a. Introduction. Run-up on vertical embankments can be calculated using the Sainflou or Goda formulae described in Chapter 5 of EM 1110-2-1100 Part VI.

C-8. Allowable Wave Overtopping.

a. Wave overtopping occurs when wave run-up and wind setup levels combine to produce a water level greater than the crest elevation of the embankment. When waves over-wash a structure it occurs intermittently, not continuously, as individual high waves among a multitude of storm waves attack the face of the structure. A structure that is built to prevent all overtopping is often cost prohibitive. Instead of designing a structure with no overtopping, typically it is more practical to design the height of the structure to a given design condition (e.g., H_s, $H_{2\%}$ or total overtopped volume), understanding that a certain percentage of waves in the incident wave field will generate run-up levels that will overtop the structure.

b. Wave overtopping is an important design element both in terms of predicting backside flooding and safeguarding structural integrity of the embankment. Several methods exist for predicting the over-wash flow rate in a given situation. Over-wash is generally measured in one of two ways, as a volume over time per unit length of structure or as a mean rate of over-wash volume per unit length over the duration of the storm event.

c. Allowable wave overtopping is the amount or rate of over-wash that is permissible on a given embankment. This rate is a function of the construction of the embankment. An unprotected earthen embankment will not tolerate a high over-wash rate. The resulting intermittent flow on the backside will quickly lead to erosion and failure. For these situations, the embankment elevation and freeboard may be increased to minimize the wave discharge over the structure. Grass, turf reinforced mats (TRM) or artificial turf mats add an element of protection to earthen slopes, allowing for higher over-wash rates and lower freeboards. Riprap, concrete, asphalt and other hard armor types result in the highest allowable discharge rates and the lowest freeboard requirements.

d. The wave overtopping discharge varies considerably from wave to wave. The majority of the discharge during a storm is due to just a small fraction of the waves. These largest, less frequent waves, can produce discharge that is 100 times the average. For practicality, most information on wave overtopping is given as the time averaged over-wash (discharge) rate, expressed as a volume per second per unit length of structure.

e. Critical values of average wave overtopping discharges. EM 1110-2-1100 Part VI, Table VI 5-6 (recreated in Figure C-9) provides general information for identifying allowable discharge rates for different structure types. These values should be considered only as rough guidelines as the same discharge rates may occur form difference intensities of wave action that could contribute to an attack on the structure integrity. Allowable wave overtopping rates must be selected based on site specific conditions including storm wave climate, geotechnical makeup, construction materials, ability to route overtopping volumes, and proximity to other structures and/or population centers.