

December 17, 2020

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San Jacinto River Authority  
2436 Sawdust Road  
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**RE: Review of Eleventh Re-measure of the Waterline W1A and W2A Benchmark Elevations in the Woodlands, Texas in November 2020**

Dear Aaron:

This letter provides our review of a November 2020 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 below.

**Review of W1A and W2A Benchmark Elevations**

The November 2020 survey represents the eleventh 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 11<sup>th</sup> re-measure of 45 benchmark 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 - Considering only elevation changes that have taken place over the last 6 months, 17 out of the 22 benchmarks had no change in elevation, 3 had an increase of elevation of +0.01 foot, and 2 had a decrease of -0.01 foot.

The eleventh re-measure shows no convincing evidence of fault movement at either of the two W1A transects since March 2015. During those 5.5 years, 3 benchmarks had no change in elevation, 10 had a decrease of -0.01 foot, 7 had a decrease of -0.02 foot, 1 had a decrease of -0.03 foot, and 1 had a decrease of -0.11 foot. The decrease of -0.11 foot occurred at benchmark #11 located near the upper edge of the downthrown fault block at the midpoint of the transect. The -0.11 foot difference is an outlier 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 foot drop in ground surface elevation is likely caused by the slow, progressing compaction of soil. Looking at the pattern of elevation changes at the 18 benchmarks along the transect in Table 1, there is some indication that the most southern segment of the transect may be declining at a rate faster than the northern segment. At the southern benchmarks 12 through 20, differences range from -0.01 to -0.02 foot, whereas at the northern benchmarks 1 through 10, differences range from to -0.01 to -0.02 foot over the last 5.5 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 5.5 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 5.5 years, the net change in elevations range between 0.00 and -0.03 foot among the four benchmarks.

W2A Transects - Considering only elevation changes that have taken place over the last 6 months, 8 out of the 23 benchmarks had no change in elevation, 13 had a decrease of -0.01 foot, and 2 had a decrease of -0.02 foot.

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 5.5 years, 1 of the 4 had no movement, 2 had a drop of -0.01 foot, and 1 had a drop of -0.02 foot (see Table 3). Our review of the data is that the fault has been inactive during the past 5.5 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 known 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 6, the elevation change ranged from -0.02 to -0.05 foot and averaged about -0.03 foot. At the eastern benchmarks 13 through 18, the elevation change ranged from 0.00 to -0.01 foot and averaged less than a drop of -0.01 foot. The differences in elevation change between the two sets of benchmarks suggest that fault may be partly responsible for the difference in vertical movement between the western segment and eastern segment of the transect.

Respectfully submitted,



Steven Young, PHD  
Professional Geologist  
Professional Engineer

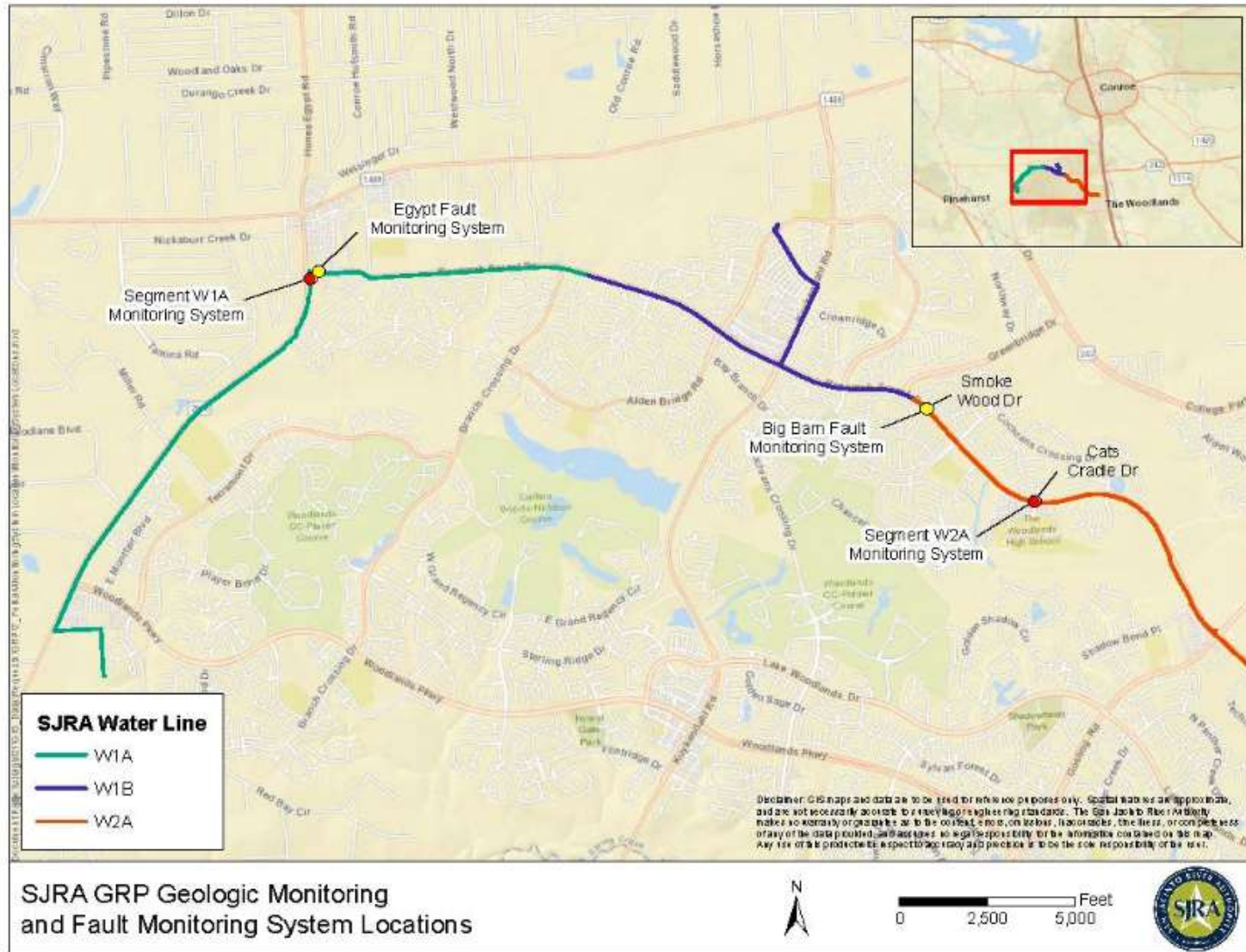


Figure 1. SJR GRP Geological Monitoring and Fault Monitoring System Locations (<https://www.sjra.net/grp/fault-monitoring/>)

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

SJRA Segment W1A Geological Monitoring Survey					
Point ID	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March, 2020 Elev.	(c) November, 2020 Elev.	Nov. 2020 minus Mar 2015 (c) - (a)	Nov. 2020 minus Mar 2020 (c) - (b)
MbM-1	189.24	189.23	189.24	0.00	0.01
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	190.39	Destroyed	n/a	n/a
MbM-6	190.26	1909.25	Destroyed	n/a	n/a
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	187.91	187.92	-0.01	0.01
MbM-10	187.76	187.75	187.75	-0.01	0.00
MbM-11	188.00	187.90	187.89	-0.11	-0.01
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	189.29	-0.02	0.00
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, March 2020, and November 2020 at Existing Fault Protection System| Egypt Fault

Station/Description	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March, 2020 Elev.	(c) November, 2020 Elev.	Nov. 2020 minus Mar 2015 (c) – (a)	Nov. 2020 minus Mar 2020 (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	190.26	190.25	-0.03	-0.01
Sta 108 + 80 Top 2" Steel Cap	190.31	190.29	190.29	-0.02	0.00

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

Station/Description	Measured Elevation			Calculated Differences	
	(a) Initial Survey March 2015 Elev.	(b) March 2020 Elev.	(c) November 2020 Elev.	Nov. 2020 minus Mar 2015 (c) – (a)	Nov. 2020 minus Mar 2020 (c) – (b)
Sta 9 + 25 Top 2" Steel Cap	177.81	177.81	177.81	0.00	0.00
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	176.72	176.71	-0.02	-0.01
Sta 9 + 95 Top 2" Steel Cap	176.78	176.77	176.77	-0.01	0.00

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

SJRA Segment W1A Geological Monitoring Survey					
Point ID	Measured Elevation			Calculated Differences	
	(a) Initial Survey March, 2015 Elev.	(b) March, 2020 Elev.	(c) November, 2020 Elev.	Nov. 2020 minus Mar 2015 (c) - (a)	Nov. 2020 minus Mar 2020 (c) - (b)
MbM-1	142.59	142.57	142.56	-0.03	-0.01
MbM-2	142.80	142.79	142.78	-0.02	-0.01
MbM-3	143.31	143.29	143.28	-0.03	-0.01
MbM-4	143.35	143.31	143.30	-0.05	-0.01
MbM-5	143.85	143.82	143.81	-0.04	-0.01
MbM-6	144.14	144.12	144.11	-0.03	-0.01
MbM-7	144.29	144.27	144.26	-0.03	-0.01
MbM-8	145.20	145.17	145.16	-0.04	-0.01
MbM-9	145.51	145.49	145.48	-0.03	-0.01
MbM-10	145.63	145.60	145.60	-0.03	0.00
MbM-11	146.16	146.13	146.11	-0.05	-0.02
MbM-12	145.42	145.40	145.38	-0.04	-0.02
MbM-13	145.00	145.00	144.99	-0.01	-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	144.78	-0.01	0.00
MbM-18	144.55	144.55	144.54	-0.01	-0.01
MbM-20	145.86	145.84	145.83	-0.03	-0.01