



October 3, 2016

Naomi M. Kelly
City Administrator
City & County of San Francisco
1 Dr. Carlton B. Goodlett Place, Room 362
San Francisco, CA 94102

Subject: No Evidence Supports Millennium Partners' Claims that Excessive Settlement and Tilting of Millennium Tower is Caused by Transbay Transit Center Construction

Dear Administrator Kelly,

You have asked the Transbay Joint Powers Authority (TJPA) to respond to a September 29, 2016 report drafted by Sage Engineers for Millennium Partners (MP), the developer of the Millennium Tower at 301 Mission. This letter responds to Sage's underlying claim that the TJPA's construction of the Transbay Transit Center contributed to the excessive vertical settlement of the Millennium Tower. The limited time for the TJPA's response did not permit a more technical rebuttal to Sage's report.

The Sage report alleges that the TJPA's dewatering of the Transbay Transit Center construction site was a significant cause of excessive settlement of the Millennium Tower. Sage's claim is a distraction. The true cause of excessive settlement of the Millennium Tower is the Tower's extraordinary weight and a foundation that is too shallow to support such a heavy building.

Sage's claim is not supported by the facts, which Sage largely ignores in its report. The timeline attached to this letter provides a context for the critical facts, which are as follows:

- MP's engineers predicted that the Millennium Tower would settle vertically a maximum of 5.5 inches from the start of construction through 20 years after the building's completion in 2009. By April 2011, when the TJPA first began construction activity below grade adjacent to the Millennium Tower, the Tower had already settled vertically 10 inches and was tilting toward the northwest away from the Transit Center. The unprecedented settlement of 10 inches is attributable to an inadequate foundation design.
- The Millennium Tower is unique in this area of San Francisco in that it is (a) very tall, (b) has a concrete frame, and (c) is not supported by foundations to bedrock. Concrete structures are significantly heavier than steel structures. As a result, the Millennium Tower exerts a pressure on the underlying soils that is more than four times that of the next heaviest high-rise on the perimeter of the Transit Center.

- A major portion of the Tower's tilt and two-thirds of the excessive settlement to date occurred before the TJPA started underground work. None of the other high-rises on the perimeter of the Transit Center are both very tall and built of concrete, and none has experienced excessive settlement or tilt before or after the TJPA started underground work. It is therefore clear that the Tower's extreme weight, combined with its inadequate (short pile) foundation, is the sole cause of the excessive settlement and tilt.
- By the time the TJPA started dewatering adjacent to the Millennium Tower in May 2013, the Tower had already settled more than 12 inches – three quarters of the total settlement to date – and was tilting further to the northwest.
- Sage alleges that the Tower's settlement was nearing completion by the time the TJPA started subsurface work, and that further settlement after the TJPA started subsurface work was primarily due to the TJPA. There is no support for that contention in the settlement monitoring data. At the time the TJPA started subsurface work, the Millennium Tower was settling in a linear fashion and the settlement showed no signs of stopping.
- The Transit Center dewatering system was designed to limit its potential impact on the groundwater levels outside of the Transit Center excavation shoring system. The TJPA's dewatering records provided to MP do not support the claim that the Transit Center dewatering was a significant cause of the fluctuations of groundwater levels outside of the TJPA's shoring system and under the Millennium Tower.
- Although the TJPA dewatered within the excavation for the Transit Center adjacent to other high rises on the perimeter of the Transit Center, none of these high rises has shown excessive settlement or tilting.
- The TJPA has since 2010 provided geotechnical data to MP showing excessive settlement and tilt of the Millennium Tower. Since 2011, the TJPA provided MP with data showing the groundwater levels under the Tower. Yet, the first time that MP requested that the TJPA modify its dewatering was after the first reports of the Tower's excessive settlement and tilt appeared in the press in August 2016. It is inconceivable that MP, being fully aware of the excessive settlement and tilt and the changes in groundwater levels under the Tower, believed that groundwater change was causing severe problems with its building, and yet failed to request that the TJPA reduce its dewatering until two months ago.
- Recognizing that due to the inadequate foundation of the Millennium Tower, the construction of the Transbay Project might contribute to the tilt of the Millennium Tower, the TJPA built a \$58 million buttress to prevent any increase in the existing tilt.
- The Millennium Tower would have settled far in excess of predicted settlement and tilted even if the Transbay project did not exist.

The Transit Center construction is a convenient target for MP to lay off blame for the deficient design of the Millennium Tower's foundation. But there is no evidence to conclude that the TJPA is responsible for the poor performance of the Tower.

We expand on these points below.

The Millennium Tower's Foundation Is Inadequate to Support Its Extraordinary Weight

The Millennium Tower is unique in this area of San Francisco in that it is both very tall and has a concrete frame. Concrete construction is significantly heavier than steel construction. The Millennium Tower's combination of height and concrete construction has resulted in an extraordinarily heavy building, unlike any other in this area of San Francisco at the time of construction.

A comparison of the pressure on the compressible clay below between the Millennium Tower and other tall buildings on the perimeter of the Transit Center demonstrates that the Millennium Tower is tilting and excessively settling because its foundation is not up to the task of supporting such a heavy structure. The table below shows that the Millennium Tower exerts a net pressure four to five times that of the next largest building on the perimeter of the Transit Center, 555 Mission Street, and more than 50 times the net pressure of 199 Fremont. A kip is 1,000 pounds; pressure is presented as kips per square foot (ksf).

	Height (feet)	Frame Type	Net Pressure (ksf)
199 Fremont	364	Steel	0.2
100 First	446	Steel	1.4
555 Mission	487	Steel	2.4
Millennium Tower	645	Concrete	11.4

[pressure data provided by ARUP]

The net pressure of the Millennium Tower loads the Old Bay Clay stratum that lies 90 feet below ground level below the tips of the piles used to support the 10-foot thick mat foundation of the Tower. These pressures are much larger than those caused by any adjacent buildings and likely caused the Old Bay Clay to enter a highly sensitive under consolidated state. This load has contributed to the excessive settlement at the Millennium Tower prior to the start of any underground construction of the Transit Center and has reduced the capability of the Tower to withstand any reduction in water table, regardless of the cause of that reduction in water table.

Therefore, MP's and Sage's claim that the foundation for the Millennium Tower is adequate because it is similar to other buildings in San Francisco is not credible. A foundation that fails to reach bedrock may have been appropriate for these other, much lighter, high-rise buildings. But given the excessive movement of the Millennium Tower before the TJPA started underground work or dewatering, a foundation consisting of piles installed to limited depths clearly was not appropriate for the Millennium Tower. The fact that other high-rises surrounding the Transit

Center, also built before the TJPA started any underground work or dewatering, have not experienced tilting and excessive settlement demonstrates that the Transit Center construction is not the cause of the poor performance of the Millennium Tower. Rather, the Millennium Tower's uniquely high weight, without an adequate foundation to support it, is the most significant cause. Because the Tower's foundation is grossly inadequate, the excessive settlement and tilt of the Tower would have occurred and would continue regardless of the TJPA's activity.

We note that Sage compares the Millennium Tower to other buildings not located on the perimeter of the Transit Center. The relevant comparison of the Millennium Tower, however, is to buildings on the perimeter of the Transit Center. These buildings have been adjacent to the same excavation and dewatering as the Millennium Tower, but did not experience excessive settlement or tilting, either before or after the TJPA commenced underground work, conclusively demonstrating that the Millennium Tower's foundation is inadequate and solely responsible for the poor performance of the Tower.

Excessive Vertical Settlement and Tilt Occurred Before the TJPA Started Underground Work

The TJPA has been collecting geotechnical monitoring data and consistently providing that data to MP for more than six years, since January 2010. That data, along with data provided to the TJPA collected by the Millennium Tower construction contractor extending back to late 2006, already showed significant vertical settlement beyond the amount MP's engineers predicted before the TJPA began any below grade construction activity adjacent to the Millennium Tower. Specifically, MP's geotechnical engineers, Treadwell & Rollo, predicted that the Millennium Tower would settle vertically a maximum of 5.5 inches in the 20 years after the building's completion in 2009. Treadwell & Rollo did not predict that the Tower would experience differential settlement (tilt) of any kind. By April 2011, however, when the TJPA first began construction activity below grade adjacent to the Millennium Tower (the first TJPA activity that could possibly have caused movement of the Tower), the Tower had already settled vertically 10 inches and was tilting to the northwest. The Millennium Tower has settled 16 inches to date. Thus, nearly two-thirds of its total settlement to date occurred *before* the TJPA started its underground work. Before the TJPA started underground work, the excessive settlement and tilt of the Tower were both long-standing and severe. The vertical settlement and tilt after April 2011 are merely the continuation of a trend that started long before the TJPA initiated its underground work.

The TJPA's Buttress Prevented the TJPA's Work From Contributing to the Tilt of the Tower

In 2004, the Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) issued for the Transbay Transit Center Project described the length, width, and depth of the TJPA's planned excavation for the train box. In 2006, MP started construction of the Millennium Tower. At the time they designed the foundation for the Millennium Tower, MP, Treadwell & Rollo, and MP's structural engineers Desimone, knew that the TJPA intended to excavate the train box and the dimensions of that excavation. Despite this knowledge, MP and its engineers designed a foundation for the Tower that did not extend piles to bedrock.

In response to MP's decision to found their building on short piles, the TJPA took the extraordinary measure of constructing a buttress under the north wall of the Transit Center adjacent to the Millennium Tower at a cost of \$58 million to the taxpayers. This extraordinary effort was not necessary on any other portion of the Transbay construction site. The buttress consists of 181 overlapping concrete piles, each seven feet in diameter and drilled into bedrock. The purpose of the buttress was to avoid a potential failure of the Millennium Tower and the TJPA's contributing to the Millennium Tower's existing tilt.

The buttress addresses the potential that the Millennium Tower, due to its great weight, would tilt to the northwest (toward Mission Street) as a result of an effect known in geotechnical parlance as a bearing capacity failure that deforms along a "slip circle." The TJPA's excavation of soil for the train box was expected to reduce the pressure on the soil below the train box, reducing resistance to soils pushing laterally from under the Millennium Tower. As the very heavy Millennium Tower placed enormous pressure on the soil below, that soil could have been pushed laterally to the southeast under the train box due to the reduced resistance of the soil under the train box and the reduced weight of the material used to construct the train box. Thus, the soil under the Millennium Tower could have moved in a circular fashion under the Transit Center from northwest to southeast. The southeast movement of the soil could have removed support from the northwest side of the Millennium Tower, resulting in differential settlement of the Tower from the southeast (high side) to the northwest (low side). The potential for the slip circle – and the buttress – could have been avoided entirely had MP installed piles to bedrock.

The TJPA's inclinometer records, provided to MP, prove that the buttress worked. The soil under the Millennium Tower was not pushed into failure under the Transit Center. The Tower was already tilting to the northwest before the TJPA started underground work, and the buttress prevented the Transit Center's underground work from contributing to the tilt through the failure mechanism outlined above. The tilt is entirely due to the Tower's deficient foundation. Of course, had MP supported the Tower on piles down to bedrock, the Tower would not be tilting today.

Excessive Vertical Settlement and Tilt Occurred Before the TJPA Started Dewatering

Sage blames the Millennium Tower's excessive settlement and tilt since 2011 on the TJPA's dewatering, which allegedly causing the water table under the Millennium Tower to drop. All evidence is to the contrary.

The TJPA started dewatering in Zone 1 at the west end of the Transit Center (farthest away from the Millennium Tower) in March 2012. By that time, the Tower had already settled vertically approximately 11 inches. At the time the TJPA started dewatering adjacent to the Millennium Tower in May 2013, the Tower had settled approximately 12.1 inches – three quarters of the total 16 inches of settlement the Millennium Tower has experienced to date. Since the TJPA started dewatering adjacent to the Millennium Tower, the Tower has continued to settle at approximately the same rate. Uncontroverted evidence confirms that the great majority of the Millennium Tower's settlement and tilt occurred before the TJPA began any dewatering.

The TJPA's Dewatering Did Not Cause Excessive Vertical Settlement or Tilt of the Tower

The Transit Center dewatering system consists of a deep soil mix shoring wall around the perimeter of the Transit Center that extends 90 feet below the surface into the Old Bay Clay. The shoring wall was designed to limit the potential impact of the TJPA's dewatering on the groundwater levels outside of the excavation shoring system. The dewatering records provided to MP do not support the claim that the Transit Center dewatering was a significant cause of the fluctuations of groundwater levels outside of the shoring system and under the Millennium Tower.

The TJPA did not start dewatering for the Transbay Project until March 2012. Although the TJPA's contractor obtained a wastewater discharge permit from the San Francisco Public Utilities Commission in April 2011, that permit was used exclusively for the discharge of slurry water required for the TJPA's construction of its shoring wall and buttress; i.e., water brought onto the site rather than water removed from the groundwater. Sage also misunderstands the TJPA's 2011 permits for dewatering in conjunction with the demolition of the Transbay Terminal and utility relocation. The dewatering under these permits was shallow and did not reach the deep aquifer 40 to 50 feet below the surface that could have affected the water table under the Millennium Tower.

As indicated above, the TJPA did not start dewatering the deep aquifer under the Transit Center construction site until March 2012. The TJPA's dewatering of the Transit Center construction site started in Zone 1, at the far west end of the Transit Center. The TJPA's dewatering proceeded east over time. The TJPA did not start dewatering in Zone 4 adjacent to the Millennium Tower until May 2013. Even without considering the barrier to water intrusion of the TJPA's shoring wall, dewatering in Zones 1-3 was far from the Millennium Tower and less likely to have affected the water table under the Millennium Tower. Again putting aside the fact that the TJPA's shoring wall was designed to limit the effects of the TJPA's dewatering on buildings outside the shoring system, the amount of dewatering conducted by the TJPA since May 2013 has been modest, and does not support a claim that the TJPA's dewatering significantly affected ground water levels outside the TJPA's shoring system. Sage fails to take full account of the fact that after April 2013, dewatering was occurring across from the Millennium Tower at the 350 Mission Street construction site and in 2015 and 2016 at 415 Mission Street for the construction of the Salesforce Tower. The City also suffered from a prolonged drought during this period. The discharge of water from the Transit Center site during this period was minor and does not support a claim of damage to the Millennium Tower.

Sage's contention that the TJPA's dewatering contributed to the excessive settlement and tilt of the Millennium Tower also fails to acknowledge that other buildings adjacent to the TJPA's excavation have not experienced any excessive settlement or tilt, although the TJPA conducted dewatering adjacent to these buildings. As explained above, the crucial difference between the Millennium Tower and other high-rises in the vicinity is the extreme weight of the Millennium Tower. The data does not show that the TJPA's dewatering has been a factor in the movement of the Millennium Tower.

Current Dewatering at the Transit Center is Negligible

Although the amount of dewatering at the Transit Center construction site currently varies slightly depending on the time of the day, for the past year the total amount of dewatering has been negligible, averaging between 1.5 to 3 gallons per minute (gpm). To put this in perspective, a kitchen faucet runs at about 2 to 2.5 gpm. Considering that the Transit Center construction site is 5.5 acres, this flow is minimal and does not support the claim that the dewatering system is having significant effects beyond the TJPA's shoring wall perimeter.

Sage implies that the TJPA withheld the facts that it is currently dewatering and that it intends to continue dewatering until the weight of the Transit Center is sufficient to counterbalance the upward water pressure. The TJPA's intent to conduct dewatering of the Transit Center site during construction has always been public information, starting with the 2004 Final EIS/EIR, which indicated that the TJPA would conduct dewatering of the Transit Center construction site, and the TJPA's SFPUC water discharge permits, which allow the TJPA to discharge water from the Transit Center construction site. Moreover, it is common knowledge that all deep excavations in this part of San Francisco must take ground water levels into account, and such dewatering is routine.

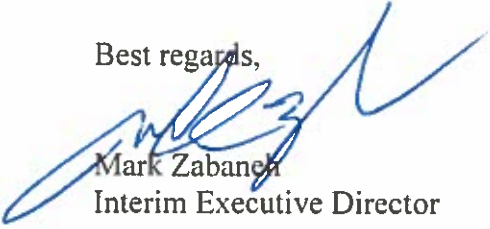
The TJPA's Dewatering is a Red Herring to Distract Attention From the Tower's Deficient Foundation

A further difficulty with Sage's claim that the TJPA's dewatering is the cause of excessive movement of the Tower is the timing of the claim. Since 2011, the TJPA has provided MP with data showing changes over time in the groundwater levels under the Tower through the Transit Center's automated monitoring system. At the same time, the TJPA provided MP with data showing the progression of vertical settlement and tilt. MP could have considered the relationship between the movement of the Millennium Tower and changes in the water table under the Tower during this period. If MP had concluded that changes in the water table under the Tower were the cause of excessive settlement or tilt, and that the TJPA was responsible for the changes in the water table, MP naturally would have requested that the TJPA modify its dewatering program. MP, however, did not request that the TJPA modify its dewatering program until after the first reports of the settlement and tilt appeared in the press in August 2016. If MP had a genuine concern that the cause of the excessive settlement and tilt was the TJPA's dewatering, MP would have, and should have, taken action to induce a change in the TJPA's dewatering. It is therefore transparent that MP has raised the dewatering issue at this late date because it is looking for someone to blame for the poor performance of its building, now that the problems with the building have surfaced.

In conclusion, before any below grade construction activity occurred at the Transit Center construction site, the Millennium Tower had settled well in excess of the amounts predicted by MP's engineers and was tilting to the northwest away from the Transit Center. Similarly, before the TJPA started dewatering adjacent to the Millennium Tower in May 2013, the Tower had settled approximately 12.1 inches - *three quarters of the total settlement to date* - and was tilting even further to the northwest than when Transit Center work began. Neither excavation nor dewatering of the Transit Center site ever had a significant or ongoing impact on this tilt and

excessive settlement. The only plausible explanation for the poor performance of the Millennium Tower is a completely inappropriate foundation for such a heavy structure. This conclusion is confirmed by the fact that the other high-rise structures adjacent to the Transit Center construction site, and adjacent to the TJPA's dewatering, have not experienced tilting or excessive settlement.

Best regards,



Mark Zabaneh
Interim Executive Director

