(Reference 2.4.6-25). Subsequent studies have led to reduced wave height predictions, but still reaching up to 10 ft. (3 m) at various East Coast locations (References 2.4.6-8 and 2.4.6-18).

<u>Tsunami due to submarine fault displacement: Hispaniola Trench</u>

The Caribbean Island chain is bounded on the north by a sequence of submarine trenches formed by subduction zone activity. The Puerto Rico Trench is often indicated as a possible source of tsunamigenic activity. However, the Hispaniola Trench to the west has slip characteristics which are more conducive to vertical motion (Reference 2.4.6-21) and, therefore, has a greater tsunamigenic potential (Reference 2.4.6-3). The eastern portion of the Hispaniola Trench has been seismically active, with a series of events with M_w of 6.8 to 7.6 occurring between 1946 and 1953. In the present study, a set of sources along the Hispaniola Trench that combine to produce an event with a total M_w of 9.0, approaching the scale of the catastrophic Indian Ocean tsunami of 2004, is used. This event magnitude is consistent with a failure of the entire length of the fault with a slip of 33 ft. (10 m) (Reference 2.4.6-21).

The PMT maximum positive amplitude and negative drawdown at the PSEG Site are computed for each of the three potential tsunami sources, using the MOST model described in Subsection 2.4.6.4. Numerical values are taken from model grid points located close to the north-south portion of the PSEG Site's western shoreline using the maximum and minimum tsunami-induced WSEL. Results for each case are reported in Subsections 2.4.6.4.5 through 2.4.6.4.7. None of the cases studied produced tsunami-induced water elevations that result in the design basis flood at the site.

2.4.6.3 Tsunami Source Characteristics

Insert "The source has a maximum along-shelf width of 72768 ft (22180 m) and a cross shelf length of 109152 ft (33270 m), with maximum excavation depth of 2461 ft (750 m)." Per RAI No. 20.

2.4.6.3.1 Currituck Landslide

For the Currituck landslide, a total slide volume of 2.16E11 cu. yd. (165 cubic kilometers [km^3]), and a vertical slide displacement of 5740 ft. (1750 m) are used (Reference 2.4.6-21). The source for the tsunami motion is given in the form of a static surface displacement, specified using the equations and procedure outlined in two sources (References 2.4.6-27 and 2.4.6-28). The tsunami source location is taken as being the location of the actual Currituck landslide. Three additional sites to the north were tested in order to determine sensitivity to slide location at the study site.

The source for the Currituck slide simulations were developed using the TOPICS program (References 2.4.6-27 and 2.4.6-28) using the source geometry as given in Reference 2.4.6-21. TOPICS itself is based on a set of p... ...s based on numerical ... which in ...n validated against ext... for translating slide masses (Referenc... ...gainst field measurements for the Papua N... ...6-33).

Insert "near" per RAI No. 20.

Insert "instantaneous" per RAI No. 20.

Insert ", with the initial source center located at 36.4°N and 74.5°W. The slide moves along a straight line track oriented at an angle of 100° relative to North." per RAI No. 20.

TOPICS has thus been shown to be an appropriate means for prescribing initial conditions for landlside tsunamis.

2.4.6.3.2 La Palma Landslide in Canary Islands

The source for this event is a possible volcanic cone collapse on the flank of the Cumbre Vieja volcano on the island of La Palma, in the Canary Islands. This hypothetical event has been extensively studied with a variety of techniques. The main input to the choice of a source is based on scientific literature. The Science Applications International Corporation (SAIC) SAIC Adaptive Grid Eulerian (SAGE) program multimaterial model has previously been applied to simulate the propagation of the landslide (Reference 2.4.6-5). SAGE is a geodynamic model used to model a moving landslide (Reference 2.4.6-5). Recently, a Boussinesq model was used to simulate near-field tsunami wave propagation across the Atlantic Ocean (Reference 2.4.6-7). The results indicate that the maximum predicted WSEL in the Canary Islands range from 33 ft. to 590 ft. (10 m to 188 m) for landslide depths between 895 ft. and 5363 ft. (273 m and 1695 m) (Reference 2.4.6-7). The recent Boussinesq model predicts smaller WSEL than Ward and Day previously predicted (Reference 2.4.6-25), but larger than the predicted results of Mader (Reference 2.4.6-8). Although these results represent qualitatively improved dynamics, as they included the full 3-dimensional representation of the wave generation, a more conservative larger surface displacement is used. The N-wave source, based on initial displacement estimated from Ward and Day (Reference 2.4.6-25), represents the largest estimate of the tsunamigenic event appearing in the literature to date and is thus conservative in that it produces a tsunami which is presently thought to be excessively large by most investigators.

Insert "The N-wave source is implemented as a static, instantaneous displacement of the water surface with a leading maximum positive elevation of 1640 ft. (500 m) and a following depression of 2133 ft. (650 m). The N-wave source is centered at 18.2° W and 28.5° N, and is oriented with its principal propagation direction lying along an axis rotated 225 degrees from North. The distance between the maximum elevation and depression in the N-wave is set as 75,590 ft (23 km) , consistent with estimates of the initial tsunami wavelength computed in Reference 2.4.6-5. The width of the wave crest is chosen to be 86,449 ft (26.35 km), consistent with source widths described in References 2.4.6-5 and 2.4.6-7." per RAI No. 20.

Tsunami simulations are performed within the Delaware Bay and for portions of the Atlantic Ocean using the MOST model system (Reference 2.4.6-22). The MOST model has been extensively verified against test data (References 2.4.6-10 and 2.4.6-19). The model operation is verified by comparing numerical results to results from the operational version of the code at the University of Southern California. Computations are based on MOST model code in effect between July and November 2009.

The MOST model provides a hierarchical environment describing tsunami generation, propagation in open water, and inundation at coastal sites. The computational scheme is comprised of a nesting of three model grids that move the computation for a lower resolution large scale grid A, through an intermediate resolution grid B, to a high resolution grid C encompassing the study site. The grids for the present tests and construction of the grids are discussed in the following subsections.

as a vertical datum origin. The Currituck Grid A includes the continental shelf and offshore areas in the Atlantic Ocean. Each case employs a different Grid A.

Grids for regional scale domains (Grid B) are based on CRM with 3 arc-second resolution (Reference 2.4.6-2). Data is available from NOAA (Reference 2.4.6-11). CRM also uses msl as the vertical datum origin. The Canary Island case and Hispaniola earthquake case use the same Grid B. The Currituck case uses a different Grid B.

All three cases studied here use the same local Grid C, developed from the CRM for bathymetry and NJ and DE digital elevation grids, and for subaerial topography (References 2.4.6-16 and 2.4.6-23). NJ and DE digital elevation data are extracted from the USGS 30 m DEM data (7.5-minute DEM, horizontal North American datum NAD83, UTM-18N, and vertical datum NAVD 88 [NAVD]).

Conversions are needed to merge the bathymetry data and the topography data in generating the local Grid C, because NOS CRM data uses mean sea level. VDatum, NOAA's vertical datum transformation tool (Reference 2.4.6-14), is used to convert the topography data to mean sea level. In simulations, depth is based on 10 percent exceedance high tide obtained from historical data at NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) Station 8557380 at Lewes, DE, located at the mouth of the Delaware Bay (Reference 2.4.6-12).

Insert "The slide has a maximum along-shelf width of 72,768 ft. (22,180 m) and a cross shelf length of 109,152 ft. (33,270 m), with maximum excavation depth of 2461 ft. (750 m)." per RAI No. 20.

2.4.6.4.4 Model Grids

Areas of grid coverage and spatial resolutio… 2.4.6-3, 2.4.6-4, and 2.4.6-5 and shown in Figures 2.4.6-4, 2.4.6-5, and 2.4.6-6. Numerical simulations are performed for each of the cases using a Manning's *n* value of 0.01, and calculations are repeated with no bottom friction for the Currituck landslide case (Reference 2.4.6-6). Results for water levels are discussed for each case. Model calculations were carried out for varying simulated elapsed times depending on the source location. The Currituck slide tsunami model ran calculations for elapsed times up to 40 hours after the initial tsunami generation event. No evidence was found of significant seiching effects within Delaware Bay after the initial arrival of the tsunami front at the PSEG Site. Results from this simulation are shown in Figure 2.4.6-7.

2.4.6.4.5 Currituck Landslide Results

Parameters used for the Currituck landslide case include a slide volume of 2.16E11 cu. yd. (165 km^3), a depth of middle slide of 5740 ft. (1750 m), and a slope along the failure plane of 2.5 degrees (Reference 2.4.6-21). Initial water surface displacements based on these parameters are generated using formulae and methodology for SMF (References 2.4.6-27 and 2.4.6-28).

Insert "The resulting instantaneous surface displacement used for input to MOST has a maximum elevation of 47.44 ft. (14.46 m) and a maximum surface depression of 79.82 ft. (24.33 m)." per RAI No. 20.

…4.5°W, and oriented … additional events, …ed, in order to … slide event. The …; and 37.2°N, 74.47°W. Numerical experiments with the four landslide locations do not indicate that wave height predictions in Delaware Bay are sensitive to the choice of landslide location, because offshore shelf bathymetry, rather than source location, controls wave height distribution and focusing patterns. Therefore, remaining simulations for this site are performed using the historic landslide location. Further numerical examples also indicate that Delaware Bay wave conditions are not sensitive to the chosen width of the landslide, given a constant total landslide volume.

The tests carried out here were done primarily to address questions on how the shelf geometry controls hydrodynamic behavior of tsunamis associated with slides in the region of the PSEG Site. Although there has been some recent literature suggesting that the region covered by the additional slide locations may be vulnerable to failure (Reference 2.4.6-4), more recent literature (Reference 2.4.6-21) suggests that slides would be less likely at the additional source locations since these locations move out of the vicinity of old river delta deposits.

Model outputs compare time series of surface elevation at Cape May, NJ, and the PSEG Site for the cases with and without bottom friction. Model results indicate that Delaware Bay effectively filters high frequency components of the tsunami signal, leaving only a low frequency response at the PSEG Site. These results occur for each of the cases studied. Low frequency waves propagate up the bay like flood waves in a river, experiencing less damping. Additional model runs using finer spatial grid resolution show a greater penetration of high frequency energy into the upper reaches of the Bay, but do not change the conclusions on the dominance or magnitude of the lower frequency components. Model results using the chosen grid resolution have thus been shown to be appropriate.

Model output indicates that there is a region of high waves in the Delaware Bay entrance extending from Cape May towards the shipping channel in the mid-bay area. This region is in an area of large sandbanks which extends 3.1 mi. in each direction. The high wave energy seen over this area is persistent for all the cases studied, and the high wave energy does not continue into the bay itself. Figures 2.4.6-8, 2.4.6-9, 2.4.6-10, 2.4.6-11, 2.4.6-12, 2.4.6-13, and 2.4.6-14 illustrate model results for the Currituck Landslide through time.

Insert ", with a leading maximum positive elevation wave of height 1640 ft. (500 m) and a following depression wave with trough depth of 2133 ft. (650 m). The N-wave source is centered at 18.2° W and 28.5° N, and is oriented with its principal propagation direction lying along an axis rotated 225 degrees from North. The distance between the maximum elevation and depression in the N-wave is set as 75,590 ft (23 km) , consistent with estimates of the initial tsunami wavelength computed in Reference 2.4.6-5. The width of the wave crest is chosen to be 86,449 ft (26.35 km), consistent with source widths described in References 2.4.6-5 and 2.4.6-7." per RAI No. 20.

2.4.6.4.6 La Palma (Canary Islands) Landslide Results

A simulation of the La Palma event is conducted using an N-wave source. An N-wave represents the geometry of a wave crest in tsunami models (Reference 2.4.6-20). This source is introduced in the model as a static initial condition. The incident wave at Cape May, NJ, is more organized than the wave in the Currituck example. This incident wave represents a wave train that has dispersed from an initial pulse over oceanic distances. The incident wave has a dominant wave period of approximately 25 minutes. This wave is filtered by the lower Delaware Bay, as in the Currituck example. There is a residual low frequency motion at the PSEG Site producing a runup elevation of 0.26 ft., with a leading wave of elevation, or positive surge at the site. The wave heights experienced from this event do not exceed 6.6 ft. in amplitude in the area