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VIA EMAIL: holly.mullen@slcgov.com
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SALT LAKE CITY DEPARTMENT OF PUBLIC UTILITIES
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Re: Comment by Kurt A. Fisher ("Applicant") on Proposed 4th Avenue Well Chlorination Project at approximately 400 North Canyon Road, Salt Lake City, Utah (the "Well")[1]
Supplemental Comment Regarding Cloudburst Flooding Risks at the Proposed Site

Sirs:

This letter is a Salt Lake City Corporation (the "City") level comment on the concept design of the proposed Well by the Salt Lake City Department of Public Utilities ("DPU") at approximately 400 North Canyon Road in Salt Lake City. This comment provides background on the geotechnical risk that the foundation of the proposed chemical treatment plant structure might be undermined by a rare, catastrophic cloudburst flooding event, resulting in a building collapse.

The DPU proposes to build a water chlorination plant directly in what geologically has been the stream bed of the City Creek Canyon[2] near the mouth of the 12 mile long canyon that rises to 9,000 feet above MSL. There is a significant historical pattern of floods coming out of City Creek Canyon and across the Well site from two types of events: spring runoff from high snow packs and cloudburst flooding. In rare cloudburst flooding events, 3 or 4 inches of rain can fall on the foothills of the Wasatch Front Mountain Range in less than one-half hour. If this rare rain event coincides with another rare event – a recent large brush fire on the foothills overlooking the City. Foothill brush fires transform northern Utah's ancient lakebed soils into non-porous hardpan. In a subsequent heavy rain fall, the resulting flash flood flows can range between 1,000 and 2,500 cubic square feet per second. This far exceeds the design capacity of the existing conduit and control structures in City Creek Canyon of about 331 cubic feet per second.

City Creek repeatedly flooded the downtown business district before 1900, principally due to spring high stream runoff. Downtown flooding occurred in 1852, 1854, 1864 (flooding North Temple), 1866, 1869, 1870, 1873, 1874 (flooding Main Street and South Temple), 1876

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[1] Salt Lake City Department of Public Utilities. 2019. Information Website on 4th Avenue Well Project (url: https://www.slc.gov/utilities/fourth-avenue-well-project/, accessed May 2019).

[2] Well location map (url: https://goo.gl/maps/XFZfkuXYPXCPdGgZA).

(between 600 East and the Jordan River, lands flooded between several inches to several feet), 1882 (possibly flooding downtown), 1884 (flooding North Temple), 1885 (flooding streets), and 1889 (flooding streets).[3].

In 1907, hundreds died in the infamous Heppner, Oregon cloudburst flood, and then City Engineer Kesley noted the impossibility of guarding the City's center from cloudburst floods emanating from City Creek Canyon:

> A part of the city is located at the mouth of City Creek canyon in such a position that a heavy cloudburst in the canyon would send a wall of water into the city that would cause a heavy loss of probably both life and property. . . . . I understand that cloudbursts in former years have done considerable damage, but nothing of that kind has ever happened while I have been here. A cloudburst of any considerable magnitude would do almost incalculable damage, and I cannot see how it could be avoided. There is no possible way to divert such a stream without an enormous expenditure of money. . . . . A wall of water coming down the canyon, similar to that at Heppner, would sweep everything before It. Residences in the canyon's mouth would fall like card houses and the wave would then sweep down North Temple and State streets.[4]

After Kelsey's caution, flooding also occurred in 1907 (flooding North Temple), 1908 (flooding North Temple) and 1909 (flooding North Temple and requiring construction of five foot emergency embankments).[5]

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[3] Woolley, R. R. (1946). Cloudburst Floods in Utah: 1850-1938. Washington, D.C. at 96-120 (url: http://pubs.er.usgs.gov/publication/wsp994); Honker, A. M. (1999). "Been Grazed Almost to Extinction": The Environment, Human Action, and Utah Flooding, 1900-1940. Utah Historical Quarterly, 76(1), 23–47 (url: http://heritage.utah.gov/history/quarterly); Boyce, R. R. (1958). A historical geography of Salt Lake City, Utah. Thesis. Masters. Department of Geography, University of Utah at 41 re 1876).

[4] Salt Lake Telegram, June 9th, 1903.

[5] Woolley at 96-120, Honker 1999.

Figure 1 - Shipler Commercial Photography. June 2, 1909. Flood at 4th (Fourth) Avenue and Canyon Road. (url: https://collections.lib.utah.edu/ark:/87278/s69c7802). The home shown in the photograph is still standing at approximately 220 North Canyon Road.

In 1910 and in response to this flooding, the City and DPU's predecessor began construction to capture the City Creek stream upstream of the proposed Well into an underground conduit[6] with a design capacity of 120 cubic feet per second squared.

Figure 2 – Entombment of City Creek Canyon Stream circa 1909. U.S. Amy Corp. of Engineers. From Love, ftn 22 *infra*.

[6] Salt Lake Herald, March 21st, 1910.

After construction of this first underground conduit, City Creek again flooded across the proposed Well site and into the downtown in 1912 (flooding South Temple with tons of sand) and in 1918 (silting 200 South with 1 foot of mud).[7]

On August 13th, 1923, Kelsey's 1903 prediction came true in a community to the north of Salt Lake's downtown. An extreme cloudburst event along the Wasatch Front sent torrents down Farmington Canyon, destroyed Farmington City, and killed seven.[8] Salt Lake's downtown also flooded.[9] City Creek again flooded across the proposed Well site and into Salt Lake's downtown also flooded in 1925 (flooding basements), 1931 (12 inches of water in streets), and in 1945 (discussed below).

Cloudburst flooding occurs all along the 200 mile north-south Wasatch Front Range. Destructive cloudburst floods were so frequent and destructive in northern Utah communities that in 1930, the State formed to Utah Flood Commission to conduct a formal investigation.[10] The Flood Commission determined that cloudburst flooding was aggravated by human factors. Excessive grazing, lumbering and lack of fire control in canyon headwaters contributed to the force of floodwaters reaching the valley floors (*id*). In response, the City implemented policies to reduce grazing in City Creek Canyon; its firefighting capabilities improved.

Despite the new practices, in 1945 and at approximately 1.5 miles from the proposed Well site, a classic cloudburst flood came out of Perry's Hollow[11] on the south facing slope of the Salt Lake City Salient. In that flood, a three foot wall of water mixed with 300 pound boulders and grave headstones came through the cemetery and down "M" and "N" Streets.[12] The Salt Lake Telegram reported that 200 to 400 lb. boulders and eight cars were washed down "M" Street.[13] An incredible 2,400 cubic feet per second came out of Perry's Hollow in 1945 (*id*). A separate flood also came down State Street (*id*). Damage to the City was estimated at 300,000 USD in 1945, or about 4 million USD today.

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[7] Woolley at 96-120, Honker 1999.

[8] Honker, 35-36.

[9] Woolley at 96-120, Honker 1999.

[10] Utah Flood Commission. (1931). Torrential floods in Northern Utah, 1930. Logan: Agricultural Experiment Station, Utah State Agricultural College (url:.http://www.lib.utah.edu).

[11] Map - location (url: https://goo.gl/maps/qkv9NkUBMravdkjL9).

[12] Craddock, G. W. (1945). The Salt Lake City Flood, 1945. Proceedings of the Utah Academy of Sciences, Arts and Letters, 23, 51–61; Salt Lake Telegram, August 20 and 27, 1945; *see* Salt Lake Tribune, August 19, 1945.

[13] Salt Lake Telegram, August 20, 1945.

Workers and trucks of Salt Lake City streets department continue work of cleaning mud, trees and huge boulders left in wake of a huge storm which reared into the city from the west Sunday night. Workers here are cleaning at 1st ave. and M st.

Figure 3 - M Street and 1st Avenue after 1954 Perry's Hollow Flood. Salt Lake Telegram, August 20, 1945. The house in the background still exists.

Craddock described causes of the Perry's Hollow flood, citing a historical pattern of overgrazing, grass fires and cloudburst rain:

> Inspection of the flood-producing watersheds revealed the plant cover to be in a seriously deteriorated condition notwithstanding many years of protection from livestock grazing and conscientious attempts to control fires. Three stages of impairment were observed. . . . .
>
> Roughly 10 percent of the watershed - including extensive slopes in the lower portion of the basins and parts of the ridge tops, roads, and mined areas - are virtually devoid of vegetation and litter as a result of grazing abuse in earlier years, old and new mining activity, and both old and recent fires. . . . .
>
> Fully 80 percent of the area, including all but patches of headwater slopes and portions of lower benchlands, was burned last fall. This fire killed many of the native bunchgrasses which had reinvaded the area since its closure to grazing. . . . [14]

Craddock estimated that in 1945, runoff from East and West Valley View Canyons (at the top of North Terrace Drive) did not show any increased runoff because those canyons did not burn. In comparison, to the 2,400 feet per second of flows seen in 1945, the 1983 snowmelt flood of City Creek peaked at 331 cubic feet per second. (In the 1990s, as part of road improvement, the City constructed a flood control dam across lower Perry's Hollow to prevent a reoccurrence.[15])

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[14] Craddock at 58.

[15] Along Chandler Drive; Map (url: https://goo.gl/maps/vvkQW7beNdfABTWu5).

A 1946 U.S.G.S. report by Ralf R. Woolley of the Intermountain Forestry Research Station examined cloudburst flooding in northern Utah from 1850 to 1938.[16] Woolley listed numerous cloudbursts floods that have come across the Avenues District and from City Creek and across the proposed Well site and into the downtown: (Woolley 1946). Summer cloudburst floods included: June 13th, 1854 (city streets flooded), September 11th, 1864 (heavy flooding of North Temple from City Creek), August 25th, 1872 (downtown flooded), July 23rd, 1874 (downtown flooded from City Creek), August 1st, 1874 (Lindsey Gardens areas flooded as in 1945), August 8th, 1884 (North Temple flooded from City Creek), July 26th, 1893 (cloudburst flooded basements in city), July 19th, 1912 (1 inch fell in 1 hour filled South Temple with sand and mud from above), July 25th, 1916 (cloudburst sent a 10 foot wall of water into city along with mud, boulders and cattle), July 30th, 1930 (cloudburst over Emigration, Red Butte, and Parley's Canyons washed out highway north of Salt Lake and washed away three homes with damages of 500,000 USD), and August 13th, 1931 (four to 12 inches of water swept through streets and 12 feet of debris washed over road near Beck Hot Springs).

In April 1952, City Creek again flooded the downtown during high spring runoff.[17]

Catastrophic high-spring run-off again occurred in 1983 with ground failures near the proposed Well site. On May 26th, 1983, City officials proclaimed a flood emergency in Salt Lake City after a winter of heavy snowfall followed by a late season warming.[18] The city pre-ordered 250,000 sandbags (*id*). Sandbagging State Street kept City Creek from flooding underground parking at ZCMI Mall (*id*). On May 28th, 1983, Mayor Ted Wilson learned that rock and tree debris from City Creek Canyon were clogging up the 1910 underground culvert down State Street and a second pipe system along North Temple (*id*). The flood waters swept fallen trees that had accumulated in the 12 miles of City Creek stream bed above Memory Grove Park and down into the lower canyon, about 600 feet north of the proposed Well site (Figure 4).

Figure 4 – Tree debris in Memory Grove Park after flood waters receded. Salt Lake City Tribune, July 22, 1983. "Restoration of Memory Grove will be a joint project."

[16] "Cloudburst Floods in Utah: 1850-1938", *supra*, at ftn. 3.

[17] Salt Lake Tribune, April 30, 1952; Salt Lake Tribune, April 29, 2011 (retrospective article in which Salt Lake Councilperson describes sandbagging efforts to control 1952 flood).

[18] Salt Lake Tribune, April 29, 2011.

The first nearby ground failure associated with the 1983 flood was at the clogged culvert about 400 feet south of the proposed Well site. The underground culvert carrying City Creek burst, and a city worker had to be lowered into the pipe full of swirling flood waters to set dynamite charges and to free the blockage.[19]

Nevertheless, flood waters were so great that the creek also flooded above its entry point

Figure 5 – Flood waters passing Ottinger Hall 300 feet north of proposed Well in June 1983. Source: KUTV News. Remembering the Floods of 1983. Web. Accessed May 2019 (url: https://kutv.com/news/local/gallery/photo-gallery-remembering-the-floods-of-1983#photo-28).

into the underground culvert (Figure 5).

A second ground failure associated with the 1983 flood was a 12 foot deep sinkhole that formed north of the proposed Well site, shown in Figure 6:

[19] Salt Lake Tribune, June 3, 1983.

Figure 6 – Twelve Foot Deep Surface Failure North of Ottinger Hall and 400 feet north of proposed Well site, looking south, June 9, 1983. Salt Tribune. 1983. Spirit of Survival: Utah Floods of 1983.

Figure 7 – Ground failures at Memory Grove entrance during 1983 flood about 600 feet from the proposed Well looking north. SLC Fire Tech. 1984. Salt Lake City Flood of 1983. Video. At min. 5:44. (url: https://youtu.be/WCU_AymQ6J0?t=344).

Figure 8 – Ground failures at Memory during the 1983 flood about 600 feet from the proposed Well. Writh, Craig (KUTV News). May 12, 2014. Remembering the flood of '83. KUTV News. At min. 1:35. (url: https://www.abc4.com/wirth/wirth-watching-remembering-the-salt-lake-city-flood-of-83/204262974).

The force of the 1983 waters at a peak of 331 cubic feet per second, the waters had sufficient force to topple stone columns in Memory Grove.

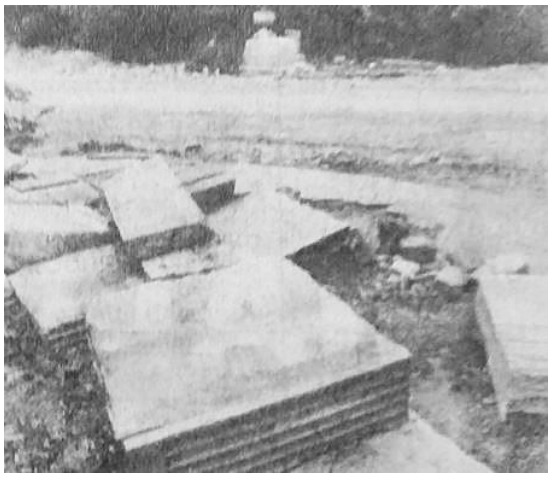

Figure 9 – Stone blocks in columns moved by water flows. Salt Lake City Tribune, July 22, 1983.

A third ground failure occurred along Spencer Court, also about 500 feet northeast of the proposed well project, not shown.[20]

Although the 1983 flood damages were a natural disaster, the severity of the damage was aggravated by human management factors. In the 1983 flood, the flood down State Street started when logs jammed the underground City Creek conduit near North Temple and State Streets about 600 feet south of the proposed Well (*supra*). In the 1890s and 1900s, the predecessor to the

[20] Fisher, personal observation, 1983. Map-location (url: https://goo.gl/maps/EN19iZK1V8bnch6NA).

DPU maintained City Creek by hiring gangs of men to remove the many dead and overhanging trees from the streambed.[21] In the 1910s, that practice ended. Before the 1983 floods and currently, the City only removes dead and fallen trees that might fall on the road, but not from the streambed.

Following catastrophic runoff of 1983, the DPU installed a redesigned conduit sufficient to capture more than the peak 1983 flood flow of 331 cubic feet per second. Two small flood control basins, about one-acre each in size, were installed upstream of the proposed Well facility at the intersection of Bonneville Drive and City Creek Canyon Road. These are designed to catch trees that might be swept downstream in a future flood. But these improvements are in no way designed to deal with a reasonably anticipated 2,400 cubic per second cloudburst flood such as occurred at Perry's Hollow in 1946.

In 2003, the Army Corps of Engineers proposed a permanent, higher capacity solution to carry City Creek storm flows. The Corps envisaged moving City Creek along North Temple from 300 West to the Jordan River on a proposed abandoned railway right-of-way.[22] But the City decided not to pursue that 20 million USD project, and instead used the proposed route for an interurban railway. The 2003 Corps of Engineer's proposal would have reconstructed the geologic City Creek streambed with an outflow connected to the Great Salt Lake.

In addition to the underground conduit and flood basins added after 1983. The City has adopted other practices to reduce the risk of grassland fires in City Creek Canyon that might lead to a severe cloudburst flood event. Fire roads have been constructed along the canyon's ridgelines. A vigorous fire prevention regime for recreation users in the canyon is enforced. The City Fire Department responds to over 900 grass fire calls, principally on the valley floor, and on the foothills.

There are some key lessons from the 1983 floods. First, the rare event where cloudburst flooding would cause a 2,400 cubic feet per second flood is a reasonable geotechnical planning criteria. Second, preventative measures that rely on human management are not fully reliable. Each facility in the flood path must fail safe. Third, the recent Paradise fire in California illustrates who natural forces are sometimes beyond human control. Once a large uncontrolled fire occurs in City Creek, the risk of a cloudburst flood is real.

The risk of cloudburst flooding continues and is not abstract. Flooding, after a large 2008 grass fire in Skull Valley west of Salt Lake City, sent a wall of mud down a canyon that created at 3 foot high alluvial fan on the valley floor.[23]

In May 2019, DPU proposed a concept design for the chemical treatment plant to be located in City Creek Canyon's geologic streambed.

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[21] Salt Lake Tribune, January 4, 1908; Salt Lake Herald, January 31, 1894.

[22] Deseret News, August 1st, 2003; Love, Ron. 2007. Bankside Salt Lake City. Chap. 5 in Rivertown: Rethinking Urban Rivers (at 101); U.S. Army Corps of Engineers. Dec. 2003. Draft City Creek Section 206, Aquatic Ecosystem Restoration Project Report.

[23] Nicoli, K. and Lundeen, Z. J., University of Utah. (2016). A case study: geomorphic effects of the 2009 Big Pole fire, Skull Valley, Utah (Vignettes: Key Concepts in Geomorphology). Northfield, Minnesota. (url: http://serc.carleton.edu/47063).

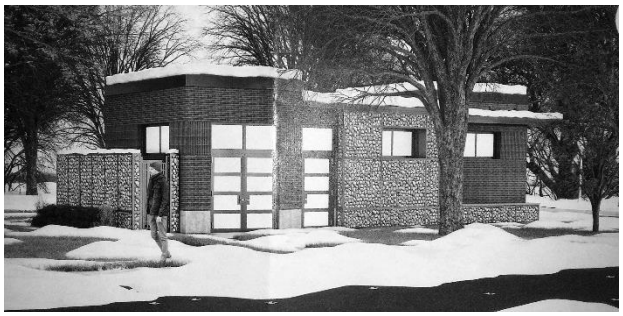

Figure 10 – DPU Architectural Rendering showing that despite known flooding risk power transformers are located at the north-upstream end of building and that proposed structure is built at grade. May 9, 2019.

The concept design (Figure 10) does not consider the flooding history at the 400 North site. The chemical plant is built at grade and not above the last known flood levels. The rectangular north end of the plant includes high-power transformers at ground level. The transformers will put residents and first responders in future floods at risk of accidental electrocution. Because the building is rectangular, the north narrow end will be susceptible to having its foundation undermined and suffering a structural collapse. If a collapse occurs during a flood, the chemical storage tank inside the building may fail and release 500 to 900 lbs. of sodium hypochlorite into floodwaters. Such a spill, in addition to creating a risk for chemical burns, may by simultaneous mixing of large a volume of sodium hypochlorite into water may release a cloud of chlorine that would be a health risk to the surrounding neighborhood.

In conclusion, there are significant flood related risks at that site which indicate that the proposed chemical treatment plant should be relocated, for example as proposed in Option 2c of the DPU-HAL Report.

I hope the above information contributes positively to the DPUs decision-making process. Please feel free to contact me with respect to this matter by the means listed above. As always your cooperation is appreciated.

Very Truly Yours

Kurt A. Fisher

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