.7). In the example shown below, 0.92 m (corresponding to MHWS) is added to MSL. If the stopbanks were open, or if a special condition had not been specified for the low-lying areas, then the water would enter these low-lying areas immediately, which is not the case here. This kind of test shows that the stopbanks are contiguous in the model and that COMCOT deals correctly with the low-lying areas with altitude under MSL or MHWS.

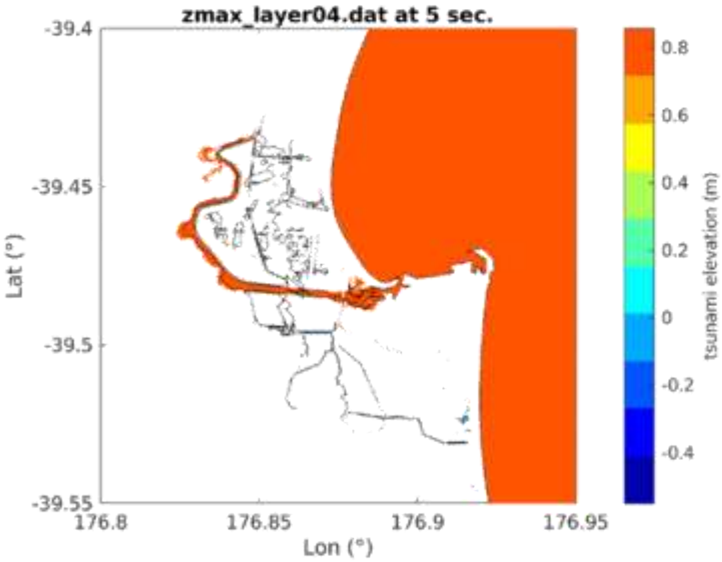


Figure 4.7 Example of the results of one of the test scenarios. Note that the stopbanks (shown as black lines along the waterway) inhibit the water to enter the low-lying areas, especially the one around Hawke's Bay airport at MHWS (+92 cm) at the beginning of the simulation (shown in the figure with a tsunami propagation time of 5 seconds).

4.9 Final Models

For each of the scenarios indicated in Section 2, we ran the models through all of the grids to inundation on the last level (grid 05). An example of one of them is shown in Figure 4.8. It shows the inundation produced by a M_W 8.9 earthquake on the Hikurangi subduction zone. This was one of the scenarios that contributed to the hazard at a return period of 2500 years and is the largest contributor to the hazard for this return period. This particular scenario also causes one of the largest amounts of inundation to Napier, along with the Napier crustal fault and the Hawkes Bay Outer Rise Fault in NTHM2021 at the current MHWS.

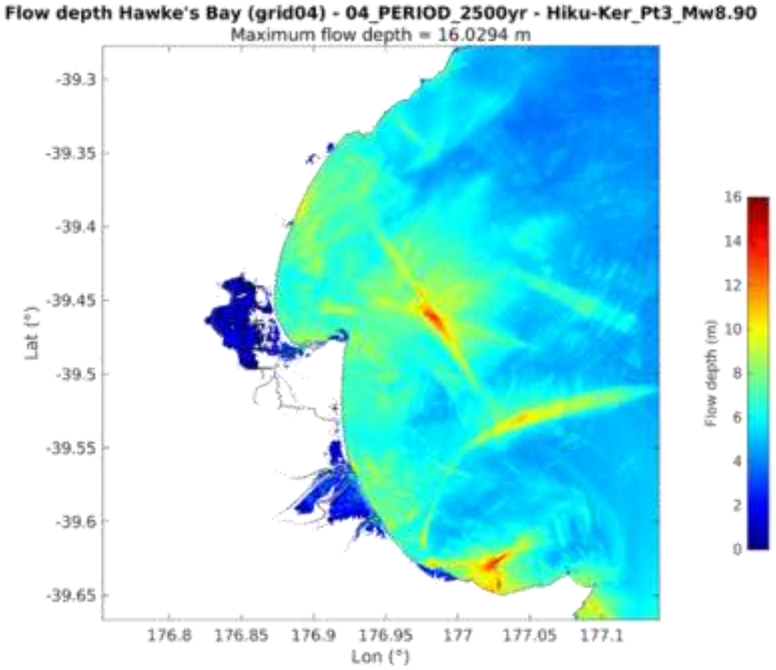


Figure 4.8 Example of the inundation produced from a M_W 8.9 event on the Hikurangi subduction zone at MHWS for a return period of 2500 years. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

5.0 PROBABILISTIC TSUNAMI INUNDATION HAZARD MAPS

The contribution of each of the inundation scenarios were then normalised according to their contribution to the hazard (the pre-normalised values are the 'weights' in Tables 2.1 and 2.2). The exact weights are shown in Tables 5.1 and 5.2 for each coastal zone. As we have two sets of weights (one for Zone 73 and 74), we have sets of maps for each combination of return period and sea-level rise. The resulting maps of median and 84th percentile flow depths/heights are shown in Figures 5.2–5.17 following the tables.

Table 5.1 Scenario normalised contribution for Zone 73.

Annual Probability of Exceedance	Source Name	Effective Magnitude	Percentage of Deaggregation	Percentage of Top Sources ('Normalised')
1:100	Hikurangi	8.28	32.18	44.40
1:100	Peru	9.30	11.50	15.87
1:100	Northern Chile	9.17	9.55	13.18
1:100	Kermadec	8.84	8.02	11.06
1:100	Center Chile	9.46	7.25	10.00
1:100	Kuril-Kamchatka	9.44	3.98	5.50
1:500	Hikurangi	8.56	42.18	56.09
1:500	Hawkes Bay Outer rise_1002	8.13	6.92	9.20
1:500	Lachlan3_231	7.80	6.82	9.06
1:500	Kermadec	9.26	6.63	8.82
1:500	North Wairarapa Outer rise	8.14	6.33	8.42
1:500	Peru	9.57	6.32	8.40
1:1000	Hikurangi	8.69	42.93	53.41
1:1000	Hawkes Bay Outer rise_1002	8.24	10.80	13.44
1:1000	North Wairarapa Outer rise_1003	8.26	9.65	12.00
1:1000	Lachlan3_231	7.91	7.85	9.77
1:1000	South Wairarapa Outer rise_1004	8.44	5.12	6.37
1:1000	Peru	9.68	4.03	5.02
1:2500	Hikurangi	8.97	34.37	38.29
1:2500	Hawkes Bay Outer rise_1002	8.49	20.83	23.21
1:2500	North Wairarapa Outer rise_1003	8.50	16.83	18.76
1:2500	Lachlan3_231	8.15	9.12	10.16
1:2500	South Wairarapa Outer rise_1004	8.68	5.73	6.39
1:2500	Napier 1931_242	8.21	2.87	3.19

Table 5.2 Scenario normalised contribution for Zones 74.

Annual Probability of Exceedance	Source Name	Effective Magnitude	Percentage of Deaggregation	Percentage of Top Sources ('Normalised')
1:100	Hikurangi	8.26	38.28	52.37
1:100	Peru	9.29	12.70	17.37
1:100	Center Chile	9.41	7.08	9.69
1:100	Northern Chile	9.18	6.47	8.85
1:100	Kermadec	8.99	5.12	7.00
1:100	Kuril-Kamchatka	9.41	3.45	4.72
1:500	Hikurangi	8.59	39.25	54.63
1:500	Peru	9.54	7.90	11.00
1:500	North Wairarapa Outer rise	8.10	6.90	9.60
1:500	Hawkes Bay Outer rise_1002	8.19	6.78	9.44
1:500	Lachlan3_231	7.85	6.30	8.77
1:500	Kermadec	9.30	4.72	6.56
1:1000	Hikurangi	8.70	42.30	54.53
1:1000	North Wairarapa Outer rise_1003	8.22	9.78	12.61
1:1000	Hawkes Bay Outer rise_1002	8.30	9.27	11.95
1:1000	Lachlan3_231	7.96	6.25	8.06
1:1000	Peru	9.63	5.27	6.79
1:1000	South Wairarapa Outer rise_1004	8.44	4.70	6.06
1:2500	Hikurangi	8.98	33.27	37.79
1:2500	North Wairarapa Outer rise_1003	8.44	20.50	23.29
1:2500	Hawkes Bay Outer rise_1002	8.53	16.55	18.80
1:2500	Lachlan3_231	8.18	6.85	7.78
1:2500	South Wairarapa Outer rise_1004	8.66	6.22	7.06
1:2500	MotuokuraE_293	8.11	4.65	5.28

As expected, at the 100-year return period, the extent of inundation is small at the current MHWS, restrained to the low-lying area around the airport and immediate neighbourhood of waterways. However, at the 1000- and 2500-year return periods, the inundation extents are much larger, with most of the inundation occurring in Napier's coastal suburbs of Ahuriri and Awatoto, the low-lying area around the Hawke's Bay Airport, Napier Port and small towns south of the Tutaekuri river (i.e. Clive, Haumoana and Te Awanga).

One other point to note is that the inundation extents for the Zone 73 scenarios are almost the same as those for the Zone 74 scenarios for all return periods and sea-level rise values considered here. This is a consequence of the deaggregation, which showed that the main source of tsunami hazard for most zones is similar. However, there are some minor differences in a few areas, particularly at the 100-year return period. As a result, ***we recommend that HBRC use the Zone 73 map for the coastal strip in Zone 73 and that the Zone 74 maps are used for the area out to point 1 (Figure 3.2) within that coastal zone***.

The effect of adding 0.65 m, 1 m or 1.99 m of sea-level rise projections is equivalent to increase the area inundated at a given return period. For example, adding 1.99 m of sea-level rise to the model increases the area inundated by the 1:100-year tsunami (Figure 5.4) beyond that inundated by the 1:2500 event at MHWS (Figure 5.13). Increasing the sea-level by these large amounts has a greater impact on the area inundated than increasing the return period within this range. Note also that the figures show the inundation caused by the sea-level rise combined with that caused by the tsunami. We have illustrated the effect of the sea-level rise component by itself in Figure 5.1(a–c). The effect of the sea-level rise is that the low-lying areas of the coast start the simulation inundated by the sea-level rise before the tsunami even arrives. This occurs in the areas between the black contour line and the other white, green or red lines, depending on the sea-level rise amount. The flow depths shown in Figures 5.2–5.17 include both this effect and the maximum flow depth of the subsequent tsunami. In other words, the flow depths in the hazard maps show the inundation depths caused by both the sea-level rise component and subsequent tsunami put together.

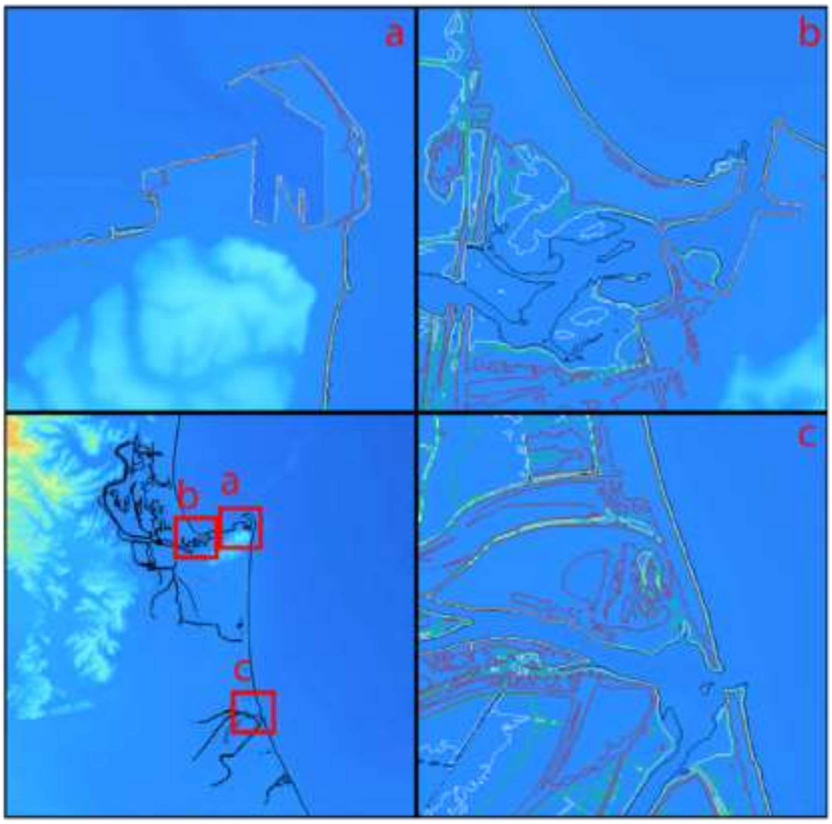
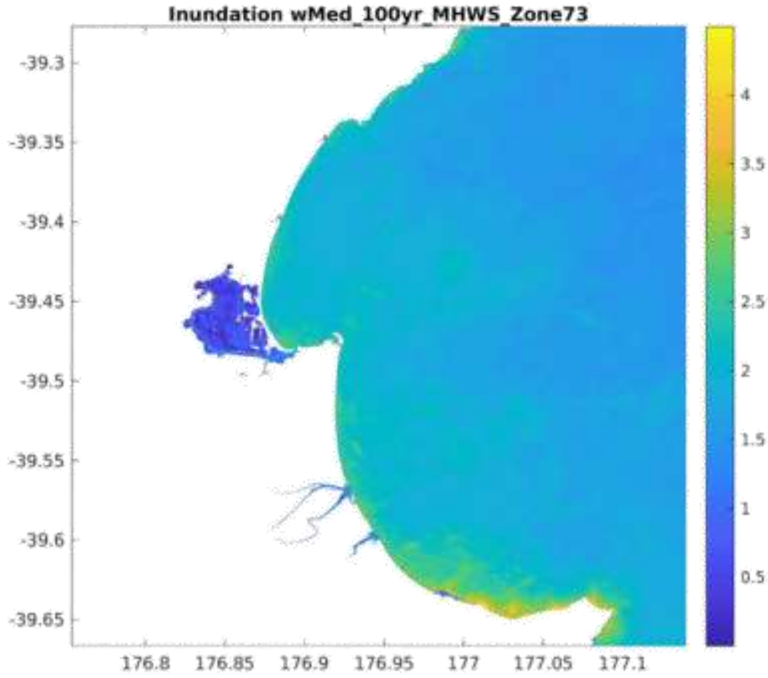


Figure 5.1 The DEM used grid 04 zoomed into (a) Napier Harbour, (b) Ahuriri Estuary and (c) Ngaruroro Estuary. The figure in the bottom left shows the DEM at a regional scale. In parts (a–c), the black line is the 0 m contour at MHWS, the white line is the 0 m contour at MHWS with the additional 0.65 m sea-level rise, the green line is the 0 m contour at MHWS plus an additional 1 m of sea-level rise and the red line is the 0 m contour at MHWS plus 1.99 m of sea-level rise. In some areas, such as those shown in (b) and (c), much of the coastal area is inundated before the tsunami even arrives by the addition of the sea-level rise component. In areas such as (a), the effect is more limited to low-lying areas just near the coast.

The data shown in the maps are provided to HBRC as rasters of the median flow depth/ height and feature classes of tsunami inundation extent. All of the datasets are in WGS 1984 geographic coordinate system but are capable of being converted to other projection systems if HBRC chooses to do so.



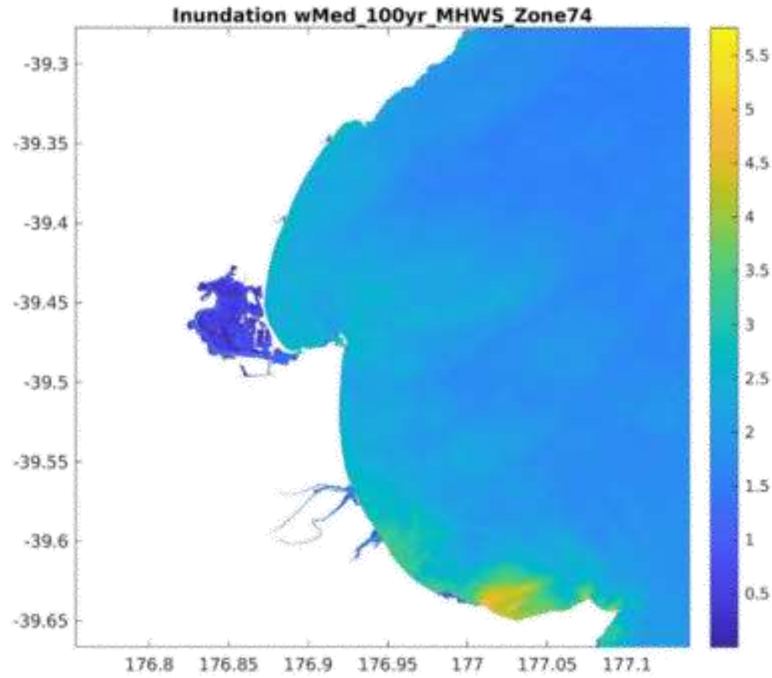


Figure 5.2 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-100-years chance of being exceeded per annum at current MHWS. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

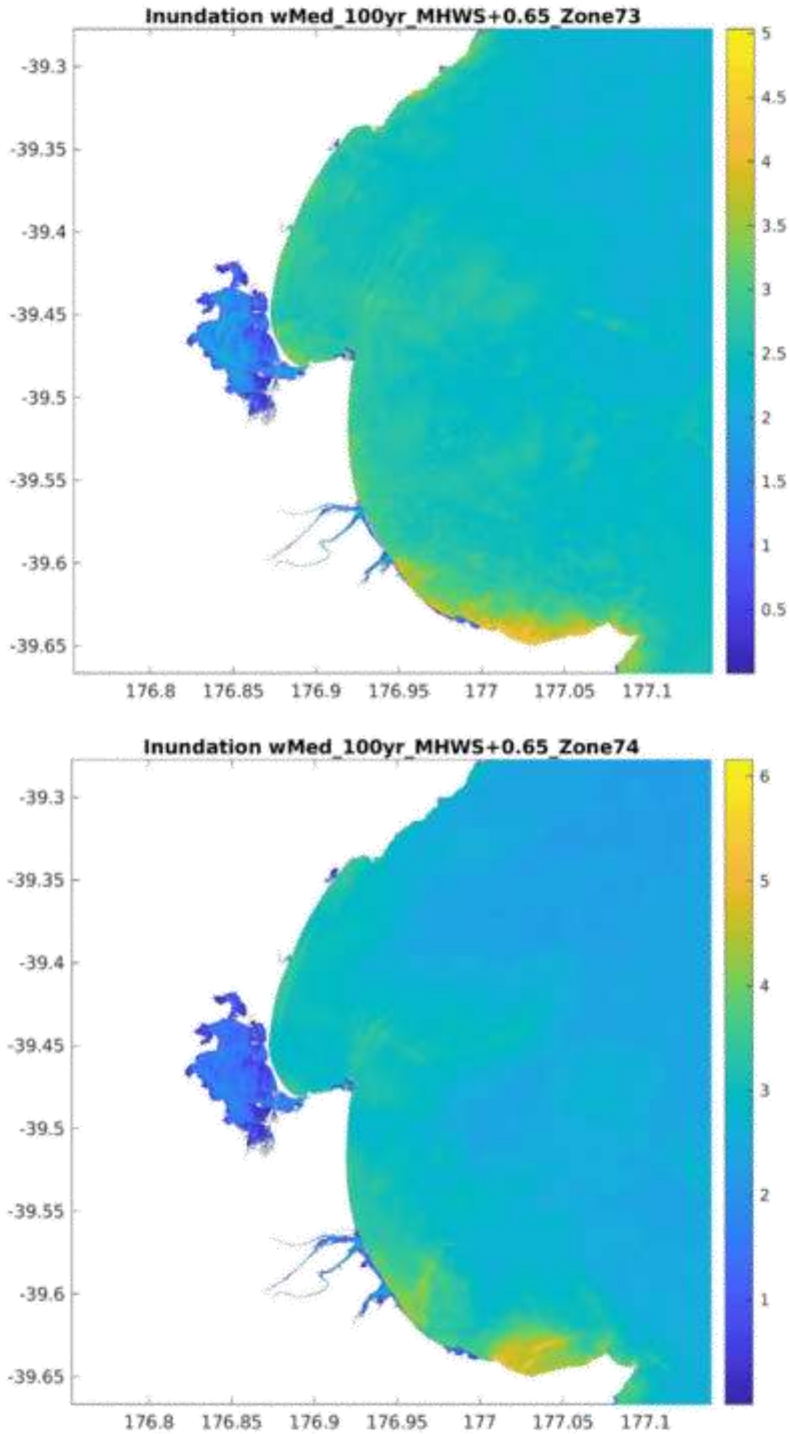
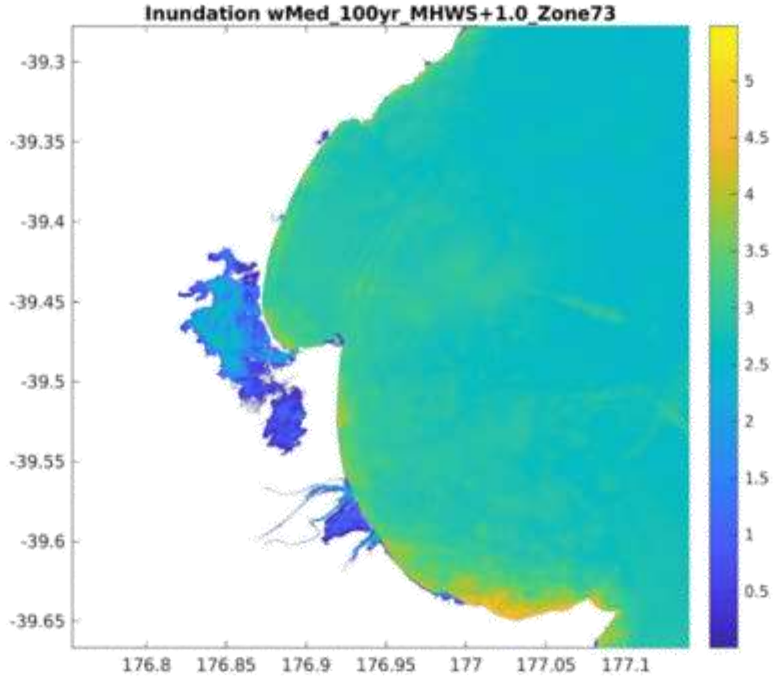


Figure 5.3 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-100-years chance of being exceeded per annum at current MHWS plus 0.65 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.



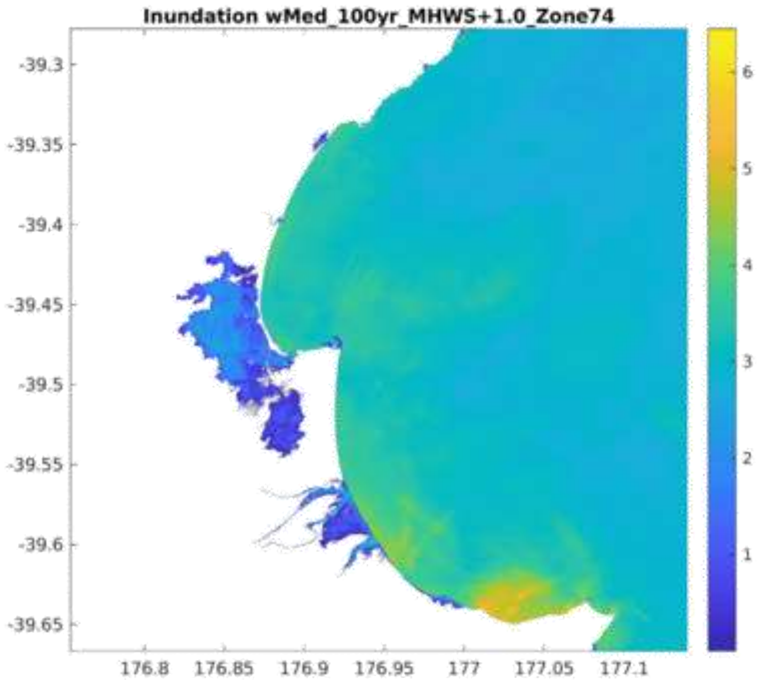


Figure 5.4 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-100-years chance of being exceeded per annum at current MHWS plus 1 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

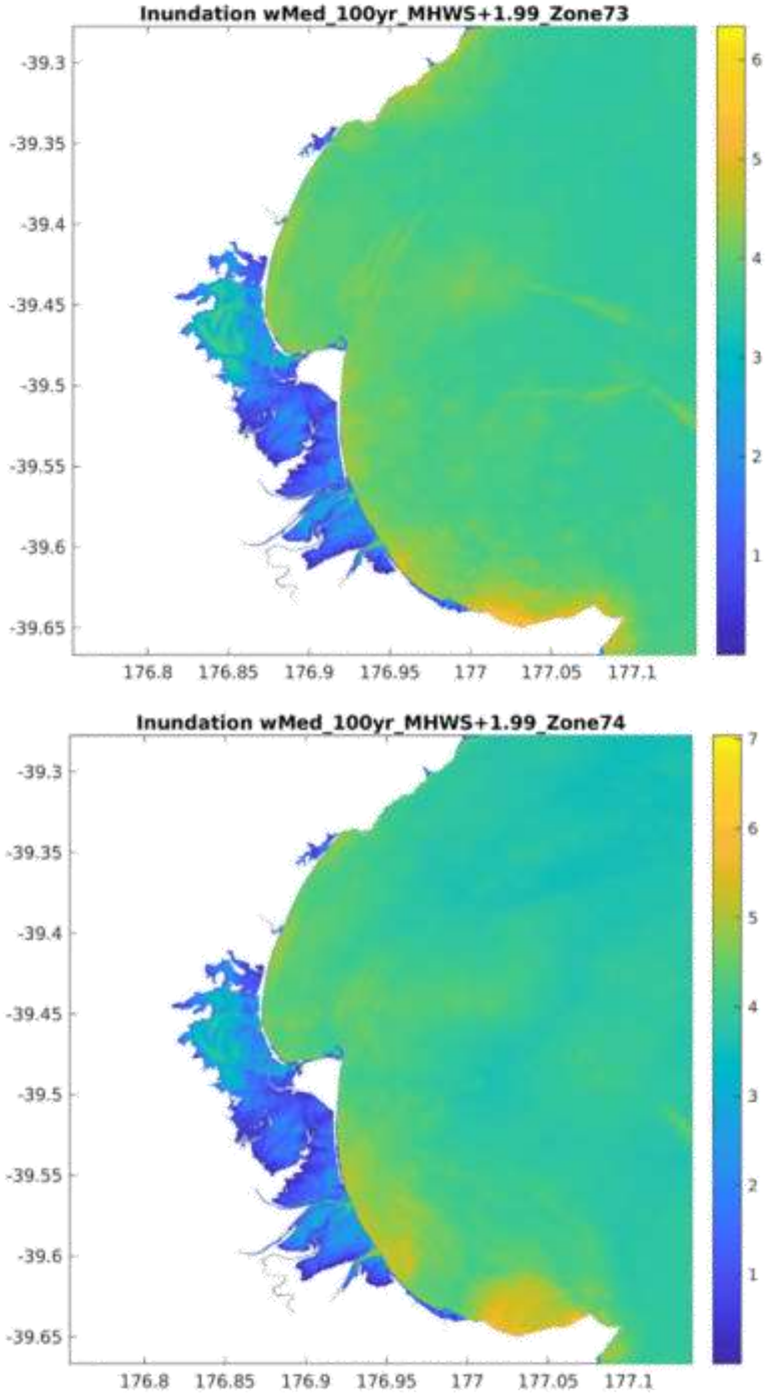


Figure 5.5 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-100-years chance of being exceeded per annum at current MHWS plus 1.99 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

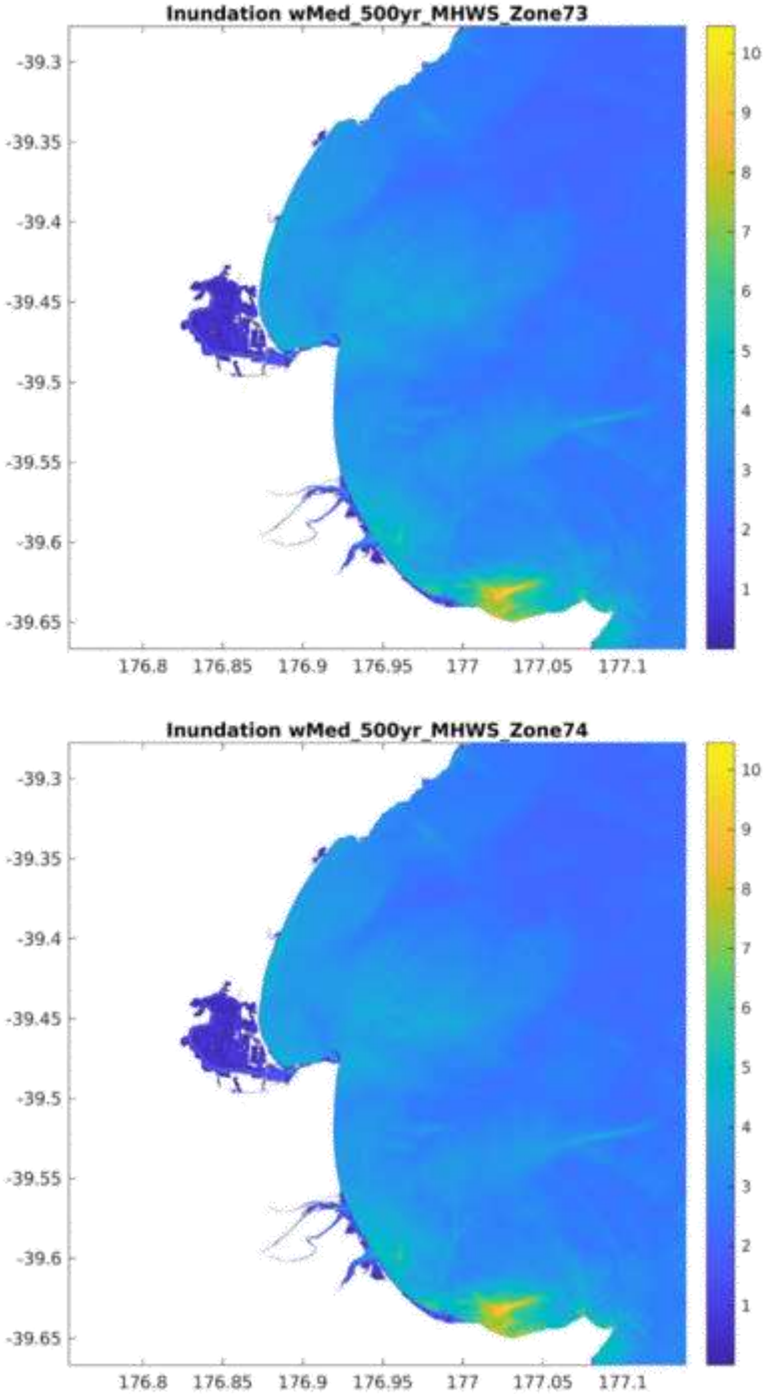


Figure 5.6 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-500-years chance of being exceeded per annum at current MHWS. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

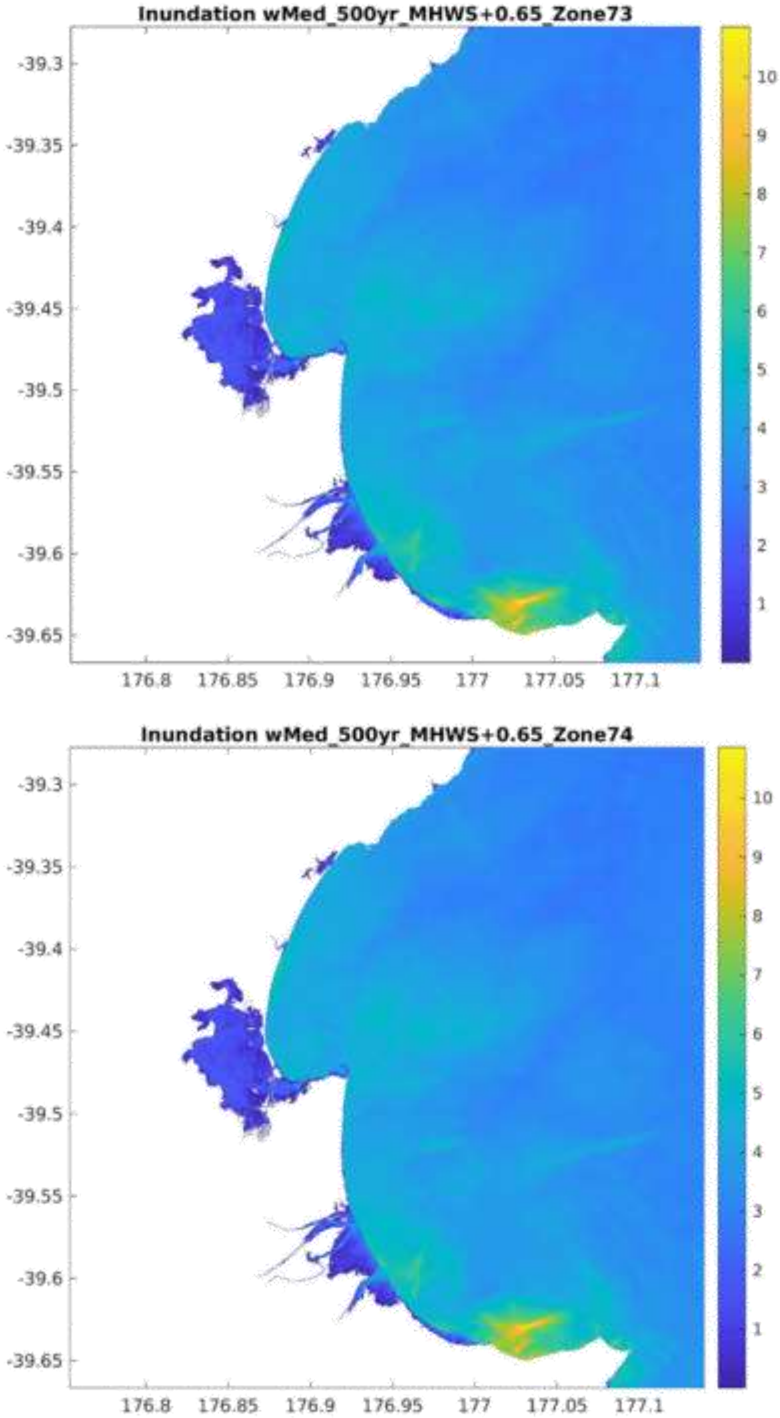
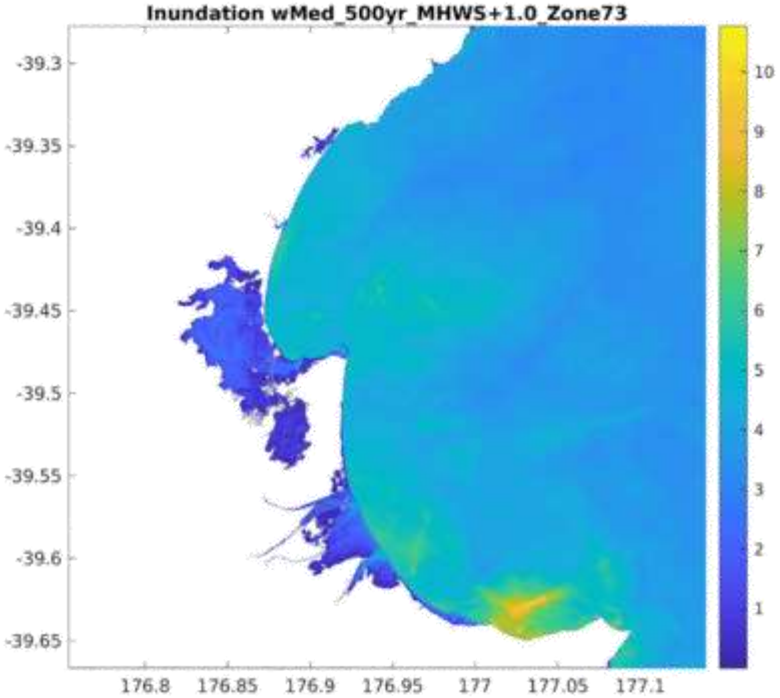


Figure 5.7 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-500-years chance of being exceeded per annum at current MHWS plus 0.65 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.



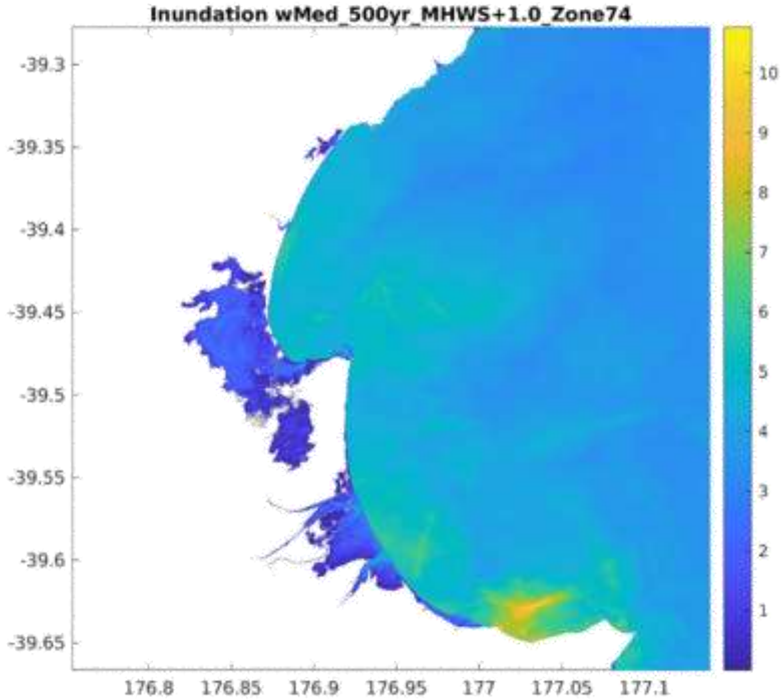


Figure 5.8 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-500-years chance of being exceeded per annum at current MHWS plus 1 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

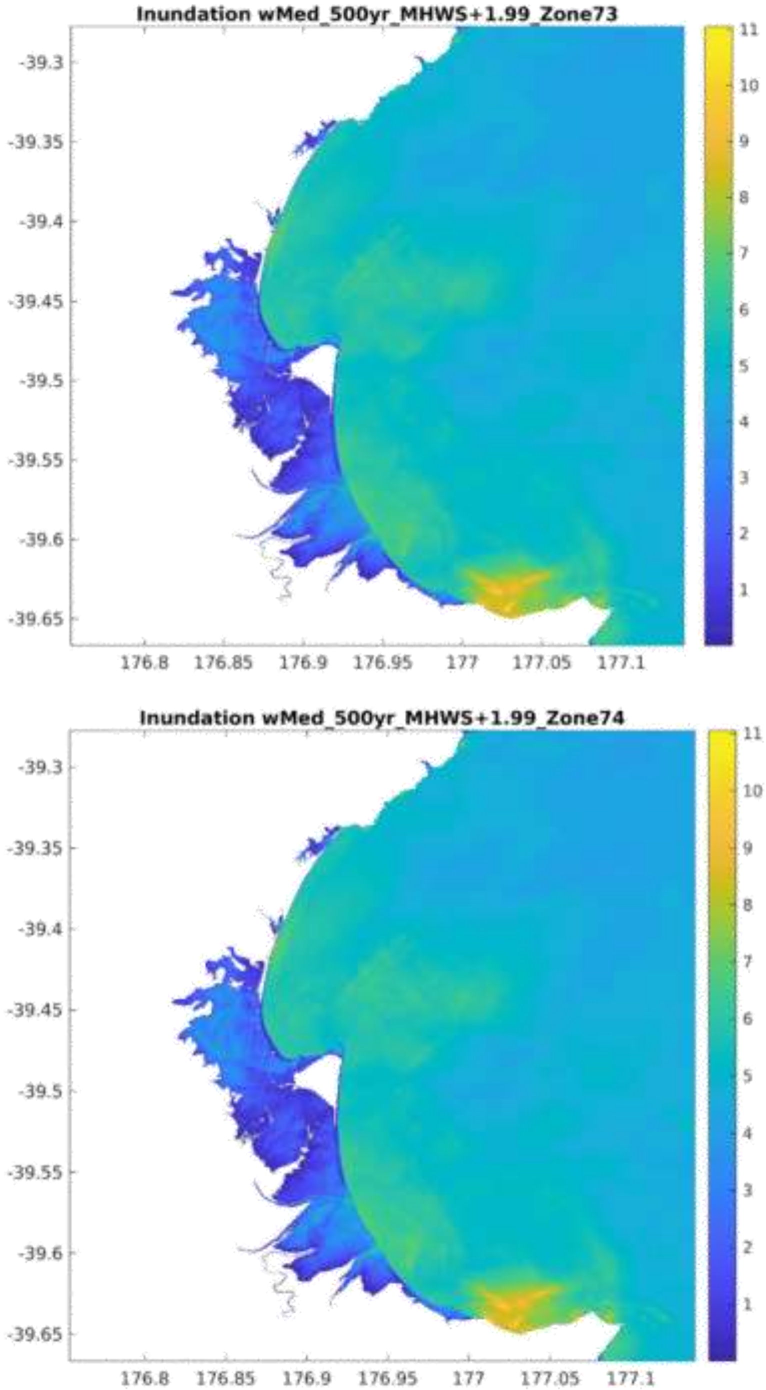
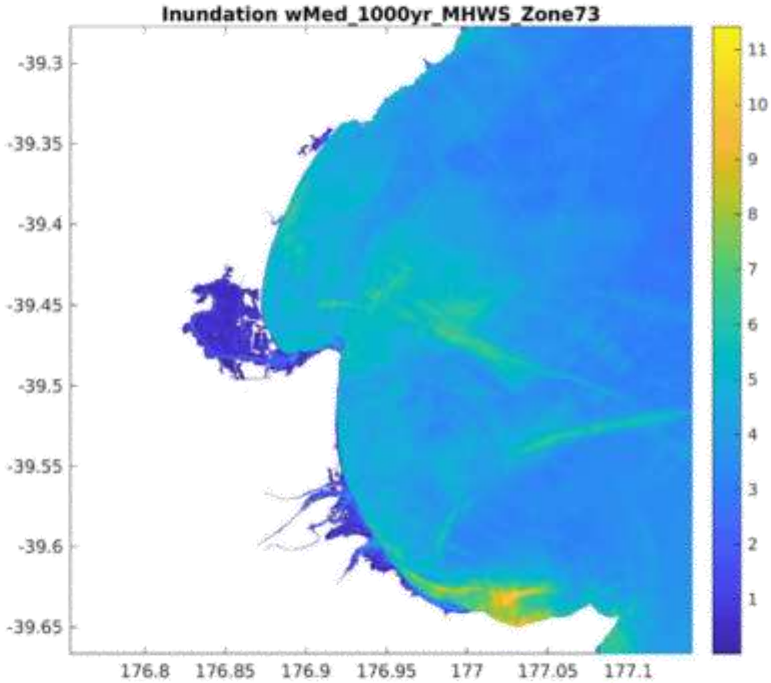


Figure 5.9 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-500-years chance of being exceeded per annum at current MHWS plus 1.99 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.



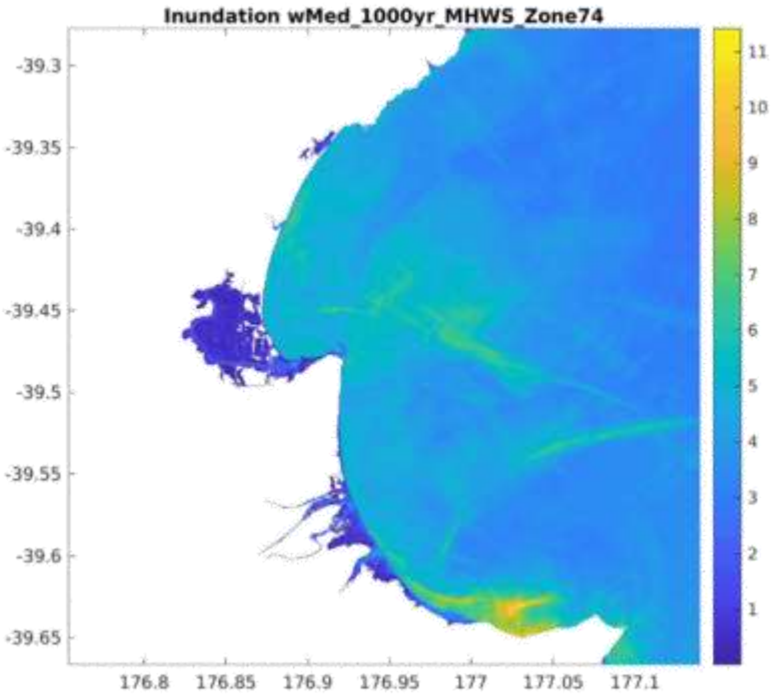
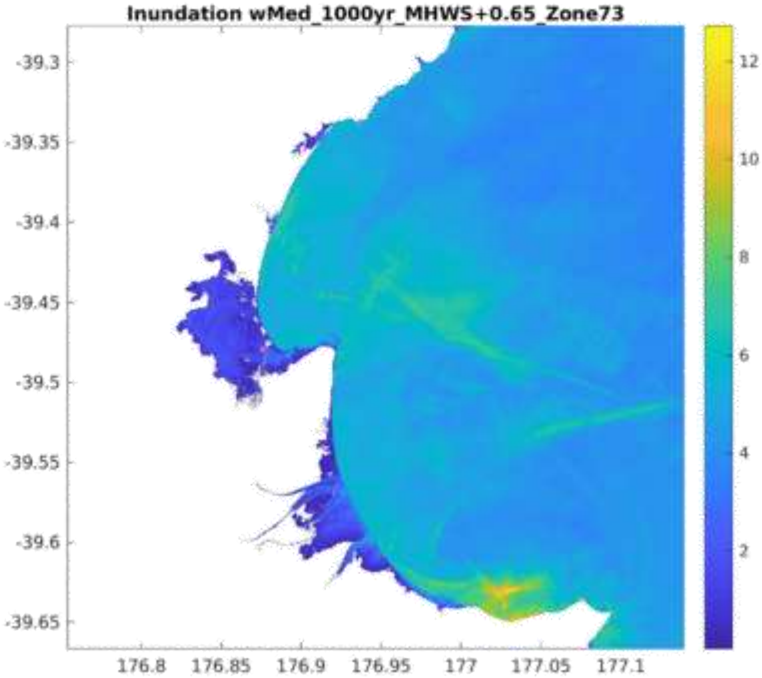


Figure 5.10 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-1000-years chance of being exceeded per annum at current MHWS. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.



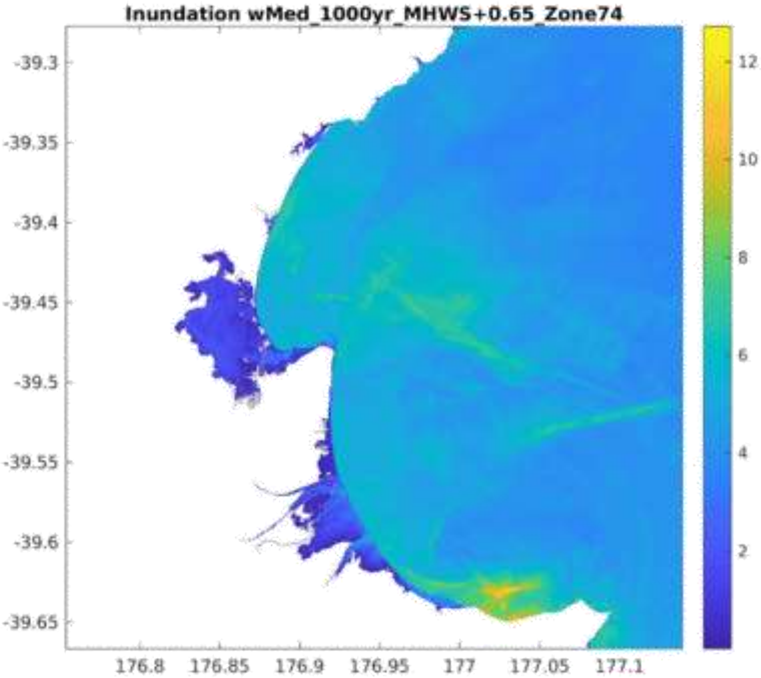


Figure 5.11 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-1000-years chance of being exceeded per annum at current MHWS of sea-level rise plus 0.65 m. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.

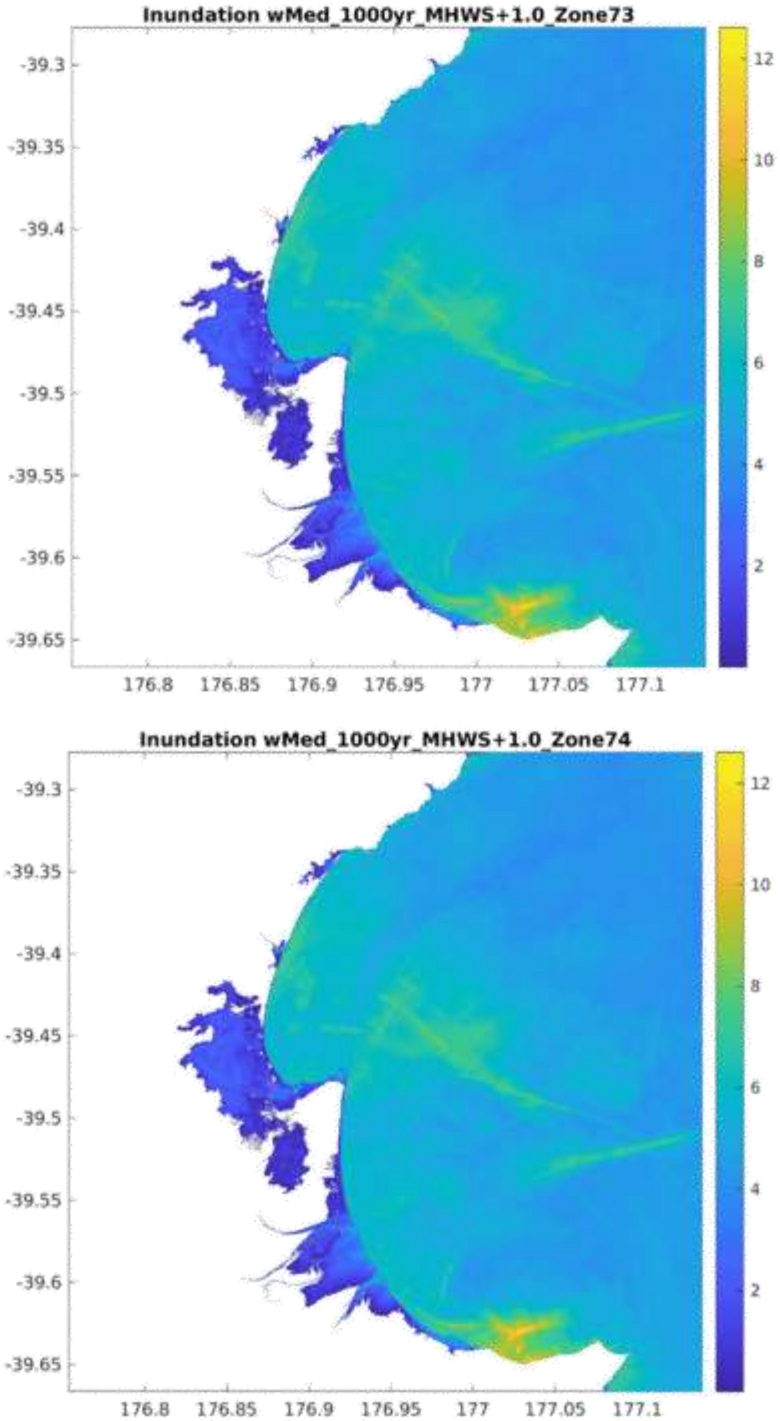
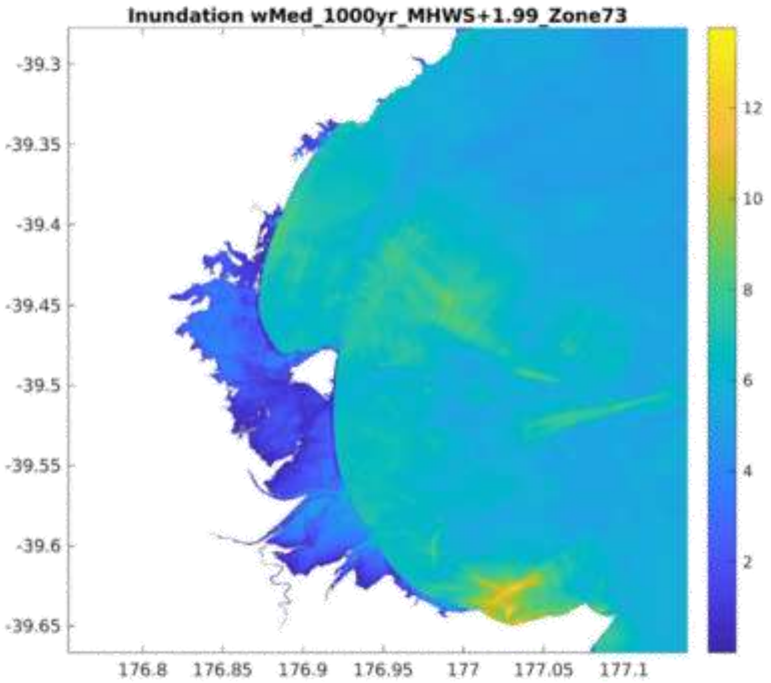


Figure 5.12 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-1000-years chance of being exceeded per annum at current MHWS plus 1 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.



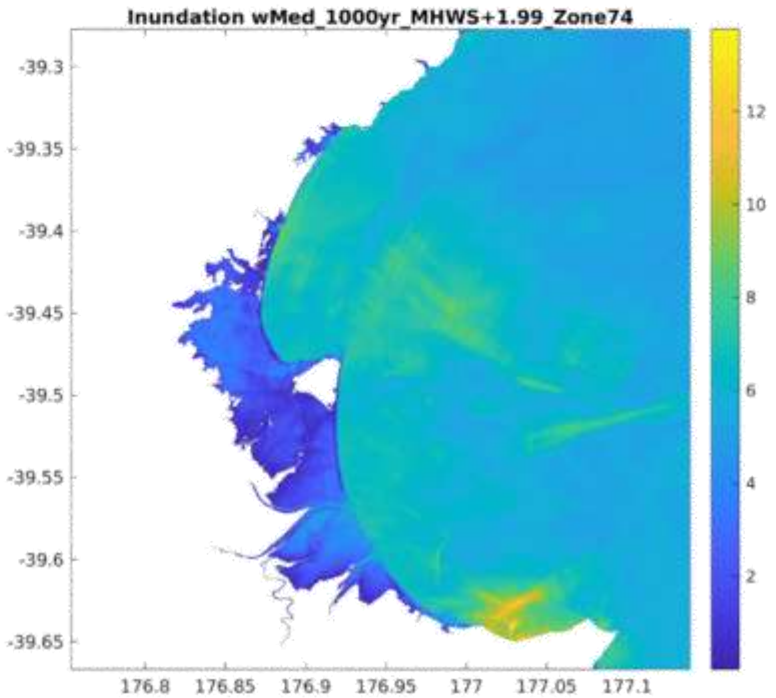
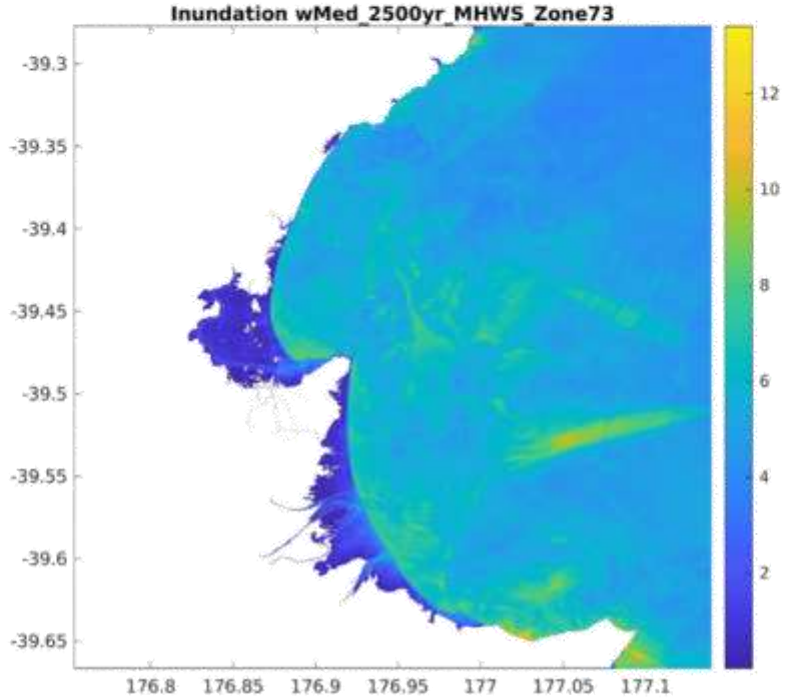


Figure 5.13 Probabilistic tsunami inundation maps for Hawke's Bay showing the median flow depths onshore and offshore tsunami heights with a 1-in-1000-years chance of being exceeded per annum at current MHWS plus 1.99 m of sea-level rise. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights.



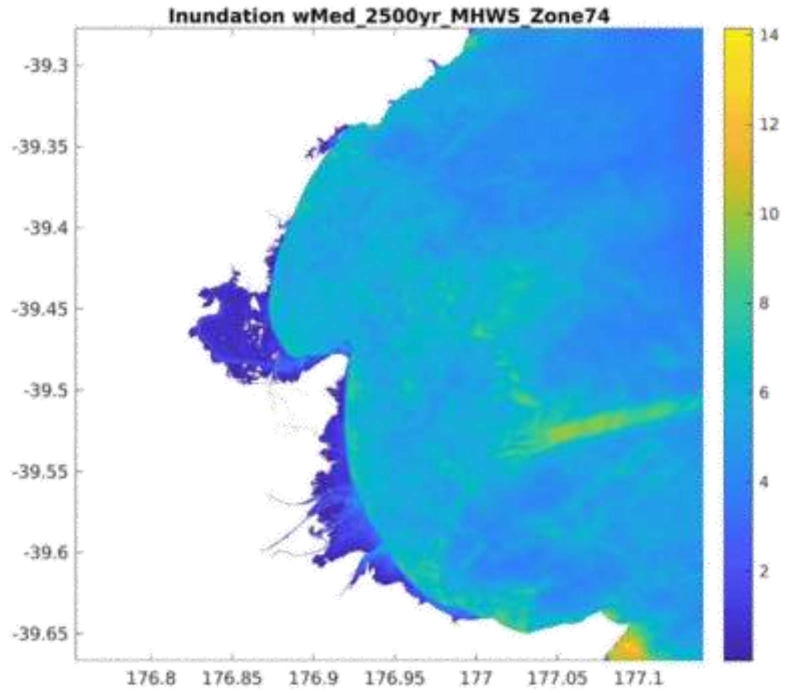
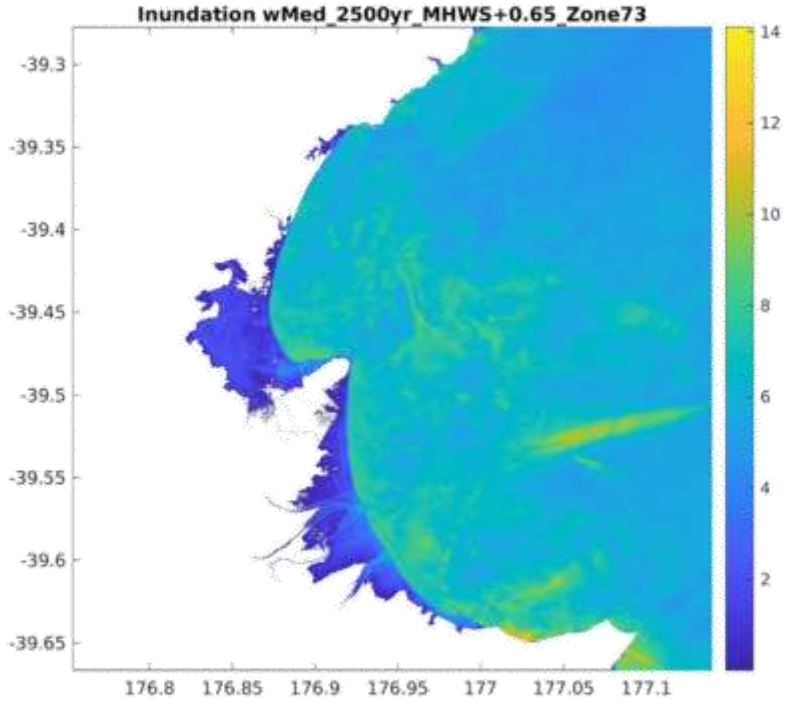


Figure 5.14 Probabilistic tsunami inundation maps for Hawke's Bay showing the 84th percentile flow depths onshore and offshore tsunami heights with a 1-in-2500-years chance of being exceeded per annum at current MHWS. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights. This is the 'maximum considered tsunami' hazard map for the current sea level.



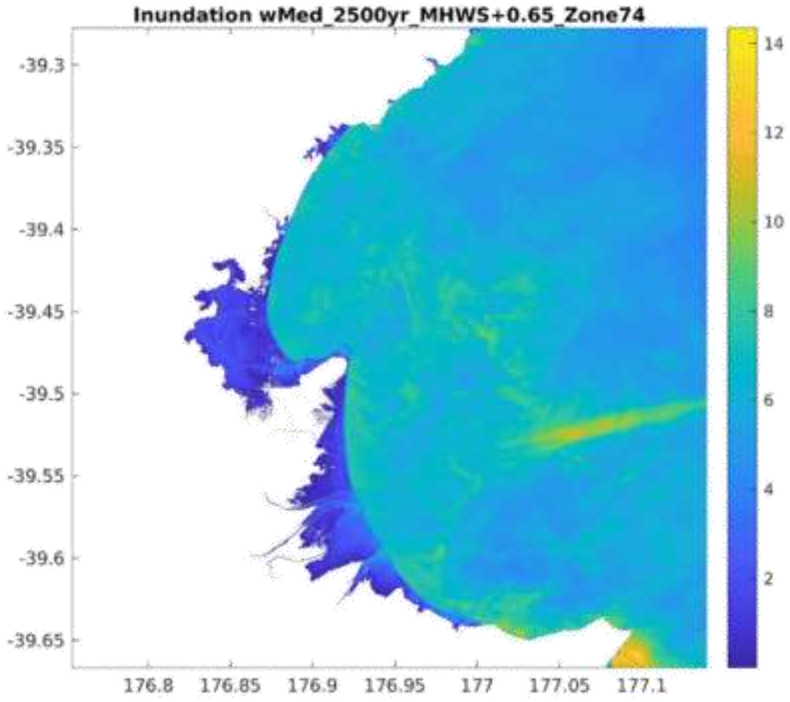


Figure 5.15　Probabilistic tsunami inundation maps for Hawke's Bay showing the 84th percentile flow depths onshore and offshore tsunami heights with a 1-in-2500-years chance of being exceeded per annum at current MHWS plus 0.65 m. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights. This is the 'maximum considered tsunami' hazard map for this sea-level rise value.

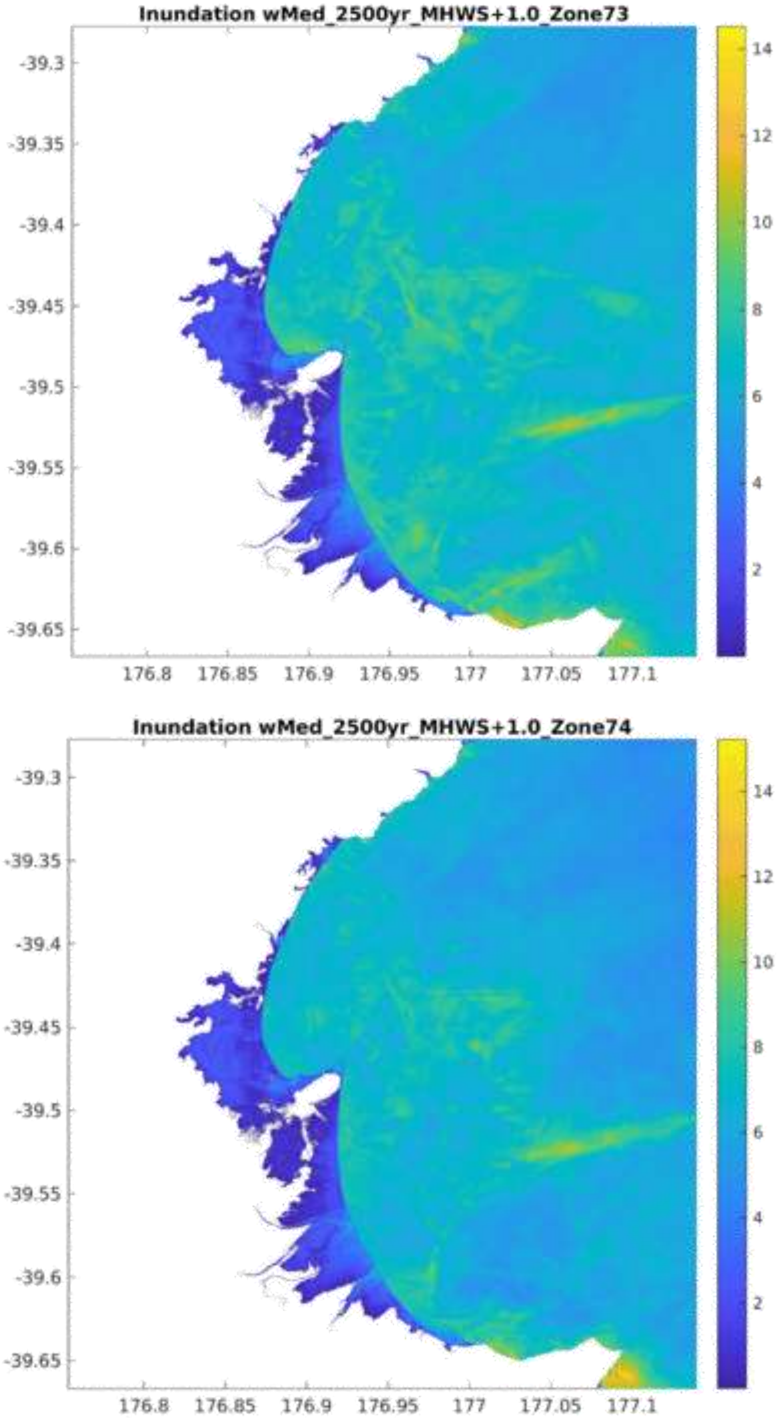


Figure 5.16 Probabilistic tsunami inundation maps for Hawke's Bay showing the 84th percentile flow depths onshore and offshore tsunami heights with a 1-in-2500-years chance of being exceeded per annum at current MHWS plus 1 m. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights. This is the 'maximum considered tsunami' hazard map for this sea-level rise value.

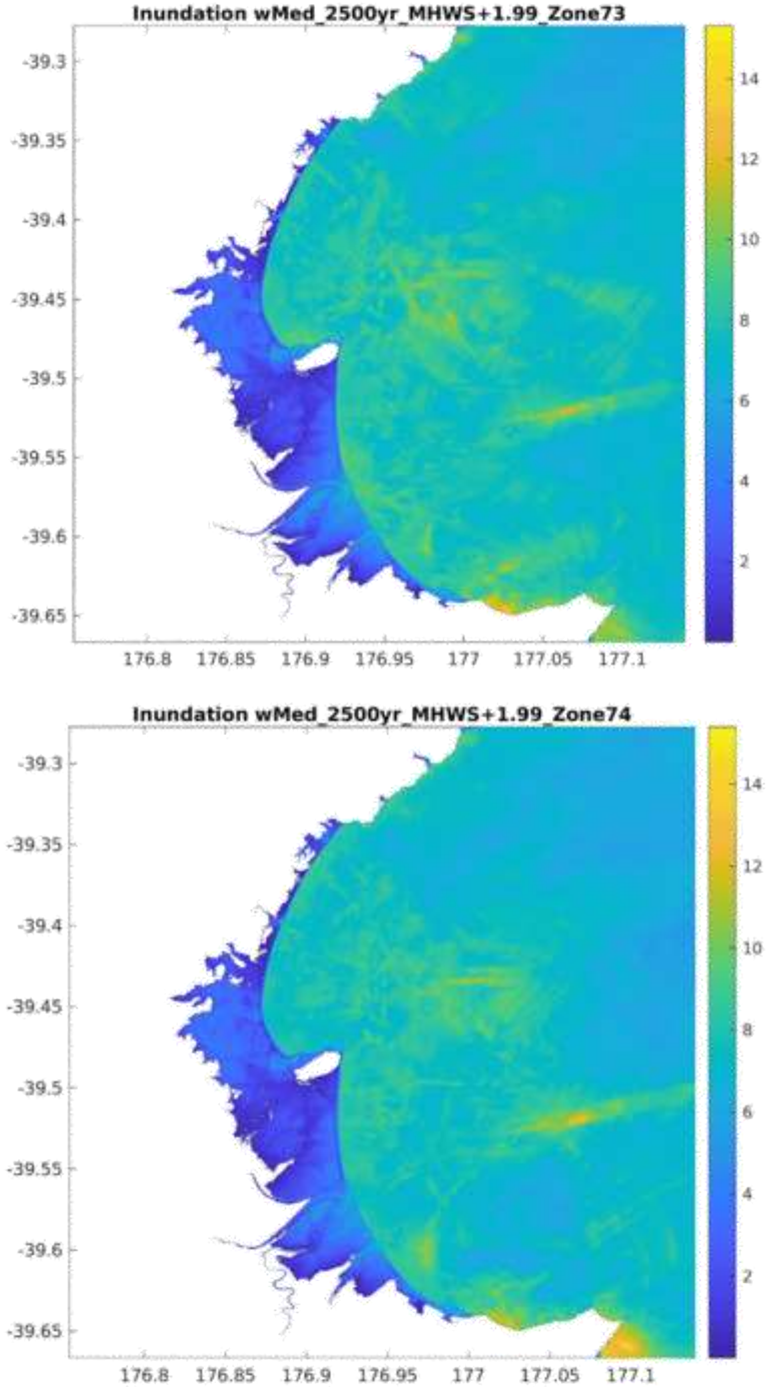


Figure 5.17 Probabilistic tsunami inundation maps for Hawke's Bay showing the 84th percentile flow depths onshore and offshore tsunami heights with a 1-in-2500-years chance of being exceeded per annum at current MHWS plus 1.99 m. Onshore values refer to flow depths, while offshore values refer to maximum tsunami heights. This is the 'maximum considered tsunami' hazard map for this sea-level rise value.

6.0 DISCUSSION

Results presented in Section 5 focused on a set of scenarios that have been directly extracted with the deaggregation methodology considering the return periods asked by HBRC. They do not represent all the scenarios that could exist.

The simulations carry several unknowns that could lead to over- or under-estimation of the actual amount of inundation observed for each scenario and thus in the combined hazard maps. These include uncertainties in modelled digital elevation and bathymetric models, especially in shallow water depths, and surface roughness, as well as variability of the modelled geometry of the rupture surface of the earthquake, non-uniform slip distribution, the sequence in which slip is triggered on that surface and the rake angle specific to individual slip patches. The effects produced by these uncertainties have not been explicitly included in this study for reasons of practicality, although an allowance for some of these effects has been incorporated into the NTHM deaggregation using the idea of an 'effective magnitude' (Power 2013; Power et al. 2022). As a result, while these uncertainties do still exist, we do not believe that they are large enough in magnitude to significantly invalidate the results in Section 5.

This study uses outputs from the NTHM2021 revision, and the uncertainties and limitations of the NTHM (see Power et al. 2022) are applicable to this study. The reader should also note that changes in DEM creation, such as more detailed representation of waterfront and stopbanks, etc., as well as changes in the location of the DEM boundaries, can cause differences in the results presented in this study when compared to the previous studies. Note also that the models run including a sea-level rise component use exactly the same elevation model and land-use model as those run at the current value of MHWS.

Finally, improvements in the models themselves or any of the other inputs, such as the NTHM, could result in changes in the final maps over time. However, GNS Science believes that the models presented here represent the best available maps based on the current science and that are achievable within the resource and time limitations of a project such as this. Thus, they should be suitable to help inform land-use planners and decision makers on how to improve their resilience to tsunami.

This project is related to the three-year EQC-funded research project 'Tsunami impact and Loss Modelling in Hawke's Bay' and to research in the 'Resilience to Natures Challenges 2' (RNC2) Earthquake and Tsunami theme that the EQC project draws upon. The EQC project is primarily focused on loss and risk modelling, mainly using scenarios and hazard maps generated by the RNC2 research. One key difference with this project is the choice of sources and the way in which they are modelled. In the EQC/RNC2 projects, the RSQsim earthquake simulator (Shaw et al. 2022) is used to generate synthetic catalogues of scenarios, likely to include several earthquake scenarios for each fault, rather than selecting a single scenario for a given fault at a specific return period using the deaggregation in the NTHM2021. As the source scenarios are different, it will be highly informative to compare the results of the two studies once the EQC project is complete.

The RSQsim synthetic catalogues currently only include sources that are local to New Zealand, so we should anticipate different and generally smaller inundation extents at short return periods, such as 100 years, in the EQC/RNC2 project, as the NTHM shows a significant contribution to the tsunami hazard from distant sources at shorter return periods. The EQC/RNC2 projects will also be using less-refined tsunami inundation grids than here in order to compensate for the need to run much larger numbers of scenarios in those projects.

The EQC project is focused on the loss and risk modelling methodology, comparing the losses when these are calculated in different ways, and should be informative with regard to the suitability of using hazard maps for loss modelling, as opposed to calculating losses for individual scenarios. With permission from HBRC, the EQC project could also estimate losses for the hazard maps generated in the current project and then compared against losses from the RSQsim-generated scenarios and hazard maps.

Comparisons with the EQC/RNC2 studies will be particularly informative if the NTHM is extended to include inundation at a national scale at a later date. One option for a future NTHM with inundation included is to continue using the 'effective' magnitude to capture the effects of non-uniform slip as in NTHM2021. One uncertainty with this approach is the level at which the magnitude should be increased to account for non-uniform slip, particularly for local sources. The results of this study when compared to those from the EQC and RNC2 studies could be used to help reduce that uncertainty. Another option would be to use the RSQsim catalogue for the NTHM extended to inundation instead of the current method used in NTHM2021. The comparison between the results of this study and the EQC/RNC2 studies will be informative for that option as well. This future work should allow the results of this study to help improve tsunami inundation hazard and risk assessment for the whole country as well as just for the communities in Hawke's Bay.

7.0 ACKNOWLEDGEMENTS

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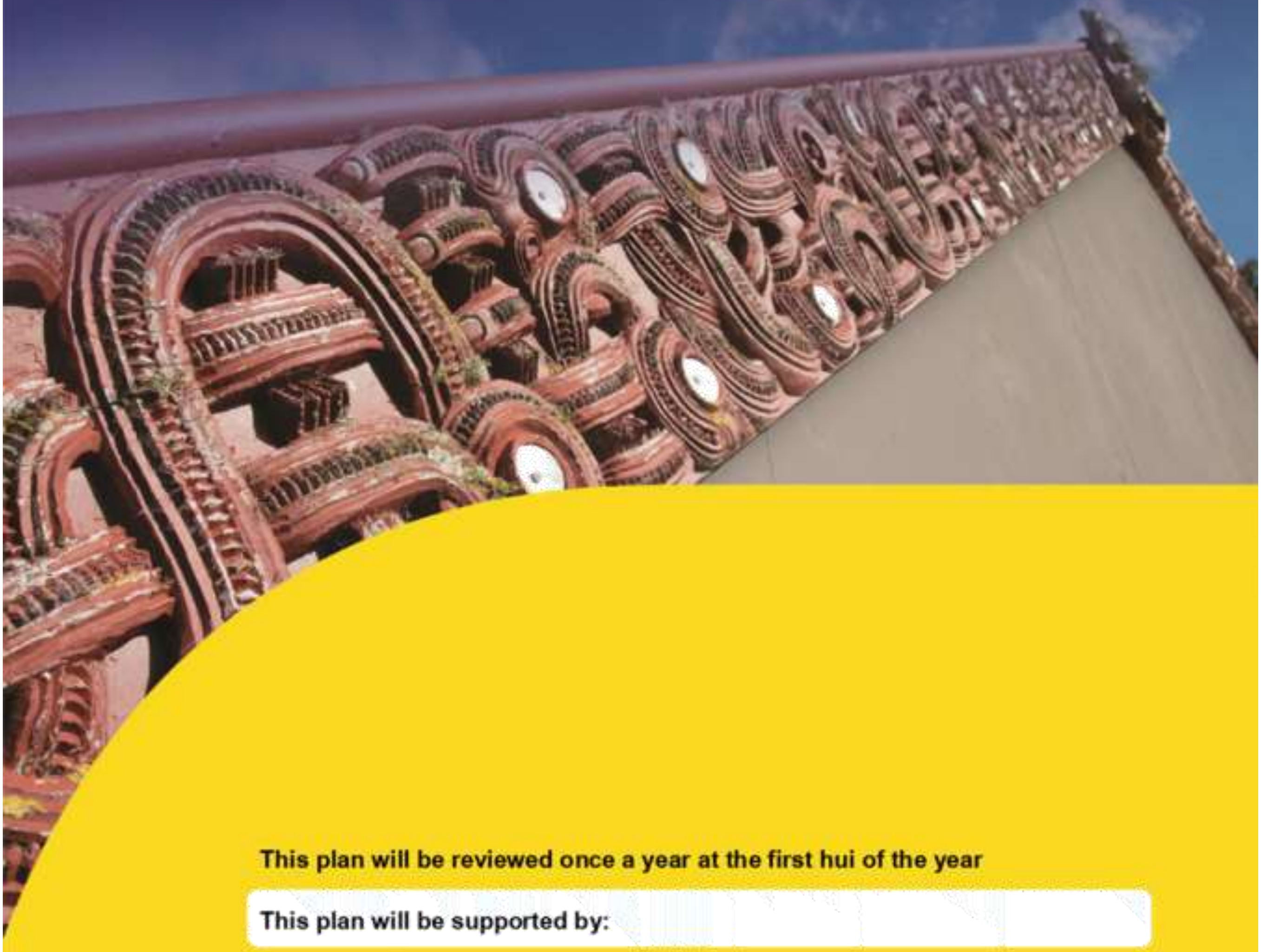
He mea waihanga tēnei MAHERE kia takatū ai TŌ TĀTAU MARAE, NGĀ TĀNGATA, me te hapori whānui mō te tūpono pā mai o tētahi Aituā, Mate Whawhati Tata rānei.

This PLAN has been created to make sure OUR MARAE, OUR PEOPLE and our wider community are ready in case of a Disaster or Emergency.



This plan will be reviewed once a year at the first hui of the year

This plan will be supported by:

Marae Emergency Preparedness Plan

Ngā Tāngata Hei Whakapā Atu
Marae contacts

The key contacts for our marae are:

Ingoa | Name:	Waea | Phone:

Hītori o Te Marae
History of the Marae

Ngā Mōreatanga
Hazards

Te Whenua Pāhekeheke | Landslide

Likely impact:

What to do:

Te Waipuke | Flood

Likely impact:

What to do:

Te Rū Whenua | Earthquake

Likely impact:

What to do:

Ngā Mōreatanga
Hazards

Ahi | Fire

Likely impact:

What to do:

Te Āwhā | Storm

Likely impact:

What to do:

Te Tai Āniwhaniwha | Tsunami

Likely impact:

What to do:

Ngā Mōreatanga
Hazards

Te Puia | Volcano

Likely impact:

What to do:

Te Mate Urutā | Pandemic

Likely impact:

What to do:

Ngā Mōrearea ā-Ringa Tangata | Man Made Hazard

Likely impact:

What to do:

Ka Pēhea Te Whakamōhio i a Tātau

How will we be warned?

WE WON'T get a WARNING for an earthquake or a landslide.

WE MIGHT get some WARNING of flooding, pandemic, forest or scrub fire, volcanic ash, or tsunami.

FOR A TSUNAMI generated far away from New Zealand, we could get as much as 14 hours warning.

We will get a FLOOD WARNING from either Civil Defence, the Emergency Response Team, or a member of the community.

WE WILL GET WARNINGS FROM A NUMBER OF SOURCES
These will come from the radio, TV, sirens, text messages, email, social media, or phone call.

Te Whakaputa i Te Kōrero

Getting the word out

At the back of this plan is a list of people and their contact details who are responsible for contacting five people each – by phone or in person – to make sure information and warnings are received by the entire whānau and hapū.

Ngā Tāngata Whakapā Ohotata

Emergency contacts

Ingoa | Name:	Waea | Phone:

If there is a FIRE or MEDICAL EMERGENCY RING 111

Ngā Tāngata Whai Pūkenga

Our skilled people

PEOPLE who can set up and operate the marae in an EMERGENCY are:

Ingoa | Name:	Waea | Phone:

PEOPLE who can perform first aid are:

Ingoa | Name:	Waea | Phone:

PEOPLE who have specialised skills:

Ingoa | Name:	Waea | Phone:
Doctor	
Nurse	
Engineer	
Heavy vehicle driving licence	

Ngā Kaiwhakarato Ratonga

Our service provider contacts

Ingoa | Name:	Waea | Phone:
Power company	
Security company	
Phone company	
Internet company	
Septic tank company	
Plumber	
Electrician	
Builders	
SPCA	
Petrol station	
Supermarket	
Schools	
Water tanker (carriers must be registered with the Ministry of Health to comply with the Health Act)	

Te Rēhita
Registering

If whānau, hapū or people from the wider community come to our marae in an emergency, we will record their name, address and contact phone number and provide them to our local Civil Defence team. These details can be used to track family members who are presumed missing, ensure the safety of whānau and wider members of the community. If these people decide to leave the marae, we will note where they intend to go to and mark them as not being on the marae anymore.

Tō Tātau Marae
Our marae

Our marae works because we have the resources and services that support it. We also know what extra resources we will need in an emergency and how to get them.

Hanganga Infrastructure:	Kei te whakamahia ināianei What we use now:	Ka whakamahia a muri ake What we will use:
Water		
Power		
Sewerage		
Telephone/internet		
Roads/bridges		
Toilets/showers		
Heating		
Buildings		
Transport		
Cooking		
Dining		
Rubbish facilities		

Ngā Mea e Hiahiatia Ana

Things we need

For our whanau, hapū and others in an emergency.

Ngā taonga Items	Rahinga Qty	Monehutanga Expiry	Kowhiringa Ke Alternative Option
Blankets			
Mattresses			
Pillows			
Linen			
Cans of food			
Dried food			
Other food			
Water (drinking)			
Water (other)			
Alternative cooking			
Gas bottle			
Firewood			
Can opener			
Torches/candles			
Radio			
Batteries			
Toilet paper			
Rubbish bags			
First Aid Kit			
Pandemic Kit			
Fire extinguishers			
Fire blankets			
Fire hose			
Spades			
Clothes dryer			
Washing machine			
Tables and chairs			
Cleaning products			

Mahere Wāhi me te Wāhi Whakahiato

Site plan and assembly point

Our FIRST AID KIT is located

Sketch the plan of your Marae and mark the fire exits and assembly point.

Tō Tātau Whāinga
Our target

This Plan will tell us how prepared our marae is to deal with any emergency that might occur.

I roto I te tau e tū mai ko tem ahi a marae | Over the next year our marae will:

Te Hunga Hei Manaaki

People we need to ensure are safe in an emergency

We need to make sure we look after our vulnerable people – the young people and our elders. We need to make sure they are safe in an emergency or warning/evacuation.

The following people will make sure our young, our elderly and our disabled are looked after:

Ingoa Name:	Kâinga Address:	Kei a wait e kawenga Who is responsible:

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Te Rākau Waea

Telephone contact tree

Tangata whai kawenga Person responsible:	Ngā tāngata he whakapā atu People to be contacted:	Taipitopito Whakapā Contact details:

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Notes