FEMA'S BENEFIT COST-ANALYSIS TOOL FOR TSUNAMI VERTICAL EVACUATION PROJECTS

General Guidance

The purpose of this document is to provide potential subapplicants with general guidance on FEMA's Hazard Mitigation Assistance (HMA) benefit-cost analysis (BCA) tool. The BCA is a required subapplication component. This guidance is not intended to provide complete information, but rather to outline basic requirements and considerations as subapplicants begin the analysis process. Cal OES is available to answer technical questions about BCAs and can be contacted by emailing HMA@caloes.ca.gov.

Tsunami Vertical Evacuation Towers Benefit-Cost Analysis

Vertical evacuation towers are used in places where there is substantial risk of tsunamis with low warning times, and there is no natural ground sufficiently high to offer protection. This situation applies to many (but not all) – coastal communities in Northern California from approximately Eureka to the Oregon border. The predominant tsunami risk in this area is from large magnitude earthquakes on the Cascadia Subduction Zone, because the available evacuation time from the time of the earthquake to the arrival of the tsunami is short, often 30 minutes or less. In other areas of California, vertical evacuation towers may be appropriate mitigation measures, but tsunami warning times are typically much longer, allowing populations to escape to higher areas, rather than requiring a tower.

BCA Software and Methodology

FEMA requires the use of its BCA software (version 6 for all BCAs). Subapplicants can get the software by visiting FEMA's Benefit-Cost Analysis Guidance and Tools website: https://www.fema.gov/media-library/assets/documents/179903.

The Version 6.0 BCA software includes "Tsunami" as one of the hazards that can be selected. Caveat: the 6.0 BCA software has no tsunami data. Thus, all of the data inputs must be entered by the analyst, and fully documented.

Data used in the Analysis

This subsection is intended as a general summary of data requirements for tsunami BCAs.

A **Tsunami BCA** requires a technical understanding of tsunamis. Consultation with engineers familiar with tsunamis and Vertical Evacuation Towers is strongly recommended. The minimum data required include the following:

1. A map showing the anticipated tsunami inundation area for the project area. Click to see the California Official Tsunami Inundation Maps www.conservation.ca.gov/cgs/tsunami/maps.
2. Define the location of the proposed tower.
3. Consult with a tsunami expert to determine the time interval between an earthquake that generates a tsunami and the expected arrival of the first tsunami wave.
4. Define the collection area surrounding the tower from which people will reasonably be able to reach the tower before the arrival of the first tsunami wave. For tsunamis from earthquakes on the Cascadia Subduction Zone, a realistic collection area may be a radius of 0.5 miles, although FEMA guidance does not address this issue.
5. Estimate the population in the collection areas from GIS mapping and estimate the average number of people per dwelling unit.
6. Estimate the percentage of people who are likely to be able to reach the tower before the first tsunami wave arrives. The longer the travel distance is, the smaller the percentage of the population is likely to reach the tower in time. For people within ½ mile only the yellow estimates below are typical for after mitigation. For ¼ mile radius only the percent deaths may be lower than the ½ mile by about 20% Less deaths. For 1-mile radius only, the deaths after mitigation would be about 10% less than the1/2 mile estimate. For BCAs that use 2 or more radii, the estimates would have to be adjusted to be proportional to the population within a ring. For example, for ½ mile and 1-mile radii, the 1 mile radius is the people between ½ mile and 1 mile.
7. Make the above estimates for at least two scenario tsunami-generating earthquakes. For Cascadia Subduction Earthquakes, typical recurrence intervals may be approximately: 525 years for typical full-rupture earthquakes, 975 years for very severe full-rupture earthquakes, and 2,475 years for the worst case full-rupture earthquakes.
8. Estimate the number of deaths for each of the selected earthquake-generated tsunamis. The death rate for people in inundated areas that do not reach a safe haven is very high – not 100% but often nearly so.

Tsunami Vertical Evacuation Projects

FEMA does not offer any guidance in this subject area. BCAs for such projects in another FEMA region used the following values for death rates vs. event probabilities (about which, see above) 90% for the 525-year event, 95% for the 975-year event, and 99% 2475-year event. Typically, the vast majority of benefits are avoided deaths, using FEMA's standard Value for deaths.

9. Project cost and annual maintenance estimates.

Benefits

Benefits of tsunami mitigation projects are typically limited to avoided deaths. The FEMA BCA guidance entitled *Baseline Standard Economic Value Methodology Report (July 28, 2016)* includes a table of values for death and injuries. The report is not available on-line, but may be obtained from OES.

Project Useful Life and Project Effectiveness

Project useful life is simply the period over which a project is effective. FEMA's 2009 BCA guidance (Appendix D) provides specific values for useful life, and can be found by visiting FEMA's Benefit-Cost Analysis Guidance and Tools website: https://www.fema.gov/media-library/assets/documents/179903.

The main design parameters for design of vertical evacuation towers , including inundation depth and flow velocity, are determined by the ASCE 7-16 Tsunami Hazard Tool https://asce7tsunami.online/.

Project Useful life is typically estimated to be at least 50 years, when necessary periodic maintenance is done.

Project effectiveness is the extent to which a mitigation activity reduces future damages. The project effectiveness of Vertical Evacuation Towers is always less than 100%. Some people are located too far from the tower to reach it before the arrival of the tsunami. Other people may delay moving towards the tower until it is too late.

Documentation

Cal OES and FEMA require subapplicants to provide documentation for all data that is used in a BCA. This must be included with the materials that are submitted as part of the application package.

Best Practices

Cal OES strongly recommends that each subapplicant BCA be supplemented by a brief technical report that summarizes the approach to the analysis, the data that was used, the sources of the data, and the results of the analysis.

Subapplicants should provide electronic copies of any data sources that are used in a BCA, including tsunami inundation maps, copies of preliminary project designs, geotechnical studies if available, maps showing the collection areas for the tower and GIS data for populations within various distances from the proposed tower location.

Ideally, every data point entered into the software will be explained in a technical report and backed up with written documentation.