Woods Hole Group 81 Technology Park Drive E. Falmouth, MA 02536 USA TELEPHONE: 508.540.8080 FAX: 508.540.1001 www.woodsholegroup.com

April 21, 2015

John Grace, CFM
FEMA Region I
99 High Street, Sixth Floor
Boston, MA 02110

Re: Re: Re: Summary of Additional Data Required to Support an Appeal of Preliminary Flood Insurance Rate Map (FIRM) number 33015CO432F in the Town of Rye, NH (dated March 5, 2015).

Dear John:

The Woods Hole Group is providing this Response to Comment document to address the email from April 16, 2015 in regards to the letter from FEMA requesting additional data for the Town of Rye, NH, Appeal dated March 5, 2015. Specific responses to the four (4) comments can be found below:

Comment 1: *The letter states you assumed 1 foot of scour based on the stone size of the seawall because there are no as-built available. However, the Guidelines and Specifications (G&S) state you can only do this for a sloping revetment (section d.2.10-11). The seawall in question is a vertical structure.*

Response: It was understood that the structure in question is a vertical seawall. FEMA requested that the wall be scoured and failed even though the total water level elevation (100-year still water level and wave setup) was below the toe of the structure and neither the FEMA G&S or Coastal Engineering Manual (CEM) outline a methodology for calculating scour at the toe of the vertical wall when there is no water depth at the toe. Therefore, engineering judgment is needed to analyze this unique case. Scour was calculated for the failed case only with the wall failing on a slope of 1V:3H. At this point the damaged, failed wall is acting as a stone revetment, rather than a vertical wall, with an armor layer thickness equivalent to the wall thickness. This is why the assumption for a stone revetment was used and a 1-ft depth of scour is a reasonable assumption for this small structure (5-6ft tall).

Comment 2: *Also in regards to the assumption of 1 foot of scour, the G&S reads "Assume scour at the base of the structure is equal to the depth of the armor layer.". It appears you used the stone size (above comment) of the wall not the depth of the armor layer.*

Response: To clarify, after the wall is damaged, breaks up, and fails on the 1V:3H slope the failed structure is acting as a stone revetment. The stones from the broken wall now function as a 1-ft thick armor layer as stone revetment. The stones used to construct this seawall are about 1-foot in diameter, and, therefore the thickness of this armor layer would 1-foot. The depth of burial of this new armor layer would be unknown, however, a reasonable assumption is that burial would equivalent to the toe stone diameter. Since there is no larger toe stone, the diameter used to calculate the burial depth would be the armor layer stone diameter (1-foot) and the resulting scour depth at the toe of the structure would also be 1-foot. The failed structure slope of 1V:3H would start at this new scoured depth of 9.4 ft NAVD88 and continue landward until it merged into the existing profile.

Comment 3: *This letter states that the elevation of the wall is 12.8 NAVD88. The original 11/28/14 appeal letter states the wall is 12.7 NAVD88. Please verify and recalculate if needed.*

Response: This was a typo. Structure crest elevation was reset to 12.7 ft NAVD88 and the runup and overtopping calculations were updated (see attached); however, the runup and overtopping results did not change as both predicted an AO 1ft Depth Zone landward of the crest.

Comment 4: *It appears that you used (FEMA's) preliminary A03 zone footprint for your proposed A01 zone leeward of the seawall. Can you please verify that even with a depth change of 2 feet the A0 zones will have the same footprint and extend that far back from the seawall based on the topography of the area?*

Response: After reviewing the LIDAR contours, a reduction of the depth of the AO Zone by 2-feet (from 3-ft to 1-ft) would only move the landward limit of the AO Zone seaward by only a few feet; therefore the FEMA boundaries were retained.

To summarize, Transect TR-39 represents a unique case where engineering judgment is utilized since there is not a readily available solution in the accepted literature. A scour depth of 1-foot is reasonable assumption for a structure where there was no initial depth-limited wave at the toe since the total water level is below the toe of the structure. Also, the toe of this 5-6ft high structure is likely not very deep.

Lastly, it should be noted that the effective May 17, 2005 FIRM has this entire stretch between transects TR-39 and TR-37 in an AO 1ft-Depth Zone, which is what our revised analysis showed for Transect TR-39. The preliminary April 9, 2014 FIRM has Transects TR-39 and TR-37 in higher risk AO (3ft) and AE (13) Zones, respectively, while the risk has been eliminated for Transect TR-38 since it is now completely removed from the SFHA. After a cursory review of the CHAMP data base and LIDAR for this area, these properties in the adjacent transect reach TR-38 do not appear to be at any less significant risk to storm damage than the properties in Transect TR-39 or TR-37 since they occupy similar beach profiles along a long, straight beach which parallel depth contours.

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If there are any questions in regards to the responses to the comments or there is need for additional data, please feel free to contact myself, Mitchell Buck, via phone (508-495-6210) or email (mbuck@whgrp.com).

Sincerely,

Mitchell Buck, P.E.
Coastal Engineer
Woods Hole Group

CC:

Fay Rubin, Project Manager
Earth Systems Research Center
Eight College Road
University of New Hampshire
Durham, New Hampshire 03824

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CALCULATIONS IN SUPPORT OF RUNUP

Analysis of Wave Runup on a Failed Seawall by TAW Method for Transect TR-39 (TR-42 in CHAMP) in Town of Rye, NH

The TAW method was originally formulated for manmade dikes, but has since successfully been applied by FEMA to natural shorelines that mimic a dike in function. The TAW method in this case was analyzed for the failed structure (seawall) case with scour. Note that initially this case was analyzed for a failed slope of 1V:1.5H as specified in the FEMA document "New_Hampshire_Failed_Structures_070313.docx"; however, it was found that Iribarren was not acceptable for the TAW Method and the failed slope was set to 1V:3H. It appears that FEMA had similar issues as a slope of 1V:3H was in fact used for TR-39/TR-42 for the TAW Method & Overtopping in the Overtopping Data Based in the Coastal Backup Data Disk.

Input Data and Assumptions

The following assumptions from are utilized:

- The Preliminary April 9, 2014 Preliminary FIRM Backup Data apply except where noted.
- Wave height, H_{mo}, is the deepwater wave height and is not in water of transitional depth.
- Wave period, T_p, remains constant and independent of depth for oscillatory waves
- Wave setup dynamically calculated by SWAN1D includes both the effects of static and dynamic wave setup.

The offshore wave parameters utilized by FEMA in the April 9, 2014 Preliminary FIRM Coastal Backup Data for Transect TR-39 apply to this location. Those parameters are:

- Peak Wave Period: **T_p = 11.66 seconds** (FEMA OFFSHORE STWAVE Results)
- Deepwater significant wave height: **H_0 = 25.1 feet** (FEMA OFFSHORE STWAVE Results)
- 1% Stillwater Elevation: **SWEL1% = 8.36 feet NAVD88** (FEMA Preliminary FIS)
- Wave Setup **η = 1.99** feet (WHG computed by SWAN1D)
- Acceleration due to gravity: **g = 32.17 ft/s^2**
- Structure Crest Elevation = **12.7 feet NAVD88**
- Maximum Topo Crest Elevation = **13.55 feet NAVD88**

STEP ONE – Determine Water Levels and Structure Configuration

The TAW method assumes that the wave that impacts the structure is the depth-limited wave at the toe of the structure; however, the total water level (SWEL1% + Wave Setup = 10.35 ft NAVD88) is below the toe of the structure in this case meaning that there is no wave impacting the structure toe. FEMA requested that we analyze scour at the toe of the wall so that the TAW method would be valid, however, the scour equations also rely on the water depth at the toe so it cannot be computed directly. Therefore, scour has to be estimated based on engineering judgment. The 2007 FEMA Guidelines state that a conservative estimate of maximum depth of scour for a structure would be equivalent to the depth of the toe of the structure. Unfortunately, there are no as-built plans or survey data for the structure to determine the burial depth of the toe.

Another assumption states that the depth of scour can be approximated to be equal to the depth of burial of the armor layer of the structure. For this failed seawall case, it is assumed that the structure fails on a 1V:3H slope with stones from the seawall falling along this slope so that it acts similar to a sloped revetment. The stones used to construct this seawall are about 1-foot in diameter, and, therefore the thickness of this armor layer would 1-foot. The depth of burial of the armor layer is unknown, however, a reasonable assumption is that burial would equivalent to the toe stone diameter. Since there is no toe stone, this diameter would be equivalent to the armor layer stone diameter of 1-foot and the resulting scour depth at the toe of the structure would also be 1-foot. The new elevation of the toe for the failed structure would be set to 9.4 feet NAVD88. The failed structure slope of 1V:3H would start at this new scoured toe depth and continue landward until it merged into the existing profile as seen in Figure 1 with a Structure Crest of 1. The depth at the toe is then calculated by subtracting the elevation of the scoured toe (9.4 ft NAVD88) from the total water level (10.35 feet NAVD88). Therefore, the depth, d_s, is calculated by:

→ d_s = SWEL1% + η – depth at toe = 8.36 + 1.99 – 9.40 = **0.95 feet**

STEP TWO – Determine Wave Parameters

Now we need to determine the wave parameters at the failed seawall based on the offshore wave characteristics and transect data.

Check if Wave is depth limited at the structure:

- "Broken" if: $H_0 \geq 0.78*d_s$
  "Not Broken" if: $H_0 < 0.78*d_s$
  "Undetermined" if: otherwise

  → $H_0 = 0.78*d_s$ = **0.74 feet** < 25.1 feet
  Therefore, the wave that impacts the seawall is **"Broken"** and H_b will be used in place of the deepwater H_{mo}.

- Need to determine the deepwater wave length, L_0, from existing wave parameters:
  $L_0 = \frac{g * Tp^2}{2\pi}$ → Therefore, $\mathbf{L_0}$ **= 696.7 feet**

The wave type at the seawall is determined by the following criteria:

- Wave Type = "Shallow" if $d_s/L_0 < 0.2$
  "Transitional" if $0.2 \leq d_s/L_0 < 0.5$
  "Deep" if $d_s/L_0 \geq 0.5$

  → $d_s/L_0 = 0.001 < 0.2$ Therefore, the wave is a **"Shallow water wave"**

Now determine the local wave parameters at the seawall (H_{mo}, T_{m10}, and L_{mo}):

- H_{mo} = "d_s * 0.78" if wave "Broken"
  "H_{mo}" if wave "Not Broken"
  "0" otherwise

  → Wave Type is "Broken" from the first bullet therefore calculate the depth-limited wave:
  $H_{mo} = d_s * 0.78$ = **0.74 feet**.

The corresponding T_{m10} and L_{mo} are calculated as follows:

- $T_{m10} = T_p/1.1 =$ **10.6 seconds**
- $L_{mo} = \frac{g * T_{m10}^2}{2\pi}$ = **575.8 feet**

STEP THREE – Check TAW validity

The TAW method is valid is the following criteria are met:

- TAW Method is valid if:
  a. $0.5 < \zeta_{om} < 8\text{-}10$ where ζ_{om} is the Iribarren Number
  b. $1{:}1 < m < 1{:}8$ where m is the slope

→ Determine Iribarren number: $\zeta_{om} = \frac{m}{\sqrt{Hmo/Lmo}}$

Now calculate the Iribarren Number ζ_{om} based on the slope *m* of the failed seawall set to 1V:3H:

→ $\zeta_{om} = \frac{m}{\sqrt{Hmo/Lmo}} =$ **8.9**

Therefore, the **TAW Method is Valid** since $0.5 < \zeta_{om} =$ **8.9** $<$ 8-10 & $1{:}1 < m =$ **1:3** $<$ 1:8-10

STEP FOUR – Calculate Runup

Runup is calculated based on the TAW by the following method:

- Runup $R_{2\%} =$

$H_{mo}\,(1.77 * \gamma_r * \gamma_b * \gamma_\beta * \gamma_p * \zeta_{om})$	if $0.5 \le \gamma_b * \zeta_{om} < 1.8$
$H_{mo}\,[\,\gamma_r * \gamma_b * \gamma_\beta * \gamma_p * (4.3 - 1.6/\sqrt{\zeta om})]$	if $1.8 \le \gamma_b * \zeta_{om}$
0	Otherwise

Where γ_r, γ_b, γ_β, and γ_p are influence or reduction factors that are determined below:

- Roughness reduction factor: $\boldsymbol{\gamma_r = 1}$
  → Default 1.

- Wave Direction Factor: $\boldsymbol{\gamma_\beta = 1}$
  → The waves are normally incident, therefore this value is set to the default of 1.

- Berm Section Factor: $\boldsymbol{\gamma_b = 1}$
  → There is no berm so this value is set to the default is 1.

- Porosity Factor: $\boldsymbol{\gamma_p = 1}$
  → For an assumed default porosity of 0.5, the default is 1.

- Now determine which runup equation to use by calculating $\gamma_b * \zeta_{om}$

→ $\gamma_b * \zeta_{om} = 1*3.77 = 3.77 > 1.8$, therefore use second equation:

$R_{2\%} = H_{mo}\ [\ \gamma_r * \gamma_b * \gamma_\beta * \gamma_p * (4.3 - 1.6/\sqrt{\xi_{om}})]$ **= 2.79 feet**

- Now calculate the runup elevation by summing the runup and SWEL1%:

  → $Z_{2\%} = R_{2\%}$ + SWEL1% = **13.14 feet NAVD88**

In order to determine the new Base Flood Zone Elevation (BFE), the Runup Elevation must be rounded to the nearest foot. Therefore the new **BFE is 13 feet NAVD88.**

STEP FIVE – Check for Overtopping

Lastly, determine whether overtopping is occurring and, if so, the severity of the overtopping.

- Is the 2% runup elevation exceeding the barrier crest?
  $Z_{2\%}$ = 13.4 ft > failed structure crest =12.7 ft but $Z_{2\%}$ is same elevation as topo crest at 13.4 feet.

  → Yes, overtopping of the structure is occurring. The runup Depth is 13.4 – 12.7 = 0.7 feet over failed structure crest (but is below the topo crest) which falls in the range 0.1 – 1.5 feet that indicates that it is an AO Zone with a Depth of 1 foot based upon the 2007 FEMA Guidelines Section D.2.8.1.7.

- The mean overtopping rate is then calculated by the Coastal Engineering Manual (CEM) using the following formula (Eqn. IV-5-25) for overtopping by Van der Meer and Jansen (1995):

  $$Q_{mean} = 0.2\sqrt{gH_s^3}\ exp\left[-2.6\ \frac{Re}{H_s}\ \frac{1}{\gamma_r\gamma_\beta\gamma_b\ \gamma_p}\right]$$

  where R_e is the crest elevation above the TWL = 12.70 ft – 10.36 ft = 2.54 ft
  $H_s = H_{mo}$ = 0.74 feet
  $\gamma_r = \gamma_b = \gamma_B = \gamma_p = 1$

  → Q_{mean}= **0.0019 cfs/ft**

→ Based on Table D.2.8-6 of FEMA Guidelines this Q_{mean} of 0.0019 cfs/ft equates to an AO Zone with a 1 foot depth which reinforces the first bullet. Therefore, the final designation is a VE Zone with a BFE of 13 ft to the crest of the failed structure, followed by an AO Zone with a depth 1 foot moving landward until it reaches the 10 foot contour based upon the revised TWL of 10.35 feet.