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October 12, 2021

Aaron K. Schindewolf, P.E.
Woodlands Division Engineer
San Jacinto River Authority
2436 Sawdust Road
The Woodlands, TX 77380

RE: Review of Thirteenth (13th) Re-measure of the Waterline W1A and W2A Benchmark Elevations in the Woodlands, Texas in September 2021

Dear Aaron:

This letter provides our review of a September 2021 re-measure of benchmarks placed along four lines in The Woodlands in March 2015. The work was performed under Master Professional Services Agreement Contract No. 20-0077 and under Work Order 5 (PO Number: 21-1257). The technical lead for this task was Dr. Steve Young. Our comments are provided in Attachment A.

Respectfully submitted,

Steven C Young

Steven Young, PHD
Professional Geologist
Professional Engineer

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ATTACHMENT A
Review of W1A and W2A Benchmark Elevations

The September 2021 survey represents is the thirteenth (13th) re-measure of the benchmarks since their initial measurements in March 2015. The benchmarks are grouped into two areas: W1A and W2A. Each of the two areas include benchmarks along two transects. Figure 1 shows the locations the two transects. Tables 1 and 2 show the re-measured benchmark elevations for the two W1A transects located near the Egypt Fault. Tables 3 and 4 show the measured benchmark elevations for the two W2A transects located near the Big Barn Fault (Table 3) and Panther Branch fault (Table 4).

The thirteenth re-measure of include measurements of elevations at 45 benchmarks along the W1A and W2A transects. Along the W1A segment with 4 benchmarks, the changes in benchmark elevation suggests that the Egypt fault is one of several factors that contributes to the differences in land subsidence rates, which are about 0.005 ft/year, across the transect it divides. Along the W2A segment, the differences in changes in benchmark elevation suggest that the Panther Branch fault may be a one of several factors that contributes to the differences in land subsidence rates of about 0.005 ft/yr, across the transect it divides.

W1A Transects

Table 1 and Table 2 provide the differences in elevations for 22 benchmarks located along the W1A Segment. The differences in benchmark elevations for the last 6 months and for the last 6.5 years are discussed below.

Last 6 months- Over the last 6 months, 13 out of the 22 benchmarks had no change in elevation, 8 benchmarks had a decrease in elevation of 0.01 feet, and 1 benchmark had no increase in elevation of 0.01 feet. In Tables 1 and 2 there are no notable differences in the average change in elevations between the 8 benchmarks located on the upthrown side of the fault compared to the 9 benchmarks located on the downthrown side of the fault.

Last 6.5 years- Since March 2015, the elevation changes at the 22 benchmarks are as follows: 9 benchmarks had a decrease in elevation of 0.01 feet, 9 had a decrease of in elevation of 0.02 feet, 1 benchmark had a decrease in elevation of 0.03 feet, 1 benchmark had a decrease in elevation of 0.04 feet, 1 benchmark had no change in elevation, and 1 benchmark had a decrease in elevation of 0.12 feet. The decrease of 0.12 feet occurred at benchmark MbM-11 located near the upper edge of the downthrown fault block at the midpoint of the transect segment A1A.

The -0.12 feet difference at benchmark MbM-11 is an outliner among the other measured differences and is attributed the benchmark being located in a narrow zone of highly disturbed soil between the upthrown and the downthrown fault blocks. The 0.12 feet drop in ground surface elevation is likely caused by the slow, progression compaction of soil. Looking at the pattern of elevation changes at the 18 benchmarks along the transect in Table 1, the elevations of the southern benchmarks has dropped about 0.016 ft more than the northern segment. Across the southern benchmarks that include MbM-12 through MbM-20, the 6.5-year elevation differences range between -0.01 and -0.02 and average -0.027 feet. Across the northern benchmarks MbM-1 to MbM-4 and MbM-7 to MbM-10, the 6.5-year elevation differences range

between -0.01 and -0.02 averaged -0.011 feet during the last 6.5 years. Given that this change is relatively small relative to measurement error there is insufficient evidence to conclude that the fault is active. For instance, the analysis of the benchmarks during the last six months does not support the trend observed over the last 6.5 years. During the last six months, the average decrease in benchmark elevations is slightly less for the southern benchmarks than for the northern benchmarks.

Over the last 6.5 years, the net change in elevation for the 4 benchmarks in the vicinity of the Egypt fault (see Table 2) range between 0 feet and -0.04 feet and the average is -0.02 feet. The two benchmarks on the upthrown side of the fault have an average decrease of 0.035 feet in elevation whereas the two benchmarks on the downthrown side of the fault have an average decrease of 0.005 feet. Over the last 6 months, the two benchmarks on the upthrown side of the fault had an average drop in elevation of 0.005 feet whereas the two benchmarks on the downthrown side of the fault had average raise is elevation of 0.005 feet. The changes in benchmark elevations that occur over both the 6 month and 6.5 year periods suggest that Egypt fault could be a contributing factor to the difference in the measured rate of elevation change, which are about 0.005 ft/year, across the transect it divides.

W2A Transects –

Table 3 and Table 4 provide the differences in elevations for 23 benchmarks located along the W2A Transect. The differences in benchmark elevations for the last 6 months and for the last 6.5 years are discussed below. For the discussion below, the September 2021 for benchmark MbM-10 has been omitted because it appears to be an outliner.

Last 6 months - Over the last 6 months, 11 out of the 22 benchmarks had no change in elevation, 9 had a decrease of 0.01 feet, 1 had a decrease of -0.02 feet, and 1 benchmark had an increase of 0.01 feet. In Table 3, there is no difference in the average change in elevations for the 2 benchmarks that are on the upthrown side of the fault and the two 2 benchmarks on the downthrown side of the fault. In Table 4, western benchmarks MbM-1 through MbM-12 average a 0.01 ft decrease in elevation and the eastern benchmarks MbM-13 through MbM-20 average no change in elevation.

Last 6.5 years – Over the last 6.5 years, 5 out of the 22 benchmarks had no change in elevation, 4 had a decrease of 0.01 feet, 1 had a decrease of 0.02 feet, 4 had a decrease of 0.03 feet, 5 had a decrease of 0.04 feet, 2 had a decrease of 0.05 feet, and 1 had a decrease of 0.07 feet.

In Table 3, the 2 benchmarks that are on the upthrown side of the fault have average elevation decrease that is 0.01 feet more than the two benchmarks on the downthrown side of the fault. Our interpretation of the results from the 6 month and 6.5 year intervals suggest that there is no conclusive evident of an active fault zone between the location of the benchmarks.

In Table 4, the 19 benchmarks along the transect indicates that the western segment of the transect has decrease in elevation more than the eastern segment of the transect. At the western benchmarks MbM-1 through Mbm-12, the elevation change ranged from -0.0 feet to -0.07 feet and averaged about -0.041 feet. At the eastern benchmarks MbM-13 through Mbm-18, the elevation change ranged from -0.00 feet to -0.04 feet and averaged -0.009 feet. Along the W2A segment, the differences in elevation suggest that a Panther Branch Fault located near benchmark Mbm-12 may be a one of several factors that contributes to the differences in land subsidence rates of about 0.005 ft/yr between the benchmarks located on the western and eastern portion of the W2A segment.

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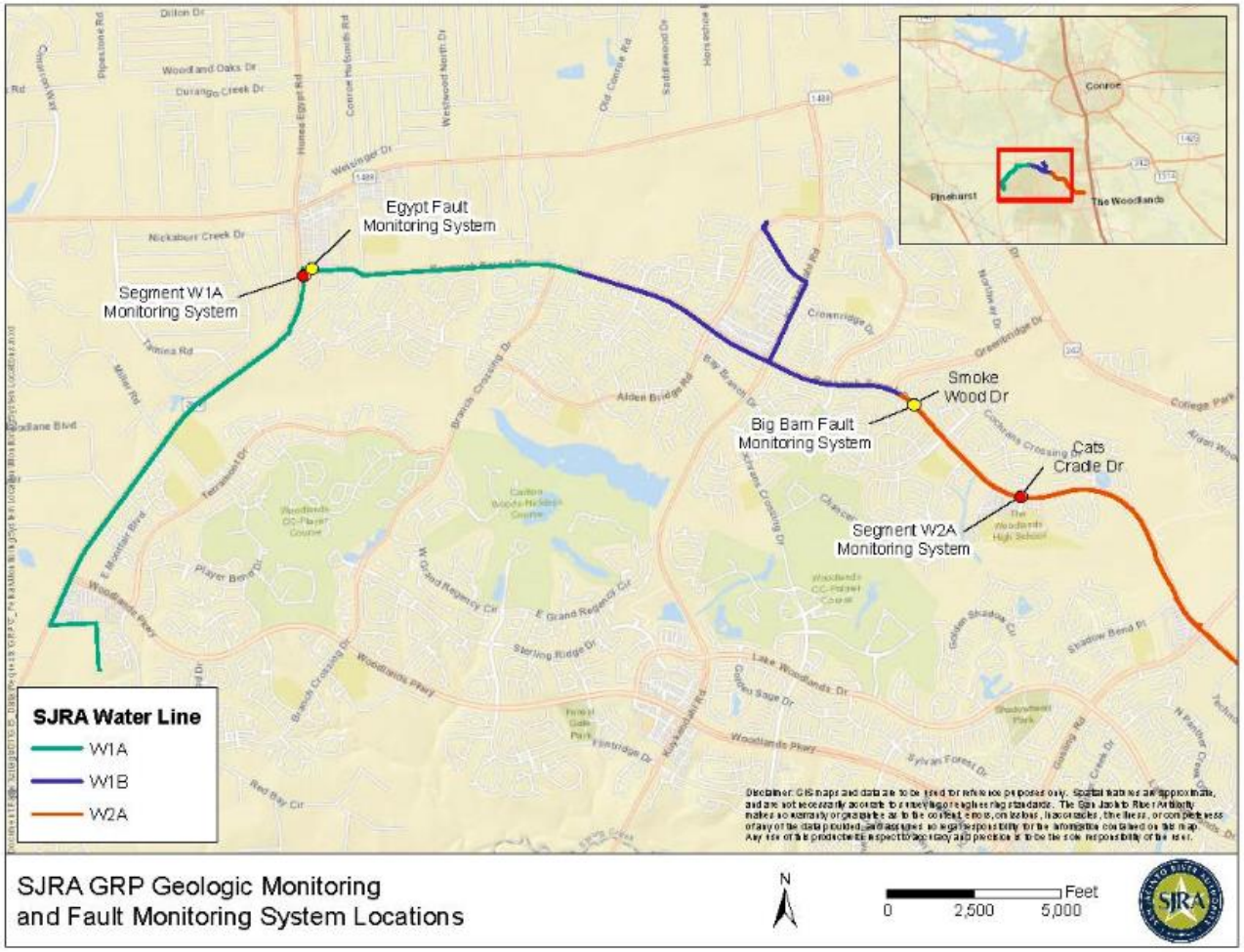

Figure 1. SJR GRP Geological Monitoring and Fault Monitoring System Locations (https://www.sjra.net/grp/fault-monitoring/)

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Table 1. Benchmark Elevations for SJRA Segment W1A Geological Monitoring Survey for March 2015, March 2021, and September 2021

Point ID	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March 2021 Elev.	(c) September 2021 Elev.	Sept 2021 minus Mar 2015 (c) - (a)	Sept. 2021 minus Mar. 2021 (c) - (b)
MbM-1	189.24	189.24	189.23	-0.01	-0.01
MbM-2	189.27	189.27	189.26	-0.01	-0.01
MbM-3	189.45	189.44	189.44	-0.01	0.00
MbM-4	189.73	189.72	189.72	-0.01	0.00
MbM-5	190.41	Destroyed	Destroyed	na	na
MbM-6	190.26	Destroyed	Destroyed	na	na
MbM-7	188.81	188.80	188.80	-0.01	0.00
MbM-8	188.28	188.27	188.27	-0.01	0.00
MbM-9	187.93	187.92	187.91	-0.02	-0.01
MbM-10	187.76	187.75	187.75	-0.01	0.00
MbM-11	188.00	187.89	187.88	-0.12	-0.01
MbM-12	187.77	187.75	187.75	-0.02	0.00
MbM-13	187.50	187.49	187.48	-0.02	-0.01
MbM-14	187.75	187.73	187.73	-0.02	0.00
MbM-15	188.49	188.48	188.48	-0.01	0.00
MbM-16	187.86	187.84	187.84	-0.02	0.00
MbM-17	189.31	189.30	189.29	-0.02	-0.01
MbM-18	189.75	189.73	189.73	-0.02	0.00
MbM-19	189.32	189.31	189.30	-0.02	-0.01
MbM-20	188.55	188.53	188.53	-0.02	0.00

note: na= not applicable

Table 2.
Benchmark Elevations for SJRA Segment W1A for March 2015, March 2021, and September 2021 at Existing Fault Protection System| Egypt Fault

Station/Description	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March 2021 Elev.	(c) September 2021 Elev.	Sept 2021 minus Mar 2015 (c) - (a)	Sept. 2021 minus Mar. 2021 (c) - (b)
Sta 103+72 Top Square Nut on 2" Steel Cap	187.2	187.19	187.2	0.00	0.01
Sta 103+82 Top 2" Steel Pipe (NO CAP)	186.93	186.92	186.92	-0.01	0.00
Sta 108+70 Top Square Nut on 2" Steel Cap	190.28	190.25	190.24	-0.04	-0.01
Sta 108+80 Top 2" Steel Cap	190.31	190.28	190.28	-0.03	0.00

Table 3.
Benchmark Elevations for SJRA Segment W2A for March 2015, March 2021, and September 2021 at Existing Fault Protection System| Big Barn Fault

Station/Description	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March 2021 Elev.	(c) September 2021 Elev.	Sept 2021 minus Mar 2015 (c) - (a)	Sept. 2021 minus Mar. 2021 (c) - (b)
Sta 9+25 Top 2" Steel Cap	177.81	177.8	177.81	0.00	0.01
Sta 9+35 Top 2" Steel Cap	177.74	177.73	177.73	-0.01	0.00
Sta 9+85 Top 2" Steel Cap	176.73	176.71	176.71	-0.02	0.00
Sta 9+95 Top 2" Steel Cap	176.78	176.76	176.77	-0.01	0.01

Table 4.
Benchmark Elevations for SJRA Segment W2A Geological Monitoring Survey for March 2015, March 2021, and September 2021

Point ID	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March 2021 Elev.	(c) September 2021 Elev.	Sept 2021 minus Mar 2015 (c) - (a)	Sept. 2021 minus Mar. 2021 (c) - (b)
MbM-1	142.59	142.56	142.55	-0.04	-0.01
MbM-2	142.80	142.78	142.77	-0.03	-0.01
MbM-3	143.31	143.27	143.26	-0.05	-0.01
MbM-4	143.35	143.30	143.28	-0.07	-0.02
MbM-5	143.85	143.82	143.81	-0.04	-0.01
MbM-6	144.14	144.11	144.11	-0.03	0.00
MbM-7	144.29	144.26	144.26	-0.03	0.00
MbM-8	145.20	145.17	145.16	-0.04	-0.01
MbM-9	145.51	145.48	145.48	-0.03	0.00
MbM-10	145.63	145.60	145.63	0.00	0.03
MbM-11	146.16	146.12	146.11	-0.05	-0.01
MbM-12	145.42	145.38	145.38	-0.04	0.00
MbM-13	145.00	145.00	145.00	0.00	0.00
MbM-14	144.99	144.98	144.98	-0.01	0.00
MbM-15	144.79	144.79	144.79	0.00	0.00
MbM-16	144.78	144.78	144.78	0.00	0.00
MbM-17	144.79	144.79	144.79	0.00	0.00
MbM-18	144.55	144.55	144.54	-0.01	-0.01
MbM-20	145.86	145.83	145.82	-0.04	-0.01