Panel Decision & Report

SRP CASMC120916 - San Mateo County, CA

April 30, 2018

National Institute of BUILDING SCIENCES

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Summary

Based on the submitted scientific and technical information, and within the limitations of the charge to this Scientific Resolution Panel (SRP or panel), the panel has determined that the appeal does not conclusively support or identify the presence of scientific errors in the preliminary flood hazard study and Flood Insurance Rate Maps (FIRMs). Therefore, this panel recommends that the appeals by both the City of San Bruno and the City of South San Francisco be denied. The data submitted by the communities do not satisfy the National Flood Insurance Program (NFIP) standards, thus the Federal Emergency Management Agency's (FEMA) data are not corrected, contradicted, or negated.

The panel is unable to justify or support the referenced appeal basis, which states that "… alternative methods or applications result in more correct estimates of base flood elevations." In this case, the alternative method(s) is primarily the use of a dynamic, hydraulic model (XP-SWMM). The model was used to propagate a time-dependent flood hydrograph, from an offshore boundary condition, across the coastal terrain and through existing conveyance channels and structures. The panel does not believe that the data submitted in the appeal packages provide "more correct estimates" of the 1% annual chance flood hazard in the Belle Air (City of San Bruno) and Lindenville (City of South San Francisco) neighborhoods. The panel cites the lack of required final mapping products and a number of weaknesses associated with the modeling and/or analyses as rationale for their final recommendation:

1. The appeal did not meet NFIP requirements regarding the submission of required data products, namely the preparation of revised FIRMs and FIS information;
2. The numerical modeling and analyses did not consider model calibration, model verification, sensitivity to model parameters and forcing conditions, and uncertainty in the model inputs and outputs;
3. The mixture of response- and event-based approaches for simulating the time-dependent flood hazard conditions of each area is inconsistent with flood mapping procedures and lacked suitable justification;
4. The proposed flood inundation areas resulting from the time-dependent modeling are not well-defined because of their inability to define the probability distribution of duration for the 1% annual chance coastal flood event;
5. Components of the appeal methodology do not follow FEMA procedures and guidance for modeling non-accredited levee systems and features as described in "Analysis and Mapping Procedures for Non-Accredited Levee Systems" dated July 2013; and
6. The appellants did not consider flood hazards resulting from combined riverine and coastal flooding and did not perform any tie-ins between their estimated coastal flooding and an existing riverine flood hazard area.

Because of the similarity of the appeals submitted by the City of San Bruno and the City of South San Francisco, and because the same model and methodologies were used for both appeals, the panel does not make any significant distinction between them in this report. The recommendations and rationale provided in this report apply to both appeals considered in this SRP review.

Introduction

This report serves as the recommendation to the Federal Emergency Management Agency (FEMA) administrator from the National Institute of Building Sciences (NIBS) San Mateo County, CA Scientific Resolution Panel (SRP). SRP's are independent panels of experts organized, administered, and managed by NIBS for the purpose of reviewing and resolving conflicting scientific and technical data submitted by a community challenging FEMA's proposed flood elevations. The SRP is charged with helping to efficiently resolve appeal and protest issues, between FEMA and communities, by acting as an independent third party in the effort to obtain the best data possible for the community's Flood Insurance Rate Maps (FIRM's).

Panel

Panel ID: CASMC120916
Panel Name: San Mateo County, CA
FEMA Region: IX

Panel members:

- **Michael Giovannozzi, PE,** is the owner and senior coastal engineer at AquaTerra Consulting International, Inc. in West Palm Beach, FL. He has over 17 years of experience in coastal engineering with the US Army Corps of Engineers and with the private sector. His wide-ranging expertise includes dredging and navigation studies, marina planning and design, wave and hydrodynamic studies, beach nourishments, physical and numerical modeling, and the design of traditional and innovative shore protection structures. He has considerable experience in FEMA coastal flood plain mapping and Letter of Map Revision (LOMR) applications. Mr. Giovannozzi is a working group member of the World Association for Waterborne Transport Infrastructure (PIANC) and a member of the American Society of Civil Engineers (ASCE) Coasts, Oceans, Ports and Rivers Institute (COPRI). He is a registered Professional Engineer in nine states.

- **Terry Hull, PE,** a Principal Engineer and Vice President at INTERA Incorporated, oversees INTERA's southeastern operations and national coastal engineering business development. His 30 years of experience is focused on water resources including hydrologic, hydraulic, and tidal/hurricane surge modeling – mostly for government agencies including state water management districts and DOTs, FEMA, and the U.S. Army Corps of Engineers (USACE). His 30 years of FEMA experience includes serving on a national FEMA Panel of Experts to recommend improvements to coastal flood hazard methodologies, and on a FEMA review panel for the New York City FEMA Flood Insurance Study appeal. As president of Taylor Engineering, Inc., he directed Region IV and VI coastal work under FEMA HQ, Region IV, and Region VI JV contracts. He also served as contract manager for multiple, consecutive FEMA and USACE contracts.

- **David Kriebel, Ph.D., P.E., D.CE.,** is a consultant in coastal and ocean engineering through his firm Coastal Analytics LLC. He is also a Professor of Ocean Engineering at the U.S. Naval Academy in Annapolis, Maryland, where he has taught coastal engineering and other courses for 30 years. He has authored about 100 papers and reports on coastal and ocean engineering

topics, including sea level rise, ocean waves, coastal flooding, coastal erosion, coastal structures, port and harbor structures, and hurricane and tsunami impacts. He has contributed to the Corps of Engineers Coastal Engineering Manual, the FEMA Coastal Construction Manual, and the American Society of Civil Engineering standard ASCE-7 Minimum Design Loads for Buildings and Other Structures. Dr. Kriebel has served as President, and on the Board of Directors, of the Coasts, Oceans, Ports, and Rivers Institute (COPRI) of the American Society of Civil Engineers (ASCE), the major professional society serving coastal engineers. He also served as one of three civilian members appointed to the Coastal Engineering Research Board, a federal advisory committee to the U.S. Army Corps of Engineers. Dr. Kriebel is a Registered Professional Engineer in Virginia and Alaska, and certified as a Diplomate in Coastal Engineering by the Academy of Coast, Ocean, Port, and Navigation Engineers.

- **Malcolm Spaulding, PhD. P.E., F. ASCE,** is a Professor Emeritus, Ocean Engineering at the University of Rhode Island (URI) and Principal, Spaulding Environmental Associates (SEA), LLC. He served for 40 years on the faculty and over a decade as department chair. He was founding President of the Northeast Regional Association for Coastal Ocean Observing Systems (NERACOOS) (2008 to 2014), and founder of Applied Science Associates (ASA) Inc. in 1979, serving in various leadership and technical roles through 2014. He currently serves as a senior advisor to RI Beach Special Area Management Plan (SAMP) and is leading an effort called **STORMTOOLS®** to make state of art modeling systems available to support coastal and riverine flooding analysis in the presence of sea level rise. Dr. Spaulding served on the National Research Council's Marine Board and liaison to the Ocean Studies Board from 1996 to 2001 and has been a member of numerous NRC committees. He served on SRP for New York city. Dr. Spaulding is a registered Professional Engineer in Rhode Island.

- **Bret M. Webb, Ph.D., P.E., D.CE (chair),** is a Professor of Coastal Engineering at the University of South Alabama with more than 15 years of experience in coastal hydrodynamic modeling, coastal engineering, and coastal flood hazard mapping. Dr. Webb's relevant experience as chair of this committee includes participating on consult teams charged with performing wave modeling for coastal flood map revisions in the Northcentral Gulf of Mexico; serving in a technical oversight role for coastal flood map revisions in Alabama and the Northwest Florida Panhandle; and service on a prior FEMA review of coastal flood maps. Dr. Webb is a registered Professional Engineer in the states of Alabama and Florida, and recognized by ACOPNE as a Board Certified Coastal Engineer.

Basis for Appeal

The City of San Bruno, CA, and the City of South San Francisco, CA, submitted formal appeals to FEMA on August 23, 2016 and August 24, 2016, respectively, challenging preliminary Flood Insurance Rate Maps (FIRMs) for neighborhoods within their municipalities. The City of San Bruno's appeal focuses on increased flood hazard exposure in the Belle Air neighborhood. The City of South San Francisco's appeal focuses on increased flood hazard exposure in the Lindenville neighborhood. Both cities contracted with Moffatt & Nichol (M&N) to assist in preparing the information required as part of the appeal process. With the exception of the locations involved, the appeal justifications, documents, methodologies, and reports are essentially identical. Similarly, the basis for appeal, for both cities, are essentially identical.

Both appeals, one lodged by each city, cite the presence of scientific error in the preliminary FIRMs. Specifically, each appeal claims that the proposed Base Flood Elevations (BFEs) and designations of the identified Special Flood Hazard Areas (SFHAs) are scientifically incorrect. Each appellant believes that FEMA's methodology of mapping all areas below the BFE contiguous to a flooding source (i.e., the Natural Valley approach, see FEMA 2013) leads to overly conservative estimates of flood extents within the subject neighborhoods. Each appeal claims that an alternative analysis, performed by their contractor (M&N), results in "significantly less" coastal flooding in the target neighborhoods. Both appeals cite the following as the basis of their appeal, "**… alternative methods or applications result in more correct estimates of base flood elevations, thus demonstrating that FEMA's estimates are incorrect (44 CFR §67.6)**."

Data Submitted by the Community and FEMA

The following data used to generate the challenged flood elevations and the contesting data submitted by the City of San Bruno (CA) and the City of South San Francisco (CA), as well as documents submitted by FEMA, were provided to the Panel for their consideration:

- **"**FEMA Region IX Floodplain Mapping TSDN San Mateo County, California: A Central San Francisco Bay Coastal Flood Hazard Study," by BakerAECOM (October 2014)
- "A Central San Francisco Bay Coastal Flood Hazard Study: San Francisco County, California Study Report," by BakerAECOM (11/2/2012)
- "A Central San Francisco Bay Coastal Flood Hazard Study: San Mateo County, California Coastal Analysis Report," by BakerAECOM (7/25/2014)
- "A Central San Francisco Bay Coastal Flood Hazard Study: San Francisco County, California Coastal Analysis Report," by BakerAECOM (6/9/2015)
- "Analysis and Mapping Procedures for Non-Accredited Levee Systems, New Approach," by FEMA (July 2013)
- "Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States," by Northwest Hydraulic Consultants (November 2004, rev. January 2005)
- "Regional Coastal Hazard Modeling Study for North and Central San Francisco Bay, Final Draft Report," by DHI (10/21/2011)
- San Mateo County, CA FIS Reports for the years 1986, 2012, 2015, 2017
- Revised FIS Reports for San Mateo County, California Volumes 1 and 2 (revised 8/13/2015)
- San Mateo Preliminary FIRM panels (33)
- "San Francisco Bay Tidal Datums and Extreme Tides Study, Final Report," by AECOM (February 2016)
- "Extreme Storms in San Francisco Bay – Past to Present, Final Report," by AECOM (April 2016)
- Appeal request from the City of South San Francisco to FEMA (August 24, 2016)
- FEMA's appeal confirmation to the City of South San Francisco (September 2, 2016)
- FEMA's appeal response and related correspondence with the City of South San Francisco (November 10, 2016, see Appendix A)

- NIBS SRP request and notification correspondence between FEMA and the City of South San Francisco (December 9, 2016)
- City of South San Francisco Community Submittal Agreement (October 17, 2017)
- "FEMA APPEAL DOCUMENT, City of South San Francisco" by Moffatt & Nichol (8/19/2016)
    - Associated digital data submissions including the XP-SWMM model files, model inputs and outputs in ArcGIS format, and model scenario animations showing the time-dependent flooding for the 1% and 0.2% annual chance flood events.
- Appeal request from the City of San Bruno to FEMA (August 23, 2016)
- FEMA's appeal confirmation to the City of San Bruno (September 2, 2016)
- FEMA's appeal response and related correspondence with the City of San Bruno (November 10, 2016, see Appendix B)
- NIBS SRP request and notification correspondence between FEMA and the City of San Bruno (December 9, 2016)
- City of San Bruno Community Submittal Agreement (September 25, 2017)
- "FEMA APPEAL DOCUMENT, City of San Bruno" by Moffatt & Nichol (8/19/2016)
    - Associated digital data submissions including the XP-SWMM model files, model inputs and outputs in ArcGIS format, and model scenario animations showing the time-dependent flooding for the 1% and 0.2% annual chance flood events.
- Correspondence/information submitted AFTER the appeal period (received by SRP March 2018)
    - Letter from Jimmy Tan, Public Works Director/City Engineer for the City of San Bruno to Dominique Fernandez, NIBS Director, dated February 22, 2018
    - Minutes of the meeting, "Flood Risk Review Meeting, California Coastal Analysis and Mapping Project – San Francisco Bay Area Coastal Study" held October 1, 2014 in Redwood City, CA
    - FEMA San Francisco Bay Area Coastal Study Frequently Asked Questions document dated June 2014

Summary of Panel Procedures

The work of this SRP was performed over the period January 4, 2018 to May 1, 2018. The panel convened by phone three times during the review period, and once more for the purpose of listening to presentations by FEMA and the appellant. Below is a brief summary of the panel's work.

The panel was officially formed and called to order during a conference call held on January 4, 2018. During that call, which was led by NIBS Institute Director, Ms. Dominique Fernandez, panelists were informed of the SRP policies and procedures; the scope and responsibilities of the panel; limitations on material review and final decisions; confidentiality; panel schedule; and use of the SRP website for obtaining appeal materials. A panel chair (Dr. Bret Webb) was appointed during that call.

The panel met again by phone on January 29, 2018 for the purpose of discussing the reports and data submitted as part of the appeal process. The primary data sources were summarized in the preceding

section. The discussion during this call primarily focused on whether the appellants' submitted information supported their claims of scientific or technical errors as defined by 44 CFR 67.6. The panel developed a list of questions for FEMA and the appellants. These questions (see Appendix C) were submitted to both parties, by Ms. Fernandez, in advance of their presentations to the panel on February 8, 2018.

The panel reconvened by web conference on February 8, 2018. During that meeting, the panel listened to presentations by the appellants and FEMA (and their designated appointees). That meeting began with an overview of the agenda and information about how the meeting would be conducted, both of which were provided by Ms. Fernandez. Ms. Connie Jackson, Manager for the City of San Bruno (CA), provided opening remarks for the panel, restating many of the points raised in the appeal packages. The appellants' representative, Moffatt & Nichol, then gave a presentation highlighting their work performed and submitted as part of the appeals process. A contractor for FEMA Region IX, Kris May, then gave a presentation of their work on the Bay Area Coastal Study and brief explanations of why the appellants' claims lacked merit. FEMA and Moffatt & Nichol then provided responses to the panel questions submitted prior to the meeting.

The panel met again by phone on March 5, 2018. The purpose of this call was to formulate a decision regarding whether the appellants' originally submitted materials supported their claims of technical and/or scientific errors. During that call, the panelists identified approximately six unique rationale supporting their final decision. Newly submitted materials by the appellants and FEMA (as of March 2018) were also briefly discussed. Those materials were submitted in response to questions regarding the riverine-coastal flood tie-ins that were raised during the February 8 presentations. Those materials, while briefly mentioned below, did not play any role in the panel's final recommendations regarding this appeal as they were beyond the scope of our deliberation.

The panel's final report was drafted during the period March 5, 2018 to April 20, 2018.

Recommendation

The panel recommends that both appeals be denied. The panelists were unanimous in their decision to deny the appeal. This recommendation is the result of thoughtful consideration of the materials submitted by the appellants, as well as the justifications they provide for their appeals of the preliminary FIRMs. The rationale for the panel's recommendation is outlined in the subsequent section. Briefly, the panel's recommendation is based on two general conclusions. First, the appellants did not submit all of the materials required as part of an appeals process (FEMA 2009), namely neither city submitted proposed revisions to the 2015 preliminary FIRM or Flood Insurance Study products (Standard 390). Second, the methodology and model application used to derive the alternative flood hazard inundation areas contain serious weaknesses, and the panel does not find the appellants' estimates of BFEs to be "more correct" as per the basis of their appeal.

Rationale for Findings

In support of the panel's recommendation for denying the appeals lodged by the City of San Bruno (CA) and the City of South San Francisco (CA), the following six justifications are provided. The rationales are enumerated below, and then further statements are provided for each. There is some general overlap between the justifications listed below and those provided by FEMA in response to the appeal of each city (see Appendices A and B). However, the panel developed their own unique comments to serve as rationale for each of the six topics that they determined to be most relevant to supporting the recommendation for denial.

1. The appeal did not meet NFIP requirements regarding the submission of required data products, namely the preparation of revised FIRMs and FIS information;
2. The numerical modeling and analyses did not consider model calibration, model verification, sensitivity to model parameters and forcing conditions, and uncertainty in the model inputs and outputs;
3. The mixture of response- and event-based approaches for simulating the time-dependent flood hazard conditions of each area is inconsistent with flood mapping procedures and lacked suitable justification;
4. The proposed flood inundation areas resulting from the time-dependent modeling are not well-defined because of their inability to define the probability distribution of duration for the 1% annual chance coastal flood event;
5. Components of the appeal methodology do not follow FEMA procedures and guidance for modeling non-accredited levee systems and features as described in "Analysis and Mapping Procedures for Non-Accredited Levee Systems" dated July 2013; and
6. The appellants did not consider flood hazards resulting from combined riverine and coastal flooding and did not perform any tie-ins between their estimated coastal flooding and an existing riverine flood hazard area.

Rationale 1: Failure to Provide Required Mapping Products

The appeal did not meet NFIP requirements regarding the submission of required data products, namely the preparation of revised FIRMs and FIS information. The appeal packages for both municipalities contained images showing the maximum depth of inundation under the 1% and 0.2% annual chance flood events across the model domain only. For example, see Figures 19 and 20 in the City of San Bruno appeal package (M&N 2016a), and Figures 20 and 21 in the City of South San Francisco appeals document (M&N 2016b). Note that 1) the appellants provided images of flood inundation depths, not BFEs; 2) there were no SFHAs identified; 3) flood boundaries were not identified; 4) no consideration was given to "tying in" newly computed coastal flood hazards with existing riverine flood hazards previously mapped (see also Rationale 6 below); and 5) no modifications to the FIS text, data, or tables were provided. During the Question & Answer period of the February 8, 2018 presentations, the appellants' contractor (M&N) confirmed they had not prepared any revised FIRMs or FIS products as part of their work. This a procedural error (FEMA 2009), and it also made it impossible for the panel to

provide a determination regarding the difference between FEMA FIRMs and an alternative modeling methodology because direct comparisons between the preliminary and proposed/revised FIRMs could not be made.

Rationale 2: Numerical Modeling & Analyses

The numerical modeling and analyses did not consider model calibration, model verification, sensitivity to model parameters and forcing conditions, and uncertainty in the model inputs and outputs. It is highly unusual to apply a numerical model without any type of calibration or verification, particularly when the area of interest are rare events. In some cases, it does happen, including FEMA Flood Insurance Studies (FIS). However, when used as the basis of an FIS appeal to suggest that other validated model results are less accurate, the lack of these standard modeling procedures is a serious concern. During the February 8, 2018 presentations, the appellants' contractor, M&N, stated that some sensitivity analyses were performed relative to model parameters such as resolution and time step. However, those results were not provided as part of the appeal packages. Furthermore, no information pertaining to the model's sensitivity to forcing conditions was provided, although M&N claimed to have performed time-dependent simulations while holding the design water level condition static at the offshore boundary. Such results were not provided as part of the appeal packages. Finally, the appellants did not address the uncertainty inherent in their model inputs and outputs. For example, model simulations using varied Manning's roughness coefficients, or culvert entrance/exit loss coefficients, were not performed to assess the model's sensitivity to such parameters. If such simulations were performed, their results were not provided in the appeal documentation.

As the basis of their appeal, the appellants claim that their time-dependent modeling approach provides "more correct estimates of base flood elevations" in the Belle Air and Lindenville neighborhoods. However, the panel finds that the appellants' results, for reasons specified previously and elsewhere in this report, cannot be justified as "more correct" than the preliminary FIRMs for the subject areas. Therefore, the appellants' claims that FEMA's preliminary FIRMs are scientifically incorrect are impossible to substantiate, and the results of their simulations and analyses do not correct, contradict, or negate FEMA's data.

Rationale 3: Mixture of Response- and Event-Based Approaches

The mixture of response- and event-based approaches for simulating the time-dependent flood hazard conditions of each area is inconsistent with flood mapping procedures and lacked suitable justification. In determining the forcing conditions for their time-dependent XP-SWMM model scenarios, the appellants selected a still water flood elevation slightly larger than the 1% annual chance flood elevation reported in the Bay Area Coastal Study reports for San Mateo County (BakerAECOM 2014a, 2014b) and San Francisco County (BakerAECOM 2012, 2015), and adopted this as the design flood elevation for their appeal (i.e., a response-based approach). An observed flood event with the longest duration on record (record length ~54 years, DHI 2011) was selected, and the elevation of that flood hydrograph scaled, to match the design flood elevation previously mentioned (i.e., an event-based approach). Existing FEMA mapping procedures and guidelines for the Pacific Coast (FEMA 2005) call for the use of "system

response analyses" because of the nature of processes that control extreme water levels in the region. The appellants' mixture of response- and event-based approaches ultimately results in a flood scenario that cannot be characterized as a 1% annual chance flood event. Furthermore, there is no probability associated with the appellants' selected flood duration, making direct comparisons between FEMA's preliminary FIRMs and the appellants' provided inundation depths untenable.

Rationale 4: Failure to Produce Probabilistic Results

The proposed flood inundation areas resulting from the time-dependent modeling are not well-defined because of their inability to define the probability distribution of duration for the 1% annual chance coastal flood event. As described in Rationale 3 above, the appellants selected a storm having the longest duration of elevated water levels from an observation record approximately 54 years in length (DHI 2011). Analysis demonstrating the statistical probability of this flood event duration was not provided. Furthermore, the potential joint probability of coastal flood event durations and elevations was not considered during development of model forcing conditions. Because the model forcing conditions are ill-defined in terms of probability (e.g., water level based on probability analysis and duration selected from a discrete event from the observation record), direct comparisons between the appellants' results and FEMA's preliminary FIRMs are not possible.

Rationale 5: Failure to Follow FEMA Guidelines

Components of the appeal methodology do not follow FEMA procedures and guidance for modeling non-accredited levee systems and features as described in "Analysis and Mapping Procedures for Non-Accredited Levee Systems" dated July 2013 (FEMA 2013). This document, also known as Levee Analysis Mapping Procedures (LAMP), outlines approved procedures for accounting for non-accredited flood protection structures, including levee systems. While such structures are retained in the modeling of wave propagation, they are supposed to be removed when propagating the final flood surface across the coastal terrain. There is an assumption in LAMP that such features serve to dissipate wave energy, but cannot be guaranteed to provide flood protection during the design (e.g., 1% or 0.2% annual chance) condition. Non-accredited structures and levee systems were not removed from the terrain data used in the M&N XP-SWMM model simulations (M&N 2016a, 2016b). For example, the appellants' model results suggest that Highway 101 provides significant protection for the Belle Air neighborhood in the City of San Bruno, forcing all flood conveyance to remain in streams, channels, and culverts (M&N 2016a, 2016b). The appellants made no attempt to evaluate the system's response to removal of Highway 101 by lowering the topographic elevations. Highways and roads are typically assumed to be static features during time-dependent model simulations, but they are not always accredited flood protection structures. Therefore, some analysis regarding the effects of their removal, via terrain lowering, would have been both prudent and consistent with guidelines in FEMA (2013).

Rationale 6: Failure to Consider Combined Riverine and Coastal Flood Hazards

The appellants did not consider flood hazards resulting from combined riverine and coastal flooding and did not perform any tie-ins between their estimated coastal flooding and an existing riverine flood hazard area. The appellants did not account for existing riverine flood hazards in determining their

alternative coastal flood inundation depths after completing the time-dependent modeling analyses. Specifically, the City of South San Francisco did not account for the existing riverine flood hazards in the Lindenville neighborhood. The mapped BFEs and SFHAs should be the maximum of the riverine and coastal surge flooding where they overlap. The existing riverine flood hazard, and how it might impact the proposed time-dependent flood hazard elevation, was not considered or addressed in the appellants' submittals. The requirement to account for "… all tie-ins to surrounding Preliminary and Effective FIRM mapping" was specifically noted in item #6 of FEMA's response[1] to the City of South San Francisco dated November 10, 2016.

References

BakerAECOM (2015). "A Central San Francisco Bay Coastal Flood Hazard Study: San Francisco County, California Coastal Analysis Report." June 9, 2015.

BakerAECOM (2012). "A Central San Francisco Bay Coastal Flood Hazard Study: San Francisco County, California Study Report." November 2, 2012.

BakerAECOM (2014a). "A Central San Francisco Bay Coastal Flood Hazard Study: San Mateo County, California Coastal Analysis Report." July 25, 2014.

BakerAECOM (2014b). **"**FEMA Region IX Floodplain Mapping TSDN San Mateo County, California: A Central San Francisco Bay Coastal Flood Hazard Study." October 2014.

DHI (2011). "Regional Coastal Hazard Modeling Study for North and Central San Francisco Bay, Final Draft Report." October 21, 2011.

FEMA (2009). "Appeals, Revisions, and Amendments to National Flood Insurance Program Maps. A Guide for Community Officials." Federal Emergency Management Agency.

FEMA (2005). "Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States." January 2005.

FEMA (2013). "Analysis and Mapping Procedures for Non-Accredited Levee Systems, New Approach." July 2013.

M&N (2016a). "FEMA Appeal Document, City of San Bruno." Moffat & Nichol, August 19, 2016.

M&N (2016b). "FEMA Appeal Document, City of South San Francisco." Moffat & Nichol, August 19, 2016.

[1] FEMA appeal resolution letter addressed to Mayor Mark Addiego, City of South San Francisco, dated November 10, 2016.

Appendix A

U.S. Department of Homeland Security
1111 Broadway, Suite 1200
Oakland, California 94607

FEMA

IN REPLY REFER TO: APPEAL RES

November 10, 2016

The Honorable Mark Addiego
Mayor, City of South San Francisco
400 Grand Avenue
South San Francisco, California 94080

Case No.:	11-09-1227S
Community Name:	City of South San Francisco San Mateo County, California
Community No.:	065062

RE: California Coastal Analysis and Mapping Project / Bay Area Coastal Study

Dear Mayor Addiego:

This letter responds to the August 24, 2016, submittal from the City of South San Francisco (and supported by San Mateo County) regarding the Preliminary Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) report for San Mateo County, California dated August 13, 2015. The submittal included a letter dated August 24, 2016, and an August 19, 2016 report concerning the proposed Special Flood Hazard Area (SFHA), Base Flood Elevations (BFEs), flood depths, and flood risk zones caused by overland flooding and wave effects from San Francisco Bay as presented on the City of San Bruno Preliminary FIRM panels 06081C0043F and 06081C0044F.

The City of South San Francisco's submittal is considered an appeal because it satisfied the requirements defined in Title 44, Chapter I, Part 67 of the Code of Federal Regulations (44 CFR Part 67), and was submitted during the 90-day appeal period for the aforementioned Preliminary FIRM and FIS report.

The appeal submitted by the City of South San Francisco includes an August 19, 2016 report prepared by Moffatt & Nichol entitled "FEMA APPEAL DOCUMENT, City of South San Francisco" (hereinafter referred to as the M&N Report). Along with the M&N Report, there was a digital data submission organized by modeling scenarios discussed in Section 3.3 of the M&N Report. The data for each scenario included XP-SWMM 1D/2D integrated hydraulic model files, model inputs and outputs in ArcGIS format, and an animation showing the inundation during the simulated flood event.

The City of South San Francisco letter and M&N Report asserts that the methodology used to generate the coastal floodplain boundaries (SFHA) and BFEs inland of San Francisco Bay in the area of South San Francisco, and specifically for the Lindenville neighborhood, as shown on the August 13, 2015 Preliminary FIRM panels is technically incorrect.

FEMA received all data necessary to resolve this appeal on August 24, 2016.

The City of South San Francisco letter contends that its appeal is supported by new overland flow modeling with limited duration flooding. The approach will account for high tide flows from San Francisco Bay that are unsteady and not in a "static state," and better determines the 1-percent-annual-chance SFHA and BFEs when included in the XP-SWMM modeling. The M&N Report and supporting documentation submitted as part of the City of South San Francisco appeal assert that the Preliminary

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FIRM methodology utilizes overly simplistic assumptions, including representation of the stillwater flood level from the San Francisco Bay as a static (steady state) water surface influencing the flood inundation mapping. As a result, the M&N Report suggests the 1-percent-annual-chance flood hazards represented in the Preliminary FIRM are overstated, and that flooding in the Lindenville neighborhood is not accurately depicted given the complex hydraulic connectivity and distance inland from San Francisco Bay.

The M&N Report and supporting documentation are the basis of assertions that the City of South San Francisco's alternative modeling provides a more refined definition of the existing conditions 1-percent-annual-chance flood hazard using a dynamic hydraulic analysis approach to determine overland flows in the appeal area. The submitted analysis consists of use of the "XP-SWMM model which is a fully dynamic hydraulic and hydrologic modeling software that combines 1D calculations for upstream to downstream flow with 2D overland flow calculations" (M&N Report, Section 3). The model also includes the base fluvial flows from Colma Creek as discharges into San Francisco Bay. The alternative modeling is purported to provide a better estimation of the overland flow processes and amount of tidal floodwaters that can pass into and out of the Bay, creeks, channels and low-lying floodplains.

We have examined the M&N Report and all submitted supporting documentation. The following is a discussion of the deficiencies found in the appeal methodology:

(1) The appeal did not claim there were any errors with FEMA's Bay Area Coastal Study modeling approach, but asserted that the approach was generalized and therefore overstated the hazard in comparison with the XP-SWMM modeling approach. The M&N Report also did not use any of the Bay Area Coastal Study analysis of wave effects and overland wave propagation analysis, since the appeal area is inland and removed from any wave effects. In general, the modeling presented in the M&N Report provides an alternative approach to the steady state approach (constant water level) used by FEMA for SFHA and BFE mapping, but no justification for why the City of South San Francisco believes the Preliminary FIRM and FIS is scientifically or technically incorrect. The M&N Report states that the Preliminary FIS approach to map coastal flooding limits using a steady-state (static) 1-percent-annual-chance stillwater elevation (SWEL) and projecting that static water level inland from the San Francisco Bay shoreline is overly simplistic and significantly overstates the SFHA boundaries, BFEs, and base flood depths, but does not provide any evidence that the study is scientifically or technically incorrect.

(2) The M&N Report's primary appeal concern is with the FEMA-adopted method for the Bay Area Coastal Study, which assumes the "Natural Valley" or "Without Levee" approach. In this approach, the 1-percent- annual-chance SWEL is extended behind or landward of non-accredited structures and non-levee embankments to a point where the SWEL floodplain boundaries are equal to controlling ground elevations. In the appeal areas, this would be a flood elevation of approximately 10.4 feet NAVD88. This approach adopted in San Francisco Bay is detailed in the FEMA July 2013 report "Analysis and Mapping Procedures for Non-Accredited Levee Systems" (also known as the Levee Analysis Mapping Procedure, LAMP) and has been deemed by FEMA to be the appropriate procedure for application landward of the San Francisco Bayfront in the absence of new modeling.

(3) The M&N Report proposes an alternative approach using the XP-SWMM and XP-2D models, which covers the City of South San Francisco and City of San Bruno appeal areas. (The resolution of the City of San Bruno submittal is handled separately from this appeal by the City of South San Francisco). The XP-SWMM model used in this submittal is an accepted computer program for FISs, but has not been applied in any of the recently adopted FEMA Bay Area Coastal Studies. The M&N Report presents this alternative modeling approach with the claim that

it can better account for the rise and fall of the tide and the flow over and around topographic features such as San Francisco Airport (SFO), and flow up streams, creeks and channel hydraulically linked from the San Francisco Bay flood source to the appeal area (and the Lindenville neighborhood). However, the M&N Report on upstream to downstream and overland flows in the XP-SWMM model did not provide any calibration or comparative analysis between measured data and computed results. Without validation, the modeling domain cannot be verified as being able to replicate the surge and tidal inundation processes for overland flow and flood routing up channels and streams.

(4) The "design storm" hydrograph used in this submittal is event-based and developed to represent a single event consistent with a 1-percent-annual-chance flood. The M&N Report noted that the configuration of peak tides and flood duration is based on three historic coastal flood events in January 1983, December 1983, and February 1988. The resulting combination is scaled to a peak storm tide of 10.4 feet NAVD88 equal to a 1-percent-annual-chance flood level used in the Preliminary FIS and FIRM at the boundary with San Francisco Bay. The hydrograph used in this submittal was based on measured event data for the January 1983 storm, December 1983 event, and February 1988 event as recorded at the NOAA Alameda gage. It was not clear why more representative local gage measurements for the three events along the western bay shoreline were not used, such as those measurements at NOAA tide gages at Oyster Point Marina (NOAA #4392) and San Mateo Bridge (NOAA #4458), located north and south of the appeal area.

(5) The most notable deficiency found in the M&N Report and technical approach is the use of the event-based approach, which conflicts with the latest recommendations developed by FEMA for the Pacific Coast region in 2005 for use in San Francisco Bay and open Pacific coast. In this FEMA Pacific coast guidance, an approach was presented for evaluating the 1-percent-annual-chance flood, based on the concept of "system response analyses" rather than traditional "event analyses." This means that the open waters of inland bays and oceans should follow the response approach, which uses a historic record of measured or predicted wave conditions along with simultaneously measured or predicted water-levels to determine site-specific storm response parameters, such as maximum water levels at points of interest. This approach is more robust than an event analysis that relies on a set time-dependent wave level condition with a specific duration. To be consistent with a "system response analysis," the appeal should have utilized water levels driven by the FEMA 54-year hindcast study as boundary condition forcing to the XP-SWMM modeling. This would allow for the largest response from each of the 54 years to be used as annual maxima for the entire period of record and analyzed (by statistical analysis) to determine the 1-percent-annual-chance flood response for overland flow conditions. Any new modeling should follow the FEMA Pacific region guidance and use of the existing spatially varying 54-year time series along the boundary for tidal forcing.

(6) NFIP regulations require submittal of the proposed map and resulting revisions to the Preliminary FIRM and FIS. This would be included in a digital data submission for Preliminary FIRM revisions, and show the flooding limit boundaries of the 1-percent-annual-chance SFHAs, BFEs, and all tie-ins to surrounding Preliminary and Effective FIRM mapping. Revisions to the Preliminary FIS should include all changes to the text, tables, and figures describing the revised modeling approach and revised results to be shown on a Revised Preliminary FIRM. In review of the City of South San Francisco appeal submittal, we found no such proposed revisions to the August 13, 2015 Preliminary FIRM or FIS products.

We have resolved this appeal in accordance with the requirements of 44 CFR Part 67. We have reviewed the submitted data, assumptions, and modeling and determined that the preliminary SFHA, BFEs, flood

depths, and flood risk zones for coastal flooding from the San Francisco Bay into the appeal area are correct as shown on the August 13, 2015 Preliminary FIRM and in the Preliminary FIS report. Therefore, no change is warranted at this time. Please submit any comments regarding this appeal resolution within 30 days of the date of this letter to the following address:

FEMA Region IX, Mitigation Division
1111 Broadway, Suite 1200
Oakland, California 94607
Attention: Juliette Hayes, Chief
Risk Analysis Branch

If you feel that the technical issues originally raised have not been adequately addressed by this resolution letter and that an acceptable resolution will not be feasible through the submittal of additional comments or revised modeling, as outlined above, please note that FEMA makes a Scientific Resolution Panel (SRP) available to support the resolution process. SRPs are independent panels of experts in hydrology, hydraulics, and other pertinent sciences established to review conflicting scientific and technical data and provide recommendations for resolution. An SRP is an option after FEMA and a local community has been engaged in a collaborative consultation process without a mutually acceptable resolution.

Your community may contact Juliette Hayes, FEMA Risk Analysis Branch Chief, by telephone at (510) 627-7211 or by email at juliette.hayes@fema.dhs.gov for information on the specific eligibility requirements for the SRP or refer to the enclosed SRP Fact Sheet. To request that an SRP review your scientific or technical data, your agency and impacted communities must complete the enclosed SRP Request Form and submit it to the address above within 30 days of the date of this letter.

If we do not receive any comments or the completed SRP Request Form from your community during the 30-day review period associated with this resolution, we will finalize the Preliminary FIRM and FIS report for San Mateo County and the appeal area by issuing Letters of Final Determination. The letters to the impacted communities explain the adoption/compliance process and state the date when the Preliminary FIRM and FIS report will become effective.

We appreciate the City of South San Francisco's comments and commitment to having the most accurate flood hazard information available reflected on the FIRM and in the FIS report for San Mateo County. If you have any questions regarding this matter, please contact Juliette Hayes at (510) 627-7211 or juliette.hayes@fema.dhs.gov.

Sincerely,

Juliette Hayes, Chief
Risk Analysis Branch

The Honorable Mark Addiego
November 10, 2016
Page 5 of 5

Enclosures:
SRP Fact Sheet
SRP Request Form

cc: Ray Towne, Acting Director of Public Works/City Engineer
Dave Pine, San Mateo County Supervisor, District 1
Brian Perkins, Representative Jackie Speier's Office, 14th District
James Eto, State NFIP Coordinator, Department of Water Resources

bcc: Juliette Hayes, Chief, Risk Analysis Branch, FEMA Region IX
Shilpa Mulik, Regional Engineer, FEMA Region IX
Xing Liu, Natural Hazards Program Specialist, FEMA Region IX
Case File
FEDD File

Appendix B

U.S. Department of Homeland Security
1111 Broadway, Suite 1200
Oakland, California 94607

FEMA

IN REPLY REFER TO: APPEAL RES

November 10, 2016

The Honorable Jim Ruane
Mayor, City of San Bruno
567 El Camino Real
San Bruno, California 94066-4299

Case No.: 11-09-1227S
Community: City of San Bruno
San Mateo County, California
Community No.: 060326

RE: California Coastal Analysis and Mapping Project / Bay Area Coastal Study

Dear Mayor Ruane:

This letter responds to the August 23, 2016, submittal from the City of San Bruno (and supported by San Mateo County) regarding the Preliminary Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) report for San Mateo County, California dated August 13, 2015. The submittal included a letter dated August 23, 2016, and an August 19, 2016 report concerning the proposed Special Flood Hazard Area (SFHA), Base Flood Elevations (BFEs), flood depths, and flood risk zones caused by overland flooding and wave effects from San Francisco Bay as presented on the City of San Bruno Preliminary FIRM panels, 06081C0043F, 06081C0044F, 06081C0131F, and 06081C0132F.

The City of San Bruno's submittal is considered an appeal because it satisfied the requirements defined in Title 44, Chapter I, Part 67 of the Code of Federal Regulations (44 CFR Part 67), and was submitted during the 90-day appeal period for the aforementioned Preliminary FIRM and FIS report.

The appeal submitted by the City of San Bruno includes an August 19, 2016 report prepared by Moffatt & Nichol entitled "FEMA APPEAL DOCUMENT, City of San Bruno" (hereinafter referred to as the M&N Report). Along with the M&N Report, there was a digital data submission organized by modeling scenarios discussed in Section 3.3 of the M&N Report. The data for each scenario included XP-SWMM 1D/2D integrated hydraulic model files, model inputs and outputs in ArcGIS format, and an animation showing the inundation during the simulated flood event.

The City of San Bruno letter and M&N Report asserts that the methodology used to generate the coastal floodplain boundaries (SFHA) and BFEs inland of San Francisco Bay in the area of San Bruno, and specifically for the Belle Air neighborhood, as shown on the August 13, 2015 Preliminary FIRM panels is technically incorrect.

FEMA received all data necessary to resolve this appeal on August 24, 2016.

The City of San Bruno letter contends that its appeal is supported by new overland flow modeling with limited duration flooding. The approach will account for high tide flows from San Francisco Bay that are unsteady and not in a "static state," and better determines the 1-percent-annual-chance SFHA and BFEs when included in the XP-SWMM modeling. The M&N Report and supporting documentation submitted as part of the City of San Bruno appeal assert that the Preliminary FIRM methodology utilizes overly simplistic assumptions, including representation of the stillwater flood level from the San Francisco Bay

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as a static (steady state) water surface influencing the flood inundation mapping. As a result, the M&N Report suggests the 1-percent-annual-chance flood hazards represented in the Preliminary FIRM are overstated, and that flooding in the Belle Air neighborhood is not accurately depicted given the complex hydraulic connectivity and distance inland from San Francisco Bay.

The M&N Report and supporting documentation are the basis of assertions that the City of San Bruno's alternative modeling provides a more refined definition of the existing conditions 1-percent-annual-chance flood hazard using a dynamic hydraulic analysis approach to determine overland flows. The submitted analysis consists of use of the "XP-SWMM model which is a fully dynamic hydraulic and hydrologic modeling software that combines 1D calculations for upstream to downstream flow with 2D overland flow calculations" (M&N Report, Section 3). The alternative modeling is purported to provide a better estimation of the overland flow processes and amount of tidal floodwaters that can pass into and out of the Bay, creeks, channels and low-lying floodplains.

We have examined the M&N Report and all submitted supporting documentation. The following is a discussion of the deficiencies found in the appeal methodology:

(1) The appeal did not claim there were any errors with FEMA's Bay Area Coastal Study modeling approach, but asserted that the approach was generalized and therefore overstated the hazard in comparison with the XP-SWMM 1D/2D modeling approach. The M&N Report also did not use any of the Bay Area Coastal Study analysis of wave effects and overland wave propagation analysis, since the appeal area is inland and removed from any wave effects. In general, the modeling presented in the M&N Report provides an alternative approach to the steady state approach (constant water level) used by FEMA for SFHA and BFE mapping, but no justification for why the City of San Bruno believes the Preliminary FIRM and FIS is scientifically or technically incorrect. The M&N Report states that the Preliminary FIS approach to map coastal flooding limits using a steady-state (static) 1-percent-annual-chance stillwater elevation (SWEL) and projecting that static water level inland from the San Francisco Bay shoreline is overly simplistic and significantly overstates the SFHA boundaries, BFEs, and base flood depths, but does not provide any evidence that the study is scientifically or technically incorrect.

(2) The M&N Report's primary appeal concern is with the FEMA-adopted method for the Bay Area Coastal Study, which assumes the "Natural Valley" or "Without Levee" approach. In this approach the 1-percent- annual-chance SWEL is extended behind or landward of non-accredited structures and non-levee embankments to a point where the 1-percent-annual-chance SWEL floodplain boundaries are equal to controlling ground elevations. In the appeal areas, this would be a flood elevation of approximately 10.4 feet NAVD88. This approach adopted in San Francisco Bay is detailed in the FEMA July 2013 report, "Analysis and Mapping Procedures for Non-Accredited Levee Systems" (also known as the Levee Analysis Mapping Procedure, LAMP), and has been deemed by FEMA to be the appropriate procedure for application landward of the San Francisco Bayfront in the absence of new modeling.

(3) The M&N Report proposes an alternative approach using the XP-SWMM model, which covers the City of San Bruno and the City of South San Francisco appeal areas. (The resolution of the City of South San Francisco submittal is handled separately from this appeal by the City of San Bruno). The XP-SWMM model used in this submittal is an accepted computer program for FEMA FISs, but has not been applied in any of the recently adopted FEMA Bay Area Coastal Studies. The M&N Report presents this alternative modeling approach with the claim that it can better account for the rise and fall of the tide and the flow over and around topographic features such as San Francisco Airport (SFO), and flow up streams, creeks and channel hydraulically

linked from the San Francisco Bay flood source to the appeal area (and the Belle Air neighborhood). However, the M&N Report on upstream to downstream and overland flows in the XP-SWMM model did not provide any calibration or comparative analysis between measured data and computed results. Without validation, the modeling domain cannot be verified as being able to replicate the surge and tidal inundation processes for overland flow and flood routing up channels and streams.

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(5) The most notable deficiency found in the M&N Report and technical approach is the use of the event-based approach, which conflicts with the latest recommendations developed by FEMA for the Pacific Coast region in 2005 for use in San Francisco Bay and open Pacific coast. In this FEMA Pacific coast guidance, an approach was presented for evaluating the 1-percent-annual-chance flood, based on the concept of "system response analyses" rather than traditional "event analyses." This means that the open waters of inland bays and oceans should follow the response approach, which uses a historic record of measured or predicted wave conditions along with simultaneously measured or predicted water-levels to determine site-specific storm response parameters, such as maximum water levels at points of interest. This approach is more robust than an event analysis that relies on a set time-dependent wave level condition with a specific duration. To be consistent with a "system response analysis," the appeal should have utilized water levels driven by the FEMA 54-year hindcast study as boundary condition forcing to the XP-SWMM modeling. This would allow for the largest response from each of the 54 years to be used as annual maxima for the entire period of record and analyzed (by statistical analysis) to determine the 1-percent-annual-chance flood response for overland flow conditions. Any new modeling should follow the FEMA Pacific region guidance and use of the existing spatially varying 54-year time series along the boundary for tidal forcing.

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FEMA Region IX, Mitigation Division
1111 Broadway, Suite 1200
Oakland, California 94607
Attention: Juliette Hayes, Chief
Risk Analysis Branch

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We appreciate the City of San Bruno's comments and commitment to having the most accurate flood hazard information available reflected on the FIRM and in the FIS report for San Mateo County. If you have any questions regarding this matter, please contact Juliette Hayes at (510) 627-7211 or juliette.hayes@fema.dhs.gov.

Sincerely,

Juliette Hayes, Chief
Risk Analysis Branch

Enclosures:
SRP Fact Sheet
SRP Request Form

cc: Brian Perkins, Representative Jackie Speier's Office, 14th District
Dave Pine, San Mateo County Supervisor, District 1
Jimmy Tan, San Bruno Deputy Public Services Director/City Engineer
James Eto, State NFIP Coordinator, Department of Water Resources

The Honorable Jim Ruane
November 10, 2016
Page 6 of 5

bcc: Juliette Hayes, Chief, Risk Analysis Branch, FEMA Region IX
Shilpa Mulik, Regional Engineer, FEMA Region IX
Xing Liu, Natural Hazards Program Specialist, FEMA Region IX
Case File
FEDD File

Appendix C

The following questions for FEMA and the appellant were prepared by the panel and submitted by NIBS to each party prior to the presentations provided on February 8, 2018.

Questions for FEMA:

1. In Comment #1 FEMA noted that the M&N report "*also did not use any of the Bay Area Coastal Study analysis of wave effects and overland propagation, since the appeal is inland and removed from any wave effects"* but the end of the comment does not note that the lack of wave analysis in the M&N report is an issue of concern. Is this lack of wave analysis a concern to FEMA?

2. In Comment #3 FEMA noted that the M&N report did not provide evidence of the calibration or validation of the XP-SWMM model application for the two study areas. The City's response was that no data were available for model calibration/validation and in particular data without uncertified levees present. What did FEMA expect in the absence of data for model calibration and validation to show that the model application to the study area was useful?

3. In performing hydrodynamic model hindcasts for the study area (DHI, 2011) simulations were performed with and without certified levees present. The latter is consistent with the methodology FEMA recommends for uncertified levees. The results show that the water level is lower in the case when uncertified levees are removed (see Figure 4.5 and 4.6). FEMA elected to use the with uncertified levees present assumption case. What is the rationale for this decision?

4. In Comment #4 FEMA asks why data from (Oyster Point #4392 and San Mateo Bridge #4458) were not used for the three largest storm events rather than data at Alameda gage. Table 6.6 and 6.7 from the DHI (2011) report shows the data availability at all stations for the top 13 storm events. Data were available for the Jan 27, 1983 event at Oyster Point and San Mateo Bridge, for the Dec 1983 event at San Mateo but not Oyster Point, and for the Feb 1998 event at neither of these two stations. Is the DHI report incorrect in terms of data availability at these locations?

5. In Comment #5, FEMA advocates the use of a response based approach to flood mapping based on hindcasts of the 54-year time period performed by DHI in comparison to the hybrid approach adopted by the city, where peak water levels are based on the response based approach and the duration based on an event analysis. As an alternative to your finding, could the city have not performed a return period analysis on the time series record of duration to match with similar return period analysis of water levels to force an event-based simulation?

6. Please explain what consideration is given to storm duration in the flood study for this area. Was any specific storm duration, or duration of flooding considered? If not (or if the peak flood level is considered to be stationary), can you point to specific FEMA guidance that suggest that duration be neglected (or that the peak flood level be assumed stationary)?

Questions for Appellants:

1. What steps did you take to determine if water level data were available to calibrate/validate your hydraulic model for selected storm events?

2. The analysis provided ignores wave effects. Do you think these are not important? What is your argument for not performing wave analyses? In order to calculate BFEs to compare your model predictions with FEMAs do you not need estimates of the wave conditions?

3. What was the domain of the model for each city? Same for both or separate grid systems?

4. Can you provide examples of the application of XP-SWMM 1D/2D to other locations in the Bay area? Other areas with similar surge and topography? Has XP-SWMM ever been used to model coastal flooding in this manner?

5. What is your experience in applying this model to similar types of studies/areas? What lessons were learned in these other applications that you applied in the present study?

6. According to your report and response to FEMA comments you performed neither calibration nor validation of the model for the present application because of a lack of data. In the absence of data for model calibration and validation, did you perform systematic sensitivity studies to uncertainties in model input data (e.g. topographic elevation data, frictional dissipation, model grid system, representation of levee structures, duration and amplitude of flooding)? Do you have a sense of how robust the model predictions are to uncertainties in these parameters?

7. In performing your analysis you elected to use a hybrid approach with water level data from the DHI model predictions (response based) and duration of the flooding (event based approach) from Feb 1998 storm. Why did you not analyze the DHI model time series to determine the 100 year duration for the flooding event? From your analysis is the peak flood elevation correlated or uncorrelated with peak water level?

8. Please explain in more detail why you chose to scale the storm duration the way you did. Was this a process that you developed, or can you point to specific FEMA guidance that you followed for selecting the duration?

9. In performing your comparative analysis between FEMA preliminary FIRMS and your independent analyses, you present the results for FEMA FIRMS in the form of BFEs but your results in the form of depth of inundation. (See San Bruno study, Figure 17). These are two different versions of the data and not directly comparable. Have you compared FEMA and your results using the same metric? For example, have you prepared a difference map that showing all locations where preliminary BFEs differ from those developed in your appeal?

10. How have you addressed uncertainty in your analysis? What steps have been taken to make sure the results are robust to uncertainty?

11. It appears in reviewing your simulations that small changes in the assumed duration of the flooding event can make substantial differences in the neighborhoods flooded. Did you investigate this issue?

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