Enclosure

SUPPLEMENT TO DOMINION FLOODING HAZARD REEVALUATION REPORT FOR MILLSTONE POWER STATION UNITS 2 AND 3 IN RESPONSE TO 50.54(F) INFORMATION REQUEST REGARDING NEAR-TERM TASK FORCE RECOMMENDATION 2.1: FLOODING

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNITS 2 AND 3

ZACHRY

Zachry Nuclear

ENGINEERING EVALUATION
18-E05

SUPPLEMENT TO DOMINION FLOODING HAZARD REEVALUATION REPORT FOR MILLSTONE POWER STATION UNITS 2 AND 3

IN RESPONSE TO 50.54(F) INFORMATION REQUEST REGARDING NEAR-TERM TASK FORCE RECOMMENDATION 2.1: FLOODING

REVISION 0

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REVISION HISTORY

Revision	Revision Description
0	Original Issue. Bin Wang was responsible for preparing the front matter of the EE, Section 1.0, Sections 3.0 through 5.0 and Section 7.0. Bryan J. Lockett was responsible for preparing Sections 2.0 and 6.0. Stephen F. Superson was the overall responsible reviewer, and in particular co-reviewed the front matter of the EE and Section 2.0 and 6.0. David Leone was responsible for reviewing Section 1.0, Sections 3.0 through 5.0 and Section 7.0. This Engineering Evaluation, while in accordance with Zachry Procedure N0302, Rev. 01, is formatted and presented in such a manner as to be consistent with the expectations of Dominion and the Nuclear Regulatory Commission (NRC). This re-formatting will include header, footer, and page number adjustments that will allow for easy topic recognition while not violating any Zachry branding guidelines. The Engineering Evaluation Verification Form will not be included as an attachment to this document, but will instead be kept in records with this EE, as a separate document. This document replaces in its entirety the Engineering Evaluation previously submitted via Zachry Transmittal 010MPS/112074/D18252.

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ATTACHMENTS

1.0 Purpose

The purpose of this engineering evaluation is to supplement Sections 2 and 3 of the existing Dominion Flood Hazard Re-evaluation Report (FHRR) for Millstone Power Station (MPS) Units 2 and 3 (Zachry Engineering Evaluation 14-E16, 2015a), focusing on additional Probabilistic Storm Surge Analysis (PSSA) at the $1x10^{-4}$ (1E-4) Annual Exceedance Probability (AEP). The 1E-4 PSSA was performed in response to NRC and MPS discussions during review of the FHRR (Zachry 2015a) presenting the 1E-6 PSSA results. During the review of the FHRR (Zachry, 2015a), NRC and MPS agreed to focus on a more frequent AEP to reduce the epistemic uncertainty around the reevaluated flood elevation estimate. The storm surge and combined effects flood analysis presented in this document refines estimates of error and uncertainty around an AEP of 1E-4, which is an AEP used in probabilistic flood analyses by the U.S. Army Corps of Engineers in independent studies of coastal flood risk.

This supplement provides additional information to FHRR Sections 2.4, 2.9, 3.4, 3.9, 4.1 and 4.5 and does not supersede information previously provided in the FHRR.

This document summarizes the results and findings based on the two calculations below:

- Annual Exceedance Probability (AEP) 1.0E-04 for Probabilistic Storm Surge Analysis (PSSA) for Millstone Power Station (Zachry calculation 18-075, 2018a); and
- Combined Effects (CE) Flood Analysis for Storm Surge Annual Exceedance Probability 1E-4 for Millstone Power Station (Zachry calculation 18-110, 2018b).

MPS is located at the shoreline of Long Island Sound with 41.311 degrees (°) North (Latitude) and -72.168° West (Longitude) in Waterford, Connecticut. MPS is subject to coastal storm surge flooding due to its proximity to the Long Island Sound.

Vertical datum: Two vertical datums were used for this report: 1) North American Vertical Datum of 1988 (NAVD88) and 2) Mean Sea Level (MSL), the plant datum. MSL is interchangeable with National Geodetic Vertical Datum of 1929 (NGVD29) (see "Introduction" of Zachry, 2015a), which was not specifically referenced or used in this report. Conversion relationship is defined as (Zachry, 2018b):

Elevation in feet, MSL plant datum = Elevation in feet, NAVD88 + 0.99 foot.

2.0 Site Information Supplemental Information

This section is a supplement to Section 1.3 of the MPS FHRR (Zachry, 2015a). As a result of the Fukushima Daiichi incident, the NRC issued order EA-12-049 which notified existing and future commercial licensees to modify all licenses with regard to requirement for mitigation strategies for beyond-design-basis external events. Specifically, the objective of this order was to ensure licensees provide sufficient mitigating strategies, onsite portable equipment and consumables (FLEX Equipment) to maintain or restore core cooling, containment, and Spent Fuel Pool (SFP) cooling capabilities until resources can be brought from off site to sustain these functions indefinitely.

Subsequent to issuing the Dominion Flooding Hazard Reevaluation Report for Millstone Power Station Units 2 and 3 (Engineering Evaluation 14-E16R1), Millstone constructed a Type I, Beyond Design Basis (BDB) Storage Building to store the FLEX Equipment. The BDB Storage Building is designed as a seismic, tornado-missile protected structure with missile-protected door construction. The purpose of the BDB Storage Building is to protect the onsite portable equipment used to maintain or restore key safety functions for the Unit 2 and Unit 3 reactors from applicable site-specific external events and provide reasonable assurance that the equipment will remain deployable following such an event.

Millstone has developed station documents which describe and document the Beyond Design Basis mitigating strategies, procedures, guidance, training, staging, or equipment installation needed for the strategies. These have been developed in accordance with NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) implementation Guide" to ensure the plant's ability to cope with an extended loss of alternating current (AC) power (ELAP) concurrent with a loss of normal access to the ultimate heat sink (LUHS). Implementing procedures provide guidance to station personnel for the preparation, response and recovery from significant storms and other hazardous phenomena to maintain operation of the Station, maintain a safe condition for personnel, prompt transition to high priority actions, prevent or mitigate damage and achieve restoration of the site as quickly as possible, and support employee and community restoration effort which include utilization of FLEX Equipment.

3.0 Storm Surge Stillwater Elevation at AEP of 1E-4 for MPS

This section is a supplement to Section 2.4 of the MPS FHRR (Zachry, 2015a). This PSSA calculated a mean stillwater elevation and confidence intervals associated with an AEP of 1E-4 in the nearshore area around MPS (Zachry, 2018a). Please note that the methodology used for the development of the 1E-4 stillwater in this calculation is specific to this AEP level. To develop mean stillwater levels for other AEP values (i.e., recurrence intervals such as 1E-5 or 1E-3), additional sensitivity tests on key input parameters (such as probability functions and/or logic tree branch weighting factors) will be needed.

3.1 Methodology

The 1E-4 PSSA calculation (Zachry, 2018a) followed the framework of the Joint Probability Method (JPM) for calculating tropical cyclone-induced storm surge flood frequency curves. The JPM was combined with Optimal Sampling (OS) technique with Response Surface (RS) method, as used by previous federal coastal flood evaluation projects such as the Federal Emergency Management Agency (FEMA) risk mapping project for parts of New York and New Jersey (FEMA, 2014) and the post-Sandy North Atlantic Coast Comprehensive Study (NACCS) performed by the U.S. Army Corps of Engineers (USACE, 2015).

The 1E-4 PSSA adopted a logic tree approach with a total of 96 branches or paths (Figure 1 and Table 1) to evaluate potential variability and epistemic uncertainty of the final flood frequency curve. Nodes on the logic tree define the input parameters such that each path results in a distinctive stillwater flood frequency curve. The weighting factors (Figure 1) represent the final selected weighting scheme, mainly based on sensitivity test results and engineering judgment. The final weight assigned for each flood frequency curve was computed as the product of all the connecting nodal weighting factors along each path. A weighted average flood frequency curve was calculated with confidence intervals (see Section 3.1 of Zachry, 2018a for more details).

Steps to calculate the mean 1E-4 storm surge stillwater elevation at MPS include:

- Compile two sources of storm surge numerical modeling data: (1) JPM-OS set simulated for the PMSS calculation (Zachry, 2015b) using the MPS site-specific Advanced Circulation (ADCIRC) model; and (2) NACCS modeling results of 1,050 tropical cyclone tracks (USACE, 2015). The model grid used by USACE is large, covering the Atlantic coast from Virginia to Maine and the large number of the synthetic hurricanes modeled with ADCIRC and STWAVE (Steady-State Spectral Wave Model) coupled provide a valuable addition to the simulated results generated by the site-specific model (Zachry, 2015a and Zachry 2015b)

- Compile source hurricane tracks and develop probability distribution functions for hurricane parameters (i.e., intensity metric including maximum wind speed (Vm) in knots and central pressure deficit (CPD) in millibars (mb), heading (Fdir) in degrees (°), forward speed (Fspd) in knots or kilometers per hour (km/hr), and radius of maximum winds (RMW) in nautical miles (nm) or kilometers (km)) based on two separate data sources:
  - Synthetic hurricane tracks generated by WindRiskTech (WRT), which was used to develop the MPS PMH and PMSS calculations (Zachry, 2014; Zachry, 2015b) and summarized in the original MPS FHRR (Zachry, 2015a); and
  - Historical hurricane tracks based on National Oceanic and Atmospheric Administration (NOAA) Reanalysis database, HURDAT and Extended Best Track Data (EBTD) (see Sections 6.5.2 and 6.5.3 of Zachry, 2018a for more details).

- Compute storm recurrence rates with upper and lower bounds for both WRT and historical hurricane datasets;

- Develop discrete probability values for the hurricane parameters at specified intervals;

- Assemble two JPM sets of synthetic hurricanes: (a) full JPM set using the MPS site-specific model results; and (b) full JPM set using the NACCS model results. Each synthetic hurricane has a distinctive probability value that includes the parameter combination, storm recurrence rate, landfall rate and tidal conditions.

- Perform the JPM-OS-RS calculation to interpolate and/or extrapolate the simulated storm surge response to the full parameter space as specified by the full JPM sets (MPS-based and NACCS-based sets), using the storm surge response factors developed using the MPS model results.

- Develop error and uncertainty parameters based on tidal conditions, modeling error, hurricane intensity variability and/or correction factors, which were based on sensitivity analysis results and engineering judgment and are applicable to the AEP of 1E-4 specifically;

- Calculate each flood frequency curve with error and uncertainty incorporated;

- Calculate the weighted mean flood frequency curve and confidence intervals based on the logic tree branch weights (using the selected weighting scheme);

- Calculate a separate extratropical flood frequency curve with confidence intervals based on water levels at Save Point 756 from 100 simulated historical extratropical cyclones

(USACE, 2015; see Figure 6 of Zachry, 2018a for location of Save Point 756, which is just south of Millstone Point); and

- Combine the tropical and extratropical flood frequency curves.

Note that the selection of hurricane parameter probability distributions and error/uncertainty parameters was specifically intended to develop a mean stillwater elevation at AEP of 1E-4. The curves shown in this document are not intended to be extrapolated beyond the vicinity of AEP of 1E-4.

3.2 Results

MPS modeling results from the JPM-OS set (Zachry, 2015b), which consists of a total of 71 synthetic storm tracks, were used for calculating storm surge values of the full MPS model-based JPM set. The output node is located at a nearshore point location between the Unit 2 and Unit 3 Intake Structures (see Figure 1 of Zachry, 2018a). The NACCS modeling results of 1,050 synthetic tropical cyclones were extracted at Save Point 756, which is located south of the plant, in the Long Island Sound (see Figure 6 of Zachry, 2018a; USACE, 2015). Branches 1 through 60 use the MPS model results and Branches 61 through 96 use the NACCS model results (Figure 1 and Table 1).

Hurricane Data Sources

Input for the WRT-based logic tree branches (Branches 1 through 4, 11 through 14, 21 through 24, 31 through 34, 41 through 44, and 51 through 54) was based on the Probable Maximum Hurricane (PMH) calculation using the WRT synthetic hurricane tracks (see Section 6.3.1 of Zachry, 2018a; Zachry, 2014; Zachry, 2015a). The data was spatially filtered to a 200-kilometer circular (offshore) zone centered at point location 40.825°N (Latitude) and 72.66°W (Longitude) near Hampton, New York (southeastern shore of Long Island) (Zachry, 2014; Zachry, 2015a).

Input for the historical data-based logic tree branches (Branches 5 through 10, 15 through 20, 25 through 30, 35 through 40, 45 through 50, 55 through 60, and 61 through 96) was developed based on the HURDAT data filtered by a 300-kilometer circular zone centered at MPS. HURDAT data was filtered to the time period between 1938 and 2016. The EBTD data was filtered to data points east of Longitude -82° to remove the data within the Gulf of Mexico. The period of record for the EBTD data is from 1988 to 2016 (Section 6.3 of Zachry, 2018a).

Storm Recurrence Rate

The MPS model-based (i.e., node i1) branches (1 through 60) use the WRT storm recurrence rate of 5.1E-4 storms per year per kilometer (storm/yr/km) or 9.4E-4 storms per year per nm, with upper and lower bound values of 7.1E-4 and 3.1E-4 storm/yr/km. The NACCS model-based (node i2) branches (61 through 96) use the historical hurricane storm recurrence rate of 4.3E-4 storms per year per kilometer (storm/yr/km), with upper and lower bound values of 6.3E-4 and 2.3E-4 storm/yr/km (See Section 6.4 of Zachry, 2018a).

Probability Distributions

The WRT-based branches use the non-parametric distributions developed in the PMH calculation (Zachry, 2014, FHRR Section 2.4 of Zachry, 2015a and Zachry, 2015b) assuming parameter independence and the 3-million (3M) vector set to calculate JPM parameter combination probabilities assuming complete dependence between the four parameters, Vm, Fdir, Fspd and RMW.

The historical data-based branches use the univariate probability distribution for each hurricane parameter. For Fdir and intensity parameters (Vm and CPD), multiple distributions were used to evaluate potential variability. For Fpsd, only one distribution Nakagami was selected, which appeared to be the best fit of the source data. RMW distributions were developed based on its dependence on the intensity parameter (Vm for i1-related paths or CPD for i2-related paths). The logic tree used both heading-independent and heading-dependent paths to assess the variability of this assumption. Source historical data was separated based on the heading parameter, Fdir, into two categories: 1) westerly tracks, west of -10° (i.e, 10° west of north) and 2) north/northeasterly tracks (i.e., east of -10°).

JPM-OS-RS Calculation

The full JPM sets for the MPS model and the NACCS model (Section 6.6 of Zachry, 2018a) were assembled based on the parameter intervals presented below.

MPS Site-specific Model-based Branches (1 through 60) used 5 landfall locations, 11 headings, 12 forward speeds, 11 maximum wind speeds and 17 radii of maximum winds, which resulted in a total number of 123,420 JPM storms, calculated as:

5 (LF) x 11 (Fdir) x 12 (Fspd) x 11 (Vm) x 17 (RMW) = 123,420.

NACCS Model-based Branches (Nos. 61 through 96) used 130 NACCS master tracks (which cover 6 different headings), 10 forward speeds, 16 central pressure deficit values and 17 radii of maximum winds, which resulted in a total number of 353,600 JPM storms, calculated as:

130 (tracks) x 10 (Fspd) x 16 (CPD) x 17 (RMW) = 353,600.

A distinct AEP value was calculated for each individual JPM synthetic track based on the storm recurrence rate, landfall probability, storm parameter combination and tidal condition.

The RS method was used to interpolate and/or extrapolate modeled surge response for any storm parameter combination in the full JPM set. For the MPS-based logic tree branches, the 71 MPS ADCIRC model simulated OS storms were used to derive the surge response factors along each parameter space (Vm, Fspd, and RMW). For the NACCS-based logic tree branches, the surge response factors were also derived for CDP, Fspd and RMW (with units consistent with the NACCS synthetic tropical cyclone tracks) based on the 71 MPS ADCIRC simulations. A test flood frequency curve was developed, which was similar to the published NACCS AEP curves at Save Point 756. This comparison indicates the approach of using NACCS model results combined with MPS model surge response factors is reasonable (see Section 6.6 of Zachry, 2018a).

Error and Uncertainty Estimates

Ten MPS model-based and 6 NACCS model-based flood frequency curves were calculated without error and uncertainty. Error and uncertainty parameters were developed for each path and incorporated into the frequency curves using FEMA's "surge_stat" program, which uses two terms (a constant "a" parameter and a proportional "b" parameter) (Section 6.7 of Zachry, 2018a).

To include potential variability due to linearly regression of a slightly non-linear behavior of the surge error function, a "b"-vector was also adopted for this analysis to fit the underlying data with a fourth order polynomial function. Attachment B (Tables) of Zachry, 2018a provides the summary of the "a" and "b" values (or vectors) required by "surge_stat". Different tidal scenarios were incorporated as a different error term in each branch. Storm recurrence rates were applied as constants to adjust the AEP values of each calculated JPM curve.

Combined Tropical and Extratropical Curve

The overall storm surge flood frequency curve resulted in a stillwater level at 1E-4 AEP of 16.1 feet, MSL at a nearshore point location between the MPS Unit 2 and 3 intake structures (Figure 3), with no projected sea level rise included. The final mean storm surge elevation at AEP of 1E-4 was 16.6 feet, MSL, which includes 0.45 foot to account for a 50-year, linear-extrapolated sea level rise at MPS (Figure 2, which also illustrates confidence levels). Please refer to Figures 60 through 63 of the 1E-4 PSSA calculation (Zachry, 2018a).

4.0 Combined Effects Flood Analysis for Stillwater at AEP of 1E-4

This section is a supplement to Section 2.9 of the original MPS FHRR (Zachry, 2015a)

4.1 Methodology

MPS Unit 2 and Unit 3 intake structures are located at the site's western shoreline. Foundation walls of the intakes are partially submerged under normal daily tides. Unit 2 Turbine Building has a typical site grade of 14 feet, MSL and is at a minimum distance of approximately 200 feet from the shoreline. Unit 3 Turbine Building has a typical site grade of 24 feet, MSL and is at a minimum distance of approximately 400 feet from the shoreline.

During a typical tropical cyclone surge event, MPS is likely to experience southernly onshore winds for an extended period of time. The wind and pressure differential from the storm system can bring significant storm surge above astronomical tides and wind-generated waves in the Long Island Sound. The stillwater level near the shoreline will likely consist of astronomical tides, storm surge, and wave setup. Deep water waves are likely to break at the shoreline (e.g., the bulkhead along MPS or shallow rock outcrops). Deep water waves will be reflected by vertical surfaces and cause wave runup, such as along the exterior walls of the Unit 2 and Unit 3 Intake Structures. When the foreshore of the site is inundated, shallow water waves will propagate towards Unit 2 Turbine Building and could cause potential wave overtopping of the concrete flood wall protecting the western side of the Unit 2 Turbine Building. The combination of wave direction and dissipation of wave energy due to the various non-safety related buildings indicate that wave effects are negligible in the Unit 2 main site / power block area, including the eastern wall of the Unit 2 Turbine Building. Therefore, wave effects were calculated on the western side only for Unit 2 Turbine Building.

The combined effects flood calculation (Zachry, 2018b) used a deterministic approach to calculate wave runup, total water level, overtopping and flood loads associated with the 1E-4 stillwater elevation at MPS (Section 3.0 of this document). Steps to develop the combined effects flood elevations, overtopping flow, and hydrostatic, hydrodynamic and debris impact loads include:

- Evaluate hurricane parameters that are representative for a tropical cyclone to induce a stillwater flood elevation consistent with the mean 1E-4 flood (i.e., stillwater elevation of

16.6 feet, MSL, including sea level rise, in the nearshore area between Unit 2 and 3 intake structures) (Figure 3; Figure 1 of Zachry, 2018a);

- Develop a set of synthetic storms for hydrodynamic and wave numerical model simulation with storm parameter combinations that are representative for the AEP of 1E-4 and will likely generate storm surge elevations in the vicinity of the 1E-4 stillwater elevation determined in the PSSA calculation (Zachry, 2018a) ;
- Perform hydrodynamic and wave numerical modeling and extract results to determine the storm surge response and coincident wave activity around the 1E-4 stillwater elevation;
- Identify the storm that is most representative of the storm conditions that will likely produce the 1E-4 stillwater elevation at MPS;
- Calculate total water levels at Unit 2 and Unit 3 intake structures including wave runup; calculate total water level at Units 2 and 3 Turbine Buildings including wave runup;
- Calculate wave overtopping at the Unit 2 Turbine Building flood wall based on modeled water level and wave time series (assuming failure of the existing wall panels);
- Calculate maximum flood loads against Units 2 and 3 Intakes and Unit 2 Turbine Building.

The European Overtopping Manual (EurOtop, 2016) was used for calculating wave runup, total water levels (i.e., the calculated flood level in the existing FHRR, Zachry, 2015a) and overtopping rate and volume to the Unit 2 Turbine Building. Additional reference documents were used for calculating flood loads, debris impact load and standing wave loads (ASCE, 2010; FEMA, 2011; FEMA, 2012).

4.2 Results

The MPS model-based JPM set (with 123,420 synthetic storm tracks) was used to evaluate "average" hurricane parameters that are representative of the stillwater at AEP of 1E-4. Branches 25 and 26 from the logic tree were used. Branch 25 is a representative branch for heading-intensity independent scenarios; Branch 26 is a representative branch for heading-intensity dependent scenarios. Both branches are based on historical hurricane data. A set of parameter combinations was compiled for numerical modeling, informed by the calculated average 1E-4 storm parameters. The calculation used a coupled ADCIRC+SWAN (Simulating WAves Nearshore) model to perform a total of 10 synthetic simulations, as presented in Table 2, which were named as "CE" storms. Figure 3 presents the model grid around Unit 2 and Unit 3. Figure 4 presents the modeled synthetic storm tracks on an area map. The simulated peak stillwater elevations, maximum significant wave height, and time series of stillwater, current, wave characteristics, and wind speed were examined to identify CE-2, with a heading of -20°, Vm of 110 knots, Fspd of 15 knots, and RMW of 30 nm, as a representative storm for evaluating combined effects associated with the stillwater level at AEP of 1E-4 at MPS (Section 3.1 of Zachry, 2018b; Attachment D.2 of Zachry, 2018b). The slightly westerly heading of CE2 generates peak wind-wave actions coincident with peak storm surge, due to the hydrological setting of the site location in the Long Island Sound. The simulated stillwater elevation in the Long Island Sound, between the Units 2 and 3 Intake Structures, is 16.7 feet, MSL, which is consistent with the calculated mean stillwater of 16.6 feet, MSL at AEP of 1E-4 (Zachry, 2018a).

Figure 5 presents three time series (i.e., stillwater, significant wave height, current velocity) at three representative locations around Units 2 and 3 Intake Structures and Unit 2 Turbine Building. Figure 6 presents a snap shot of the stillwater elevation around the power block and intake structures approximately at the time of peak storm surge at MPS due to CE-2. Figure 7 presents the wave height and direction at the time of peak wave height around MPS. The Combined Effects calculation (Attachment C of Zachry, 2018b) provides additional snap shots and time series.

Stillwater elevations, current velocities, calculated wave runups and total water levels from the CE2 simulation are summarized at selected locations around MPS in Table 3. Total water levels were calculated as the sum of stillwater (including wave setup) and wave runup. Wave runup (exceeded by 2 percent of the incoming waves) for Unit 3 Turbine Building was estimated using an iterative method along a selected transect (red line in Figure 8; calculation presented in Attachment E of Zachry, 2018b). For other locations, wave runup (exceeded by 2 percent of the incoming waves) was estimated proportionally with a constant factor of 1.93 using significant deep water wave height (EurOtop, 2016).

Total water levels at the west side of Unit 2 and Unit 3 Turbine Buildings are 19.8 feet, MSL and 22.2 feet, MSL, respectively. Total water levels at the south side of Units 2 and 3 Intakes are up to 37.2 feet, MSL and 42.6 feet, MSL, respectively. Stillwater levels elsewhere in the Unit 2 main site / power block area are approximately the same as the west side, based on the modeling results. Therefore, the stillwater level value reported for the west side of the Unit 2 Turbine Building is also applicable to the Unit 2 main site / power block area.

The Unit 2 Turbine Building has an internal flood wall with a top elevation of 22 feet, MSL and siding panels above the wall that, if in place, would protect the interior of Unit 2 Turbine Building from flooding. Assuming the siding is not present (e.g., due to wind or other effects), wave overtopping of the flood wall due to intermittent wave splashing on the west wall of Unit 2 Turbine Building was estimated using the method outlined in the EurOtop Manual (EurOtop, 2016) and adopting a 3-stage approach based on wave crest and stillwater elevations. The three consecutive stages (e.g., periods of time) are (1) prior to foreshore inundation; (2) during foreshore inundation; and (3) post-inundation (see Section 2.7 of Zachry, 2018b). The overtopping analysis was performed along a selected transect (green line in Figure 8 of Attachment B; calculation presented in Attachment G of Zachry, 2018b). The calculated cumulative overtopping volume during Stages 1 and 3 was 1,324 gallons and 2,655 gallons, respectively. The calculated overtopping volume during Stage 2 was estimated to be 22 gallons (with obliquity) or 4,862 gallons (without obliquity). Therefore, the total overtopping volume is approximately 4,000 gallons inside the Unit 2 Turbine Building, with obliquity effects included. The total overtopping volume is approximately 8,840 gallons inside Unit 2 Turbine Building, with obliquity effects conservatively ignored.

Hydrostatic, hydrodynamic, debris impact and standing wave loads were individually calculated. The maximum hydrostatic pressure was calculated to be 3,002 and 3,014 pounds-per-square-foot (psf) for the south sides of the Unit 2 Intake Structure and the east sides of the Unit 3 Intake Structure, respectively. The maximum hydrostatic pressure was calculated to be 224 psf for the west side of Unit 2 Turbine Building. The maximum hydrodynamic pressure against the Unit 2 Intake Structure was calculated as 34 psf at the west side and 59 psf at the south side. The maximum hydrodynamic pressure against the Unit 3 Intake Structure was calculated as 5.0 psf at the south side and 32 psf at the east side. The maximum hydrodynamic pressure against the Unit 2 Turbine Building was calculated as 224 psf.

Two types of objects were used: a 2,000-pound (lbs) log or a 5,291-lbs container for evaluating debris impact, based on current velocity. Debris impact loads were calculated to be 13,800 lbs or 36,508 lbs on the south side of Unit 2 Intake, due to a log or a container, respectively. Debris impact loads were calculated to be 10,200 lbs or 26,984 lbs on the east side of Unit 3 Intake, due to a log or a container, respectively.

Standing (non-breaking) wave loads were calculated for Units 2 and 3 Intake Structures using both significant wave height and maximum wave height. Tables 4 and 5 summarize the different types of loads at various structures at MPS, based on significant wave height and maximum wave height, respectively.

Duration of significant flooding (including stillwater and wave runup) around the intake structures and Unit 2 Turbine Building was estimated to be up to 4.5 to 5 hours. Duration of significant wave overtopping at Unit 2 Turbine Building flood wall was estimated to last approximately 7 to 8 hours in total.

4.3 Conclusions

The overall storm surge flood frequency curve resulted in a stillwater level at 1E-4 AEP of 16.1 feet, MSL at a nearshore point location between MPS Unit 2 and 3 intake structures, with no projected sea level rise included. The final mean storm surge elevation at AEP of 1E-4 was 16.6 feet, MSL, which includes 0.45 foot to account for a 50-year, linear-extrapolated sea level rise at MPS (Figure 2, which also illustrates confidence levels).

Calculated combined effects results are summarized in Tables 3 through 5 of this document (see Section 5.0 and Tables 6 through 10 of Zachry, 2018b). The combined effects flood stillwater elevations (including wave setup) range from 16.8 to 17.1 feet around Unit 2 and Unit 3 Intake Structures and from 17.5 to 17.7 feet MSL around Unit 2 and Unit 3 Turbine Buildings. Wave runup heights range from 2.3 to 4.5 feet on the west side of the Unit 2 and 3 Turbine Buildings to more than 20 feet around the Unit 2 and 3 Intake Structures. Except for the west side of the Unit 2 Turbine Building, wave effects were judged to be negligible within the Unit 2 main site / power block area due to the distance from the shoreline and the presence and density of buildings and structures. The stillwater level value reported for the west side of the Unit 2 Turbine Building is applicable to the Unit 2 main site / power block area.

Unit 2 Turbine Building overtopping volume can reach up to 1.4 and 3.2 percent of the available storage (i.e., 280,000 gallons) inside the building, with and without obliquity considered, respectively. The Unit 3 total water level, 22.2 feet MSL, is lower than the Unit 3 average site grade of 24 feet, MSL. Therefore, the total water level only reaches the foreshore approaching the Unit 3 Turbine Building and does not impact the Unit 3 Turbine Building or any other buildings in the Unit 3 main site / power block.

5.0 Comparison of Current Design Basis and Reevaluated Flood Causing Mechanisms

This section supplements Section 3.4 (Storm Surge) and 3.9 (Combined Effect Flood) of the MPS FHRR (Zachry, 2015a). It also supplements Tables 3.0-1 and 3.0-2 of MPS FHRR (Zachry, 2015a) with the 1E-4 PSSA results (see Tables 6 and 7, Attachment A of this document). Please refer to the MPS FHRR (Zachry, 2015a) for more detailed discussion of MPS current design basis for flooding.

5.1 Storm Surge

The 1E-4 PSSA (Zachry, 2018a) calculated the mean 1E-4 stillwater elevation of 16.6 feet MSL at a nearshore location around MPS (Figure 3), which is applicable to both Units 2 and 3. The MPS FHRR (Zachry, 2015a) summarizes the current design basis elevation for storm surge stillwater as 18.2 feet MSL at MPS Unit 2 and at 19.7 feet MSL at MPS Unit 3. The mean 1E-4 stillwater elevation is, therefore, bounded by the current design basis at MPS Units 2 and 3.

5.2 Combined Effects Flooding

The synthetic storm track CE2 produced a stillwater elevation of 16.7 feet MSL in the nearshore area (Table 3; Figures 5 and 6). Stillwater elevations including wave setup varies spatially. The simulated stillwater elevations varied between 16.8 and 17.1 feet MSL around the Intake Structures (Table 3; Figures 5 and 6). The simulated stillwater elevations caused by CE2 were 17.5 feet MSL and 17.7 feet MSL at the Unit 2 Turbine Building and at the Unit 3 foreshore approaching the Unit 3 Turbine Building, respectively (Table 3; Figures 5 and 6).

The 1E-4 Combined Effects calculation (Zachry, 2018b) calculated the mean 1E-4 combined effect elevation (i.e., total water level, also referred to as "reevaluated flood level" in the MPS FHRR, which is stillwater level and wave effects combined) for the storm surge to be:

- 19.8 feet, MSL at the west side of Unit 2 Turbine Building (Table 3);
- 37.2 feet, MSL at the south side of Unit 2 Intake Structure (Table 3);
- 22.2 feet, MSL at the foreshore approaching the Unit 3 Turbine Building (Table 3);
- 42.6 feet, MSL at the south side of Unit 3 Intake Structure (Table 3).
- Except for the west side of the Unit 2 Turbine Building, wave effects were judged to be negligible within the Unit 2 main site / power block area due to the distance from the shoreline and the presence and density of buildings and structures.

The MPS FHRR (Zachry, 2015a) summarizes the current design basis elevation for MPS Unit 2 combined effect flooding (total water level) as:

- 25.1 feet at the MPS Unit 2 Turbine Building and other MPS Unit 2 buildings (Section 3.9 of Zachry, 2015a);
- 42.5 feet at the vertical wall of the Intake Structure (Section 3.9 of Zachry, 2015a).

The MPS FHRR (Zachry, 2015a) summarizes the current design basis elevation for MPS Unit 3 combined effects flooding (total water level) as:

- 23.8 feet at the MPS Unit 3 buildings (not including intake structure) (Section 3.9 of Zachry, 2015a);
- 41.2 feet at the vertical wall of the Intake Structure (Section 3.9 of Zachry, 2015a).

The 1E-4 combined effects flood elevations are, therefore, bounded by the current design basis at MPS Units 2 and 3, with the exception of the MPS Unit 3 Intake Structure. The MP3 Intake Structure would still have an available physical margin of 0.8 feet to the unsealed cable penetrations. Internal water levels within the intake structures are analyzed in NAI Calculation NAI-1996-001, Rev. 1 (MP2) and NAI Report NAI-1996-002, Rev. 1 (MP3) (Zachry 2018c and 2018d).

The overall conclusions reported in the FHRR regarding flood-related loading and debris impact forces for the 1E-4 AEP remain unchanged (Zachry, 2015a).

6.0 Supplement to Interim Evaluations and Actions

6.1 Combined Effects Flooding Supplemental Information

This section is a supplement to Section 4.1 of the MPS FHRR (Zachry, 2015a).

Based on the AEP of 1E-04, the Combined Effects Flooding analysis produced stillwater elevations of 17.5 feet, MSL and 17.7 feet, MSL for MPS Unit 2 and Unit 3, respectively. The calculated 1E-4 stillwater elevations are below the current licensing basis stillwater elevations, which are 18.1 feet, MSL and 19.7 feet, MSL for MPS Unit 2 and Unit 3, respectively. The 1E-4 combined effects flood elevations are, therefore, bounded by the current design basis at MPS Units 2 and 3, with the exception of the MPS Unit 3 Intake Structure. However, the 1E-4 stillwater elevations are below the current flood protection levels, including at the MPS Unit 3 Intake Structure.

The equipment and planned actions for Millstone site to address combined effects flooding are contained in Design Change MPG-13-00010, Rev. 1 (Dominion, 2014) and the Engineering Technical Evaluations ETE-CPR-2012-0008/9 for Millstone Unit 3 and 2 respectively (Dominion, 2018a and 2018b). These were updated as part of the implementation of the FLEX strategies to respond to a loss of ultimate heat sink (UHS) event for Beyond Design Basis flooding.

The MP2 and MP3 Intake Structures were re-analyzed in Zachry, 2018c and 2018d respectively, for 1.0E-04 Annual Exceedance Probability (AEP) results and no changes were required to the existing designs.

6.2 Conclusion Supplemental Information

This section is a supplement to Section 4.5 of the MPS FHRR (Zachry, 2015a).

The impact from combined effects flooding at an AEP of 1.0E-04 are within the current licensing basis designs and / or mitigation strategies developed as part of the FLEX strategies therefore no supplemental changes to the original FHRR are noted.

For Sections 4.2 and 4.3 of the original FHRR (Zachry, 2015a), the site procedures, Dominion, 2017a, 2018c, and 2018d were updated to implement station flood protection features based on notifications of an imminent LIP event or tsunami (tsunami warning from NOAA's/NWS National Tsunami Warning Center) and to initiate required actions.

7.0 References

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Zachry, 2018d. NAI Report NAI-1996-002, Revision 1, MP3 Intake Structure Service Water Pump Room Available Physical Margin during Beyond Design Basis Inundation, Numerical Applications, Inc., 2018.

Attachment A

Tables

Note: Tables presented in Attachment A are from Zachry Calculations 2018a and 2018b.

Table 1: Logic Tree Branches Defined by Node Identifiers

Path ID	Surge Interpolation	SRR	Antecedent Water Level	Heading	Forward Speed	Dependent or Independent	Intensity	Radius of Maximum Winds	Error and Uncertainty
	(I)	(R)	(T)	(H)	(F)	(D)	(VP)	(W)	(E)
1	i1	r1	t1	h1	f1	d1	vp1	vp1	e1
2	i1	r1	t1	h1	f1	d1	vp1	vp1	e2
3	i1	r1	t1	h1	f1	d2	vp2	vp2	e1
4	i1	r1	t1	h1	f1	d2	vp2	vp2	e2
5	i1	r1	t1	h2	f2	d3	vp3	vp3	e3
6	i1	r1	t1	h2	f2	d4	vp4	vp4	e3
7	i1	r1	t1	h2	f2	d4	vp5	vp5	e3
8	i1	r1	t1	h3	f2	d3	vp3	vp3	e3
9	i1	r1	t1	h3	f2	d4	vp4	vp4	e3
10	i1	r1	t1	h3	f2	d4	vp5	vp5	e3
11	i1	r1	t2	h1	f1	d1	vp1	vp1	e1
12	i1	r1	t2	h1	f1	d1	vp1	vp1	e2
13	i1	r1	t2	h1	f1	d2	vp2	vp2	e1
14	i1	r1	t2	h1	f1	d2	vp2	vp2	e2
15	i1	r1	t2	h2	f2	d3	vp3	vp3	e3
16	i1	r1	t2	h2	f2	d4	vp4	vp4	e3
17	i1	r1	t2	h2	f2	d4	vp5	vp5	e3
18	i1	r1	t2	h3	f2	d3	vp3	vp3	e3
19	i1	r1	t2	h3	f2	d4	vp4	vp4	e3
20	i1	r1	t2	h3	f2	d4	vp5	vp5	e3
21	i1	r2	t1	h1	f1	d1	vp1	vp1	e1
22	i1	r2	t1	h1	f1	d1	vp1	vp1	e2
23	i1	r2	t1	h1	f1	d2	vp2	vp2	e1
24	i1	r2	t1	h1	f1	d2	vp2	vp2	e2
25	i1	r2	t1	h2	f2	d3	vp3	vp3	e3
26	i1	r2	t1	h2	f2	d4	vp4	vp4	e3
27	i1	r2	t1	h2	f2	d4	vp5	vp5	e3
28	i1	r2	t1	h3	f2	d3	vp3	vp3	e3
29	i1	r2	t1	h3	f2	d4	vp4	vp4	e3
30	i1	r2	t1	h3	f2	d4	vp5	vp5	e3
31	i1	r2	t2	h1	f1	d1	vp1	vp1	e1
32	i1	r2	t2	h1	f1	d1	vp1	vp1	e2
33	i1	r2	t2	h1	f1	d2	vp2	vp2	e1
34	i1	r2	t2	h1	f1	d2	vp2	vp2	e2
35	i1	r2	t2	h2	f2	d3	vp3	vp3	e3
36	i1	r2	t2	h2	f2	d4	vp4	vp4	e3
37	i1	r2	t2	h2	f2	d4	vp5	vp5	e3
38	i1	r2	t2	h3	f2	d3	vp3	vp3	e3
39	i1	r2	t2	h3	f2	d4	vp4	vp4	e3
40	i1	r2	t2	h3	f2	d4	vp5	vp5	e3
41	i1	r3	t1	h1	f1	d1	vp1	vp1	e1
42	i1	r3	t1	h1	f1	d1	vp1	vp1	e2

Path ID	Surge Interpolation	SRR	Antecedent Water Level	Heading	Forward Speed	Dependent or Independent	Intensity	Radius of Maximum Winds	Error and Uncertainty
	(I)	(R)	(T)	(H)	(F)	(D)	(VP)	(W)	(E)
43	i1	r3	t1	h1	f1	d2	vp2	vp2	e1
44	i1	r3	t1	h1	f1	d2	vp2	vp2	e2
45	i1	r3	t1	h2	f2	d3	vp3	vp3	e3
46	i1	r3	t1	h2	f2	d4	vp4	vp4	e3
47	i1	r3	t1	h2	f2	d4	vp5	vp5	e3
48	i1	r3	t1	h3	f2	d3	vp3	vp3	e3
49	i1	r3	t1	h3	f2	d4	vp4	vp4	e3
50	i1	r3	t1	h3	f2	d4	vp5	vp5	e3
51	i1	r3	t2	h1	f1	d1	vp1	vp1	e1
52	i1	r3	t2	h1	f1	d1	vp1	vp1	e2
53	i1	r3	t2	h1	f1	d2	vp2	vp2	e1
54	i1	r3	t2	h1	f1	d2	vp2	vp2	e2
55	i1	r3	t2	h2	f2	d3	vp3	vp3	e3
56	i1	r3	t2	h2	f2	d4	vp4	vp4	e3
57	i1	r3	t2	h2	f2	d4	vp5	vp5	e3
58	i1	r3	t2	h3	f2	d3	vp3	vp3	e3
59	i1	r3	t2	h3	f2	d4	vp4	vp4	e3
60	i1	r3	t2	h3	f2	d4	vp5	vp5	e3
61	i2	r4	t1	h4	f3	d5	vp6	vp6	e4
62	i2	r4	t1	h4	f3	d6	vp7	vp7	e4
63	i2	r4	t1	h4	f3	d6	vp8	vp8	e4
64	i2	r4	t1	h5	f3	d5	vp6	vp6	e4
65	i2	r4	t1	h5	f3	d6	vp7	vp7	e4
66	i2	r4	t1	h5	f3	d6	vp8	vp8	e4
67	i2	r4	t2	h4	f3	d5	vp6	vp6	e4
68	i2	r4	t2	h4	f3	d6	vp7	vp7	e4
69	i2	r4	t2	h4	f3	d6	vp8	vp8	e4
70	i2	r4	t2	h5	f3	d5	vp6	vp6	e4
71	i2	r4	t2	h5	f3	d6	vp7	vp7	e4
72	i2	r4	t2	h5	f3	d6	vp8	vp8	e4
73	i2	r5	t1	h4	f3	d5	vp6	vp6	e4
74	i2	r5	t1	h4	f3	d6	vp7	vp7	e4
75	i2	r5	t1	h4	f3	d6	vp8	vp8	e4
76	i2	r5	t1	h5	f3	d5	vp6	vp6	e4
77	i2	r5	t1	h5	f3	d6	vp7	vp7	e4
78	i2	r5	t1	h5	f3	d6	vp8	vp8	e4
79	i2	r5	t2	h4	f3	d5	vp6	vp6	e4
80	i2	r5	t2	h4	f3	d6	vp7	vp7	e4
81	i2	r5	t2	h4	f3	d6	vp8	vp8	e4
82	i2	r5	t2	h5	f3	d5	vp6	vp6	e4
83	i2	r5	t2	h5	f3	d6	vp7	vp7	e4
84	i2	r5	t2	h5	f3	d6	vp8	vp8	e4
85	i2	r6	t1	h4	f3	d5	vp6	vp6	e4
86	i2	r6	t1	h4	f3	d6	vp7	vp7	e4

Path ID	Surge Interpolation	SRR	Antecedent Water Level	Heading	Forward Speed	Dependent or Independent	Intensity	Radius of Maximum Winds	Error and Uncertainty
	(I)	(R)	(T)	(H)	(F)	(D)	(VP)	(W)	(E)
87	i2	r6	t1	h4	f3	d6	vp8	vp8	e4
88	i2	r6	t1	h5	f3	d5	vp6	vp6	e4
89	i2	r6	t1	h5	f3	d6	vp7	vp7	e4
90	i2	r6	t1	h5	f3	d6	vp8	vp8	e4
91	i2	r6	t2	h4	f3	d5	vp6	vp6	e4
92	i2	r6	t2	h4	f3	d6	vp7	vp7	e4
93	i2	r6	t2	h4	f3	d6	vp8	vp8	e4
94	i2	r6	t2	h5	f3	d5	vp6	vp6	e4
95	i2	r6	t2	h5	f3	d6	vp7	vp7	e4
96	i2	r6	t2	h5	f3	d6	vp8	vp8	e4

Note: Node identification (e.g., t1) as shown in Figure 1.

Table 2: Summary Results for Ten Simulated Synthetic Hurricanes for Combined Effects

Simulation ID	Landfall Location	Forward Direction (°)	Central Pressure Deficit (mb)	Maximum Wind Speed Vm (kt)	Forward Speed (kt)	Radius of Maximum Winds (nm)	Antecedent Water Level (ft, NAVD88)	Nearshore (Point 2) Maximum Stillwater Level (ft, MSL)	West of TB2 (Point 10) Maximum Stillwater Level (ft, MSL)	West of TB2 (Point 10) Peak Significant Wave Height (ft)
CE1	3	-40	79	110	15	30	1.16	18.2	18.5	1.6
CE2	3	-20	79	110	15	30	1.16	16.7	17.1	1.1
CE3	3	0	79	110	15	30	1.16	14.5	15.1	0.7
CE6	3	-20	103	125	15	30	1.16	21.0	21.3	2.8
CE7	3	-20	86	110	5	30	1.16	14.0	14.5	0.4
CE8	3	-20	72	110	25	30	1.16	16.9	17.6	1.2
CE11	3	-20	100	110	15	45	1.16	19.1	19.3	1.8
CE13	6	-20	128	51	15	100	1.16	7.1	n/a	n/a
CE14	6	-40	116	47	15	100	1.16	6.9	n/a	n/a
CE15	3	-20	79	110	15	30	2.16	17.7	18.1	1.4

Note: ° denotes degrees; mb denotes millibars; kt denotes knots; nm denotes nautical miles; and ft denotes feet. "n/a" denotes foreshore not flooded and results not available. Refer to Figure 3 for output node locations. TB2 stands for Unit 2 Turbine Building.

Table 3: Wave Runup and Total Water Level

Location[1]		Maximum Flow Velocity (feet / second)	Stillwater Elevation (feet, MSL)	Wave Runup, $R_{u2\%}$ (feet)	Total Water Level (feet, MSL)
Unit 2 Intake Structure	West Side	5.2	16.8	19.9	36.7
	South Side	6.9	16.9	20.3	37.2
Unit 3 Intake Structure	East Side	5.1	17.1	25.1	42.2
	South Side	2.0	16.9	25.7	42.6
Unit 3 Turbine Building [2]	West Side	n/a	17.7	4.5 [2]	22.2 [4]
Unit 2 Turbine Building [3]	West Side	1.3	17.5	2.3	19.8

Notes:

1. See Figure 13 and Figure 23 in Attachment C of Zachry, 2018b for locations of structures.
2. Runup calculation sheet in Attachment E of Zachry, 2018b.
3. Except for the west side of the Unit 2 Turbine Building, wave effects are judged to be negligible in the Unit 2 main site / power block areas.
4. 22.2 feet, MSL occurs at the foreshore approaching the Unit 3 Turbine Building. The Unit 3 main site / power block average site grade is 24 feet, MSL.

Table 4: Flood Loads Results based on Significant Wave Height

Structure	Location	Hydrostatic Pressure (psf)[1]	Current Velocity Hydrodynamic Pressure (psf)	Standing Wave Pressure (psf)[3]	Composite Pressure (psf)[4]	Debris Load Considering a Log of 2,000 lb (lb)[3]	Debris Load Considering a Shipping Container of 5,291 lb (lb)[3]
Unit 2 Intake West Side	Stillwater Elevation	0	34	691	725	10,400	27,513
	Bottom of Structure[2]	2,995	34	442	3,471	N/A	N/A
Unit 2 Intake South Side	Stillwater Elevation	0	59	707	766	13,800	36,508
	Bottom of Structure[2]	3,002	59	467	3,528	N/A	N/A
Unit 3 Intake South Side	Stillwater Elevation	0	5	898	903	4,000	10,582
	Bottom of Structure[2]	3,002	5	570	3,577	N/A	N/A
Unit 3 Intake East Side	Stillwater Elevation	0	32	877	909	10,200	26,984
	Bottom of Structure[2]	3,014	32	556	3,602	N/A	N/A
Unit 2 Turbine Building West Side [5]	Stillwater Elevation	0	224	N/A	224	21,200	N/A
	Bottom of Structure[2]	224	224	N/A	448	N/A	N/A

Notes:
1) psf = pounds per square foot (lb/ft^2)
2) Toe Elevation at Unit 2 and Unit 3 intake structures = -30.0 ft MSL. Toe Elevation at Unit 2 Turbine Building = 14 ft MSL
3) Debris loads assumed to act at the maximum stillwater elevation. Standing wave pressures are based on significant wave height.
4) The composite pressure at a given location is the sum of the hydrostatic pressure, current velocity hydrodynamic pressure and standing wave pressure.
5) Flood loads except for hydrostatic load do not apply to other sides of Unit 2 Turbine Building and structures in the Unit 2 main site / power block area (see Table 3, note 3).

Table 5: Flood Loads Results based on Maximum Wave Height

Structure	Location	Hydrostatic Pressure (psf)[1]	Current Velocity Hydrodynamic Pressure (psf)	Standing Wave Pressure (psf)[3]	Composite Pressure (psf)[4]	Debris Load Considering a Log of 2,000 lb (lb)[3]	Debris Load Considering a Shipping Container of 5,291 lb (lb)[3]
Unit 2 Intake West Side	Stillwater Elevation	0	34	1,168	1,202	10,400	27,513
	Bottom of Structure[2]	2,995	34	738	3,767	N/A	N/A
Unit 2 Intake South Side	Stillwater Elevation	0	59	1,196	1,255	13,800	36,508
	Bottom of Structure[2]	3,002	59	781	3,842	N/A	N/A
Unit 3 Intake South Side	Stillwater Elevation	0	5	1,512	1,517	4,000	10,582
	Bottom of Structure[2]	3,002	5	953	3,960	N/A	N/A
Unit 3 Intake East Side	Stillwater Elevation	0	32	1,477	1,509	10,200	26,984
	Bottom of Structure[2]	3,014	32	929	3,975	N/A	N/A
Unit 2 Turbine Building West Side[5]	Stillwater Elevation	0	224	N/A	224	21,200	N/A
	Bottom of Structure[2]	224	224	N/A	448	N/A	N/A

Notes: 1) psf = pounds per square foot (lb/ft^2)
2) Toe Elevation at Unit 2 and Unit 3 intake structures = -30.0 ft MSL. Toe Elevation at Unit 2 Turbine Building = 14 ft MSL.
3) Debris loads assumed to act at the maximum stillwater elevation. Standing wave pressures are based on maximum wave height.
4) The composite pressure at a given location is the sum of the hydrostatic pressure, current velocity hydrodynamic pressure and standing wave pressure.
5) Flood loads except for hydrostatic load do not apply to other sides of Unit 2 Turbine Building and structures in the Unit 2 main site / power block area (see Table 3, note 3).

Table 6: Summary of the Comparison of Current Design Basis and Reevaluated (1E-4 AEP) Flood Causing Mechanisms for MPS Unit 2

Flooding Mechanism	Flood Critical Structure (Per FSAR)	Current Design Basis Flood Level (MSL)	Current Flood Protection Elevation (MSL) [2]	Reevaluated 1E-4 AEP Flood Level (MSL)
Combined Effects for AEP of 1E-4	MPS2, except Intake Structure	21.3 ft (Stillwater plus wave crest) 25.1 ft (Wave runup)	22 ft	17.5 ft at east side of MPS2; 19.8 ft at west side of MPS2
	MPS2 Intake Structure	26.5 ft (standing wave inside Intake Structure)	22 ft except 26.5 ft (at one service water pump motor)	Wave runup up to 37.2 ft at the Intake structure
Storm Surge (Stillwater Elevation) for AEP of 1E-4	MPS2, except Intake Structure	18.2 ft [3]	22 ft	17.5 ft
	Diesel Generator & Intake Structure	18.2 ft [3]	22 ft	16.9 ft

Notes:
1. This table is a supplement to Table 3.0-1 of the MPS FHRR (Zachry, 2015a). "ft" denotes "feet". Flood level is location dependent;
2. Flood Protection Elevation 22 ft. assumes that there is sufficient warning time to close all MPS2 flood gates;
3. Current Design Basis Flood Level considers stillwater level plus wave runup. Wave action in conjunction with wave runup is projected to cause higher levels in some locations and was independently calculated.

Table 7: Summary of the Comparison of Current Design Basis and Reevaluated (1E-4 AEP) Flood Causing Mechanisms for MPS Unit 3

<table>
<tr><th>Flooding Mechanism</th><th>Flood Critical Structure (Per FSAR)</th><th>Current Design Basis Flood Level (MSL)</th><th>Current Flood Protection Elevation (MSL)</th><th>Reevaluated 1E-4 AEP Flood Level (MSL)</th></tr>
<tr><td rowspan="2">Combined Effects for AEP of 1E-4</td><td>MPS3, except Intake Structure</td><td>23.8 ft (near MPS3 except at front of Intake Structure)
[2]</td><td rowspan="2">24 ft (25.5 ft for SW Pumps)</td><td>22.2 ft (site grade at 24 ft MSL protects against wave runup except at Intake)</td></tr>
<tr><td>Intake Structure</td><td>41.2 ft (at seaward wall of Intake Structure)
[2]</td><td>Wave runup up to 42.6 ft at the Intake structure</td></tr>
<tr><td rowspan="2">Storm Surge (Stillwater Elevation) for AEP of 1E-4</td><td>MPS3, except Intake Structure</td><td>19.7 ft
[2]</td><td rowspan="2">24 ft (25.5 ft for SW Pumps)</td><td>17.7 ft</td></tr>
<tr><td>Intake Structure</td><td>19.7 ft
[2]</td><td>17.1 ft</td></tr>
</table>

Notes:

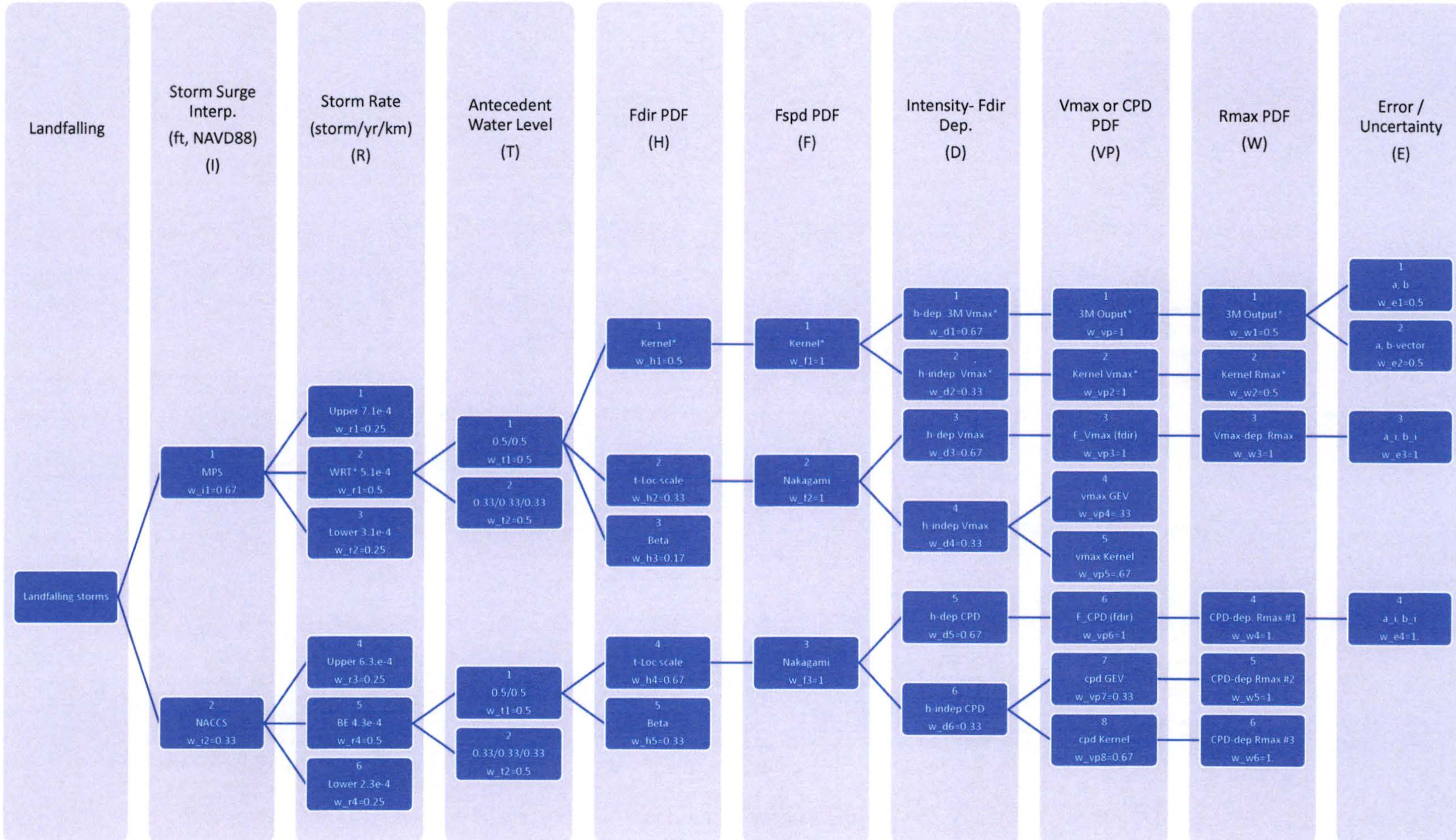
1. This table is a supplement to Table 3.0-2 of the MPS FHRR (Zachry, 2015a). "ft" denotes "feet". Flood level is location dependent;
2. Current Design Basis Flood Level considers stillwater level plus wave runup. Wave action in conjunction with wave runup is projected to cause higher levels in some locations and was independently calculated.

Attachment B

Figures

Note: Figures presented in Attachment B are from Zachry Calculations 2018a and 2018b.

Figure 1: Weighted Mean and Confidence Levels for All Tropical Hazard Curves – Final Selected Weighting Scheme



Notes for Figure 1:

1. Branches are not replicated at "parallel" nodes for clarity. This tree structure yields a total of 96 end nodes, which correspond to 96 storm surge flood hazard curves.
2. "*" denotes nodes that were based on WRT synthetic hurricane data.
3. "BE" stands for Best Estimate. "Upper" stands for upper bound; "Lower" stands for lower bound.
4. "0.5/0.5" denotes half probability for high and low tides each. "0.33/0.33/0.33" denotes one third probability for high, mean and low tides each.
5. "t-Loc scale" stands for t-Location scale distribution; "Beta" stands for Beta Distribution.
6. "Nakagami" stands for Nakagami distribution.
7. "h-dep" and "h-indep" stand for heading dependent and independent intensity metric (Vmax or CPD), respectively.
8. "gev" stands for generalized extreme value distribution; "kernel" stands for non-parametric kernel function.
9. "Vmax-dep" and "CPD-dep" stand for Vmax- and CPD-dependent Rmax distribution functions, respectively.
10. "w_xi" denotes weighting factors, where "x" corresponds to the column ID on the header row (e.g., (T) for antecedent water levels or tidal conditions in this analysis). The values shown in this figure represent the final selected weighting scheme. Please note that weighting factors vary between different scenarios.
11. The tree structure yields a total of 96 end nodes, which correspond to 96 storm surge flood hazard curves.

Figure 2: Combined Tropical and Extratropical Storm Surge for AEP 1E-4 with 50-year Sea Level Rise at MPS

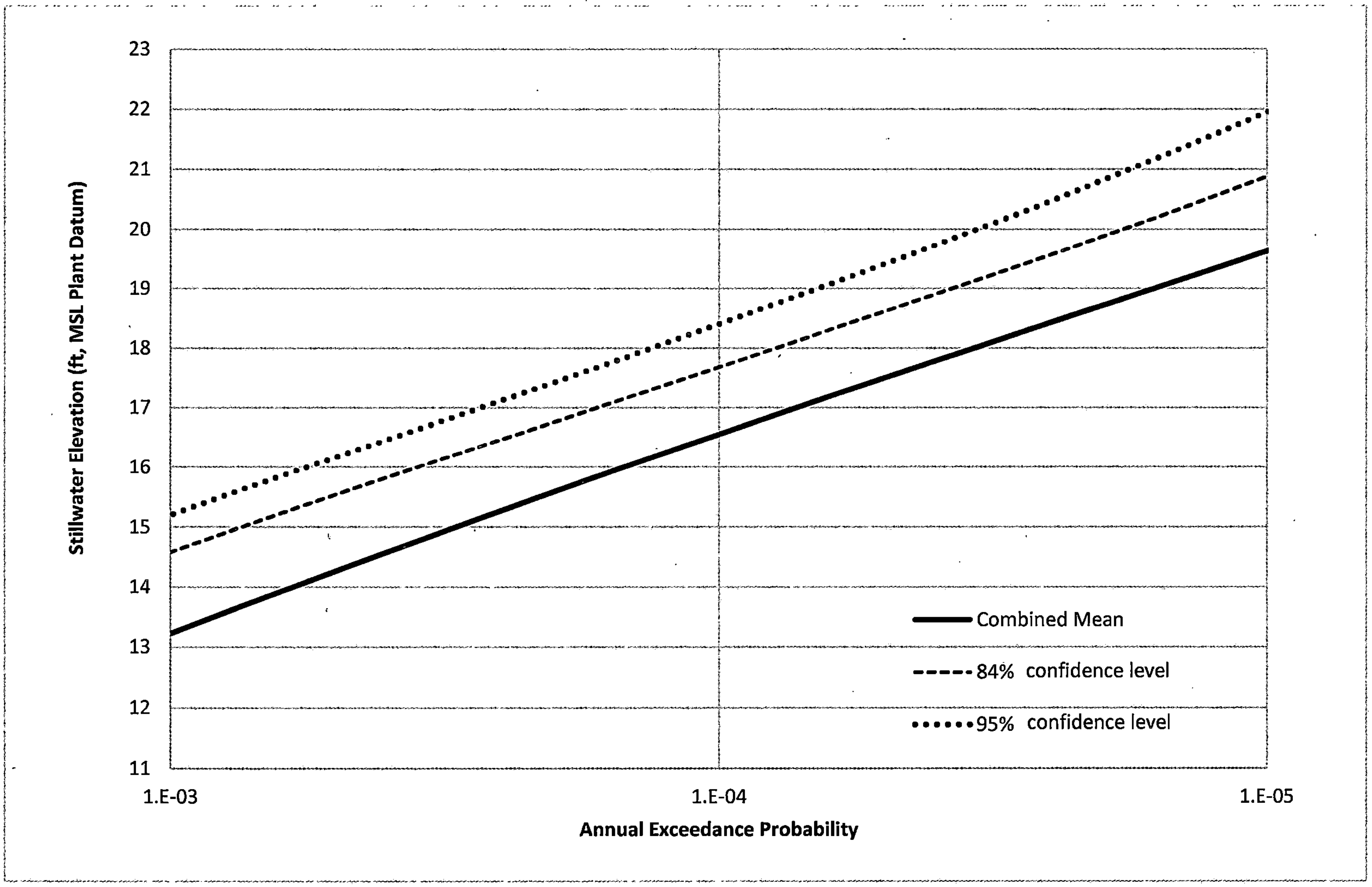


Figure 3: Refined ADCIRC+SWAN Model Mesh with Bathymetry

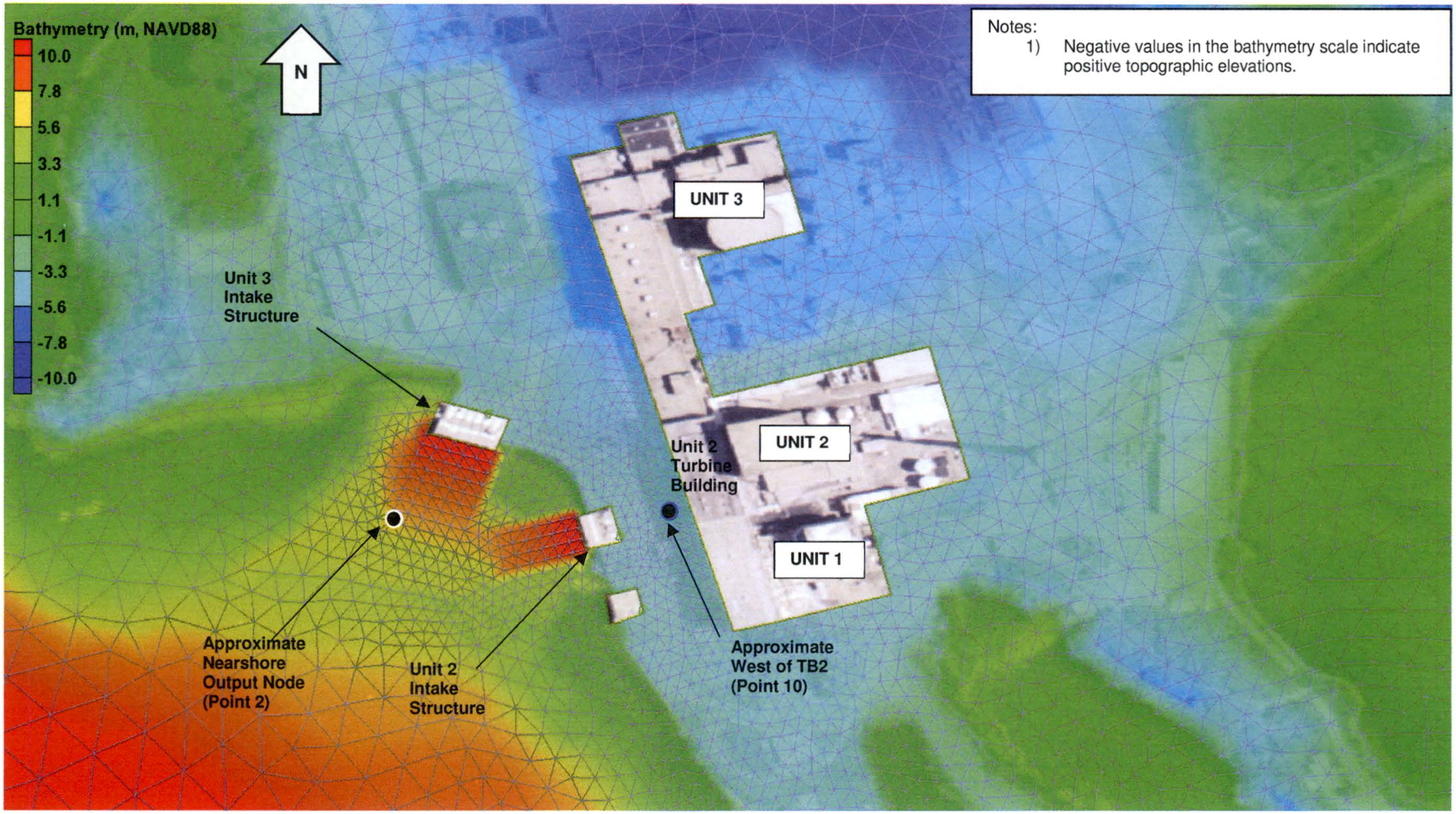
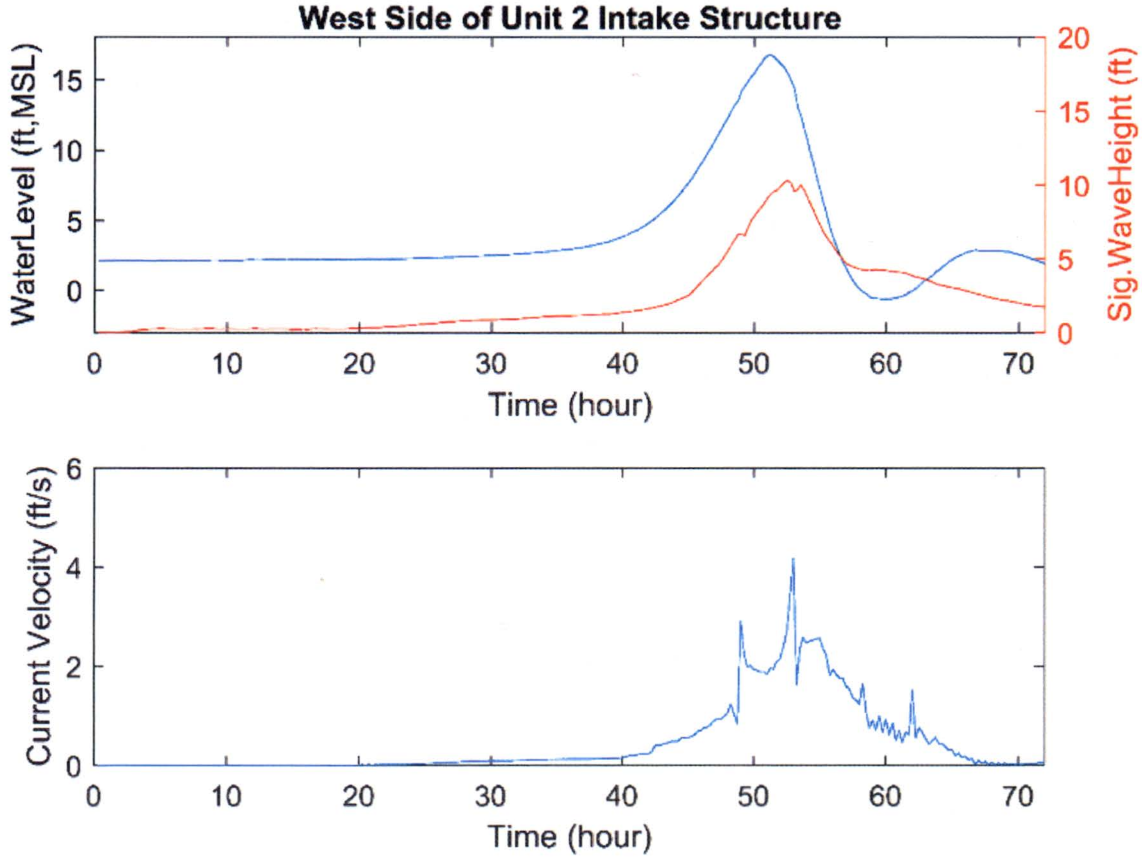


Figure 4: Ten ADCIRC+SWAN Simulated Synthetic Hurricane Tracks for Combined Effects Calculation

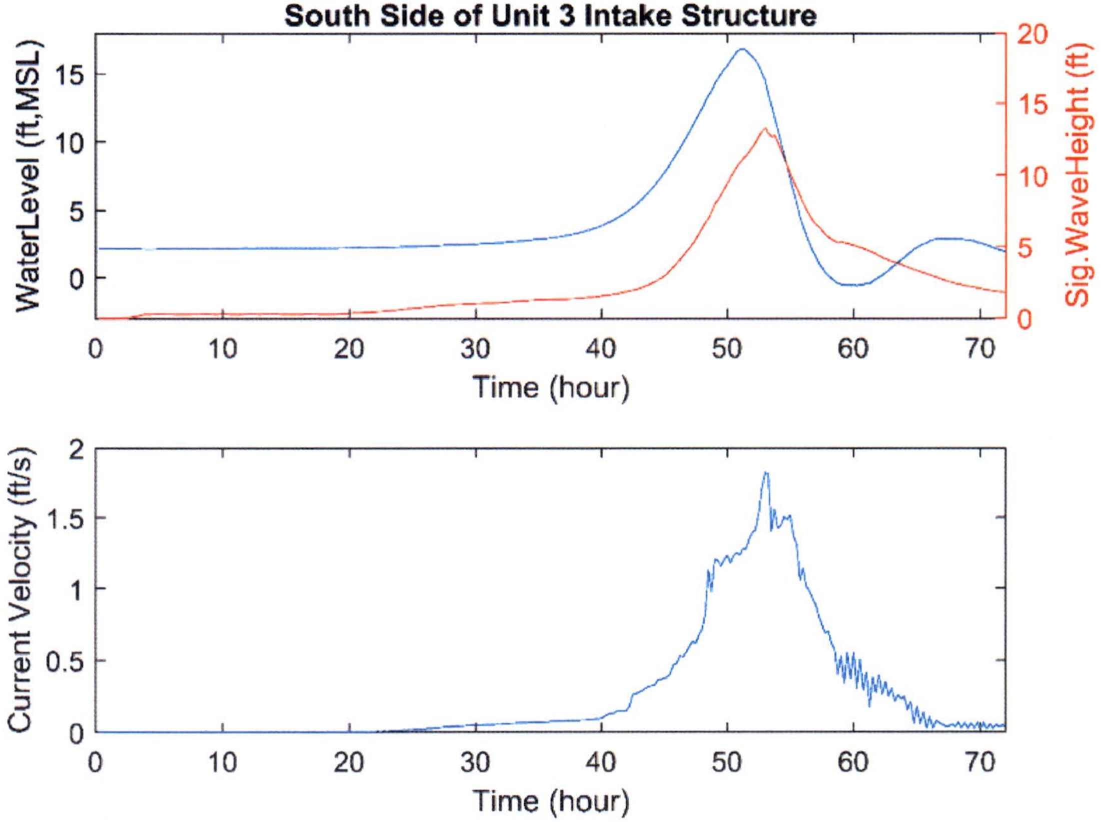
Note: This figure presents the tracks summarized in Table 2.

Figure 5: Stillwater Elevation, Significant Wave Height and Depth-averaged Velocity at Selected Locations – CE2

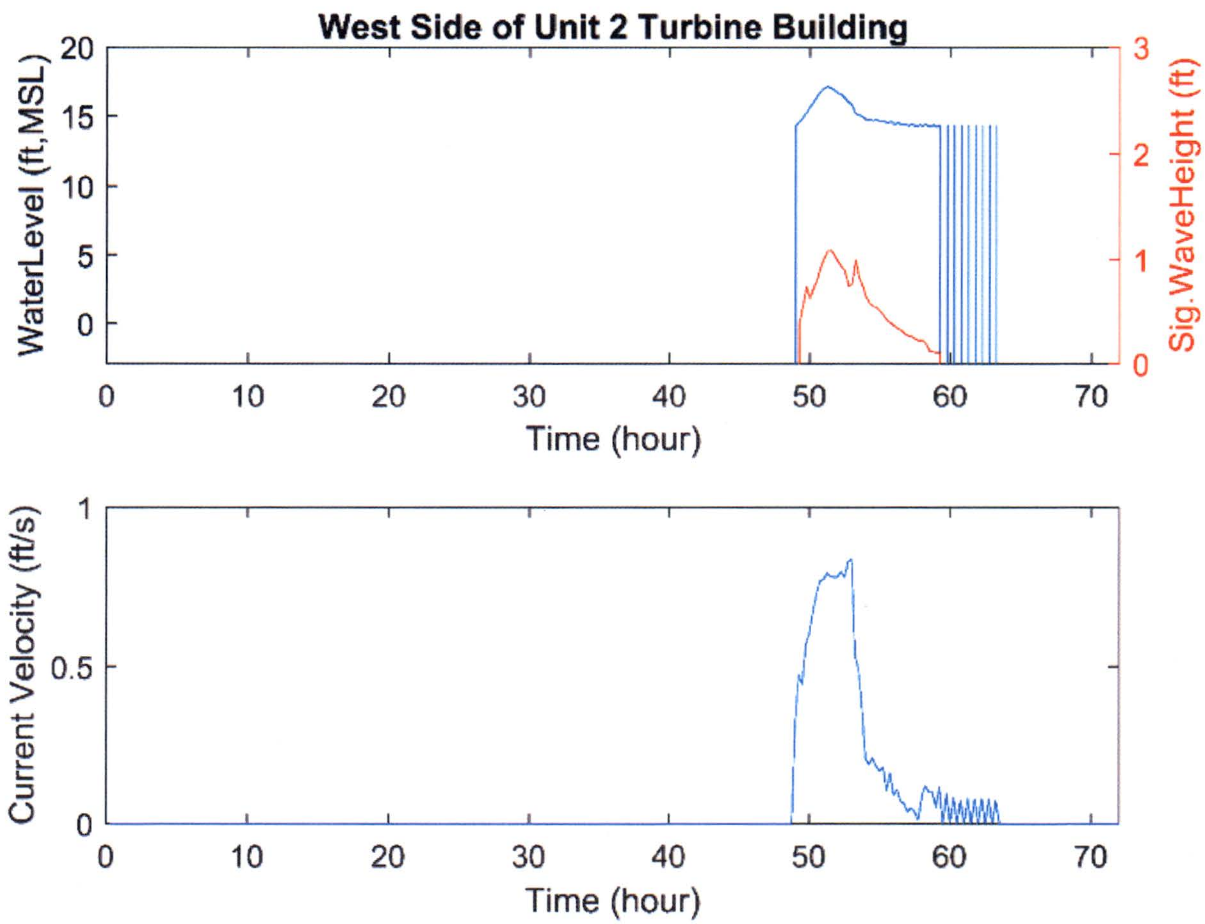
(a) West Side of Unit 2 Intake Structure



(b) South Side of Unit 3 Intake Structure (Figure 5 continued)



(c) West Side of Unit 2 Turbine Building (Figure 5 continued)



Note: Red curve for significant wave height. Top blue curve for stillwater elevation. Bottom blue curve for current velocity. Additional time series plots available in Calculation 18-110 (Zachry, 2018b).

Figure 6: Stillwater Elevation at Approximate Time of Peak Surge (Time = 51.25 hour) – CE2

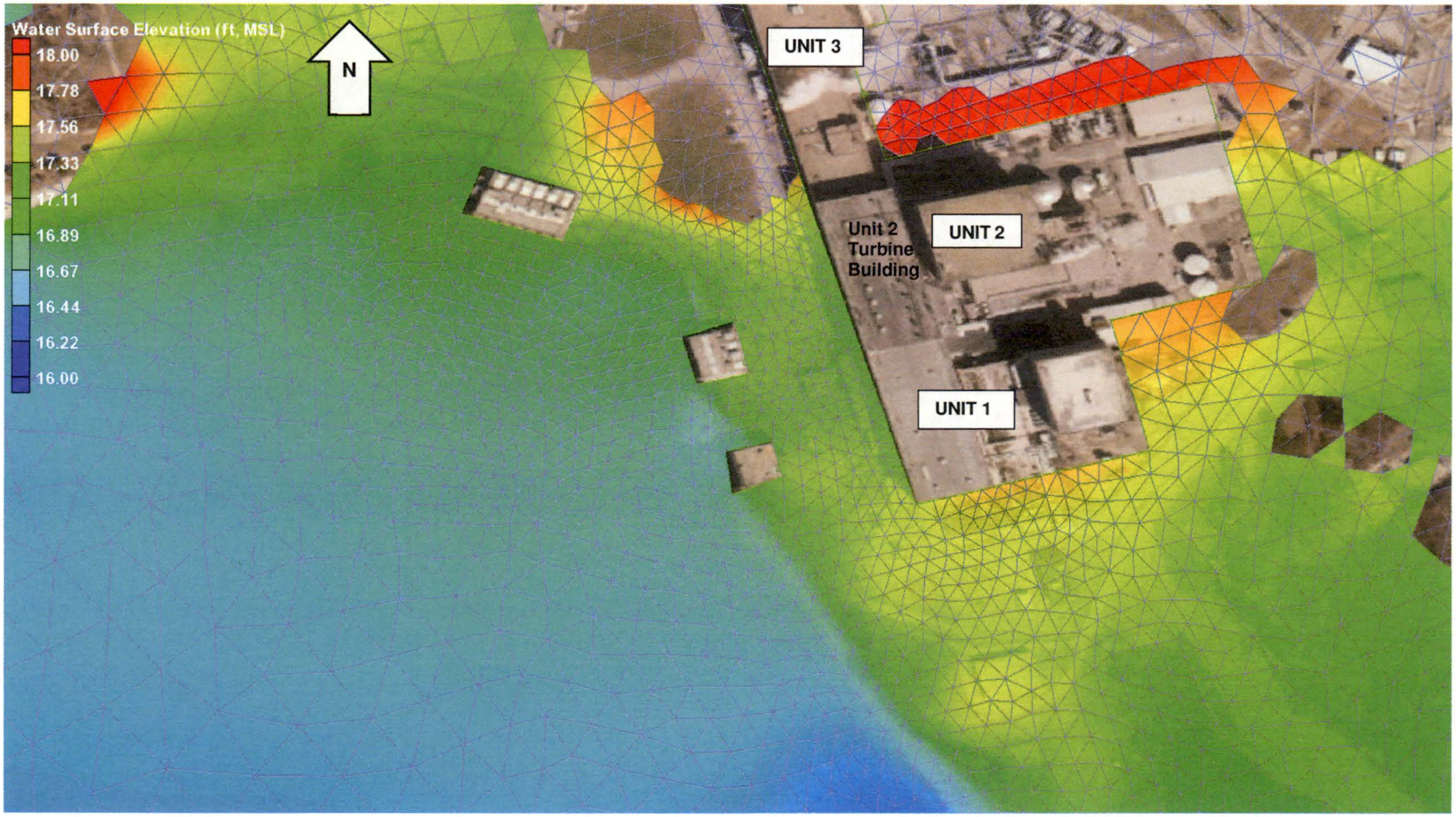


Figure 7: Significant Wave Height and Direction at Approximate Time of Peak Significant Wave Height (Time = 53.00 hour) – CE2

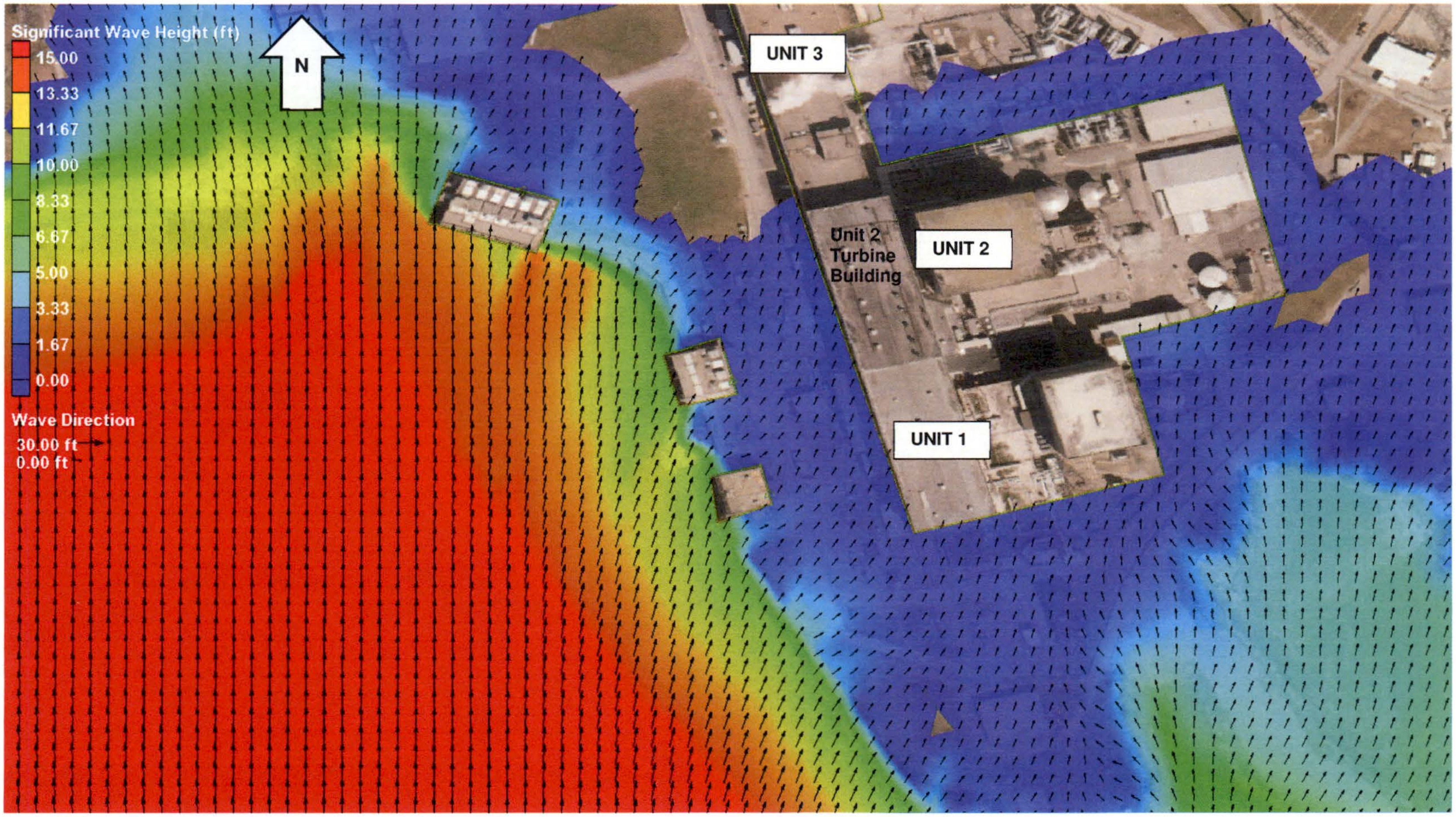


Figure 8: Transects for Wave Runup at Unit 3 Turbine Building and Wave Overtopping at Unit 2 Turbine Building for CE2