MCUA Edison Flood Wall
Flood Wall Wave Loads

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This document summarizes the work done to compute wave loads on the Edison Pump Station flood wall along the Raritan River. Based on the FEMA criteria the wave loads from a 0.2% occurrence (500 year return period) event needs to be computed. Numerical wave modeling was performed to transform and propagate the wind generated waves to the project site and then the wave conditions at the project site were used to compute the wave loading on the walls using standard coastal engineering practice. The following sections summarize the wave modeling and wave loading calculations performed.

1 WAVE MODELING

Wind wave generation and transformation to the nearshore project area was performed using the SWAN wave model (Delft University of Technology, 2012), which is a well-known 2-D spectral (phase-averaged) wave transformation model.

The wave modeling grid bathymetry and topography were developed using available data sources. The National Geophysical Data Center (NGDC) Coastal Relief Model (CRM) was used for the bathymetric data for the project area and vicinity. The CRM is composed of several NOAA bathymetric surveys from 1880 to present (NOAA National Geophysical Data Center, 2014). The Coastal Services Center (CSC) digital coast database was used for the topography data for the project area and vicinity. The CSC compiles data from multiple sources into one data base. The data used for the topography came from a 2012 US Army Corps of Engineers Post Super Storm Sandy study that included LIDAR data for the New York and New Jersey coastlines (NOAA Coastal Services Center, 2012).

SWAN model was run using the wind speed of 120 mph and water level of +17.4 ft NAVD, which corresponds to a 500 year storm event (FEMA, 2014). The model was run using wind directions clockwise from the north to the south at 22.5 degree intervals to determine the highest possible wave heights at the project site. The maximum wave conditions generated resulted a significant wave height (Hs) of 7.5 ft and peak wave period (Tp) of 5 sec. Wave height results from the SWAN wave modeling for the maximum scenario is shown in Figure 1.

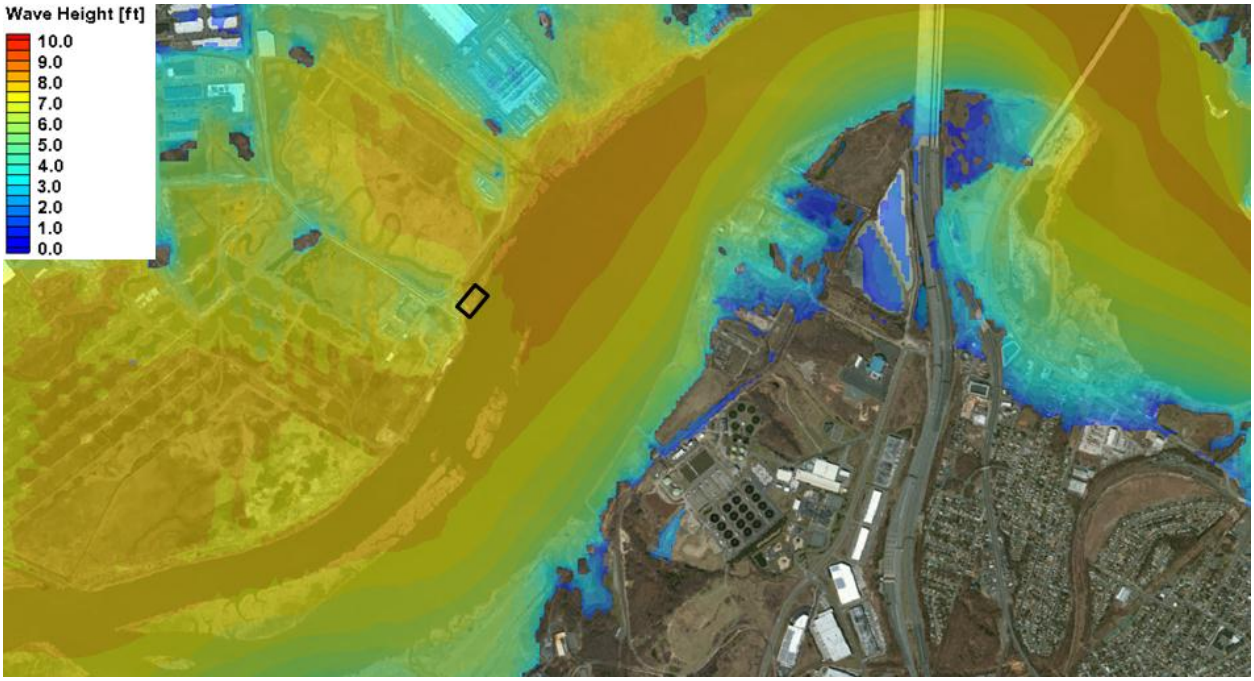

Figure 1. Wave heights in feet for a 500 year storm event at the project site, indicated as the black outlined box.

2 WAVE LOADING

Two different methods were used to calculate the impact loads from waves on the walls. The first method uses the American Society of Civil Engineers (ASCE) flood load design method (7-05) (ASCE, 2006). The second method uses the US Army Corps of Engineer's Coastal Engineering Manual's Goda formulation (USACE, 2002). The conditions used in the wave impact load calculations are listed in Table 1.

Table 1. Wave Load Eqation Inputs.

Inputs for Wave loading calculations	
WSE	+17.4 ft NAVD88
Bed Elevation	+7.0 ft NAVD88
Wall Crest Elevation	+23.0 ft NAVD88
Wall Height	16.0 ft
Design Wave Height (1.8*Hs)	13.5 ft
Water Depth	10.4 ft
Wave Period	5 seconds

2.1 ASCE 7-05

The ASCE method uses the still water depth to calculate the combined hydrostatic and hydrodynamic loads caused by the waves impacting the wall. Building Category III was chosen for the calculations as it corresponds to a 500 year storm event (probability of exceedance of 0.2 %). The resulting maximum pressure at the still water level and the force acting on the wall computed using this method is listed in Table 2. It should be noted that the

ASCE load computations assume an infinitely high wall and assumes formation of standing waves in front of the wall, which will result in conservative results.

Table 2. ASCE 7-05 results.

ASCE Wave loads	
P_{max}	2930 lb/ft^3
Force	41.0 kips/ft

2.2 CEM VI-5 Goda's formulation

Goda's formulation for head-on breaking waves uses the still water depth as well as wave conditions and the crest height of the structure to compute the hydrostatic and hydrodynamic loads caused by the waves impacting the wall. The resulting maximum pressure at the still water level and the force acting on the wall computed using this method is listed in Table 3.

Table 3. CEM Goda's formulation results.

Goda Wave loads	
P_{max}	720 lb/ft^3
Force	13.6 kips/ft

3 CONCLUSION

It is recommended that wave loads computed by Goda's formulation be used in the design of the flood wall. Assumptions used in the development of Goda's formulation are more applicable to the project conditions (ie, a wall of finite height subject to breaking waves) unlike the ASCE 7-05 which assumes more broadly applicable conditions. The generality of ASCE 7-05 results in extremely conservative loads

4 REFERENCES

American Society of Civil Engineers (2006), Minimum Design Loads for Buildings and Other Structures (7-05).

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