

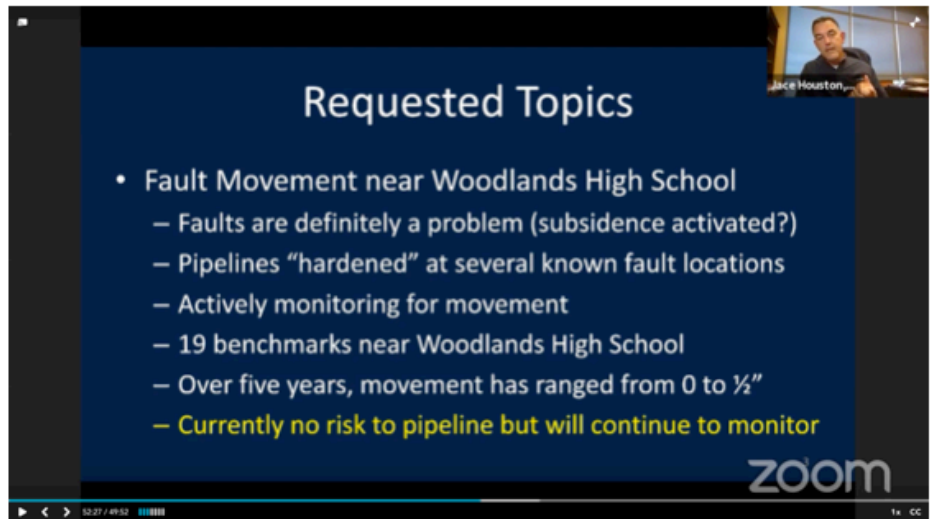
Chris Meeks and Ed Shackelford,

Please reconsider GRP's decision to reduce the number of times you remeasure the elevation monuments on the W2A Fault Monitoring Survey from twice a year, in March and September, to once a year in March. This decision is justified based on a flawed assumption by Lockwood, Andrews, and Newnam (LAN) that the average fault movement in the first six to eight years after the GRP came online accurately predicts movement in the next six to eight years. LAN's analysis is myopic. Estimates from SJRA's current in-house geological consultant, INTERA, and Mike Turco, Manager of Houston-Galveston Subsidence District (HGSD), predict future elevation changes will show a non-linear, more geometric increase in the downward velocity of the elevation monuments west of the Panther Branch Fault scarp, close to where it crosses the GRP at an unprotected 42-inch pipeline.

As Jace Houston pointed out in a Township Board of Directors Meeting on August 26, 2022, when the GRP introduced surface water into The Woodlands' drinking water in 2015, fault movement slowed almost to a stop. He said, "...at this time there is not a risk to the pipeline. The pipeline is sleeved in that location...We don't want to see any risk occur to the pipeline. At this time there is not, BUT IT DOES REQUIRE ONGOING MONITORING."

Woodlands Township Board of Directors Regular Meeting

August 26, 2020



The screenshot shows a Zoom meeting interface. At the top right, there is a small video feed of Jace Houston. The main content is a blue slide with the title "Requested Topics" in white. Below the title is a bulleted list of items. The last item is highlighted in yellow. At the bottom right of the slide is the Zoom logo. Below the slide, there is a Zoom control bar with a play button, a progress bar, and a timestamp of 12:27 / 49:52. At the bottom of the screenshot, there is a URL and a timestamp: "https://woodlandstx.new.swagit.com/videos/75128?ts=2712.781 ~ Minute 52:30".

Requested Topics

- Fault Movement near Woodlands High School
 - Faults are definitely a problem (subsidence activated?)
 - Pipelines "hardened" at several known fault locations
 - Actively monitoring for movement
 - 19 benchmarks near Woodlands High School
 - Over five years, movement has ranged from 0 to ½"
 - **Currently no risk to pipeline but will continue to monitor**

<https://woodlandstx.new.swagit.com/videos/75128?ts=2712.781>

~ Minute 52:30

GRP's in-house geological consultant, INTERA, is repeatedly urging GRP to continue to monitor fault movement. Comments from INTERA's reports following the Fourteenth, Fifteenth, and the last Sixteenth Remeasure include:

- 14th Remeasure April 2022

"Per discussion with SJRA, SJRA plans to continue to monitor any subsidence observed from the Segment W2A Monitoring System and discuss with water line experts if significant movement is observed."

- 15th Remeasure. November 2022

"INTERA recommends SJRA continue with the suspected Panther Branch Fault study to determine if and where the suspected Panther Branch Fault crosses the SJRA GRP water line and any associated mitigation measures recommended."

- 16th Remeasure March 2023

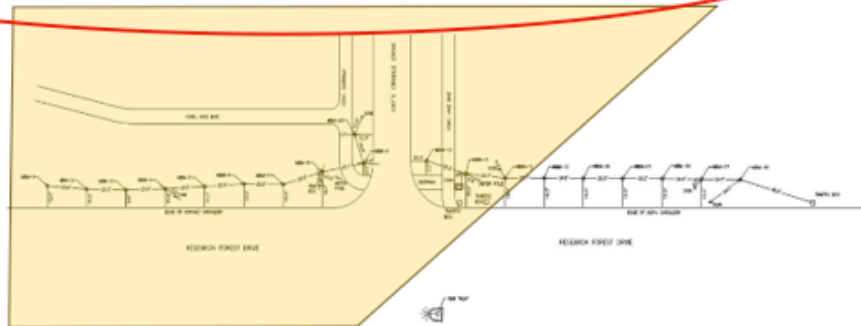
"Because the Fugro report (2012) did not show that the suspected Panther Branch Fault crossing the water line, SJRA's consultant did not design nor did SJRA's contractor construct safeguards to protect the water line from differential subsidence associated with the suspected Panther Branch Fault. Per discussion with SJRA, SJRA plans to continue to monitor subsidence using the benchmarks associated with the Segment W2A Monitoring System. SJRA has also commissioned a consultant to study the suspected Panther Branch Fault to determine if the fault crosses the water line and if so, what safeguards may be needed."

INTERA and Lockwood, Andrews, and Newnam are looking at the same data as INTERA. What do they see, miss, or interpret differently.

LAN estimated downthrown velocity is not to exceed -0.13 in/yr. LAN's recent study estimates the downthrown side of the fault, i.e., the monuments west of the fault line, have lost at most -0.13 in/yr of elevation during the eight years that the GRP has been in operation. This figure represents the monument showing the most significant loss of height (Mbm-4) divided by eight, the number of years since the GRP came online and the Fault Monitoring Study has been underway. The subsidence velocity of MBM-4 is -0.13 in/yr ($-1.08 \text{ in} / 8 \text{ yr} = -0.135 \text{ in/yr}$). LAN concludes such small losses are insufficient to damage the unprotected 42-inch pipeline, even if it continues to drop at this rate for 20 years.

Surface Monitoring Summary

- Measured negative surface movement (settlement), west of interpolated fault line
- ~~Maximum settlement = 1.08" at one point, BM4~~
 - Average rate of **0.13"/yr**
- Average movement of points on the west side = **0.10"/yr**



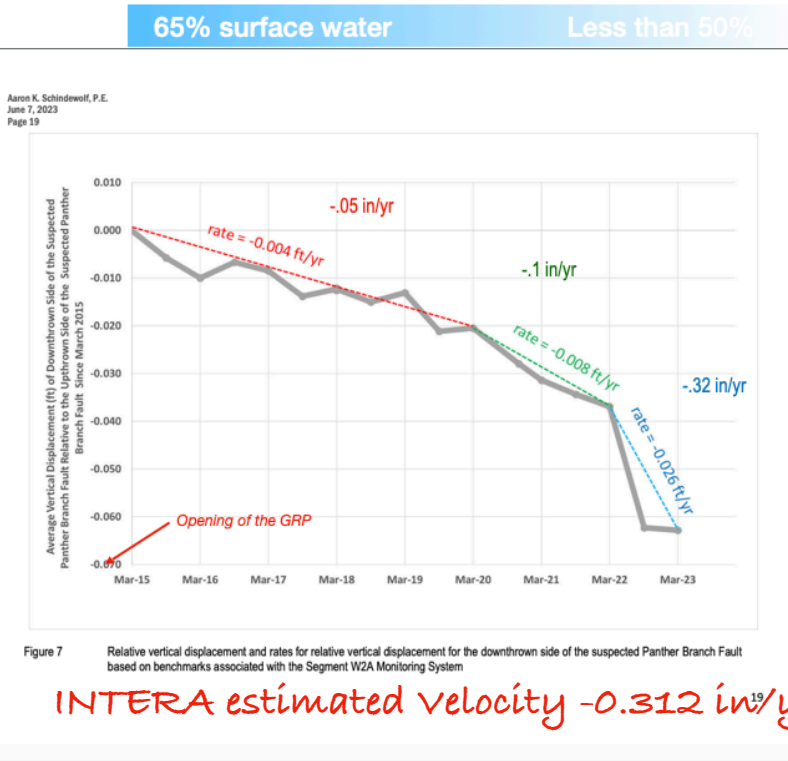
LAN estimated velocity -0.13 in/yr

INTERA's estimated ddownthrown velocity is -0.312 in/yr. INTERA, the current in-house consultant, takes a more granular look at elevation changes over time and has summarized their post-GRP elevation changes as follows:

- Post-GRP Years 1-5 (2015-2020), the western monuments Mbm 1-12 & Mbm-20 showed an average vertical elevation velocity of -0.004 ft/yr, or -0.05 in/yr.
- Post-GRP Years 6 & 7, elevation velocities doubled to -0.008 ft/yr or -0.1 in/yr.
- Post-GRP Year 8, elevation velocities tripled to -0.026 ft/yr, or -0.321 in/yr.

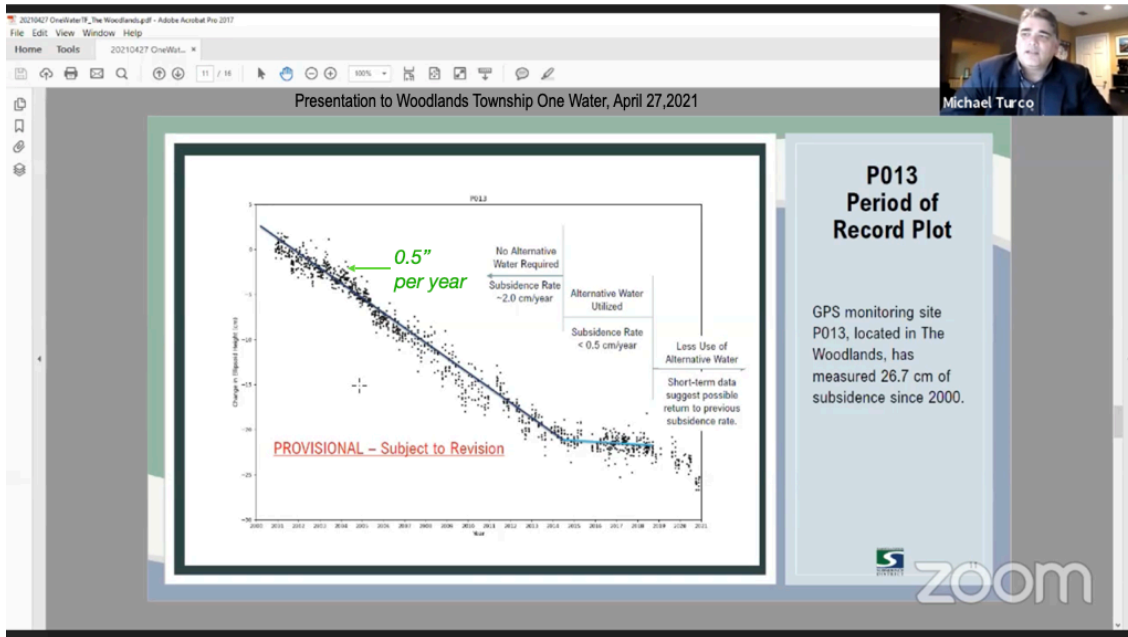
In other words, INTERA finds more of an exponential increase in elevation loss over the eight years. INTERA results suggest that next month's (September 2023) elevations on the ddownthrown side of the fault will be at or beyond -0.5 in/yr.

INTERA estimate of Panther Branch Fault activity post-GRP is SJRA's W2A Fault Monitoring Survey Results. As can be seen, as the contribution of surface water to the freshwater mix in Cochrans Crossing has decreased, the vertical velocity on the ddownthrown side of fault is accelerating in a downward direction.



Mike Turco's data estimates ddownthrown velocity is -0.62 in/yr. In a presentation to [The Woodlands Township on April 27, 2021](#), Mike Turco, Manager at Houston-Galveston Subsidence District (HGSD), presented precision elevation data on the surface of the Woodlands in the local area around Bear Branch, which includes the High School, my house, and the upper mile of the Panther Branch.

Subsidence at Pam-13 before and after the GRP pipeline began delivering surface water



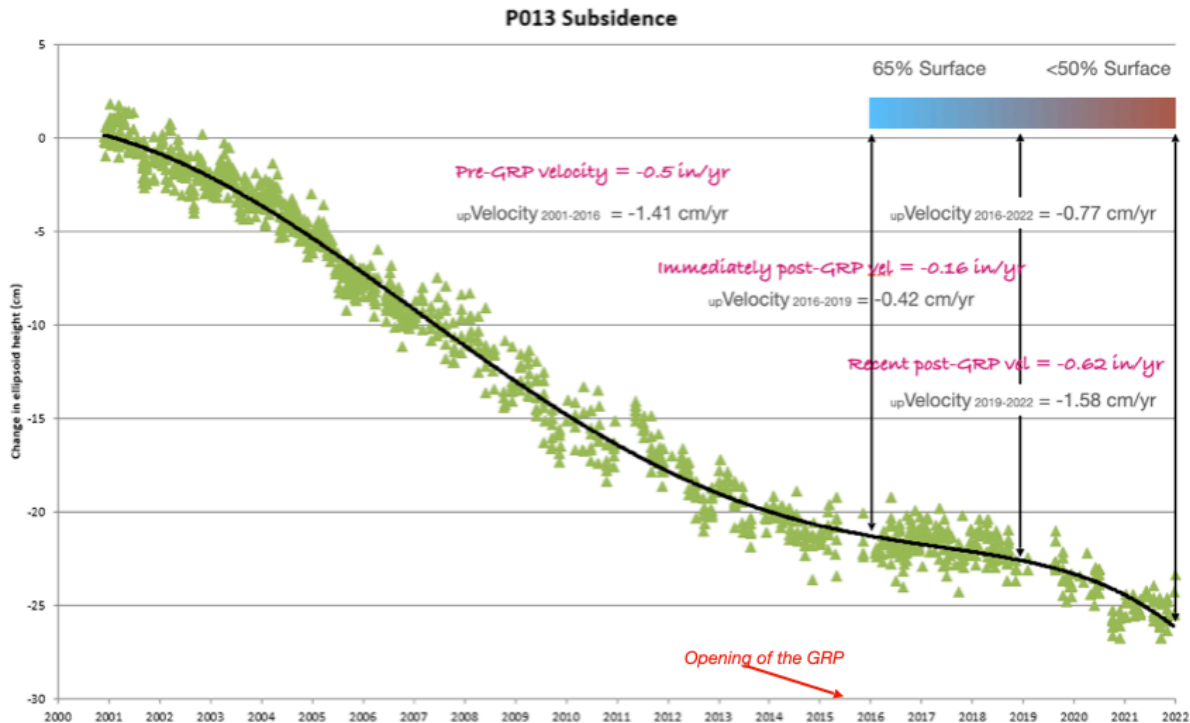
Mike Turco is with the Harris-Galveston Subsidence District
Presentation at <https://woodlandsb.new.swagit.com/videos/120118?ts=897>

HGSD estimated velocity -0.62 in/yr

Installed in CY2000, PAM-13 continues to collect elevation data today. Elevations at PAM-13 consistently sink at a velocity of -0.5 in/yr between 2000 and 2015, when the GRP began delivering a mix of 65% surface water and 35% groundwater. With the introduction of surface water in 2015, subsidence suddenly slowed to -0.16 in/yr, almost to a stop. As groundwater contributions increase and surface water decreases in the next three years (2019-2022), surface subsidence increases to -0.62 in/yr, at or above pre-GRP subsidence rates.

Mike's data suggests that the Panther Branch fault is related to subsidence. Changes in elevation velocity on the downthrown side of the Panther Branch have been consistent with changes in surface velocities. This relationship might explain how my house on the Panther Branch Fault sinks at a half-inch a year before the GRP comes online but slows to a level that requires greater precision than the tilt of my foundation to measure post-GRP. When the GRP came online in 2015, surface subsidence in Turco's data and subsidence at the W2A Fault Monitoring site slowed to about -0.15 in/yr—between LAN's -0.13 in/yr and INTERA's -0.16 in/yr. After a slow start in the first five years, elevation velocities accelerate. Turco's last velocity increase is -0.62 in/yr, and INTERA's is -0.321 in/yr. Of course, LAN's is still the lowest estimate at -0.13 in/yr.

Activity on the Downthrown side of the Panther Branch following the introduction of surface water with the opening of the GRP surface water transmission line in 2015.



For the first six years of elevation remeasure reports, the assumption was the unprotected pipe at the Panther Branch crossing could withstand at least 0.15 ft/yr (1.8 in/yr). After the fifth remeasure, Mark Smith presented a review of the risk of this unprotected pipe at a [Woodlands Township Board Meeting on March 22, 2018](#). In his study, he noted in passing that the pattern of elevation supported my active fault claim but then added that SJRA's geologist needed to see 0.15 ft/yr of elevation change to consider this fault a threat to the pipeline. He claims the elevation changes they saw at the time were so small that they were not a threat to the transmission line, so he proposed, like Chris Meeks suggests, to reduce the number of remeasures to once a year. As you can see from the Video of Agenda Item 11 of that meeting, Township Board Members who were familiar with Woodland's faults recognized that the need to see a 2-inch per year change in elevation was unrealistic, the pattern of elevation changes is compelling, and so Mark Smith was pressured into to commit not only to remeasuring twice a year but extending this fault monitoring program beyond its original five-year commitment.

Nobody challenged the idea that unprotected Panther Branch pipe can withstand -0.15 ft/yr (or -2.0 in/yr) elevation change without breaking until the 13th Remeasure Report. INTERA delivered this report in person to the Board of Trustees of Woodlands Water meeting in November of 2021. At about 12.5 minutes into his presentation, someone in the audience asked INTERA how much subsidence this unprotected pipe could handle. His response is this

unprotected pipe can handle up to "two inches a year for 25 years." Of course, that is impossible. Fifty inches of differential movement on a 42-inch diameter pipe in any perpendicular direction means the line has come completely apart.

I left the November Board of Trustees meeting. Then, I filed a Public Information Request with SJRA to learn how much differential elevation (vertical shift) the unprotected 42-inch pipe at the high school could withstand. The answer came back: "Allowable Movement, 0.04" of horizontal movement per year, for 20 years, one inch in total." This answer stipulates horizontal direction, which is confusing. Horizontal movement refers to an elongating or shortening of the pipeline at adjoining pipe segments.

I am not a mechanical engineer, but I know that when I ask how much differential elevation, or subsidence, the pipeline can handle, I am asking about how high or low something can move without breaking, not how far it can be stretched or compressed. SJRA's geologist designed the W2A Fault Monitoring Survey to look for vertical movement. If he were interested in horizontal direction, he would have LandTech record the distance between the elevation monuments. If I ask how long your boat is, I am not asking about its beam or displacement.

While I cannot empirically relate elevation changes to horizontal pipeline stress, I can provide a down-home analysis or comparison. GSEC, a CORS precision elevation monitor adjacent to the Big Barn fault, shows that the upthrown side of the pipe loses about a quarter inch of altitude every year after the GRP opened up. WHCR, a similar precision elevation monitor on the upthrown side of the Panther Branch Fault shows Mbm-19, the elevation standard for the W2A Fault Monitoring Survey, shows surface elevation at the Panther Branch losing -0.236 in/yr. My Public Information Request about pipe design limits response says the Big Barn can lose up to -0.25 in/yr for 50 years, or 12.5 inches total. The unprotected pipe at the Panther Branch can lose up to 1 inch total, or -0.04 in/yr maximum. So, as a thought experiment, let us see how long it will take for the Panther Branch to reach its subsidence limit. LAN's estimated elevation velocity of -0.13 in/yr will take 7.7 years. (According to LAN's average elevation velocity of -0.13 in/yr, the GRP pipe exceeded its design limit sometime last year). At INTERA's projection of -0.32 in/yr, it will take 3.1 years from the start to reach the design limit. At -0.62 in/yr projected by Turco's data, the design limit is only 1.6 years away.

Another way of visualizing the risk is to consider that at current subsidence velocities, INTERA and Turco's estimates suggest that the Panther Branch is already losing more elevation each year than the Big Barn can handle. Big Barn limit is -0.25 in/yr. Panther Branch elevation velocity is either -0.32 according to INTERA or -0.62 according to Turco's model.

In closing, Chris Meeks and Ed Shackelford, I implore you to reconsider cutting back on monitoring the W2A Fault Monitoring Survey to once a year in March. Both March and September are valuable because March shows the maximum annual elevation, and September is the lowest, but if you have to choose between the two, please keep September. With subsidence, you never fully recover once you establish a new low. Now that SJRA and Woodlands Water is truly entering the true post-GRP era, the need for continued monitoring is great.

Current Protection System – W2A

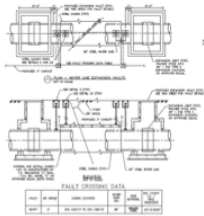
<u>Geotechnical Investigation</u> <u>Terracon</u> <u>2012</u>	<u>Pipe Details</u>	<u>Allowable Movement</u>
"The Panther Branch Fault approaches Research Forest from the northeast, but apparently dies out before reaching it."	Spiral welded steel pipe with interior and exterior cement mortar coating. Welded joints within casing Outside of casing bell and spigot with O-rings	0.04" of horizontal movement per year, for 20 years 1" in total

Maximum allowable movement at Panther Branch is -0.04 in/yr, or 1 inch total over 20 year life of pipe.

LAN estimated velocity -0.13 in/yr
 INTERA estimated velocity -0.312 in/yr
 HQSD estimated velocity -0.62 in/yr

Panther Branch upthrown moving at -0.236 in/yr

Current Protection Systems



W1A – Egypt Fault
 0.25" of movement per year, for 50 years

12.5" in total

W2A – Big Barn
 0.25" of movement per year, for 50 years

12.5" in total

Maximum allowable movement at Big Barn is -0.25 in/yr, or 12.5 inches total over 25 year life of pipe.

Big Barn upthrown moving at -0.275 in/yr

Thank you for your understanding,
 Mark Meinrath

Problems with the Current Protection System

Current Protection System – W2A

<u>Geotechnical Investigation</u> <u>Terracon</u> <u>2012</u>	<u>Pipe Details</u>	<u>Allowable Movement</u>
"The Panther Branch Fault approaches Research Forest from the northeast, but apparently dies out before reaching it."	Spiral welded steel pipe with interior and exterior cement mortar coating. Welded joints within casing Outside of casing bell and spigot with O-rings	0.04" of horizontal movement per year, for 20 years 1" in total

Panther Branch Fault DOES NOT die out before reaching Research Forest.

The 42" GRP Transmission line under the Panther Branch Fault and the Jones Fault is NOT PROTECTED.

Velocity of the Downthrown side of the Panther Branch Fault is currently -0.321 inches per year and accelerating.

From Depleting Aquifers, The New York Times, August 30,2023.

"In the Houston area, overpumping of groundwater, along with oil extraction, has caused some land to sink by more than 10 feet over the course of decades, according to local officials. In Florida, overpumping sometimes causes sinkholes."

"Pumping water can cause the earth above an aquifer to slump, collapsing the space left behind by the water that was removed. Once that space is lost, it can no longer hold water. That process, called subsidence, is happening around the country, and more than 80 percent of it is the result of groundwater use, according to the U.S. Geological Survey. The agency says subsidence has affected more than 47,000 square miles of land and waterways across the United States."

"As the land sinks, home foundations, sewer pipes and other structures are damaged. But among the most dramatic consequences of subsidence is a fissure. As softer ground slumps, sometimes an adjacent patch of ground stays put. The resulting movement shears the earth apart."