Evacuation lessons learned
Support for “Playbook” Approach

- Two options for evacuation (all or none) insufficient for distant “Warning” events (given time for response and highly accurate forecast wave heights)

- Secondary evacuation zones that could have been utilized during the Warning-level 2011 Tohoku-oki tsunami in California and 2012 Haida Gwaii tsunami in Hawaii

- Incorporation of tidal and storm conditions during tsunami important for understanding full inundation potential

- Future real-time inundation products from the Warning Centers will require established secondary evacuation zones in local response plans

- Coastal high-resolution LIDAR DEMs available for creating evacuation “playbook” lines based on elevation
Purpose and Use of this Tsunami Playbook

PURPOSE: NOTE: Emergency managers should become familiar with this Playbook plan prior to use. A significant issue for emergency managers is that existing tsunami evacuation plans call for evacuation of the predetermined tsunami evacuation zone (typically at a 30- to 50-foot elevation) during a “Warning” level event; the alternative is to not call an evacuation at all. A solution to provide more detailed information has been the development of tsunami evacuation “Playbooks” to plan for tsunami scenarios of various sizes and source locations. NOAA-issued Tsunami Alert Bulletins received in advance of a distant event will contain a tsunami alert level, forecasted tsunami amplitude (or wave height) and arrival time for a number of locations along the coastline. Elevation “playbook” evacuation lines can be useful for partial tsunami evacuations when information about forecasted tsunami amplitudes and arrival times is available to coastal communities and there is sufficient time to implement a partial evacuation. Provision for multiple elevation evacuation lines and response plans for those lines enables planning for different evacuation scenarios based on the forecast tsunami amplitude, potentially alleviating the need for an “all or nothing” decision with regard to evacuation.

USE: This playbook is designed to help the emergency managers with tsunami evacuation and response activities. First, it requires that the emergency manager become familiar with the information herein, especially the “Tsunami Response Decision Tree” (Page 2), the overall Playbook approach, and FASTER calculation (Page 3). When a distant-source tsunami is occurring, fill out the information on Page 2 regarding the earthquake (magnitude, location) and tsunami (alert level, forecasted amplitude and arrival time). Keep in mind that this information can change during the first hour or two after the earthquake occurs.

Use this information to determine which branch of the decision tree applies to the event. Refer to information on Page 3 regarding the “Elevation Evacuation Playbook,” the “Scenario Evacuation Playbook,” and the FASTER calculation value. FASTER will be calculated and provided to each community by the county or regional Weather Forecast Office. Each scenario Playbook will be accompanied by a digital file identifying the full evacuation zone for a community. This file should be referenced and used during an event. Communities may wish to use these maps to establish “reverse 911” calling areas.

Table of Contents – Tsunami Response Plan Playbooks

Page 1: Purpose and use evacuation playbooks, tsunami alert bulletins
Page 2: Real-time quick reference page and “decision tree” for response
Page 3: Real-time evacuation playbook reference page and FASTER explanation
Pages 4-9: Tsunami elevation evacuation scenario playbook plans pages
Page 10: Notable historical tsunamis and state tsunami program modeling results

Tsunami Alert Bulletins: During the typical tsunami alert, the Warning Center provides information about the tsunami in “bulletins” to the state and local jurisdictions. There are four levels of “alert” that can be sent by the NTWC (from least to greatest significance):

Tsunami Information Statement - Issued to inform and update emergency managers and the public that an earthquake has occurred, or that a tsunami Watch, Advisory or Warning has been issued elsewhere in the ocean.

Tsunami Watch - Issued to alert emergency managers and the public of an event which may later impact the Watch area. May be upgraded to an Advisory or Warning - or canceled - based on updated information and analysis.

Tsunami Advisory - Issued due to the threat of a tsunami which may produce strong currents or waves dangerous to those in or near the water; typically called when forecasted tsunami amplitudes are between 0.3m and 1m (1ft and 3ft) above existing tidal conditions are expected. Coastal communities are advised that beach and harbor areas could expect rapid, moderate tidal changes and strong currents.

Tsunami Warning - Issued when a tsunami with significant widespread inundation is imminent or expected; typically called when forecasted tsunami amplitudes are equal to or greater than 1m (3ft). Coastal communities are advised to evacuate people from low-lying areas identified as vulnerable to tsunamis.
Quick Reference Page for Determining Real-Time Tsunami Response Activities

**Step 1:** Obtain information about earthquake and tsunami from National Tsunami Warning Center in Alaska, regional NOAA-Weather Forecast Office, and/or county emergency manager. The explanation of the FASTER calculation is provided on Page 3. The FASTER value is used to determine which Playbook scenario to use.

Earthquake location ____________________________
Earthquake magnitude ____________________________
Tsunami Alert level _____________________________
Forecasted tsunami amplitude/wave height ______________
Forecasted tsunami arrival time _________________
Highest projected tidal height (above Mean Sea Level) for first 5 hrs after arrival _________________
Ambient ocean/storm conditions for first 5 hrs after arrival: _______________________________________
Calculate/obtain FASTER tsunami run-up value in first 5 hours: ____________
Calculate/obtain FASTER tsunami run-up value at highest tide _____________

**Step 2:** Compare the information from Step 1 to the Tsunami Response Decision Tree on the right. Select the decision tree branch that best fits the forecast tsunami information.

**Step 3:** Go to Page 3 “Playbook reference” page and utilize the appropriate Playbook or strategy for evacuation and response.

A set of digital evacuation maps and response instructions will accompany each of the Elevation Evacuation Playbook scenarios. These files can be used to develop “reverse 911” calling areas prior to the event.
Real-time Playbook Evacuation and FASTER Calculation Reference Page

FASTER Analytical Tool: To determine the full impact of the tsunami, other variables such as tidal and storm conditions must be considered. An analytical method has been created which incorporates important variables that will impact the ultimate tsunami flood level. The FASTER calculation, which will be provided to communities by the county or regional NWS Weather Forecast Office during a tsunami event, is used to help determine if inundation of dry land will occur. Communities can use the FASTER value to match which evacuation “playbook” to use. The simplified components of the calculation are as follows:

Working example: Formula for determining playbook evacuation line to use (F-A-S-T-E-R):
FA: Forecasted Amplitude (Wave Height) from Warning Center
S: Storm surge or existing ocean conditions
T: Maximum tidal height (first 5 hours of tsunami)
E: Forecast error potential (30%; analysis of 2010-11 events)
R: Site amplified run-up potential (from existing modeling, unique to each location; applied if inundation expected)

= Maximum tsunami run-up height = Playbook elevation line

Elevation Evacuation Playbook: The table below can be used to select the appropriate elevation evacuation playbook response plan. Once the FASTER value is obtained, it should be compared to the appropriate playbook reference page for evacuation and response activities.

<table>
<thead>
<tr>
<th>Reference Pages for Detailed Evacuation and Response Information</th>
<th>Community Evacuation Zone for Playbook Evacuation Plans</th>
<th>Recommended FASTER Expected Flood Level Value (METERS)</th>
<th>Recommended FASTER Expected Flood Level Value (FEET)</th>
<th>Anticipated NOAA Tsunami Alert Level</th>
<th>Community recommended areas to evacuate (local decision)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page 4</td>
<td>Level/Stage/Phase 1</td>
<td>less than 1.00m</td>
<td>less than 3.3ft</td>
<td>Advisory</td>
<td>beaches, docks, waterfront areas</td>
</tr>
<tr>
<td>Page 5</td>
<td>Level/Stage/Phase 2</td>
<td>1.00m to 1.50m</td>
<td>3.3ft to 5.0ft</td>
<td>Warning</td>
<td>Stage 1/Phase 1 and low-lying areas prone to normal flooding</td>
</tr>
<tr>
<td>Page 6</td>
<td>Level/Stage/Phase 3</td>
<td>1.50m to 2.50m</td>
<td>5.0ft to 8.2ft</td>
<td>Warning</td>
<td>Areas mapped as Stage 2 (if applicable)</td>
</tr>
<tr>
<td>Page 7</td>
<td>Level/Stage/Phase 4</td>
<td>2.50m to 3.50m</td>
<td>8.2ft to 11.5ft</td>
<td>Warning</td>
<td>Areas mapped as Stage 3 (if applicable)</td>
</tr>
<tr>
<td>Page 8</td>
<td>Level/Stage/Phase 5</td>
<td>3.50m to 4.50m</td>
<td>11.5ft to 14.8ft</td>
<td>Warning</td>
<td>Areas mapped as Stage 4 (if applicable)</td>
</tr>
<tr>
<td>Page 9</td>
<td>Maximum Phase (as recommended by existing NOAA protocol)</td>
<td>more than 4.50m</td>
<td>more than 14.0ft</td>
<td>Warning</td>
<td>Evacuate to maximum evacuation zone</td>
</tr>
</tbody>
</table>

Scenario Evacuation Playbook: Scenario tsunami playbooks and guidance have been developed for maximum local and distant tsunamis, and for tsunamis coming from the Cascadia subduction zone toward central and southern California. Scenario playbook information about the expected tsunami amplitude and travel time is available from the numerical modeling results for these sources. These are important scenarios for emergency managers to prepare for as there could only be tens of minutes to evacuate or just a few hours to conduct response or evacuation activities before the tsunami arrives. Because of the short time for making response decisions, the following evacuation and response plans are recommended for all of San Diego County:

- Local coastal earthquake >M6.5: 10-15 minutes; Maximum evacuation zone
- Cascadia subduction zone >M8.5: 2 hours; Level/Stage/Phase 3 Elevation Playbook
- Alaska or Aleutians subduction zone >M8.5: 6 hours; Maximum evacuation zone
Level/State/Phase 1  
(example from Imperial Beach)

Background Information:
Alert level = Advisory  
FASTER tsunami value = less than 1.0m (3.3 ft)

Specific Instructions:
• Follow general guidance for Advisory-level tsunamis (Page 1)
• Consider evacuating beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
• A digital file showing evacuation maps and response instructions is available for use.
• Specific evacuation and response instructions...... (completed with the community input)
Level/State/Phase 2
(example from Imperial Beach)

Background Information:
Alert level = Warning
FASTER tsunami value = between 1.0m (3.3 ft) and 1.5m (5.0ft)

Specific Instructions:
• Follow general guidance for Warning-level tsunamis (Page 1)
• Consider evacuating of areas outlined by the black line, including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
• A digital file showing evacuation maps and response instructions is available for use.
• Specific evacuation and response instructions...... (completed with the community input)
Level/State/Phase 3  
(example from Imperial Beach)

Background Information:
Alert level = Warning  
FASTER tsunami value = between 1.5m (5.0ft) and 2.5m (8.2ft)

Specific Instructions:
• Follow general guidance for Warning-level tsunamis (Page 1)
• Consider evacuating of areas outlined by the gold line, including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
• A digital file showing evacuation maps and response instructions is available for use.
• Specific evacuation and response instructions...... (completed with the community input)
Level/State/Phase 4
(example from Imperial Beach)

Background Information:
Alert level = Warning
FASTER tsunami value = between 2.5m (8.2ft) and 3.5m (11.5ft)

Specific Instructions:
• Follow general guidance for Warning-level tsunamis (Page 1)
• Consider evacuating of areas outlined by the purple line, including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
• A digital file showing evacuation maps and response instructions is available for use.
• Specific evacuation and response instructions...... (completed with the community input)
Level/State/Phase 5
(example from Imperial Beach)

Background Information:
Alert level = Warning
FASTER tsunami value = between 3.5m (11.5ft) to 4.5m (14.3ft)

Specific Instructions:
• Follow general guidance for Warning-level tsunamis (Page 1)
• Consider evacuating of areas outlined by the red line (the maximum tsunami evacuation zone), including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
• A digital file showing evacuation maps and response instructions is available for use.
• Specific evacuation and response instructions...... (completed with the community input)
Background Information:
Alert level = Warning
FASTER tsunami value = greater than 4.5m (14.3ft)

Specific Instructions:
• Follow general guidance for Warning-level tsunamis (Page 1)
• Consider evacuating of areas outlined by the red line (the maximum tsunami evacuation zone), including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
• A digital file showing evacuation maps and response instructions is available for use.
• Specific evacuation and response instructions...... (completed with the community input)
Reference Material: Notable Historical Tsunamis and State Tsunami Program Modeling Results

**Notable Historical Tsunamis**: The following table provides very basic information about historical tsunami events; not all tsunamis are represented, especially minor or small tsunamis. Note that the largest, most damaging tsunamis in San Diego County history have come from large earthquakes in the Alaska-Aleutian Islands region and the Chile region. Although the potential for local tsunamis exists, they are much less frequent than distant source tsunamis.

### Notable Historical Tsunamis in San Diego County

<table>
<thead>
<tr>
<th>Date</th>
<th>Magnitude-Mercalli area</th>
<th>Tsunami location</th>
<th>Run-Up Amplitude</th>
<th>Remarks</th>
<th>NDR - no damage reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/7/1982</td>
<td>M5.5 - Hokkaido</td>
<td>San Diego</td>
<td>4 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/2/1988</td>
<td>M5.5 - Chile</td>
<td>La Jolla</td>
<td>1 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/11/1977</td>
<td>M5.5 - Chile</td>
<td>La Jolla</td>
<td>1 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/10/1972</td>
<td>M6.8 - Aleutian Islands</td>
<td>San Diego</td>
<td>1 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/4/1992</td>
<td>M7.5 - Kachemashima</td>
<td>La Jolla</td>
<td>1 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/3/1997</td>
<td>M8.4 - Aleutian Islands</td>
<td>Shelter Island</td>
<td>4 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/22/1980</td>
<td>M7.5 - Chile</td>
<td>Shelter Island</td>
<td>2 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/29/1994</td>
<td>M7.2 - Alaska</td>
<td>Shelter Island</td>
<td>4 ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/27/2000</td>
<td>M8.9 - Chile</td>
<td>Shelter Island</td>
<td>4 ft</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Run-up amplitude, in feet, above normal tide conditions
- Distant Source - Tsunami without felt earthquakes
- Local Source - Earthquake and tsunami together
- NDR = no specific reports of effects or damage

**Modeled Tsunami Scenarios**: Because very large tsunamis are infrequent and the likelihood that the largest potential tsunamis have not yet occurred in the San Diego County area, the state tsunami program developed a suite of maximum credible tsunami scenarios as part of their tsunami inundation mapping project for local evacuation planning. The general tsunami wave height for key locations from these scenarios are provided below. As identified in the historical tsunami table, the largest tsunamis could occur from large earthquakes in the Alaska-Aleutian Islands region and the Chile region, or from a large submarine landslide offshore from the Bay.

**Additional information about the length of activity for recent events**: Tsunamis activity can last for many hours after first wave arrival. The table to the right shows nearby tide gauge information (San Diego) for several recent, real events on the timing of the various tsunami peaks, i.e. how many hours after arrival did the maximum positive wave occur, the maximum negative wave and the maximum peak to trough wave. This information shows that peak/maximum tsunami conditions can occur nearly 14 hours after first arrival.

### San Diego Tide Gauge Information

<table>
<thead>
<tr>
<th>Time (Hrs after Arrival)</th>
<th>Max. Amp (m)</th>
<th>Assoc. Trough (m)</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 Samoa</td>
<td>13.7</td>
<td>0.36</td>
<td>-0.28</td>
</tr>
<tr>
<td>2010 Chile</td>
<td>14.3</td>
<td>0.6</td>
<td>-0.44</td>
</tr>
<tr>
<td>2011 Japan</td>
<td>11.4</td>
<td>0.6</td>
<td>-0.44</td>
</tr>
</tbody>
</table>