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To: **Mr. Michael Johnson**
Director of Community and Economic Development
City of Cottonwood Heights

From: **Timothy J. Thompson, P.G., Principal Geologist**

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Date: **July 21, 2021**

Subject: **Response to Utah Citizens for Earthquake Safety June 15, 2021 letter to Cottonwood Heights City Leadership Subject: Wasatch Rock Redevelopment, 6694 S. Wasatch Blvd.**

Introduction

At the request of Mr. Michael Johnson, GeoStrata reviewed the above referenced letter. The purpose of this response memorandum is to address the issues raised in the June 15, 2021 Utah Citizens for Earthquake Safety (UCEQS) letter. Our response to the June 15, 2021 UCEQS letter is provided to Cottonwood Heights City to assist the city in protecting public health, safety, and welfare. At issue is whether or not the geologic hazard reports and geotechnical reports submitted for the "Wasatch Rock Redevelopment" (Gravel Pit Development) project adequately address the geologic hazards associated with the project consistent with reasonable standards of practice and in accordance with Cottonwood Heights City's Sensitive Lands Evaluation & Development Standards (SLEDS) (Title 19 Chapter 19.72 of the Cottonwood Heights City Municipal code).

General Discussion

The June 15, 2021 UCEQS letter presents five issues related to geologic hazards that the letter states are significant issues that they find concerning about the project. The letter further states: *"We believe these issues must be fully understood and addressed to safely construct buildings in which the citizens of Cottonwood Heights will live and work."* The five issues listed in the introduction of the UCEQS letter are as follows:

1. The potential for surface-fault rupture between the existing fault lines that have been mapped.
2. The potential for ground tilting, which will result in building tipping.
3. The potential for significantly larger shaking than required by the IBC.
4. The potential for inadequate building performance following a Wasatch Fault earthquake.
5. The potential for a landslide during an earthquake.

Other comments associated with these five issues are also made within the UCEQS letter which we will also address in this memorandum.

Review Discussion

UCEQS Issue 1 Surface-Fault Rupture

In the Surface-Fault Rupture section of the June 15, 2021 UCEQS letter it states: *"Structures on the site will be located between the mapped faults, and the borders of the structures will be offset from the mapped faults. The Circular provides equations for calculating offsets at ground level. The offsets must also be accounted for at the depths of building foundations. This is a good approach because faults tend to rupture where the ground has previously ruptured, and an existing fault has weakened the ground. However, as the Circular notes, there is significant uncertainty, and a future earthquake has the potential to rupture the ground in between the existing faults where the structures will be located.*

The potential for surface-fault rupture through a building on this project should not be ignored. It is a possibility that could happen. If it does happen, we recommend that the engineering criteria be such that the building does not collapse and the occupants can exit safely…"

"…We strongly recommend that Dr. Bray be hired as a consultant on the Gravel Pit Development to provide expertise and recommendations to the design team."

GeoStrata Response to UCEQS Issue 1 Surface-Fault Rupture

In Bowman and Lund (2020) "The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah", Utah Geological Survey Circular 128, Chapter 3: Guidelines For Evaluating Surface-Fault-Rupture Hazards In Utah, INTRODUCTION, Purpose it states: *"A surface-faulting investigation uses the characteristics of past surface faulting at a site as a scientific basis for providing recommendations to reduce the risk for damage, injury, or death from future, presumably similar, surface faulting…"*

In Bowman and Lund (2020) "The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah", Utah Geological Survey Circular 128, Chapter 3: Guidelines For Evaluating Surface-Fault-Rupture Hazards In Utah, Surface-Fault-Hazard Investigation, Background it states: *"Designing a building to withstand surface faulting has generally been considered impractical for economic, engineering, and architectural reasons, and it is only within the relatively recent past that the geotechnical community has begun a serious discussion regarding using engineering design to mitigate surface-faulting risk (e.g., Bray, 2015). Therefore, avoiding active fault traces that pose a surface-faulting hazard has been the risk-reduction measure most often applied in Utah. A typical surface-faulting investigation in Utah documents the presence or absence of faults determined to be active at a site. When active faults are present, a fault setback is recommended based on the width of the deformation zone and the amount and direction of displacement along the fault."*

In Bowman and Lund (2020) "The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah", Utah Geological Survey Circular 128, Chapter 3: Guidelines For Evaluating Surface-Fault-Rupture Hazards In Utah, Surface-Fault-Hazard Investigation, Hazardous Fault Avoidance it states: *"Utah's Quaternary faults exhibit a wide range of recurrence intervals and slip rates. Ideally, decisions regarding the need to mitigate surface faulting should be based on a risk assessment that considers the time of the most recent surface faulting and the average recurrence interval between previous surface-*

faulting earthquakes to determine the probability of surface faulting within a future time frame of interest (see Characterizing Fault Activity section above). However, with the possible exception of the five central, Holocene-active segments of the Wasatch fault zone (DuRoss and Hylland, 2015; DuRoss and others, 2016; WGUEP, 2016), available paleoseismic data for faults in Utah are generally insufficient to make such data-based risk determinations, and the ability to acquire the new earthquake timing, recurrence, and displacement data necessary to do so may be limited by site geologic conditions, property access, and/or budget and time constraints. Additionally, the natural variability of fault behavior (aleatory variability) and the uncertainty resulting from lack of necessary data to characterize fault activity (epistemic uncertainty) may combine to preclude the confident determination of the probability of future earthquake timing, displacement, and rupture complexity at a site. Therefore, setting back from and thereby avoiding potentially hazardous faults is often the most technically feasible and effective method to mitigate surface faulting. It is also the most satisfactory and safest (conservative) long-term solution for both current and future land owners, since the hazard is avoided regardless of the timing of the next surface-faulting earthquake. For those reasons, avoidance is the principal surface-faulting risk-mitigation technique specified by geologic-hazard ordinances in Utah, and the UGS considers avoidance the safest long-term surface-faulting mitigation option presently available."

In the Cottonwood Heights City Municipal code Title 19, Chapter 19.72 Sensitive Lands Evaluation & Development Standards (SLEDS), Appendix B Minimum Standards for Surface Fault Rupture Hazard Studies, 1.0 INTRODUCTION it states: *"...In the event of an earthquake, a fault could break the ground surface below or near a structure and cause significant property damage, injuries and loss of life. In order to reduce risk from surface-fault-rupture hazards and to protect public health and safety, the city has defined a boundary for the sensitive lands that may have a heightened potential for surface fault ruptures and is requiring study for all new development or redevelopment within this area. Quaternary faults located within the Surface Fault Rupture Hazard Study Area should be considered active until proven otherwise.*

The city requires a site specific geologic study for all properties that may be impacted by the Wasatch Fault Zone. The study must address the surface fault rupture potential and assess the suitability of the proposed development. In the event that a fault is discovered and deemed active (i.e., Holocene-age), appropriate building setbacks are required to minimize the potential damage during an earthquake…"

The June 15, 2021 UCEQS letter states that the UGS Circular128 notes that there is significant uncertainty in the assessing the nature of future surface faulting events and that future surface faulting events have the potential to rupture the ground in between the existing faults where the structures will be located. However, Bowman and Lund (2020) state that the purpose for conducting surface-faulting investigations is to assess the characteristics of past surface faulting at a site as a scientific basis for providing recommendations to reduce the risk for damage, injury, or death from future, presumably similar, surface faulting. The presumption is that future surface faulting events will be similar to past surface faulting events. Additionally, Bowman and Lund (2020) state "*…the natural variability of fault behavior (aleatory variability) and the uncertainty resulting from lack of necessary data to characterize fault activity (epistemic uncertainty) may combine to preclude the confident determination of the probability of future earthquake timing, displacement, and rupture complexity at a site. Therefore, setting back from and thereby avoiding potentially hazardous faults is often the most technically feasible and effective method to mitigate surface faulting. It is also the most satisfactory and safest (conservative) long-term solution... For those reasons, avoidance is the principal surface-faulting risk-mitigation* *technique specified by geologic-hazard ordinances in Utah, and the UGS considers avoidance the safest long-term surface-faulting mitigation option presently available.”* Bowman and Lund (2020) further state “*…it is only within the relatively recent past that the geotechnical community has begun a serious discussion regarding using engineering design to mitigate surface-faulting risk (e.g., Bray, 2015). Therefore, avoiding active fault traces that pose a surface-faulting hazard has been the risk-reduction measure most often applied in Utah…”* The assessment and delineation of setbacks from identified active faults is recommended by the UGS as the safest (conservative) long-term surface-faulting risk-mitigation technique.

UCEQS Issue 2 Ground Tilting

In the Ground Tilting section of the June 15, 2021 UCEQS letter it states: *“Even if surface-fault rupture does not occur under a structure, there is a potential that the ground below the structure will be permanently deformed resulting in a tilted building. Tilting displacement from the roof of a 13-story structure will be much more extensive than for a 3-story structure and will require significant understanding of the potential for roof displacement. If the structure is engineered for a surface-fault rupture as noted above, this tilting will not result in a life-safety issue, but it is important to understand that the tilting could result in a building that cannot be occupied until the tilting is resolved.”*

GeoStrata Response to UCEQS Issue 2 Ground Tilting

In Bowman and Lund (2020) “The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah”, Utah Geological Survey Circular 128, Chapter 3: Guidelines For Evaluating Surface-Fault-Rupture Hazards In Utah, Surface-Fault-Hazard Investigation, Special Cases, Grabens it states: *“...Surface faulting may subject structures within a graben to coseismic displacement and ground tilting from the main and antithetic faults. Designing structures to withstand the effects of coseismic, near-field surface faulting on multiple faults is the responsibility of the geotechnical and structural engineers. The geologist conducting a site-specific surface-faulting-hazard investigation is responsible for providing the structural design team, to the extent possible, with quantified data (which is largely controlled by the site location within the graben) on fault displacement and ground tilting, such that safe building designs are possible…”* The geologic reports prepared for the Gravel Pit Development have provided quantitative data on fault displacement and ground tilting for the site. Designs for the proposed buildings have not been completed at this stage in the planning of the development. The geotechnical and structural engineers will be responsible to design the proposed structures to withstand the effects of coseismic displacement and ground tilting from the main and antithetic faults as part of the building designs when the designs are completed. The engineers responsible for the design of the proposed structures should be qualified professionals licensed to practice in the State of Utah in accordance with Cottonwood Heights City’s SLEDS ordinance.

UCEQS Issue 3 Ground Shaking

In the Ground Shaking section of the June 15, 2021 UCEQS letter it states: *“To understand the shaking potential on the site, we reached out to seismologist Ivan Wong, who is a world-renowned expert on seismic hazard and seismic risk evaluations. He has performed studies around the world, and he is intimately familiar with Utah and the Wasatch Fault. We have attached a copy of a letter he wrote to us regarding the significant hazard associated with this site. Unfortunately, the International Building Code does not consider the hazards expressed in Mr. Wong’s letter.*

A quote from Mr. Wong's letter reads, "The location of the proposed development within the Wasatch fault zone poses unique challenges to developing ground motions and a failure to account for these issues by simply using code-based design ground motions poses in my judgment an unjustified risk to those people who may work or live within this development." Mr. Wong emphasizes there will likely be an amplification of seismic waves that is not accounted for in the building code…"

<u>GeoStrata Response to UCEQS Issue 3 Ground Shaking</u>
In Bowman and Lund (2020) "The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah", Utah Geological Survey Circular 128, Chapter 2: Guidelines For Conducting Engineering-Geology Investigations And Preparing Engineering Reports In Utah, International Building/Residential Code and Local Requirements it states: *"The 2018 International Building and Residential Codes (IBC/IRC; International Code Council, 2017a, 2017b), adopted statewide in Utah after July 1, 2019 (Title 15A, https://le.utah. gov/xcode/Title15A/15A.html), specify requirements for geotechnical investigations that also include evaluation of some geologic hazards. Local governments (Utah cities, counties, and special service districts) may also adopt ordinances related to geologic hazards that must be followed for development projects... The 2018 IBC/IRC specify seismic provisions for earthquake hazards. Section 1613.1 of the IBC states, "Every structure, and portion thereof…shall be designed and constructed to resist the effects of earthquake motions…" and Section R301.1 of the IRC states, "Buildings and structures, and all parts thereof, shall be constructed to safely support all loads, including…seismic loads as prescribed by this code." Both the IBC and IRC assign structures, with some exceptions, to a Seismic Design Category (IBC Section 1613.2.5 and IRC Section R301.2.2.1). Engineering-geology and geotechnical investigations are often needed to properly determine the seismic design parameters required to implement the code requirements. Seismic provisions of the IBC and IRC are intended to minimize injury and loss of life by ensuring the structural integrity of a building, but do not ensure that a structure or its contents will not be damaged during an earthquake…"*

In Bowman and Lund (2020) "The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah", Utah Geological Survey Circular 128, Chapter 4: Guidelines For Evaluating Landslide Hazards In Utah, Slope Stability Analysis, Seismic Slope Stability Analysis it states: *"…For a pseudostatic FS, the UGS recommends using an appropriate seismic coefficient (typically 1/3 to 2/3 of a peak horizontal ground acceleration [PGA])…"*

In the Cottonwood Heights City Municipal code Title 19, Chapter 19.72 Sensitive Lands Evaluation & Development Standards (SLEDS), Appendix C Minimum Standards for Slope Stability Analysis, 12.0 Seismic Slope Stability it states: *"…Acceptable methods for evaluating seismic slope stability using calibrated pseudostatic limit-equilibrium procedures and simplified methods (e.g., those based on Newmark, 1965) to estimate permanent seismic slope movements are summarized in Blake et al. (2002)…"*

In the Cottonwood Heights City Municipal code Title 19, Chapter 19.72 Sensitive Lands Evaluation & Development Standards (SLEDS), Appendix C Minimum Standards for Slope Stability Analysis, 12.1 Ground Motion for Pseudostatic and Seismic Deformation Analysyses, (b) it states: *"Regarding design ground accelerations for seismic slope-stability analyses, the city prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a particular site* *within a given time period. In order to more closely represent the seismic characteristics of the WFZ and better capture this possible high likelihood of a surface-faulting earthquake on the Salt Lake City segment, design ground motion parameters for seismic slope stability analyses shall be based on the peak accelerations with a 2.0 percent probability in 50 years (2,500-year return period). Peak bedrock ground motions can be readily obtained via the internet from the United States Geological Survey (USGS) National Seismic Hazard Maps, Data and Documentation web page (USGS, 2002), which is based on Frankel et al., 2002. PGAs obtained from the USGS (2002) web page should be adjusted for effects of soil/rock (site-class) conditions in accordance with Seed et al. (2001). Site specific response analysis may also be used to develop PGA values as long as the procedures, input data, and results are thoroughly documented, and deemed acceptable by the city."*

The June 15, 2021 UCEQS letter states that the International Building Code does not consider the hazards expressed in Mr. Wong in his letter and that simply using code-based design ground motions poses in Mr. Wong's judgment an unjustified risk to those people who may work or live within this development. However, the State of Utah has adopted the 2018 International Building and Residential Codes (IBC/IRC; International Code Council, 2017a, 2017b), statewide in Utah after July 1, 2019 (Title 15A, https://le.utah. gov/xcode/Title15A/15A.html). Also, while we do not disagree that a site specific response analysis could be developed by Mr. Wong or another qualified professional, the city's SLEDS ordinance states that the city prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a particular site within a given time period with design ground motion parameters for seismic slope stability analyses based on the peak accelerations with a 2.0 percent probability in 50 years (2,500-year return period). If a site specific response analysis is completed, the engineer or geologist responsible for the site specific response analysis should be a qualified professional licensed to practice in the State of Utah in accordance with Cottonwood Heights City's SLEDS ordinance.

UCEQS Issue 4 Building Performance

In the Building Performance section of the June 15, 2021 UCEQS letter it states: *"An issue closely related to shaking discussed above is building performance following a Wasatch Fault earthquake. In an ideal scenario following a Wasatch Fault earthquake, the residents will be able to reoccupy their building while repairs are being made. This ideal scenario is obviously impossible for the one or two buildings that could experience surface-fault rupture or ground tilting as discussed above, but these conditions would not likely happen to all buildings on the site. It is important for the Cottonwood Heights community leaders to understand and articulate specific building performance goals for the site from various levels of shaking. This is a topic that is not discussed often enough, and most structures are constructed based on shaking levels and building performance provided by the building code. But as noted in this letter, specific structural criteria must be provided for this site.*

Here are some recommendations that should be considered by the Cottonwood Heights City leaders.

1. *Ensure that each structure does not collapse if a surface-fault rupture occurs below the structure.*
2. *Provide a robust foundation system that will allow each structure to be re-leveled if it is left tilting following a Wasatch Fault rupture.*
3. *Ensure that each structure does not collapse due to the 84th percentile shaking from a Wasatch Fault earthquake. (This is the shaking level that has an 84 percent chance of not being exceeded when the Wasatch Fault earthquake happens.)*
4. *Provide structures that can be reoccupied while repairs are being made if the structure receives*

a median shaking level from a Wasatch Fault earthquake. (This is the shaking level that has a 50/50 chance of being exceeded when a Wasatch Fault earthquake happens.) This recommendation may also include a functional recovery measure of time following the earthquake when re-occupancy could occur (say two weeks following the earthquake)."

GeoStrata Response to UCEQS Issue 4 Building Performance

In Bowman and Lund (2020) "The Guidelines For Investigating Geologic Hazards And Preparing Engineering-Geology Reports, With A Suggested Approach To Geologic-Hazard Ordinances In Utah", Utah Geological Survey Circular 128, Chapter 2: Guidelines For Conducting Engineering-Geology Investigations And Preparing Engineering Reports In Utah, International Building/Residential Code and Local Requirements it states: *"…Engineering-geology and geotechnical investigations are often needed to properly determine the seismic design parameters required to implement the code requirements. Seismic provisions of the IBC and IRC are intended to minimize injury and loss of life by ensuring the structural integrity of a building, but do not ensure that a structure or its contents will not be damaged during an earthquake…"*

It should be noted that the primary intention of the IBC, IRC, and the City's SLEDS ordinance is to minimize injury and loss of life due to the effects of geologic hazards. Bowman and Lund (2020) states that designing structures to withstand the effects of coseismic, near-field surface faulting on multiple faults is the responsibility of the geotechnical and structural engineers and that the geologist conducting a site-specific surface-faulting-hazard investigation is responsible for providing the structural design team, to the extent possible, with quantified data on fault displacement, ground tilting, and seismic shaking, such that safe building designs are possible. The geologic reports prepared for the Gravel Pit Development have provided quantitative data on fault displacement, ground tilting, and seismic shaking for the site. Designs for the proposed buildings have not been completed at this stage in the planning of the development. The geotechnical and structural engineers will be responsible to design the proposed structures to withstand the effects of coseismic displacement, ground tilting, and seismic shaking from the main and antithetic faults as part of the building designs when the designs are completed. The June 15, 2021 UCEQS letter provides four recommendations for specific structural criteria for building design for the Gravel Pit Development that they state should be considered by the Cottonwood Heights City leaders. The specific structural design for each proposed building will be reviewed by the city at the time that the design for each building is completed. It is our recommendation that the structural deigns for each building meet or exceed all applicable requirements of the 2018 International Building and Residential Codes (IBC/IRC; International Code Council, 2017a, 2017b) and all applicable requirements of the Cottonwood Heights City Municipal code.

UCEQS Issue 5 Landslide

In the Landslide section of the June 15, 2021 UCEQS letter it states: *"The geotechnical study performed for this site includes a slope stability analysis. We recommend that a peer review be performed on the slope stability analysis once the shaking levels from the site-specific seismic hazard analysis are completed. Given the significantly higher shaking potential for the site, and given the history of past landslides here, and given the potential catastrophic effects from a landslide, we feel that it would be very prudent to ensure that this very important topic has been adequately addressed."*

GeoStrata Response to UCEQS Issue 5 Landslide

A peer review was performed by GeoStrata at the request of Cottonwood Heights City on the slope stability analysis provided as part of the geotechnical study performed for the Gravel Pit Development by Gordon Geotechnical. For details regarding the GeoStrata peer review, please see the GeoStrata review memorandums dated June 17, 2020, November 3, 2020, January 20, 2021, and April 8, 2021.

References

Review of Report Geotechnical Study and Slope Stability Analysis Proposed Wasatch Rock Development, 6695 South Wasatch Boulevard Cottonwood Heights, Utah (Gordon Geotechnical, May 13, 2020, Job No. 528-005-20) (June 17, 2020)

Review of Response Letter, Review of Geotechnical Study and Slope Stability Analysis, Proposed Wasatch Rock Development, 6695 South Wasatch Boulevard, Cottonwood Heights, Utah (Gordon Geotechnical, July 9, 2020, Job No. 528-005-20) (November 3, 2020)

Review of Report Final Slope Stability Analysis, Proposed Wasatch Rock Development 6695 South Wasatch Boulevard, Cottonwood Heights, Utah (Gordon Geotechnical, October 7, 2020, Job No. 528-006-20) (November 3, 2020)

Review of Response Letter 3-rev1, Review of Geotechnical Study and Slope Stability Analysis, Proposed Wasatch Rock Development, 6695 South Wasatch Boulevard, Cottonwood Heights, Utah (Gordon Geotechnical, December 16, 2020, Job No. 528-006-20) (January 20, 2021)

Response Letter No. 4, Review of Geotechnical Study and Slope Stability Analysis, Proposed Wasatch Rock Development, 6695 South Wasatch Boulevard, Cottonwood Heights, Utah (Gordon Geotechnical, March 18, 2021, Job No. 528-006-20) (April 8, 2021)

For our response to the need for a site-specific seismic hazard analysis please refer to the GeoStrata Response to UCEQS Issue 3 Ground Shaking above.

Closure

This response letter is issued in response to the June 15, 2021 UCEQS letter provided to Cottonwood Heights City regarding the above referenced site. Comments and recommendations in this response letter are based on published documents referenced in the body of this memorandum and field data presented by the Consultants assessing the geology, geologic hazards, and geotechnical engineering for the above referenced site. GeoStrata has not performed an independent site assessment. GeoStrata has relied on the Consultants' reports in performing its services. Consequently, it does not represent or warrant that the Consultants' reports contain accurate data or proper recommendations. Recommendations and Comments presented in this review letter are provided to Cottonwood Heights City to aid in reducing risks from geologic hazards. GeoStrata makes no warranty; either expressed or implied and shall not be liable for any direct, special, incidental, or consequential damages with respect to claims by users of this response.

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