

## MEMORANDUM

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**Date:** July 24<sup>th</sup>, 2017 **BKF Job Number:** 20145024-11

**Deliver To:** J. Cleve Livingston  
Laconia Development LLC

**From:** Jason White, PE

**Subject:** Terminal One - Project Design Features and Adaptive Measures to Mitigate Flood Risk Associated with 100-Year Storm Events and Sea Level Rise

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In preparation for the Engineering Criteria Review Board's consideration of the Latitude Project (also known as the Terminal One Project) at ECRB's May 24, 2017 meeting, the Board was provided a copy of BKF's January 15, 2015 memorandum addressing the subject "Evaluation of Terminal One Base Flood Elevation and Area of Inundation" (the "Hydrologic Impact Report"). This 2015 memorandum reports the results of the hydrologic/hydraulic impact evaluation performed by BKF to determine the design parameters to be followed in mitigating the flood risks associated with a 100-year storm event and with projected sea level rise.

As BKF's Hydrologic Impact Report notes, the Terminal One site is subject to the revised Flood Insurance Rate Map ("FIRM") issued by the Federal Emergency Management Agency ("FEMA") on September 30, 2015. This recently revised FEMA flood plain map indicates that a portion of the San Francisco Bay abutting the Terminal One site as well as a portion of the Terminal One shoreline underlying the existing warehouse and extending to the east, are situated within coastal Zone VE, with a Base Flood Elevation ("BFE") of 11 feet NAVD 88. Areas that are designated Zone VE are subject to inundation by a 100-year flood event with additional hazards that result from storm-induced velocity wave action by a 3-foot or higher wave.

BKF's 2015 memorandum also discusses the potential for sea level rise ("SLR") as a result of climate change and references a 2012 report prepared by BCDC and the NOAA Coastal Services Center entitled "Vulnerability and Risk Assessment Report" which predicts that sea levels will rise 16 inches by 2050 and 55 inches by 2100.

BKF presented the results of its hydrologic impact analysis to the Board at its May 24, 2017 meeting. A number of questions and comments were raised by the Board at this meeting regarding the resiliency of the Latitude Project relative to flood risks posed by a 100-year storm event in combination with projected sea level rise. The principal objectives of this memorandum are (a) to provide the Board with additional information regarding the design features and adaptive measures the purpose of which is to mitigate such flood impacts and (b) to otherwise respond to the input provided by the Board.

### **Mitigating Flood Impacts Associated with a Rise in Sea Level of up to 3 Feet**

At the May 24, 2017 ECRB meeting, the suggestion was made that, instead of using a projected increase in sea level of 16 inches by 2050 and a mid-century planning horizon as the design criteria for addressing the potential flood impacts of sea level rise on the Project, the Latitude Project should be evaluated to determine the extent

to which the design of the Project can accommodate a 3-foot increase in sea level that is assumed to occur within a 2070-2100 planning horizon. BKF has performed this evaluation with the following results.

The Latitude Project includes the following design features and adaptive measures which collectively provide most of the Latitude site with a relatively robust level of protection against future base flood elevations associated with sea level rise of up to 3 feet. Please note the following features will be detailed in collaboration with the complete design team.

1. The finished floors of all ground level residential structures have been set at a minimum elevation of 16.0 feet – a finished floor elevation (“FFE”) equal to the current site-specific BFE of 11 feet, plus 3 feet of sea level rise, plus 2 feet of freeboard as an additional safety margin.
2. The FFE of the two podium garages has been set at a minimum elevation of 14.1 feet – a FFE greater than the current BFE of 11 feet plus 3 feet of SLR. Increasing the minimum FFE to capture the additional margin of safety that freeboard provides was deemed to be unwarranted because the podium garage is not a habitable structure, will be designed to minimize water intrusion, and is situated inside the protective embankment that will be provided by the Bay Trail Loop (see #3 and #5 below).
3. The finished elevation (“FE”) of the Bay Trail Loop has been set at or above 14.5 feet – an elevation equal to the current BFE of 11 feet, plus 3 feet of sea level rise, plus .5 feet of freeboard as an additional safety margin.
4. The finished elevation of the north/south Public Promenade and the Public Entry Plaza have been set at a minimum elevation of 14.0 feet and 14.5 feet, respectively – elevations that are at or above the elevation of the current BFE of 11 feet, plus 3 feet of sea level rise.
5. As further discussed in the section of this memorandum entitled "Preparation of an Adaptive Flood Risk Management Plan," the Latitude Project's conditions of approval include the requirement that an "Adaptive Flood Risk Management Plan" be prepared and that the Plan

include an “installation schedule” and “financing strategy” for the following two additional flood risk mitigation measures:

- (a) "Any backflow prevention devices that are required to address flood impacts associated with a 2-foot increase in sea level"; and
- (b) "Any protective features that will enable the Bay Trail Loop (and/or other protective features as needed) to serve as a flood protection measure to address flood impacts associated with a 3-foot increase in sea level."

The purpose of the “backflow prevention devices” referenced above is to prevent the limited inundation of the Shoreline Drive roadway caused by the backflow of drainage through the storm drain inlets at the roadway edge. BKF’s analysis suggests that without the mitigation that the backflow prevention devices provide, the flood impacts associated with storm water backflows would be expected to occur with a rise in sea level of 2 feet or more during a 100-year storm event.

The purpose of the “protective features” referenced above is to allow the Bay Trail Loop to function as a protective embankment, shielding the area and facilities inside the Loop (including the Entry Plaza, the north/south Public Promenade, and the other public amenities) from inundation at BFE levels below its height. Where the Bay Trail’s minimum FE is set at 14.5 feet, the height of the protective embankment should be more than adequate to protect the interior of the site from the 100-year flood risks associated with a rise in sea level of up to 3 feet (i.e., a SLR-adjusted BFE of 14 feet).

6. The minimum finished elevation of the wharf deck will be set at 13.5 feet – a FE equal to the current BFE of 11 feet plus 2.5 feet of sea level rise. As a result, the wharf would be vulnerable to over-topping in the event of a 3-foot rise in sea level and a 100-year storm with a SLR-adjusted BFE of 14 feet. The seismic retrofit plans for the wharf being prepared by SGH, the Project’s marine structural engineer, contemplate a 6 inch reinforced concrete overlay of the existing wharf deck which will be tied back to new landside pilings and should significantly reduce the risk that the wharf would incur major structural damage as a result of over-topping in the event of a 100-year storm. Nevertheless, the potential that the wharf deck may be over-topped during a 100-year storm puts anyone using the wharf promenade during such a storm at risk. The Project proposes to mitigate this flood risk through the use of adaptive measures such as the use of signage warning of the dangers posed by flood risks and other adaptive measures designed to limit public access to the wharf during storm events.
7. The improvement plans for the wharf also include elevated program areas that will be constructed within an 18-inch high stem wall that will wrap the perimeter of the programmed space. The stem wall will be designed and engineered as an integrated part of the wharf deck structure. As a result, the programmed space, which occupies approximately 2/3rds of the wharf’s surface area, will have a minimum FE of approximately 15 feet – equal to the current BFE of 11 feet, plus 3 feet of sea level rise, plus 1 foot of freeboard as an additional safety margin.

In comments offered by the Board at the May 24, 2017 ECRB meeting, it was suggested that, in evaluating the resiliency of the design features of the Project with respect to sea level rise-induced 100-year flood impacts, particular attention be given to the narrow band of shoreline extending east of the wharf for a distance of

approximately 240 feet. This waterfront property is bounded on its southern edge by the rip-rap that lines the shore and on its northern edge by the toe of the Bay Trail slope. The rip-rap protecting this narrow shoreline band consists of large blocks of stone ranging in size from ¼ ton to 1 ton. The elevation of this relatively level reach of shoreline varies from a low point of approximately 8 feet at its western end to a high point of approximately 9 feet at its eastern end. The height of the rip-rap protecting this narrow shoreline band ranges from approximately 8.0 feet to 10.5 feet.

This section of the Terminal One shoreline is relatively unique in that it is one of the only land areas that will retain much of its essential historic character. Running most of the length of this section of shoreline are railroad tracks that were used to provide direct rail access to the Terminal One Warehouse. The landscape improvement plans for the Latitude Project contemplate the reuse of this rail line as a rails-to-trails footpath that will provide the public with access to this original portion of the Terminal One waterfront.

SGH has performed a condition assessment of the shoreline protection at this location (see SGH’s “Condition Assessment and Design Criteria for Structural Evaluation of Latitude Wharf” as submitted to ECRB for consideration at May 24, 2017 meeting) and determined that, with the addition of a 4 foot “splash apron” along the inboard edge of the existing rip-rap, the protection afforded by the existing rip-rap “should be adequate for shoreline protection for [the] 100-year storm.” SGH’s analysis calls for the splash apron to be constructed using “RSP Class Light” materials and “to extend 4 feet beyond the current RSP . . . in order to avoid possible ponding and erosion of the back soil behind and beneath the existing rip-rap.” (See SGH’s Condition Assessment and Design Criteria Report at page 22.)

Although the SGH assessment does not evaluate the adequacy of the existing shoreline protection to address the increased flood risk associated with a rise in sea level, it is reasonable to assume, given the elevations of the both the rip-rap barrier and the band of shoreline it protects, that additional adaptive measures will be required to mitigate the flood impacts associated with higher sea levels – including the increased potential: (a) for overtopping of the shoreline protection, (b) for erosion and mobilization of soil behind the shoreline protection, (c) for compromising the stability of the slope connecting the Bay Trail with existing grades, and (d) for structural failure of the shoreline protection. These adaptive mitigation measures could include raising the level of the rip-rap barrier, extending the splash apron further into the site, armoring the Bay Trail slope, and restricting public use of the shoreline band. Consideration could also be given either to importing fill to raise the elevation of the shoreline band or to allowing the Bay to reclaim this portion of the shoreline.

In any case, the applicant proposes to proceed with its plans to provide near term public access to this portion of the shoreline by way of a rail-to-trails pathway and to address the long term resiliency of the property as part of an Adaptive Flood Risk Management Plan that is prepared in accordance with the conditions of Project approval discussed below.

### **Preparation of an Adaptive Flood Risk Management Plan**

The previous discussion suggests that the design features of the Latitude Project, either as initially constructed or as implemented on an as-needed basis, should be adequate to mitigate the potential 100-year flood impacts associated with a rise in sea level of up to 3 feet. Where a project includes design features that are part of an adaptive mitigation strategy to be implemented on an as-needed basis, however, successful management of flood risks requires:

1. That the need for such adaptive mitigation measures be periodically reassessed and that an implementation schedule be formulated to assure that the adaptive mitigation measures are in place by the time they are needed; and
2. That a financing plan be developed to assure that the funding required to implement the adaptive mitigation measures will also be in place by the time it is needed.

These basic prerequisites of a successful adaptive mitigation strategy apply with equal force to management of the 100-year flood risk associated with a rise in sea level of greater than 3 feet. The need to remain flexible with regard to the formulation of such a long term adaptive mitigation strategy places even greater importance on the periodic monitoring, strategic programming, need-based scheduling, and financial planning functions. In recognition of this point, the City of Richmond included a mitigation measure in the Project Environmental Impact Report requiring the preparation of an Adaptive Flood Risk Management Plan as a condition of Project approval. The actual language of this requirement is instructive:

***“Project Design Feature HYD-3: Sea Level Rise Adaptation Strategies:*** *The applicant shall include provisions in the project's Covenants, Conditions, and Restrictions that require the Homeowner's Association to engage a degreed coastal geomorphologist, a licensed engineer, or a comparably qualified expert in the management of flood risks associated with sea level rise to prepare an Adaptive Flood Risk Management Plan. The initial adaptive management plan shall be completed and submitted to the City for review and comment by January 1, 2035. The plan shall be updated every ten years, with the first plan update to be completed and submitted to the City for review and comment by January 1, 2045 and with subsequent updates to be completed and submitted to the City on January 1 every ten years thereafter.*

*The Adaptive Flood Risk Management Plan shall include:*

1. *A Monitoring and Reporting Program - to include:*
  - a. *A review of scientific literature including up-to-date estimates of local sea level rise and available data and studies from other shoreline sites in Richmond as well as neighboring/regional jurisdictions to estimate the actual increase in sea level at the site;*
  - b. *A review of federal, State, local, and regional law, regulations, and guidance that address sea level rise;*
  - c. *A report that addresses the following points:*
    - i. *A discussion of any estimated difference in sea level at the site since the previous 10-year report;*
    - ii. *A discussion of how the project complies with any new applicable statutory or regulatory requirements;*
    - iii. *A discussion of the observed characteristics and impacts, if any, related to flooding on the site, based on site observations and photos as well as conversations with site residents and City Public Works staff;*
    - iv. *A discussion of the monitoring triggers that will be used to determine the installation schedule for:*
      - *Any backflow prevention devices that are required to address flood impacts associated with a 2-foot increase in sea level;*
      - *Any protective features that will enable the Bay Trail Loop (and/or other protective features as needed) to serve as a flood protection measure to address flood impacts associated with a 3-foot increase in sea level; and/or*
      - *Any additional adaptive flood risk management measures that will be required to address flood impacts associated with a rise in sea level of greater than 3 feet.*
    - v. *A recommended schedule for implementing the adaptive flood risk management measures referenced in subsection iv. above and/or an update to a previously presented recommended schedule; and*
    - vi. *A report on the adaptation measures financing mechanism (see subsection 3. below), and an estimated projection of funds that would be available 10 years into the future.*
2. *An Adaptive Flood Risk Management Strategy to address 100-year flood impacts associated with a rise in sea level of greater than 3 feet. If the monitoring program and the updated monitoring report prepared every ten years' results in a projection that the rise in sea level will exceed 3 feet during the subsequent 25-year period, the Adaptive Flood Risk Management Plan shall also include:*
  - a. *An analysis of adaptive measures which, if implemented, either on a stand-alone basis or in combination with other measures, would prevent or substantially reduce human health and safety impacts as well as property loss and damage related to 100-year flooding and an increase in sea level of greater than 3 feet;*
  - b. *The formulation of an adaptive measures strategy which reflects a best practices and cost-effective approach to addressing the 100-year flood risk associated with an increase in sea level greater than 3 feet; and*
  - c. *An estimate of the costs and timeframes involved in implementing the adaptive measures strategy formulated in accordance with subsection b. above.*

*The nature of the adaptation measure/s to be implemented will be reviewed and approved by the City Planning Division and Public Works Department and other regulatory agencies as necessary, and will be based on the results of monitoring and reporting.*

3. *A Financing Strategy which will be designed to:*
  - a. *Generate sufficient resources to cover the costs of:*
    - i. *The backflow prevention devices as required to address flood impacts associated with a 2-foot increase in sea level (to the extent these devices were not already installed when the storm drain system was initially constructed);*
    - ii. *The protective features as required to enable the Bay Trail Loop to serve as an effective barrier to address flood impacts associated with a 3-foot increase in sea level (to the extent these protective features were not already incorporated in the Bay Trail Loop when it was originally constructed); and*
    - iii. *The adaptive measures strategy formulated to address flood impacts associated with an increase in sea level of greater than 3 feet;*
  - b. *Generate such funds and to make such funds available within a timeframe to cover the flood improvement costs as they are incurred in accordance with the implementation schedule.*

*The financing strategy may include funding from the following private and public financing mechanisms:*

    - a. *Homeowner Association fees;*
    - b. *Mello Roos Community Services District special taxes;*
    - c. *Assessment District Assessments; and*
    - d. *Other public or private financing mechanisms as determined by the Homeowner Association and the City to be appropriate and feasible."*

As a result of this EIR mitigation measure and condition of Project approval, a process has been put in play that will, for the reasons discussed above, reach far into the future to foster the timely development, financing, and implementation of creative adaptive strategies to mitigate flood risks associated with sea level rise in advance of the need they are designed to address.