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May 3, 2021

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

RE: Review of Twelveth (12th) Re-measure of the Waterline W1A and W2A Benchmark Elevations in the Woodlands, Texas in March 2021

Dear Aaron:

This letter provides our review of a March 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 1 – On Call Hydrogeology and Groundwater Management. 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 March 2021 survey represents the twelveth (12th) 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 four 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.

The twelveth re-measure of 45 benchmarks in the W1A and W2A areas show no convincing evidence of vertical movement associated with an active fault at any of the 4 transects since March 2015.

W1A Transects

Table 1 provides the differences in benchmark elevations for 22 locations. The differences in benchmark elevations for the last 6 months and for the last 6 years are discussed below.

Last 6 months- Over the last 6 months, 19 out of the 22 benchmarks had no change in elevation, 1 had an increase of elevation of +0.01 feet, and 2 had a decrease of -0.01 feet.

Last 6 years -Since March 2015, the elevation changes at the 22 benchmarks are as follows: 2 benchmarks had no change in elevation, 11 had a decrease of -0.01 feet, 6 had a decrease of -0.02 feet, 2 had a decrease of -0.03 feet, and 1 had a decrease of -0.11 feet. The decrease of -0.11 feet occurred at benchmark #11 located near the upper edge of the downthrown fault block at the midpoint of the transect. The -0.11 feet difference is an outliner among the other measured differences and is attributed to benchmark #11 being located in a narrow zone of highly disturbed soil between the upthrown and the downthrown fault blocks. The -0.11 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 0.01 more than the northern segment. At the southern benchmarks 12 through 20, the 6-year elevation differences averaged -0.016 feet whereas at the northern benchmarks 1 to 4 and 6 to 10, the 6-year elevation differences averaged -0.007 feet during the last 6 years. Our interpretation of the movement pattern along the transect of 18 benchmarks (2 out of original 20 benchmarks have been destroyed) that movement along the transect has occurred during the last 6 years but that movement has been too small to be associated with an active fault at this location.

The above conclusion also applies to the transect of 4 benchmarks across the Egypt fault in the vicinity where it crosses Research Forest Drive and few hundred feet east of FM 2978 (see Table 2). Over the last 6 years, the net change in elevations for the 4 benchmarks ranged between -0.01 feet and -0.03 feet and averaged -0.02 feet.

W2A Transects –

Table 2 provides the differences in benchmark elevations for 22 locations. The differences in benchmark elevations for the last 6 months and for the last 6 years are discussed below.

Last 6 months - Over the last 6 months, 14 out of the 23 benchmarks had no change in elevation, 6 had an increase of 0.01 feet, and 3 had a decrease of -0.01 feet.

Last 6 years - A line of 4 benchmarks along Research Forest Drive crosses the well-known Big Barn Fault just east of Green Bridge Drive. Over the past 6 years, 2 of the 4 benchmarks had no movement and the remaining 2 had a decrease of -0.01 feet (see Table 3). Our review of the data is that the fault has been inactive during the past 6 years.

Farther to the east, an east-west line of 19 benchmarks (see Table 4) along the north side of Research Forest Drive at and near Cat's Cradle Drive, crosses an area where a northeast-southwest gap exists between 2 known active faults or subsurface evidence for the existence of an active fault in the gap, the 19 benchmarks were installed near its center to identify ground movements that might be expected to occur across a know fault. Looking at the pattern of elevation changes at the 19 benchmarks along the transect, there is evidence that the western segment of the transect has dropped more than the eastern segment of the transect. At the western benchmarks 1 through 12, the elevation change ranged from -0.02 feet to -0.05 feet and averaged about -0.033 feet. At the eastern benchmarks 13 through 18, the elevation change ranged from -0.00 feet to -0.03 feet and averaged -0.006 feet. Although there is a difference in elevation change between the two sets of benchmarks, there is insufficient movement during the last 6 years and during the last six months to attribute the difference in elevation change to an active fault.

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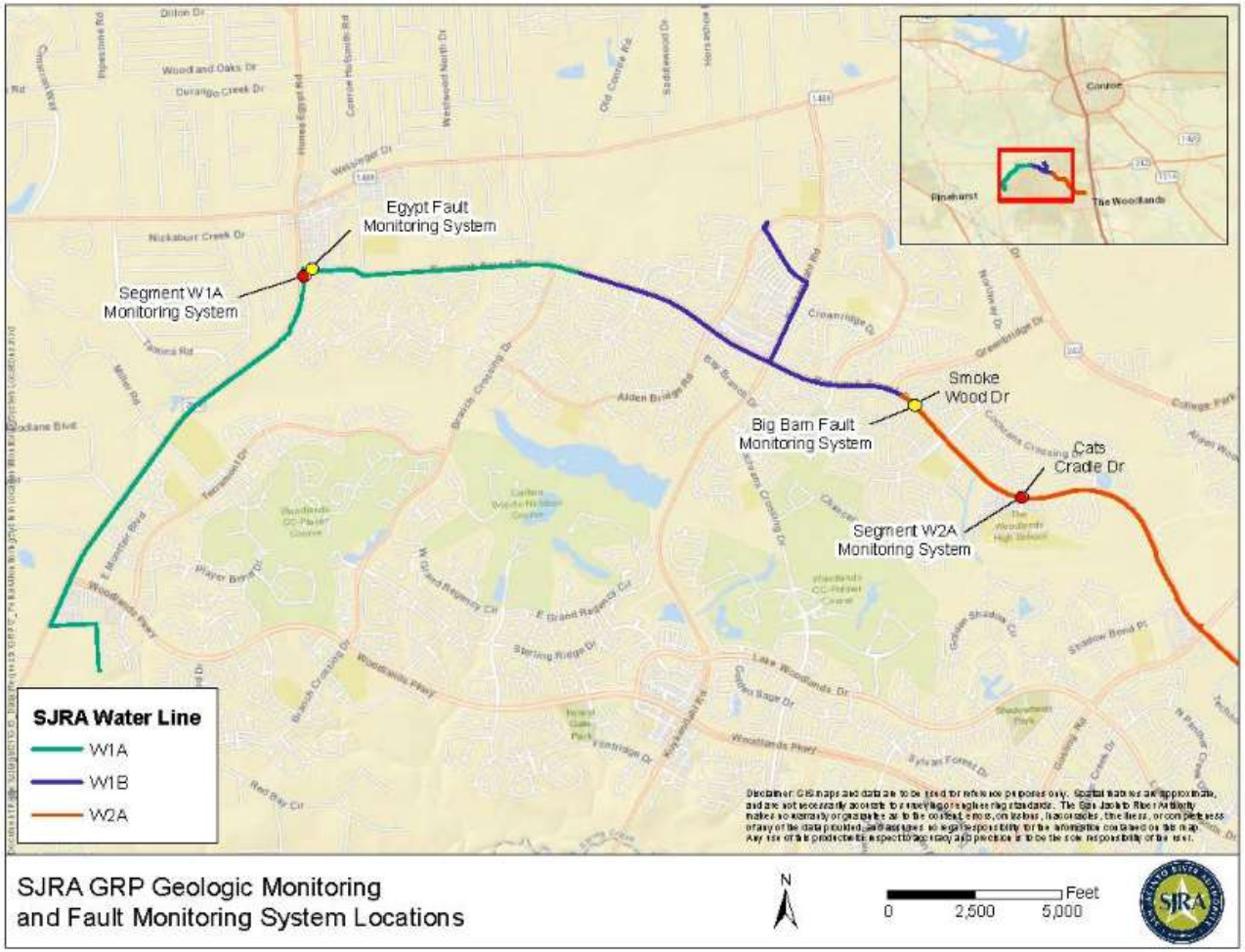

Figure 1. SJR GRP Geological Monitoring and Fault Monitoring System Locations (https://www.sjra.net/grp/fault-monitoring/)

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Table 1. Benchmark Elevations for SJRA Segment W1A Geological Monitoring Survey for March 2015, November 2020, and March 2021

Point ID	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) November, 2020 Elev.	(c) March, 2021 Elev.	Mar 2021 minus Mar 2015 (c) - (a)	Mar. 2021 minus Nov 2020 (c) - (b)
MbM-1	189.24	189.24	189.24	0.00	0.00
MbM-2	189.27	189.27	189.27	0.00	0.00
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	187.92	-0.01	0.00
MbM-10	187.76	187.75	187.75	-0.01	0.00
MbM-11	188.00	187.89	187.89	-0.11	0.00
MbM-12	187.77	187.75	187.75	-0.02	0.00
MbM-13	187.50	187.49	187.49	-0.01	0.00
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	189.29	189.30	-0.01	0.01
MbM-18	189.75	189.73	189.73	-0.02	0.00
MbM-19	189.32	189.31	189.31	-0.01	0.00
MbM-20	188.55	188.53	188.53	-0.02	0.00

Table 2.
Benchmark Elevations for SJRA Segment W1A for March 2015, November 2020, and March 2021 at Existing Fault Protection System| Egypt Fault

Station/Description	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) Nov, 2020 Elev.	(c) March 2021 Elev.	Mar 2021 minus Mar 2015 (c) - (a)	Mar. 2021 minus Nov 2020 (c) - (b)
Sta 103+72 Top Square Nut on 2" Steel Cap	187.2	187.2	187.19	-0.01	-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	190.25	-0.03	0.00
Sta 108+80 Top 2" Steel Cap	190.31	190.29	190.28	-0.03	-0.01

Table 3.
Benchmark Elevations for SJRA Segment W2A for March 2015, November 2020, and March 2021 at Existing Fault Protection System| Big Barn Fault

Station/Description	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) November, 2020 Elev.	(c) March 2021 Elev.	Mar. 2021 minus Mar 2015 (c) - (a)	Mar. 2021 minus Nov. 2020 (c) - (b)
Sta 9+25 Top 2" Steel Cap	177.81	177.81	177.8	-0.01	-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	176.77	176.76	-0.02	-0.01

Table 4.
Benchmark Elevations for SJRA Segment W2A Geological Monitoring Survey for March 2015, November 2020, and March 2021

Point ID	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) November, 2020 Elev.	(c) March, 2021 Elev.	Mar. 2021 minus Mar 2015 (c) - (a)	Mar. 2021 minus Nov 2020 (c) - (b)
MbM-1	142.59	142.56	142.56	-0.03	0.00
MbM-2	142.80	142.78	142.78	-0.02	0.00
MbM-3	143.31	143.28	143.27	-0.04	-0.01
MbM-4	143.35	143.30	143.30	-0.05	0.00
MbM-5	143.85	143.81	143.82	-0.03	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	145.16	145.17	-0.03	0.01
MbM-9	145.51	145.48	145.48	-0.03	0.00
MbM-10	145.63	145.60	145.60	-0.03	0.00
MbM-11	146.16	146.11	146.12	-0.04	0.01
MbM-12	145.42	145.38	145.38	-0.04	0.00
MbM-13	145.00	144.99	145.00	0.00	0.01
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	144.78	144.79	0.00	0.01
MbM-18	144.55	144.54	144.55	0.00	0.01
MbM-20	145.86	145.83	145.83	-0.03	0.00