DRAFT Jollyville Transmission Main Environmental Monitoring Report #5

Reporting period 4/2/13 – 8/15/13

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*to be added when complete

BACKGROUND

Monitoring is being conducted in the Bull Creek watershed to determine effects, if any, of shaft construction and tunneling associated with the construction of the Jollyville Transmission Main (JVTM) for Water Treatment Plant #4 (WTP4). The design of both the JVTM and WTP4 have been subject to the Environmental Commissioning (EC) process conducted by the City of Austin's Watershed Protection Department. The EC process integrates environmental review and oversight into the design and construction process to meet defined environmental goals that generally exceed regulatory requirements.

The City's EC process includes environmental monitoring along the length of the transmission main to detect environmental impacts from JVTM construction. Monitoring includes City of Austin, Travis County, and private preserves and consists of evaluating water levels and taking water quality samples from surface water, springs, and groundwater wells. These data are used to observe environmental conditions in the project area and in adaptive management during the construction of the JVTM, as needed. The monitoring program is designed to meet these objectives from the Environmental Commissioning Plan for WTP4:

- Document baseline hydrology, and stream and spring water quality prior to construction;
- Monitor during and following construction to detect possible changes from baseline conditions; and
- Identify changes from baseline conditions attributable to WTP4 from other changes that are observed in the watershed.

MONITORING PLAN OVERVIEW

Sites

This project currently conducts monitoring at 24 wells, 5 stream sites and 5 springs in the Bull Creek, Lake Travis, and Rattan basins located in northwest Austin (fig 1). Wells with an "A" designation are newer wells constructed near older wells (e.g.., JT-120 and JT-120A are within 10 feet of each other) and generally intended as replacements for the older wells. For detailed site information, see Table 1.

Four significantly older wells in the Balcones Canyonlands Preserve (BCP) were also checked during the construction phase, but are not formally included in this analysis due to lack of baseline data and because they are open over large intervals, sometimes across multiple formations, which may mask small construction-related changes in water level.

A groundwater trace and groundwater age dating study was conducted at some monitoring sites in the summer of 2012. The results of that study can be found in Appendix 2 (to be added).

Timeline

This project is broken into three phases: Baseline (Spring 2011- Fall 2011), Construction (Fall 2011-Spring 2014) and Post-construction (Spring 2014 – Fall 2014). Earlier baseline water-level data was also collected from monitoring wells as they were installed beginning in November 2010.

Construction/Monitoring Events

7/1/2011	Beginning of Baseline Monitoring
9/7/2011	Site Prep Clearing begins at Four Points Shaft (4P)
9/2011	Baseline monitoring ends for groundwater but is extended for surface monitoring due to drought
10/7/11	2" rain results in first surface flow
10/28/11	Excavation begins at Jollyville Shaft (JR)
11/1/11	**JVTM Monitoring Report #1**
11/15/11	Groundwater layer at 4P reached in excavation
1/27/12	Grout injection at 4P; eventually causes recovery in groundwater levels
2/10/12	JR: excavation through Comanche Peak confining layer results in 57-foot groundwater drop in JT-127 well and change in water characteristics
3/2012	Baseline monitoring period ends for surface water
4/5/12	Jollyville Plateau Salamander found in Trib 4 by Spicewood shaft site (SS); triggers shaft redesign
4/2012	Reach 1 (R1) excavation begins
6/18/12	JR shaft excavation complete; Reach 3 (R3) excavation begins
6/20/12	**JVTM Monitoring Report #2**
7/2012	R1 excavation complete
8/2012	4P shaft excavation complete; Reach 2 (R2) excavation begins
9/28/12	SS excavation begins
10/2012	R2 tunneling passes BCP piezometers and decline is seen in B8-b
10/24/12	Water-bearing layer encountered at SS
11/9/12	Extra grout injected at SS seals liner plates and causes a recovery in groundwater in JT-130 well
11/15/12	**JVTM Monitoring Report #3**
2/5/13	SS shaft excavation complete
3/23/13	R3 excavation complete; Only observable declines in wells appear to be shaft influences
4/2013	**JVTM Monitoring Report #4**
4/15/13	R2 excavation past BCP boundary (out of BCP)
6/6/13	Pipe placement in Reach 1 completed; grouting begins
6/18/13	JT-130 surface completion modified to accommodate truck traffic
8/14/13	R2 excavation complete; tunnel fully excavated
9/2013	**JVTM Monitoring Report #5**
12/2013*	All pipe and grouting complete
4/2014*	Surface restoration complete; pipeline operational (contractual signoff date)
4/2014*	**JVTM Monitoring Report #6**
4/2014- 10/2014*	Post-construction Monitoring
***11/2014**	**Final JVTM Monitoring Report/ End of Monitoring Program**

*dates projected into the future

The reporting period, April 2013-August 2013, comprises construction-phase monitoring for all sites.

Excavation at all shafts and reaches is complete (fig 2). Reach 2 tunneling began at the Four Points shaft in mid-August 2012 and was fully excavated as of 8/14/13. Reach 3 tunneling began at JR shaft in late August 2012 and was completed on 3/23/13. Spicewood Shaft excavation began 9/28/12 and was essentially complete by 2/5/13 with the exception of minor tail tunnel chipping, which was materially complete by 8/14/13 with 1-2 feet remaining.

Changes to Monitoring Plan

A number of changes to the monitoring plan were made as part of the EC adaptive management process. The rationale for these changes is detailed in Table 2. The monitoring schedule through the various phases of construction is detailed in Appendix 1.

Four Points Shaft Impact Monitoring

Monitoring sites (see Table 1):

- Wells:
  - JT-112 screened at Edwards/Walnut contact approximately 120 feet in a downgradient direction from the shaft
  - JT-128 screened at Edwards/Walnut contact; immediately adjacent to shaft (~5 feet)
- Surface sites:
  - Bull Creek “above WTP4” (BCAW), downstream from shaft location. Site is in the BCP; name reflects location relative to original proposed site and is not located above the current WTP4 site
  - Gaas spring, downstream from shaft location (quarterly monitoring for phthalate contamination only)

Four Points Groundwater Elevations

Site preparation (tree and vegetation clearing) at Four Points began on September 7, 2011. Shaft excavation began in early October, and beginning on November 15, 2011 the groundwater layer above the Edwards/Walnut contact was reached and excavated through, resulting in water-level declines in the JT-112 and JT-128 wells. After a permeable ring, cementitious grout, and liner plates were installed in the shaft at the lower part of the Edwards formation and the excavation proceeded, it became clear that the wells were not showing a recovery in water level, and that the groundwater from the Edwards at that elevation was continuing to drain into the shaft. While the total rate of flow from the Edwards, Walnut and Glen Rose formations never exceeded the design limit for the shaft of 10 gallons per minute (gpm), continuing water-level declines in the Edwards wells were a consequence of the very low flow rate of 2 to 3 gpm from the Edwards into the shaft. As part of the EC adaptive management process, the decision was made to inject a hydrophobic grout behind the shaft liner plates into the spaces between cementitious grout pours to further reduce groundwater inflow (*Report on Adaptive Management Process for Four Points Shaft Groundwater Loss, February 2012*).

Monitoring of nearby JT-113, JT-114, JT-115, and JT-101A wells indicated that the zone of influence from shaft construction did not expand into these wells and was limited to the immediate vicinity of the shaft. A contaminant transport analysis was conducted due to concerns over the phthalate content

of the grout (30-60%) and the possible toxic effect on salamanders in a nearby spring (at a distance of 2,100 ft). Results of a thorough hydrogeologic assessment indicated that concentration levels were unlikely to reach the Lowest Effects Concentration limit of 0.1 mg/L even in groundwater at the shaft permeable ring (*Assessment of Potential Di-n-butyl phthalate Concentration in Groundwater from Hydro Active Cut Grout Emplacement at the Four Points Shaft April 4, 2012*), and no transport above that concentration was predicted beyond the shaft. The grout injection was performed on 1/27/12. Afterwards, groundwater levels in the nearby wells began to recover. Water levels in the JT-112 and JT-128 wells rose steadily, and once recovery was above preconstruction levels, the TROLLs were removed and dedicated to the Spicewood shaft wells and JT-108A respectively (see Appendix 1 for schedule). JT-128 and JT-112 levels are now monitored monthly using an e-line.

To ascertain whether groundwater in the area returned to prior flowpaths after installation of the permeable ring, a dye trace was performed in July 2012. The dye was introduced via a standpipe directly into the ring, and flushed in with 2,300 gallons of water drawn from the site tanks. The water in the tanks was comprised of primarily hydrant water from tunnel excavation and tested for contaminants prior to use. This resulted in a rise in groundwater elevation in the adjacent Edwards wells, which attenuated over time. No effects were seen in the Edwards wells farther away (JT-113, JT-114, JT-115, JT-101-A).

During the spring of 2013, JT-128 and JT-112 wells were monitored using an e-line (fig. 3). Water levels gradually declined 0.36 and 0.38 ft respectively, attributable in part to equilibration after the dye injection in July of 2012. Compared to pre-injection water levels, the declines were 0.52 (JT-128) and 0.18 (JT-112) ft, representing 77% (JT-128) and 82% (JT-112) of preconstruction water levels. Given that the water levels are relatively near the preconstruction levels and do not appear to have experienced a precipitous drop/are gradual in nature, the water level decline over the reporting period is likely due to drought and attenuation of dye injection rather than a recurrence of shaft effects. No effects were seen in the surrounding Edwards wells (JT113, JT114, JT115, JT101A) (fig 4).

Current Activity: No water level monitoring was performed at the Four Points Shaft this quarter, as semi-annual monitoring began in April 2013.

Shaft inflows: Shaft inflow to the Four Points shaft remained a relatively steady ~5gpm through the reporting period (fig. 5). Estimated inflows to the shafts are based on calculations from volume pumped out and in onsite storage corresponding to groundwater inflow periods of varying duration. The large variability shown is the result of a range of factors including on whether mucking was or was not being conducted in the measurement period, pump malfunctions, and diversion of pumped water for other operations such as dust control and mixing of grout. Mixing of grout in particular is responsible for the large dip in values in June-July 2013.

Four Points Water Quality

Twenty-three water quality samples were taken from JT-112 (monthly until 2/23/12 and quarterly thereafter), ten from Bull Creek above WTP4 (BCAW; monthly during preconstruction and in the event of a spill thereafter), and 8 from Gaas spring (monthly until 2/23/12 and quarterly thereafter for phthalates only), and tested for physical and chemical parameters (Table 3). All parameters fell within expected range and below TCEQ screening levels with the following exceptions:

- JT-112 TSS rose to 60 mg/L on February 22, 2012 after a baseline period of non-detects. This spike is attributed to a significant rain event.

- JT-112 Ammonia peaked at 0.43 mg/L (above TCEQ levels of 0.33 mg/L) on September 7, 2012, before excavation began. This level is attributed to natural variability in ammonia concentrations.
- JT-112 Nitrate was higher in the 9/11/12 sample(0.797 mg/L), and 12/6/12 sample (0.740 mg/L), than in the baseline sample (0.701 mg/L maximum; fig. 6). However, the difference of <0.1 mg/L and existence of several baseline samples near to the maximum shows this sample not to be an indicator of adverse construction impacts.
- Bull Above WTP4 registered Zinc levels of 0.564 mg/L on April 5, 2012. In general, this site had experienced no significant zinc during this study's baseline period. This value is higher than the 99th percentile of historic measurements for this site. In comparison to citywide stormwater runoff event concentrations, median zinc values from COA's most recent assessment range from approximately 6 mg/L in undeveloped areas to 300 mg/L in densely developed areas. An accompanying spike in zinc at the reference spring Tanglewood, not connected to the Four Points shaft area, is supportive of a stormwater runoff explanation for this event.
- No phthalates have been detected at JT-112 or Gaas spring (detection limit <0.002 mg/l).
- Bull Creek Above WTP4 construction phase water quality monitoring only occurs when there is a spill occurs at the Four Points shaft construction site. Although a water spill occurred in the spring of 2013, no samples were taken because BCAW was dry during this period.

Current Activity: Water Quality sampling in JT-112 and Gaas spring was reduced to semi-annual in April 2013. No water sampling has taken place this quarter. The next scheduled water sampling event will be early September 2013. Bull Creek Above WTP4 (BCAW) construction phase water quality monitoring only occurs during this phase when there is a spill onsite. There were no spills this quarter (and the reach was dry), therefore no samples were taken.

Jollyville Reservoir Shaft Impact Monitoring

Monitoring sites (Table 1):

- JT-127 well, screened in the Edwards and equipped with continuous water-level monitoring equipment and a bladder pump to withdraw water quality samples from the well.

Jollyville Reservoir construction began 10/28/11 and was excavated to total depth as of 4/1/13.

JT-127 Groundwater Elevations

The JT-127 monitoring well is screened at the base of the Edwards at the contact with the underlying Walnut. The water level in JT-127 indicated by the continuous monitoring has been prone to sudden shifts. In all cases, reported levels have been verified with an e-line. The first of these was a three-foot jump in September 2011 before construction began onsite. Subsequently it showed a 2-foot drop on 12/21/11 and a 1-foot rise on 1/5/12. Normal variability for this well tends to be ~0.2 – 0.4 ft (associated with a combination of barometric and earth tide effects).

On February 10, 2012, just after the project excavated through the bottom of the Comanche Peak formation and back into the Edwards, the water level in JT-127 experienced a 56.5-foot drop over a 24-hour period (fig. 7). Water levels had been about 70 ft BGS previously, and settled at 126.5 ft BGS. Geologically, the Comanche Peak interfingers within the Edwards in this area. The EC Team currently believes that the Comanche Peak acts as a flow barrier within the Edwards and makes the

Edwards below the Comanche Peak respond as a confined aquifer. Shaft excavation released the groundwater pressure and caused the drop in the local water potentiometric surface.

Groundwater inflows into the JR shaft did not change significantly during this event as indicated by pumping records and visual observations. Shaft inflow rates are generally about 20 to 25 gpm since completion of the shaft excavation in June 2012 (fig. 5). In general terms, the best estimates of inflow for Jollyville Reservoir can be summarized as follows: less than 5 gpm during excavation through the Edwards and Walnut, increasing to about 20-25 gpm after excavation into the upper 35 m of the Glen Rose, and continuing within the same range of 20-25 gpm as the shaft excavation continued and was completed.

The water-level drop in the Edwards did not appear to present an environmental threat because of the following:

- Closest spring with known salamander habitat (Tanglewood Spring) is about 4,700 ft west of JR shaft, and is likely beyond the possible zone of influence from groundwater declines due to shaft inflows. An Edwards well (JT-124A) approximately 4,380 ft away between the shaft and near Tanglewood Spring did not indicate any sudden water-level change near or since the time of the drop at JT-127. Since that time, however, the well has dropped gradually.
- Observations of Tanglewood Spring did not indicate any significant changes in discharge flow or other characteristics; and
- Once the JVTM project is complete in 2014, the JR shaft will be backfilled with tunnel sediment and bentonite layers beneath water-level horizons (location to be determined). Recovery of groundwater levels will be monitored in the post-construction phase.

The water level in JT-127 as shown in figure 7 did not change substantively thereafter, stabilizing around 820 ft MSL. Well levels were read monthly to biweekly in the spring of 2013, and semi-annually beginning in April 2013.

Current Activity: No monitoring was performed at the Jollyville Reservoir Shaft this quarter, as semi-annual monitoring began in April 2013. The next sampling event is scheduled for September 2013.

JT-127 Water Quality

Twenty-eight water quality samples were pumped from JT-127 between 7/13/11 and 3/7/13, with the majority being pumped on a weekly basis during shaft excavation. Samples showed a shift in water quality parameters associated with a 56.5-ft water-level drop on 2/10/12 due to mining through the Comanche Peak confining layer. Further analysis indicated that the shift was significant. Since groundwater flowed continuously into the shaft during the period in which groundwater chemistry shifted, it is not plausible that the observed groundwater chemistry change was associated with contamination from the shaft itself, and was more likely due to a change in source water after the drop (figs. 8, 9). However, we cannot conclusively determine with current analysis the source of the water responsible for the shift.

An operating diesel generator parked very close to the well as of 9/1/12 has made it possible that the samples could have been contaminated by the exhaust. The sample collected on 9/11/12 was taken without shielding; in the two samples made since (12/4/13 and 3/7/13), cardboard shielding was used in an attempt to block the exhaust during well sampling. All three samples had physical and chemical parameters generally within or near the top of the baseline range: Turbidity, Chloride, Nitrogen,

Sulfate, Conductivity, and Phosphorous were at or just above the baseline maximum for this well and are representative of the shift in water chemistry seen after mining through the Comanche Peak.

JT-127 Nitrate was higher in the Jan-Feb 2012 collection of samples and in the 12/4/12 (2.25 mg/L) and 3/7/13 (2.2 mg/L) samples than baseline maximum (1.82 mg/L). However, the difference of <0.5 mg/L and existence of several baseline samples near to the maximum shows this sample not to be an indicator of contamination due to construction (fig 6), although possibly related to the change in source water after the sudden groundwater drop in Feb 2012.

Current Activity: No monitoring was performed at the Jollyville Reservoir Shaft this quarter, as semi-annual monitoring began in April 2013. The next sampling event is scheduled for October 2013.

Spicewood Shaft Impact Monitoring

Monitoring sites (see Table 1):

- Wells:
  - JT-120A. Screened in Glen Rose. Not initially planned for monitoring program; added after JPS identified near shaft site.
  - JT-130. Screened in Glen Rose just below soil layer. Not initially planned for monitoring program; designed and installed after JPS identified near site. Modified 6/18/13 to accommodate truck traffic (stickup removed, pad reinforced).
  - JT-118 (reference well). Screened in Glen Rose. Located approximately 1,550 ft west of the site.
- Surface sites:
  - Trib 4 Downstream from Spicewood Shaft (T4DS).
  - Trib 4 Upstream of Spicewood Shaft (T4US) reference site, phased out June 2012.
  - Trib 4 Above Spicewood Springs Road (T4AR) replaced T4US in June 2012 to more accurately capture upstream conditions, after T4US was judged to have been placed in an area that could possibly still see site effects.

Initially no well monitoring was planned for this location, and the monitoring plan restricted monitoring to an upstream (of the shaft site) and downstream location on Trib 4 of Bull Creek.

However, on April 5, 2012 COA staff identified and confirmed a Jollyville Plateau Salamander at the Trib 4 downstream site. Adaptive management resulted in a redesign of the shaft lining, enhanced E/S controls, and modification to the monitoring plan (*Adaptive Management Recommendations – Spicewood Shaft*). Changes to the monitoring plan in the light of the new JPS site included:

1. A third streamflow monitoring location added on Trib 4 (Trib 4 Above Spicewood Springs Road, T4AR) to more accurately capture upstream conditions.
2. A new well (JT-130) added at the Spicewood shaft and screened in a porous dolomitic horizon that is at the same elevation as the newly discovered salamander location.
3. Continuous monitoring devices installed in JT-120A and JT-130 at the Spicewood Shaft and JT-118 as reference.
4. Survey of the salamander population once before, during, and after the construction of the shaft (actual surveys exceeded this plan), and then quarterly until completion of shaft and tunneling activities associated with the JVTM in Spring 2013.

Groundwater Elevations at Spicewood Shaft

Spicewood Shaft excavation began 9/28/12, excavated to final depth on 2/5/13, and the R2 tail tunnel has made incremental progress since with 1-2 feet left to go as of 8/14/13. An altered shaft design featuring a continuous grout pour from 30 feet depth to ground surface was put in place as the shaft progressed; however, just below the continuous pour a permeable zone was identified. It appears that excavation had an impact on JT-130, causing water levels to drop (fig. 10). Extra standard grout was injected behind the liner plates in response, and the water levels rebounded to within two feet of the initial level, consistent with the previous drought-related downward trajectory of water levels at that horizon.

JT-120A is located less than 20 feet from the shaft wall, and water levels quickly dropped as shaft excavation proceeded downward. Declines in this well were expected, as is eventual recovery with backfilling of the shaft. JT-118 is currently ~10 feet below the lows reached last summer, indicating a possible effect from the Spicewood shaft. Declines in this well attributable to both tunnel and shaft influence would be consistent with packer test results; the lack of observed declines in the JT-130 groundwater levels leads us to expect that the Glen Rose above JT-118 is similarly expected to be unaffected. Channel bottom of the Bull Creek trib located nearest to JT-118 is at 726 msl, and JT-118 is screened from 667-647 msl. Flow measurements in the Bull Creek tributary closest to JT-118 indicate no flow declines associated with the observed groundwater level declines approximately 70 feet below the level of the channel bottom.

Spicewood shaft inflow rates have been consistently low, <5gpm (fig 5).

Water Quality/ Quantity Monitoring Results in Trib 4 at T4US, T4DS, T4AR

Trib 4 flow

- T4DS and T4AR maintained low flow through the reporting period (fig 11).
- T4AR replaced T4US in May 2012, although three readings were taken from May-July to correlate flow readings between the two sites. There was no significant difference in flow observed between the two sites prior to excavation of the shaft through the geologic layer most likely bearing groundwater that fed the trib on or around 12/1/12 (mean difference -0.004 cfs, n=20, Pr > |S| = 0.4144 in in a non-paired Wilcoxon signed-rank test). The difference in flow was also not significantly different afterwards (-0.028 cfs, n=20, Pr>|S| = 0.2246 (two-tailed)). As the error of the Marsh-McBirney meter used to measure flow is approximately 0.1 cfs, the mean differences are less than the error of the instrument.

- A rise in flow at both sites in March appears to be not attributable to rainfall, and is not consistent with declining flows on the main stem of Bull Creek. As Trib 4 is developed and is known to carry some water quality indicators of hydrant water used to water lawns, it is possible that the increase in flow comes from increased lawn or nearby golf course watering during a dry spell.

Trib 4 Water Chemistry

In general, contaminants rose and fell at the T4AR and T4DS sites in concert and were correlated with flow, and were not at levels above the baseline period, with the following exceptions:

- a TSS and Turbidity spike at T4AR in April as a result of an algal bloom (fig.12).
- phosphorous values were generally above baseline for both sites and probably reflect a higher true baseline max than was calculated in our baseline period. Notably, once baselines were revised to reflect only Trib 4 sites, the baseline value was near zero (0.05 mg/L). Phosphorous appears to be closer to 0.2 mg/L on the high end.
- a high value for zinc (0.148 mg/L) on October 26, 2012 at T4DS downstream of the Spicewood Shaft. Although they were excavating the shaft during this period, near-constant extrusion of groundwater into the shaft rules out impacts from subsurface shaft excavation. An initial value for zinc at Bull Abv WTP4 higher than this (0.155 mg/L) was used as an initial baseline; once the baseline value was revised downward in spring of 2013 to reflect only the T4AR values, this value became an above-baseline value. However, it appears to be an outlier for the following reasons:
    - It is more than 4 times higher than the next highest observation and more than 10 times higher than most of the observations higher than the detection limit;
    - All but one of the subsequent observations were less than the detection limit, and samples were being taken weekly during that time;
    - There does not appear to be any relationship between zinc and other parameter measurements indicating a more general change in chemistry associated with the high observation (Pearson, 2-tailed significance at 0.95).

Tunnel Impact Monitoring

Monitoring sites (see Table 1) proceeding west to east along the tunnel route:

- Reach 1
    - JT-110A, screened just below tunnel depth (transducer) in Glen Rose
- Reach 2
    - JT-101A (above) screened at Edwards/Walnut contact
    - JT-113, JT-114, JT-115, located in quick succession along Riverplace Drive and screened at the Edwards/Walnut contact (e-line)
    - Vibrating wire piezometers B-8, B-9, B-10 (various depths permanently installed transducers)
    - Bull Creek above WTP4 (BCAW), surface site monitored for flow, equipped with COA bubbler station
    - Lanier Spring (LS; surface water transducer)
    - JT-107A well cluster (various depths, transducers and solar-powered modem) screened in Glen Rose
    - JT-108A screened at ~90 ft depth below ground surface (bgs) in the Glen Rose
    - Pit Spring (visual estimates only)
    - Bull Creek at Trib 7 (BCT7; surface water transducer)
    - JT-118 (screened at ~90 ft depth bgs in Glen Rose; transducer)

  - Bull Creek at Spicewood Springs 7th crossing) (BC7C; surface water transducer)
- Reach 3
  - JT-104A (screened in Walnut; e-line)
  - JT-124A(screened in Edwards; e-line)
  - JT-125A (screened in Glen rose; e-line)
  - JT-126 (screened in Glen Rose near tunnel level; e-line)

Reach 1 (Four Points → WTP4)

Tunneling of Reach 1 (Four Points Shaft to Water Treatment Plant shaft site) with the tunnel boring machine (TBM) began in April 2012, and was complete by July 2012. Monitoring sites are situated along the length of the tunnel, with one monitoring well along Reach 1 (JT-110A). This well experienced a decrease in water level of approximately 17 ft as the tunnel passed (Fig 20). The beginning of the decline was seen when the tunnel was approximately 400 feet from the well and passed within about 100 feet from the well on June 5. There was a 16-foot water-level drop from June 1-10 with water level gently dropping by less than one foot from June 10-20 (i.e., water level was stabilizing). The closest tunnel location with observed water inflows was at about 430 feet before passing the well and occurred for less than a 24-hr period. The sudden water-level drop observed in JT-110A is related to hydraulic connection with the tunnel. Minimal inflows observed during the ground water-level drop reflect the relatively low hydraulic conductivity within the Glen Rose at this location.

During sampling for tritium age dating, a pump became lodged in the JT-110A well (8/6/12) and was irretrievable. The pump lodged above the water level at that time, but below the usual water level, and useful readings can not be taken until/if the water level rises back up above the pump post-grouting of the tunnel. It was ultimately decided that the construction of the WTP4 Chemical building which abuts the well would make it difficult to plug and abandon the well after the building was complete, and that it was worthwhile to go ahead and plug the well during the plugging of other unused transmission main wells, scheduled to occur in late 2012 but delayed as of August 2013. An absence of tunnel inflow combined with the attenuation of water-level decline in the well prior to 8/6/12 makes it unlikely that further drops associated with the tunnel will occur, and we do not expect a lasting impact to the groundwater elevations in this area. In addition, the tunnel in Reach 2 passes near piezometer B-8b, where we have been monitoring a similar drop-and-attenuation as the tunnel proceeds, and this well will remain available to us for monitoring into the post-construction period. Recovery in piezometer B-8B will be taken as a indication of groundwater level recover in the Glen Rose associated with similar conditions along Reach 1.

Reach 1 grouting around the placed pipe was completed in July 2013. JT-110A is currently being monitored via e-line for recovery on a monthly schedule with other sites until it is plugged. As of this reporting period, water has not yet been detected in the well.

Reach 2 (Four Points → Spicewood Shaft)

<u>Vibrating Wire Piezometers:</u>

Tunneling of Reach 2 with a second tunnel-boring machine began in mid-August 2012 and was fully excavated by 8/15/13. Water levels in JT-113, JT-114, JT-115, and JT-101A remained relatively flat (fig. 4) and show no response to tunneling activities. The lack of response in these wells was

predicted since the tunnel excavation is within the Glen Rose and much deeper than the monitoring intervals of these Edwards wells, and the wells are isolated from the Glen Rose by the relatively low permeability and connectivity of the Walnut.

Monitoring in these wells is officially complete, with the last reading taken 5/29/13. No monitoring for these wells were scheduled for postconstruction, and due to the consistency of the water levels in these wells, none is warranted.

Tunneling passed the B-8, B-9, and B-10 piezometers in October 2012 (monitored using vibrating wire transducers). Only B-8B –at tunnel depth in the Glen Rose – has shown a water-level change, dropping 52 feet, with most of the drop occurring over a few weeks (10/16/12 – 11/27/13) and proceeding asymptotically thereafter (fig. 13). The response observed at B-8B is expected as it is at tunnel depth and is proximal to the tunnel. The other monitored intervals at B-8, and at B-9 and B-10, had no observable water-level response to tunneling activities. This reflects the low hydraulic conductivity and limited connectivity of the Glen Rose at this location. As there has been almost no observable groundwater inflow into the tunnel, any water-level changes are likely to be related to pressure transmission through the rock in response to atmospheric pressure conditions in the excavated tunnel.

Grouting of the Reach 2 tunnel is scheduled for winter 2013, and water levels will be taken monthly in these wells through construction to monitor for water level recovery.

Lanier Spring:

A weir was installed in early October 2012 and removed mid-June 2013. As a result, water levels can only be directly compared during that time period. The transducer installed in Lanier Spring indicates no water depth decline during that time as the tunnel excavation proceeds beneath 1/20/13 (fig. 14). Changes in spring water levels are closely associated with Bull Creek Flow changes and associated rainfall events.

JT-107 Well Cluster/ JT-108A:

As the tunnel passed the JT-107 well cluster, a water level drop (~5 ft) was apparent in the well completion nearest the tunnel (JT-107DA) and is ongoing. In addition, a water-level drop is evident in the mid-range JT-107PZA well, although this well also appears to respond to rain events, indicating some connection to the shallow groundwater system. Water levels in the shallowest well show no changes, indicating no impacts from the tunnel at the surface-water level (fig. 15). As there has been almost no observable groundwater inflow into the tunnel, any groundwater changes are likely to be pressure transmission through the rock in response to atmospheric pressure conditions in the excavated tunnel. JT-108A (fig. 16)has shown a steady water-level decline after the tunnel passed in early March 2013 and is suggestive of tunneling impacts, but the water level does not ultimately drop below levels in the baseline period collected in the drought of 2011 (fig. 16). JT-108A also responds to rain events and/or flows in Bull Creek, indicating some connection to the surface.

Pit Spring/ BCT7

Twice-weekly visual observations of Pit Spring (no measurements) just after tunnel excavation indicated that the spring was a little higher in flow than before the tunnel excavation reached the area,

and continued to show low or average flow thereafter; these visual observations are supported by data from the transducer in Bull Creek where Trib 7 enters (BCT7), which is just downstream from Pit Spring and serves as a proxy for Pit Springs flow (fig. 17). In past years, Pit Spring has had minimal or no flow during the summer months, and 2013 was an unusually good year for springflow according to the BCP preserve manager (M. Sanders, pers. comm.). The slightly higher spring flow is attributed to be the result of periodic rainfall events; rainfall events are also responsible for periodic drops in conductivity shown in the BCT7 Troll.

Reach 3 (Jollyville Reservoir → Spicewood Shaft)

Reach 3 tunneling began in late August 2012 and was completed to the Spicewood shaft on 3/23/13.

JT-126 and JT-125A, screened in the Glen Rose and intended as tunnel monitoring sites, have shown water-level declines that upon analysis are attributable to the excavation of the Jollyville Reservoir shaft (fig. 18). Formal analysis in November 2012 concluded that the water-level drops in the Glen Rose are unlikely to be transmitted to the Walnut or Edwards formations, consistent with the Conceptual Groundwater Model (reference).

Since the completion of this analysis, well levels have continued to drop in JT-125A and JT-126, and levels in JT-104A screened in the Walnut have dropped as well. Declines in JT-104A are stronger than might be expected based on the packer test results at and immediately below its screened interval. It is suspected that the JT-104A response is affected in part by hydraulic communication along the old well sand pack located in JT-104, about a 105-ft sand pack that extended up to within about 4 ft of the sand pack of JT-104A, thus transmitting seasonal declines and recoveries that are in the Glen Rose in this area (J. Pickens, pers. comm.). The project team plans to plug and abandon the initial monitoring wells JT-104 and JT-124 located within a few feet of monitoring wells JT-104A and JT-124A. Effects on the monitored wells from the plugging are anticipated, and JT-104A water levels will be monitored with a transducer during the process.

JT-124A screened in the Edwards formation continues to be relatively flat (fig. 18). This is expected since it is completed in the Edwards, much shallower than the tunnel depth, and is isolated from the Glen Rose by the relatively low permeability and connectivity of the Walnut.

Reference Sites

With the exception of T4US (Spicewood shaft), surface reference sites (Tanglewood Spring and Ribelin Spring) are on the same semi-annual sampling regime as the Four Points and Jollyville wells, and have not been sampled this quarter. T4US generally shows variation in flow consistent with rainfall. Water quality physical and chemical parameters are within the historic range, with the exceptions noted for T4AR above in the Spicewood Shaft section.

Tanglewood spring had high levels of nitrate (up to 6 mg/L) during 2012 that was relatively consistent and not a result of seasonal fertilization (fig. 19).

Well reference sites were either:

- essentially flat (JT-101A, JT-113, JT-114, JT-115, and deepest layers of B-8, B-9, B10),
- responded to lake level (B-4a, B-5b), or
- responded to seasonal decline and recovery (JT-118), or
- appear to be responding to excavation of the Jollyville Reservoir shaft (JT-104A and JT-125A), as discussed in Tunnel Monitoring – Reach 3 above.

Post-Construction Monitoring

Tunnel excavation is complete. Construction activities at this point will consist of pipe installation and grouting, followed by restoration of shaft sites. Table 1 and Appendix 1 detail the post-construction monitoring plan, which generally consists of monthly downloads of installed transducers and monthly water quality sampling at Trib 4 until surface restoration of SS site is complete, and semi-annual water quality sampling from JT-112, JT127 and Gaas spring until the shafts have been backfilled.

SUMMARY

Environmental monitoring along the length of the tunnel alignment has shown the construction of the Jollyville Transmission Main to result in some changes to groundwater levels in the Glen Rose Formation near tunnel depth as a result of pressure changes, and some changes to groundwater levels between the tunnel and the surface in wells that also show rainfall influence. There have been no water-level changes attributable to tunnel construction in wells completed at shallower depths, almost no inflow of groundwater into the tunnel (<0.15 gpm in R2, <0.1gpm in R1) and no surface water quality or quantity changes attributable to project construction either in springs or in the main stem of Bull Creek. Water quality sampling in Tanglewood spring has shown levels of some parameters (in particular nitrate) to be quite high, indicating possible urban runoff or septic contamination.

Excavation of the Four Points shaft resulted in temporary depressions of Edwards groundwater levels in nearby wells which fully recovered after hydrophobic grouting of the permeable ring and injection of water for a dye trace. Water levels in the affected wells then declined moderately due to attenuation of the dye trace injection water and drought. Current groundwater inflows to the Four Points shaft are 5-7 gpm.

Excavation of the Jollyville Reservoir shaft excavation resulted in a 56.5-foot drop in water level at JT-127 after the confining Comanche Peak layer was penetrated in February 2012, and a 60-foot decline in JT-126 and JT-125A during and after reaching shaft full depth. Jollyville Reservoir shaft inflows averaged 20-25 gpm through the reporting period. No recovery of the water level at JT-127 is expected until the shaft is backfilled at completion of the project. JT-125A, JT-126 and JT-104A are still declining, and while no impacts to the Jollyville Plateau Salamander are expected, declining groundwater levels are being closely monitored and are expected to ultimately recover after project completion.

Identification of an active JPS site near the Spicewood Shaft resulted in enhancements to the E/S controls and significant changes to the monitoring plan with an increase in locations and frequency. So far, excavation of the Spicewood shaft appears to have resulted in a water-level drop in all nearby wells (JT-130, JT-120A, and JT-118) but extra standard grouting behind the lining has allowed the water in JT-130, which most directly measures the water that enters the Bull Creek, to recover. Drops at JT-120A and JT-118 are expected to recover after backfill of the shaft. No evident impacts in surface water quality or quantity in Trib 4 of Bull Creek are attributable to the Spicewood Shaft. Spicewood Shaft inflows have remained quite low, under 5 gpm.

REFERENCES

1. Report on Adaptive Management Process for Four Points Shaft Groundwater Loss, February 2012 (COA)
2. Assessment of Potential Di-n-butyl phthalate Concentration in Groundwater from Hydro Active Cut Grout Emplacement at the Four Points Shaft April 4, 2012 (INTERA)
3. Adaptive Management Recommendations – Spicewood Shaft (COA)

ADDITIONAL TABLES AND FIGURES

Facility Monitored	Site	Rationale	Parameter	Baseline Sampling Events Taken/Planned	Construction Phase Sampling Events (Taken/Planned)	Post-Construction Sampling Events Planned	Formation
Four Points Shaft	JT-112	Shaft location dye traces to this well within 3 weeks. Contaminants, if any, will be more mobile in the Edwards and potential impacts of water interception more significant.	Water level	Continuous/ Telemetered TROLL	Continuous/ Telemetered TROLL to 11/2012; e-lines monthly thereafter (5/5)	Semi-annual	Edwards/Walnut Contact
			Water quality	6/6	weekly (14/14) and then quarterly (6/9)	Semi-annual	
	JT-128	Proximity to shaft	Water level	6/6	Continuous/ Telemetered TROLL from 10/5/11 until repair in May 2012, then monthly e-lines (8/8)	Semi-annual	Edwards/Walnut Contact
	Bull Creek above WTP4	Downstream from shaft locations	Water level	Continuous/ Bubbler Station	Continuous/ Bubbler Station	Continuous/ Bubbler Station	N/A
			Water quality	9/12*	only if shaft or tunnel water is discharged to surface (1/4)**	None	N/A
Jollyville Reservoir Shaft	JT-127	Near shaft location to monitor Edwards formation; contaminants, if any, will be more mobile in the Edwards and potential impacts of water interception could be more significant	Water level	Continuous/ Telemetered TROLL/ bladder pump	Continuous/ Telemetered TROLL/ bladder pump/ e-lines; TROLL pulled 7/2012 for Spicewood shaft wells	Semi-annual	Edwards
			Water quality	6/6	weekly during excavation past well depth (20/20) and then quarterly (6/8)	Semi-annual	Edwards
Spicewood Shaft****	JT-120A	Near shaft location to monitor Glen Rose formation; added into monitoring program after JPS identified near shaft in April 2012.	Water level	n/a***	Continuous	Continuous	Glen Rose

	JT-130	In between shaft location and JPS stream reach; added into monitoring program after JPS identified near shaft in April 2012.	water level	n/a***	twice weekly until TROLL installation; then, continuous until TROLL removal; then, monthly e-lines	None	Glen Rose
	Trib 4 Downstream of Spicewood Shaft	Downstream from shaft locations	Water level	8/12*	monthly until shaft construction (4/4), weekly during shaft construction (24/12) and then monthly thereafter (4/7)	None	n/a
			Water quality	8/12*	monthly until shaft construction (4/4), weekly during shaft construction (24/12) and then monthly thereafter (4/7)	None	n/a
Jollyville Transmission Main Tunnel	JT-107D-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	TROLL pulled in November and monthly e-lines taken (7) until re-installation in May 2012	Continuous	Glen Rose
	JT-107PZ-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT-107S-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT108A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT110A	Western end of tunnel	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT126	Eastern end of tunnel	Water level	Continuous	Continuous	Continuous	Glen Rose
	Lanier	Proximate to tunnel	Water level	Continuous	Continuous	Continuous	Glen Rose

	Spring	alignment	Specific Conductance	Continuous	Continuous	Continuous	Glen Rose
	Pit Spring	Proximate to the tunnel alignment below Bull Creek. Distrubuted discharge along the bank near the channel bottom eliminates the opportunity for direct flow measurement	Water level	6/6	36/36	none	Glen Rose
	Bull Creek above WTP4	Proximate to the tunnel alignment below Bull Creek. Distributed discharge along the bank near the channel bottom eliminates the opportunity for direct flow measurement	Water level	Continuous	Continuous	Continuous	n/a
	Bull Creek at Tributary 7	Available historical surface water monitoring data; captures flow discharging from Pit Springs, combined with any stream flow	Water level	Continuous	Continuous	Continuous	n/a
			Specific Conductance	Continuous	Continuous	Continuous	n/a
	Bull Creek at Spicewood Springs 7th Crossing	Located on Bull Creek just downstream of the last point where the Jollyville Transmission Main parallels Bull Creek	Water level	Continuous	Continuous	Continuous	n/a

Reference Sites	Trib 4 Upstream of Spicewood Shaft (T4US)	Characterizes background surface water condition. Discontinued and replaced by Trib 4 upstream of Spicewood road (T4AR) in April 2012 after site was understood to drain more to the northeast than originally thought.	Water level	6/6	monthly until shaft construction (7/7), and then 3 times (1/3) to establish relationship with T4AR. Replaced by T4AR.	None	n/a
			Water quality	6/6	monthly until shaft construction (7/7). Replaced by T4AR.	None	n/a
	Trib 4 Above Spicewood Road (T4AR)	Characterizes background surface water condition. Replaced T4US in April 2012 after site was understood to drain more to the northeast than originally thought.	Water level	n/a***	monthly to establish baseline and relationship with T4US (3/3) and then weekly during shaft construction (24/12), monthly thereafter (9)	None	n/a
			Water quality	n/a***	monthly (1/3) and then weekly during shaft construction (12), monthly thereafter (9)	None	n/a
	Tanglewood Spring	Significant spring with habitat	Water level	6/6	26/36	None	
			Water quality	6/6	26/36	None	n/a
	Ribelin Spring	Significant spring with habitat/ characterizes background conditions	Water level	6/6	26/36	None	n/a
			water quality	6/6	26/36	None	n/a
	JT-101-A		Water level	6/6	39/36*	None	Edwards
	JT-113		Water level	6/6	28/36* (continuous TROLL from 12/7 to 4/19)	None	Edwards
	JT-114		Water level	6/6	54/36*	None	Edwards
	JT-115		Water level	6/6	54/36*	None	Edwards
	B-4		Water level	n/a***	20/0	None	Glen Rose
	B-5		Water level	n/a***	20/0	None	Glen Rose
	B-8		Water level	n/a***	47/0	Monthly	Glen Rose
	B-9		Water level	6/6	47/36	Monthly	Glen Rose

	B-10		Water level	6/6	47/36	Monthly	Glen Rose
	JT-118		Water level	6/6	12/36 (continuous TROLL from 7/2012)	None	Glen Rose
	JT-104A		Water level	6/6	52/36	None	Walnut
	JT-124A		Water level	6/6	52/36	None	Edwards
	JT-125A		Water level	6/6	52/36	None	Glen Rose

*for surface water sites, baseline samples unable to be taken during 2010-2011 drought.

**shaft/tunnel water discharged to surface at Four Points once, during week of 5/1/12

***site not in initial plan. For details on plan changes, see table 2

****changes from initial plan due to discovery of JPS site in early 2012. For details on plan changes, see Spicewood Shaft section

Table 1. Summary of monitoring sites

Date	Change to Monitoring Plan
10/2011	Decision to increase water quality sampling at JT-112 and JT-127 to weekly pulls during shaft construction. Dual purpose of increasing scrutiny of water quality parameters due to change in construction method and added benefit of increasing EC presence onsite.
12/2011	Decision to start taking e-line readings weekly to more closely monitor expanding zone of influence from Four Points shaft
12/7/11	Decision to pull JT-108 troll (convenient) and install in JT-115 to check for expanding zone of influence from Four Points shaft. This was later amended to the closer JT-113 well.
2/2012	East E-lines: Increased to biweekly from monthly to more closely monitor Glen Rose groundwater increase
1/24/12	Grout Injection monitoring begins at JT-112 and Gaas Springs. This is the first sample for Phthalates pre-injection. The property owner of Gaas springs (the closest spring site to 4pts shaft according to dye trace) permits access and site is added into grout injection and regular WQ monitoring schedule on a weekly basis until further notice.
2/8/11	West e-lines: reduced to biweekly readings from weekly to balance workload.
2/23/12	JT-127: Once mining is past the screened interval for this well (probably next week), water quality pulls will be quarterly rather than weekly. Quarterly water quality pulls will test for surface impacts.
2/23/12	JT-112: Phthalate analysis is still important, and should proceed every week for 8 weeks and then monthly for a year from the date of grout injection. The rest of the parameter suite (Alkalinity, Metals, etc.) can be dropped as excavation is below the screened interval for this well.
2/23/12	Gaas Spring: Should be tested for phthalates at same frequency as above for JT-112.
4/3/12	Decision to abandon JT-109 as is not used in monitoring plan
4/19/12	Move troll in JT-113 to JT-108 once more. This will allow the rental cable to be returned to In-Situ.
4/19/12	Change sampling frequency for Gaas spring to once monthly for the next 4 months, and then quarterly.
4/24/12	(ECCG Meeting) In light of identification of new JPS site, relocate TROLLs from JT-128 (Four Points) and JT-127 (Jollyville Reservoir) to JT-120A and JT-130 (Spicewood Shaft) to provide continuous monitoring during shaft construction.
4/25/12	(Data Review Meeting) Discontinue T4US and establish new T4AR site further upstream to better capture conditions upstream of Spicewood shaft. It was

	decided that the current T4US site was likely to see more shaft site runoff than originally thought.
6/2012	Placement of TROLLS in JT-120, JT-130, and JT-118.
8/13/12	New monitoring schedule created to increase monitoring in light of start of tunneling for Reach 2, Reach 3, and Spicewood shaft excavation (Appendix 1)
8/15/12	JT-110A well – Age Dating pump stuck at 220 feet BTOC, incapacitating well. Well retained to monitor for water rebound after Reach 1 is grouted, but water level is currently below the stuck pump.
4/24/13	review of monitoring plan with JVTM Data Report #4 resulted in the following changes to post-excavation schedule: • Post-excavation monitoring (begins in May-June). i. Tunnel: Transducers downloaded monthly, vw piezometers read monthly, east e-lines taken monthly. ii. Shaft sites: Semi-annual well elevations and water quality sampling in JT-127 and JT-112, and Gaas; also Ribelin and Tanglewood for reference. (should mean one sample near end of summer, one in spring 2014, and one near end of post-construction period). Monthly water quality sampling in Trib 4. b. Post-construction monitoring (April 2014 - September 2014) i. Tunnel: Transducers downloaded monthly, vw piezometers read monthly, east e-lines taken monthly. ii. One post-construction level and water quality sample from JT-127 and JT-112, and Gaas; also Ribelin and Tanglewood for reference.
6/18/13	JT-130 well pad had to be modified to accommodate truck traffic. Stickup was removed and a new surface completion poured reinforced by rebar. TROLL removed; e-lines to be taken weekly through final tunnel excavation and monthly thereafter.
7/2013	Grouting of Reach 1 complete; JT110A to be checked monthly for recovery of water levels

Table 2: Changes to monitoring plan.

*Since 8/13/12, monitoring plan has proceeded as outlined in Appendix 1.

Parameter	Purpose
Potentiometric level	Detects groundwater interception by shafts or tunnel
Surface water level	Detects groundwater interception by shafts or tunnel as reflected by a decrease in spring or base channel flow
Temperature	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
pH	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Specific conductance	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Total Suspended Solids (TSS)	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Standard anions and cations: Ca, Mg, Na, SO4, HCO3, Cl	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Nitrate	Associated with blasting by-products, fertilizers
Ammonia	Associated with blasting by-products, fertilizers
Phosphate	Associated with fertilizers
Copper	Associated with drilling and mining operations, vehicular and equipment use
Chromium	Associated with drilling and mining operations, vehicular and equipment use
Zinc	Associated with drilling and mining operations, vehicular and equipment use
Total Petroleum Hydrocarbons (TPH)	Associated with drilling and mining operations, vehicular and equipment use
Di-n-butyl phthalate	Associated with hydrophobic grout injection at Four Points Shaft
Rainfall	Correlating factor measured by others
Tunnel and shaft inflow	Correlating factor measured by contractor
Tunnel surface discharge	Correlating factor measured by contractor

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Figure 14. A weir was installed in early October 2012 and removed mid-June 2013. As a result, water levels can only be compared during this time period. The transducer installed in Lanier Spring indicates no water depth decline as the tunnel excavation proceeds beneath 1/20/13. Changes in spring water levels are closely associated with Bull Creek Flow changes and associated rainfall events. 16

Figure 15. After tunnel passed the 107 cluster on 2/13/13, declines in water level are apparent in the lowest well completion. JT-107PZA shows a decline that is likely due to the tunnel, but also responsive to rain events, indicating some connection to the surface. JT-107SA shows no impact from the tunnel. 17

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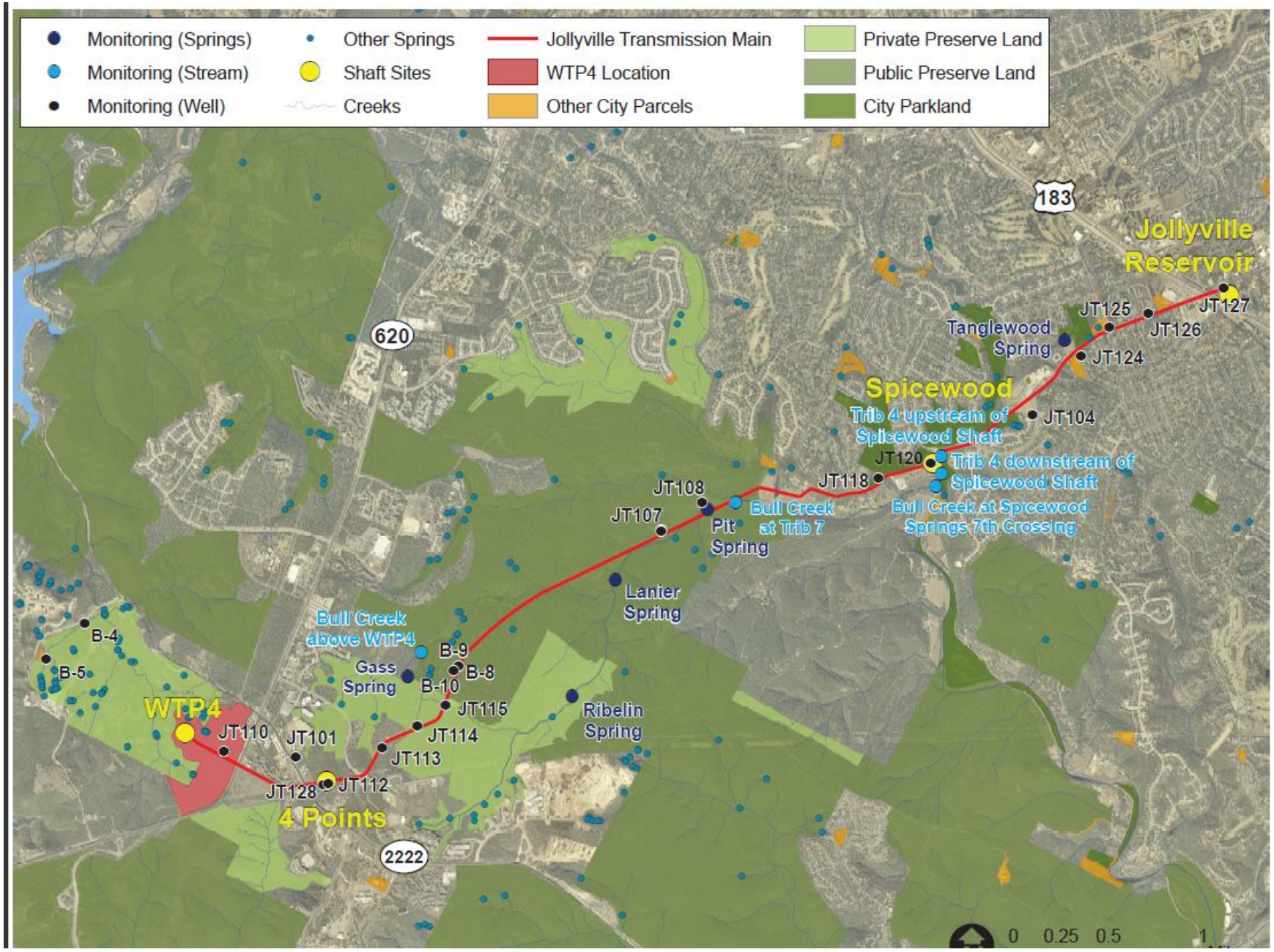


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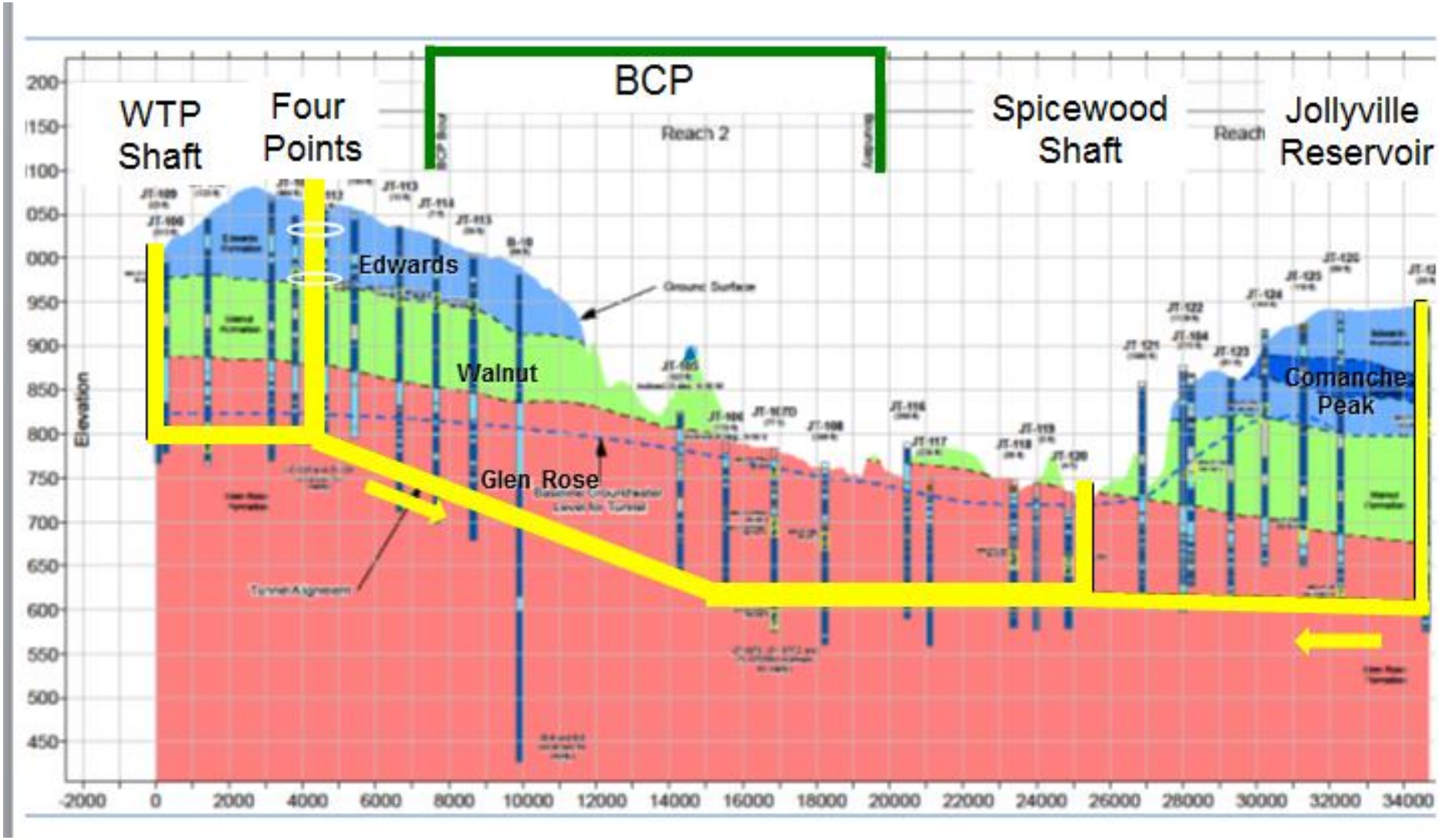


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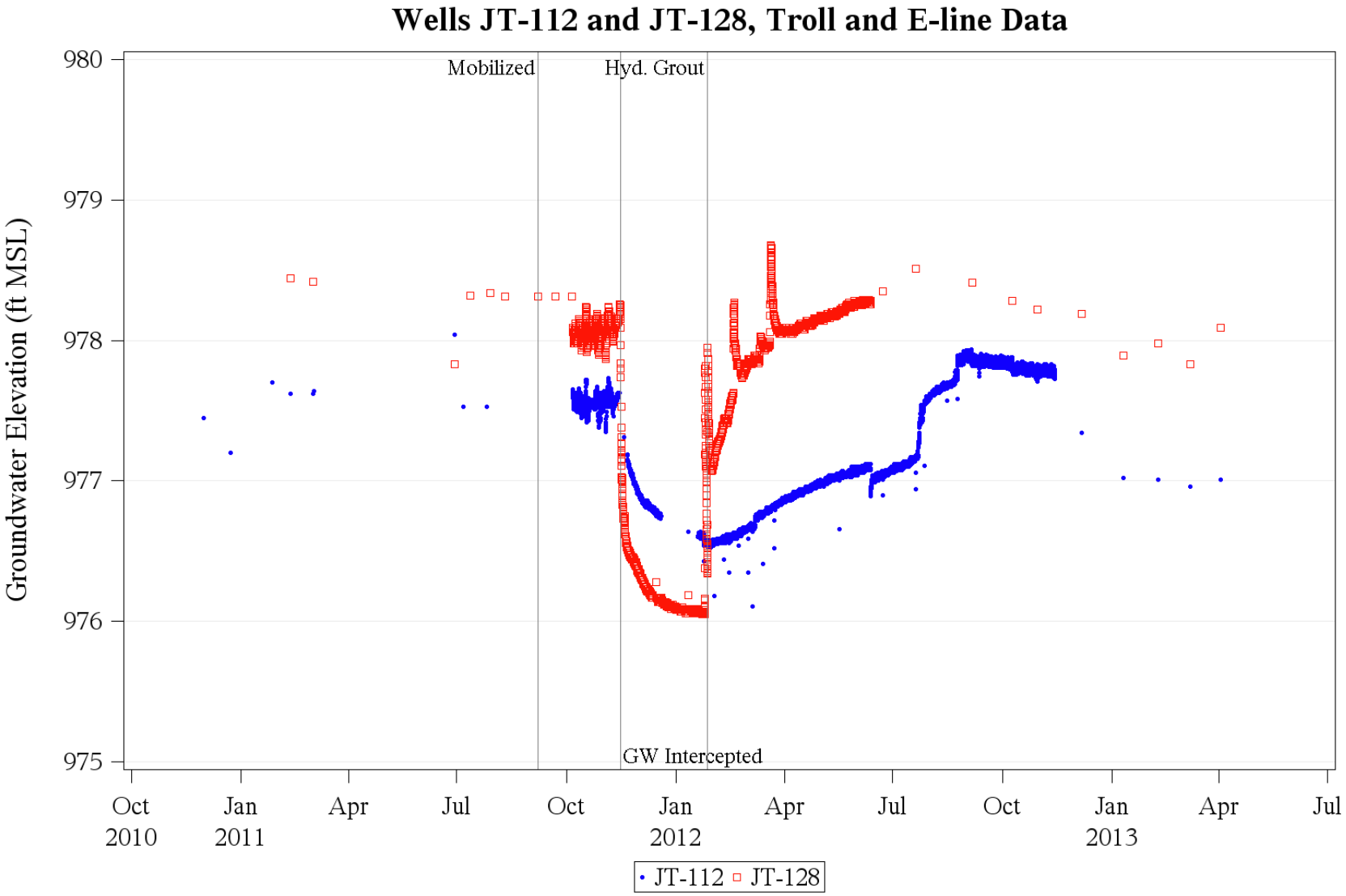


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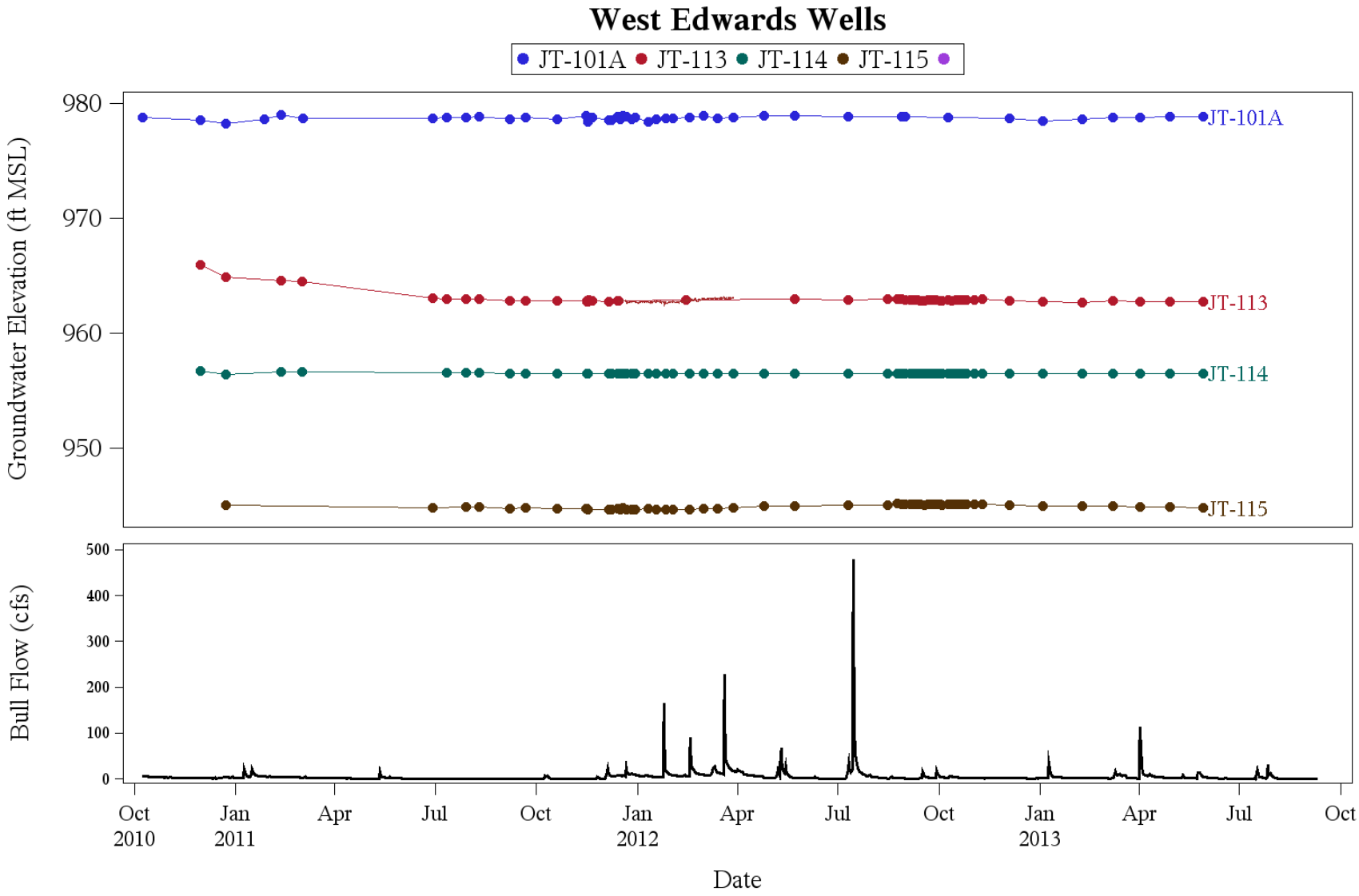


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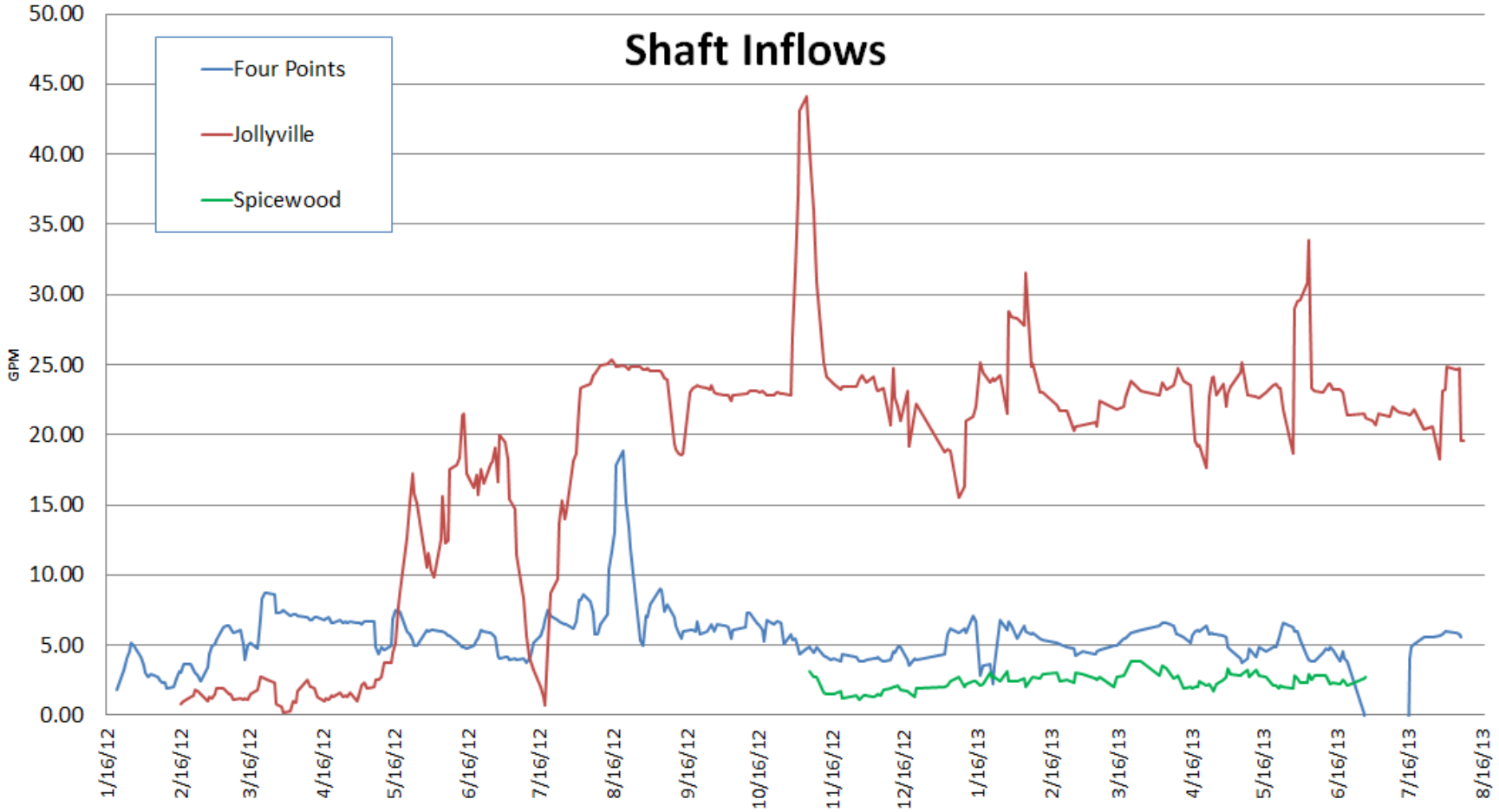


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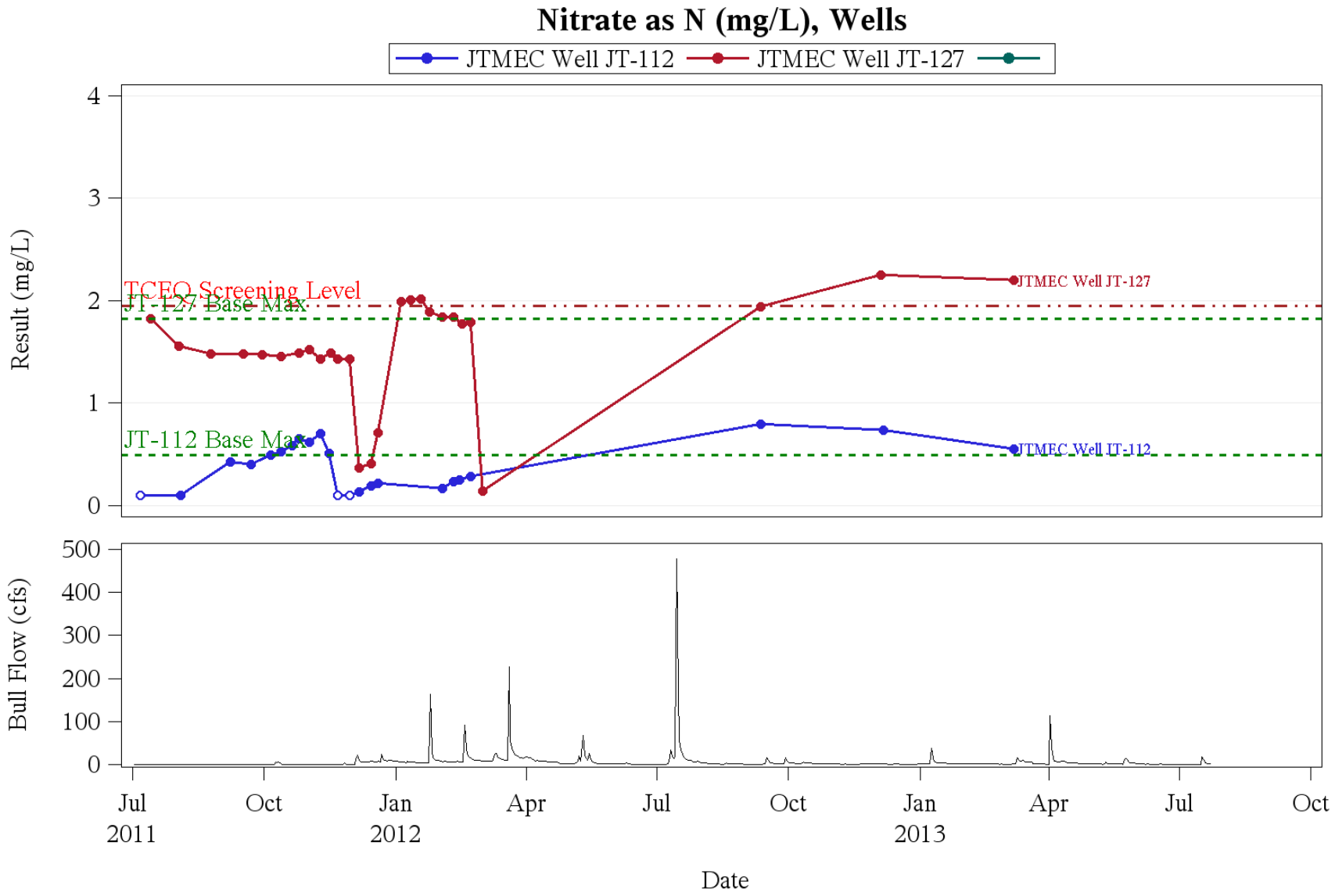


Figure 6. Nitrate as N (mg/L) in groundwater wells JT-112 and JT-127

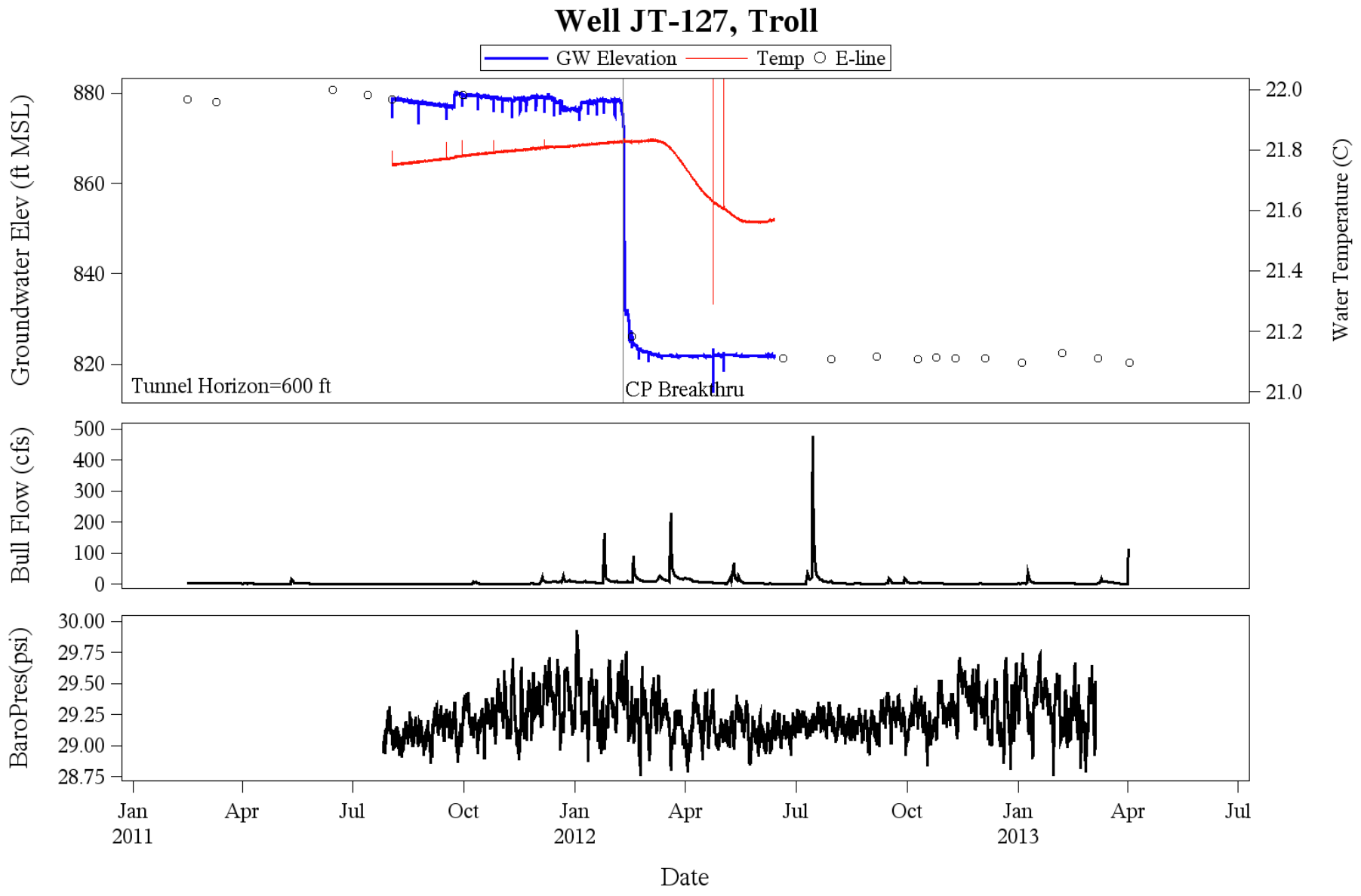


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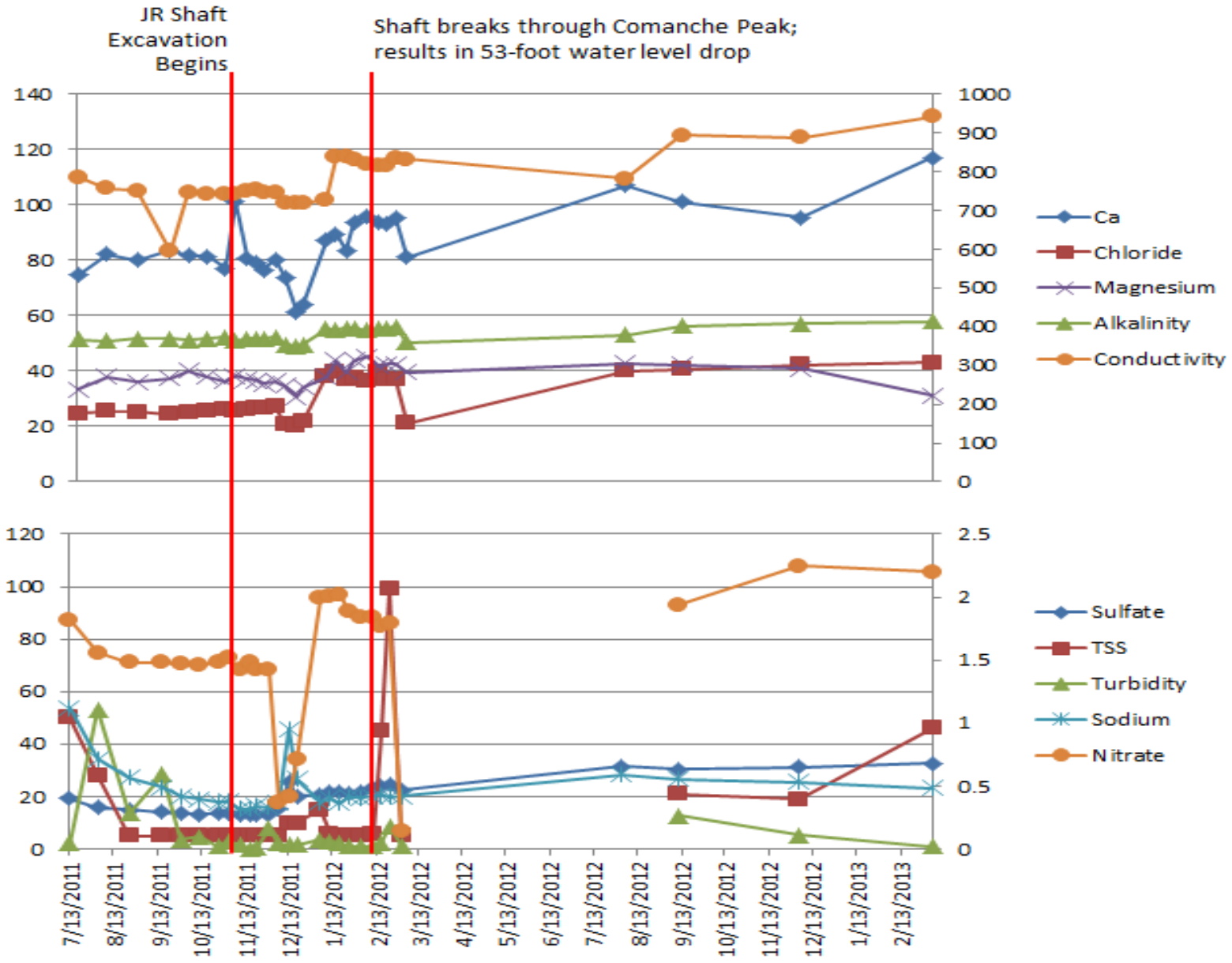


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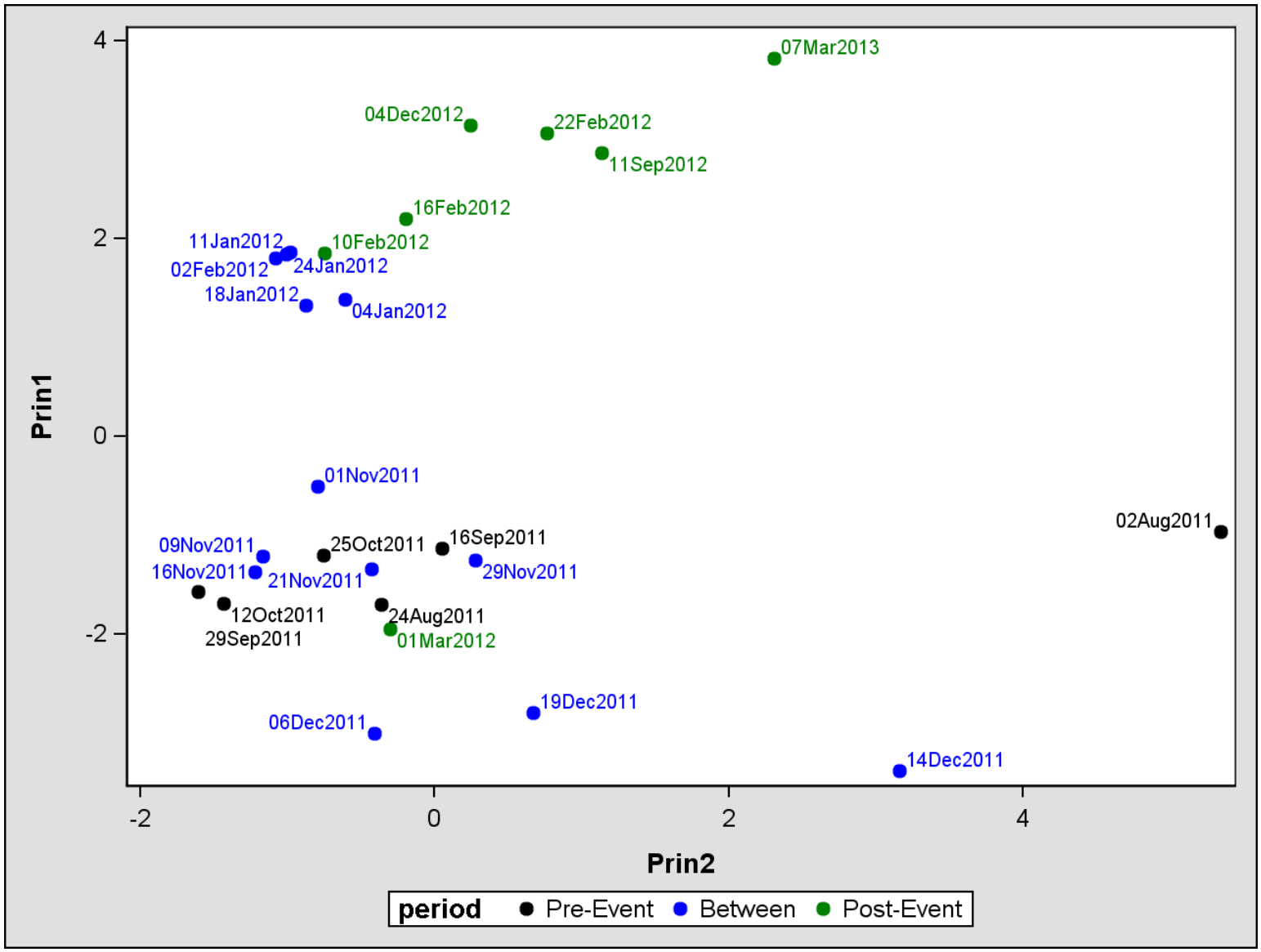


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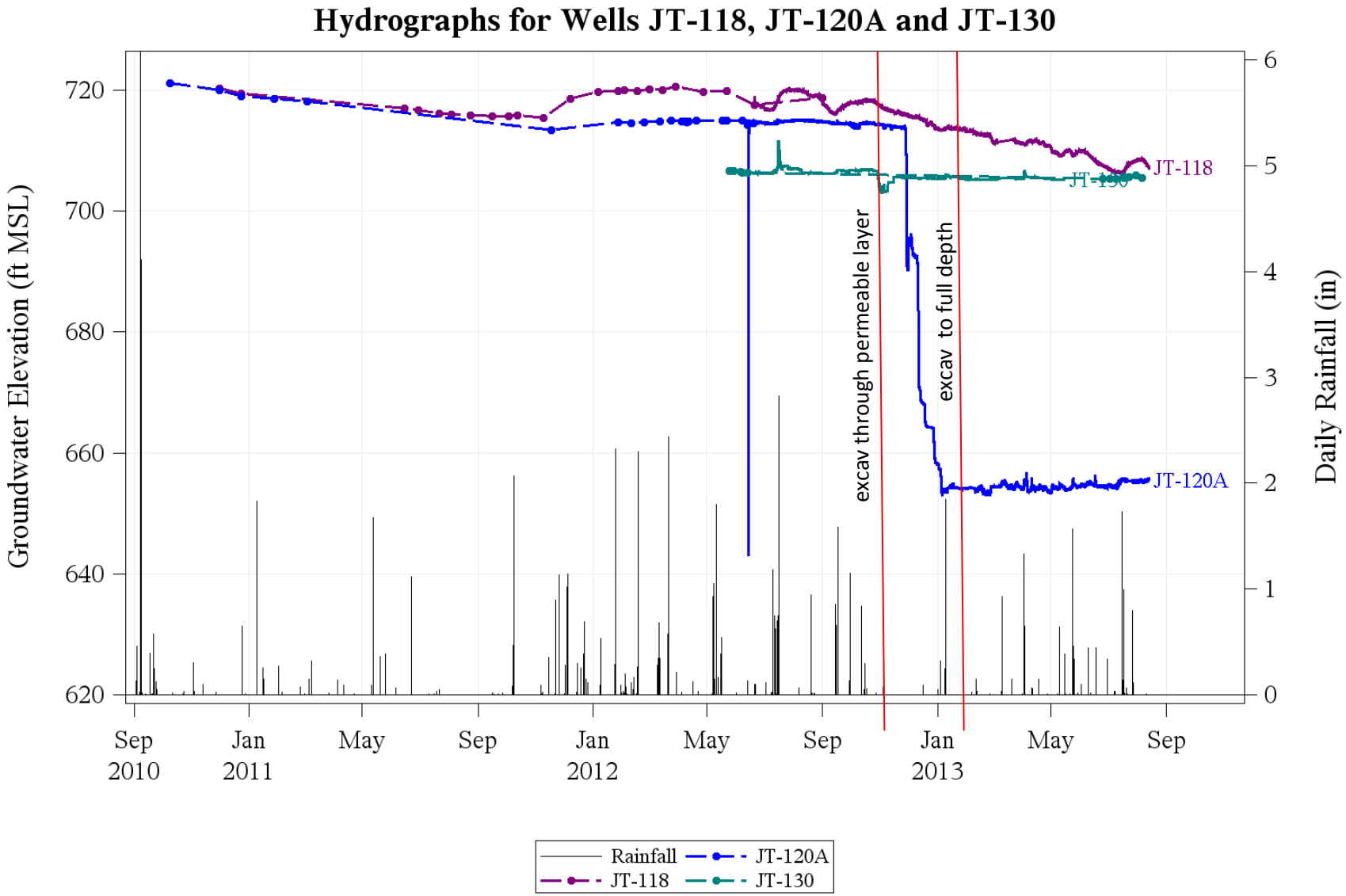
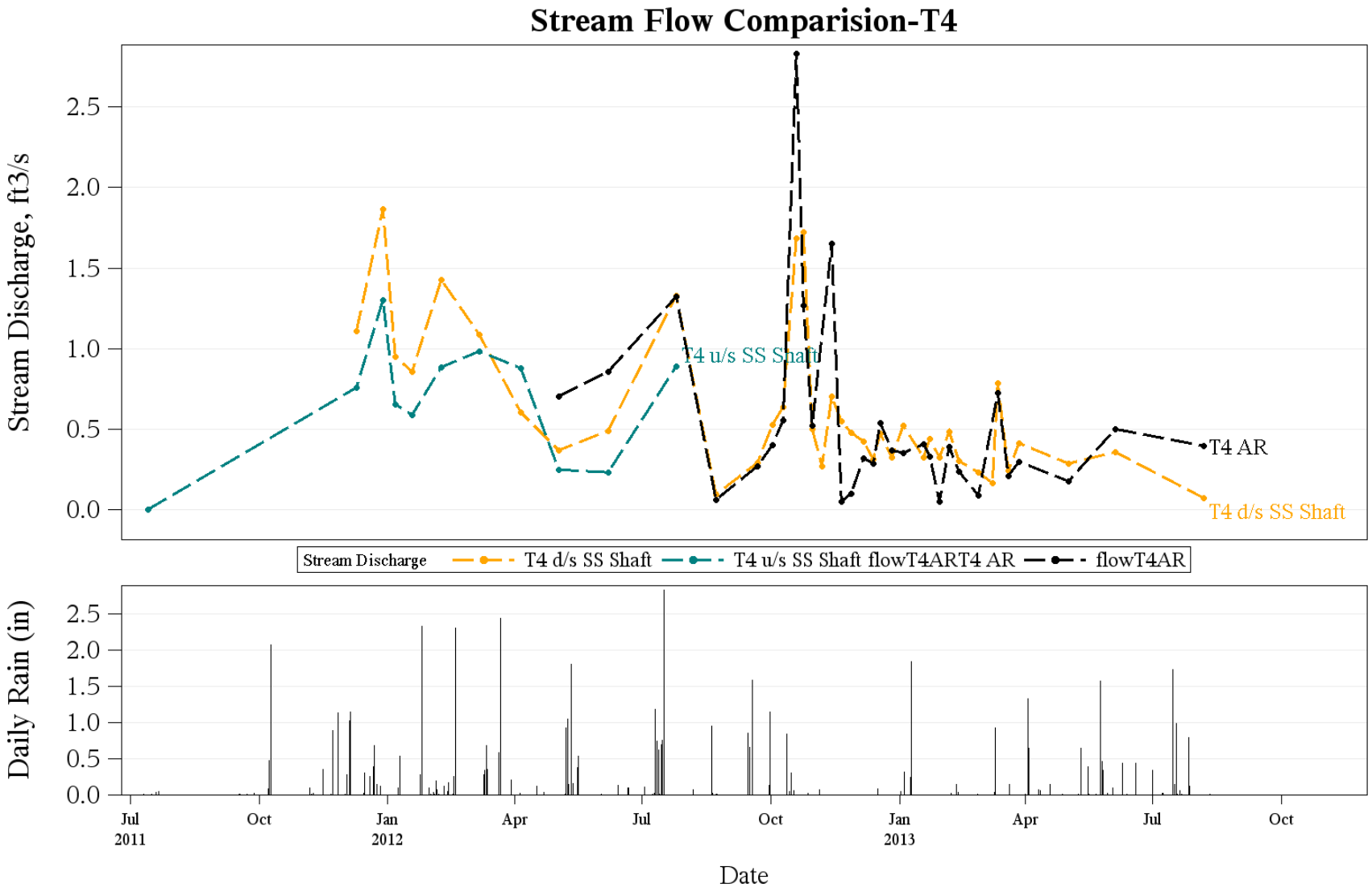
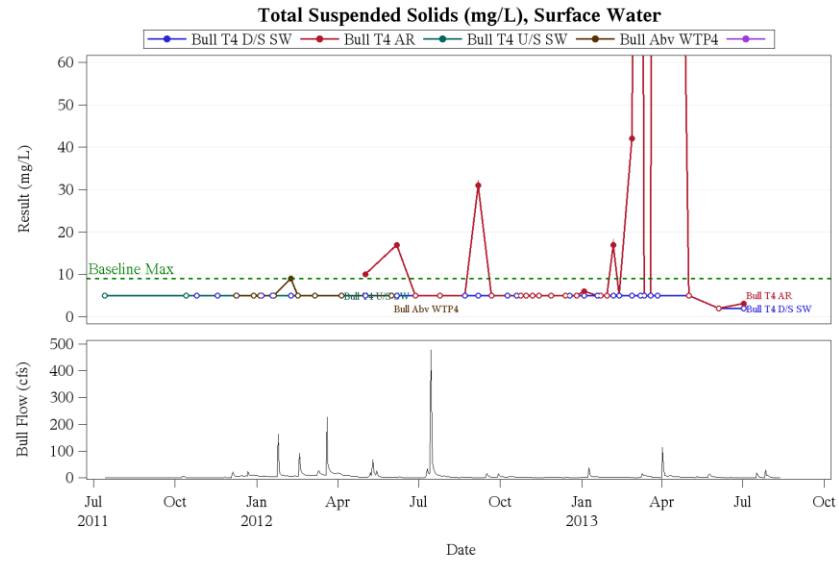


Figure 10. JT-130, JT-118, JT-120A Groundwater elevations. Red lines indicate when excavation cut through wet vuggy layer below two-ring continuous pour on 10/24/12, and when shaft reached full depth on 2/5/13.



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Figure 11. T4DS and T4AR maintained low flow through the reporting period.



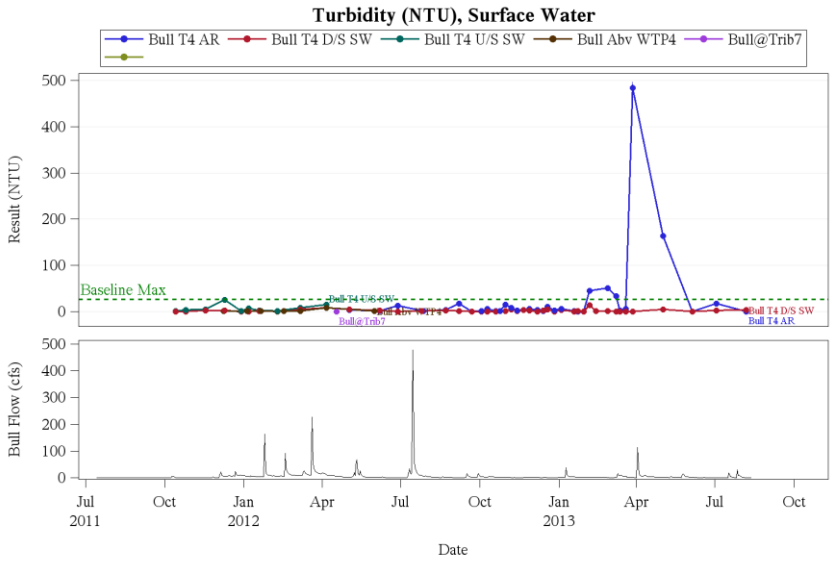




Figure 12. An algal bloom in T4AR resulted in high turbidity and TSS values for that site in April-May 2013. Note the colors on the two graphs are switched.

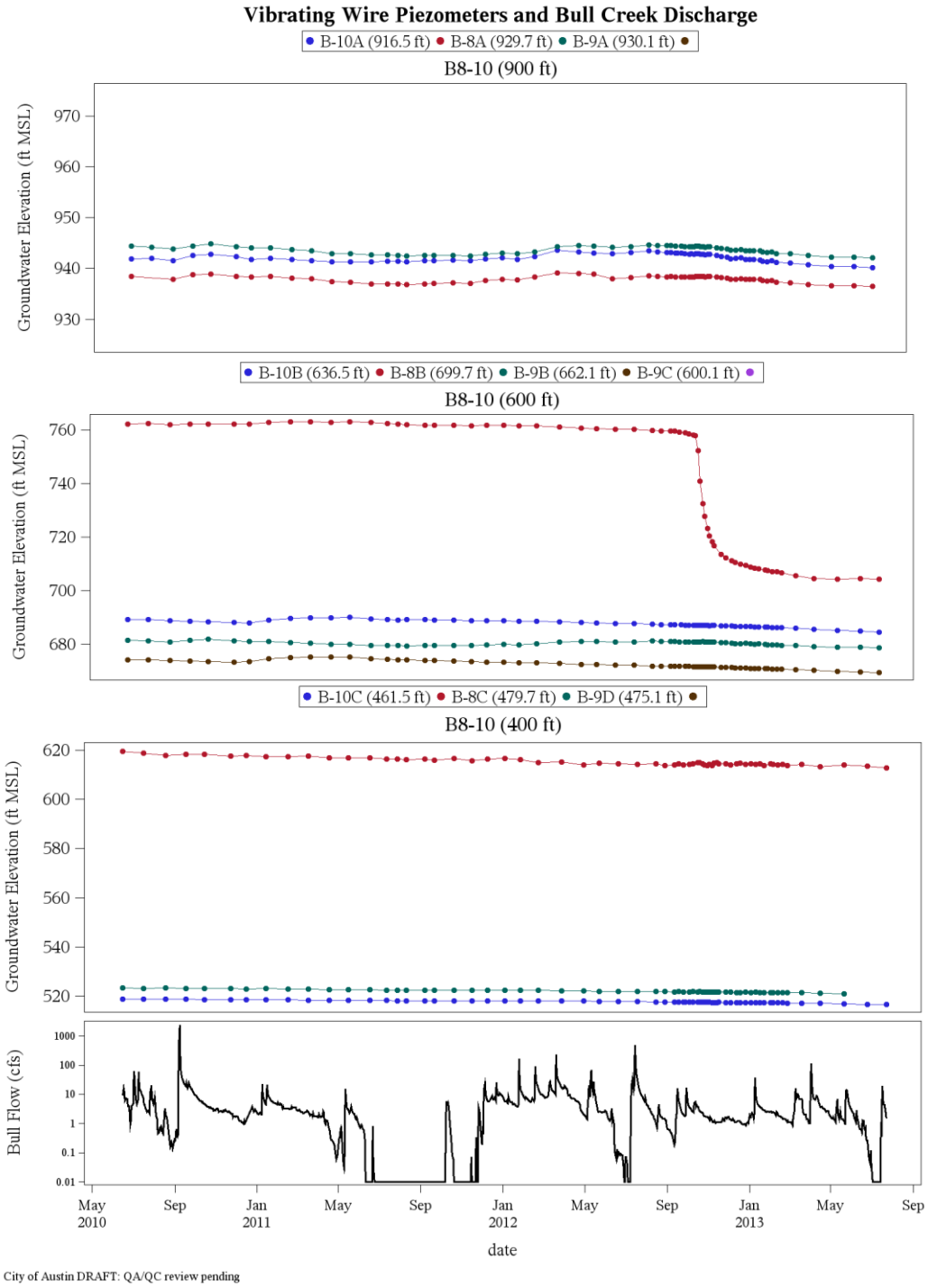


Figure 13. B-8B is the only piezometer near tunnel depth that shows a decline in water level.

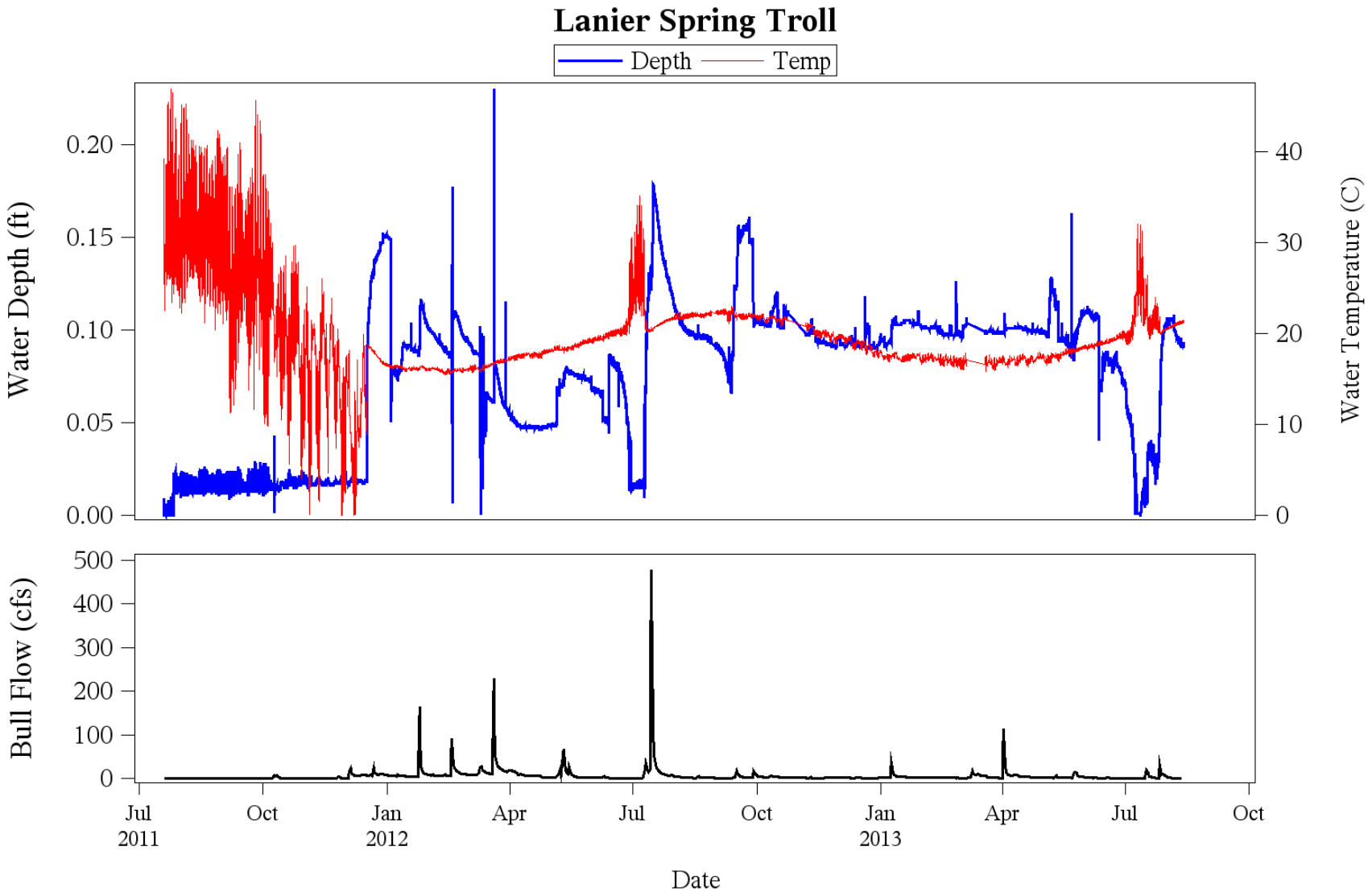


Figure 14. A weir was installed in early October 2012 and removed mid-June 2013. As a result, water levels can only be compared during this time period. The transducer installed in Lanier Spring indicates no water depth decline as the tunnel excavation proceeds beneath 1/20/13. Changes in spring water levels are closely associated with Bull Creek Flow changes and associated rainfall events.

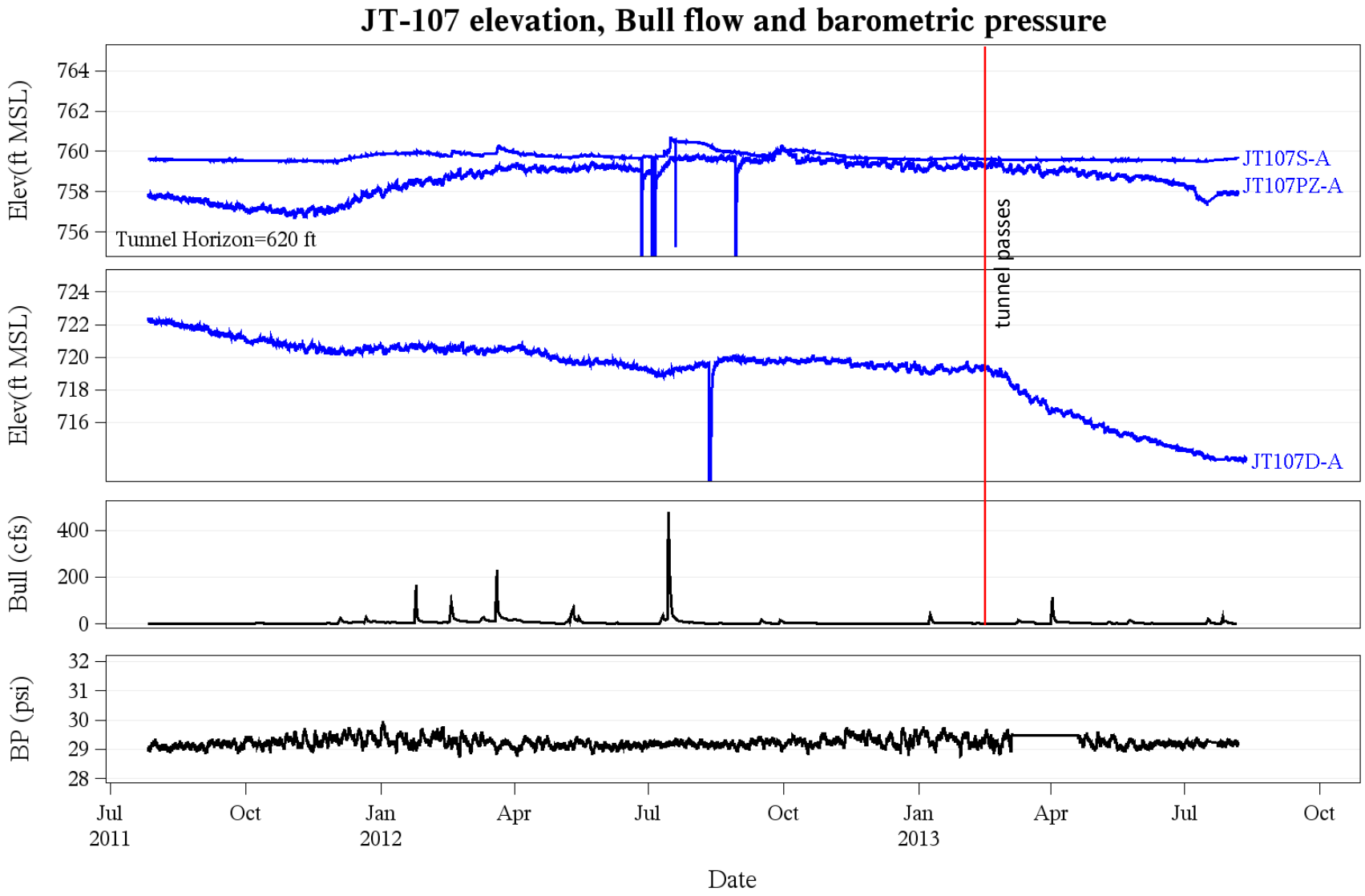


Figure 15. After tunnel passed the 107 cluster on 2/13/13, declines in water level are apparent in the lowest well completion. JT-107PZA shows a decline that is likely due to the tunnel, but also responsive to rain events, indicating some connection to the surface. JT-107SA shows no impact from the tunnel.

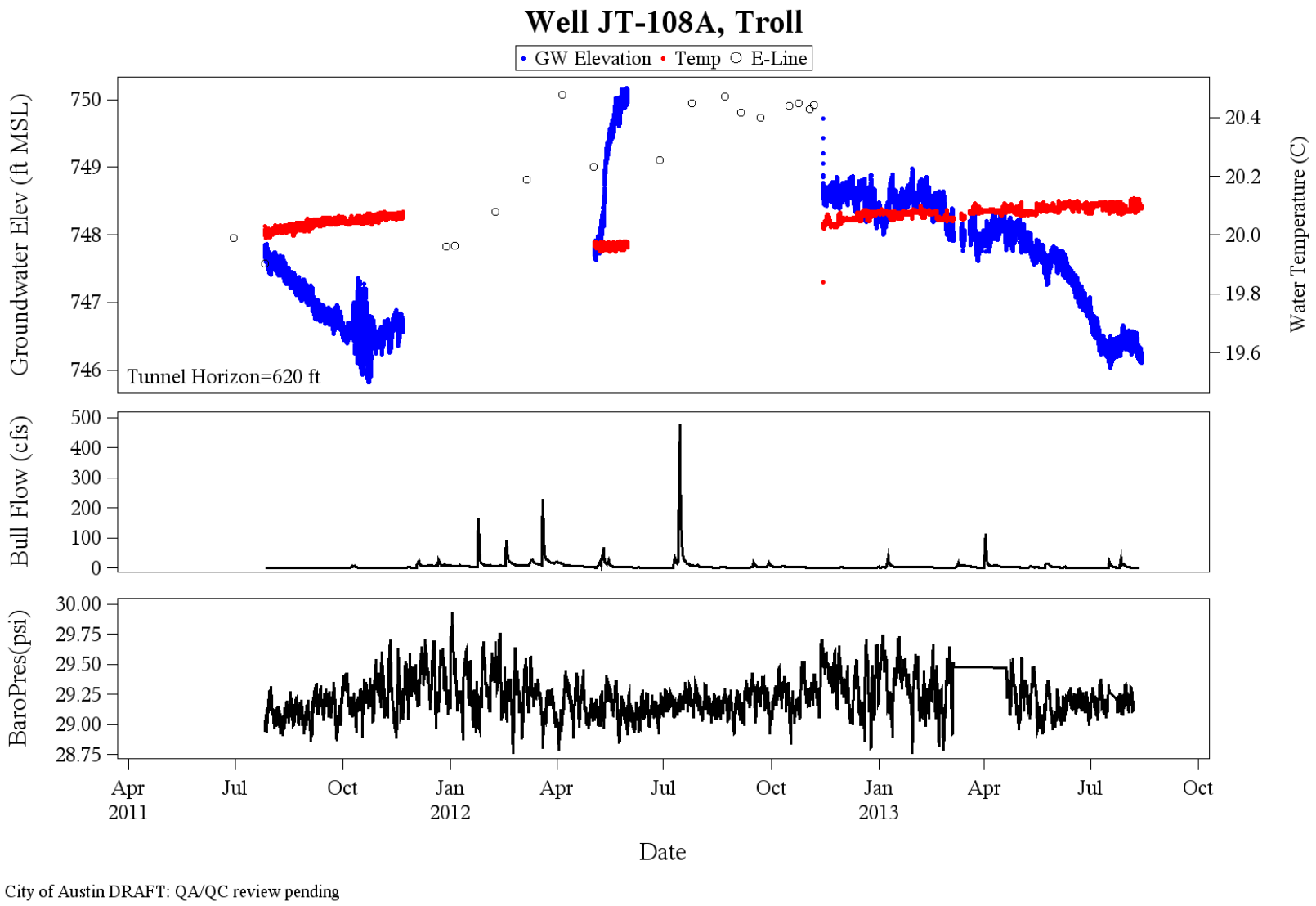


Figure 16. JT-108A shows a decline after the tunnel passes in early March 2013, but does not drop below levels seen in the baseline period.

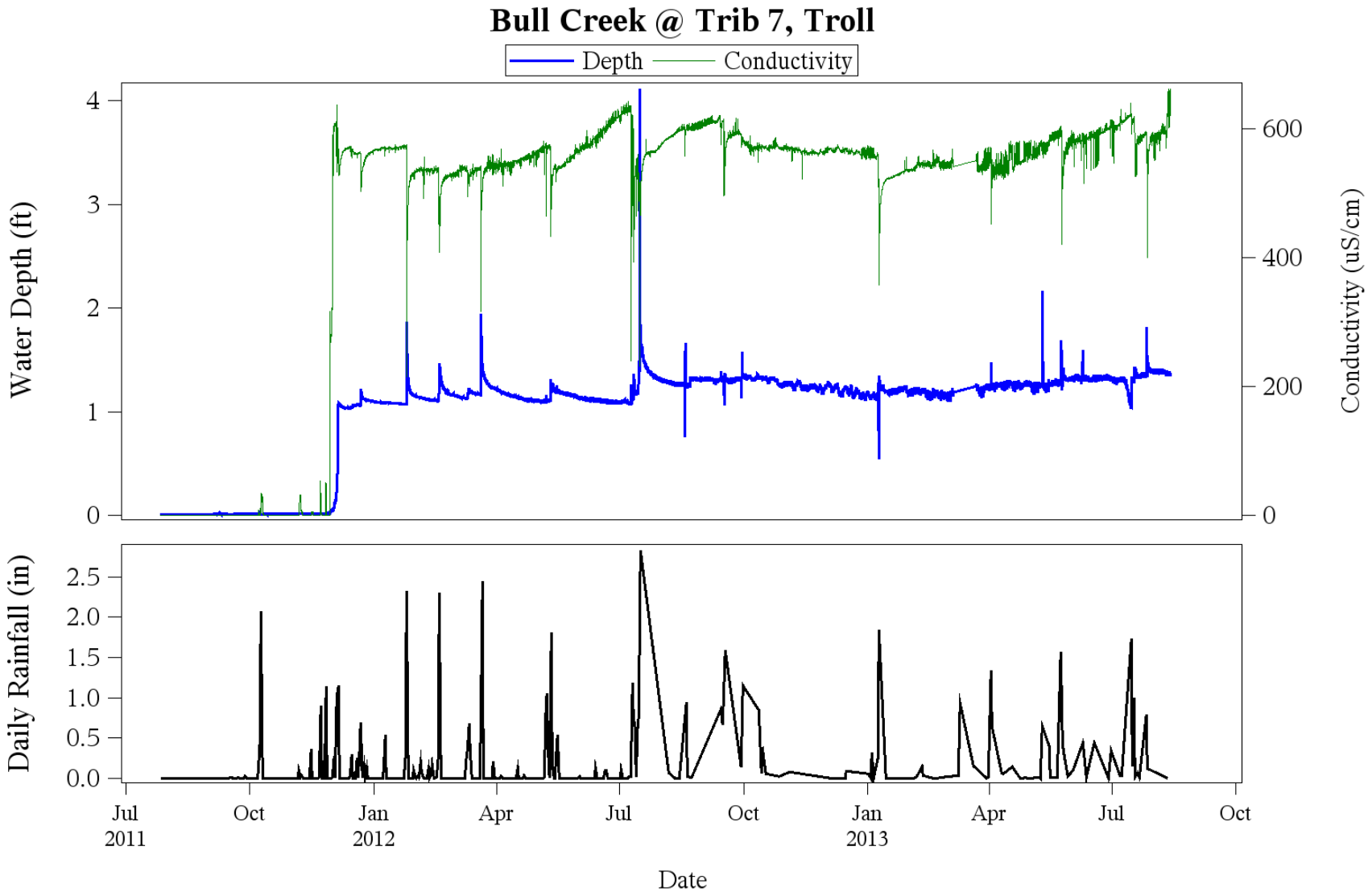
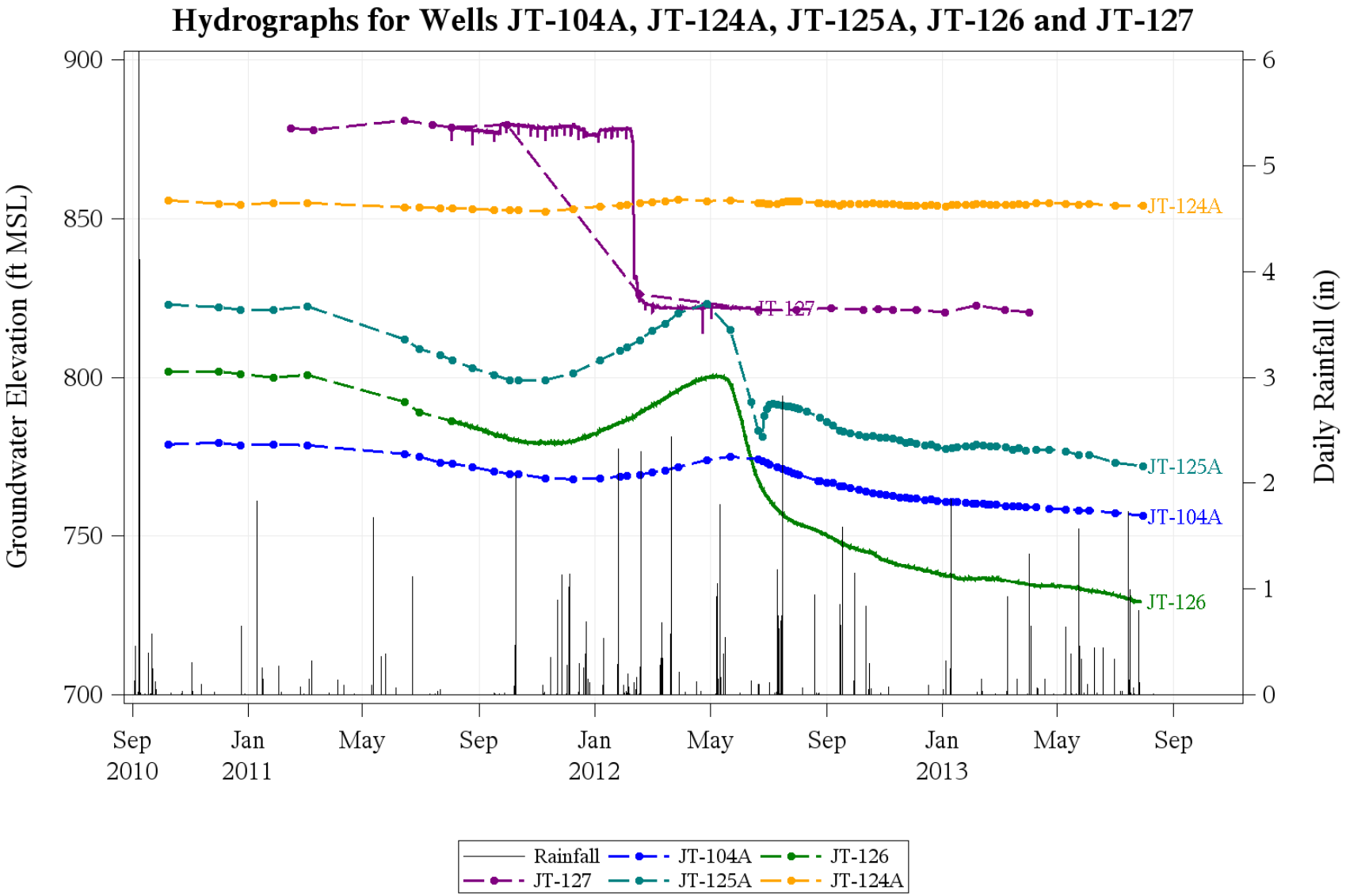


Figure 17. No evident declines in Bull Creek @ Trib 7as the tunnel nears Pit Spring in March 2013



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Figure 18. Groundwater levels in the eastern wells.

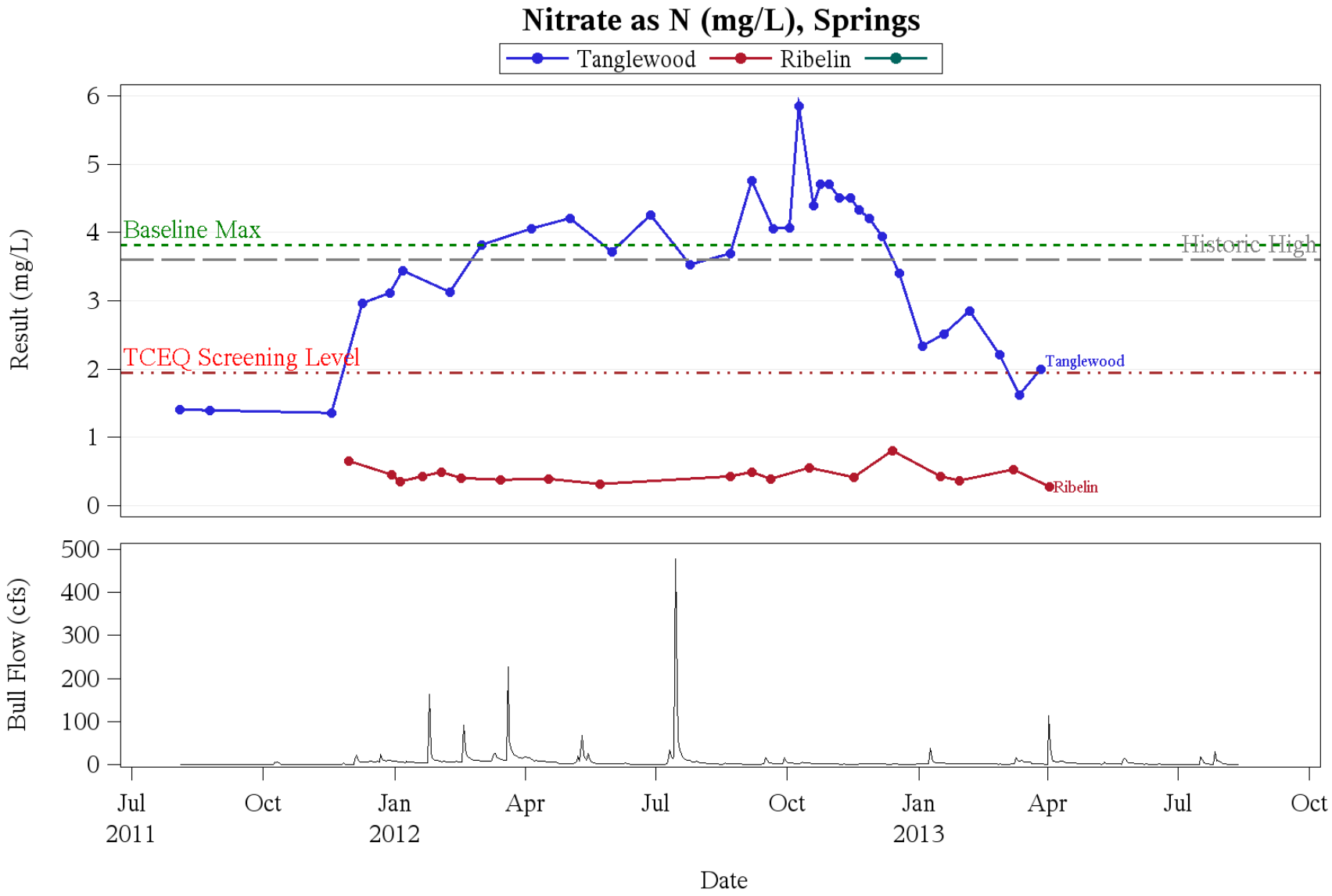
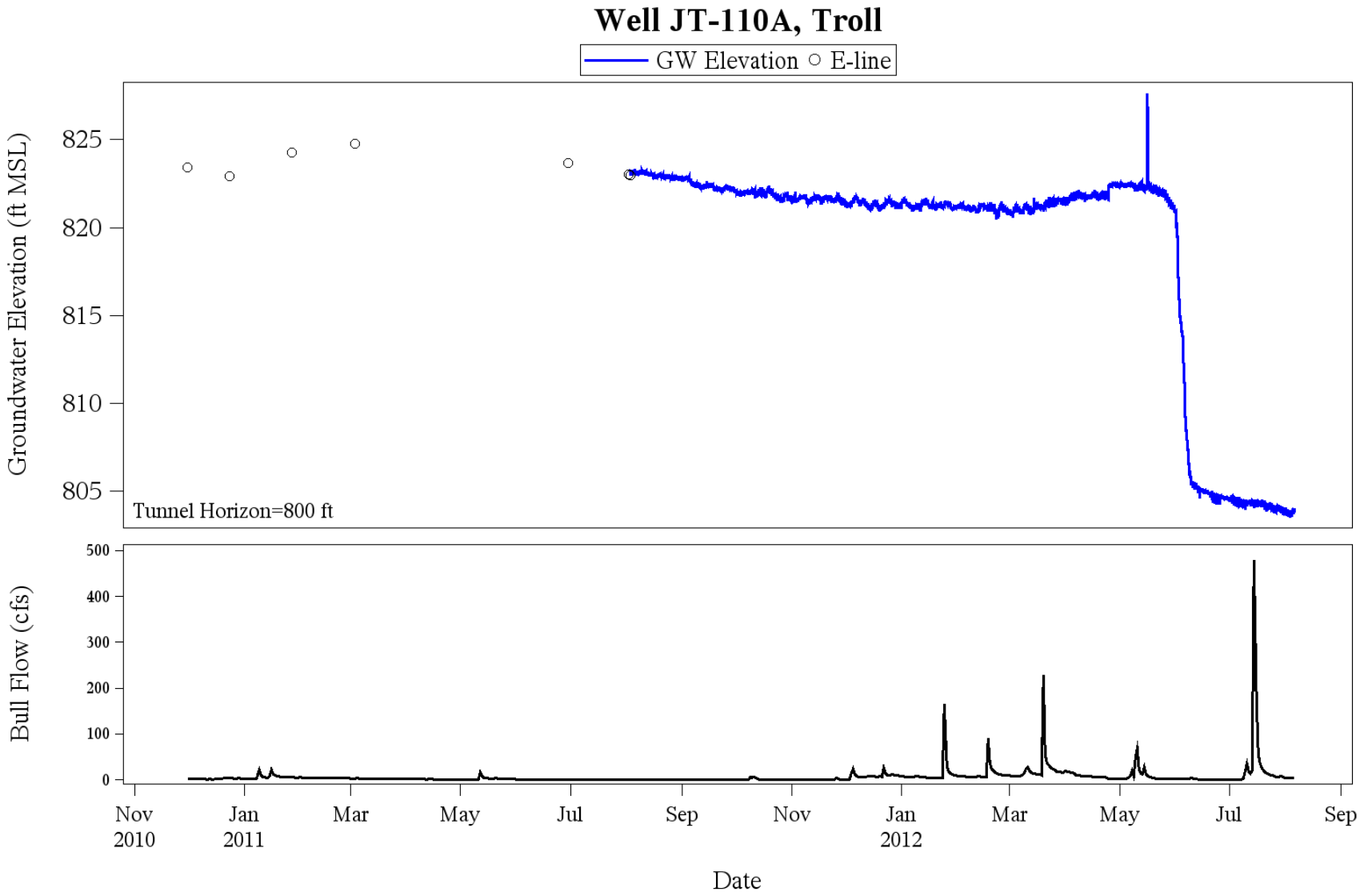


Figure 19. Tanglewood Spring had high levels of nitrates during 2012.



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Fig. 20. JT-110A.

REACH 2

Sampling Intensity

quarterly
monthly
twice monthly
weekly
twice weekly
not sampled

continuous device installed

as of 8/15/13 --->

* time estimates at 600 ft/week

Reach 2 Construction Progress:				CONSTRUCTION: Excavation												CONSTRUCTION: Pipe Installation								POST-CONSTRUCTION							
				2012						2013										2014											
				August	Sept	Oct	Nov	Nov-Dec	Dec	Jan	Jan	Feb	Mar-Apri	May-June	July	July-Aug	Aug	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
				44+50 to 42+00	42+00 to 87+00	87+00 to 96+00	96+00 to 108+00	108+00 to 138+00	138+00 to 158 +00	158+00 to 172+00	172+00 to 178+00	178+00 to 192+00	192+00 to 202+00	202+00 to 223+00	223+00 to 236+00	236+00 to 244+00	244+00 to 249 +00	pipe installation and grouting						surface restoration		operational						
Site Type	Site	Data Type	Equip	4P to JT-113	113 to 115	JT-115 to B piezos	end of buffer	piezo buffer to	Lanier Spring	107 cluster		108/ Pit buffer	sensitive reach	between pit and 118	JT-118	BC7C	Spicewood Shaft																
West Well	JT-101-A	manual	e-line			90+21 10/15																									
West Well	JT-113	manual	e-line		8/30/12 @5	95+76 10/29				*monthly dep'd on no effect seen												none									
West Well	JT-114	manual	e-line		9/6/12 @ 54+48																											
West Well	JT-115	manual	e-line		9/12 @ 60+60									*monthly dep'd on no effect seen																		
vw peizos - l	B-10	manual	vw peizos		9/24 @ 67+70																				monthly if needed						
vw peizos - l	B-8	manual	vw peizos		9/27 @ 71.43					weekly																					
vw peizos - l	B-9	manual	vw peizos		10/1 74+40		99+44 11-1																								
BCP Surface	Bull Creek above	cont	Roger's Bubbler		10/4 @ 80+20			108+86 11/12																							
BCP Surface	Lanier Spring	cont	AquaTROLL		10/9 83+87			122.65 on 1	144+17 @ 1/14														*monthly								
BCP Well	JT-107D-A	cont	LevelTROLL/tel		twice monthly				150+70 @ 1/28																						
BCP Well	JT-107IPZ-A	cont	LevelTROLL/tel						153.33 @ 1/30																						
BCP Well	JT-107S-A	cont	LevelTROLL/tel																												
BCP Well	JT-108-A	cont	TROLL or eline				weekly				174.29 on 2	179+57 on 3/1						*monthly dep'd on				none				none					
BCP Surface	Pit Spring	manual	none/visual									185+25 on 3	194+00																		
BCP Surface	Bull Creek at Trib 7	cont	AquaTROLL downlo										196+32	202 on 5/2/13									*monthly								
East Well	JT-118-A	cont	LevelTROLL											218+36 on 6/13	231+57 on 7/11																
East Surface	Bull Creek @ Spice Spgs 7th Crossing	cont downlo ad	LevelTROLL													242+49 on 8/1															
West Surfac	Ribelin Spring -	manual	gauge				twice monthly - reference site						*monthly dep'd on no effect seen													none					
West Surfac	Ribelin Spring -	wq	gauge				monthly - reference																								
vw peizos - l	B-4						monthly - reference site																								
vw peizos - l	B-5																														
Four Points	JT-128 - level	manual	eline																												
Four Points	JT-112 level	cont	LevelTROLL				monthly - postconstruction																								
Four Points	JT-112 - wq	wq	bladder pump																												
Four Points	JT112-Phthalates	wq	bladder pump				quarterly - postconstruction							semi-annual - postconstruction					semi-annual - postconstruction												
Four Points	GS- wq	wq																													
Four Points	GS-Phthalates	wq																													

REACH 3

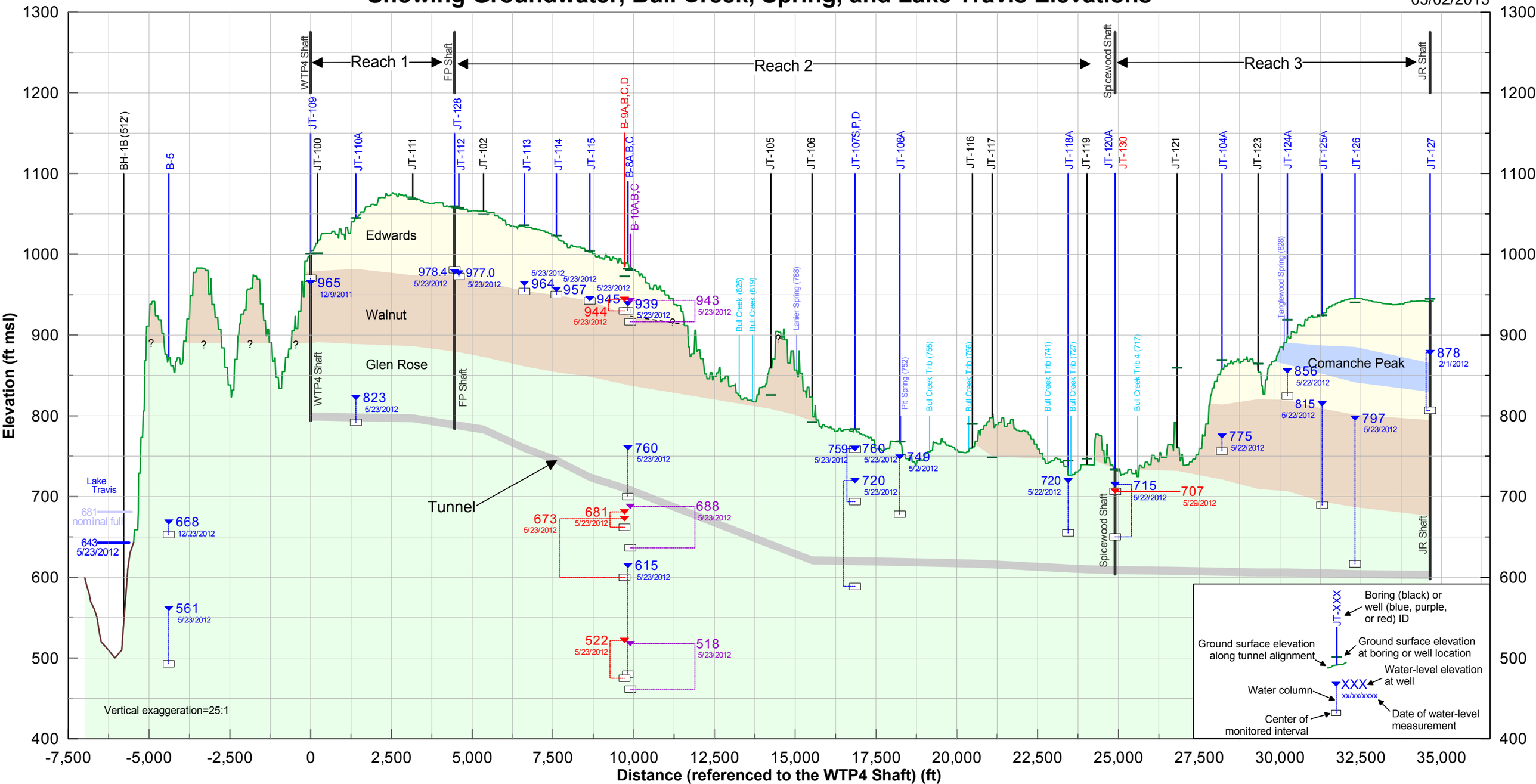
Reach 3 Construction Progress				CONSTRUCTION: Excavation										CONSTRUCTION: Pipe Installation, Grouting										POST-CONSTRUCTION							
				2012						2013										2014											
				August	Sept	Oct	Nov	Nov-Dec	Dec	Jan	Jan	Feb	Mar-Apri	May-June	July	July-Aug	Aug	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
				346+00 to 332+00		332+00 to 293+00			293+00 to 272+00		274 to 249+00			pipe installation and grouting								surface restoration			operational						
East Surfac	Tanglewood	manual	gauge	twice monthly		327+76 10/15		twice monthly						*monthly dep'd on no effect seen																	
East Surfac	Tanglewood	wq	gauge		weekly	315+20 10/29		285+60 1/:	275+57 @ 1/31		262.25 on 2/22		COMPLETE on 3/21/13																		
East Well	JT-104-A	manual	e-line	8/30/12 @ 343 + 72		312+67 11-1									every other week							none								
East Well	JT-124-A	manual	e-line	9/6/12 stalled		308+19 on 11/12																									
East Well	JT-125-A	manual	e-line	9/26 340+46		297.60 on 11/30																									
East Well	JT-126	cont	LevelTROLL	9/27 @ 339.71																				*monthly						
East Well	JT-127 - level	manual	e-line	10/1 338+(	monthly - postconstruction							semi-annual - postconstruction																			
East Well	JT-127 wq	wq	bladder pump	10/4 336+(	quarterly - postconstruction							semi-annual - postconstruction										none									

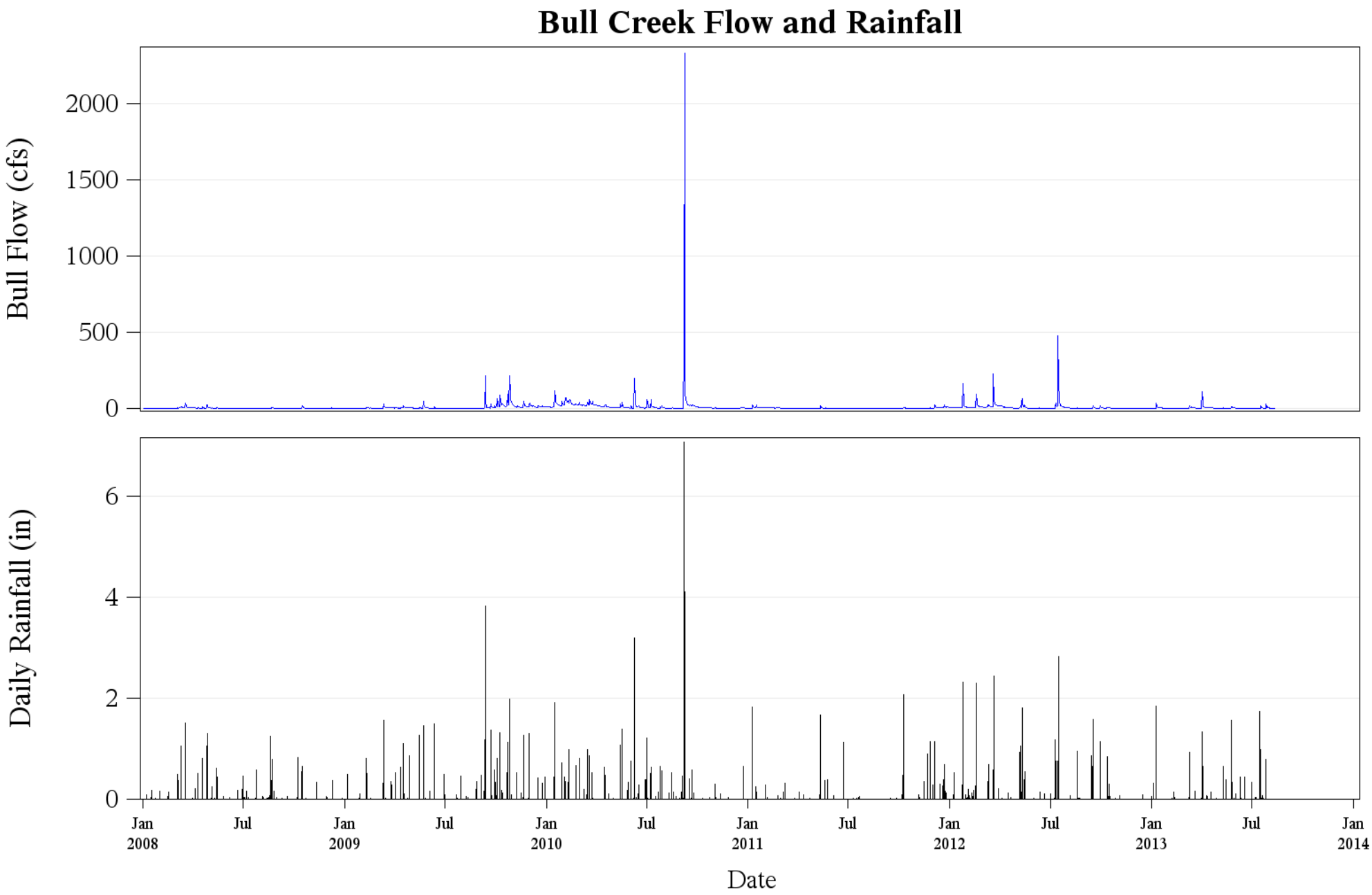
SPICEWOOD SHAFT

Shaft Construction Progress				CONSTRUCTION: Excavation										CONSTRUCTION: Pipe Installation, Grouting										POST-CONSTRUCTION							
				2012						2013										2014											
				August	Sept	Oct	Nov	Nov-Dec	Dec	Jan	Jan	Feb	Mar-Apri	May-June	July	July-Aug	Aug	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
				excavation										pipe installation and grouting								surface restoration			operational						
Spicewood	T4DS Trib 4 downstream from	manual	gauge		10/1 activ	10/4 9 feet	61 feet 11/30			112 feet 1/14					*monthly				*monthly											
Spicewood	T4DS Trib 4 downstream from	wq samplin								115 feet 1/28			COMPLETE on 4/1													none				
Spicewood	T4AR Trib 4 above Spicewood	manual level		monthly		weekly																									
Spicewood	T4AR Trib 4 above Spicewood	wq samplin																													
Spicewood	JT-120	cont	LevelTROLL																		*monthly					*monthly				
Spicewood	JT-130	cont	LevelTROLL																							*monthly				

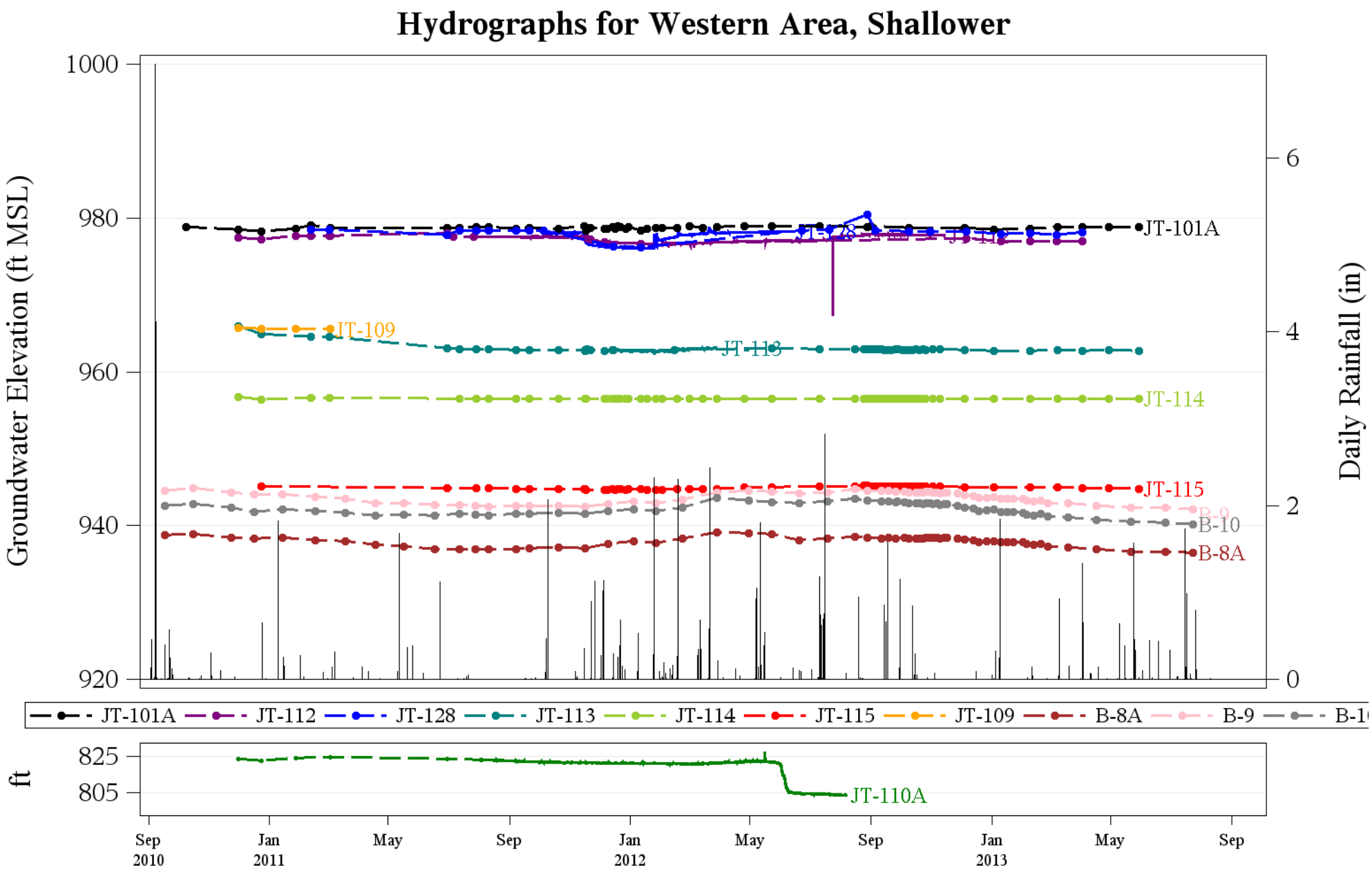
Cross Section through Eastern Lake Travis, Well B-5 and the Jollyville Transmission Main Route
Showing Groundwater, Bull Creek, Spring, and Lake Travis Elevations

05/02/2013



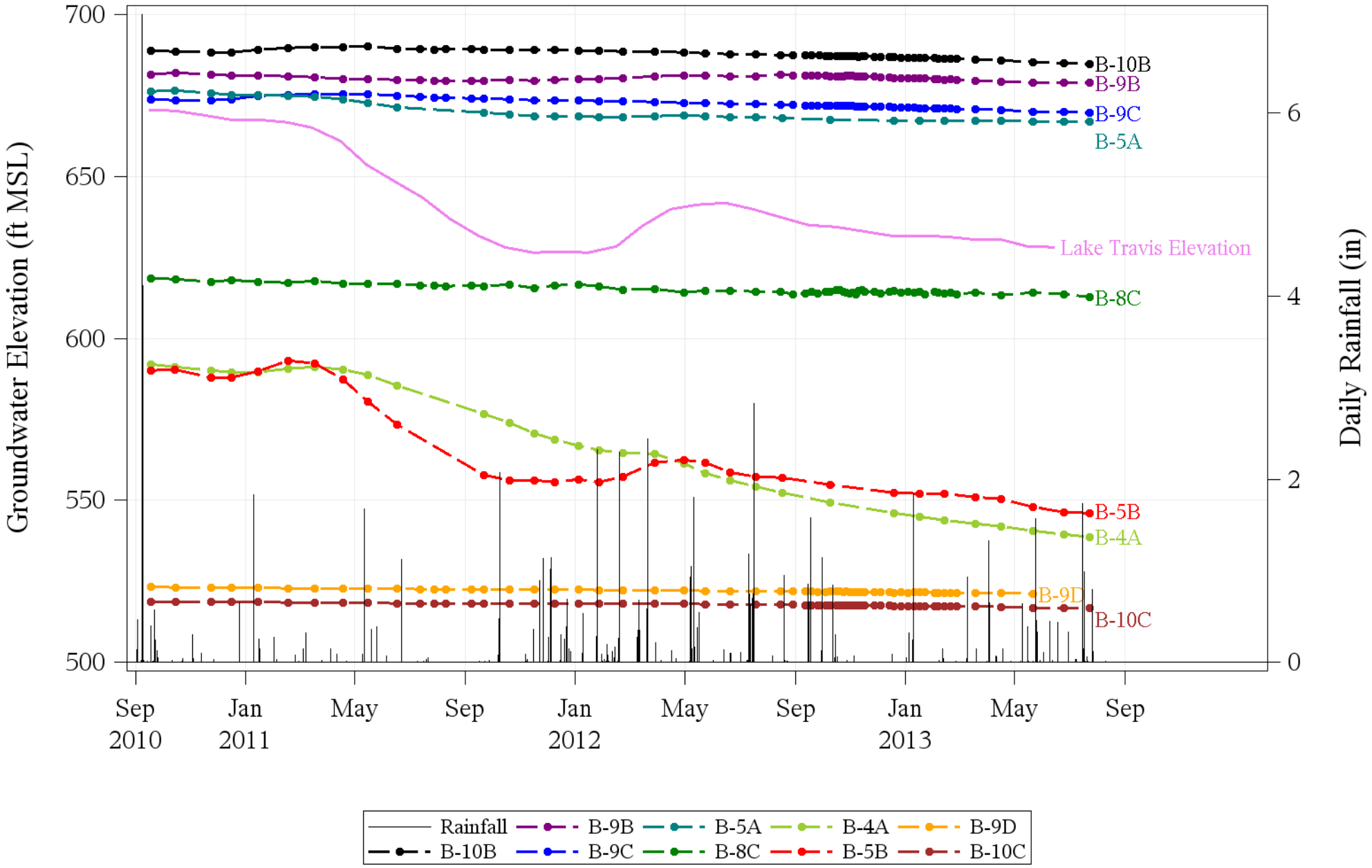


City of Austin DRAFT: QA/QC review pending



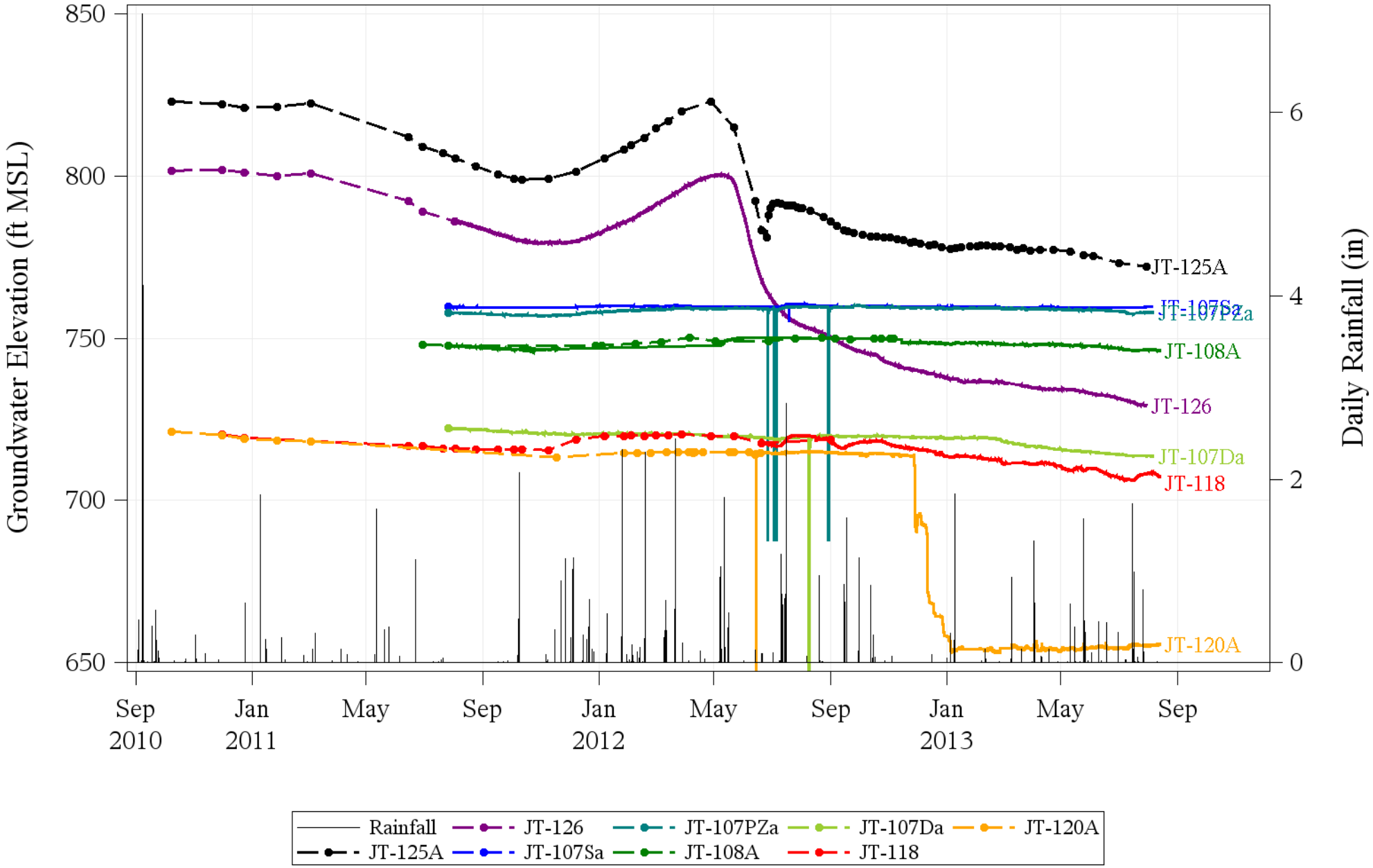
City of Austin DRAFT: QA/QC review pending

Hydrographs for Western Area, Deep



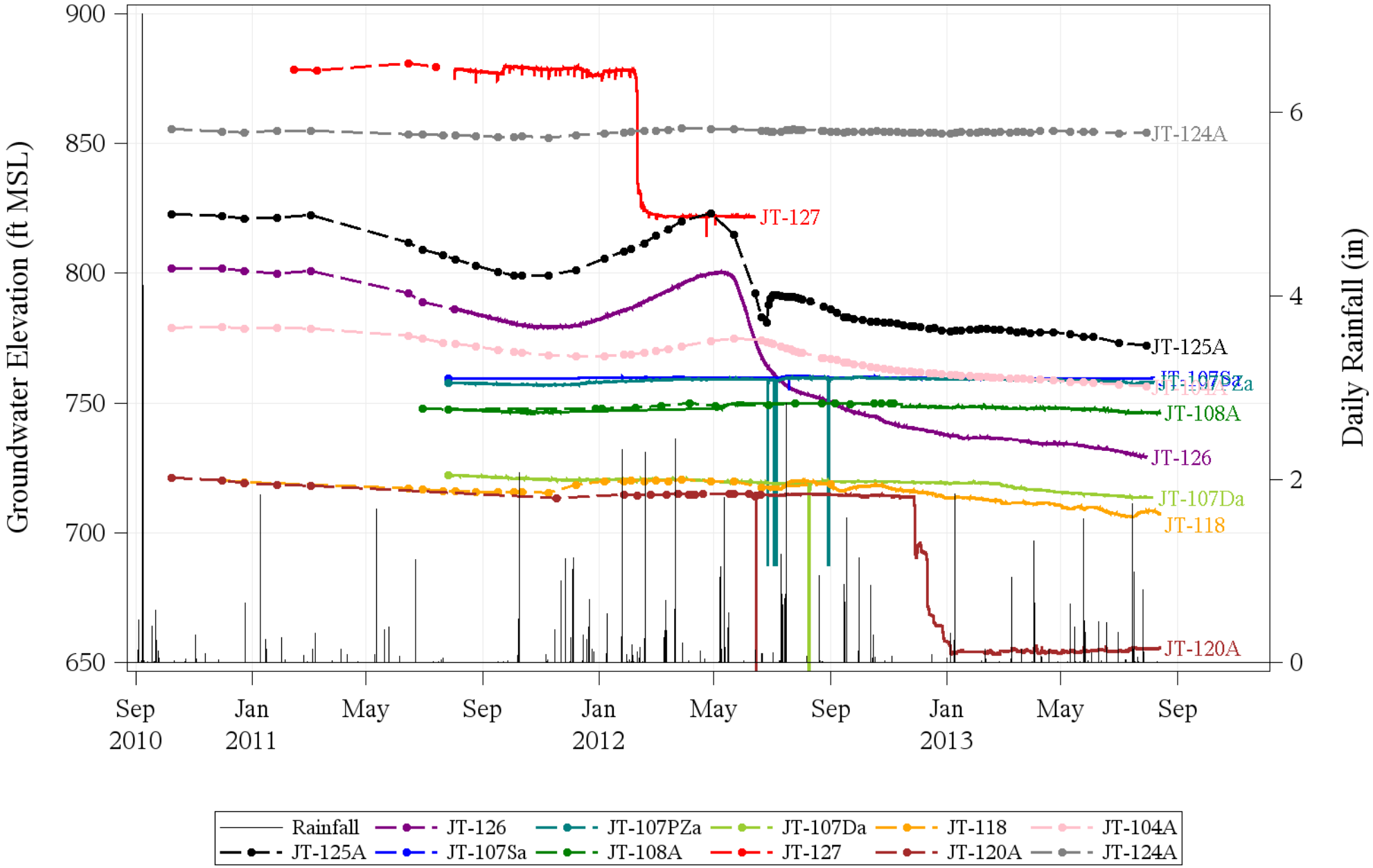
City of Austin DRAFT: QA/QC review pending

Monitoring Wells in Glen Rose in Eastern JVTM Region

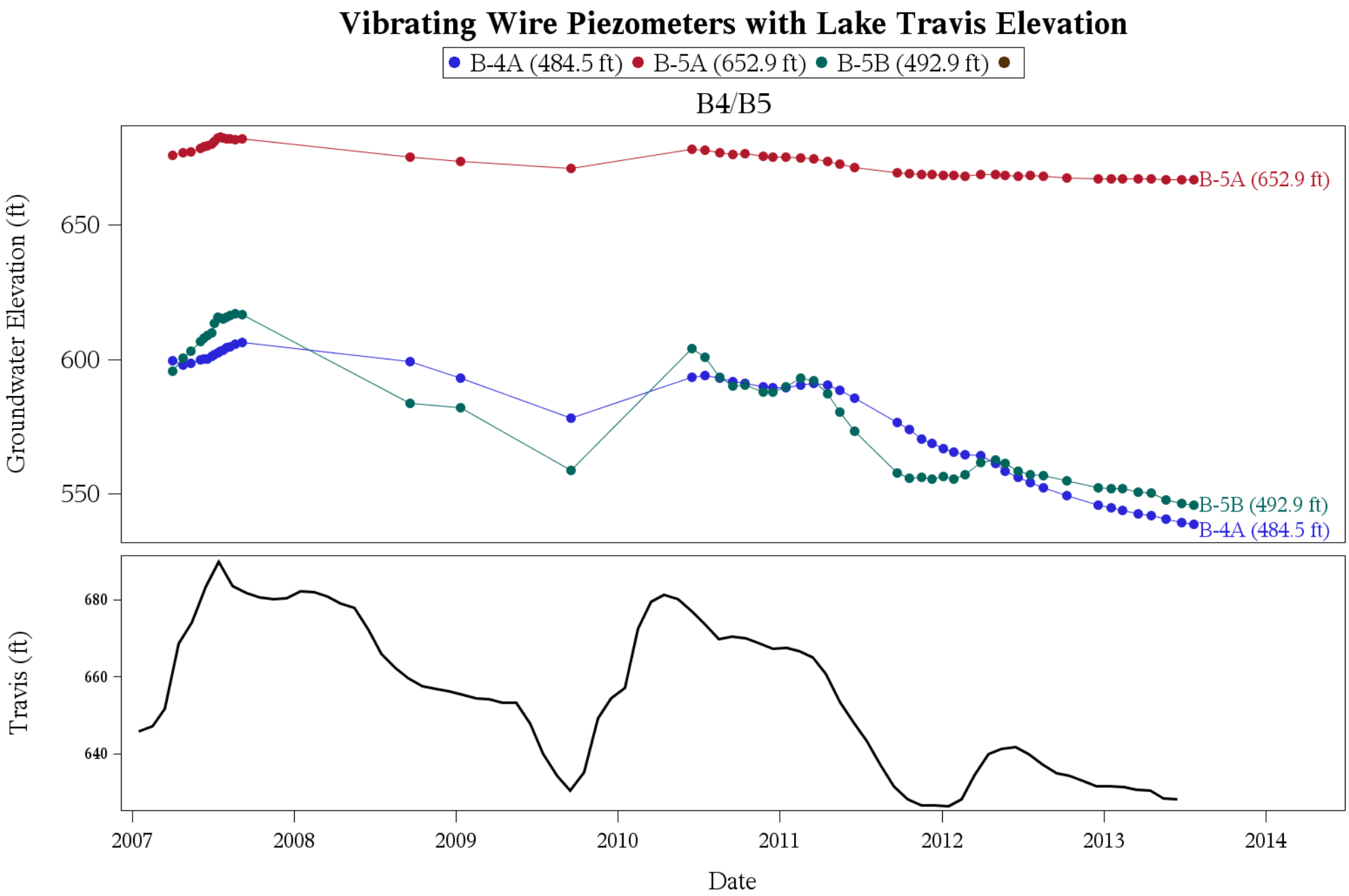


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Hydrographs for Eastern Area

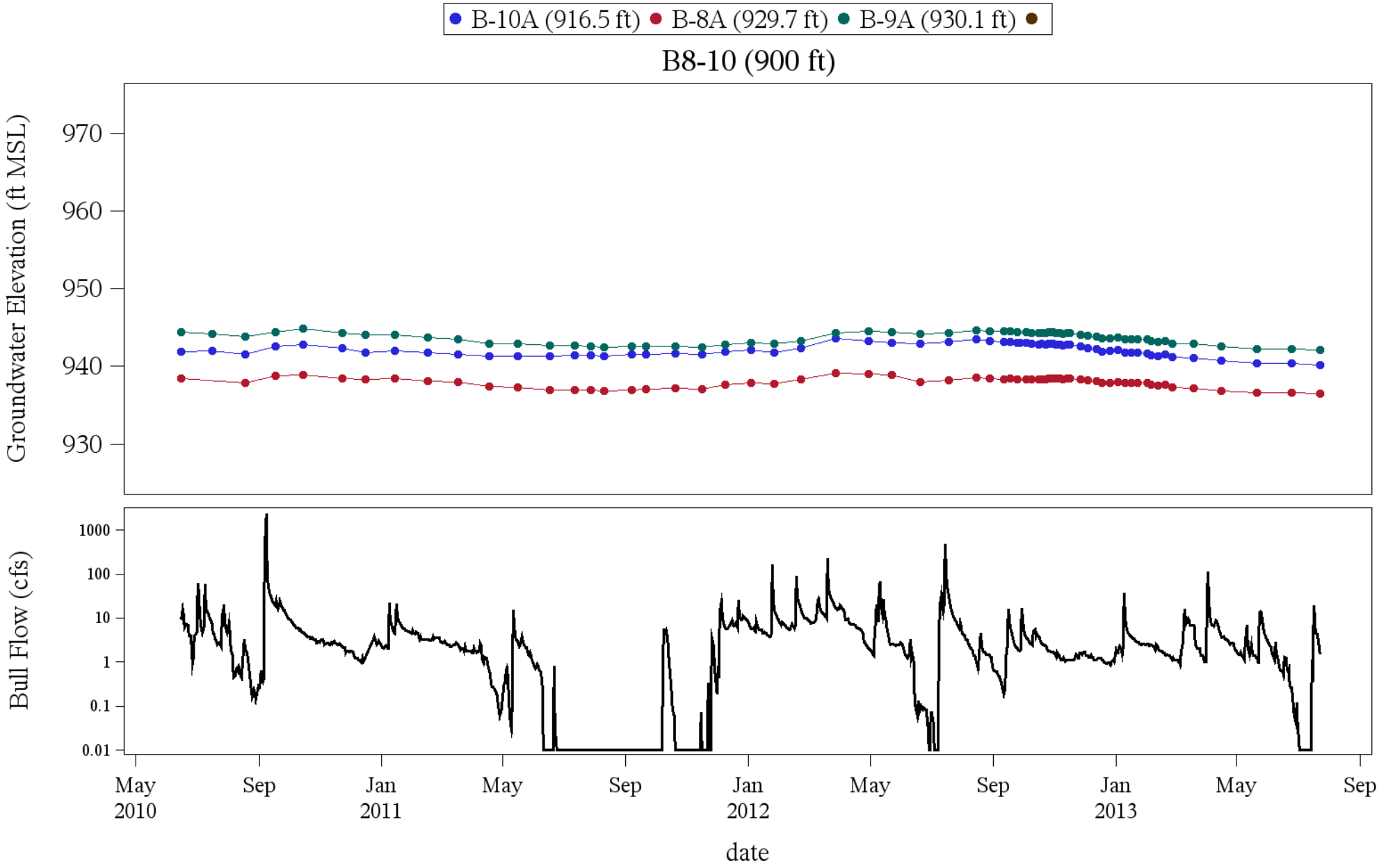


City of Austin DRAFT: QA/QC review pending

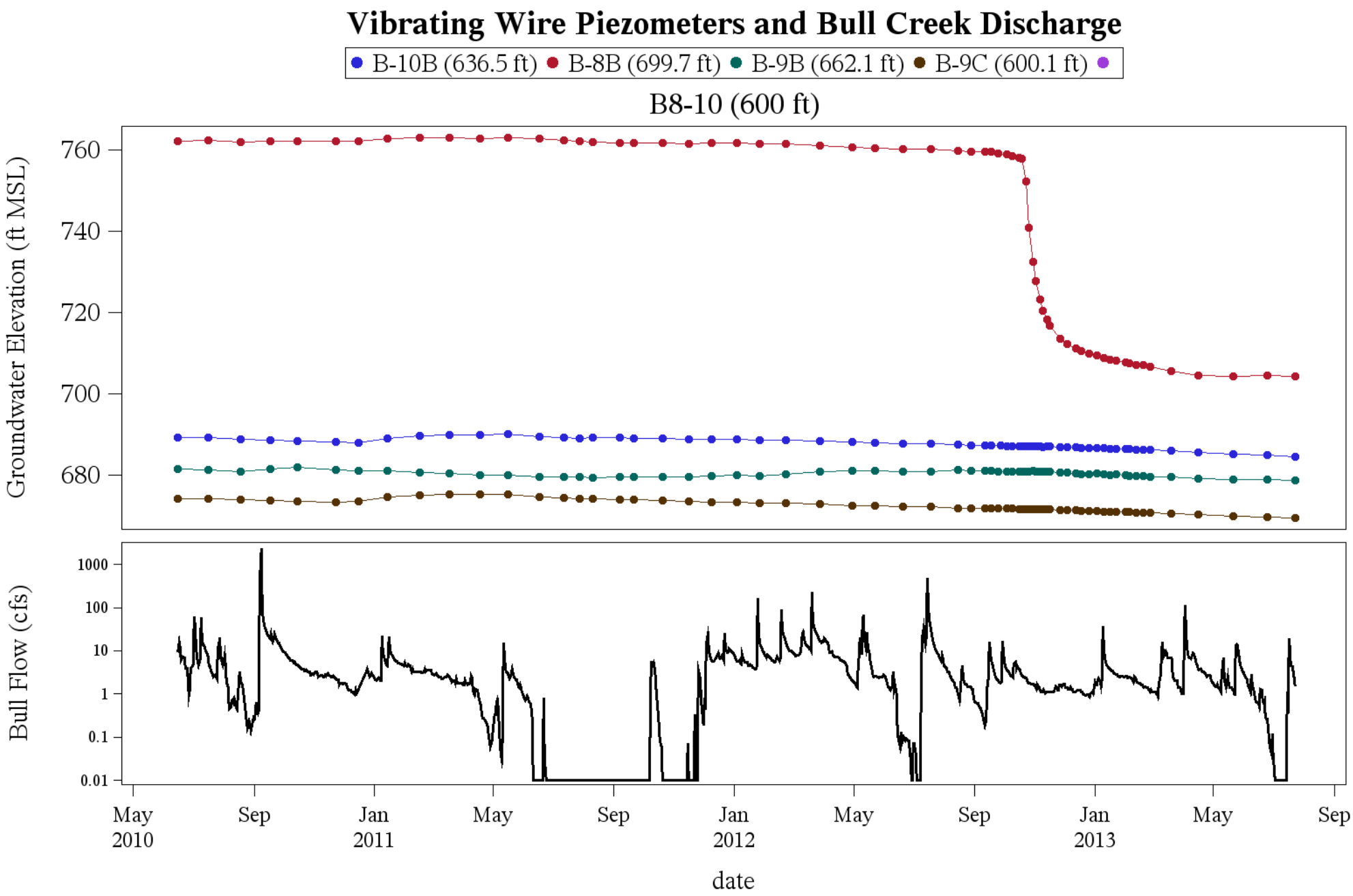


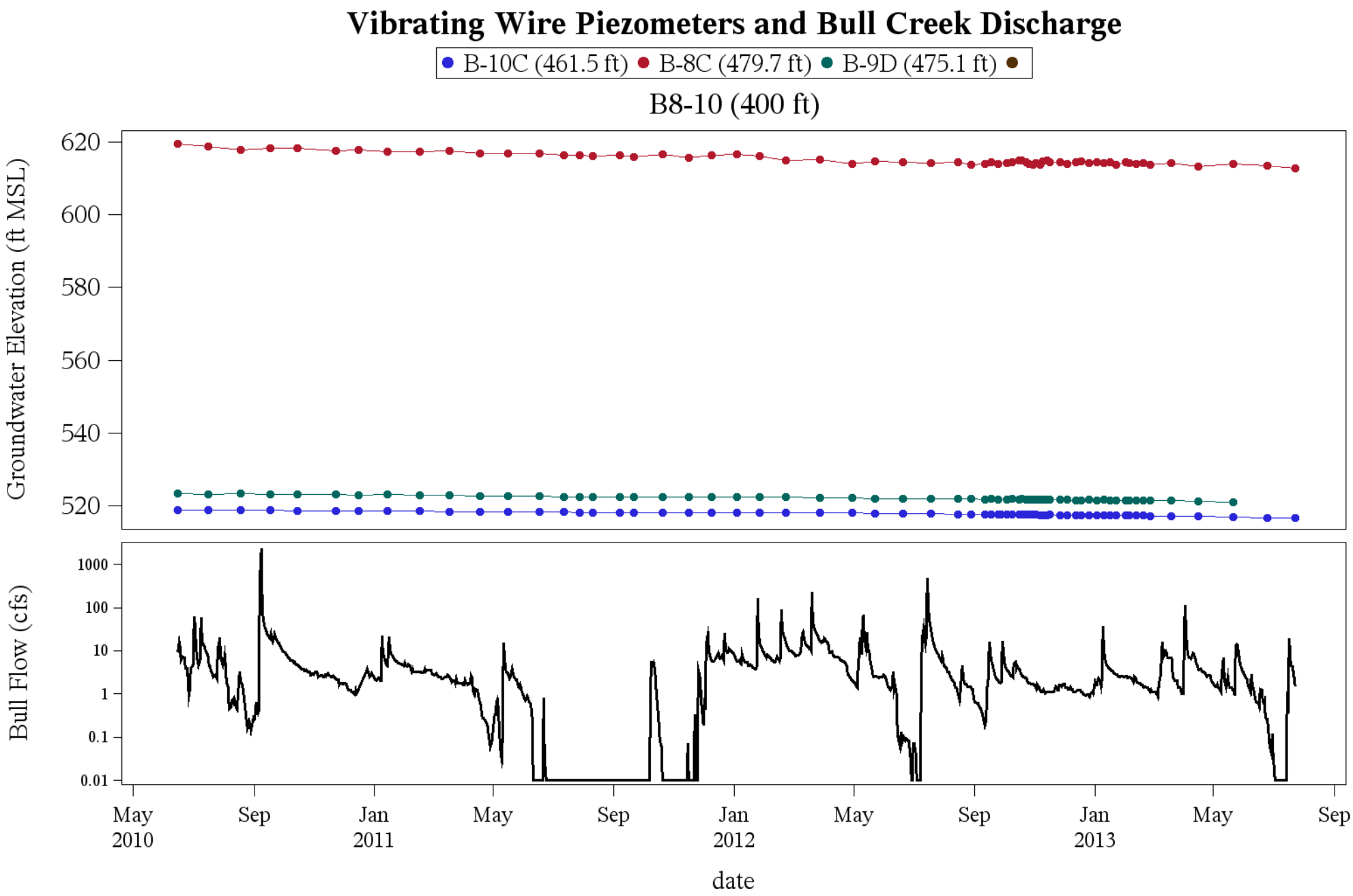
City of Austin DRAFT: QA/QC review pending

Vibrating Wire Piezometers and Bull Creek Discharge

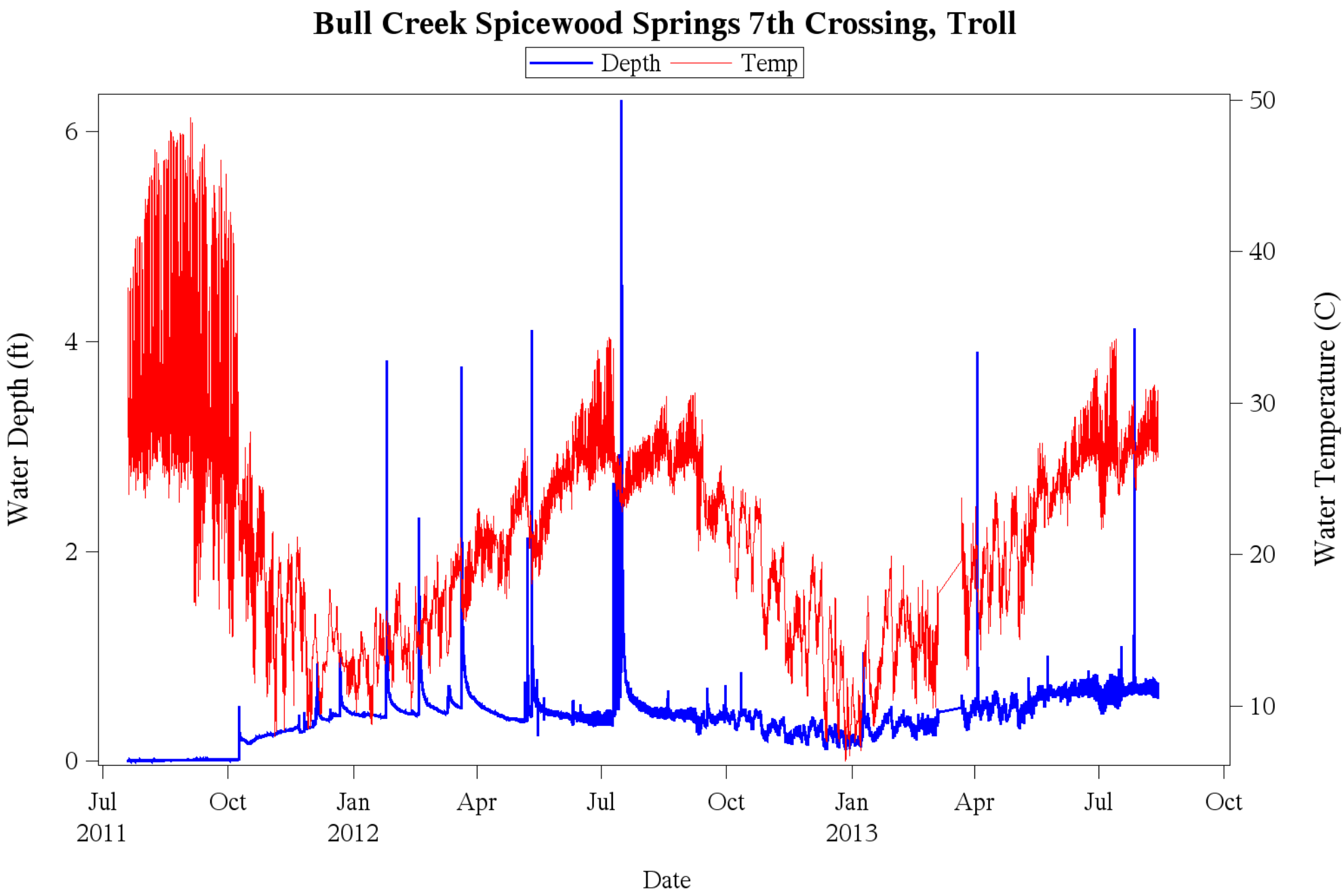


City of Austin DRAFT: QA/QC review pending

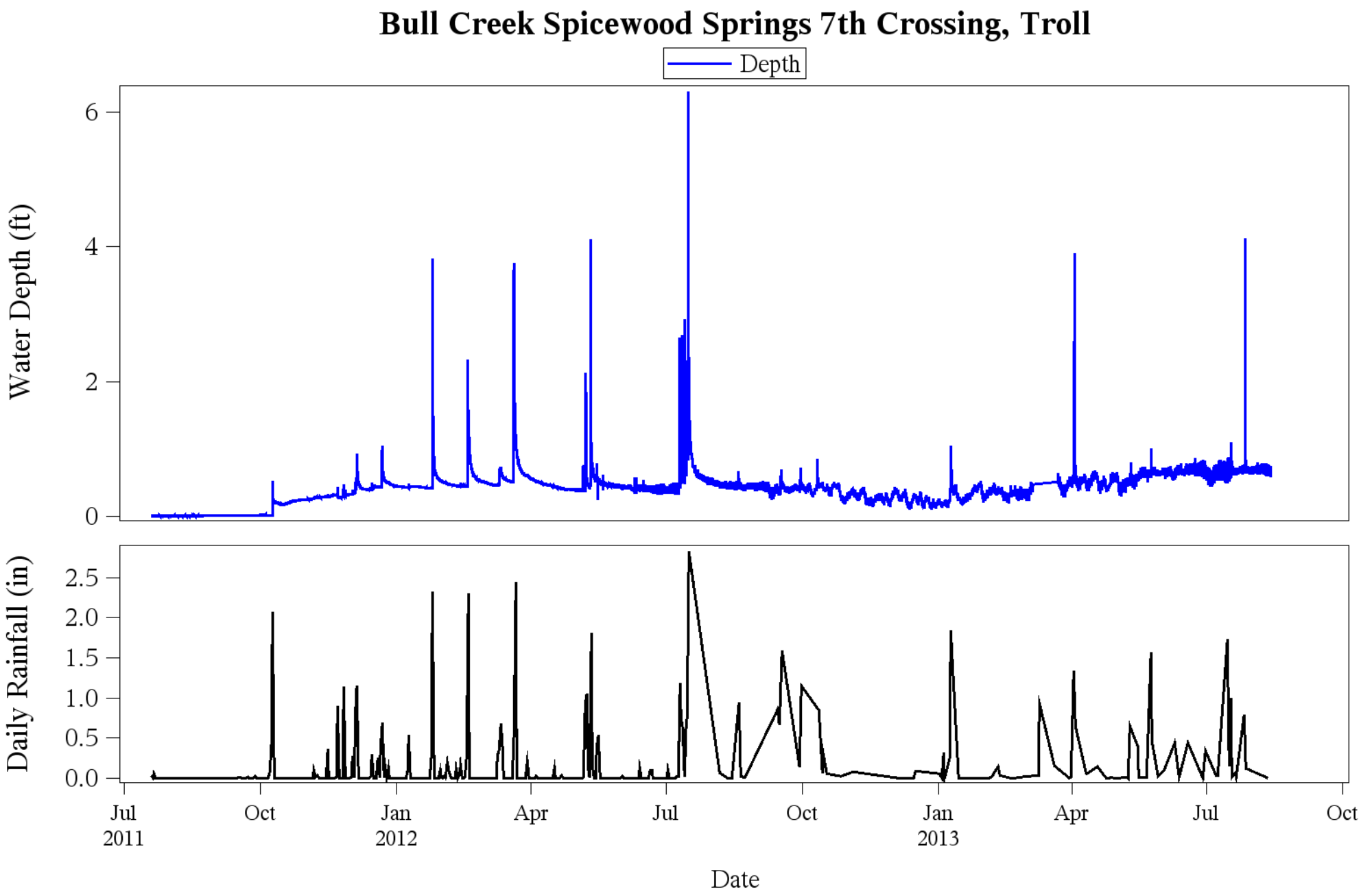

Vibrating Wire Piezometers and Bull Creek Discharge
B-10B (636.5 ft)
B-8B (699.7 ft)
B-9B (662.1 ft)
B-9C (600.1 ft)
B8-10 (600 ft)
Groundwater Elevation (ft MSL)
760
740
720
700
680
Bull Flow (cfs)
1000
100
10
1
0.1
0.01
May 2010
Sep
Jan 2011
May
Sep
Jan 2012
May
Sep
Jan 2013
May
Sep
date



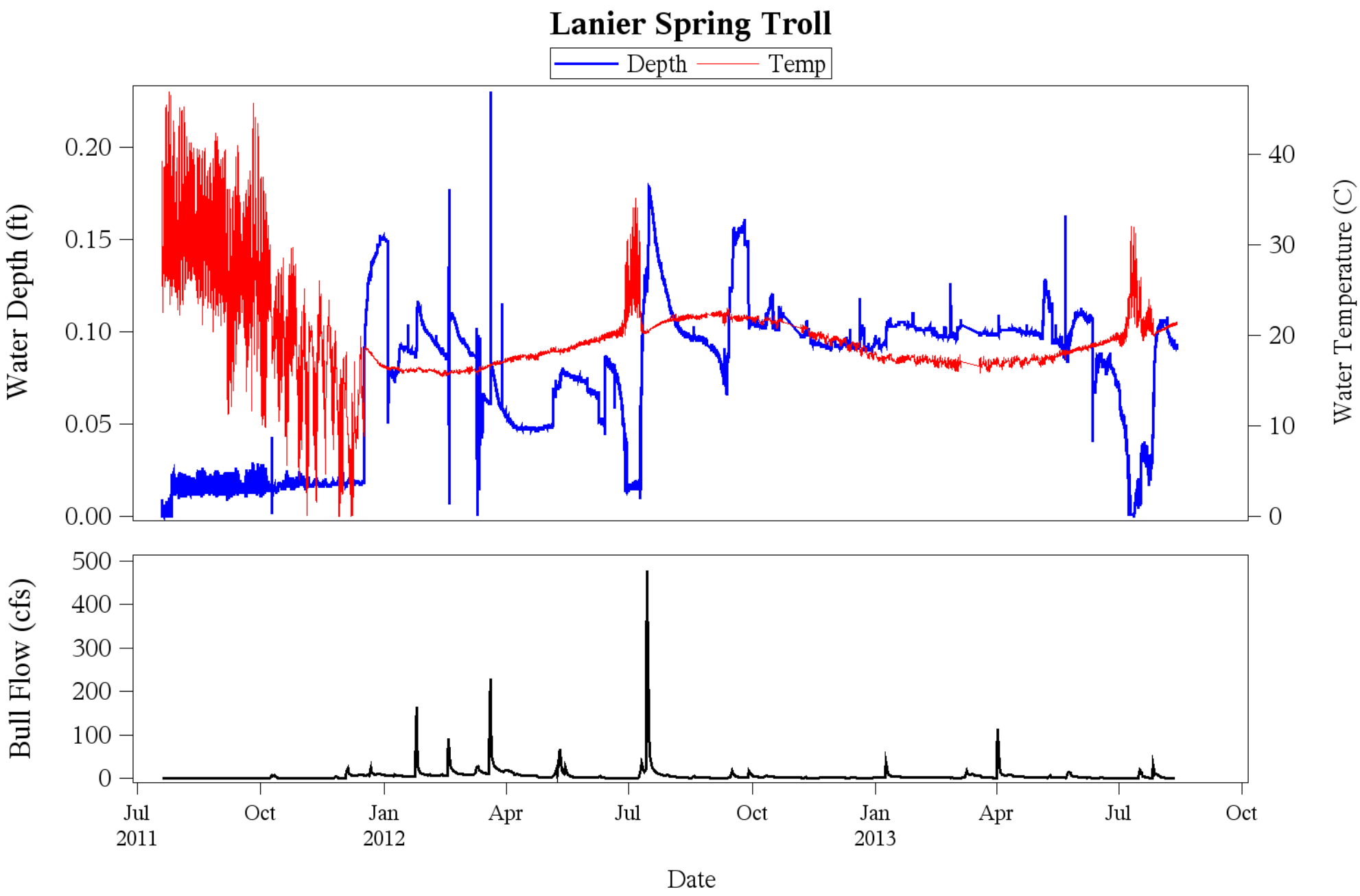
City of Austin DRAFT: QA/QC review pending



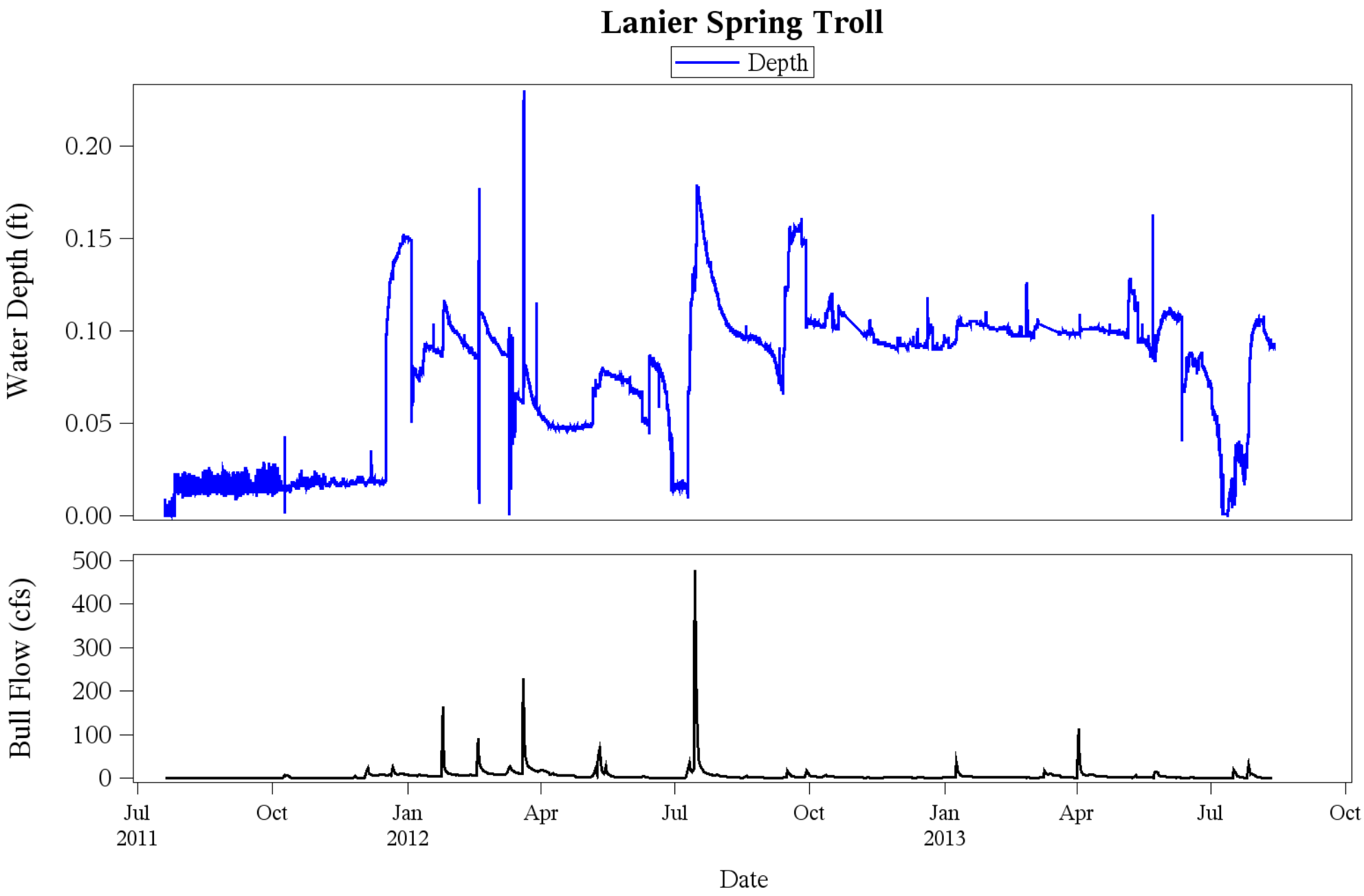
City of Austin DRAFT: QA/QC review pending



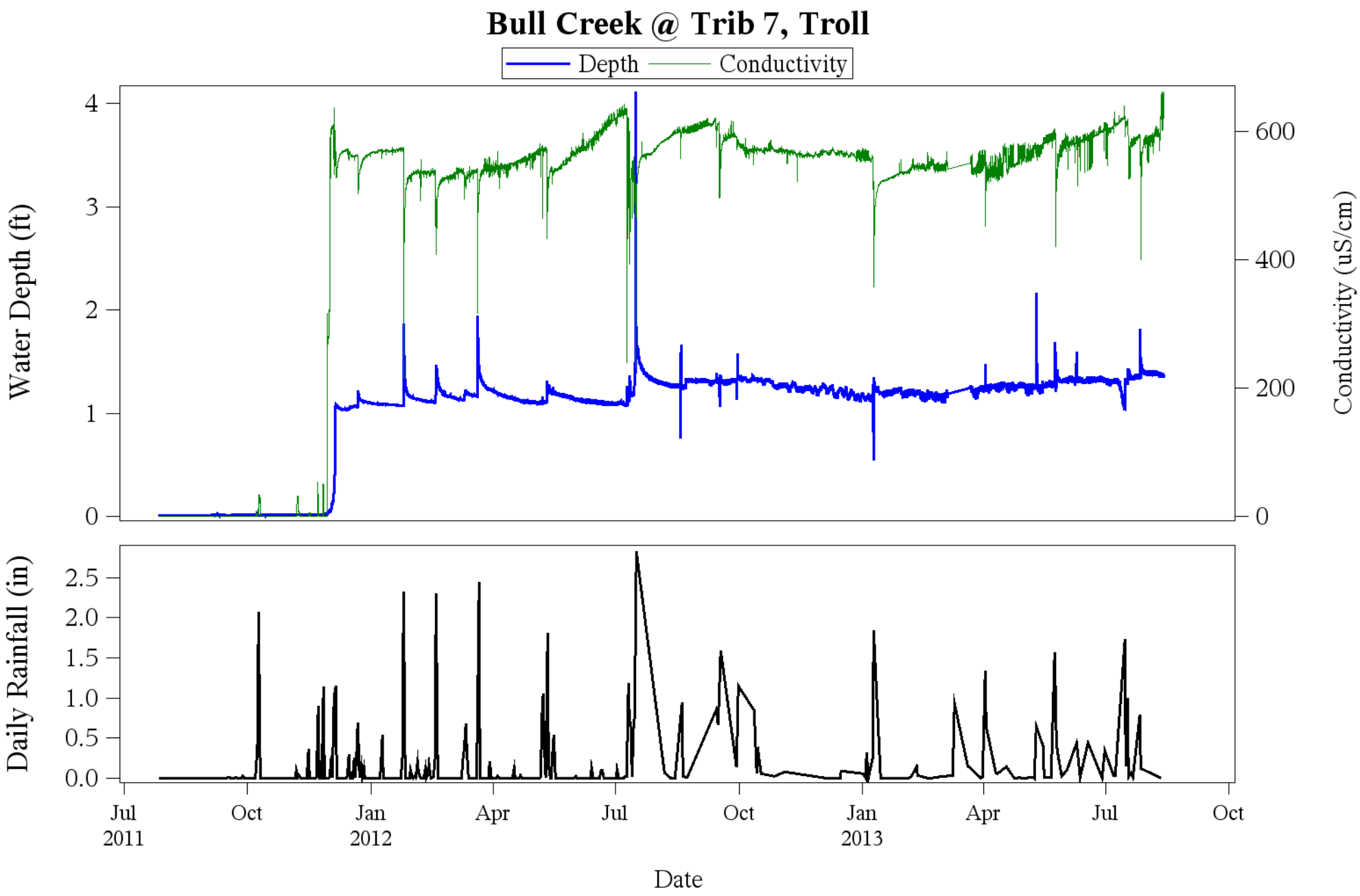
City of Austin DRAFT: QA/QC review pending

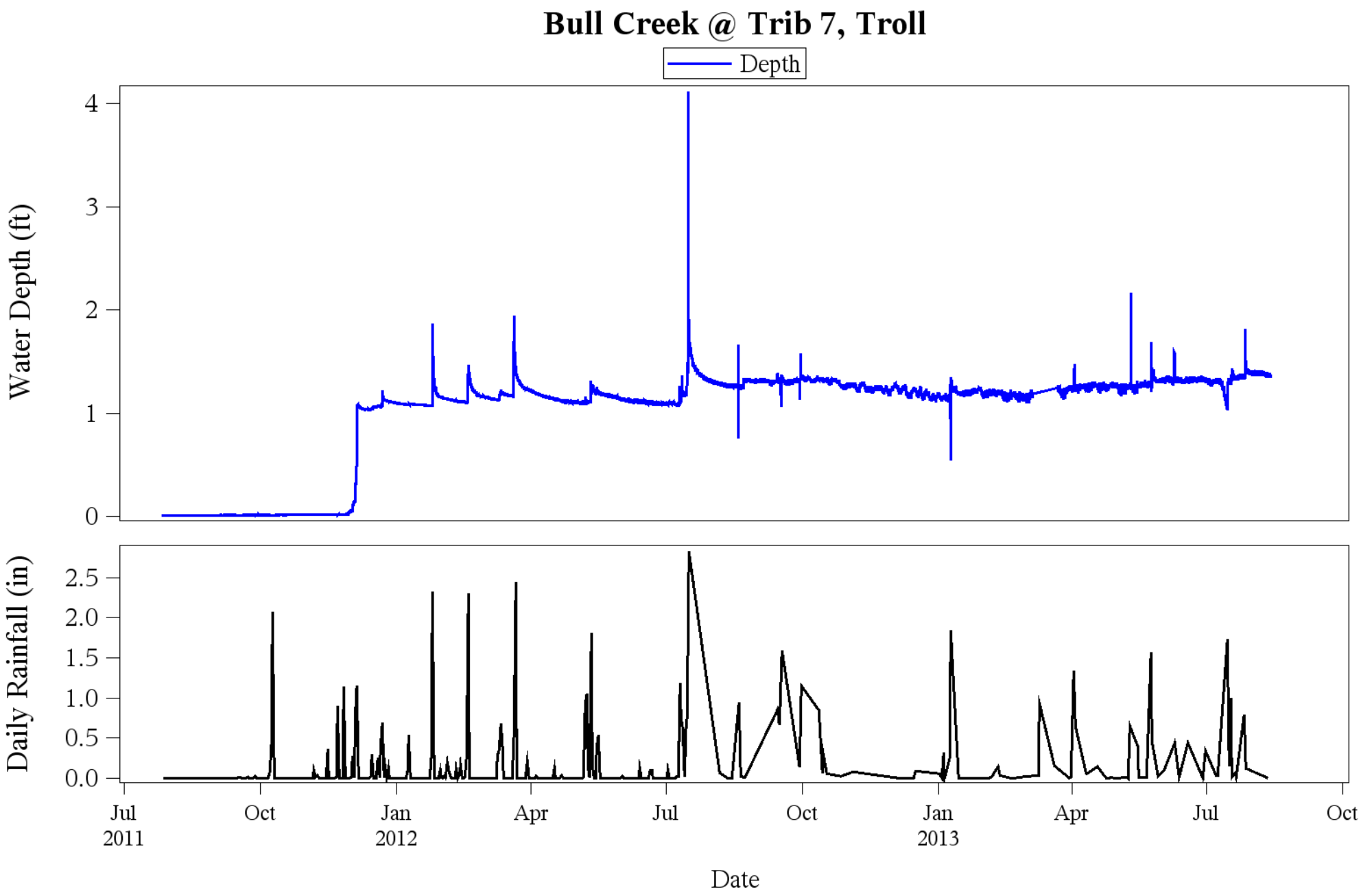


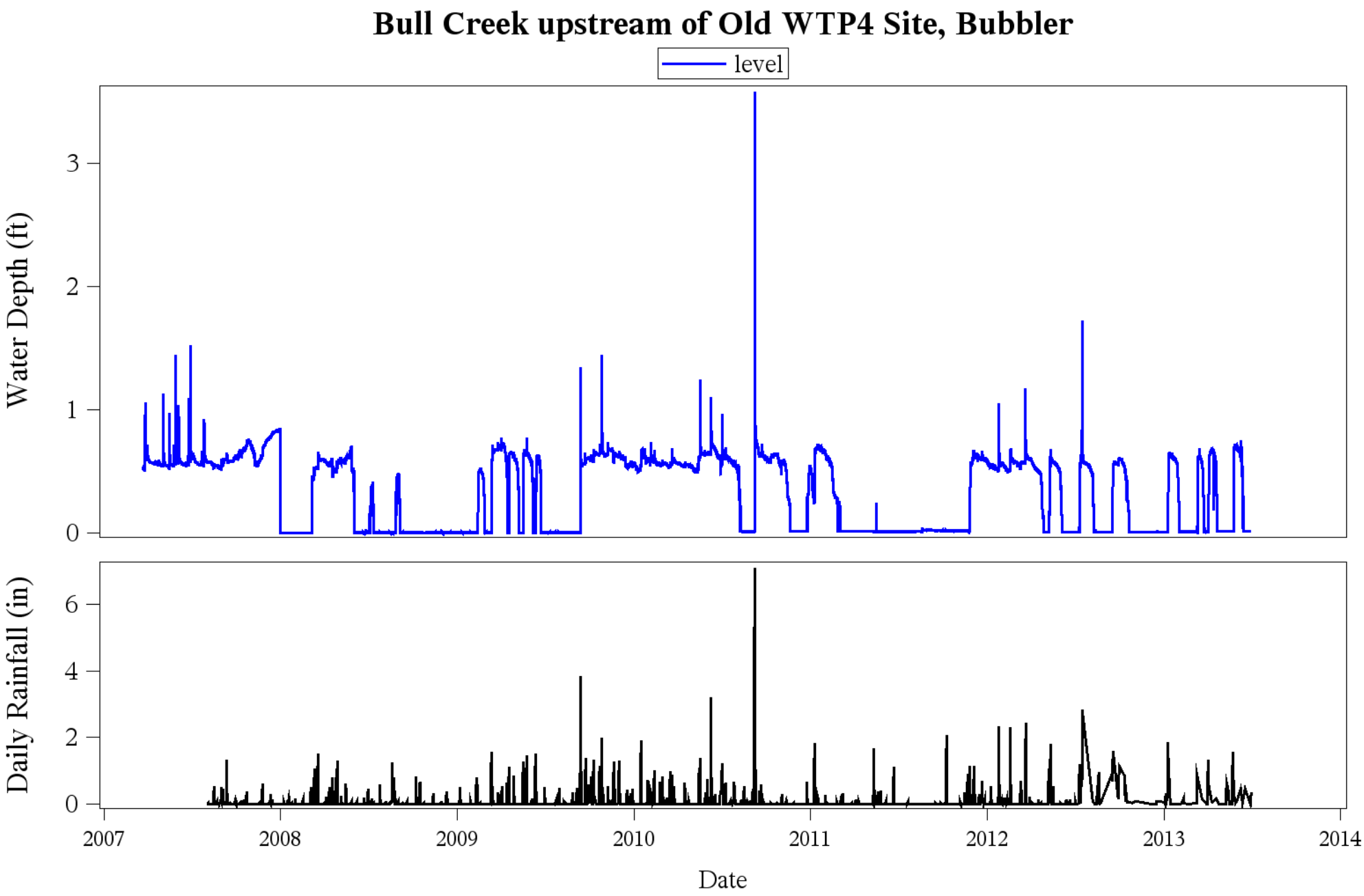
City of Austin DRAFT: QA/QC review pending

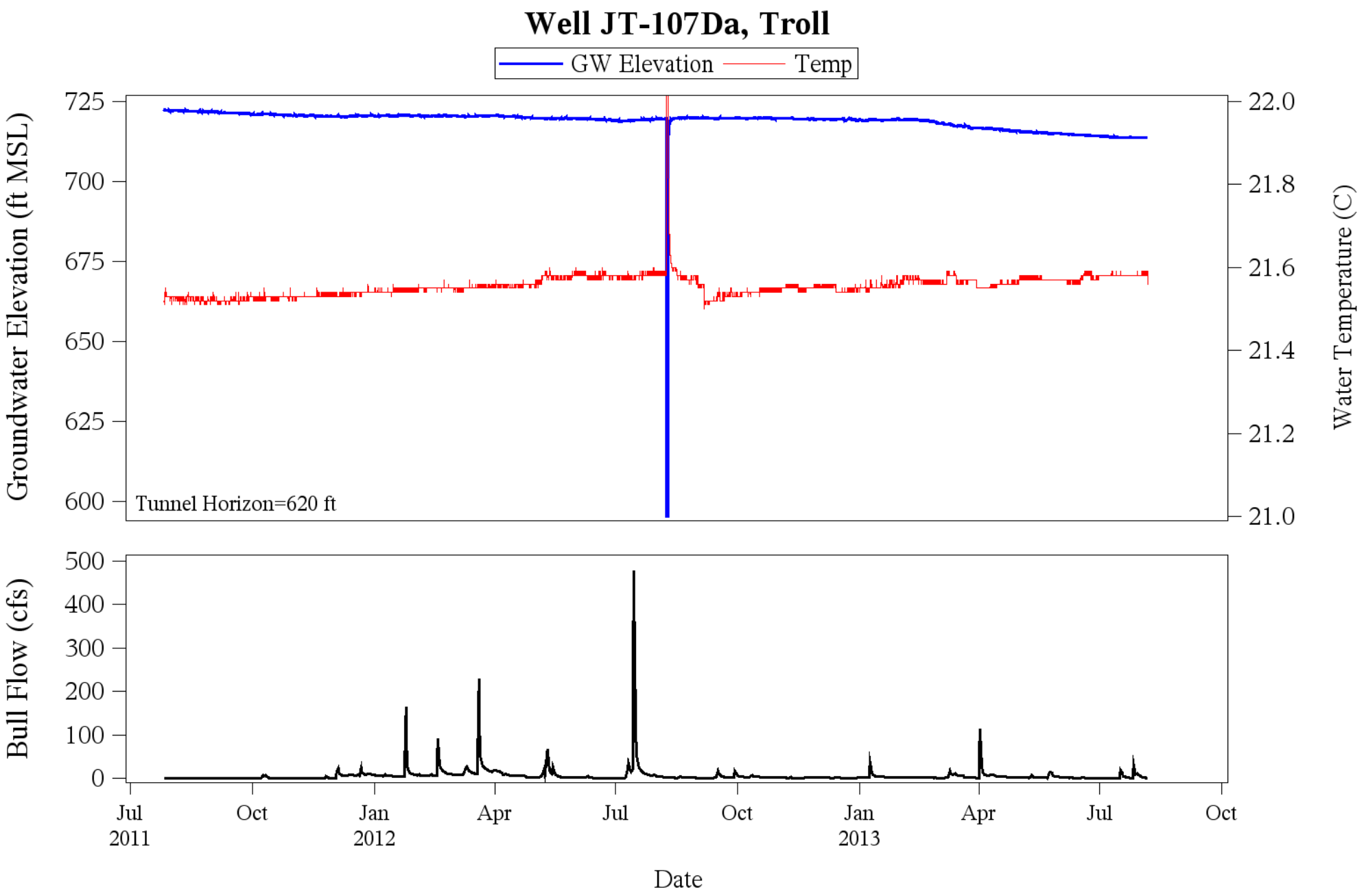


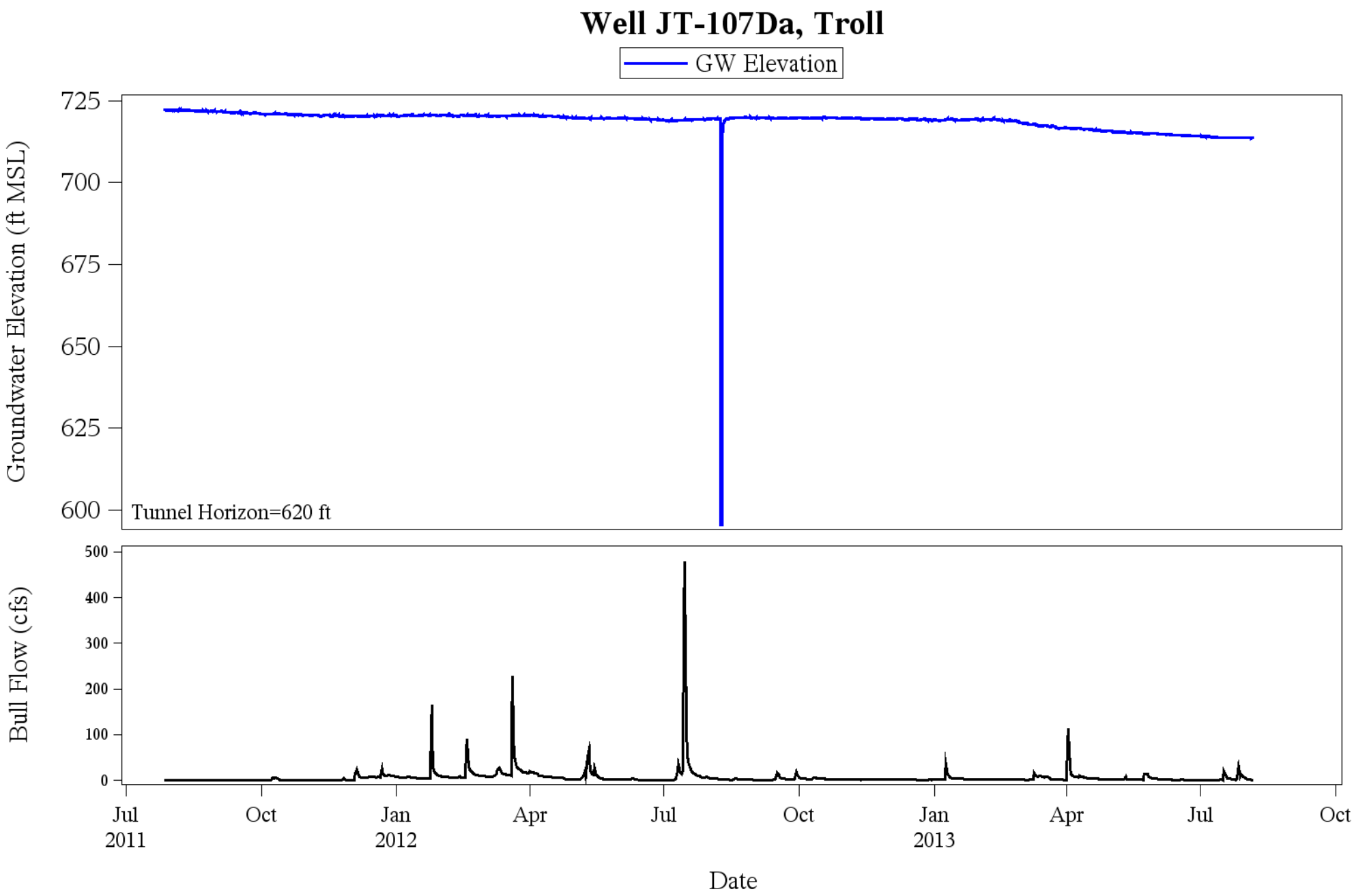
City of Austin DRAFT: QA/QC review pending

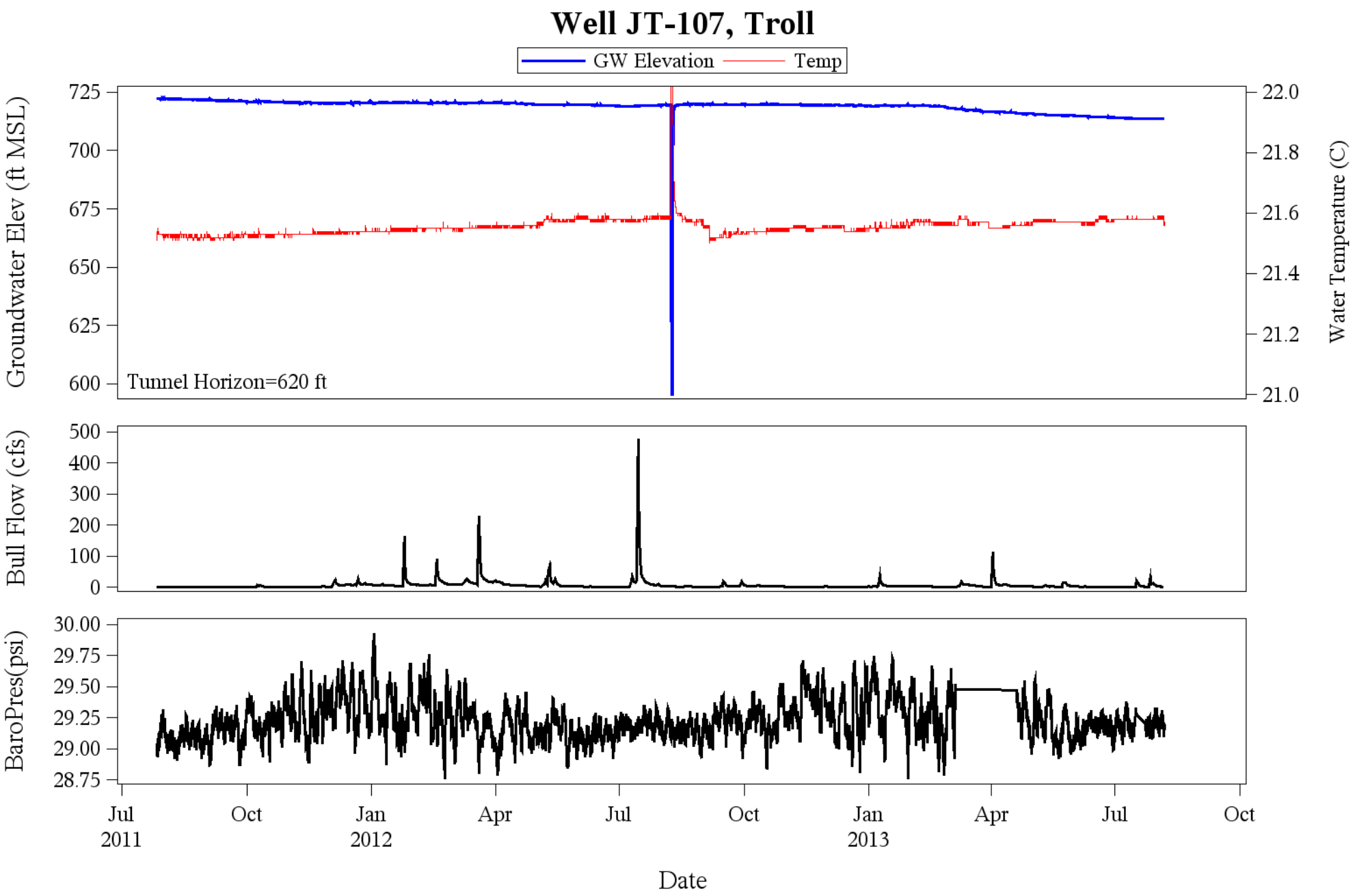

Bull Creek @ Trib 7, Troll
Depth
Conductivity
Water Depth (ft)
Conductivity (uS/cm)
Daily Rainfall (in)
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date


Bull Creek @ Trib 7, Troll
Depth
Water Depth (ft)
0
1
2
3
4
Daily Rainfall (in)
0.0
0.5
1.0
1.5
2.0
2.5
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

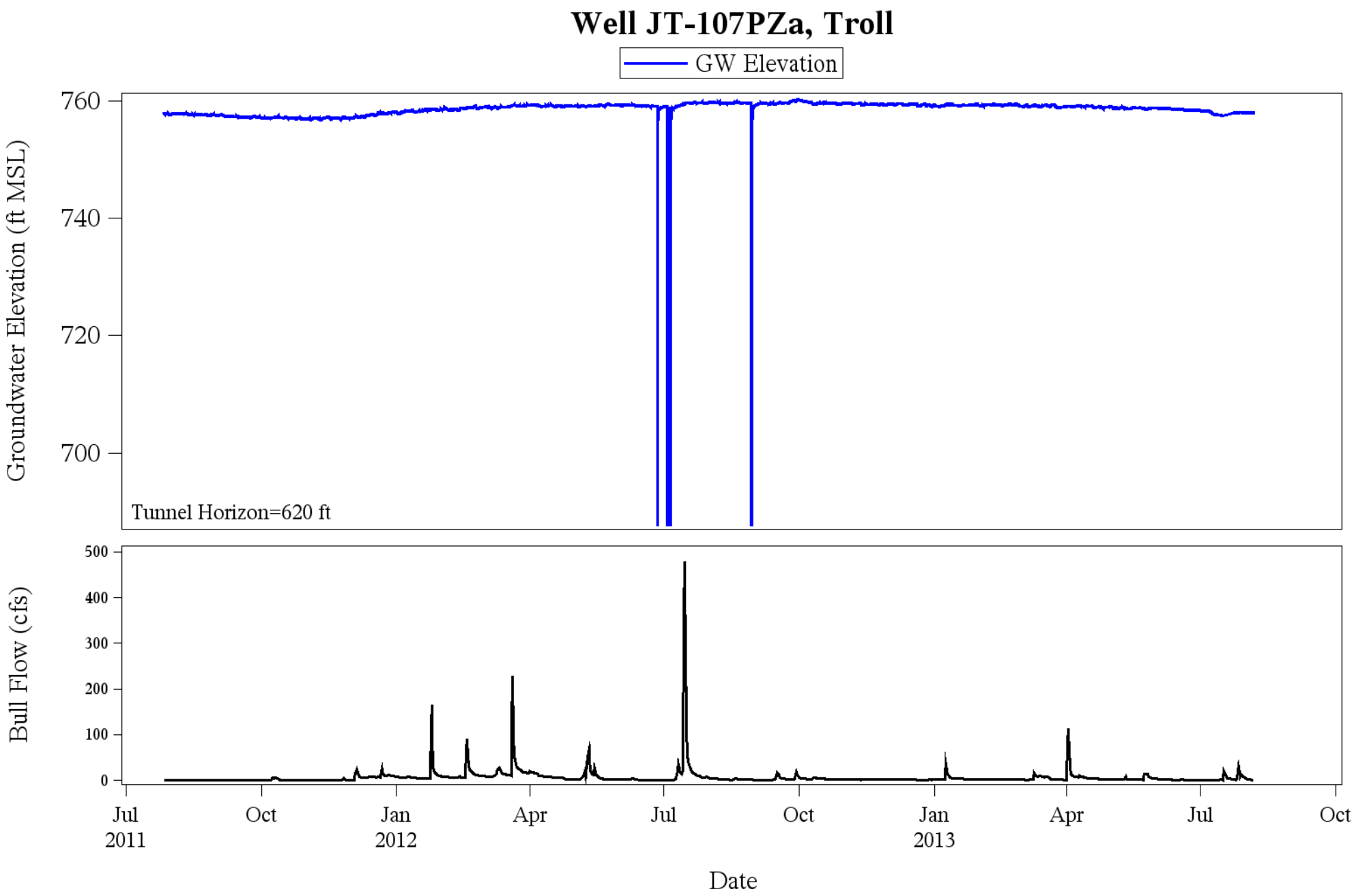

Bull Creek upstream of Old WTP4 Site, Bubbler
level
Water Depth (ft)
0
1
2
3
Daily Rainfall (in)
0
2
4
6
2007
2008
2009
2010
2011
2012
2013
2014
Date


Well JT-107Da, Troll
GW Elevation
Temp
Groundwater Elevation (ft MSL)
725
700
675
650
625
600
Tunnel Horizon=620 ft
22.0
21.8
21.6
21.4
21.2
21.0
Water Temperature (C)
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

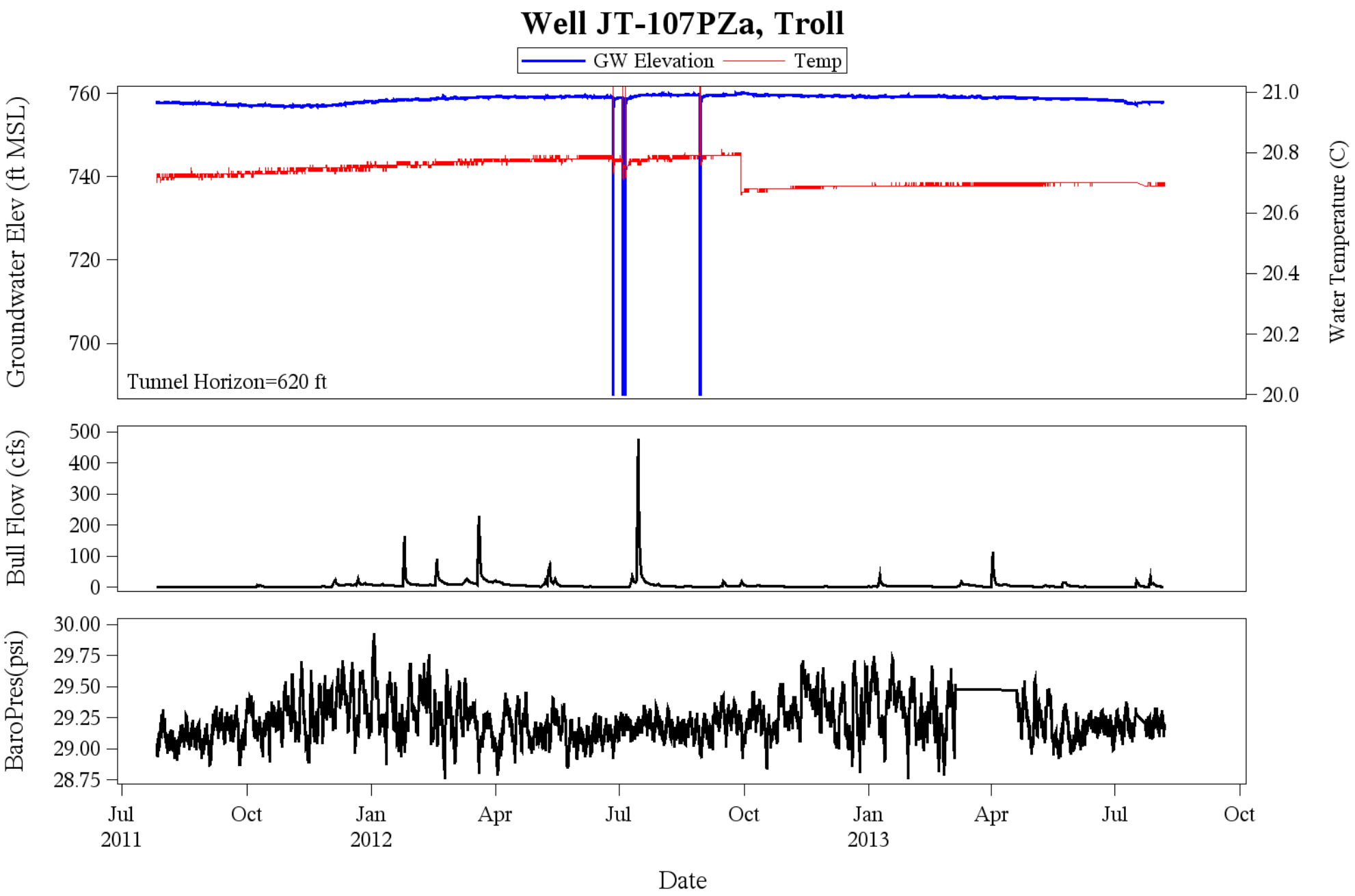

Well JT-107Da, Troll
GW Elevation
Groundwater Elevation (ft MSL)
725
700
675
650
625
600
Tunnel Horizon=620 ft
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

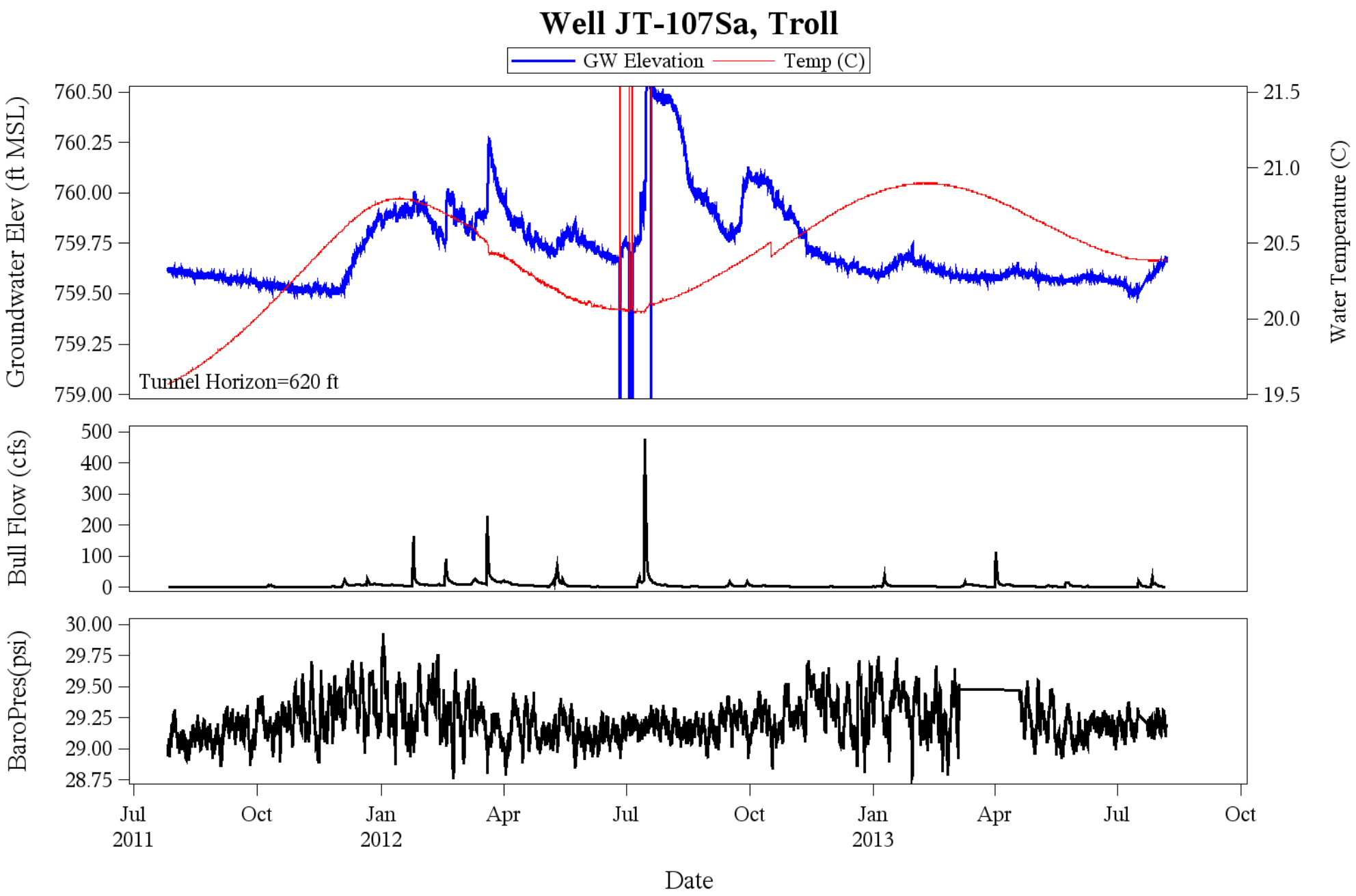


City of Austin DRAFT: QA/QC review pending

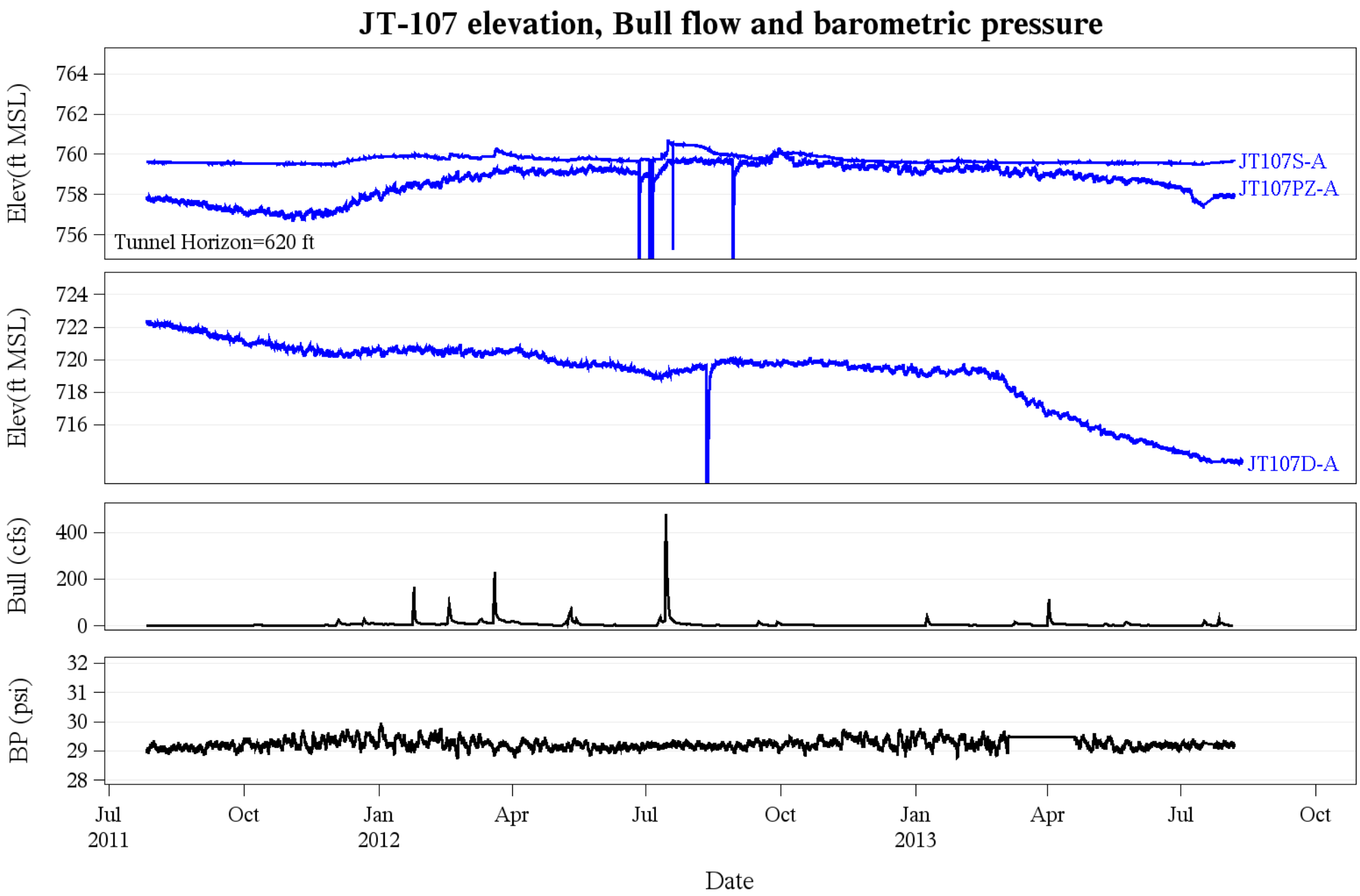


City of Austin DRAFT: QA/QC review pending


Well JT-107PZa, Troll
GW Elevation
Temp
Groundwater Elev (ft MSL)
760
740
720
700
Tunnel Horizon=620 ft
Water Temperature (C)
21.0
20.8
20.6
20.4
20.2
20.0
Bull Flow (cfs)
500
400
300
200
100
0
BaroPres(psi)
30.00
29.75
29.50
29.25
29.00
28.75
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

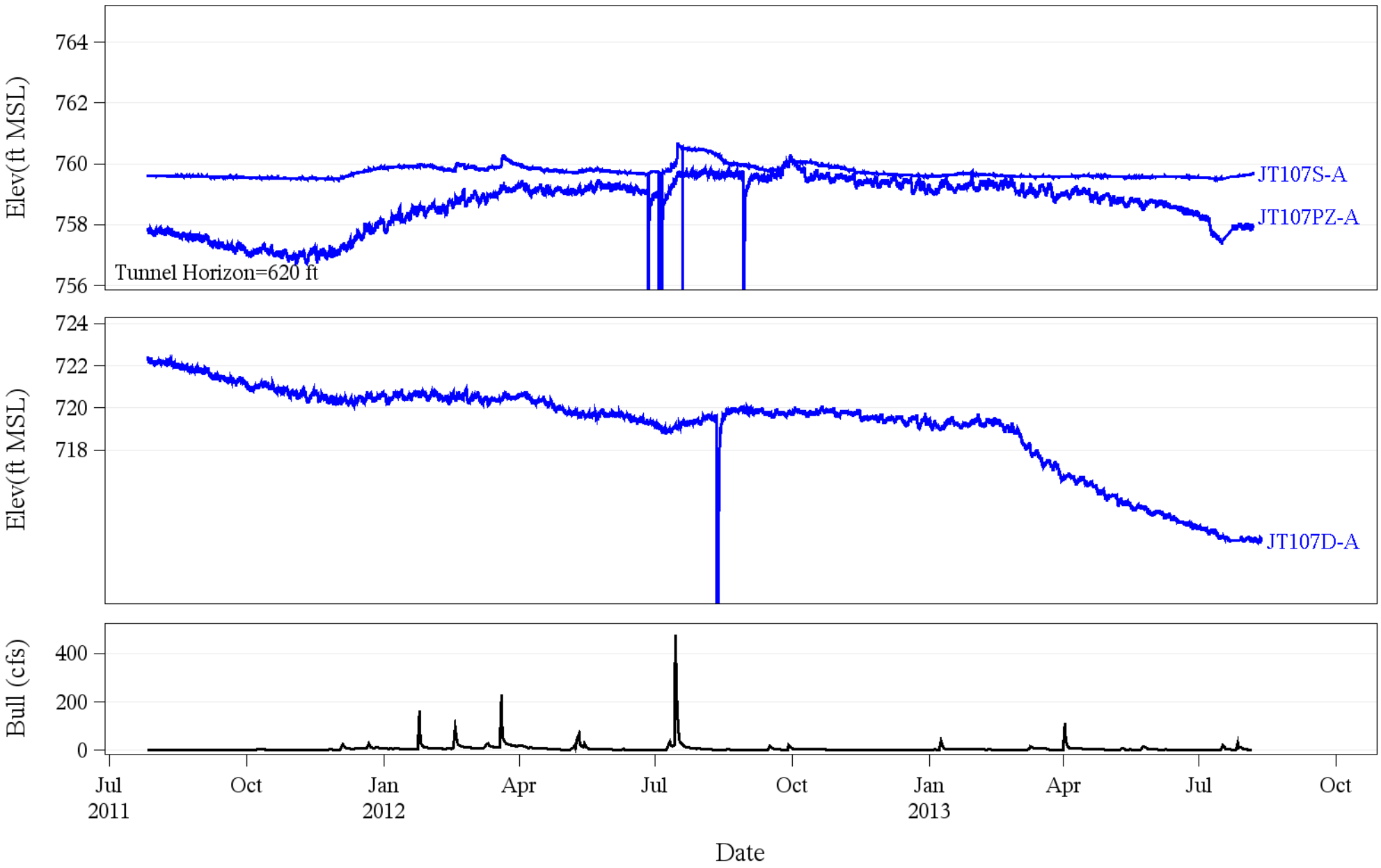


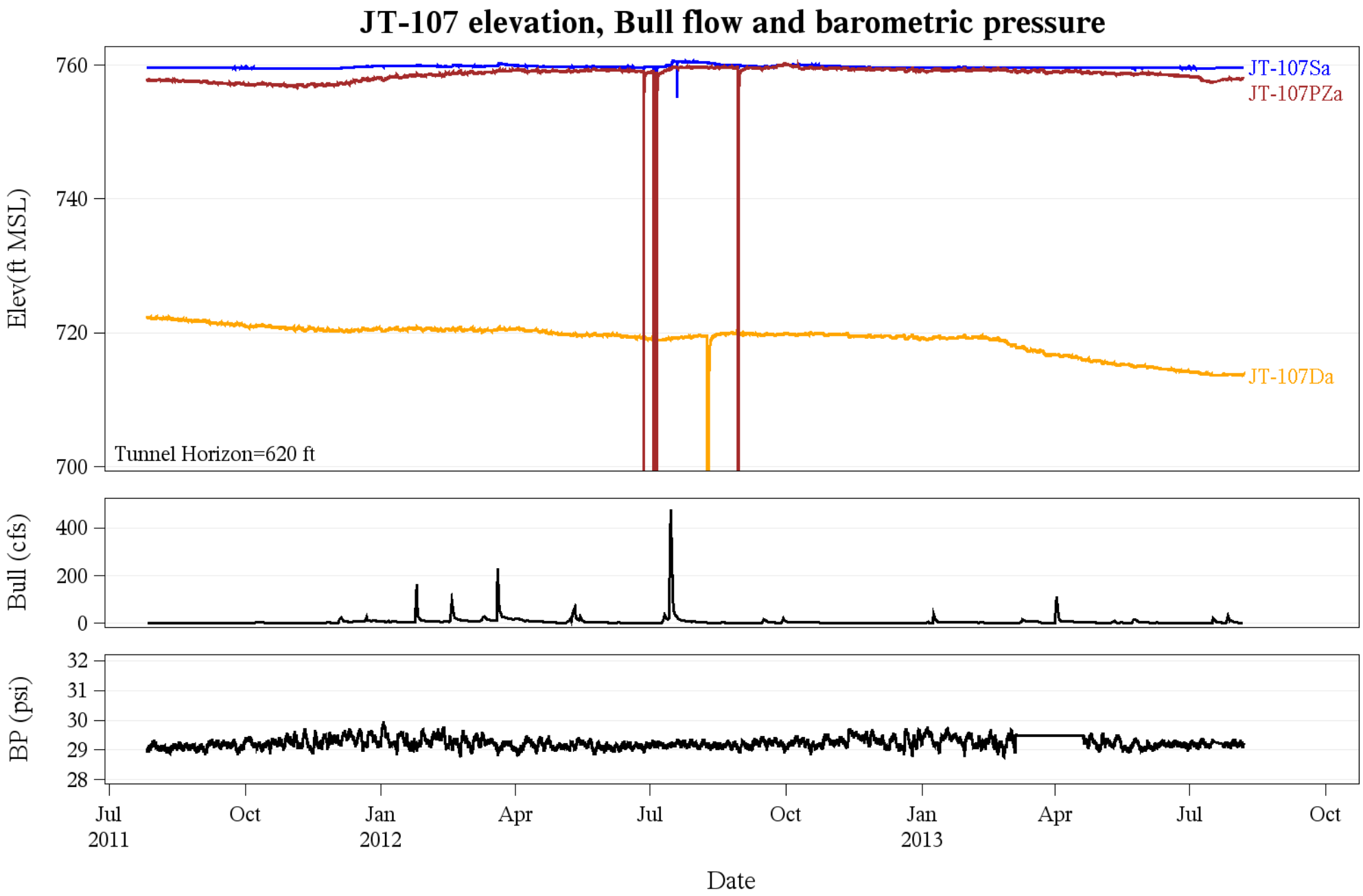
City of Austin DRAFT: QA/QC review pending



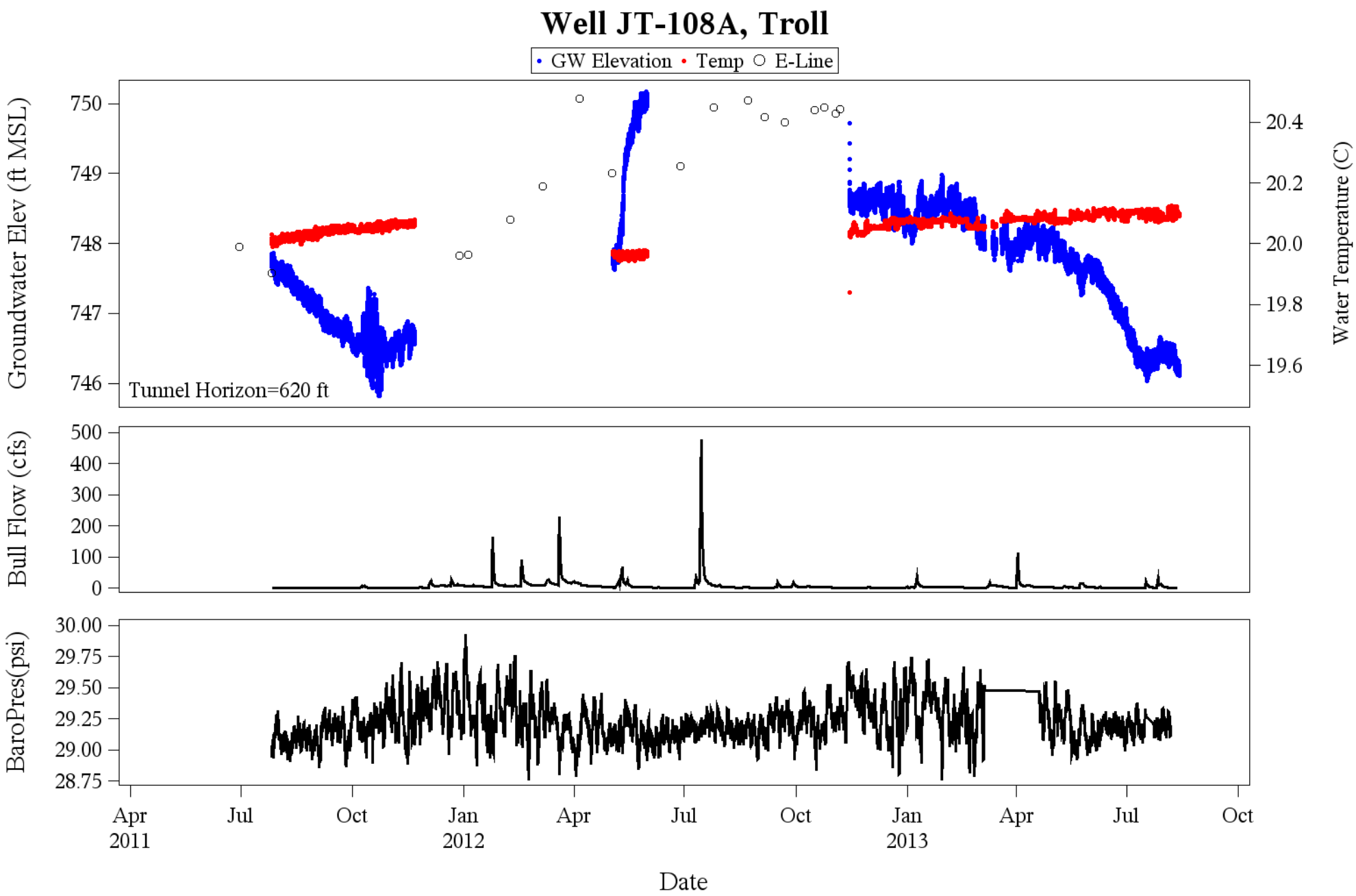
City of Austin DRAFT: QA/QC review pending

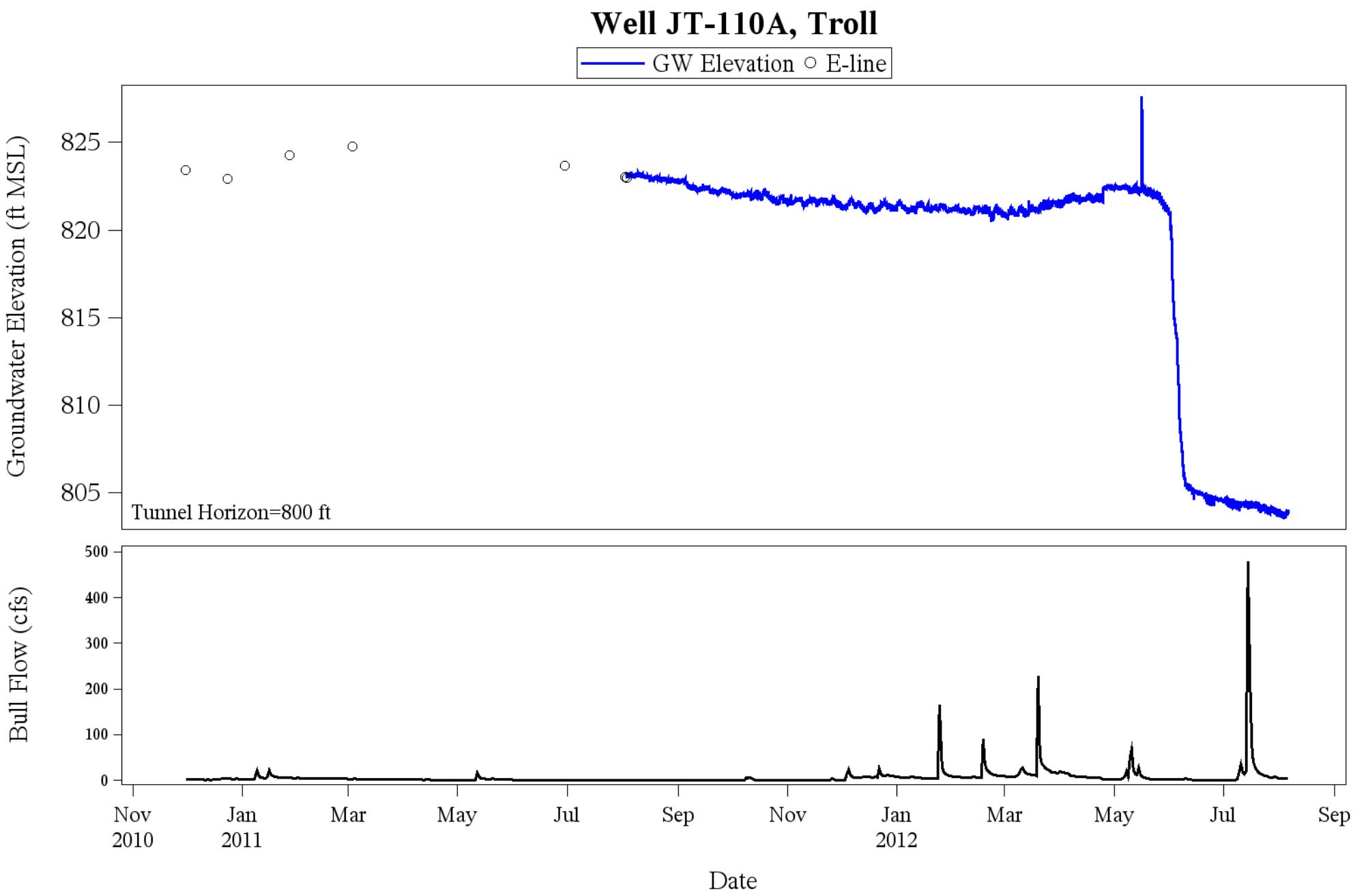
JT-107 elevation and Bull flow

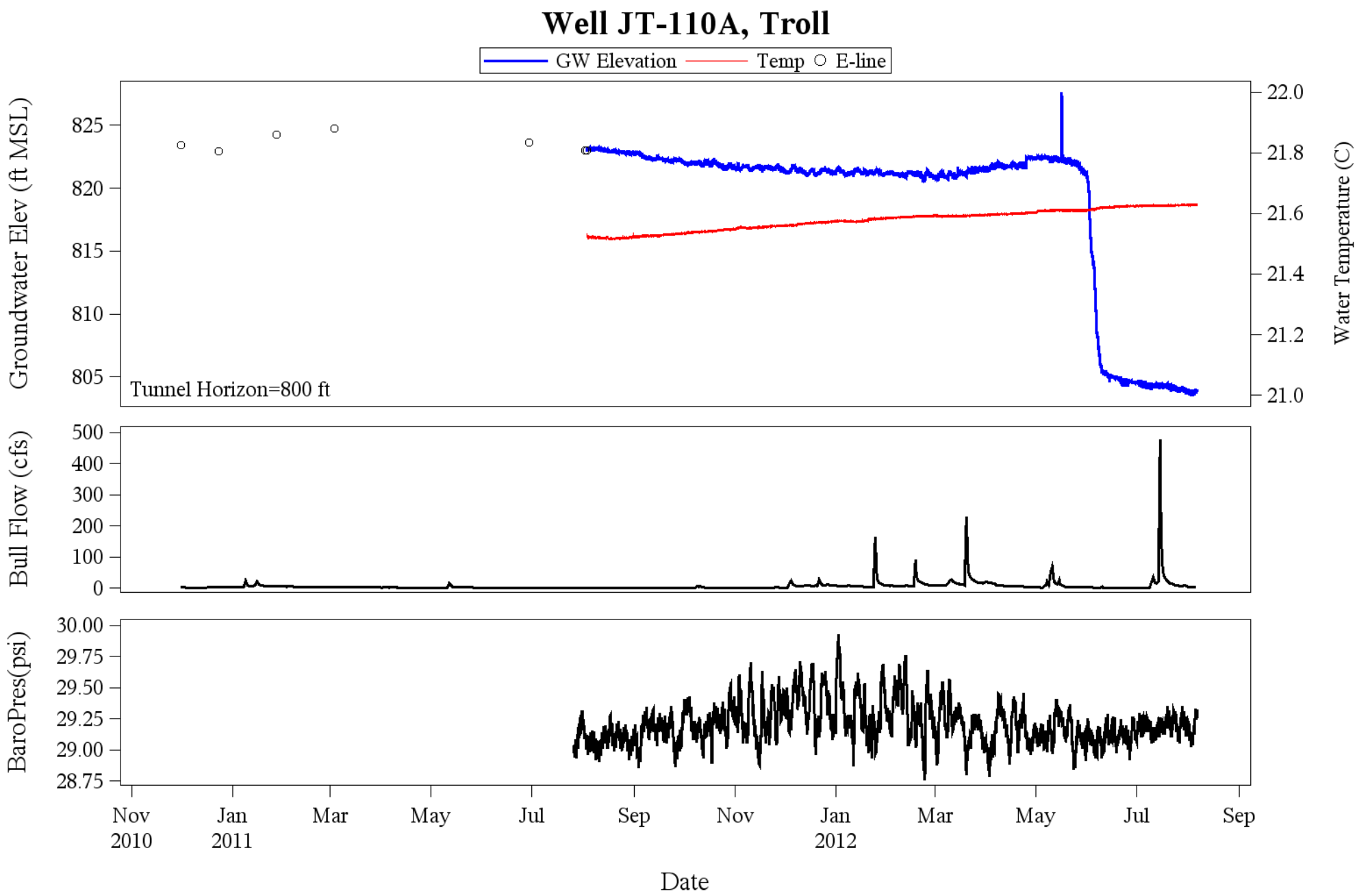




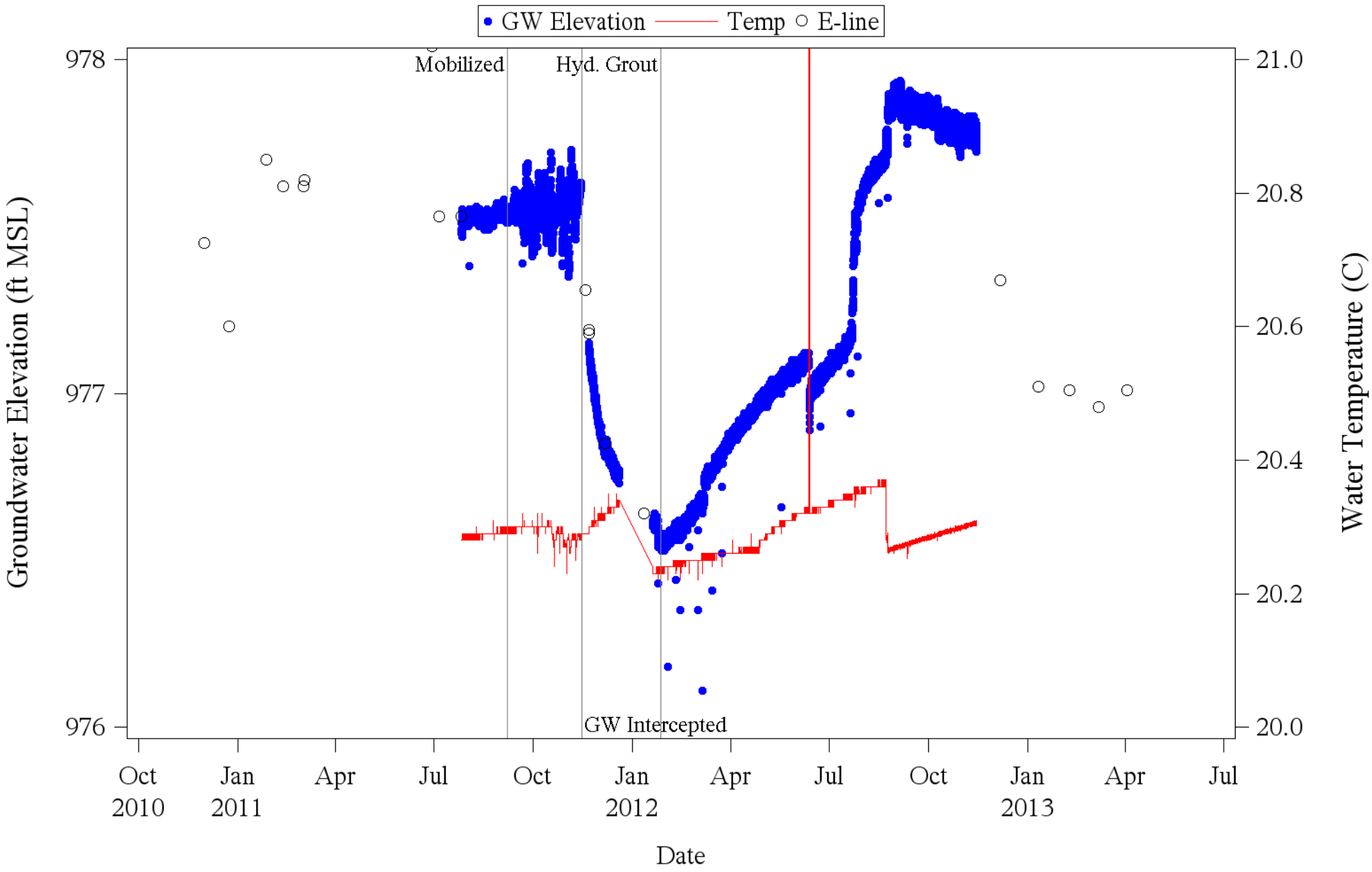
City of Austin DRAFT: QA/QC review pending


Well JT-108A, Troll
GW Elevation
Temp
E-Line
Groundwater Elev (ft MSL)
750
749
748
747
746
Tunnel Horizon=620 ft
Water Temperature (C)
20.4
20.2
20.0
19.8
19.6
Bull Flow (cfs)
500
400
300
200
100
0
BaroPres(psi)
30.00
29.75
29.50
29.25
29.00
28.75
Apr
2011
Jul
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

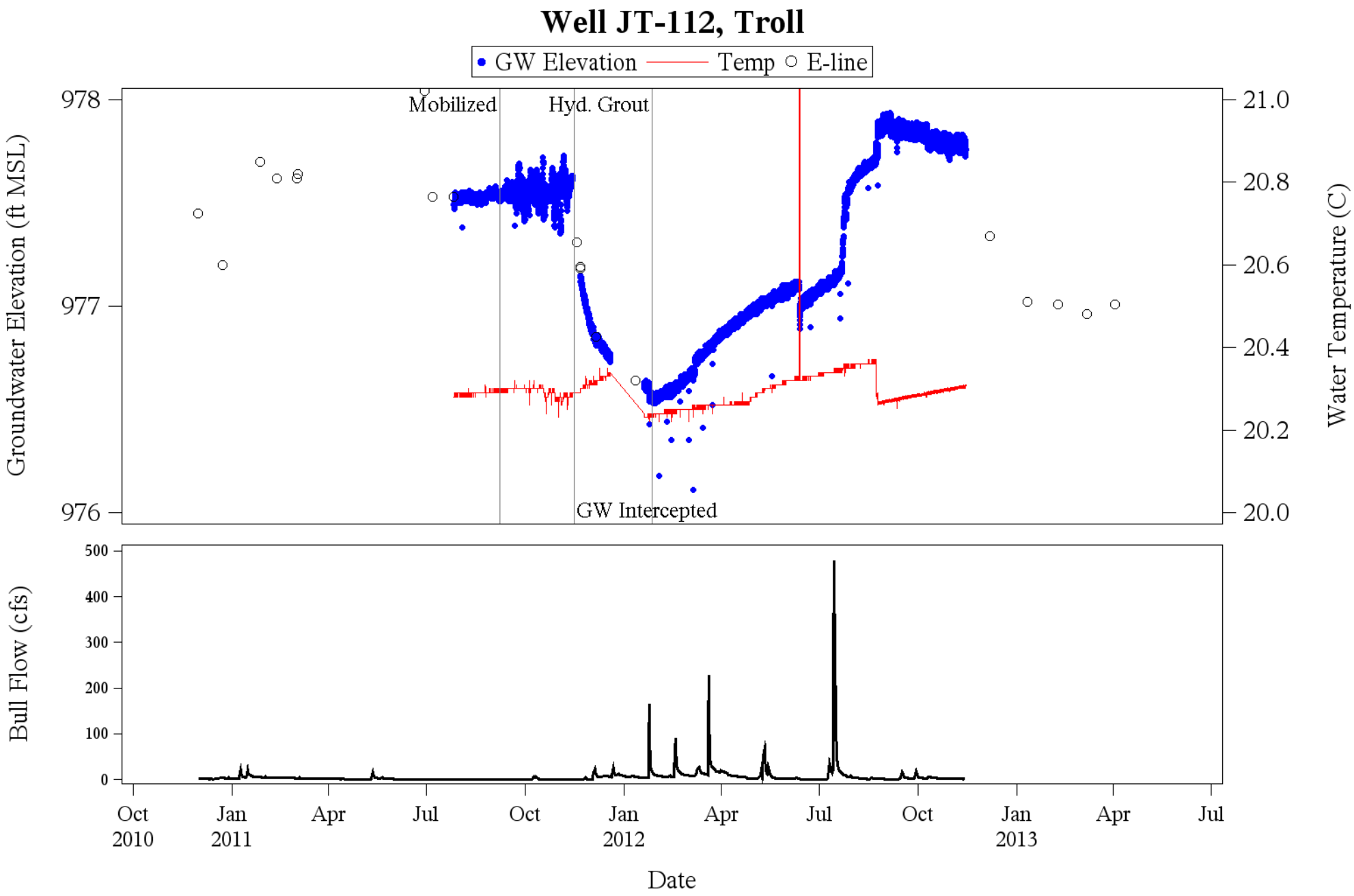

Well JT-110A, Troll
GW Elevation
E-line
Groundwater Elevation (ft MSL)
825
820
815
810
805
Tunnel Horizon=800 ft
Bull Flow (cfs)
500
400
300
200
100
0
Nov 2010
Jan 2011
Mar
May
Jul
Sep
Nov
Jan 2012
Mar
May
Jul
Sep
Date


Well JT-110A, Troll
GW Elevation
Temp
E-line
Groundwater Elev (ft MSL)
825
820
815
810
805
Tunnel Horizon=800 ft
22.0
21.8
21.6
21.4
21.2
21.0
Water Temperature (C)
Bull Flow (cfs)
500
400
300
200
100
0
BaroPres(psi)
30.00
29.75
29.50
29.25
29.00
28.75
Nov 2010
Jan 2011
Mar
May
Jul
Sep
Nov
Jan 2012
Mar
May
Jul
Sep
Date

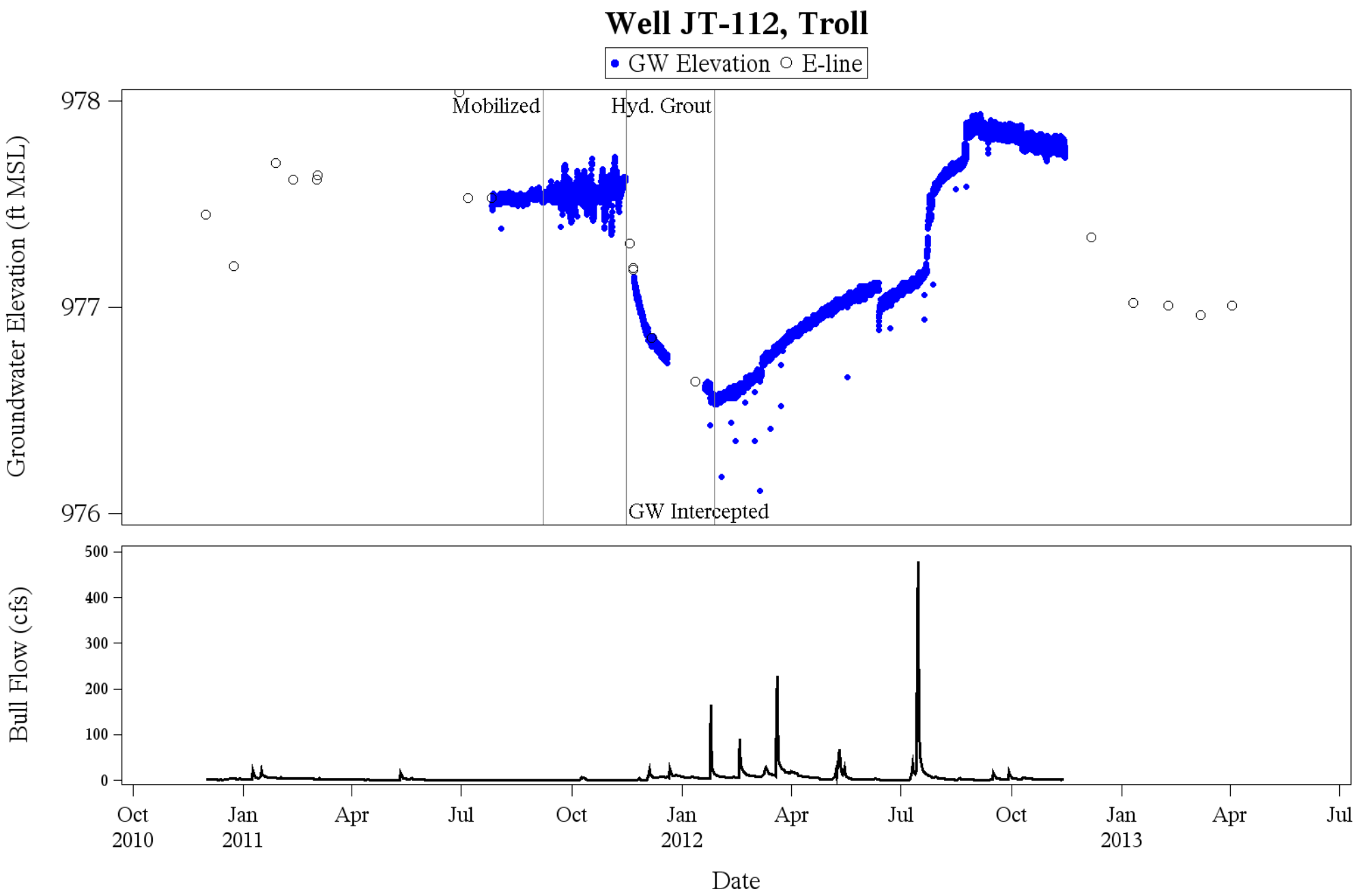
Well JT-112 Troll, All Data Including Bad Data



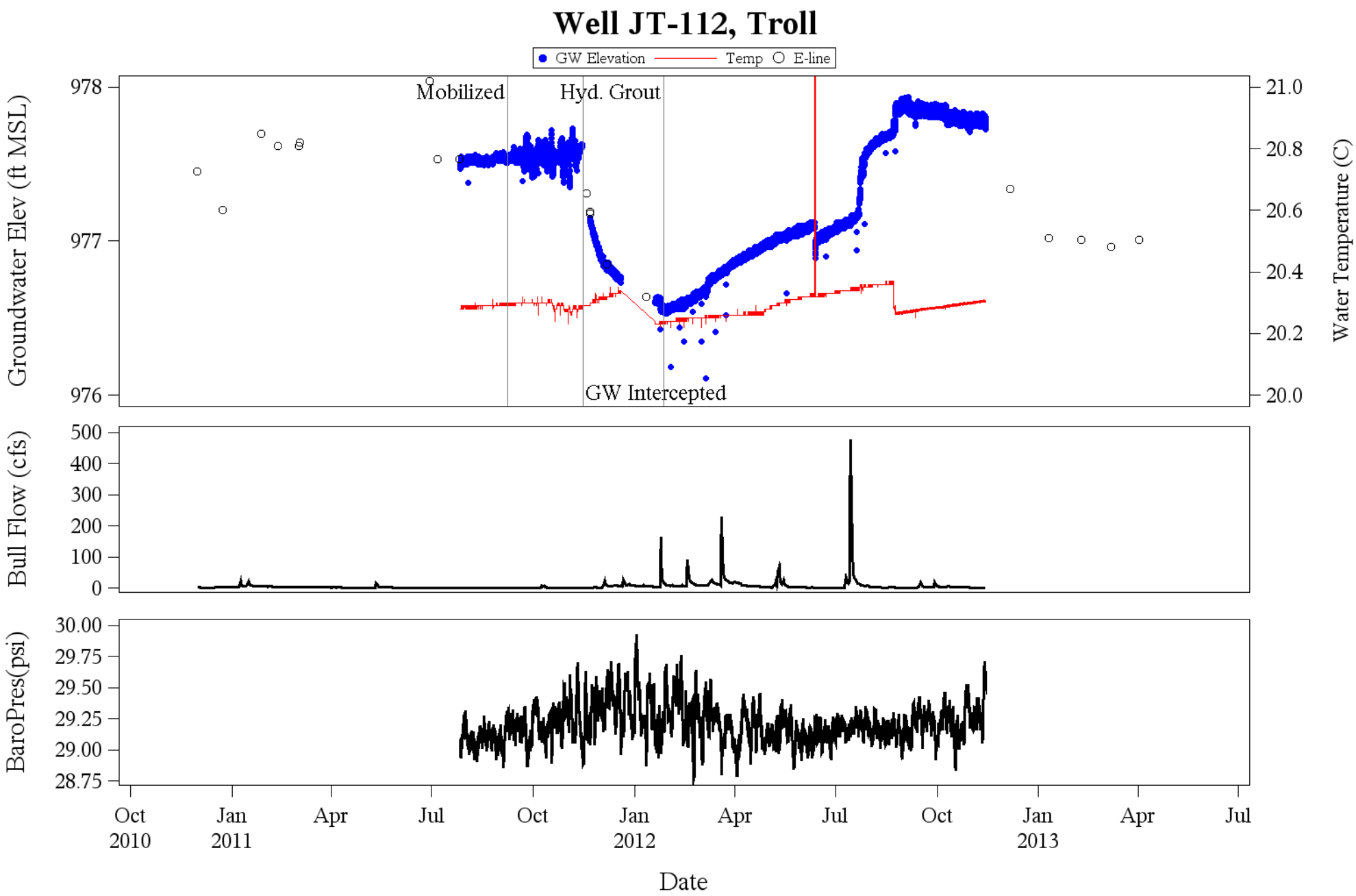
City of Austin DRAFT: QA/QC review pending



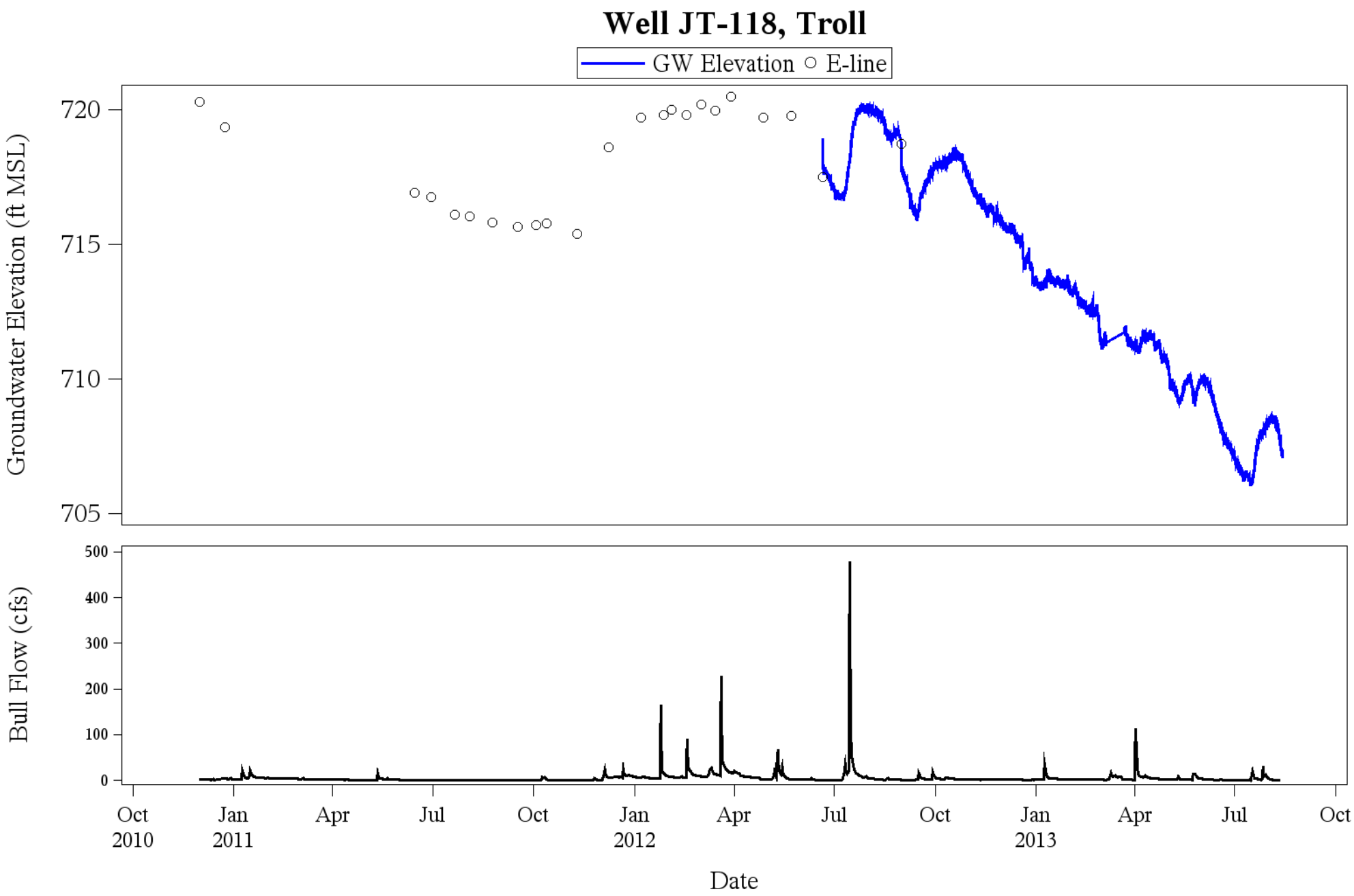
City of Austin DRAFT: QA/QC review pending

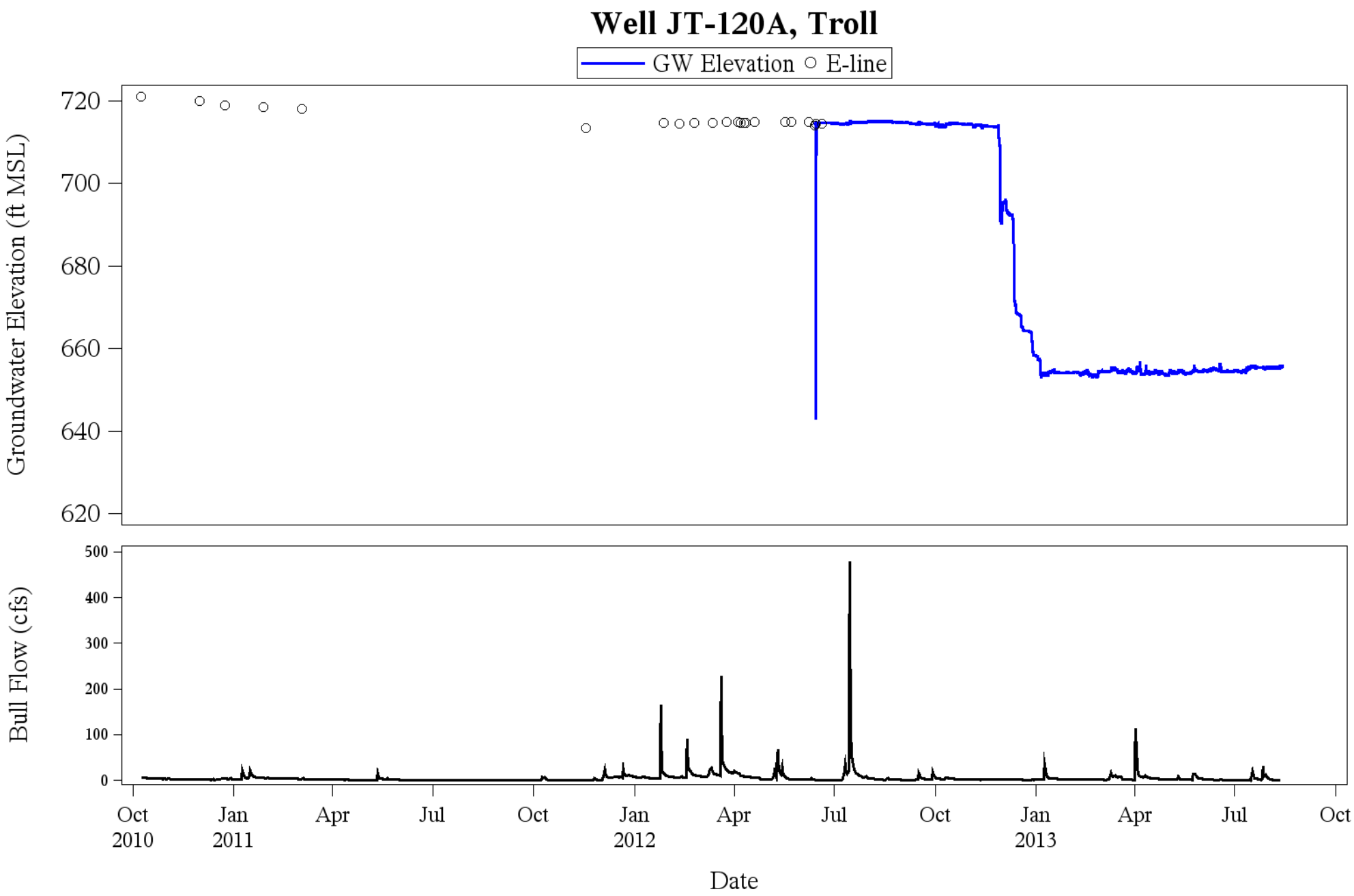


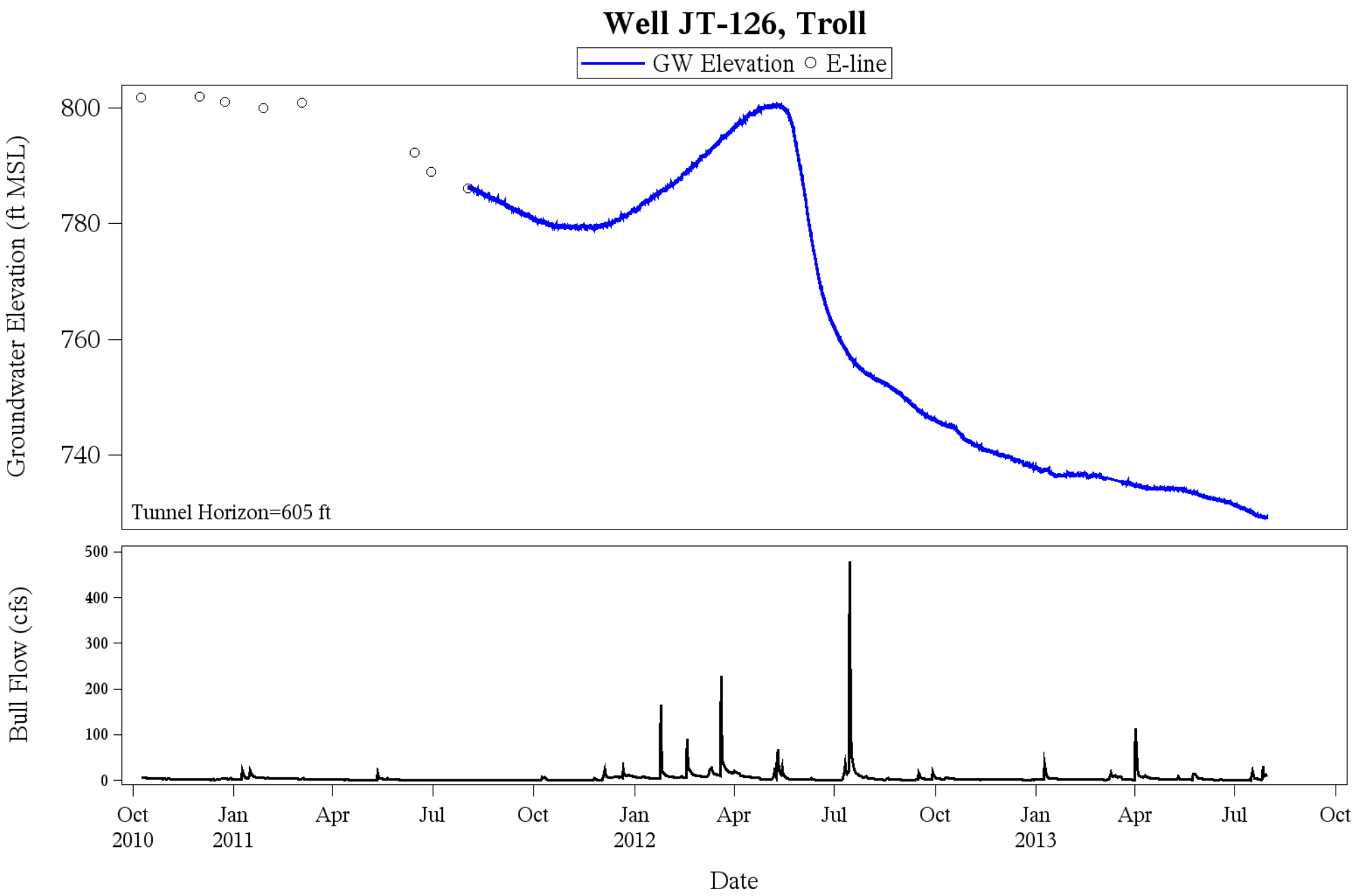
City of Austin DRAFT: QA/QC review pending



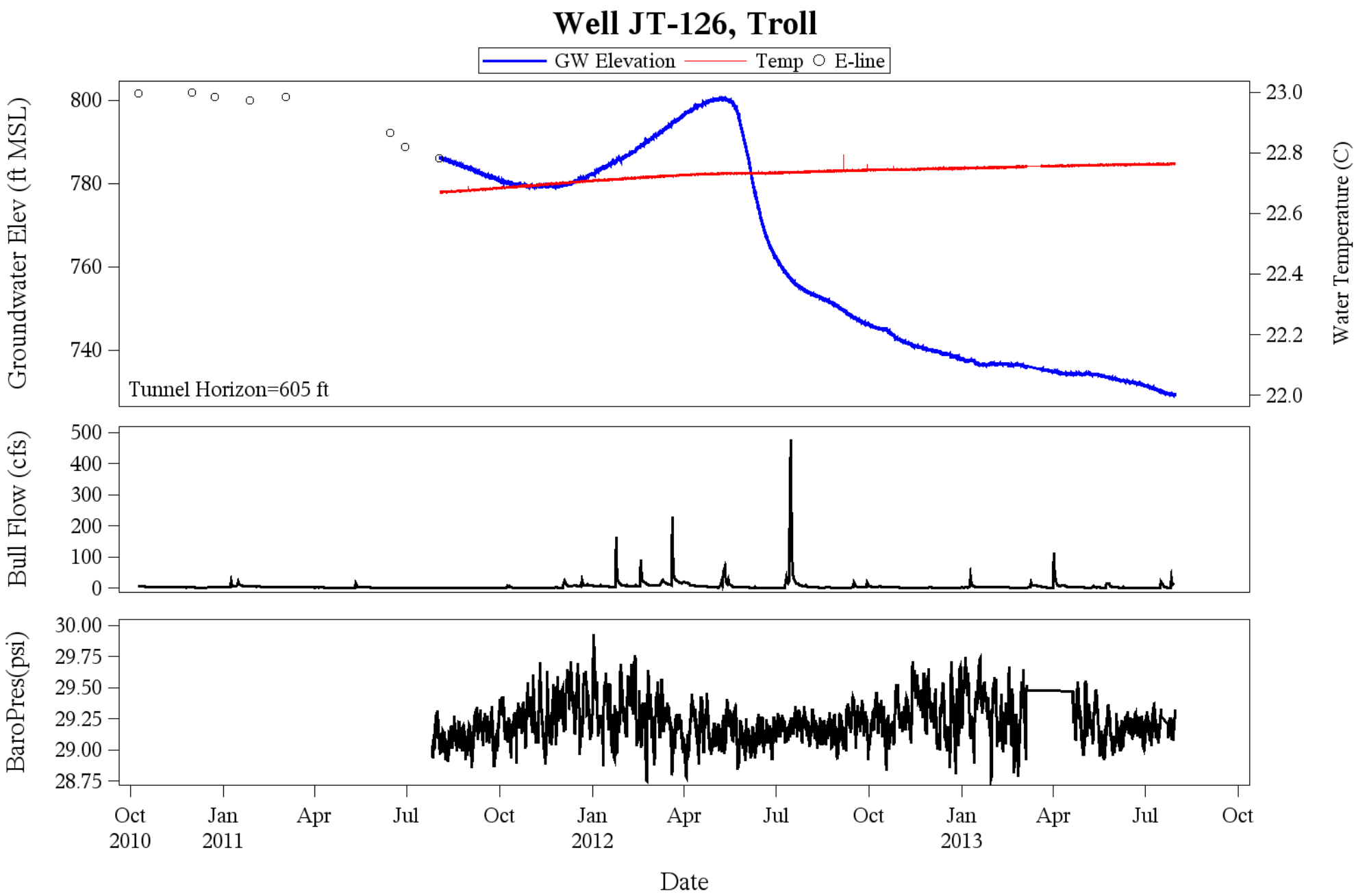
City of Austin DRAFT: QA/QC review pending


Well JT-118, Troll
GW Elevation
E-line
Groundwater Elevation (ft MSL)
720
715
710
705
Bull Flow (cfs)
500
400
300
200
100
0
Oct 2010
Jan 2011
Apr
Jul
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

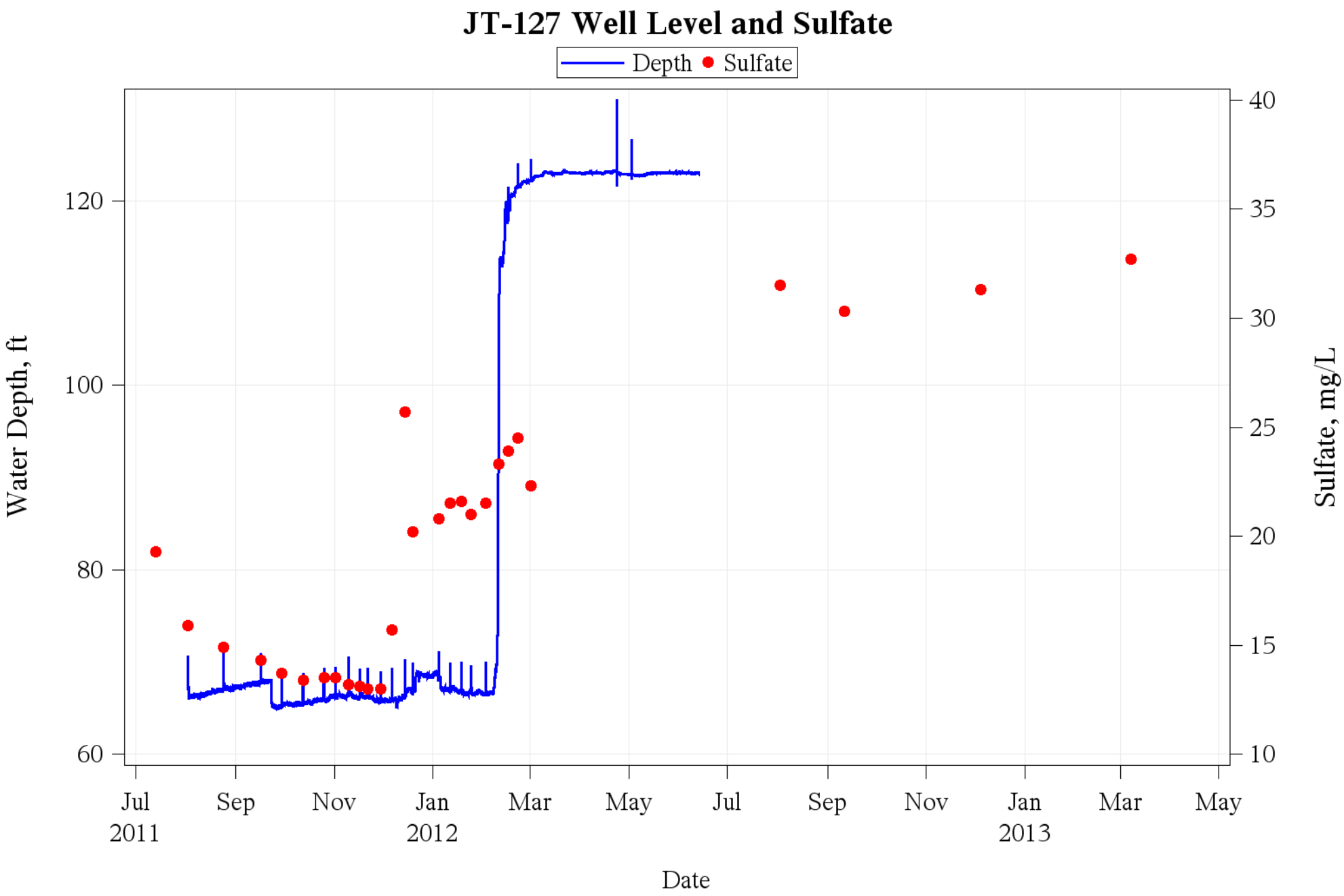

Well JT-120A, Troll
GW Elevation
E-line
Groundwater Elevation (ft MSL)
720
700
680
660
640
620
Bull Flow (cfs)
500
400
300
200
100
0
Oct 2010
Jan 2011
Apr
Jul
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date



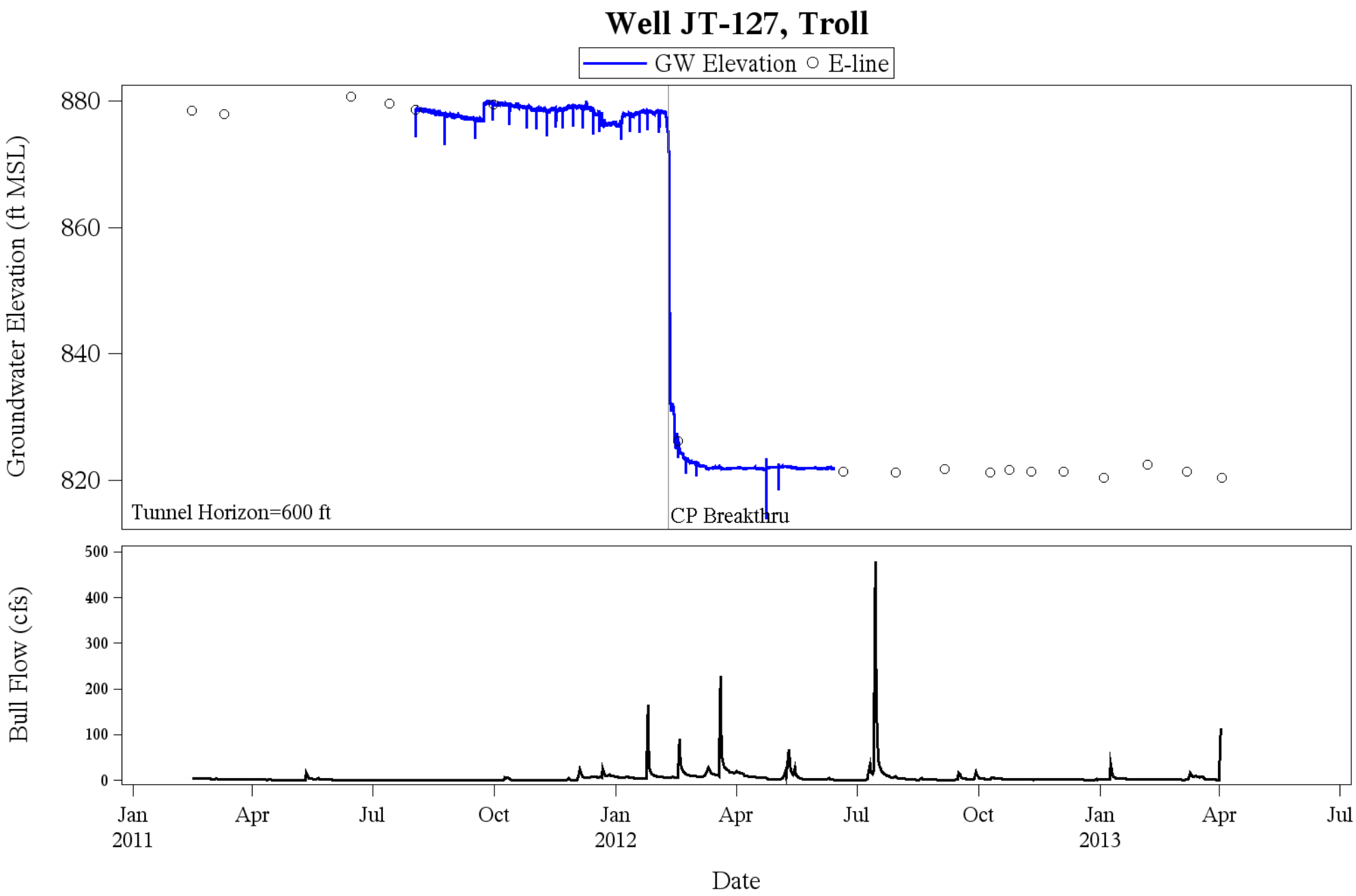
City of Austin DRAFT: QA/QC review pending

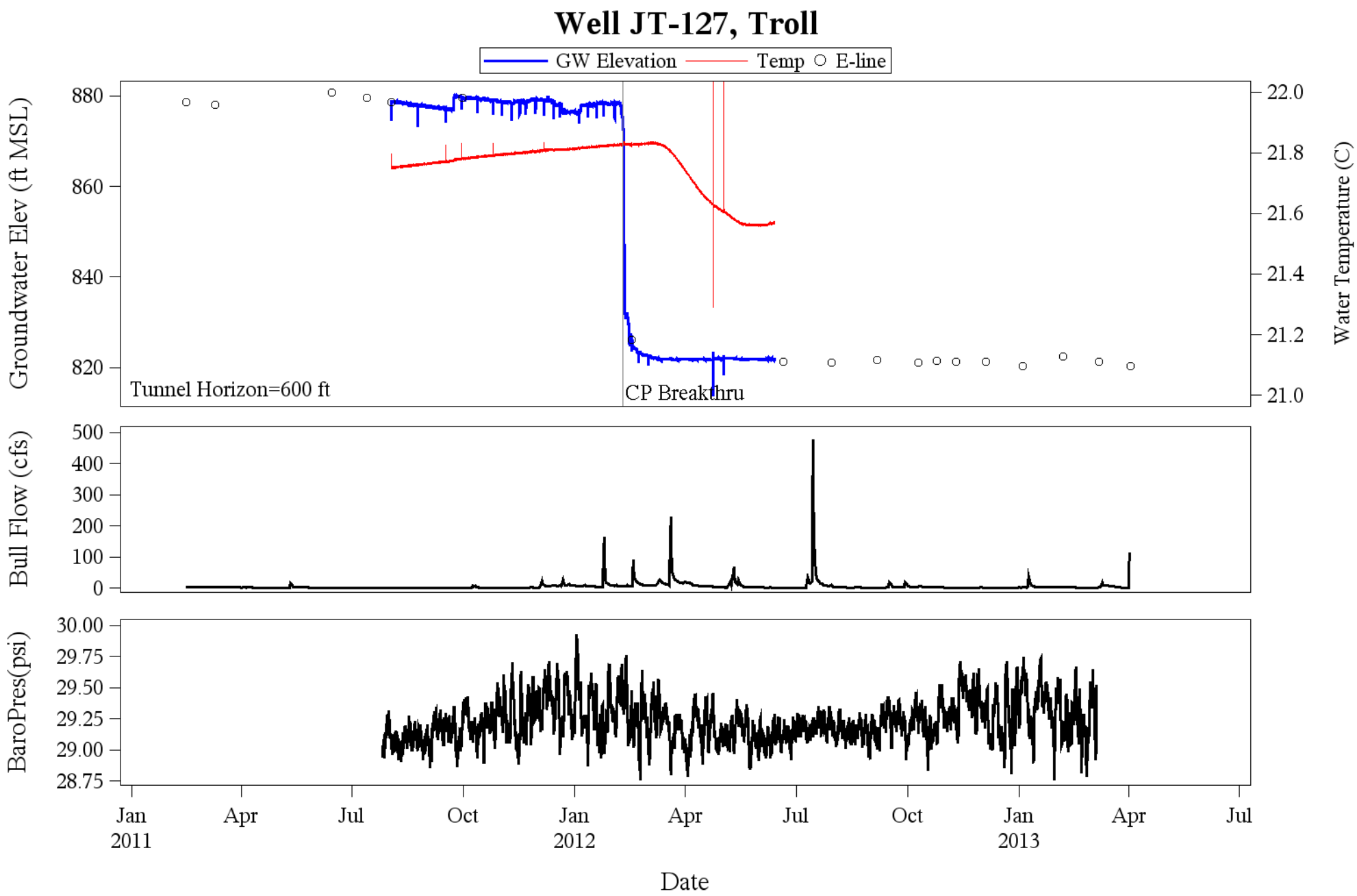


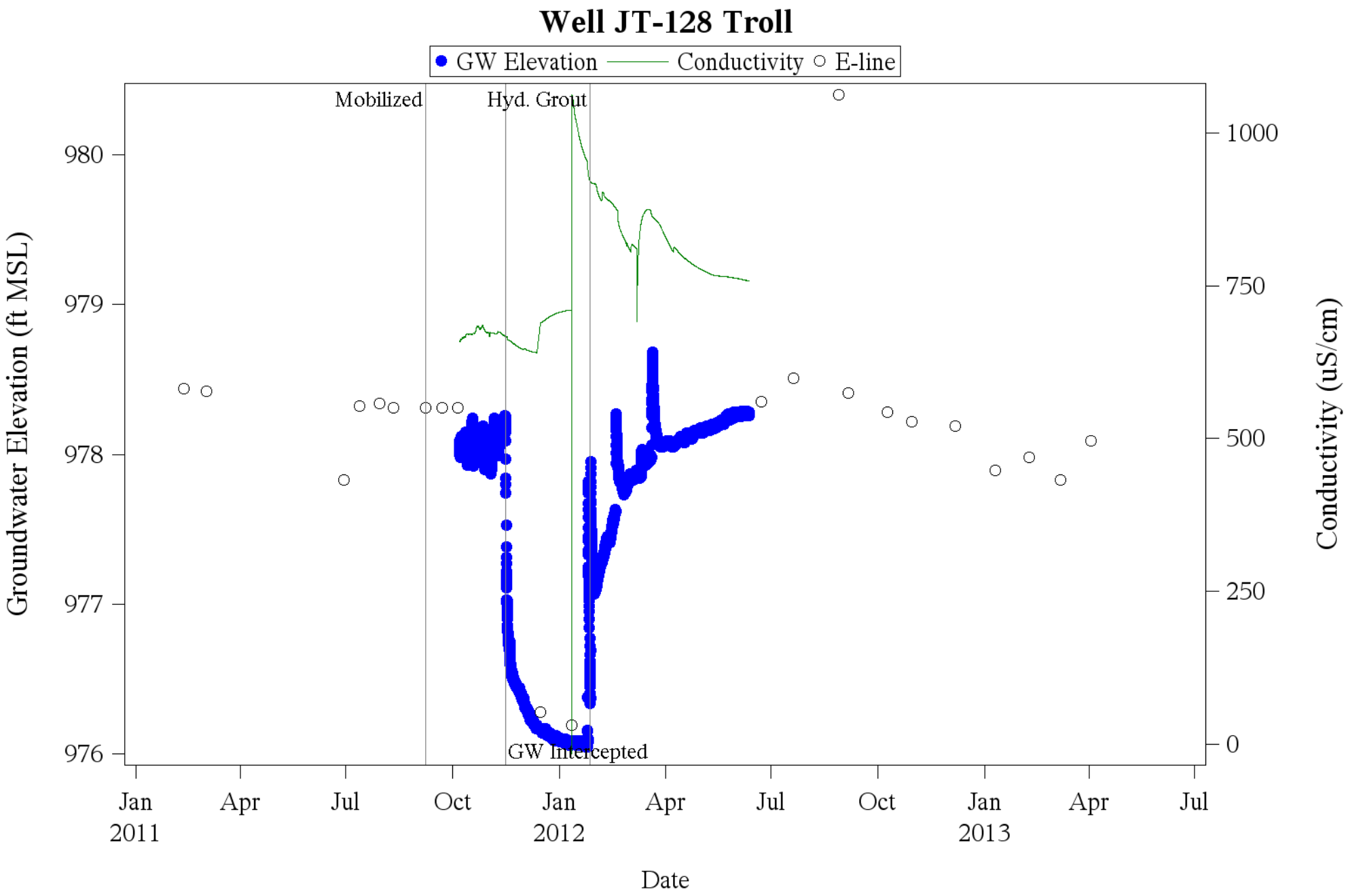
City of Austin DRAFT: QA/QC review pending



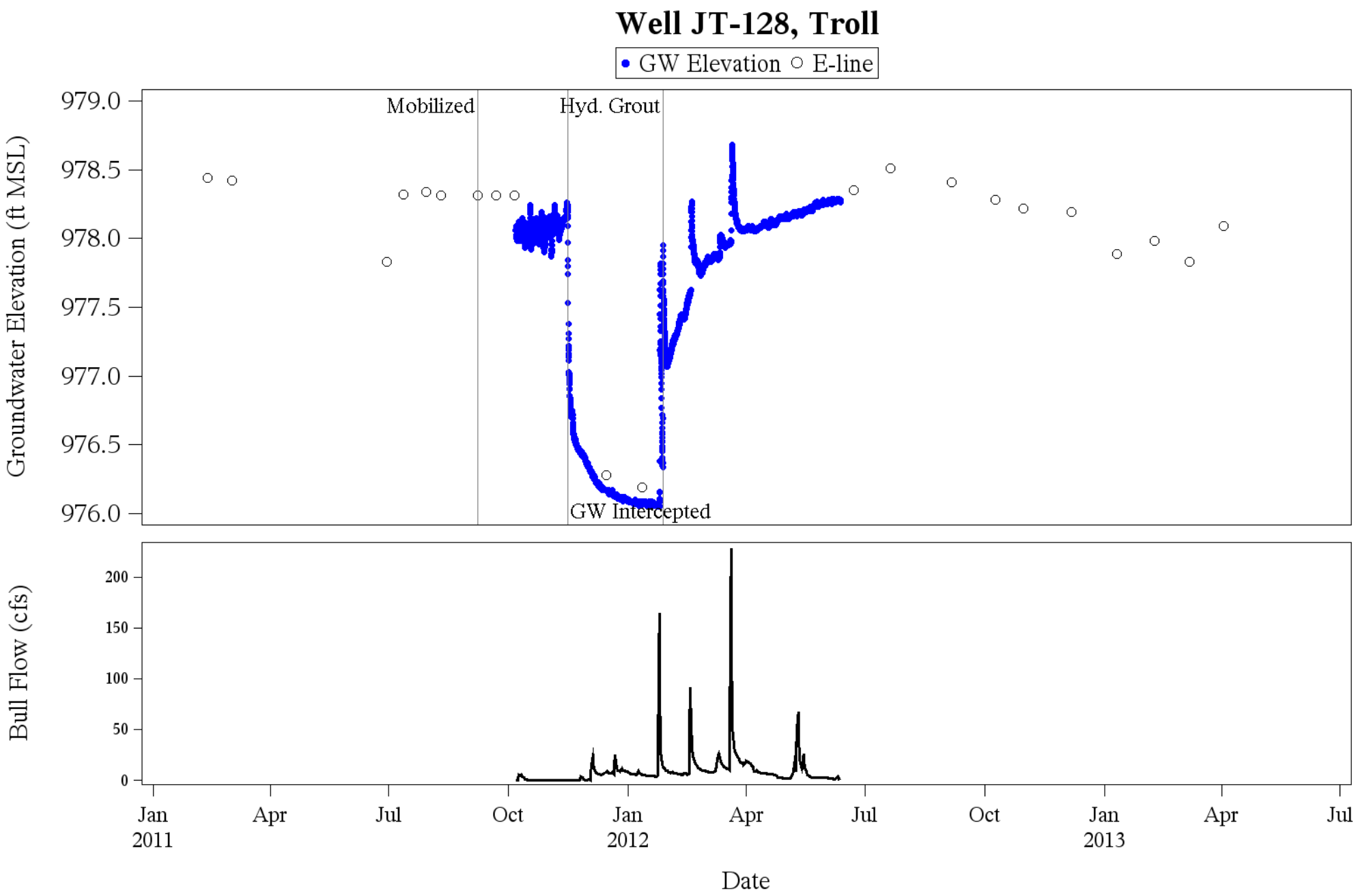
City of Austin DRAFT: QA/QC review pending

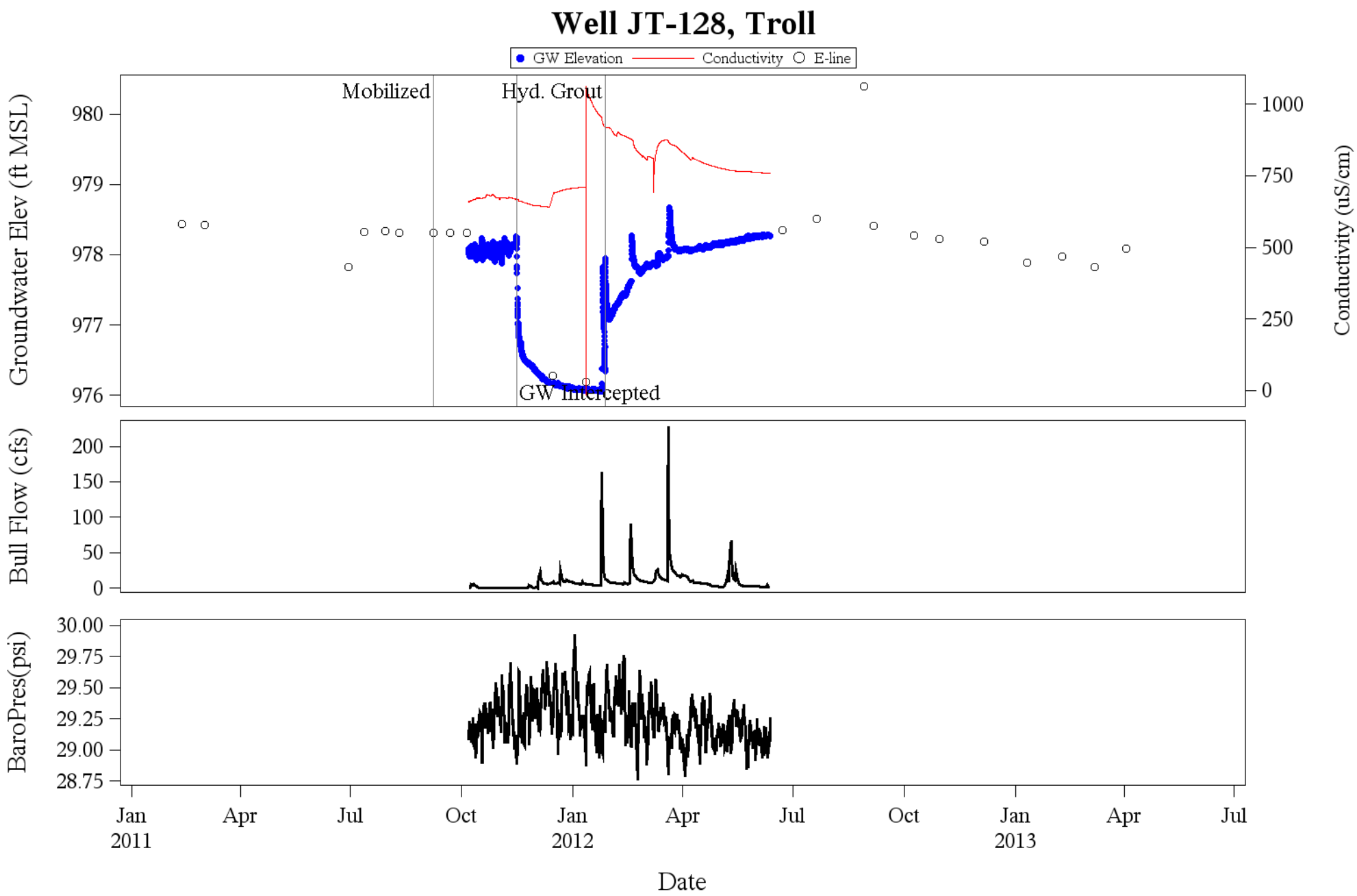

Well JT-127, Troll
GW Elevation
E-line
Groundwater Elevation (ft MSL)
880
860
840
820
Tunnel Horizon=600 ft
CP Breakthru
Bull Flow (cfs)
500
400
300
200
100
0
Jan 2011
Apr
Jul
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Date


Well JT-127, Troll
GW Elevation
Temp
E-line
Groundwater Elev (ft MSL)
880
860
840
820
22.0
21.8
21.6
21.4
21.2
21.0
Water Temperature (C)
Tunnel Horizon=600 ft
CP Breakthru
Bull Flow (cfs)
500
400
300
200
100
0
BaroPres(psi)
30.00
29.75
29.50
29.25
29.00
28.75
Jan
2011
Apr
Jul
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Date

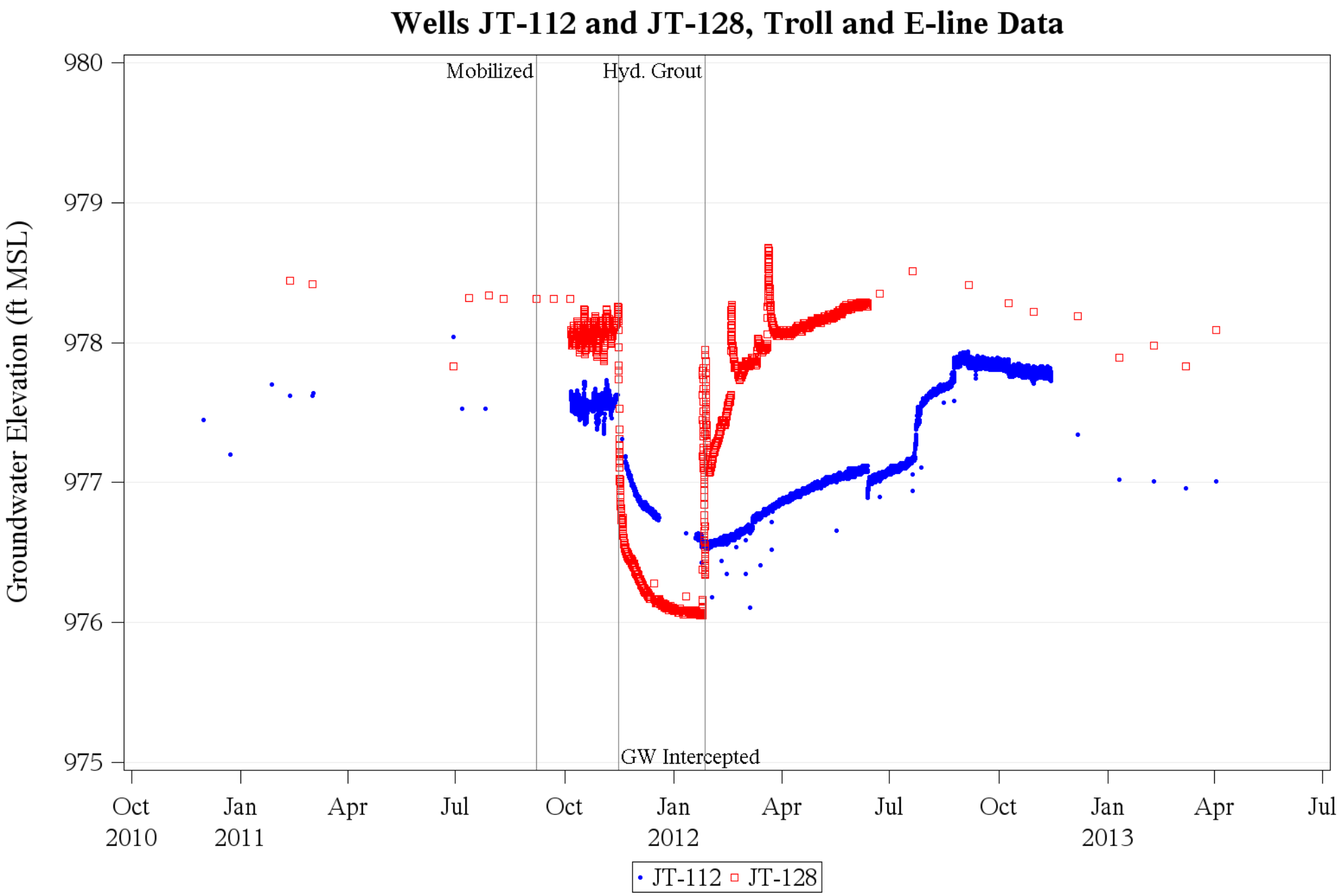


City of Austin DRAFT: QA/QC review pending

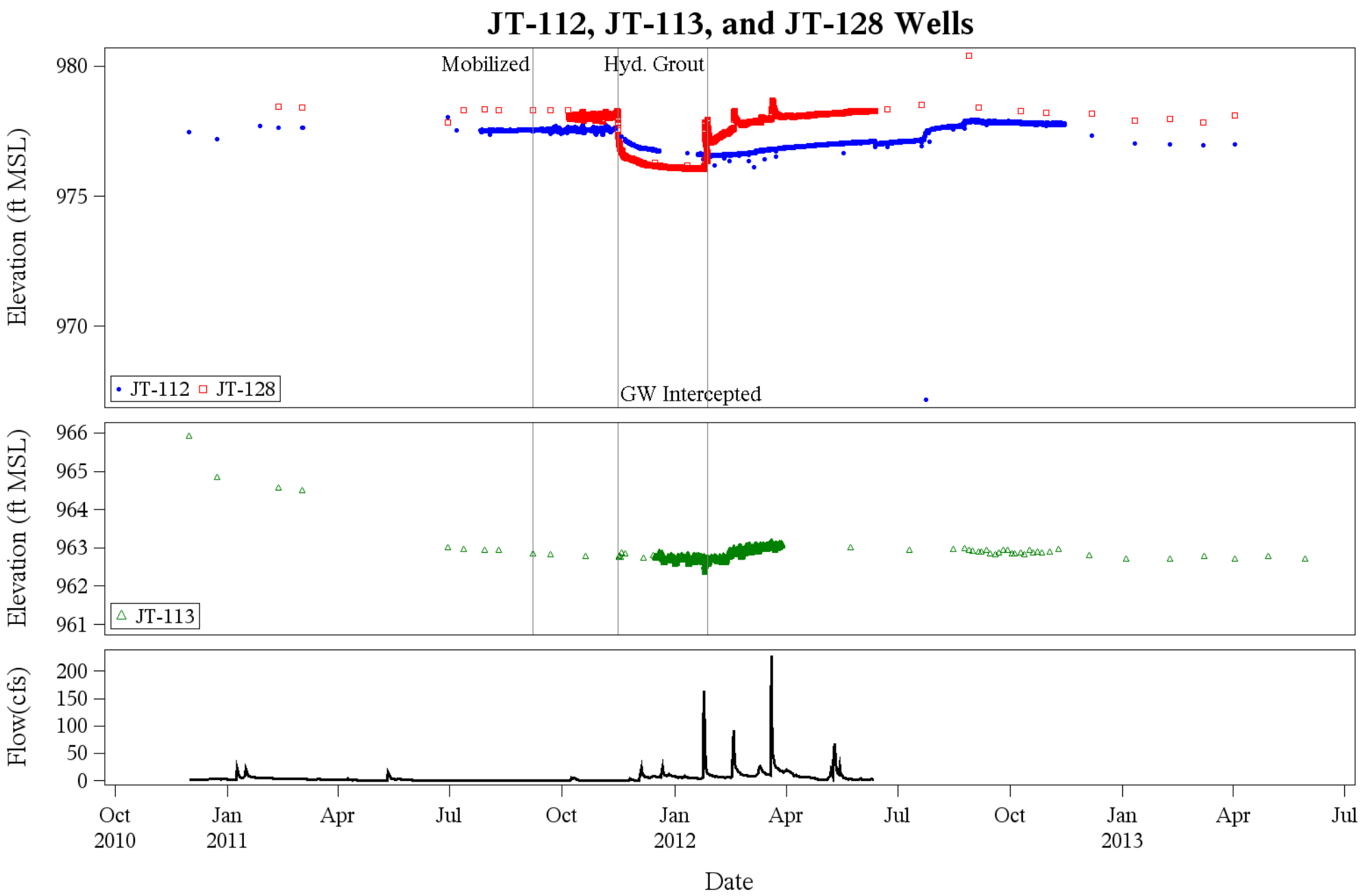

Well JT-128, Troll
GW Elevation
E-line
Mobilized
Hyd. Grout
GW Intercepted
Groundwater Elevation (ft MSL)
979.0
978.5
978.0
977.5
977.0
976.5
976.0
Bull Flow (cfs)
200
150
100
50
0
Jan
2011
Apr
Jul
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Date



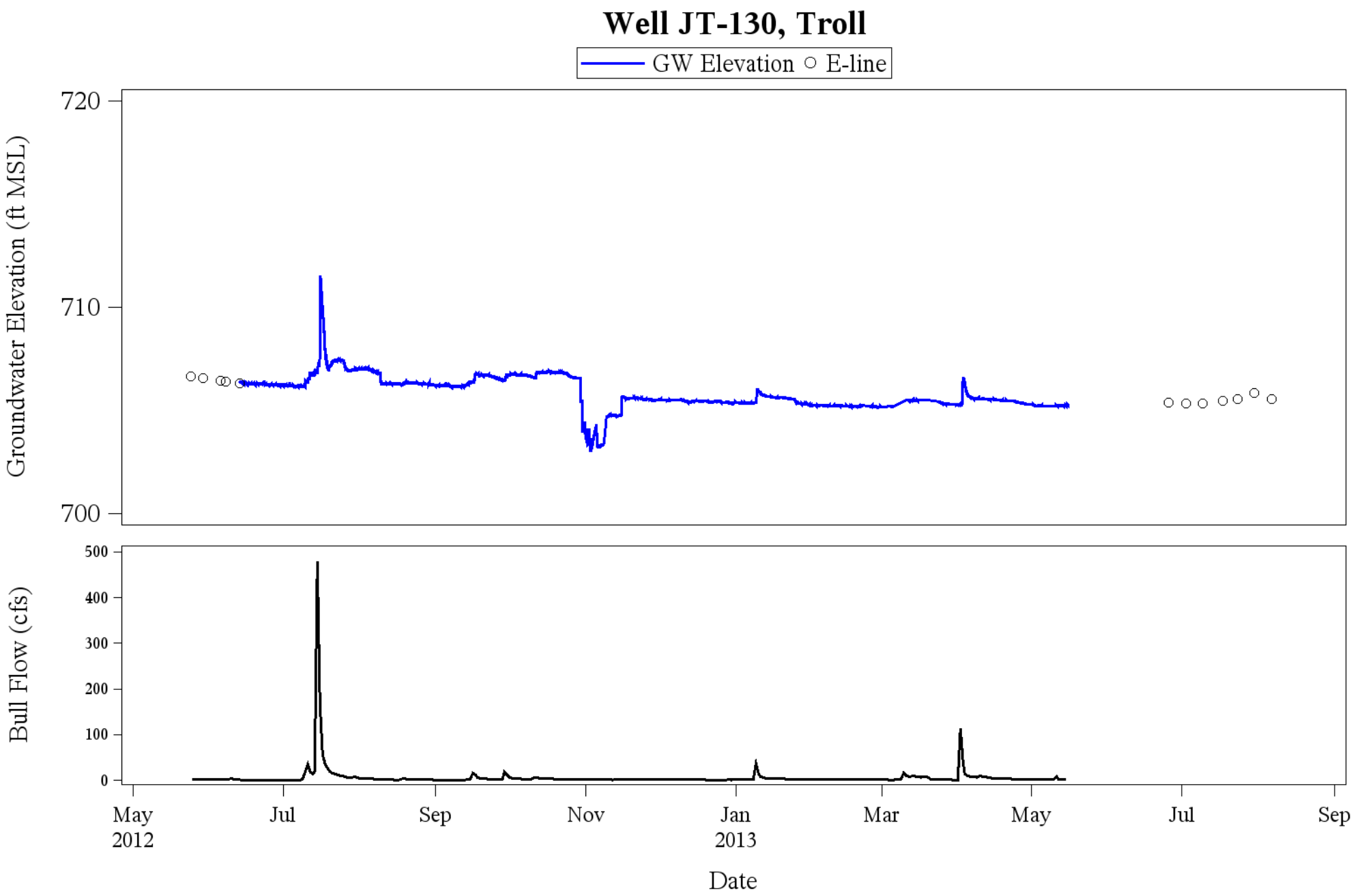
City of Austin DRAFT: QA/QC review pending

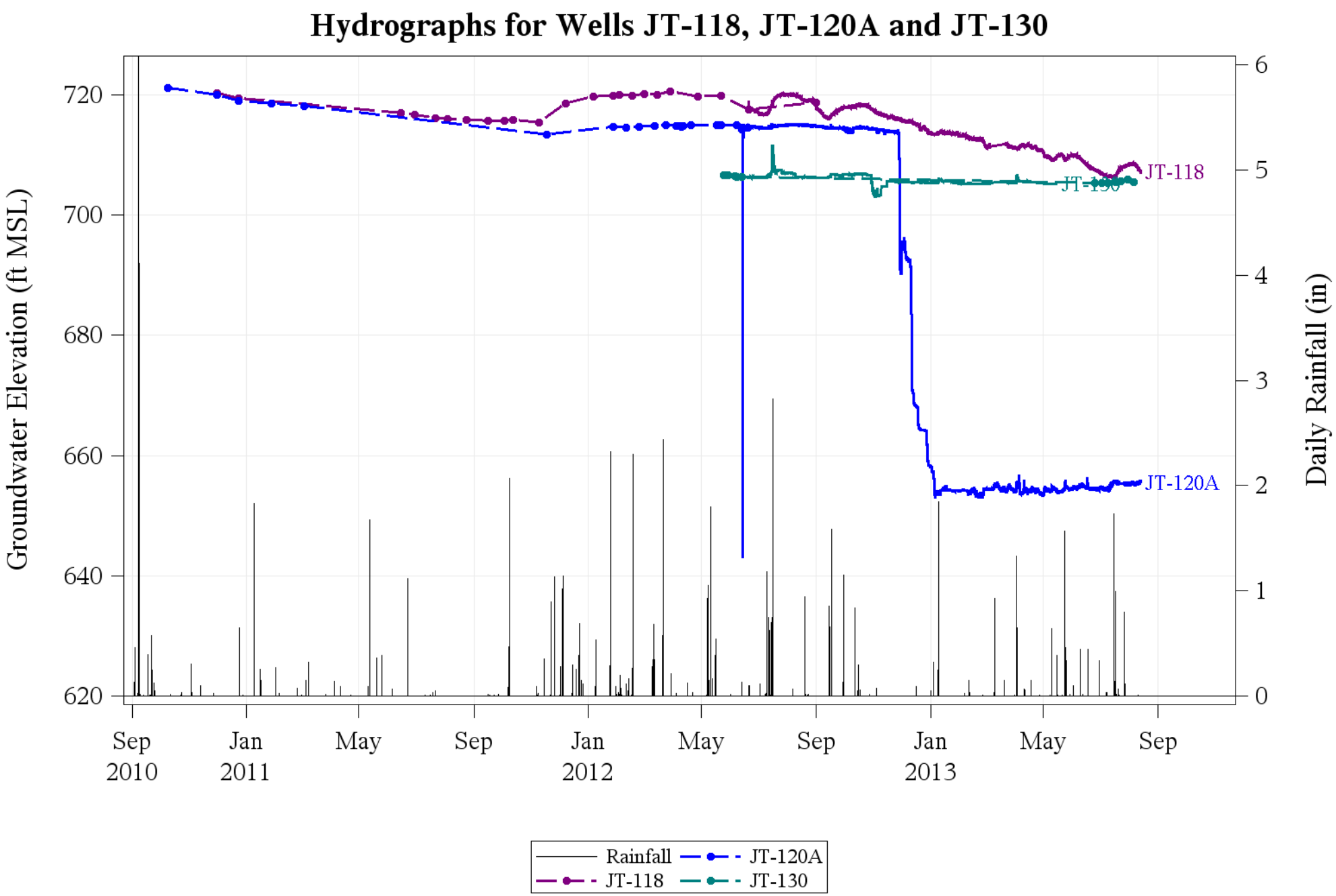


City of Austin DRAFT: QA/QC review pending



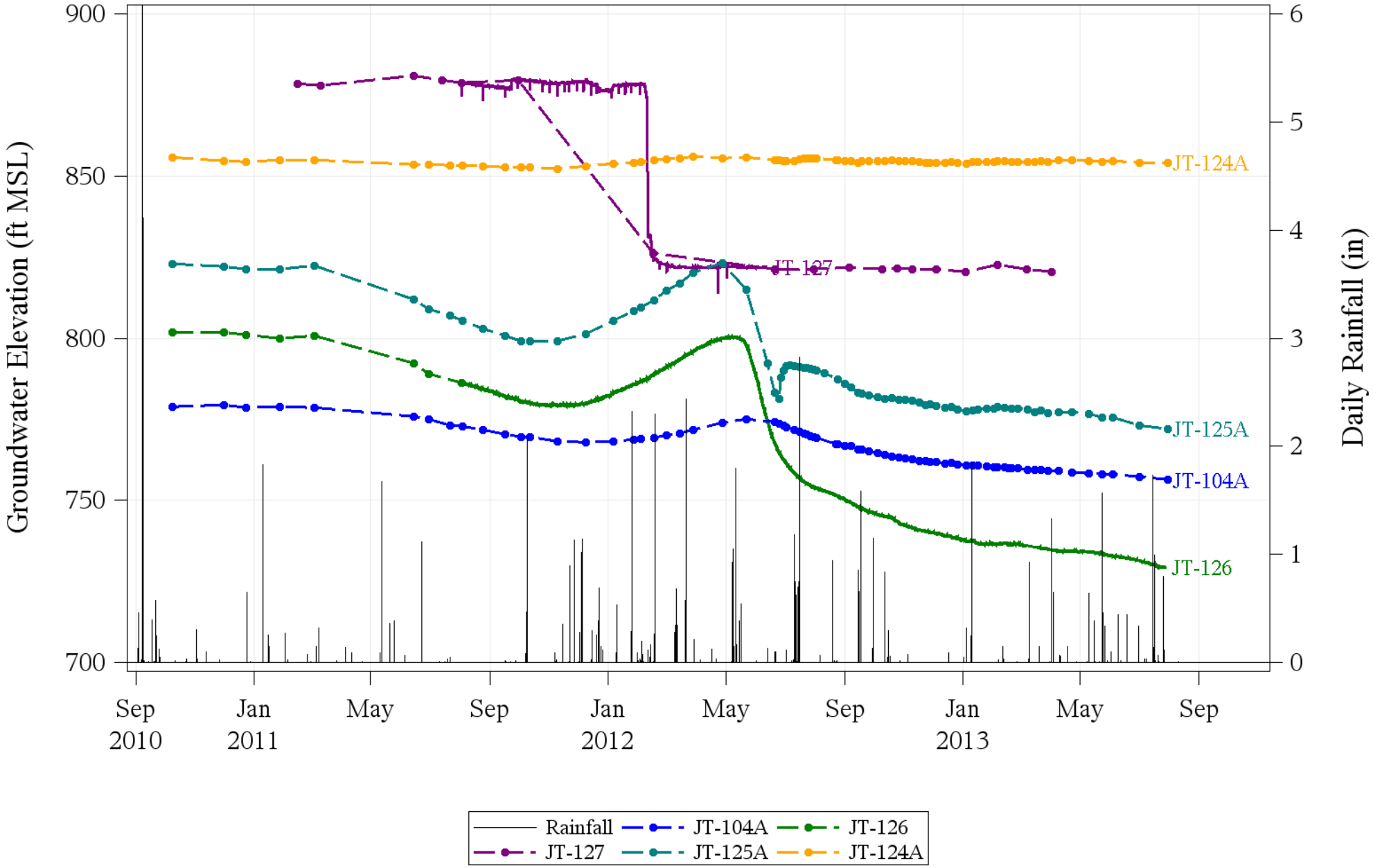
City of Austin DRAFT: QA/QC review pending


Well JT-130, Troll
GW Elevation
E-line
Groundwater Elevation (ft MSL)
720
710
700
Bull Flow (cfs)
500
400
300
200
100
0
May 2012
Jul
Sep
Nov
Jan 2013
Mar
May
Jul
Sep
Date

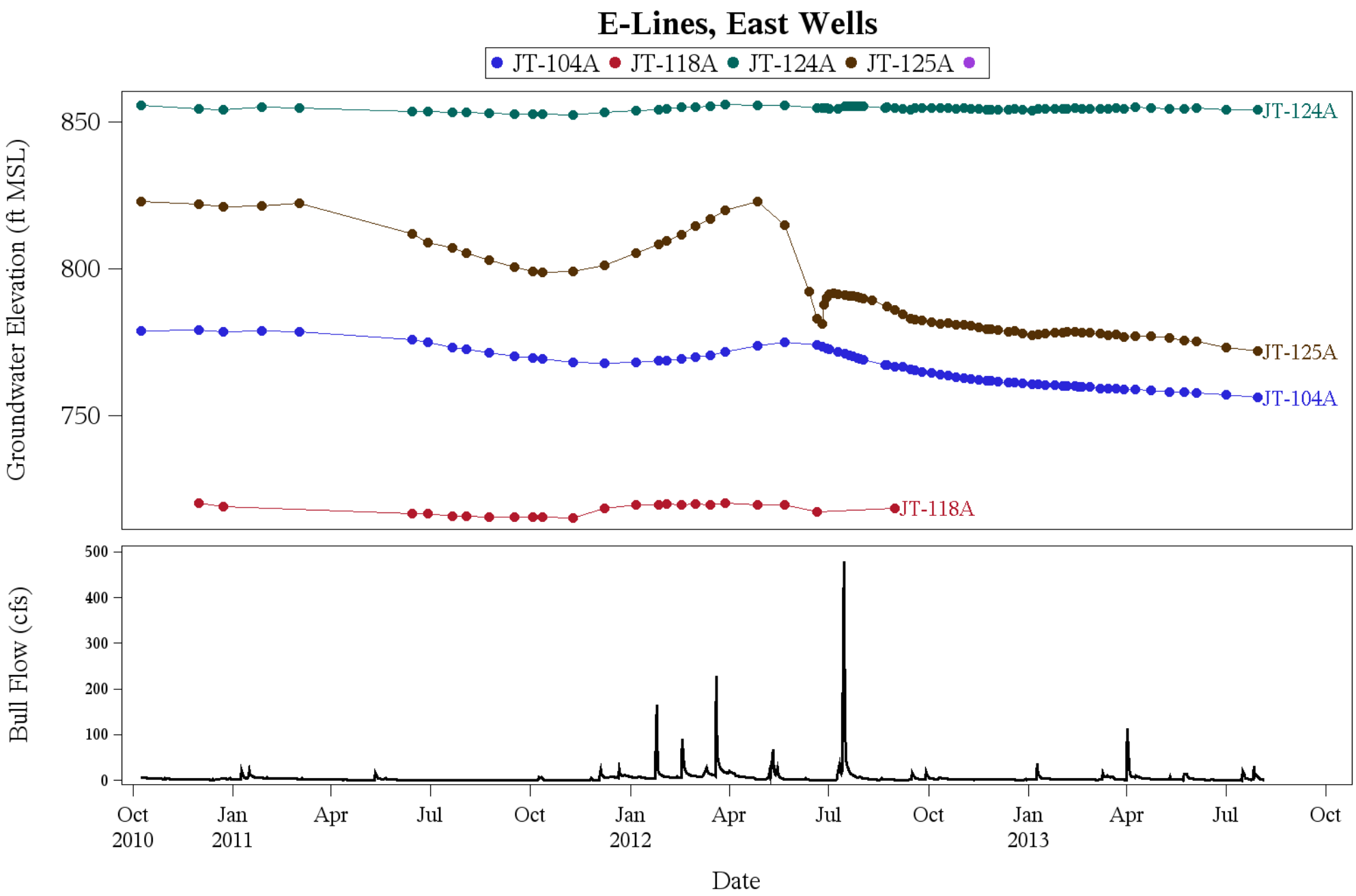


City of Austin DRAFT: QA/QC review pending

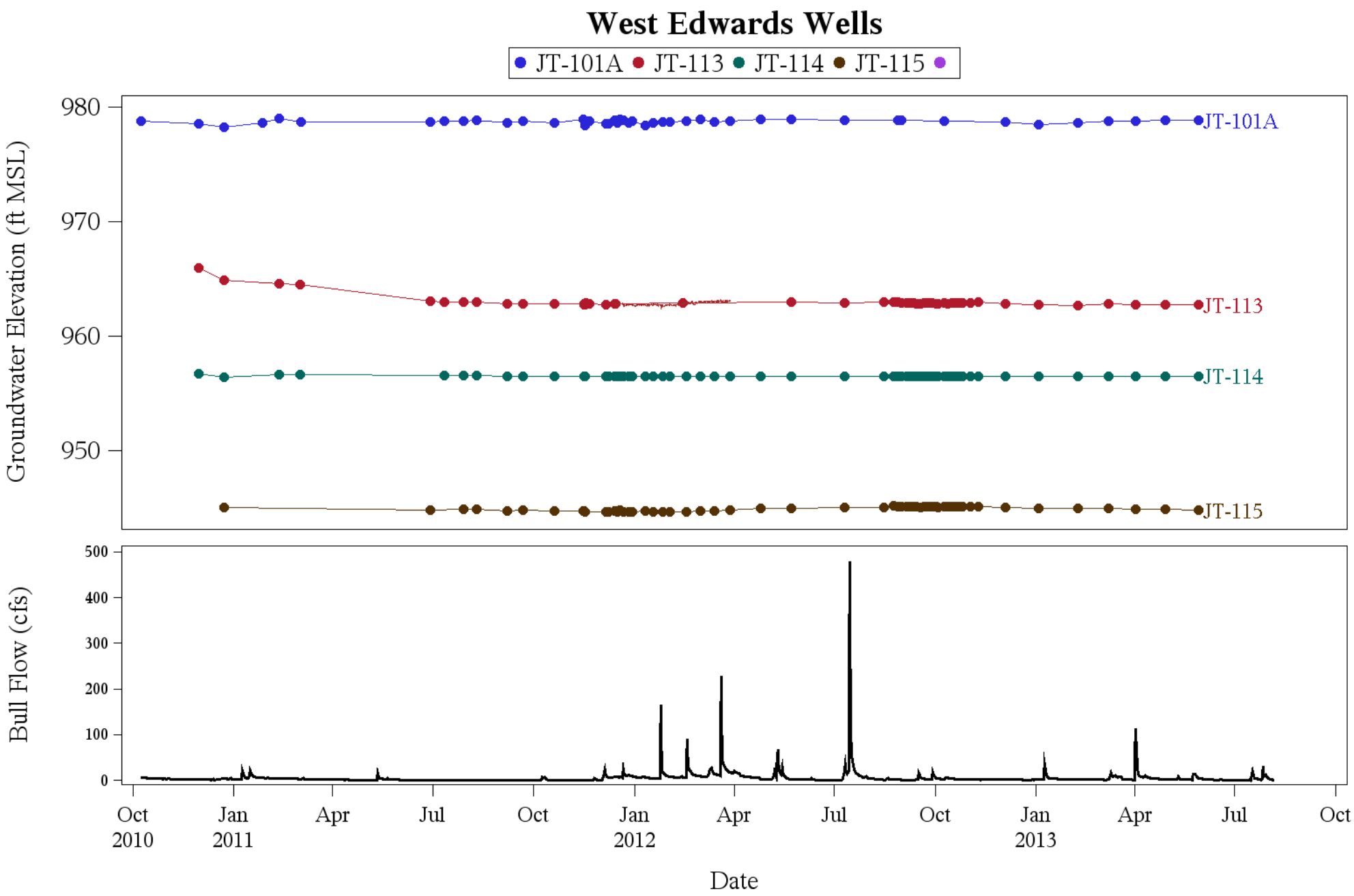
Hydrographs for Wells JT-104A, JT-124A, JT-125A, JT-126 and JT-127



City of Austin DRAFT: QA/QC review pending

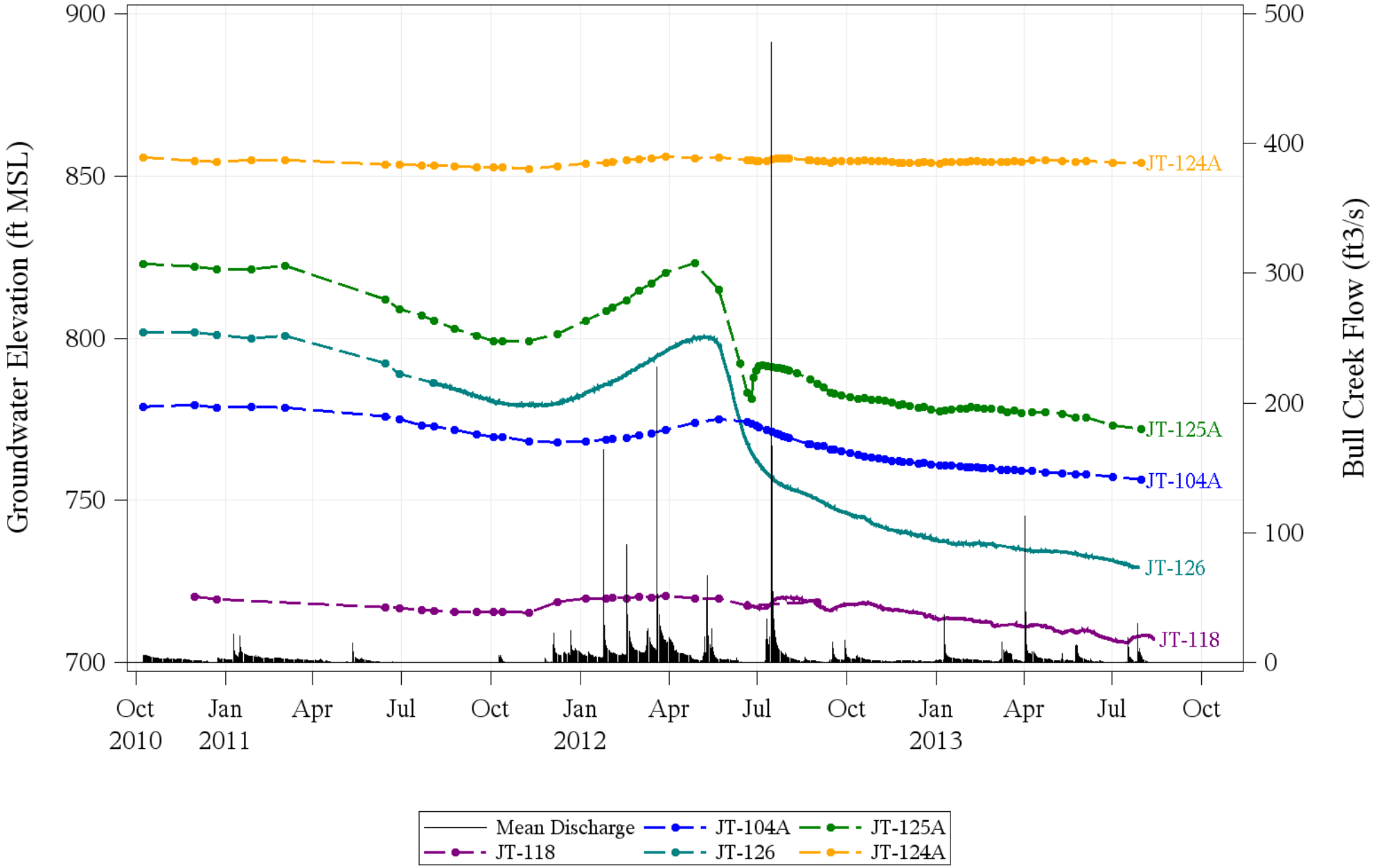


City of Austin DRAFT: QA/QC review pending

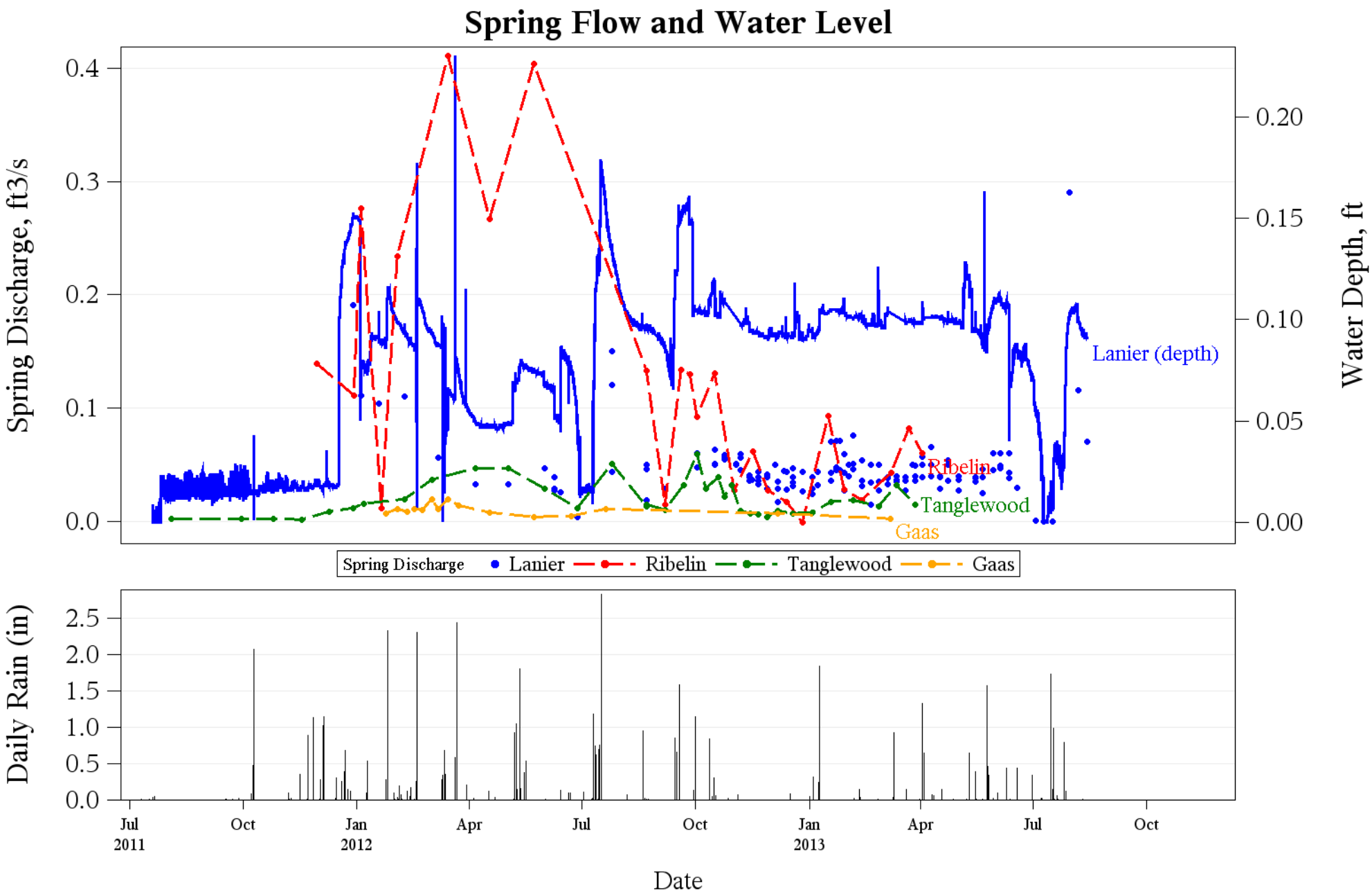


City of Austin DRAFT: QA/QC review pending

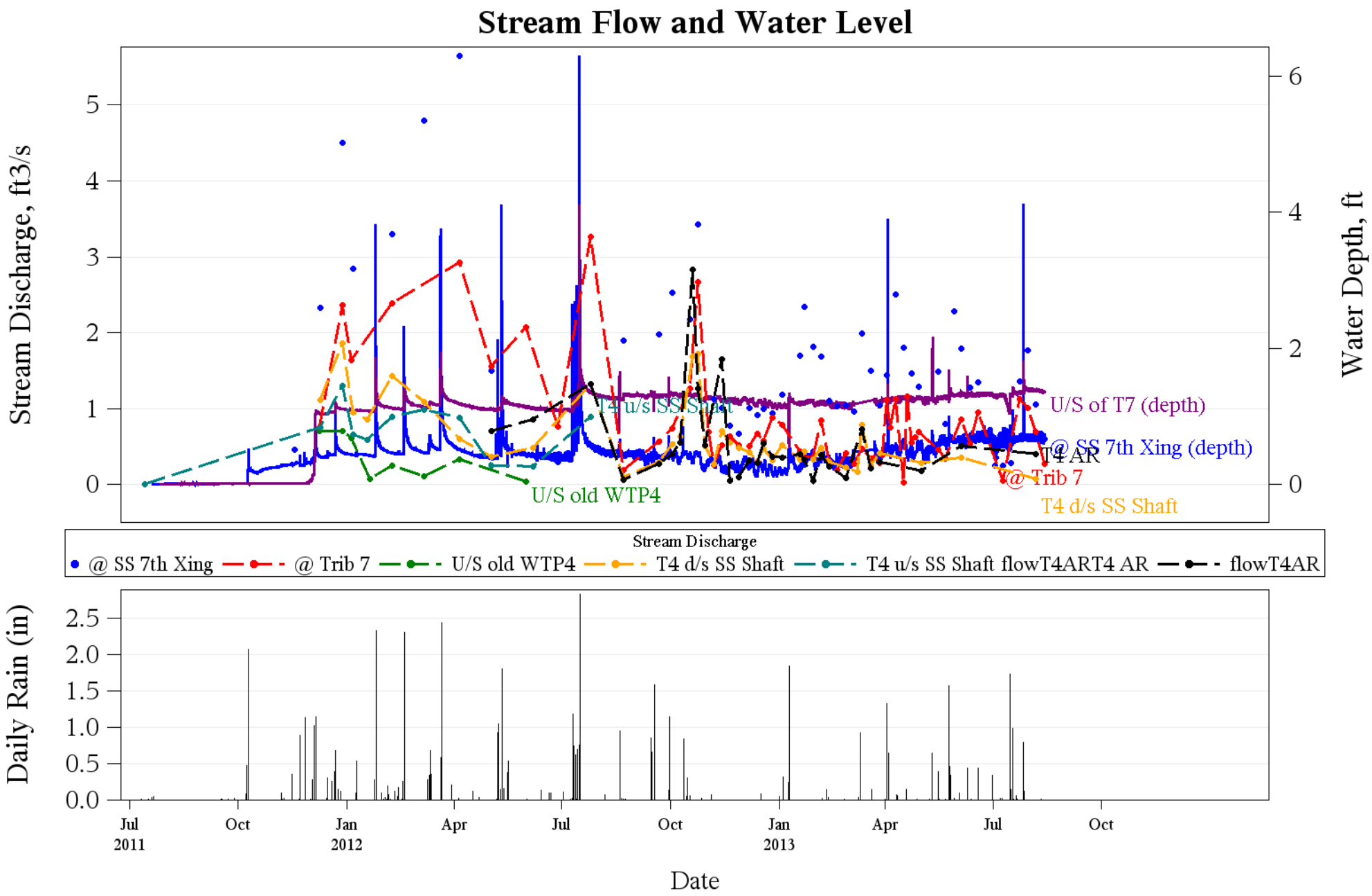
Hydrographs for Wells JT-104A, JT-118, JT-124A, JT-125A and JT-126

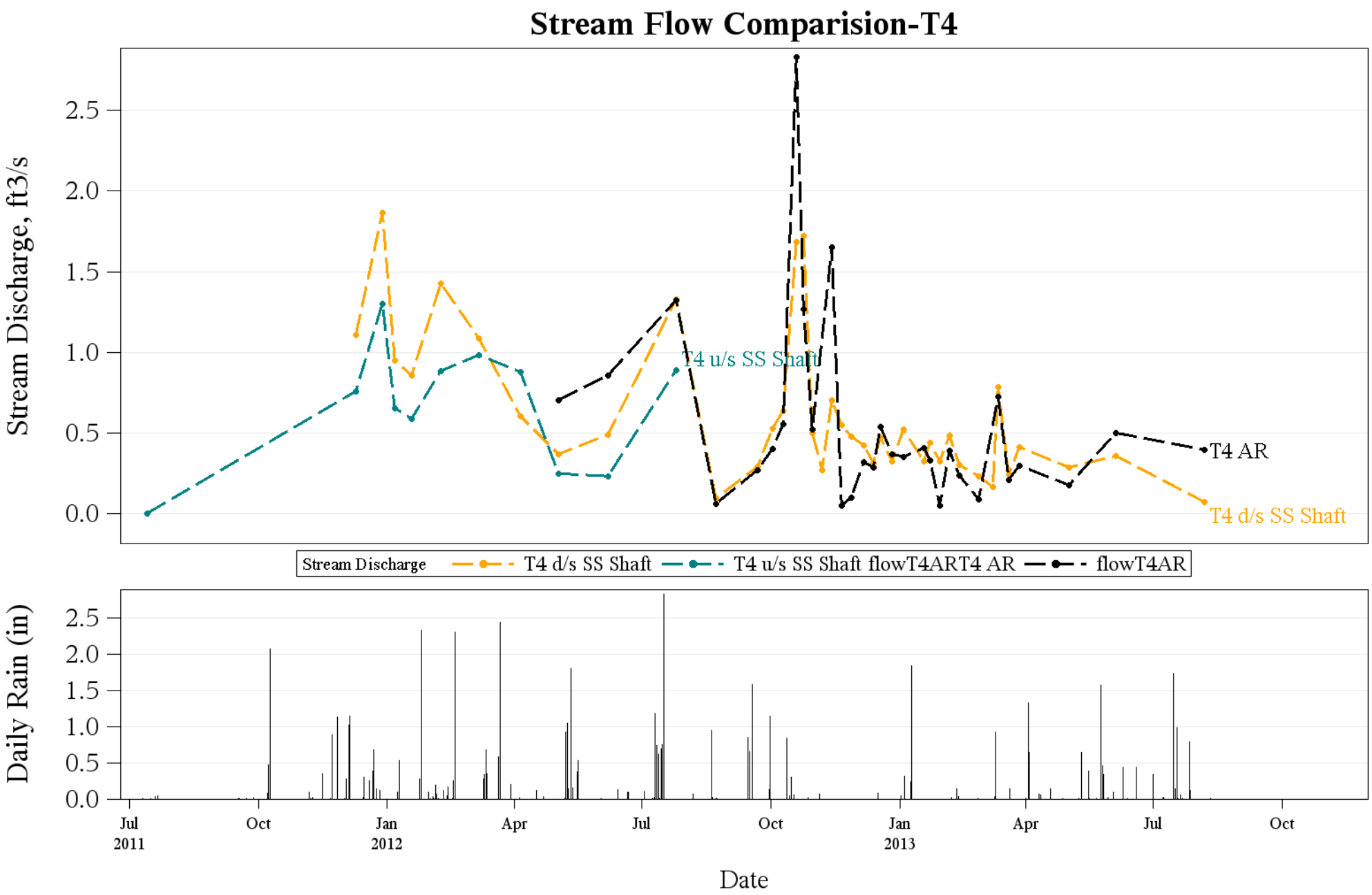


City of Austin DRAFT: QA/QC review pending

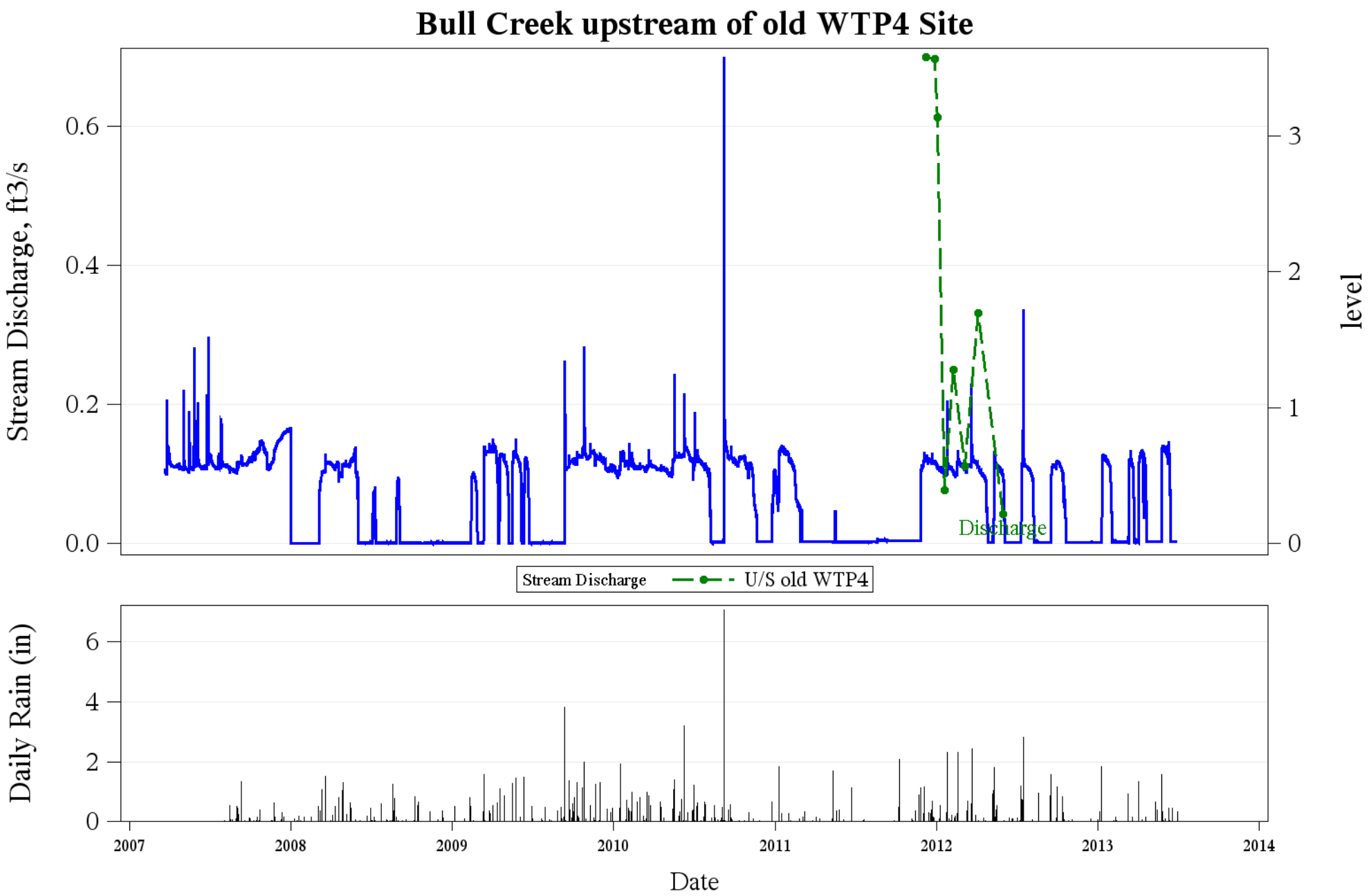


City of Austin DRAFT: QA/QC review pending

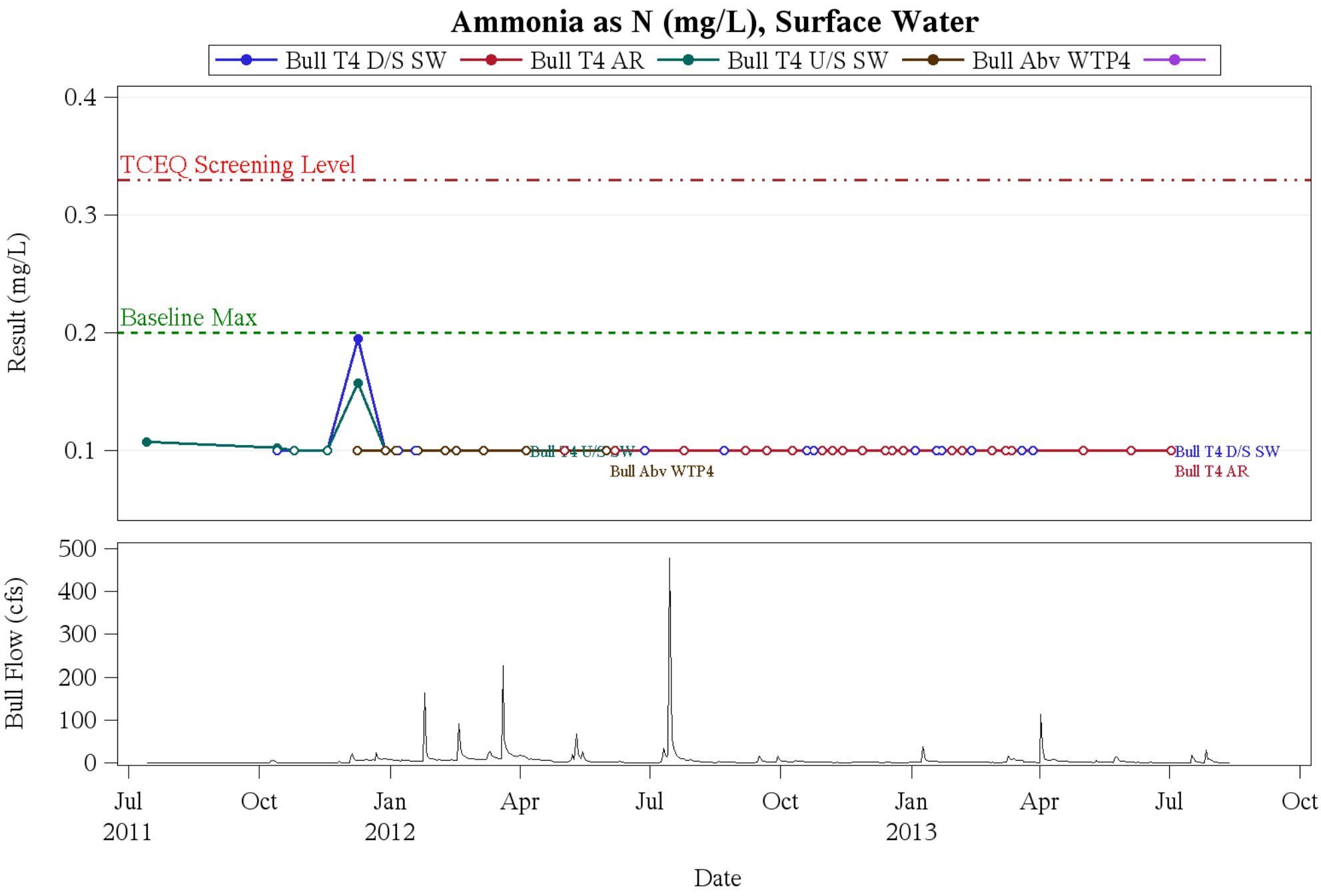

Stream Flow and Water Level
Stream Discharge, ft3/s
Water Depth, ft
0
1
2
3
4
5
0
2
4
6
T4 u/s SS Shaft
U/S of T7 (depth)
@ SS 7th Xing (depth)
T4 AR
@ Trib 7
T4 d/s SS Shaft
U/S old WTP4
Stream Discharge
@ SS 7th Xing
@ Trib 7
U/S old WTP4
T4 d/s SS Shaft
T4 u/s SS Shaft flowT4ART4 AR
flowT4AR
Daily Rain (in)
0.0
0.5
1.0
1.5
2.0
2.5
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

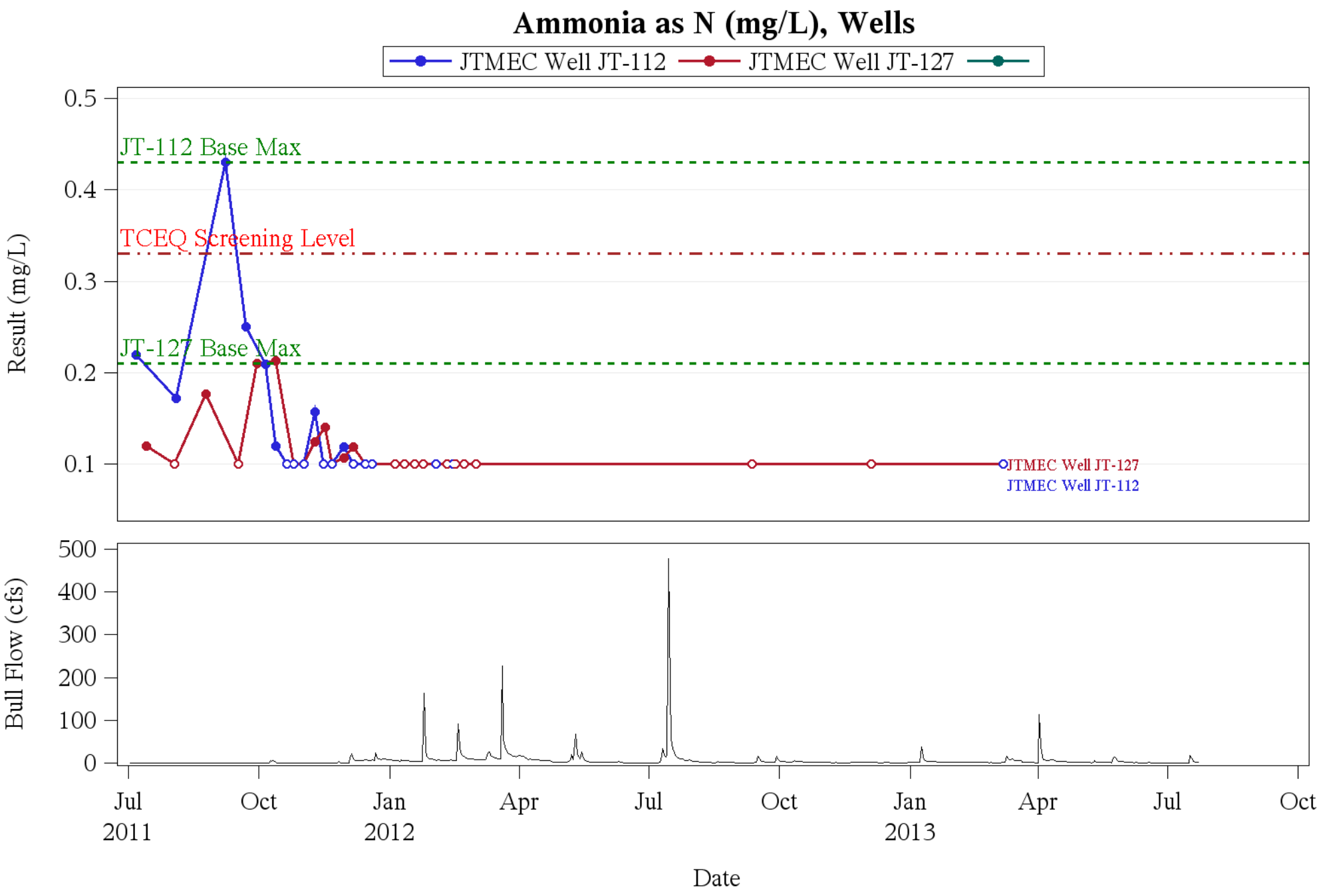


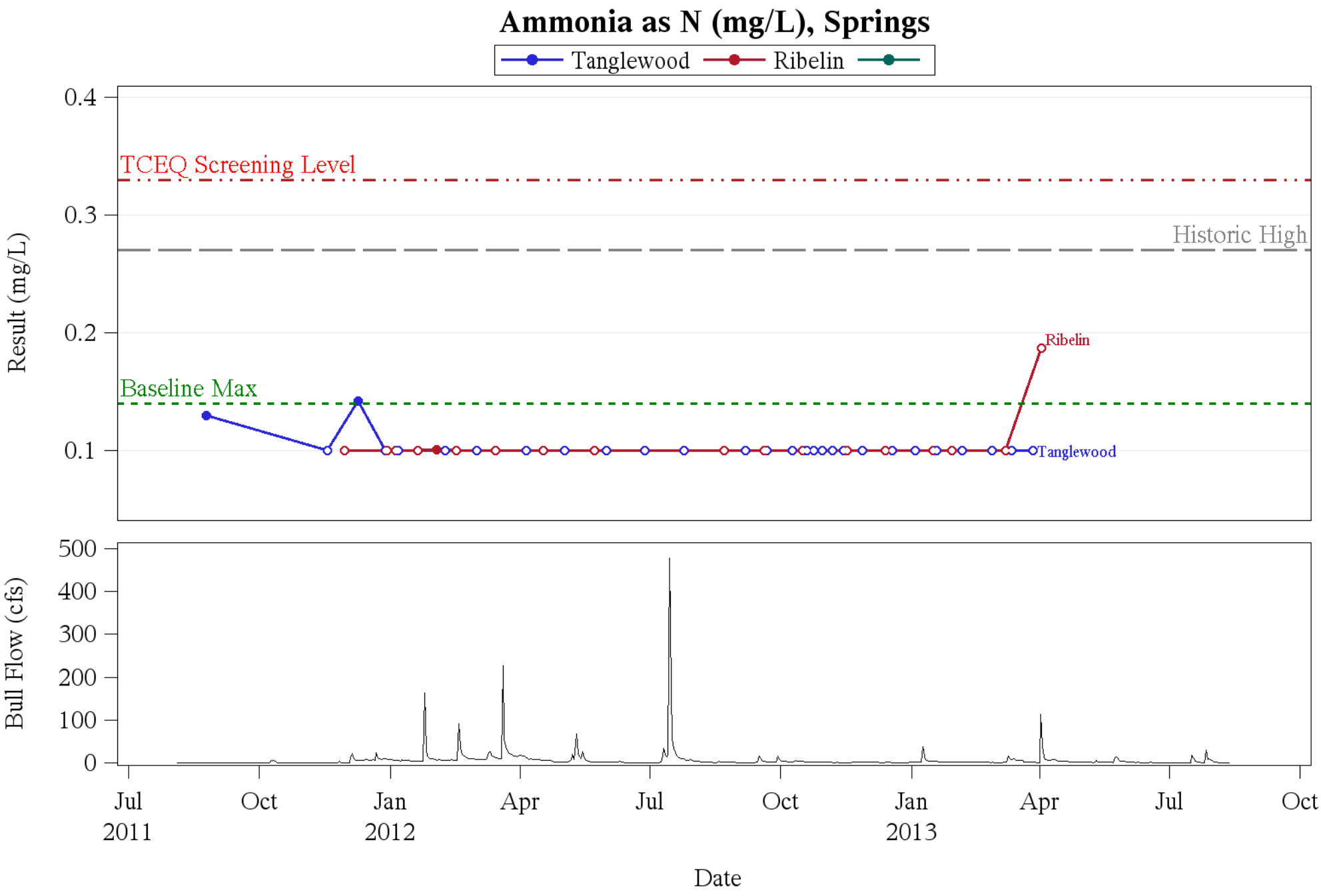
City of Austin DRAFT: QA/QC review pending

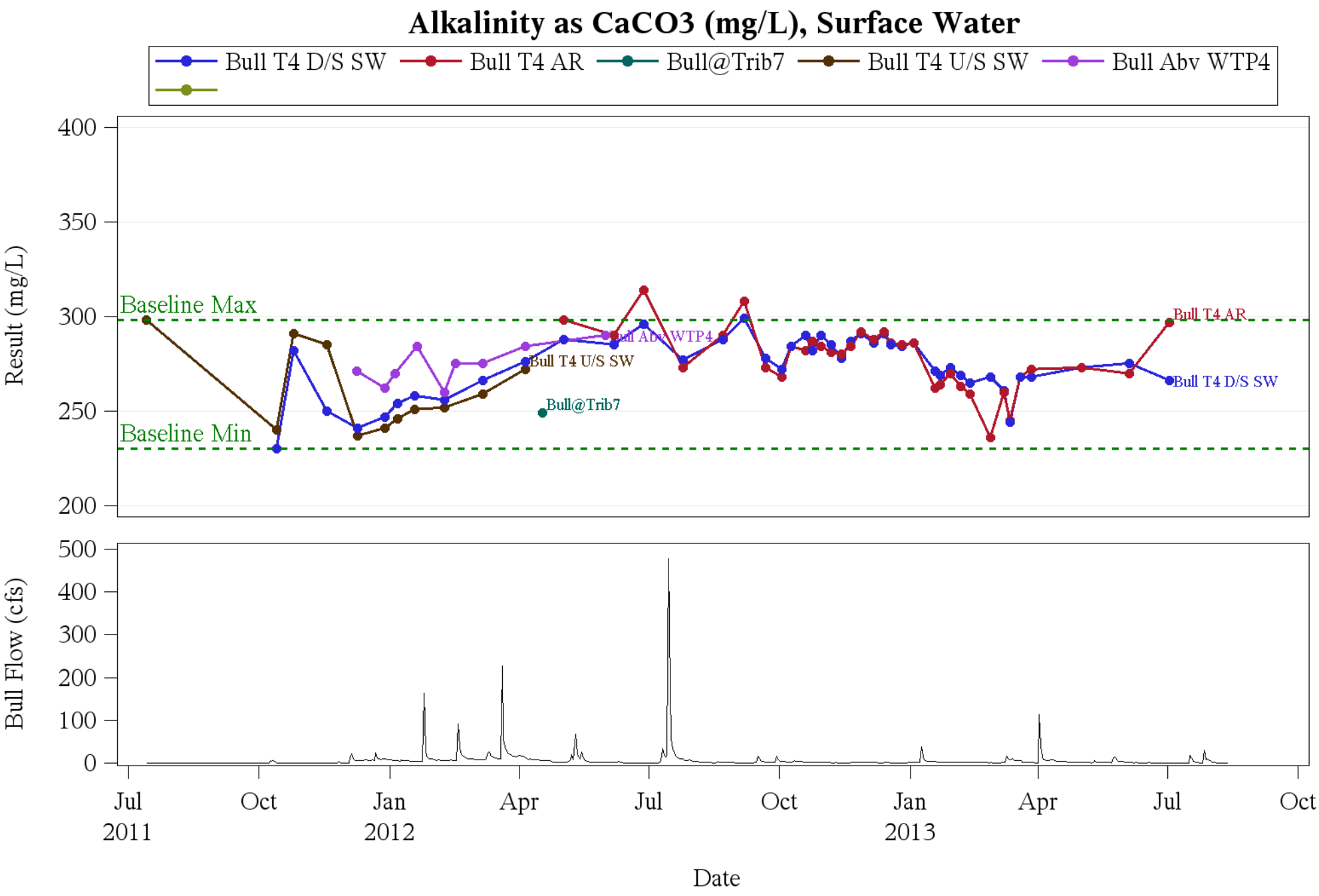


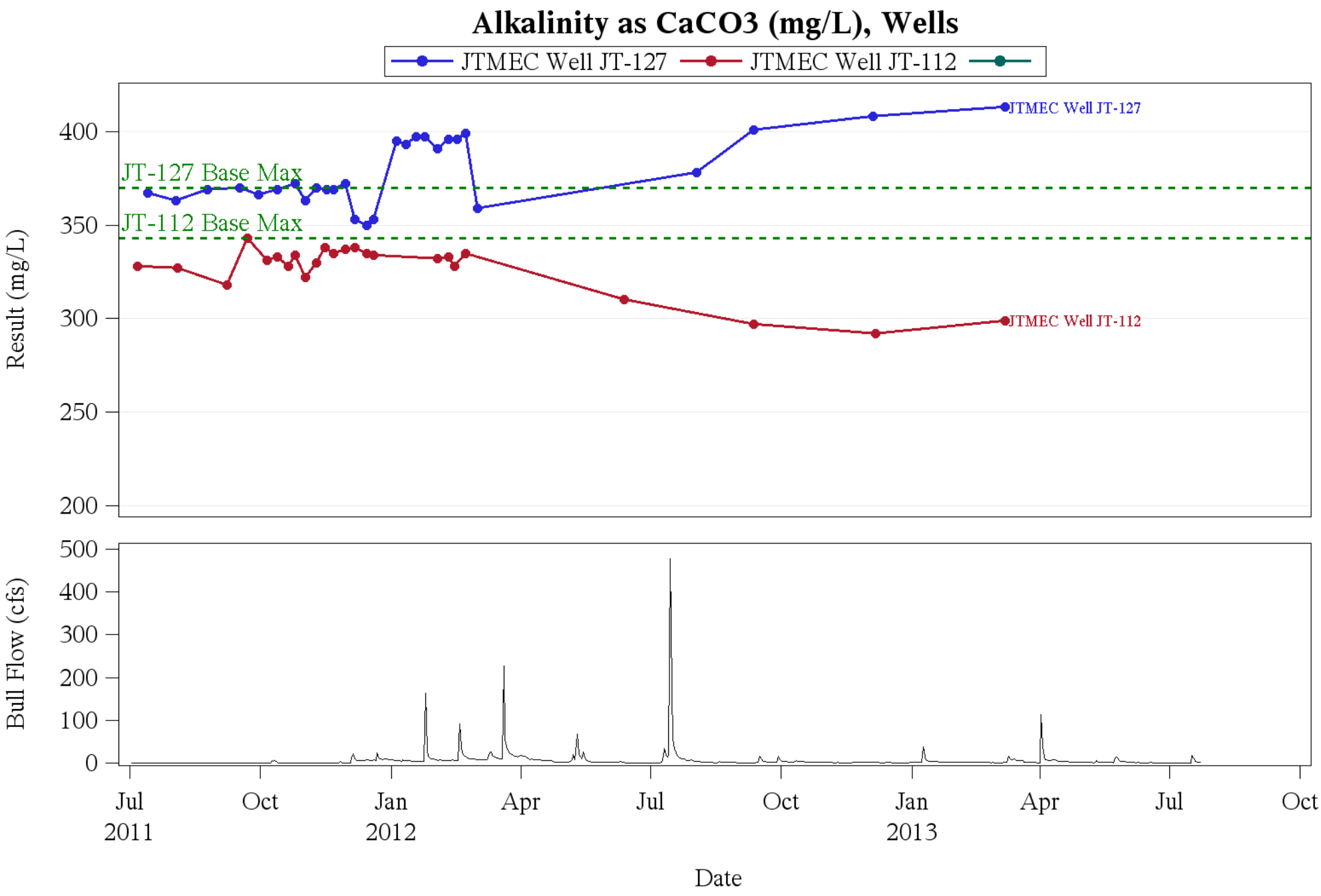
City of Austin DRAFT: QA/QC review pending

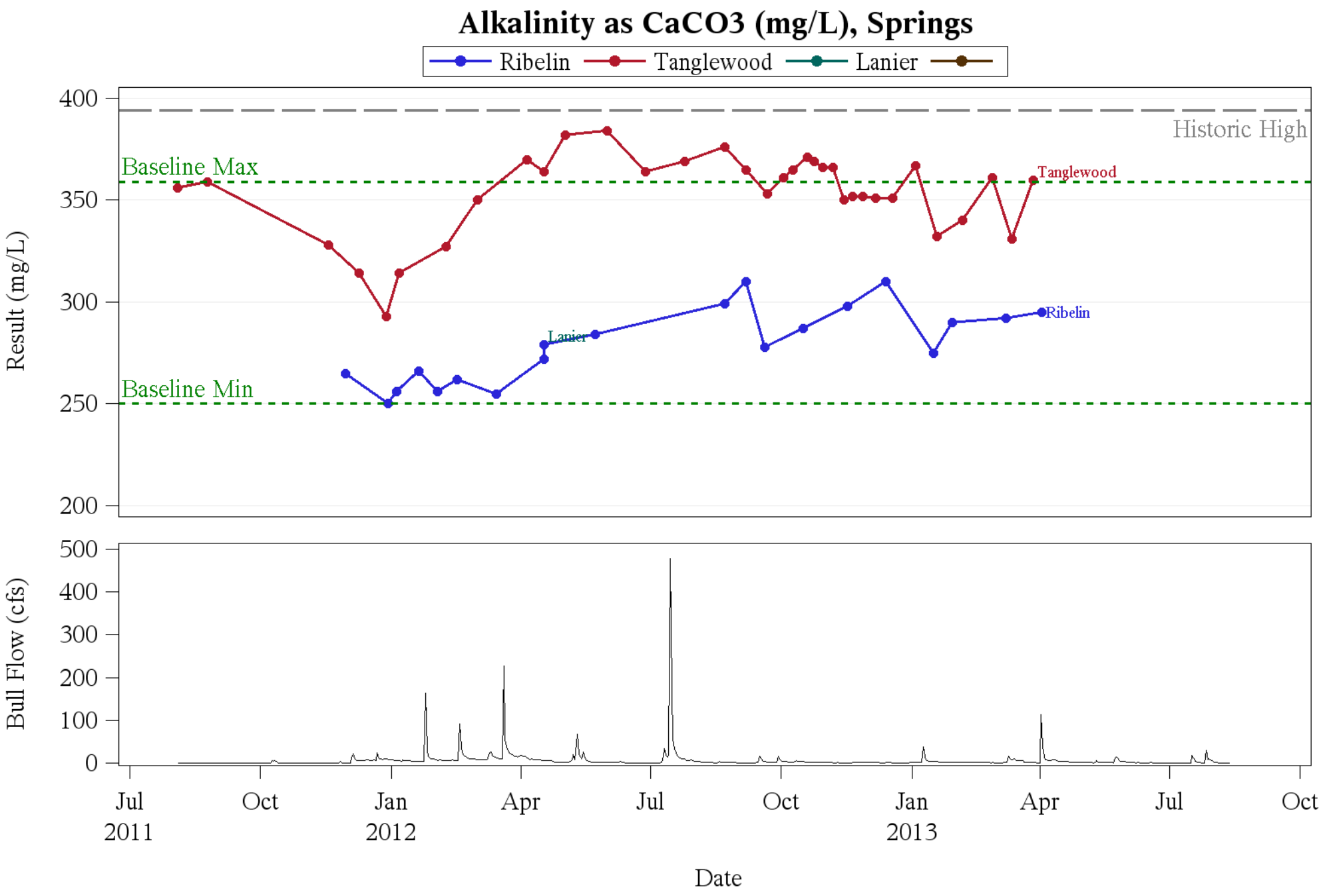

Ammonia as N (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
0.4
0.3
0.2
0.1
TCEQ Screening Level
Baseline Max
Result (mg/L)
Bull T4 U/S SW
Bull Abv WTP4
Bull T4 D/S SW
Bull T4 AR
500
400
300
200
100
0
Bull Flow (cfs)
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

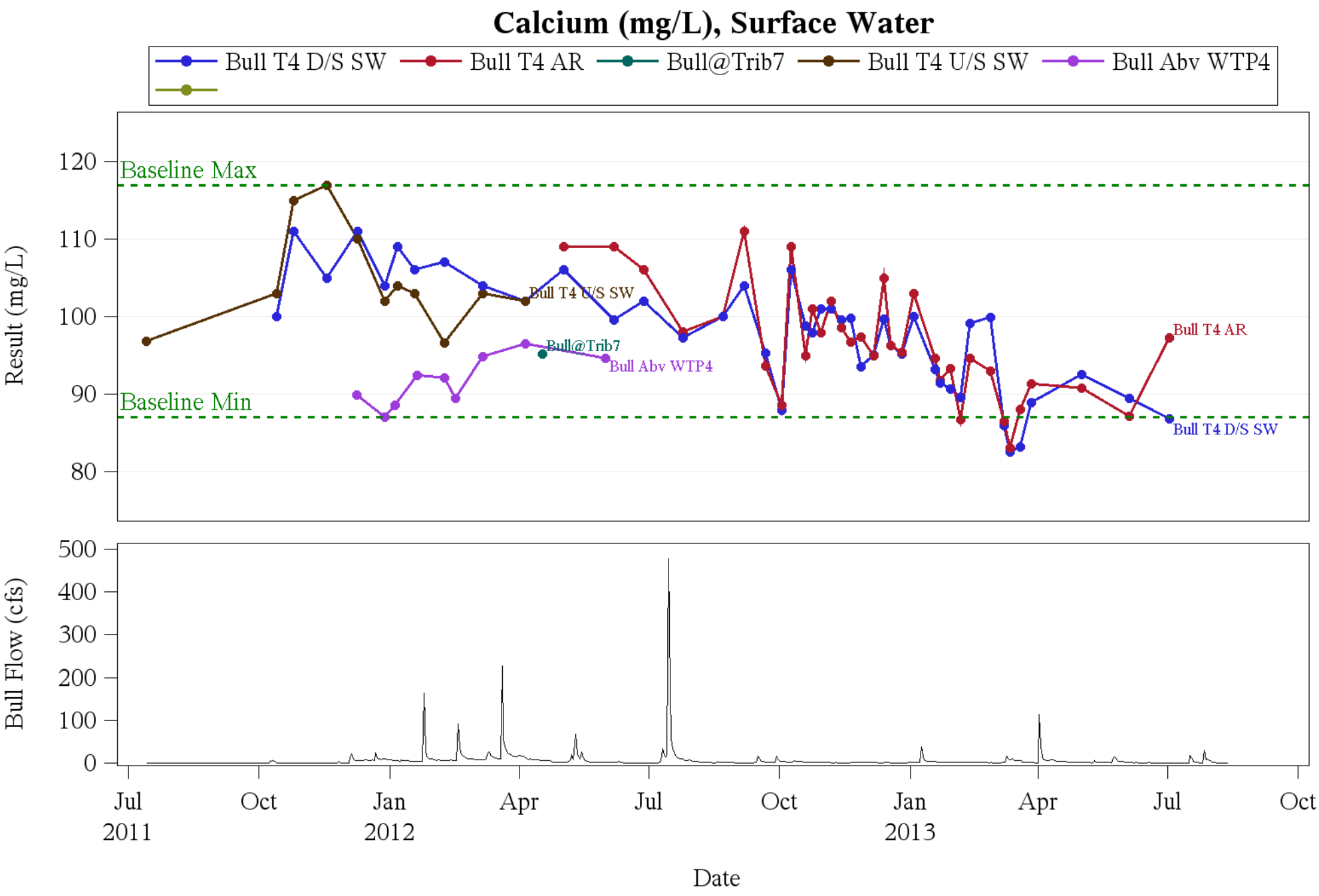

Ammonia as N (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
0.5
0.4
0.3
0.2
0.1
JT-112 Base Max
TCEQ Screening Level
JT-127 Base Max
Result (mg/L)
JTMEC Well JT-127
JTMEC Well JT-112
500
400
300
200
100
0
Bull Flow (cfs)
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

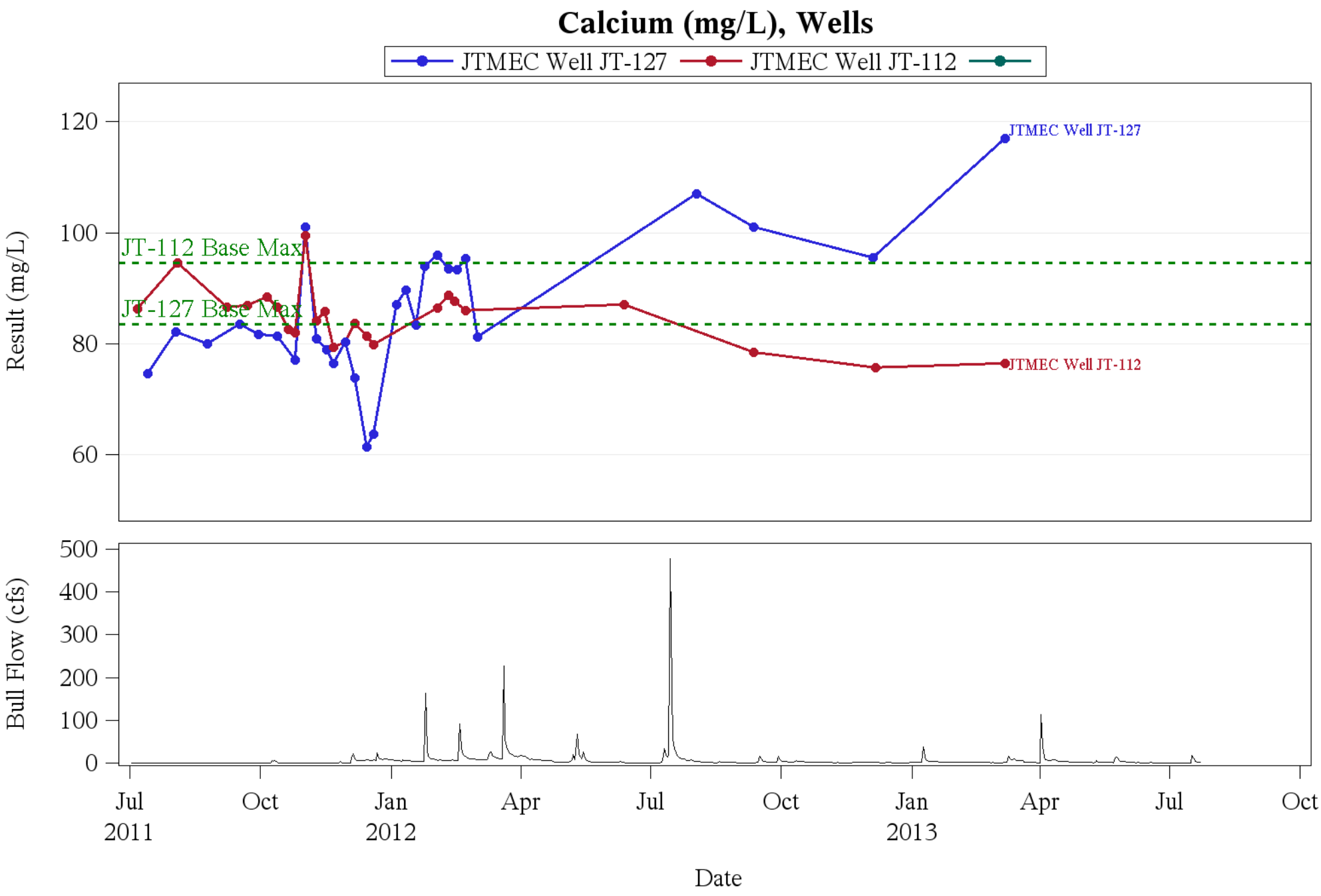

Ammonia as N (mg/L), Springs
Tanglewood
Ribelin
0.4
0.3
0.2
0.1
TCEQ Screening Level
Historic High
Baseline Max
Result (mg/L)
Ribelin
Tanglewood
500
400
300
200
100
0
Bull Flow (cfs)
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

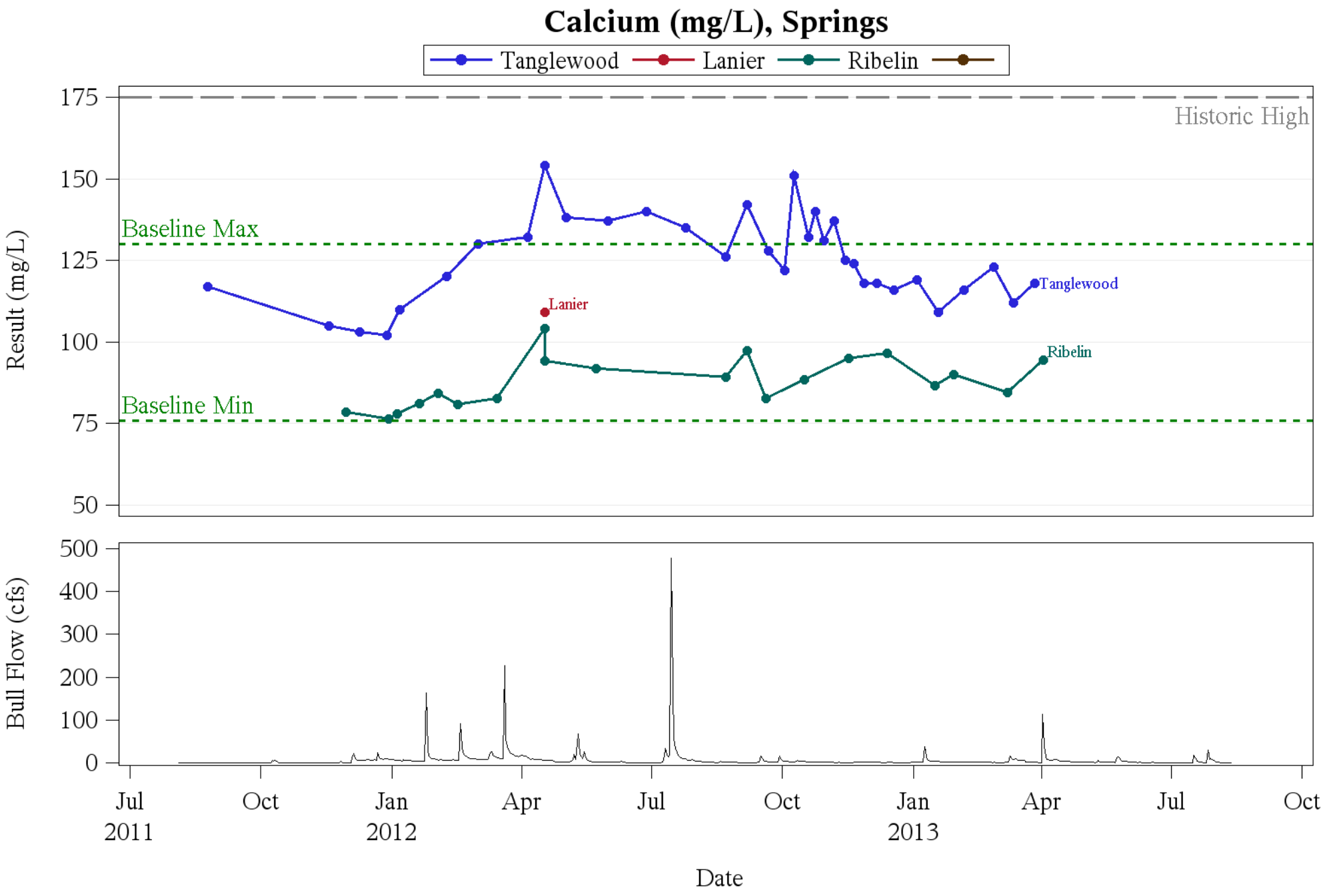

Alkalinity as CaCO3 (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull@Trib7
Bull T4 U/S SW
Bull Abv WTP4
Result (mg/L)
400
350
300
250
200
Baseline Max
Baseline Min
Bull T4 AR
Bull Abv WTP4
Bull T4 U/S SW
Bull@Trib7
Bull T4 D/S SW
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

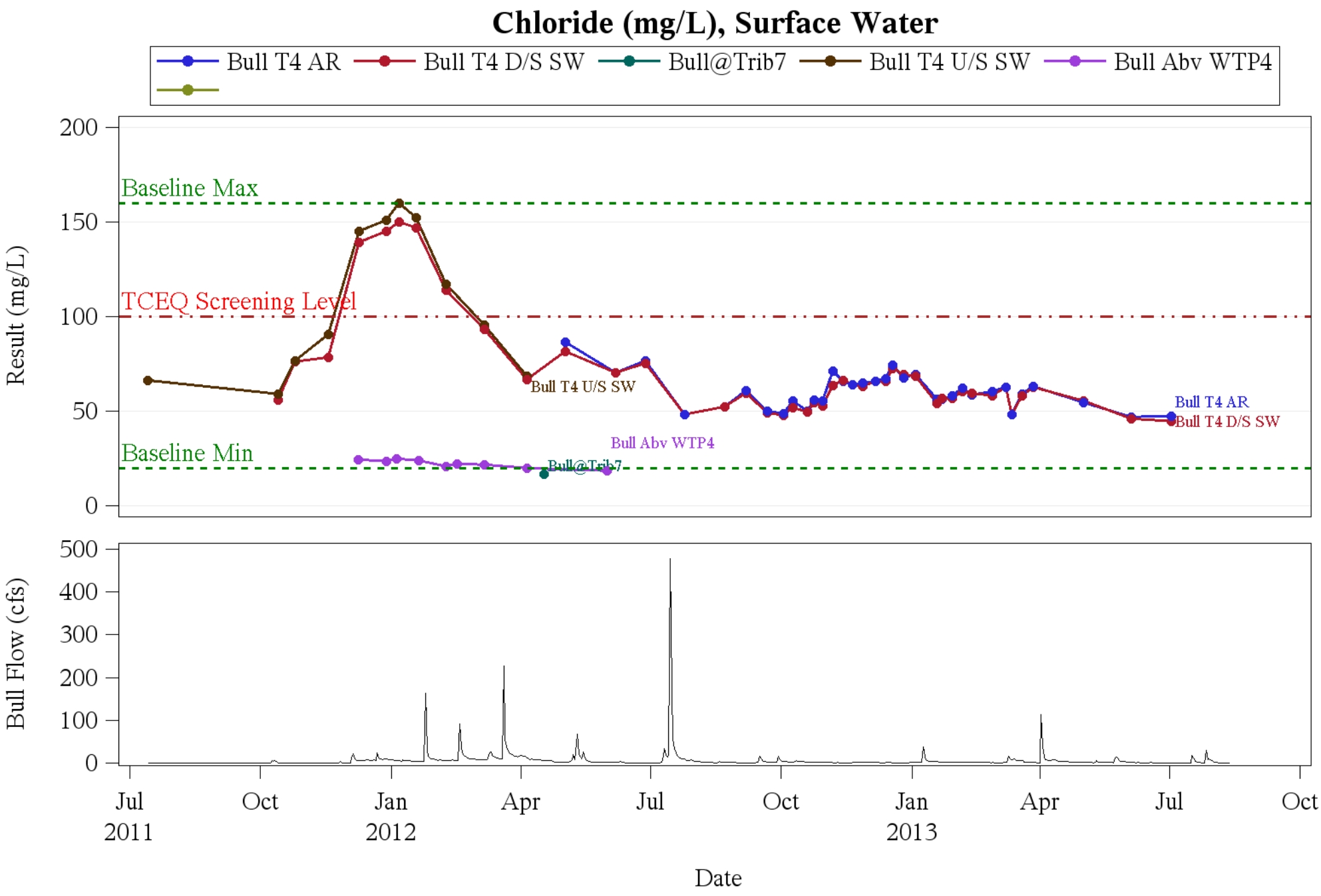

Alkalinity as CaCO3 (mg/L), Wells
JTMEC Well JT-127
JTMEC Well JT-112
JT-127 Base Max
JT-112 Base Max
Result (mg/L)
400
350
300
250
200
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

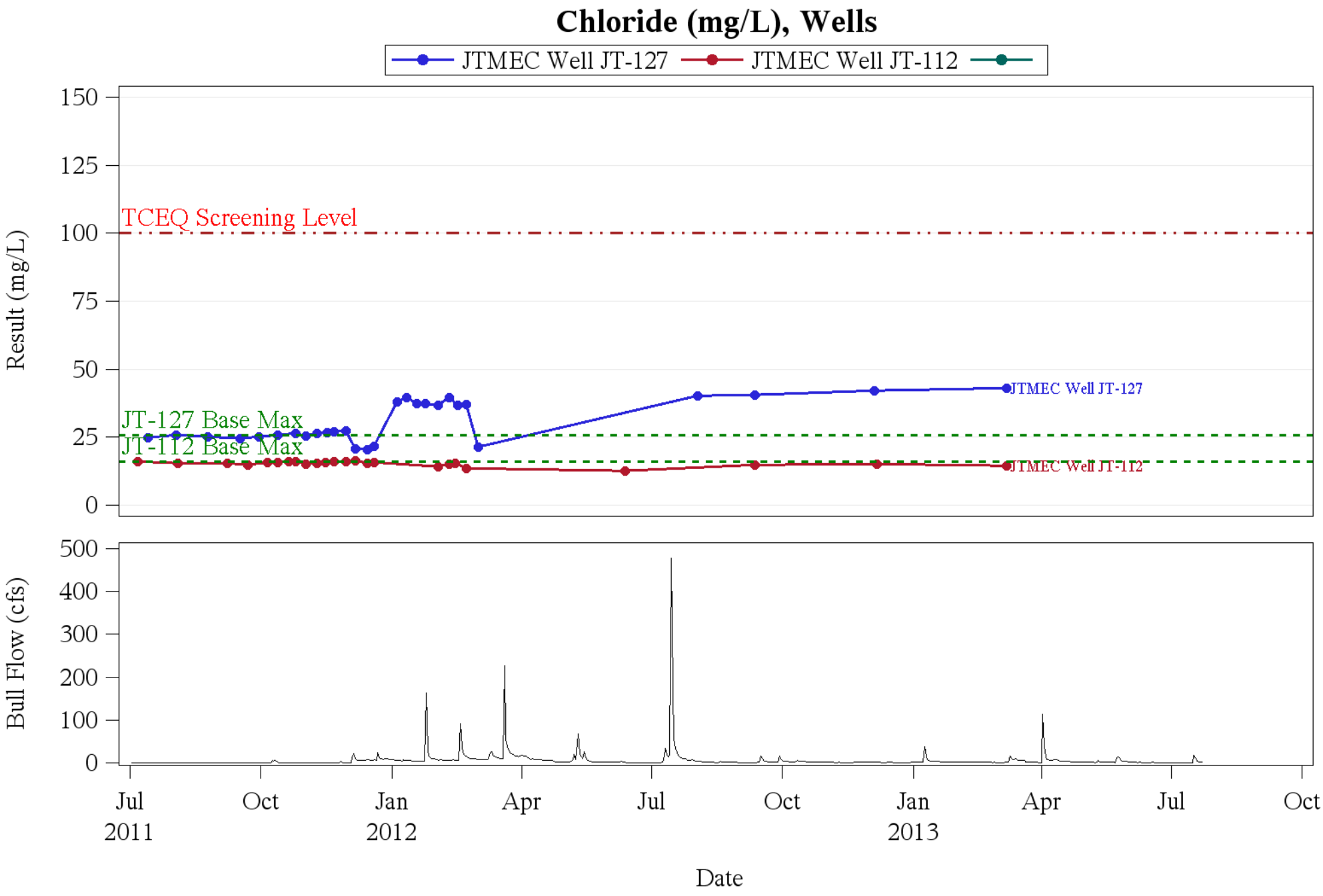

Alkalinity as CaCO3 (mg/L), Springs
Ribelin
Tanglewood
Lanier
Historic High
Baseline Max
Baseline Min
Tanglewood
Ribelin
Lanier
Result (mg/L)
400
350
300
250
200
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

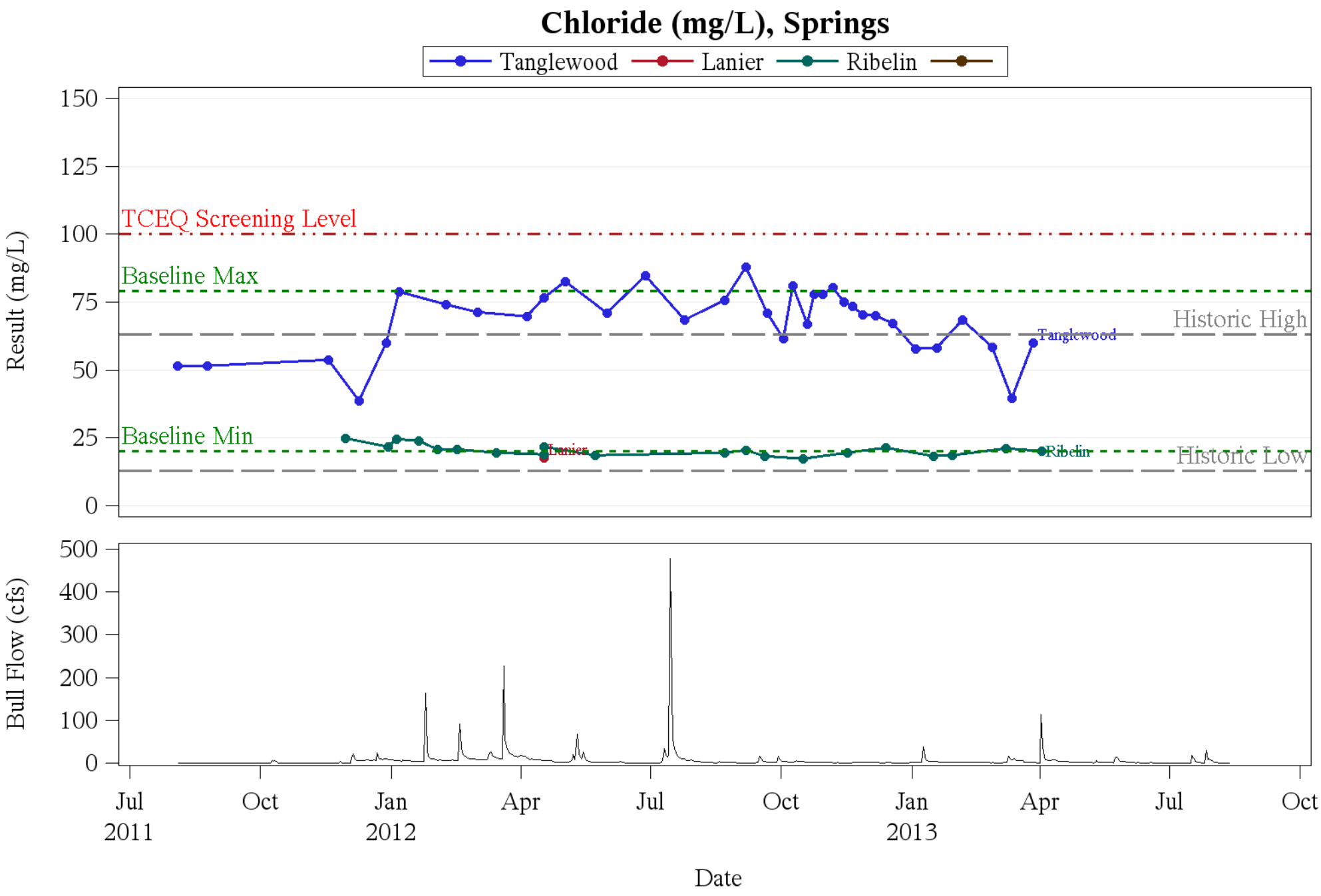

Calcium (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull@Trib7
Bull T4 U/S SW
Bull Abv WTP4
Result (mg/L)
120
110
100
90
80
Baseline Max
Baseline Min
Bull T4 U/S SW
Bull@Trib7
Bull Abv WTP4
Bull T4 AR
Bull T4 D/S SW
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

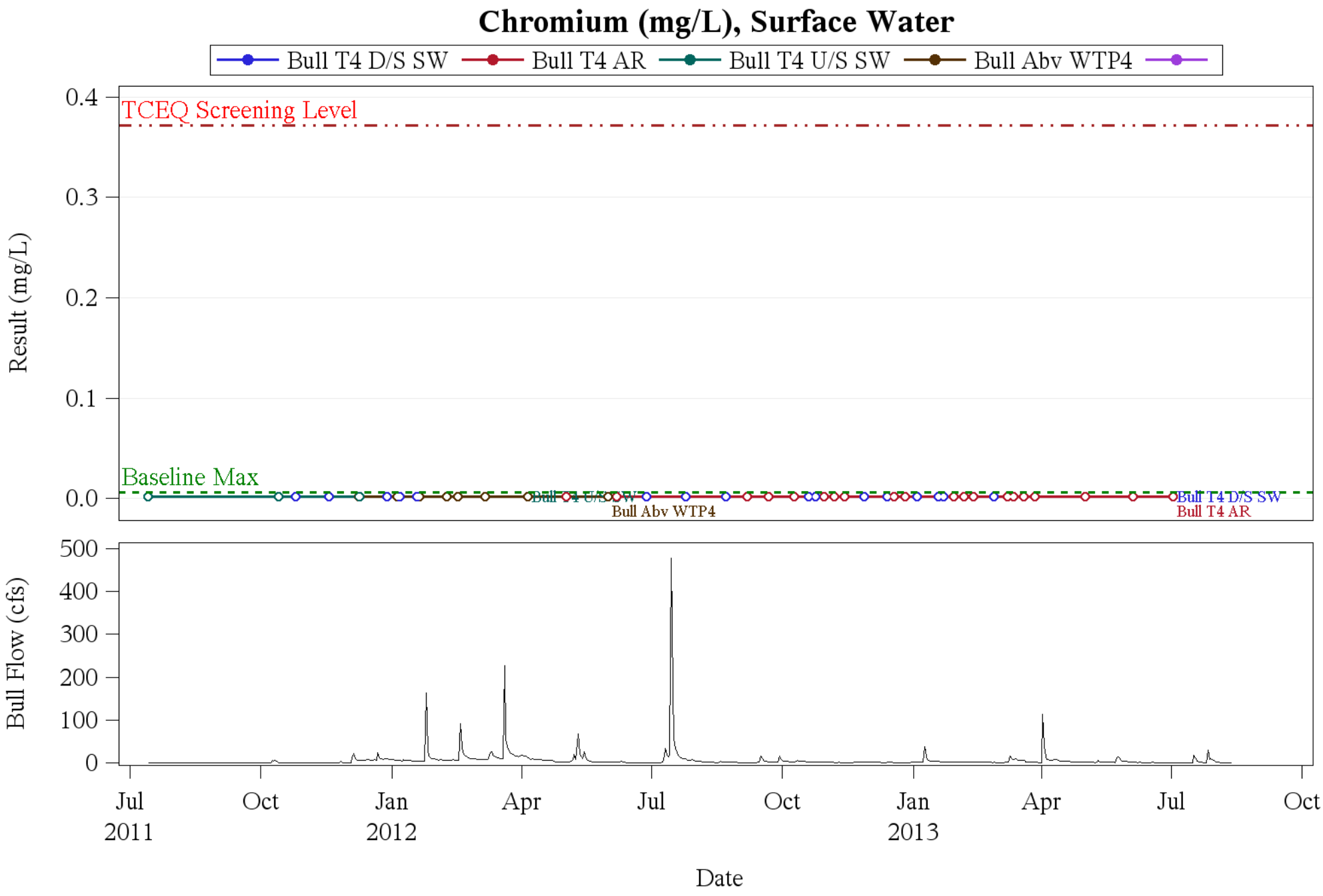

Calcium (mg/L), Wells
JTMEC Well JT-127
JTMEC Well JT-112
Result (mg/L)
120
100
80
60
JT-112 Base Max
JT-127 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

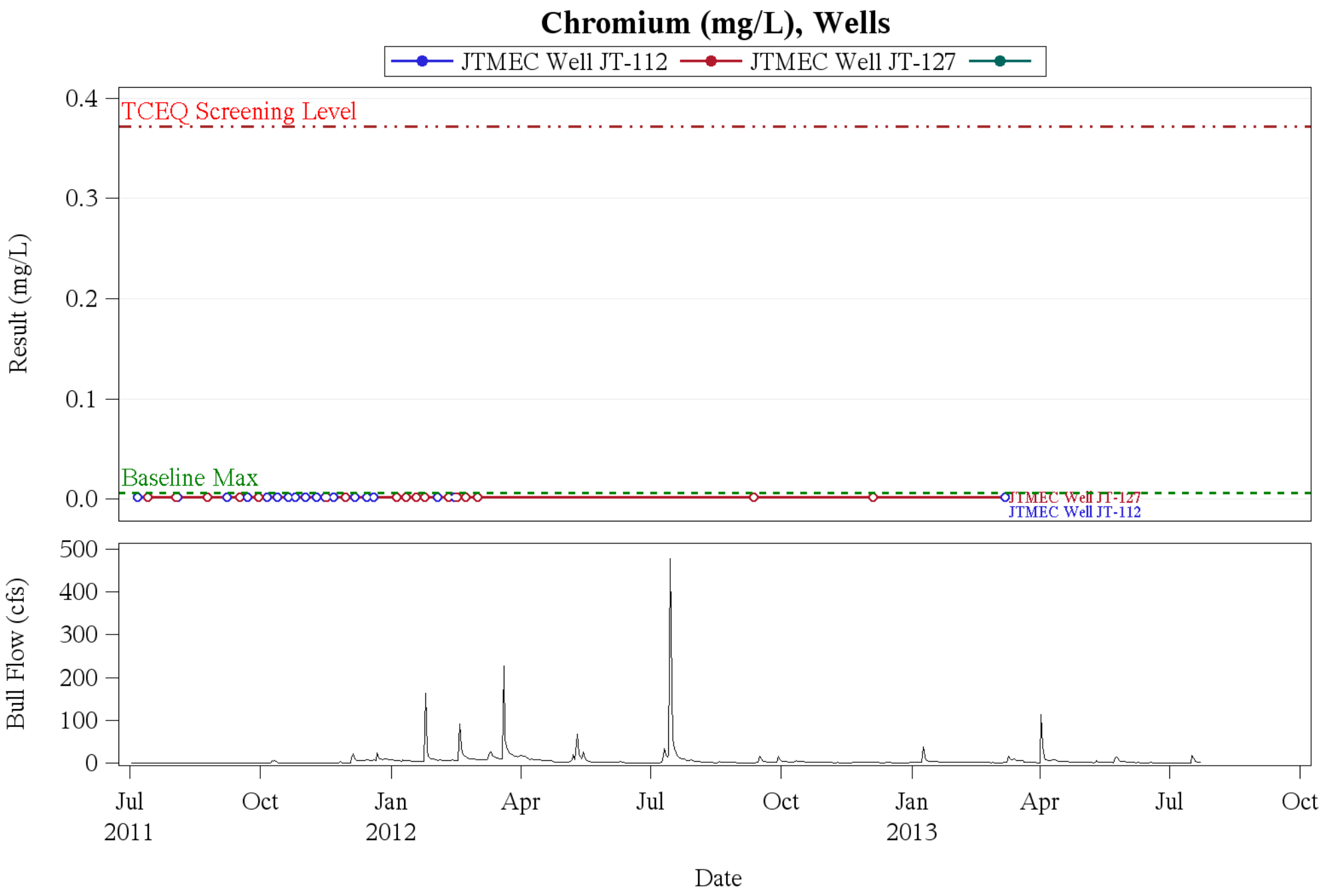

Calcium (mg/L), Springs
Tanglewood
Lanier
Ribelin
Result (mg/L)
175
150
125
100
75
50
Historic High
Baseline Max
Baseline Min
Tanglewood
Lanier
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

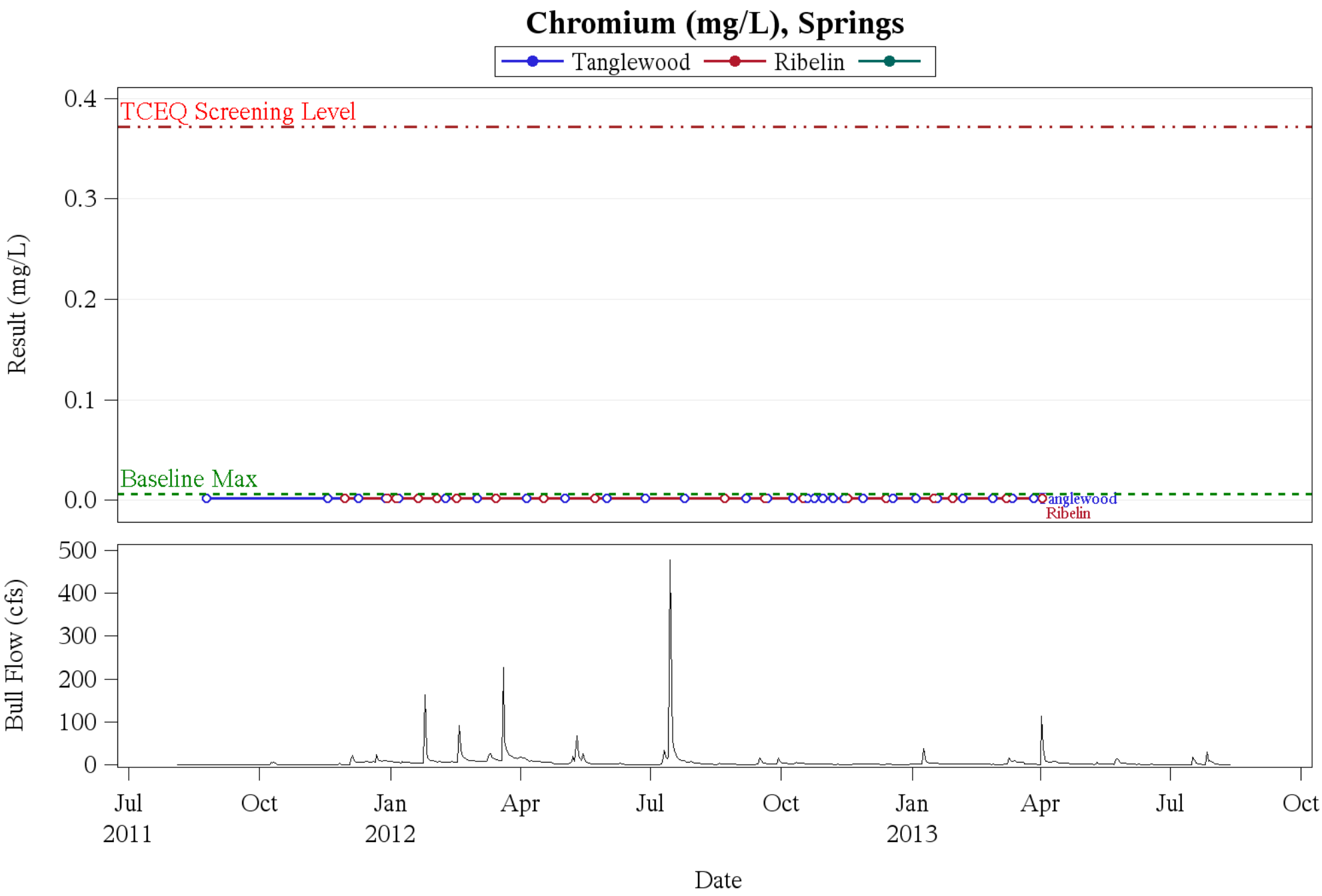

Chloride (mg/L), Surface Water
Bull T4 AR
Bull T4 D/S SW
Bull@Trib7
Bull T4 U/S SW
Bull Abv WTP4
Baseline Max
TCEQ Screening Level
Baseline Min
Result (mg/L)
Bull Flow (cfs)
Date
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct

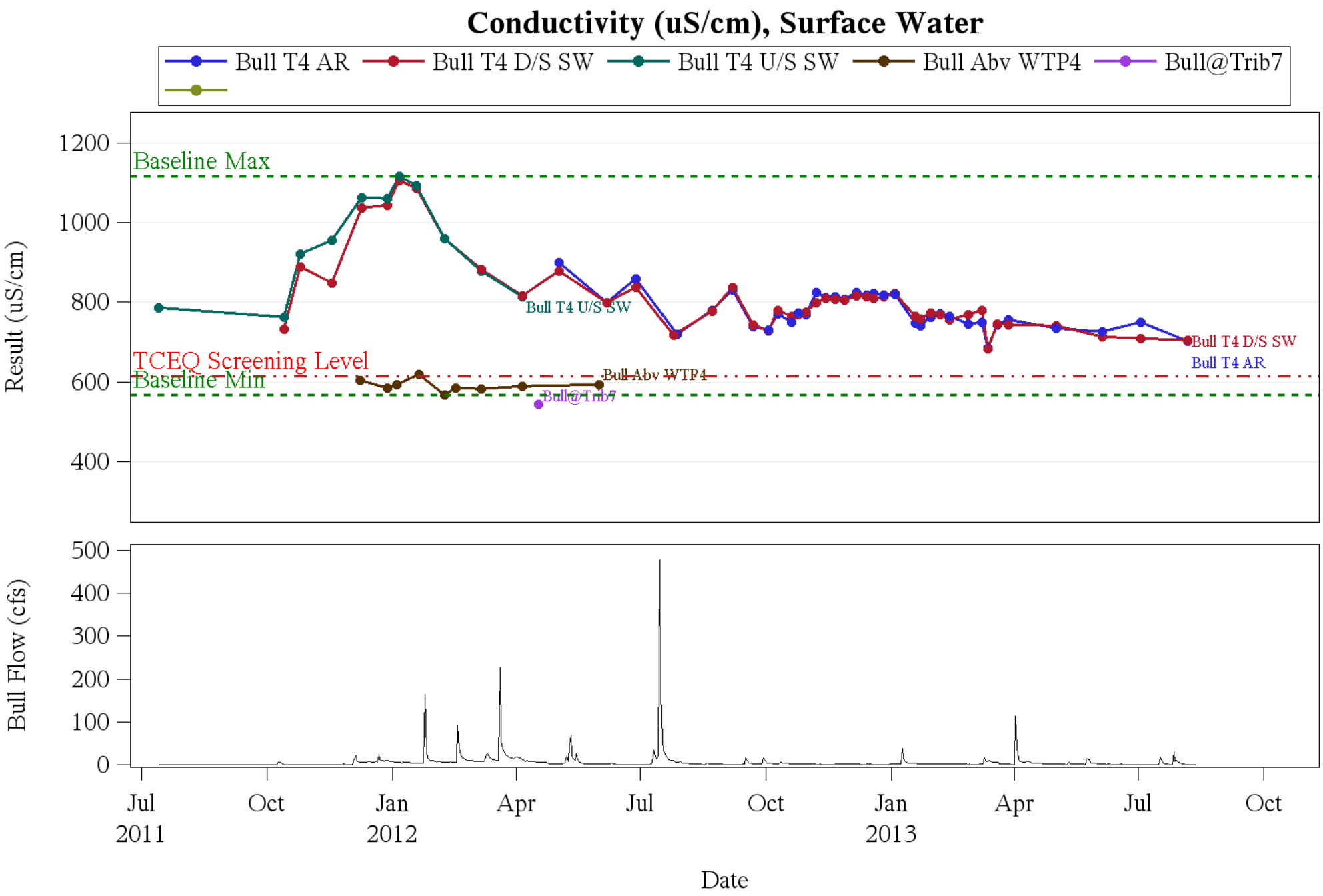

Chloride (mg/L), Wells
JTMEC Well JT-127
JTMEC Well JT-112
Result (mg/L)
150
125
100
75
50
25
0
TCEQ Screening Level
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

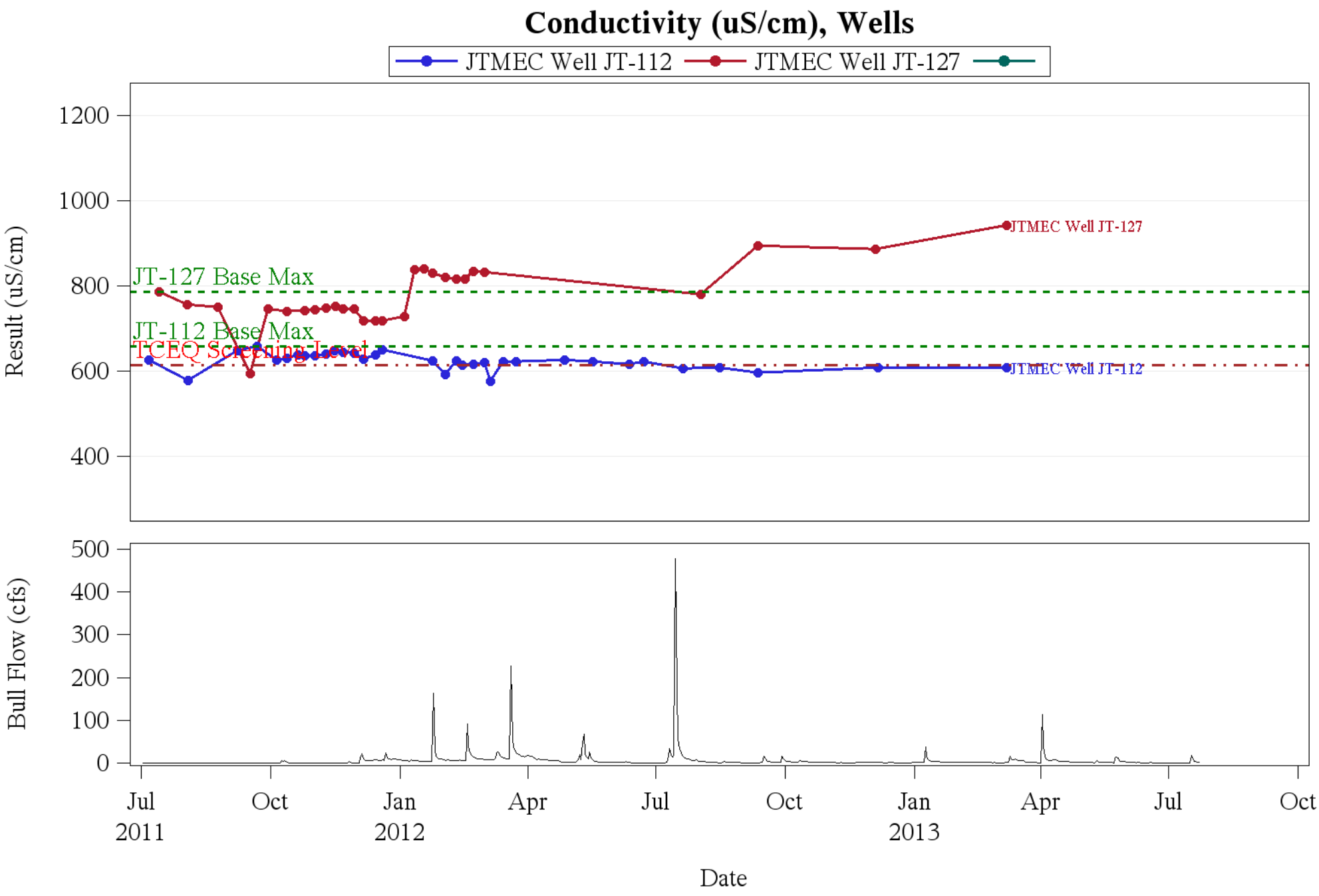

Chloride (mg/L), Springs
Tanglewood
Lanier
Ribelin
150
125
100
75
50
25
0
Result (mg/L)
TCEQ Screening Level
Baseline Max
Baseline Min
Historic High
Historic Low
Tanglewood
Lanier
Ribelin
500
400
300
200
100
0
Bull Flow (cfs)
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

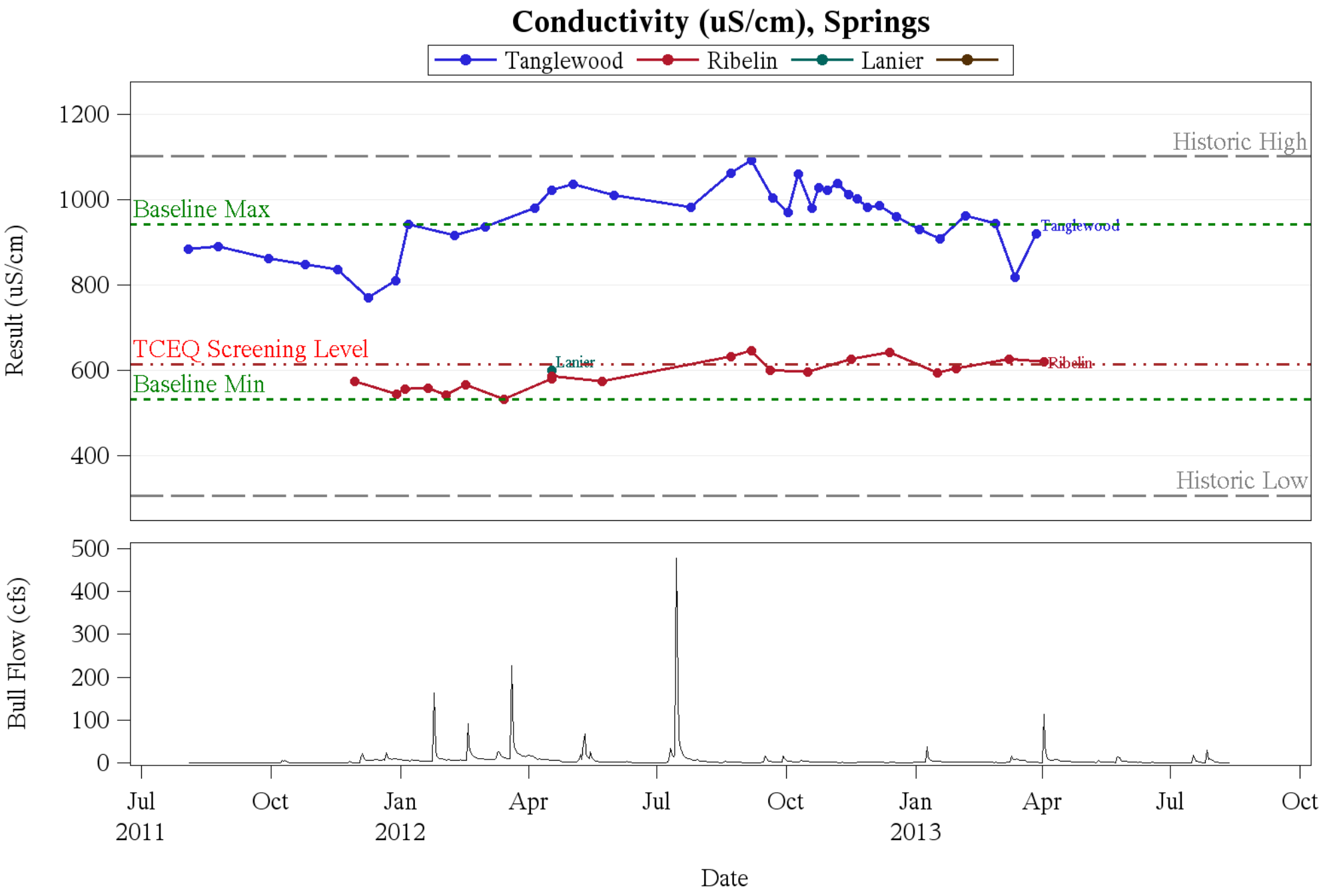

Chromium (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.4
0.3
0.2
0.1
0.0
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

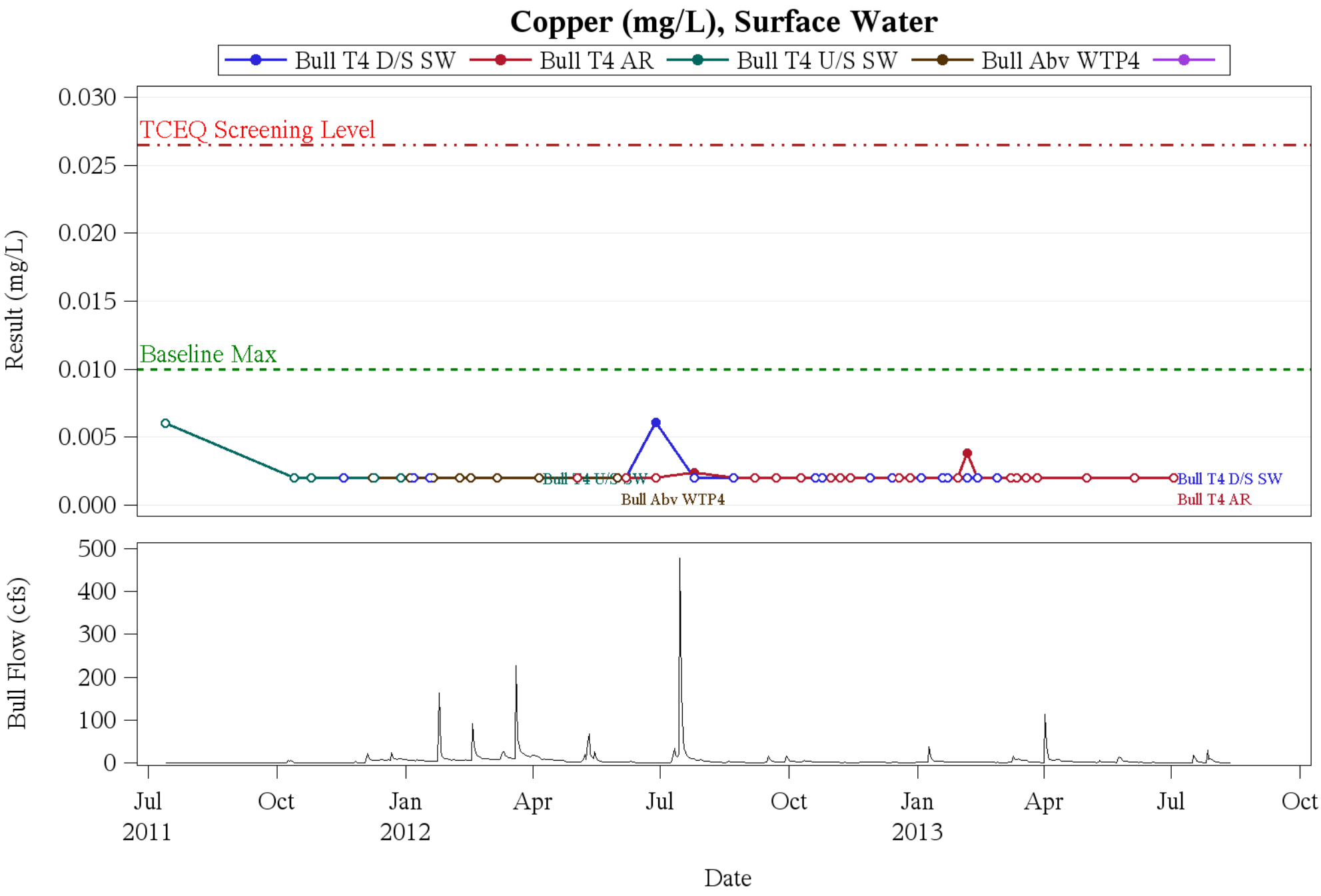

Chromium (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.4
0.3
0.2
0.1
0.0
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

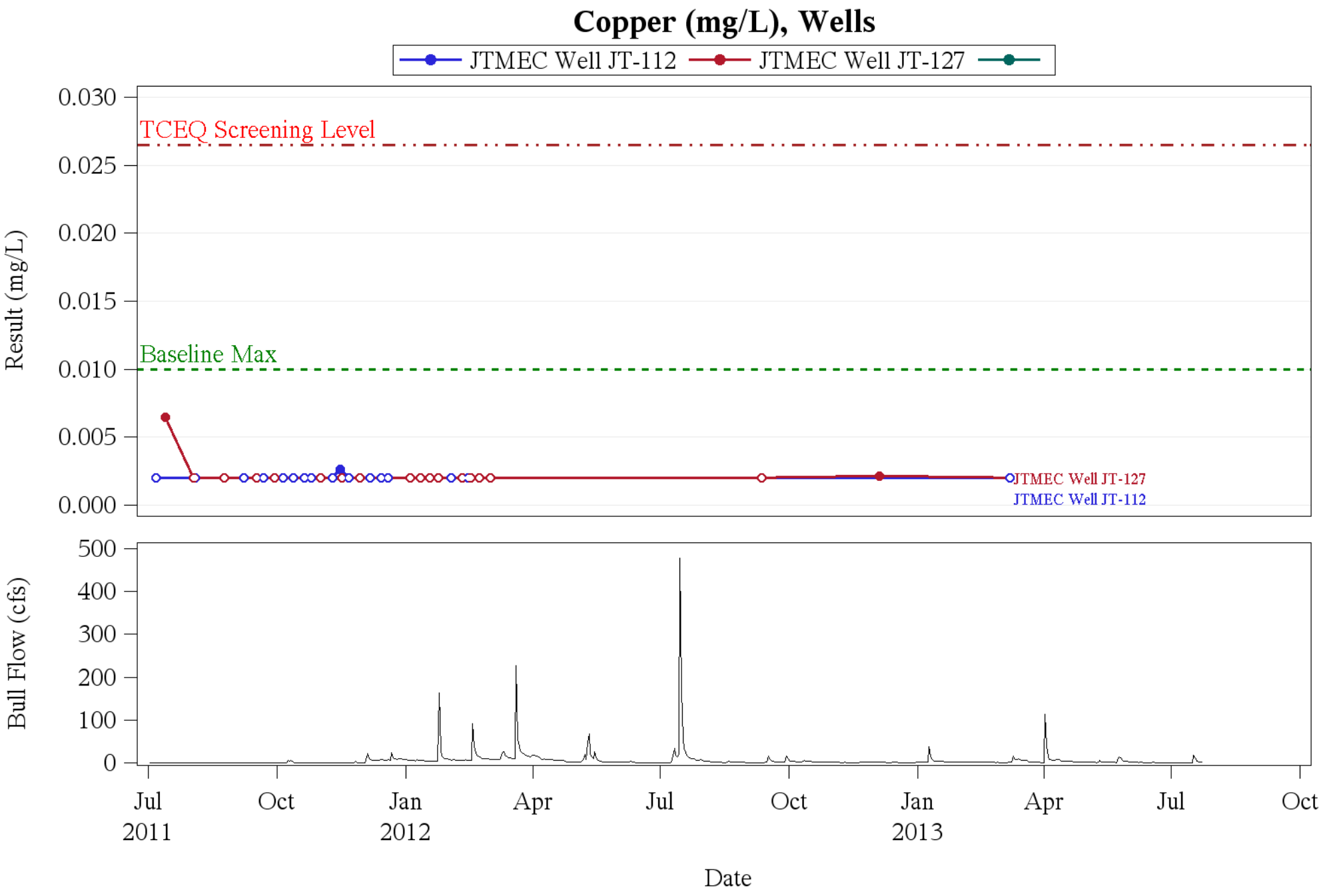

Chromium (mg/L), Springs
Tanglewood
Ribelin
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.4
0.3
0.2
0.1
0.0
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

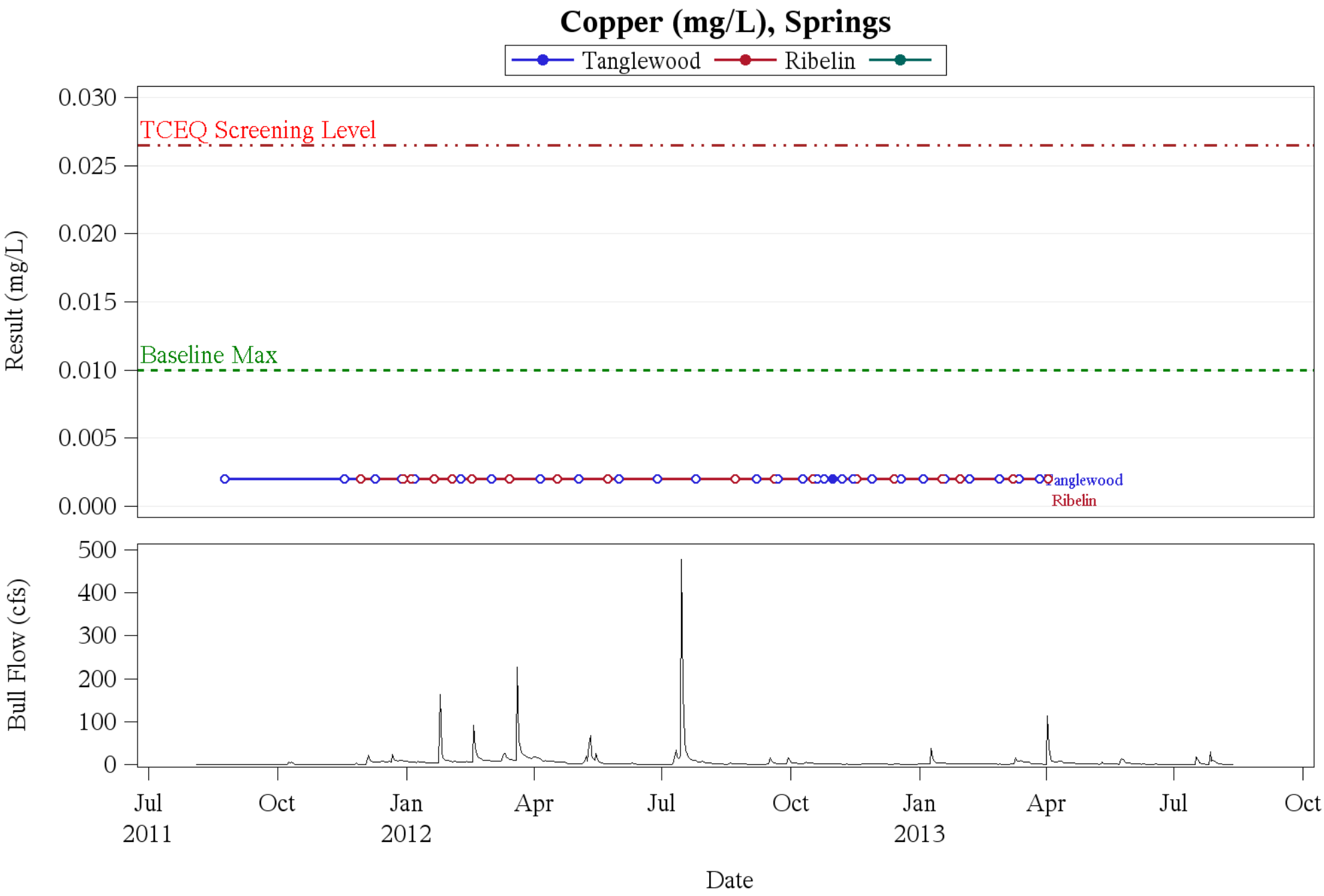

Conductivity (uS/cm), Surface Water
Bull T4 AR
Bull T4 D/S SW
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Result (uS/cm)
1200
1000
800
600
400
Baseline Max
TCEQ Screening Level
Baseline Min
Bull T4 U/S SW
Bull T4 D/S SW
Bull T4 AR
Bull Abv WTP4
Bull@Trib7
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

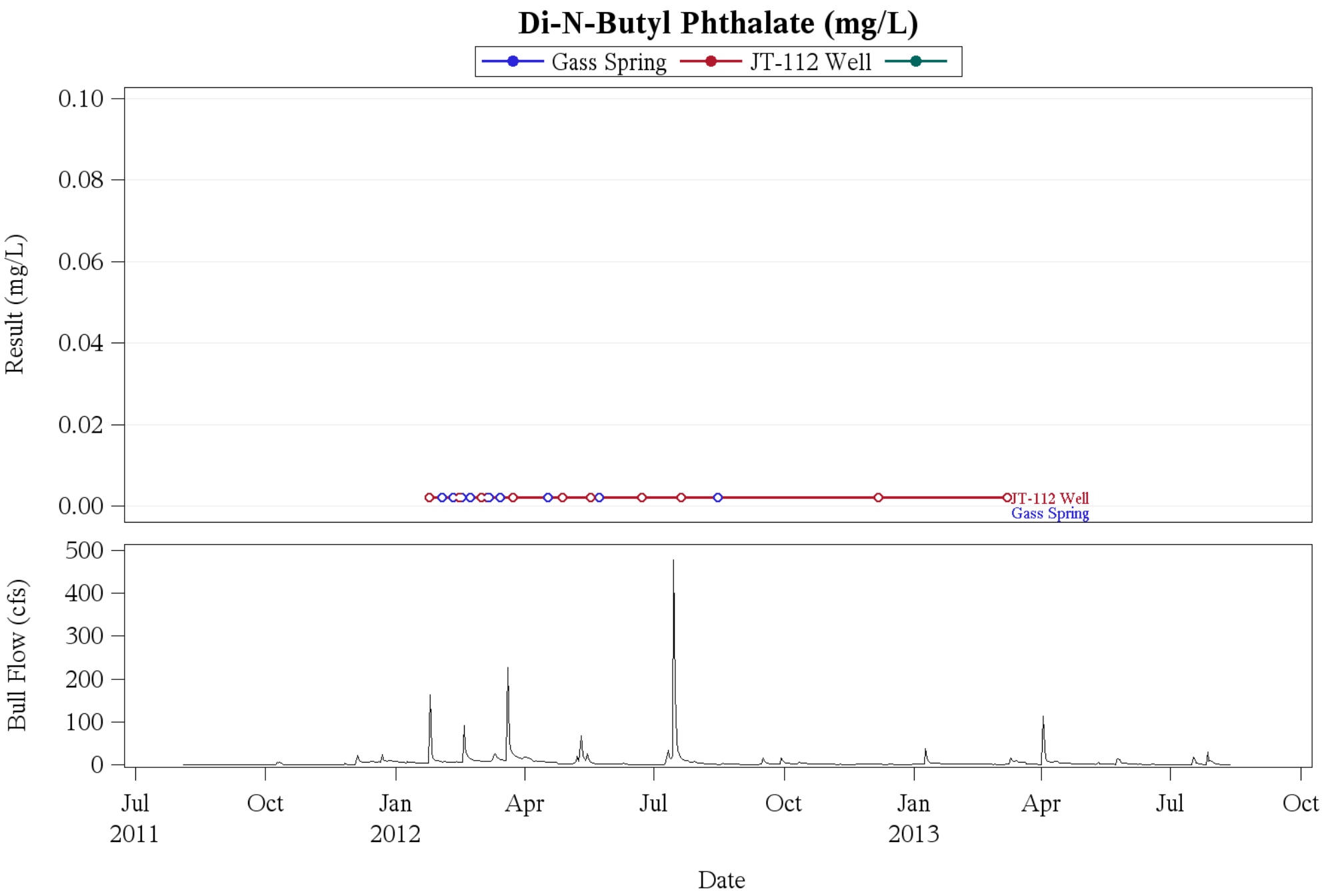

Conductivity (uS/cm), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (uS/cm)
1200
1000
800
600
400
JT-127 Base Max
JT-112 Base Max
TCEQ Screening Level
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

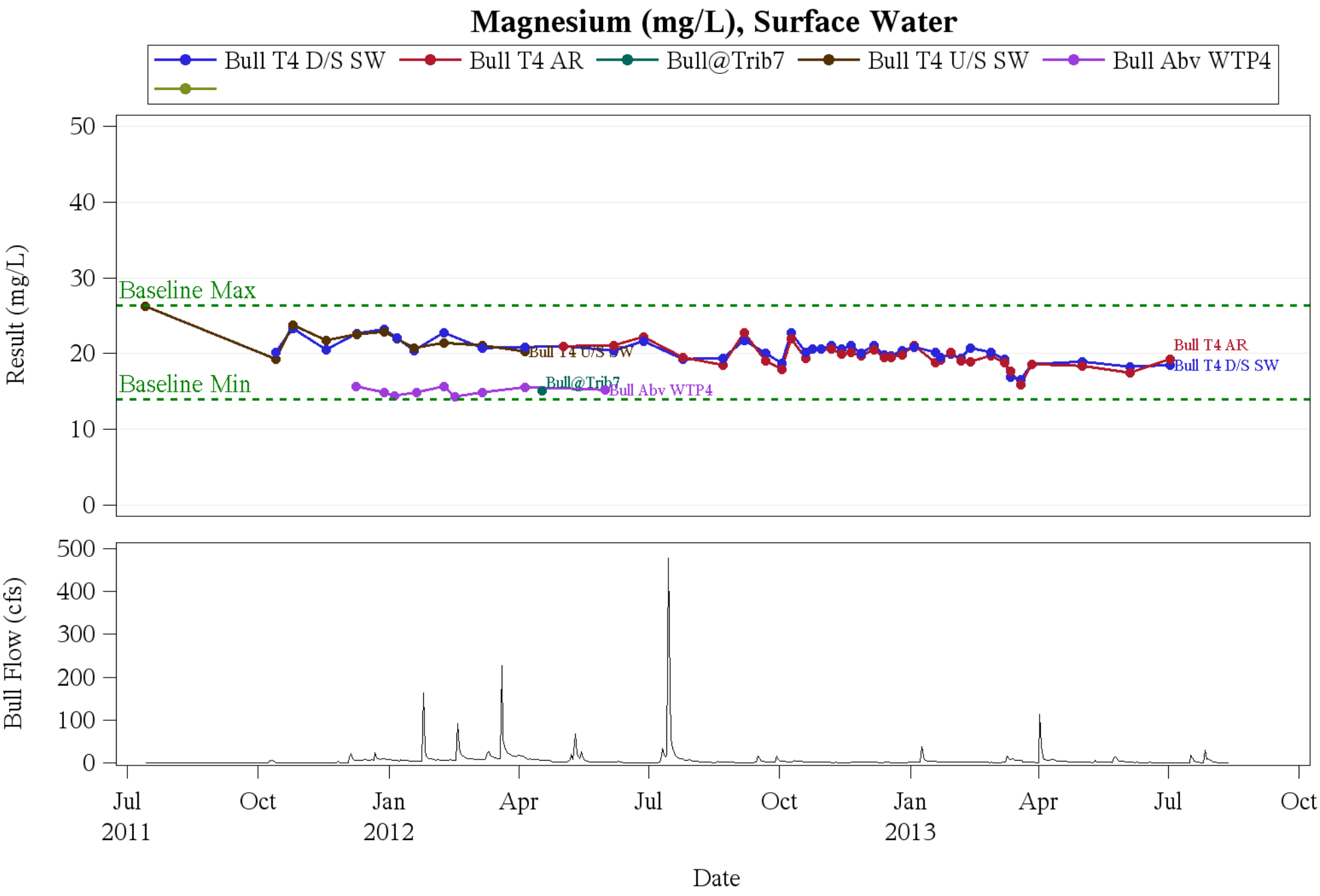

Conductivity (uS/cm), Springs
Tanglewood
Ribelin
Lanier
Result (uS/cm)
1200
1000
800
600
400
Historic High
Baseline Max
TCEQ Screening Level
Baseline Min
Historic Low
Tanglewood
Lanier
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

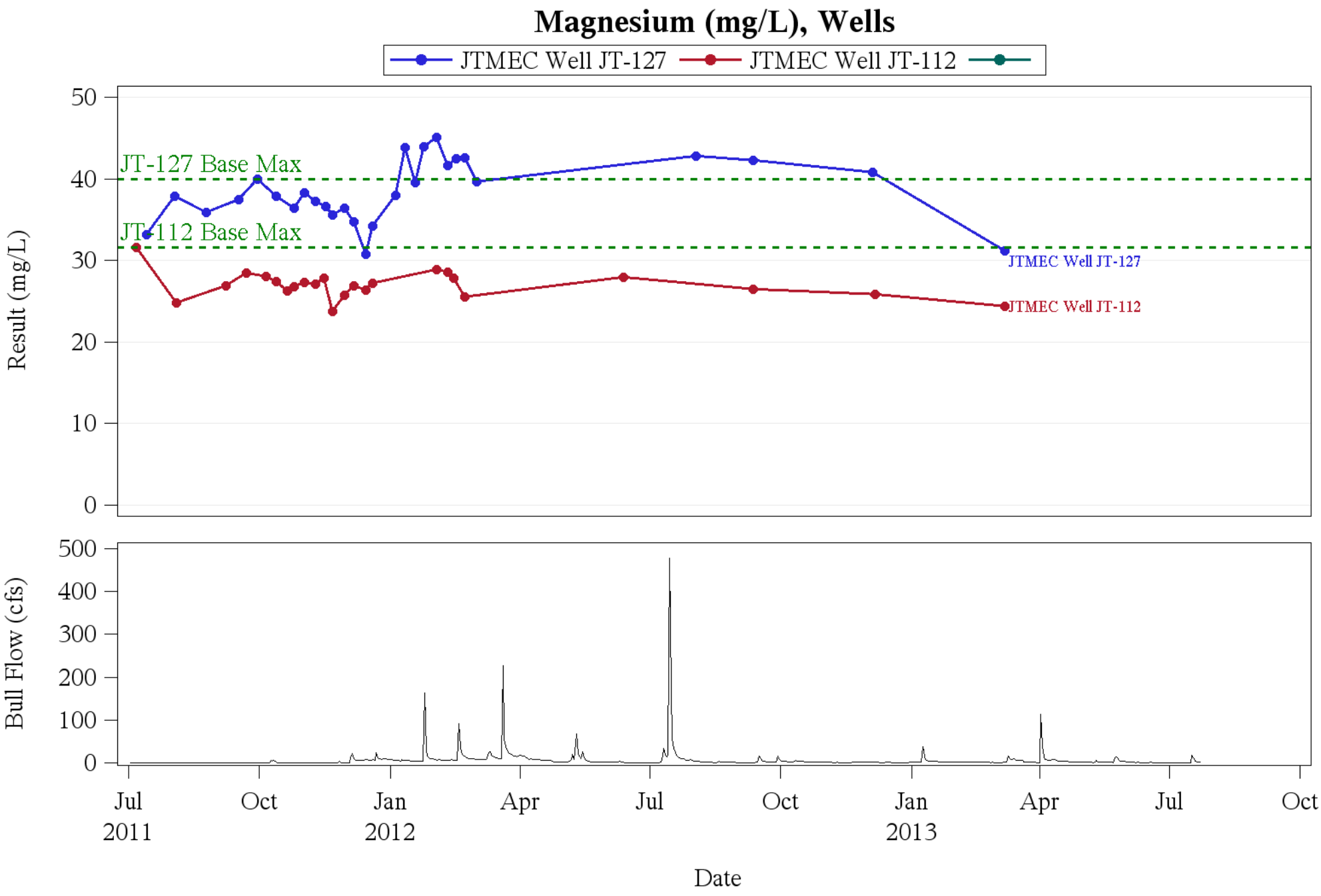

Copper (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Bull T4 U/S SW
Bull Abv WTP4
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

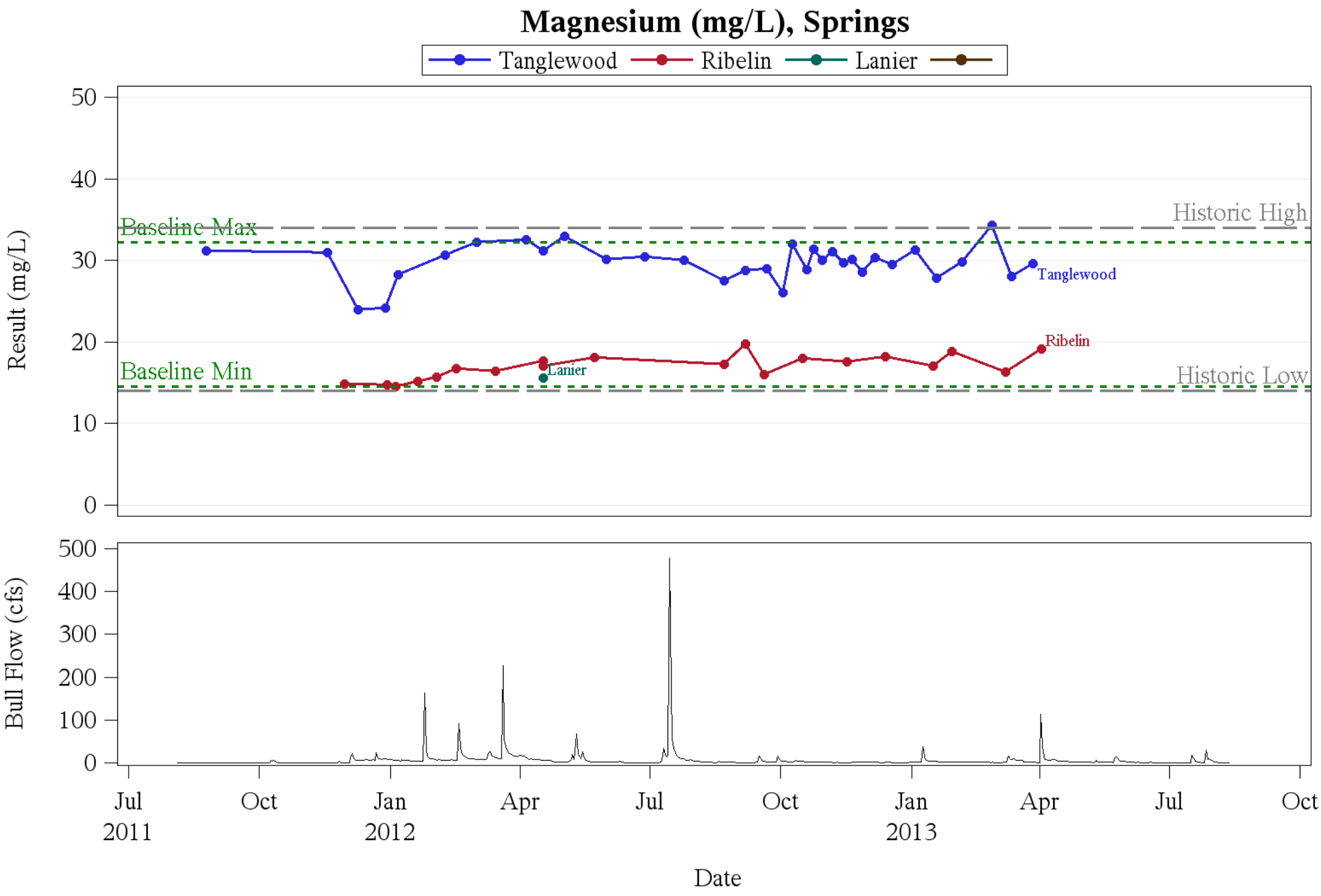

Copper (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TCEQ Screening Level
Baseline Max
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

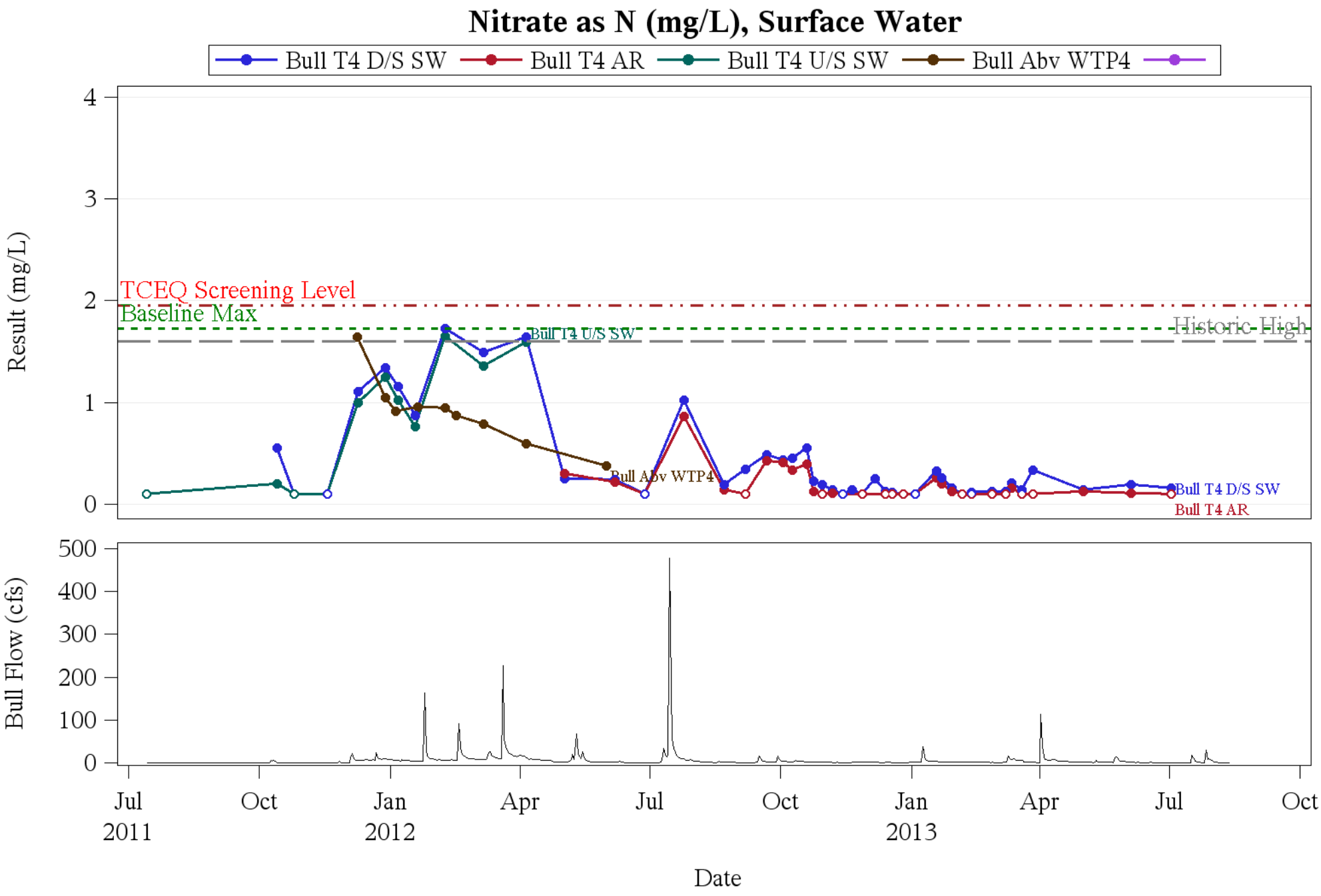

Copper (mg/L), Springs
Tanglewood
Ribelin
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

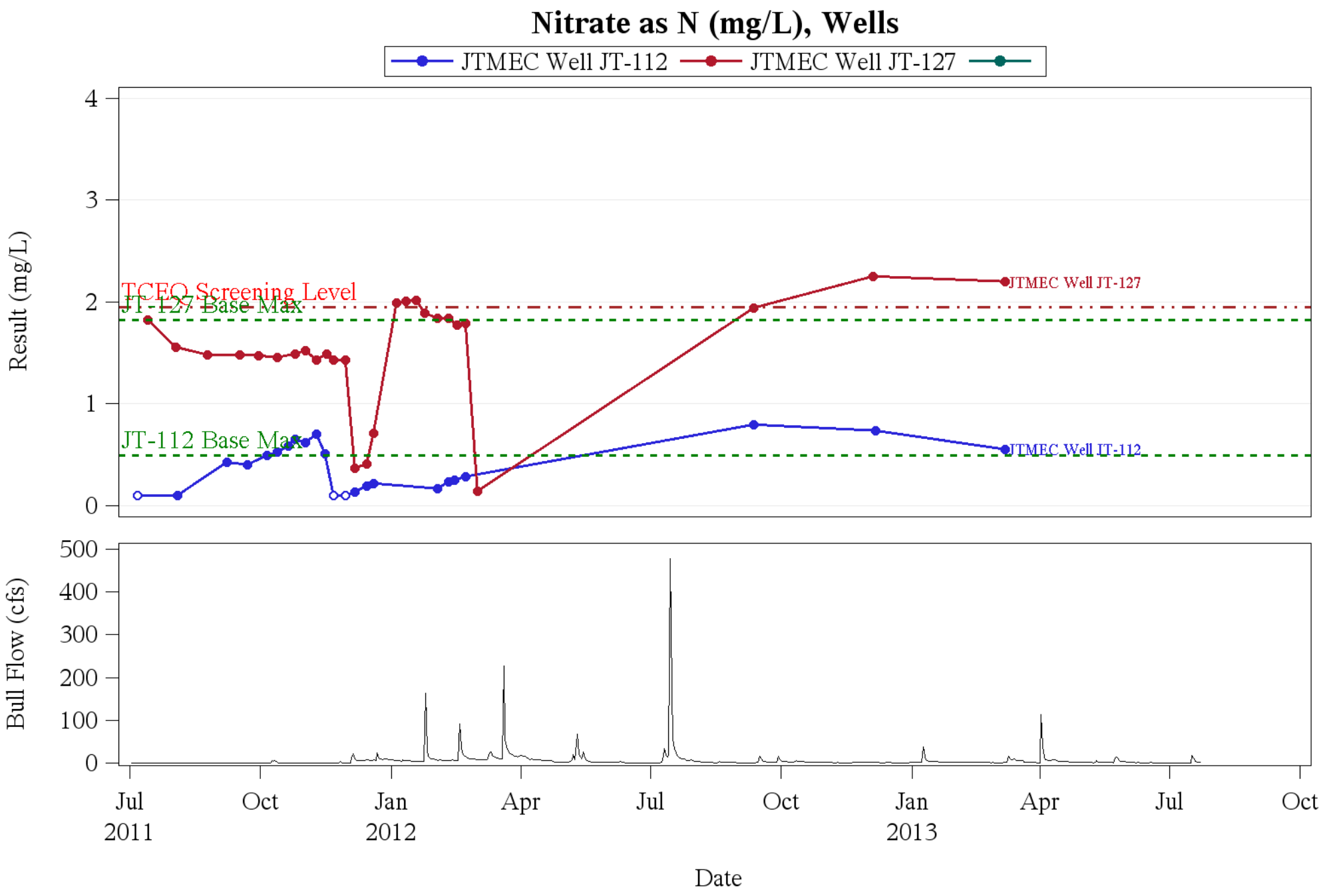

Di-N-Butyl Phthalate (mg/L)
Gass Spring
JT-112 Well
Result (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
JT-112 Well
Gass Spring
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

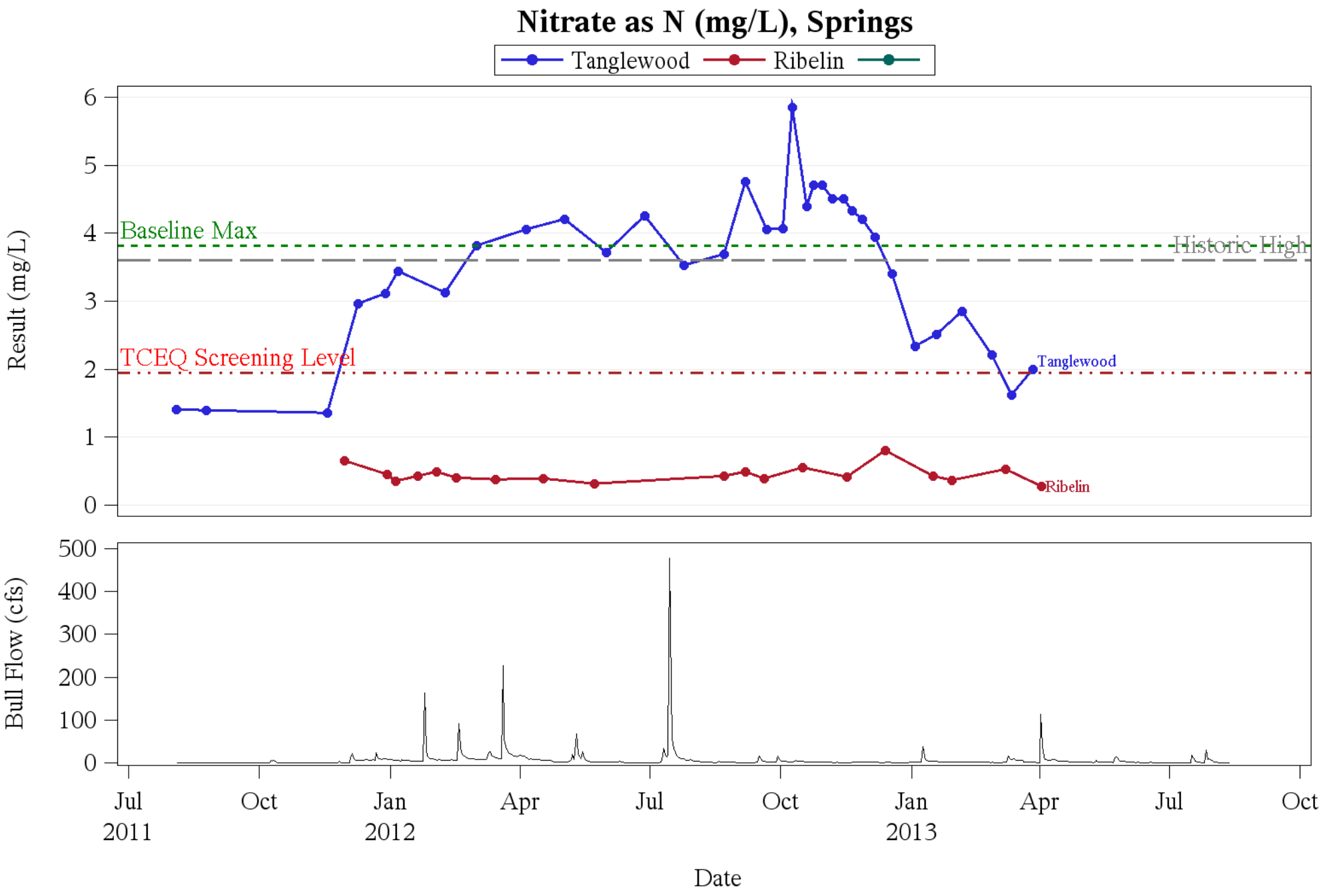

Magnesium (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull@Trib7
Bull T4 U/S SW
Bull Abv WTP4
Result (mg/L)
50
40
30
20
10
0
Baseline Max
Baseline Min
Bull T4 U/S SW
Bull@Trib7
Bull Abv WTP4
Bull T4 AR
Bull T4 D/S SW
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

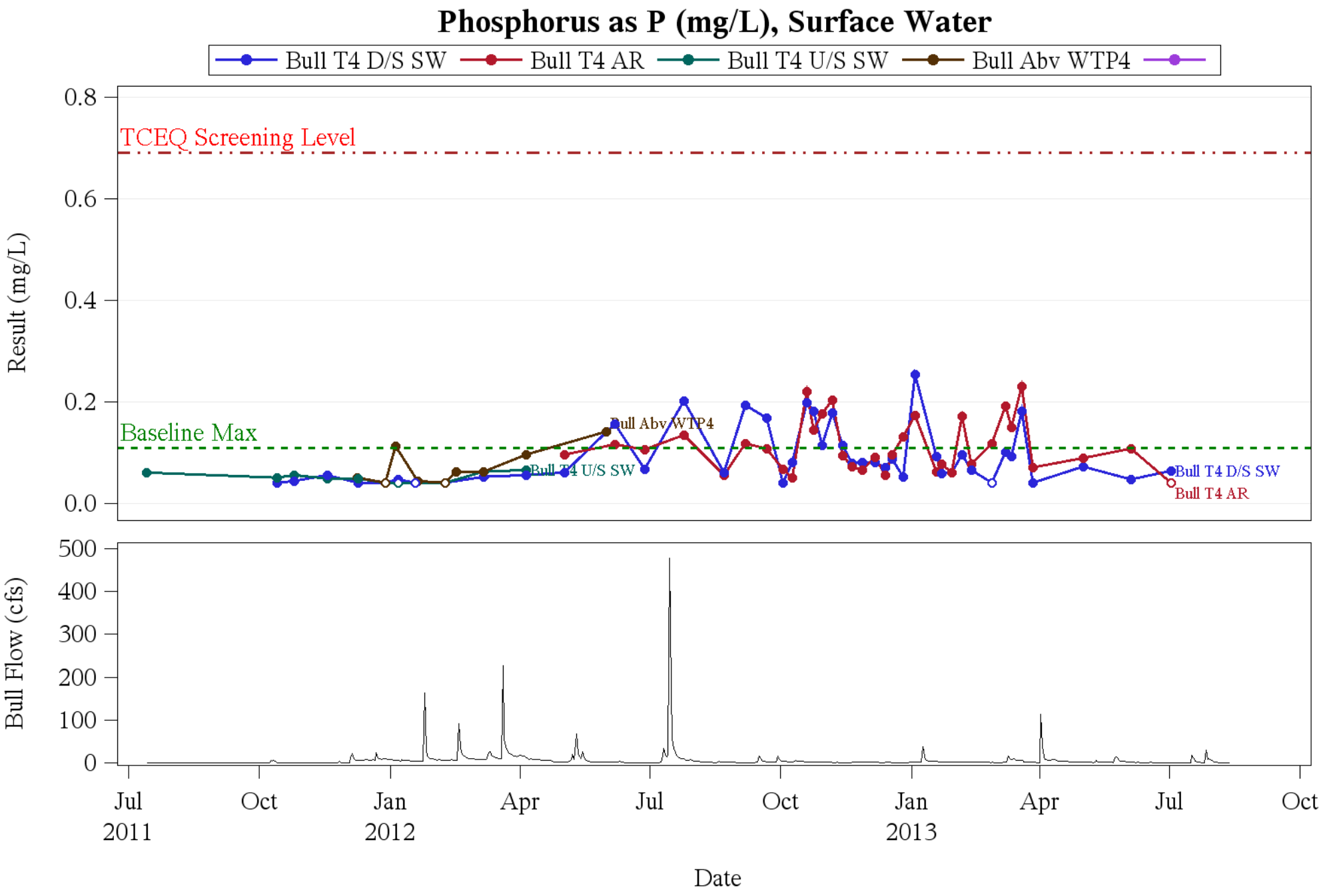

Magnesium (mg/L), Wells
JTMEC Well JT-127
JTMEC Well JT-112
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Result (mg/L)
50
40
30
20
10
0
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

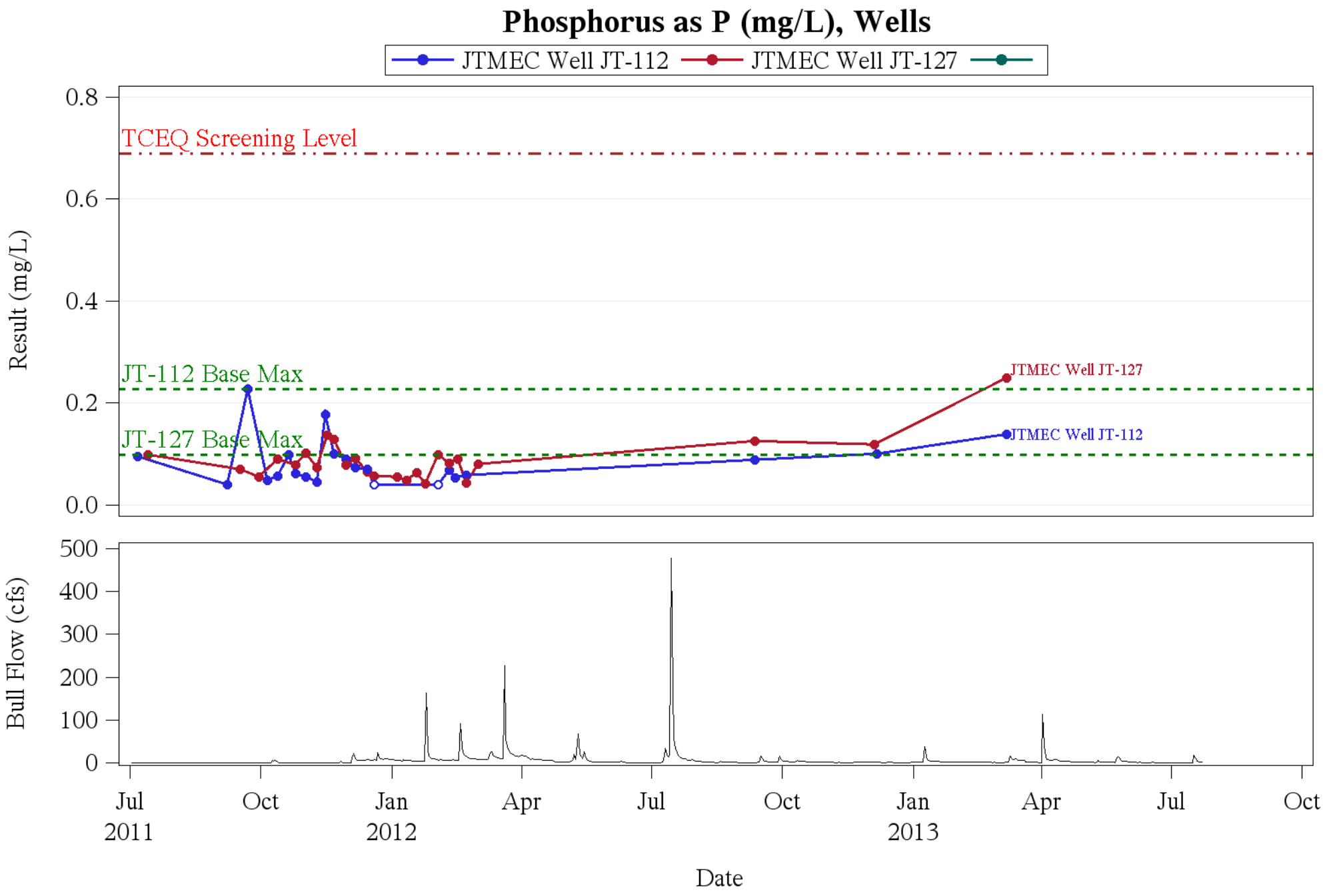

Magnesium (mg/L), Springs
Tanglewood
Ribelin
Lanier
Result (mg/L)
50
40
30
20
10
0
Baseline Max
Baseline Min
Historic High
Historic Low
Tanglewood
Ribelin
Lanier
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

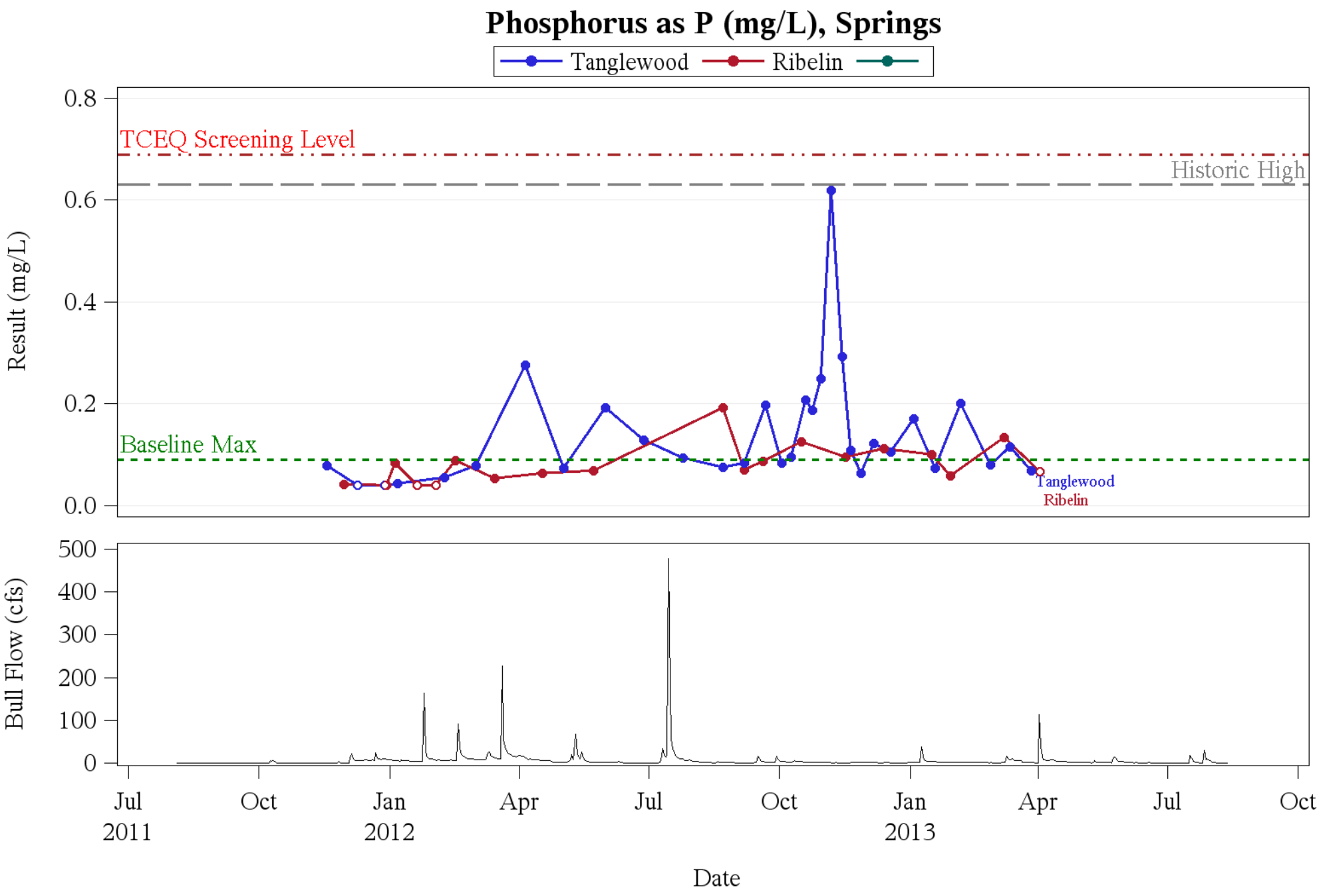

Nitrate as N (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
Result (mg/L)
TCEQ Screening Level
Baseline Max
Historic High
Bull T4 U/S SW
Bull Abv WTP4
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

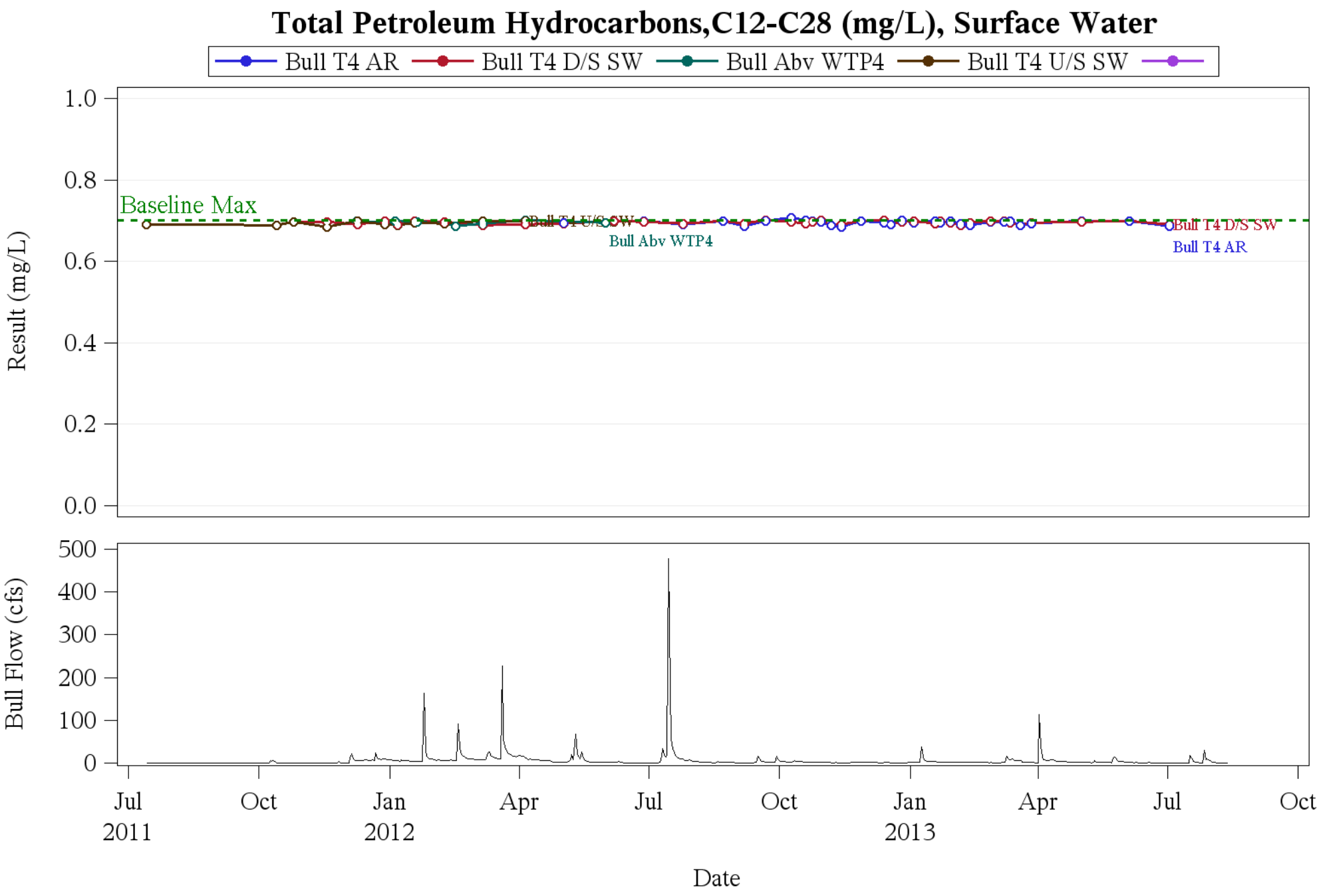

Nitrate as N (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
TCEQ Screening Level
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

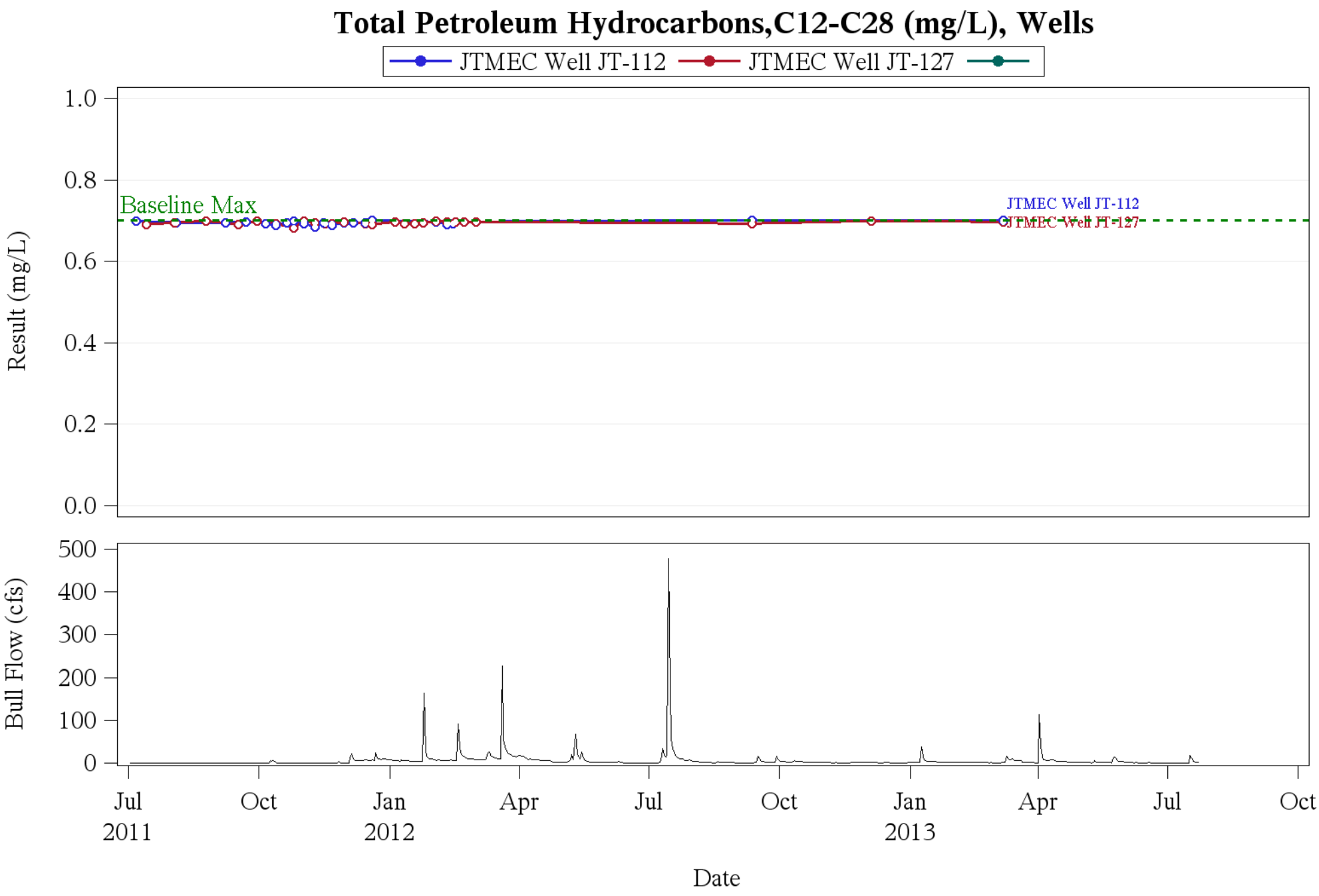

Nitrate as N (mg/L), Springs
Tanglewood
Ribelin
Result (mg/L)
Baseline Max
Historic High
TCEQ Screening Level
Tanglewood
Ribelin
Bull Flow (cfs)
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

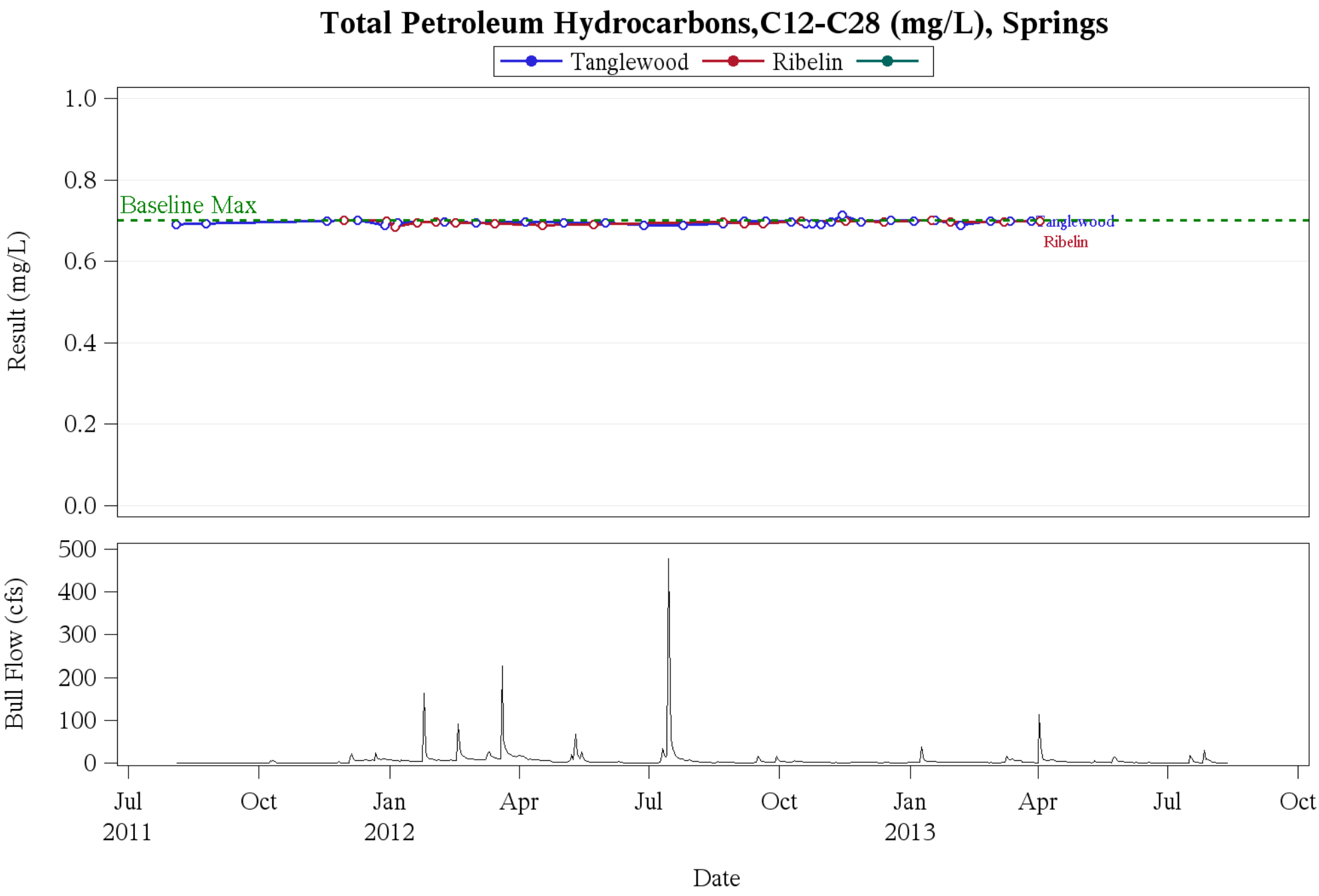

Phosphorus as P (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.8
0.6
0.4
0.2
0.0
Bull Abv WTP4
Bull T4 U/S SW
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

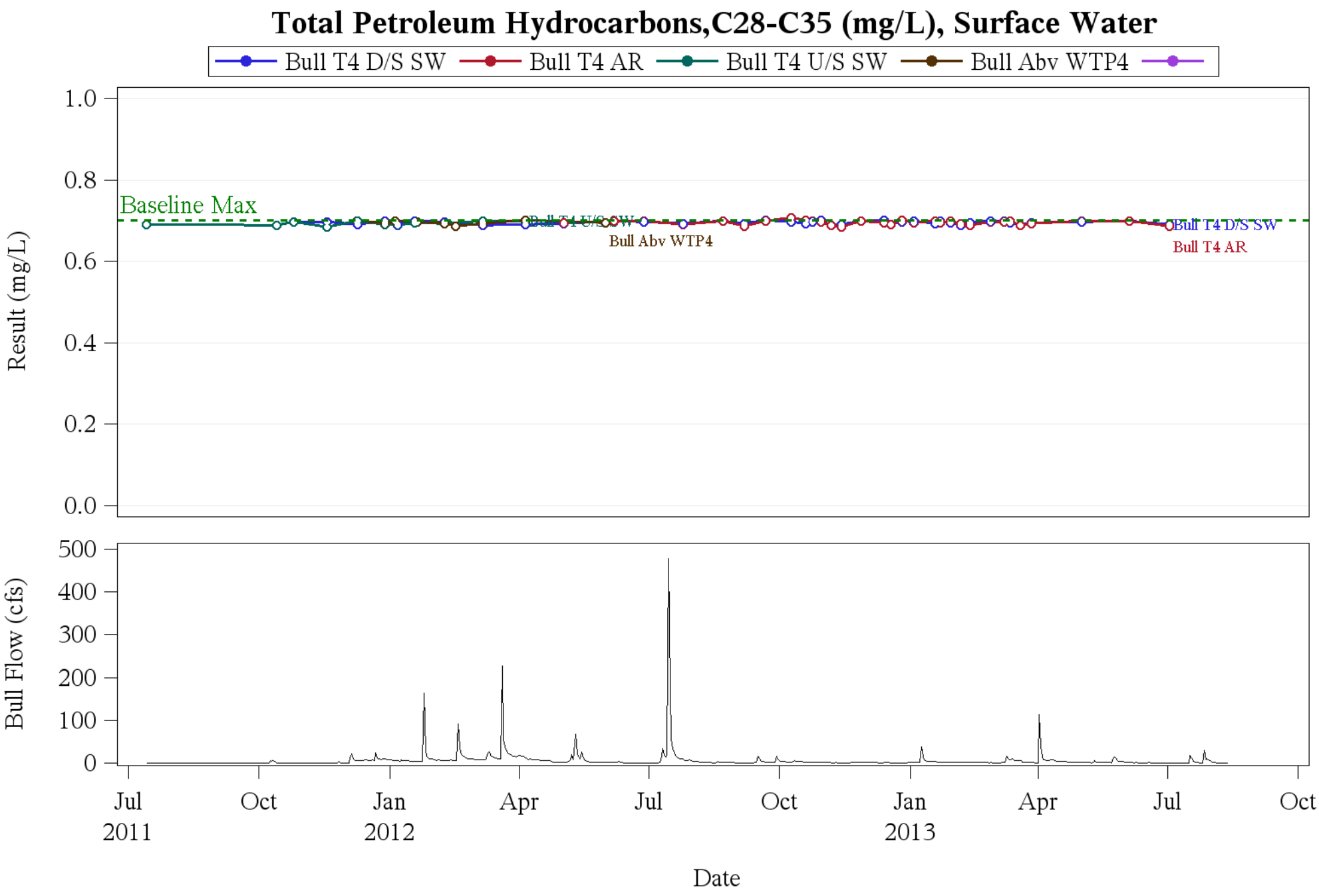

Phosphorus as P (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
0.8
0.6
0.4
0.2
0.0
Result (mg/L)
TCEQ Screening Level
JT-112 Base Max
JT-127 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
500
400
300
200
100
0
Bull Flow (cfs)
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

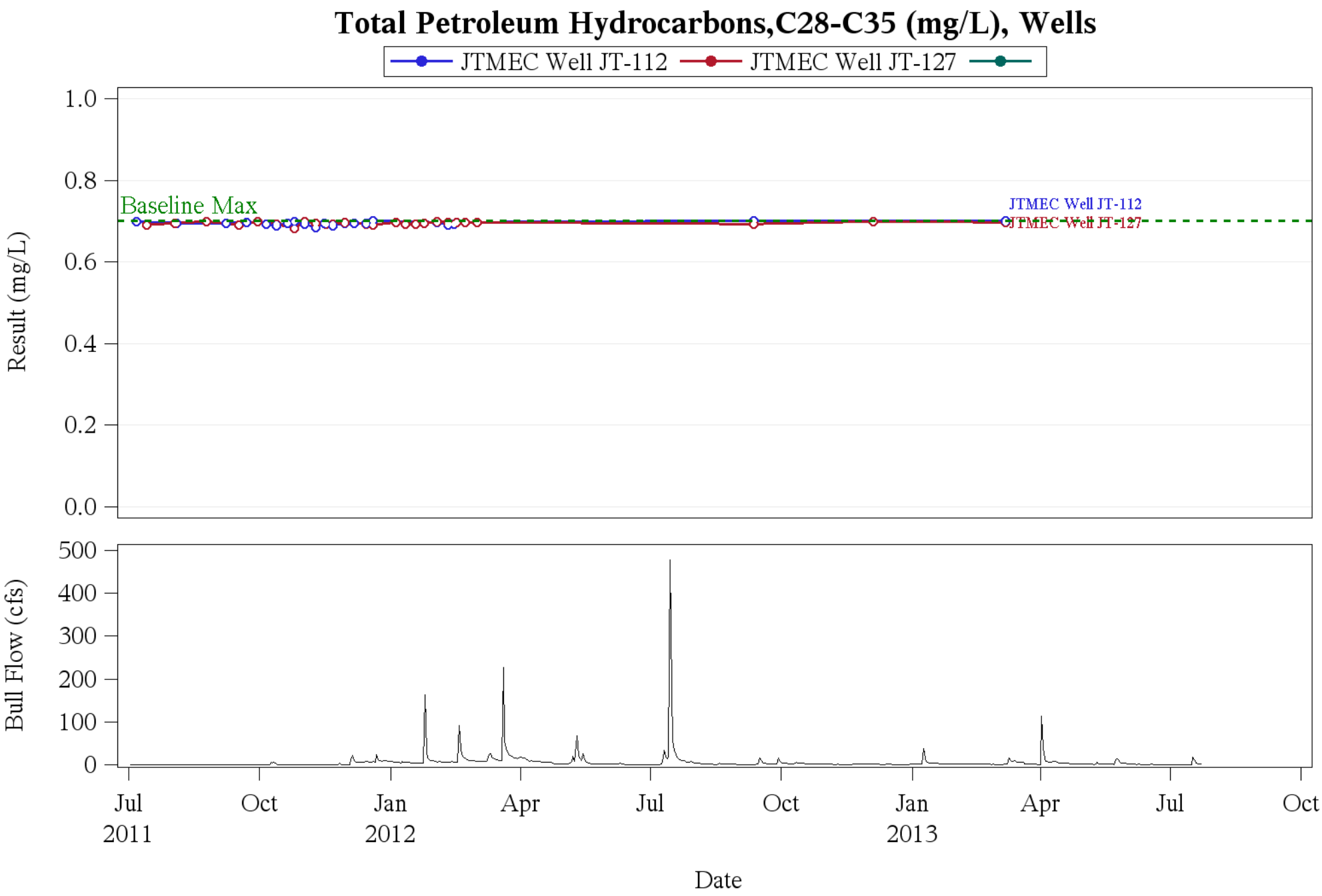

Phosphorus as P (mg/L), Springs
Tanglewood
Ribelin
TCEQ Screening Level
Historic High
Baseline Max
Result (mg/L)
0.8
0.6
0.4
0.2
0.0
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

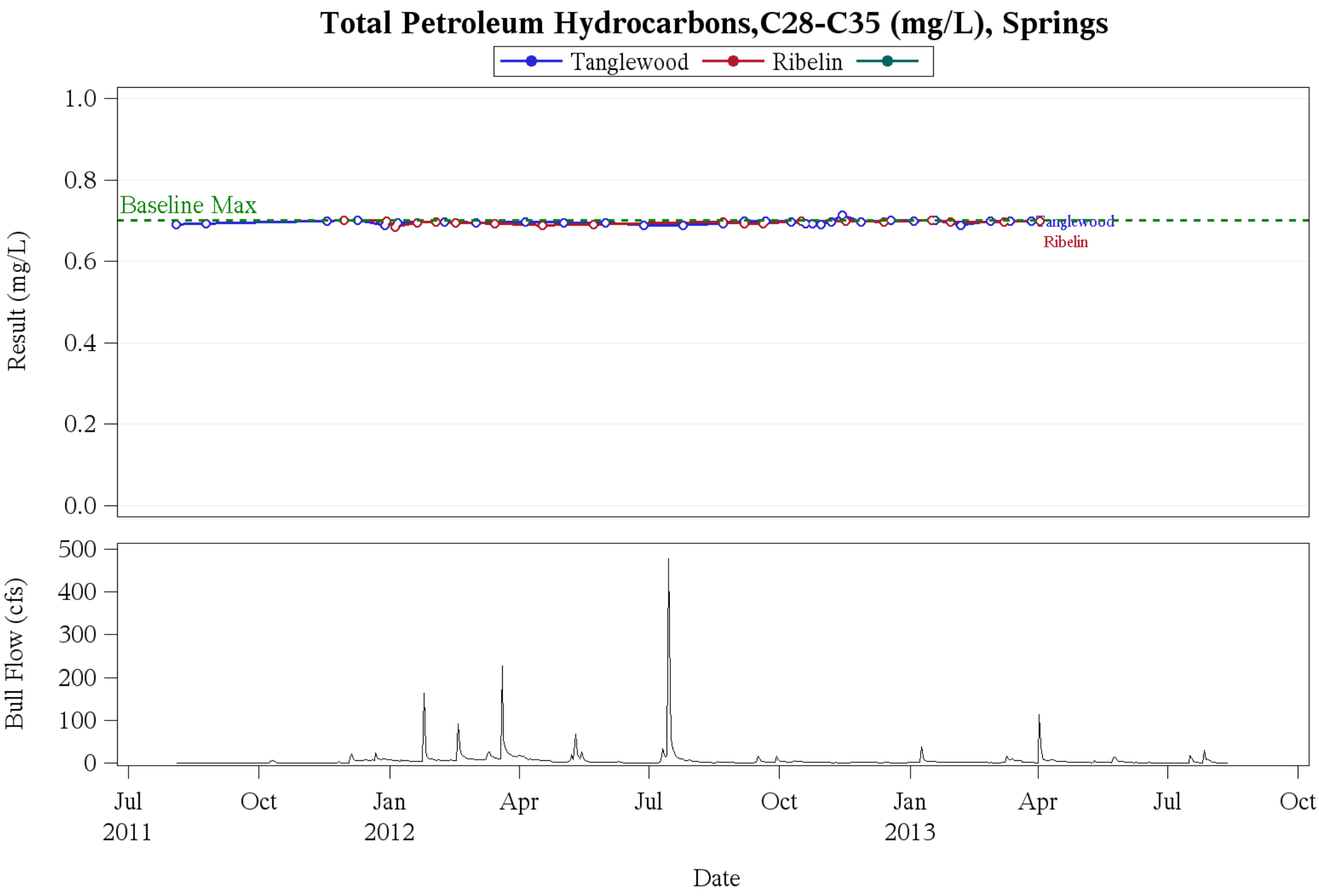

Total Petroleum Hydrocarbons,C12-C28 (mg/L), Surface Water
Bull T4 AR
Bull T4 D/S SW
Bull Abv WTP4
Bull T4 U/S SW
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Baseline Max
Bull T4 U/S SW
Bull Abv WTP4
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

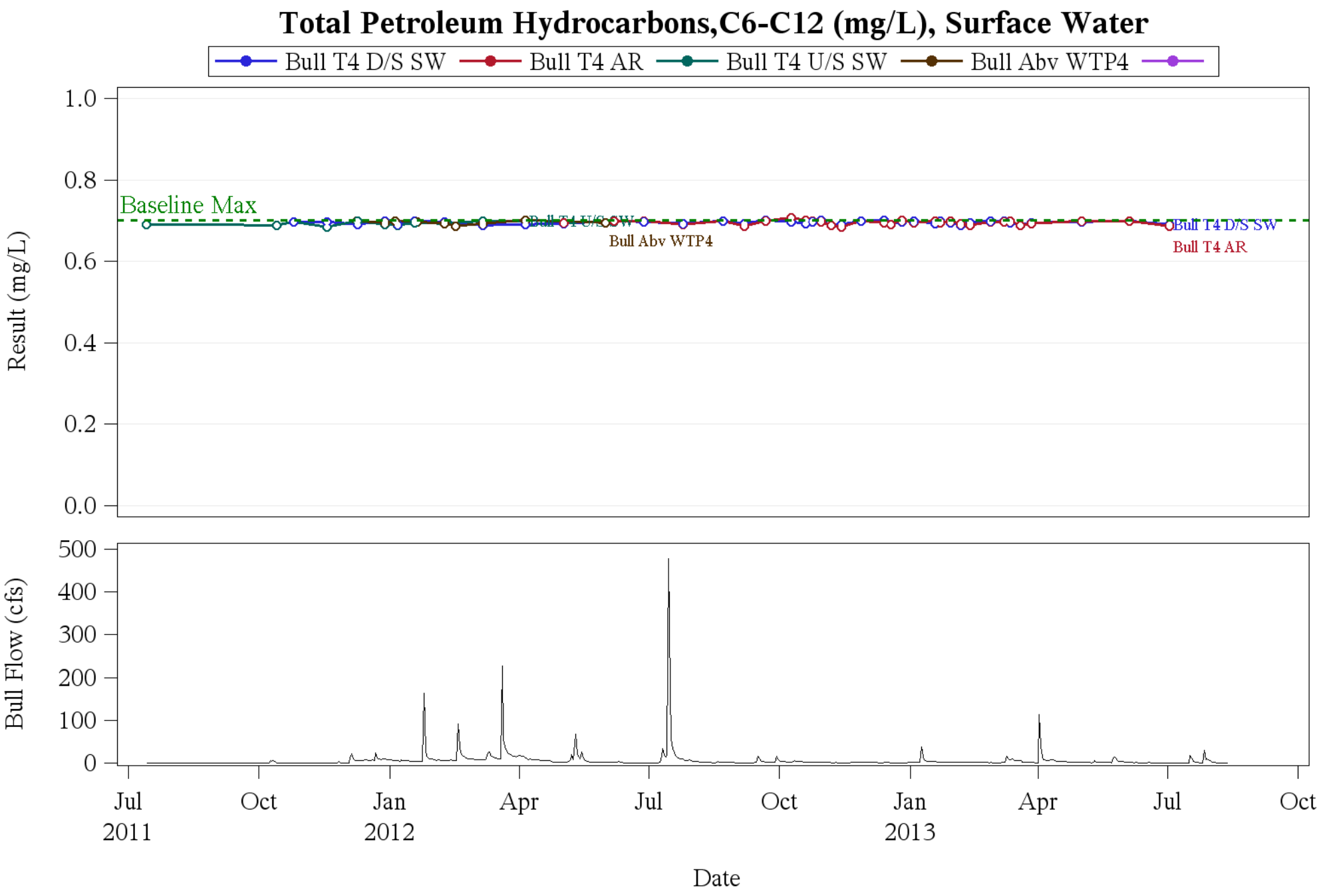

Total Petroleum Hydrocarbons,C12-C28 (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Baseline Max
JTMEC Well JT-112
JTMEC Well JT-127
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

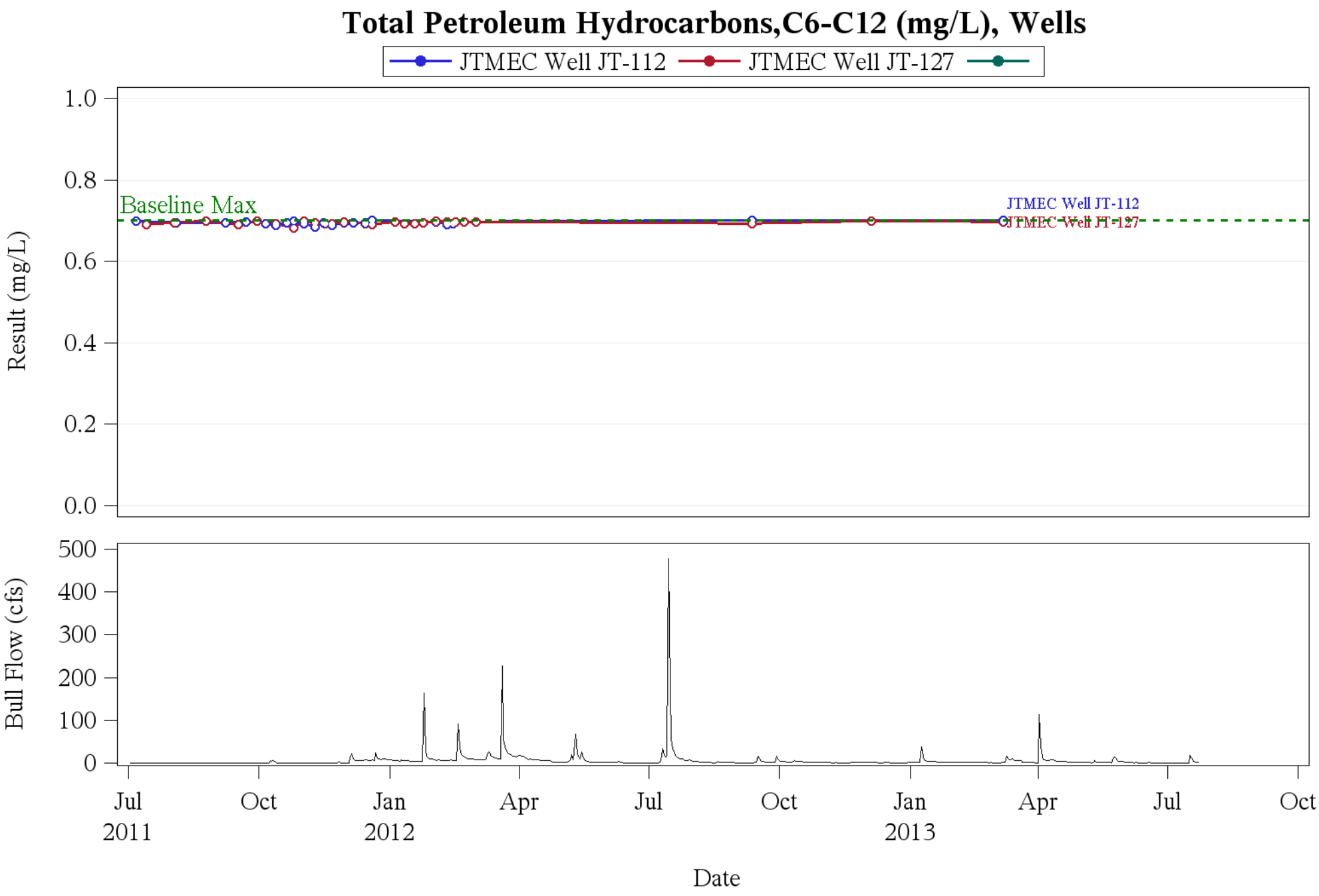

Total Petroleum Hydrocarbons,C12-C28 (mg/L), Springs
Tanglewood
Ribelin
Baseline Max
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

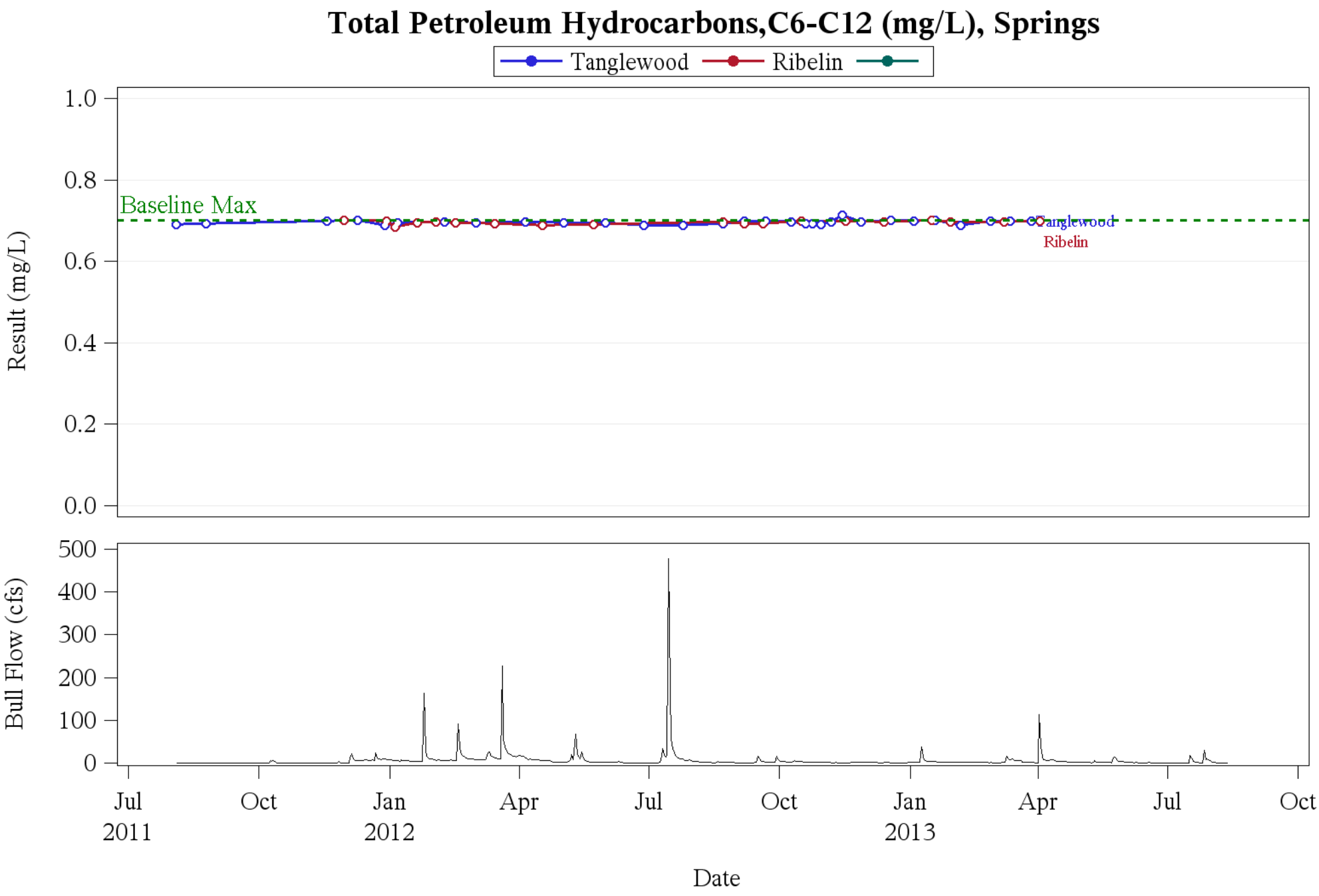

Total Petroleum Hydrocarbons,C28-C35 (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
Baseline Max
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

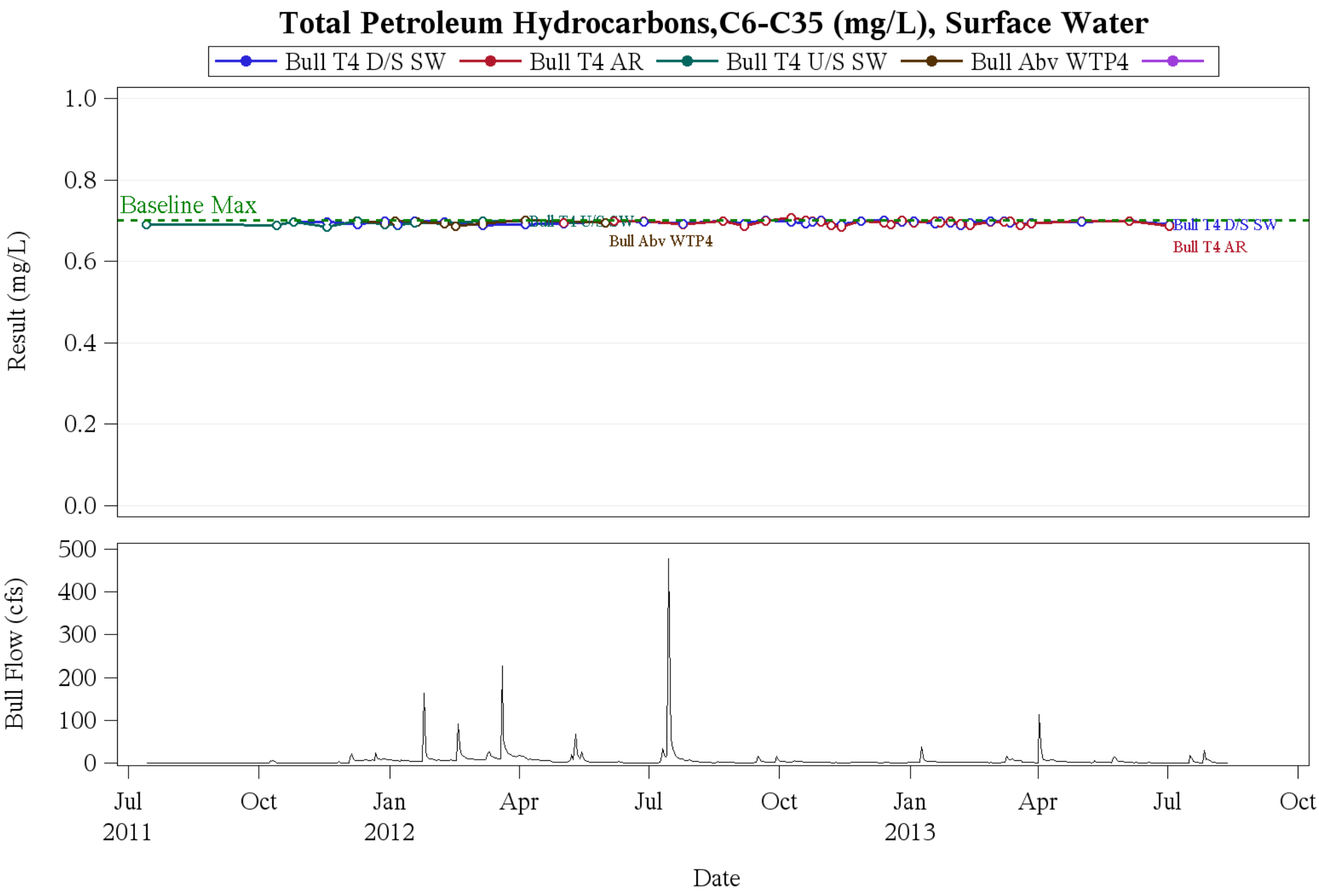

Total Petroleum Hydrocarbons,C28-C35 (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Baseline Max
JTMEC Well JT-112
JTMEC Well JT-127
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

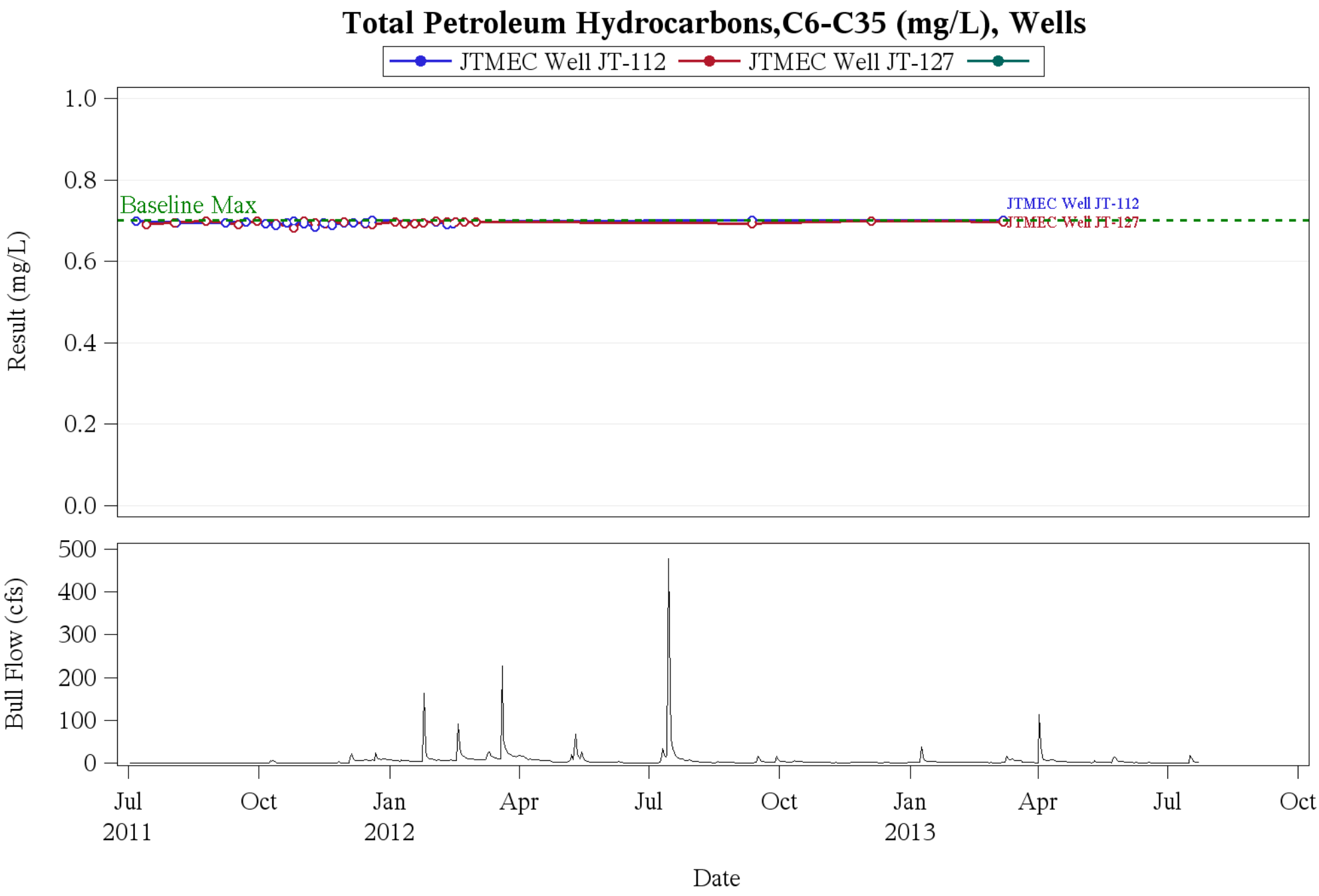

Total Petroleum Hydrocarbons,C28-C35 (mg/L), Springs
Tanglewood
Ribelin
Baseline Max
Tanglewood
Ribelin
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

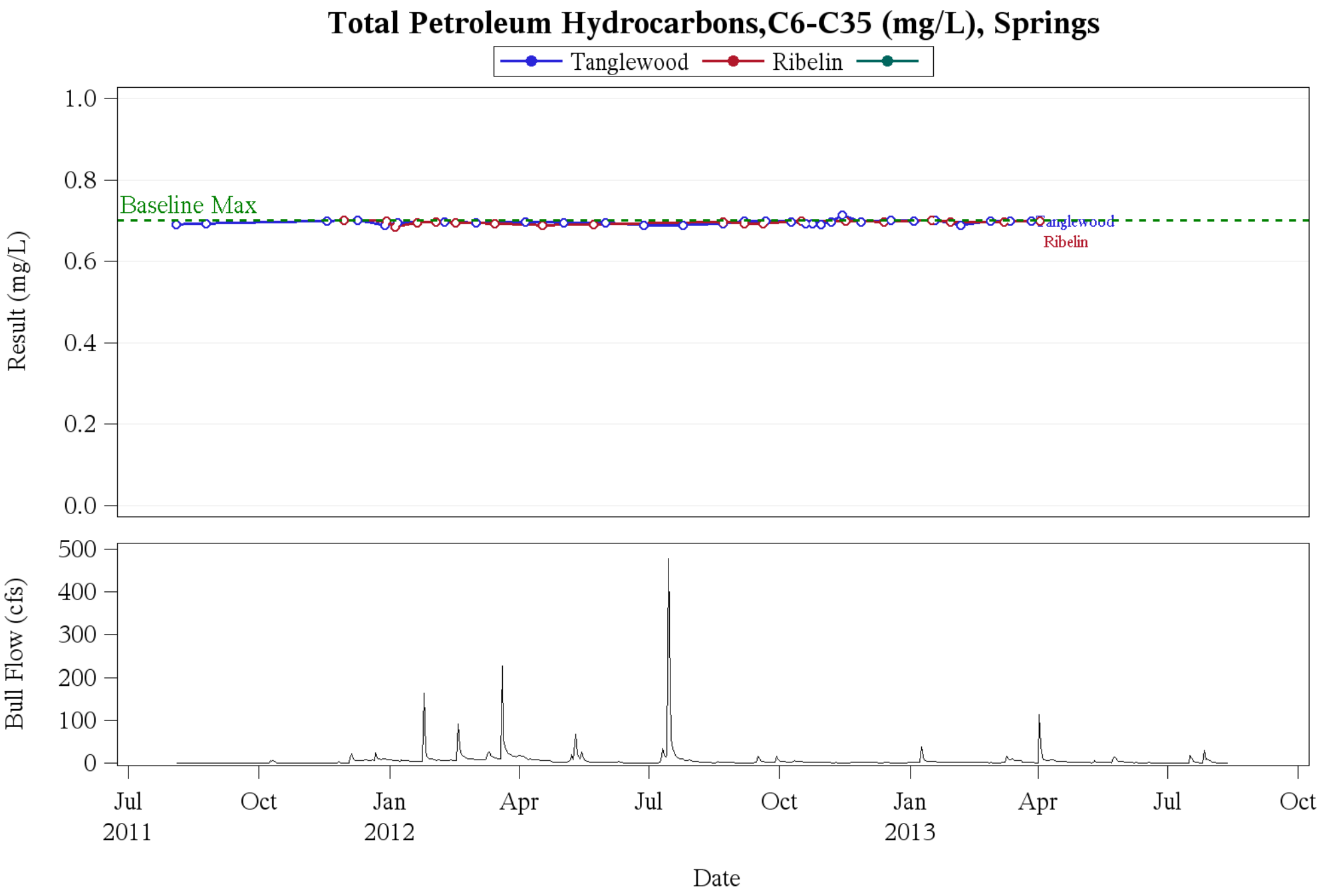

Total Petroleum Hydrocarbons,C6-C12 (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
Baseline Max
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

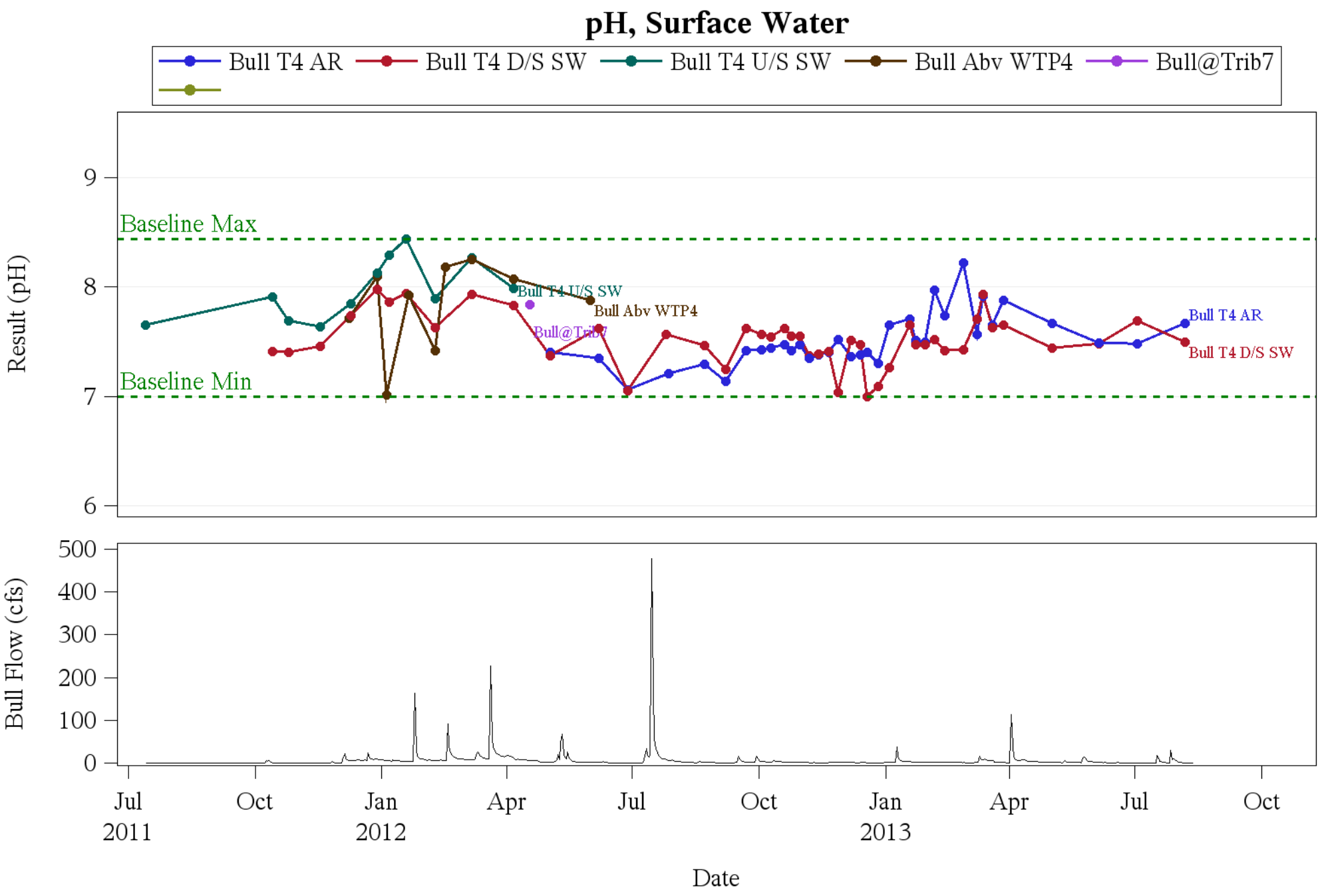

Total Petroleum Hydrocarbons,C6-C12 (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Baseline Max
JTMEC Well JT-112
JTMEC Well JT-127
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

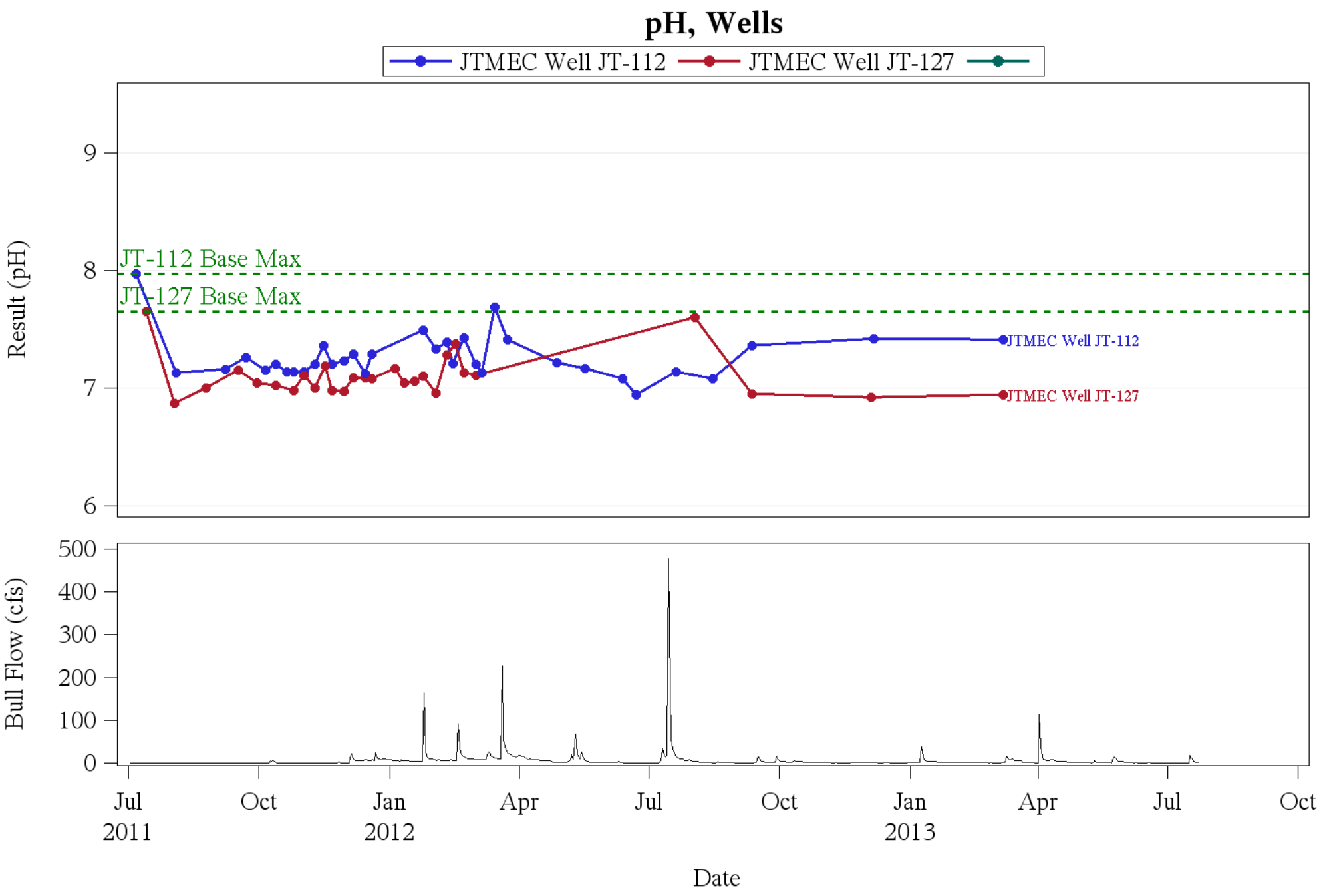

Total Petroleum Hydrocarbons,C6-C12 (mg/L), Springs
Tanglewood
Ribelin
1.0
0.8
0.6
0.4
0.2
0.0
Result (mg/L)
Baseline Max
Tanglewood
Ribelin
500
400
300
200
100
0
Bull Flow (cfs)
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

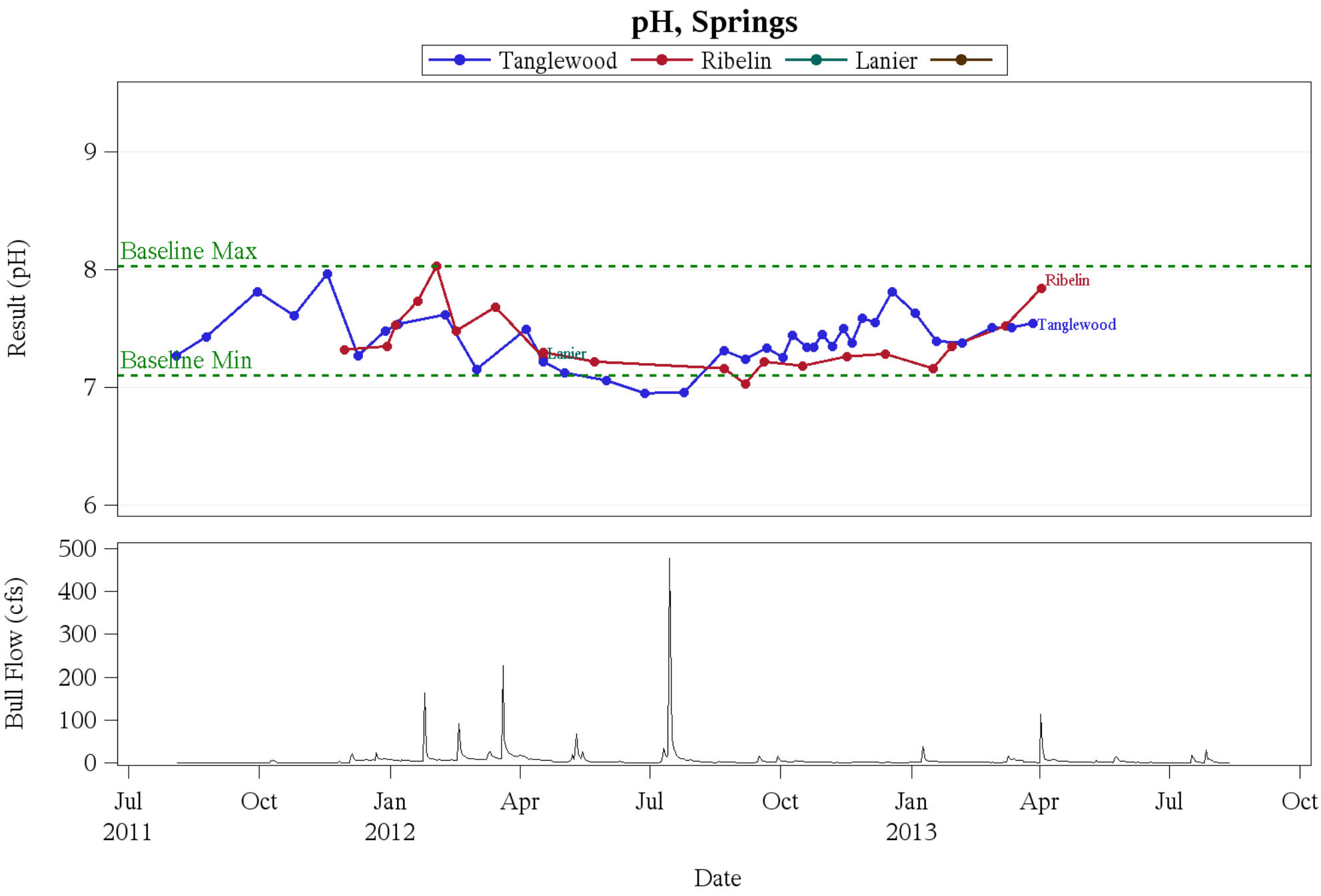

Total Petroleum Hydrocarbons,C6-C35 (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
Baseline Max
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

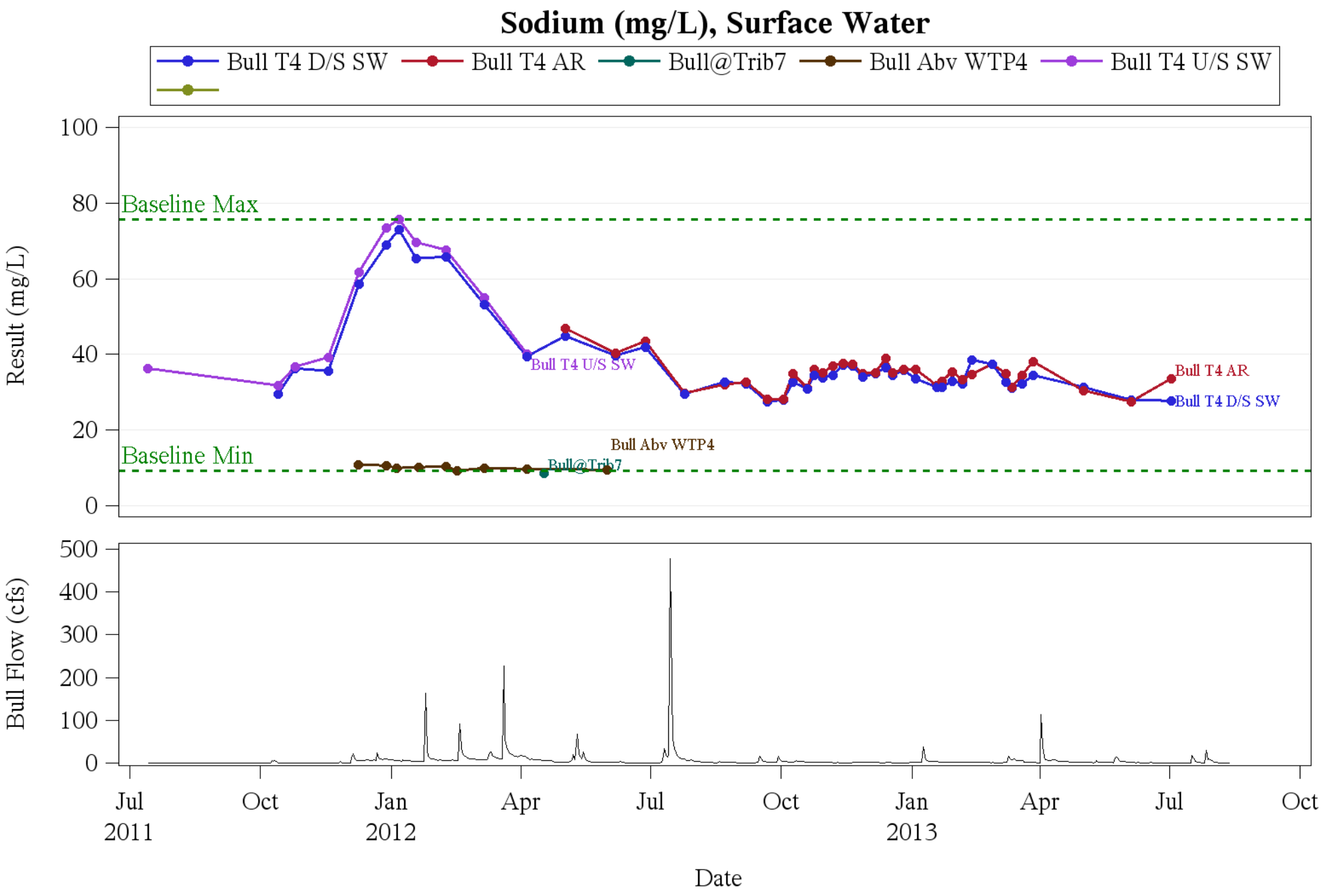

Total Petroleum Hydrocarbons,C6-C35 (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Baseline Max
JTMEC Well JT-112
JTMEC Well JT-127
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date


Total Petroleum Hydrocarbons,C6-C35 (mg/L), Springs
Tanglewood
Ribelin
Baseline Max
Result (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
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Oct
Jan
2013
Apr
Jul
Oct
Date

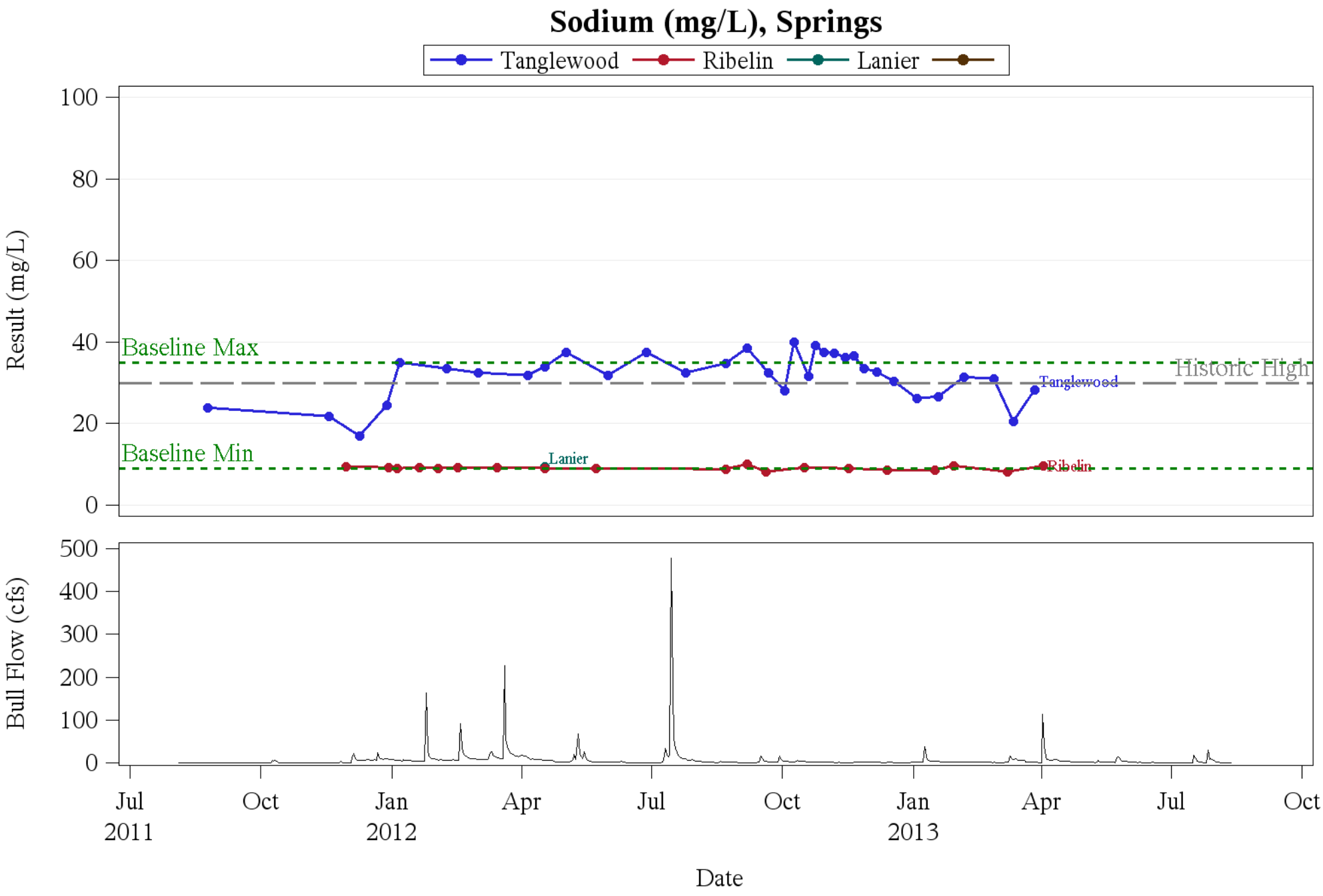

pH, Surface Water
Bull T4 AR
Bull T4 D/S SW
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Result (pH)
9
8
7
6
Baseline Max
Baseline Min
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Bull T4 AR
Bull T4 D/S SW
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

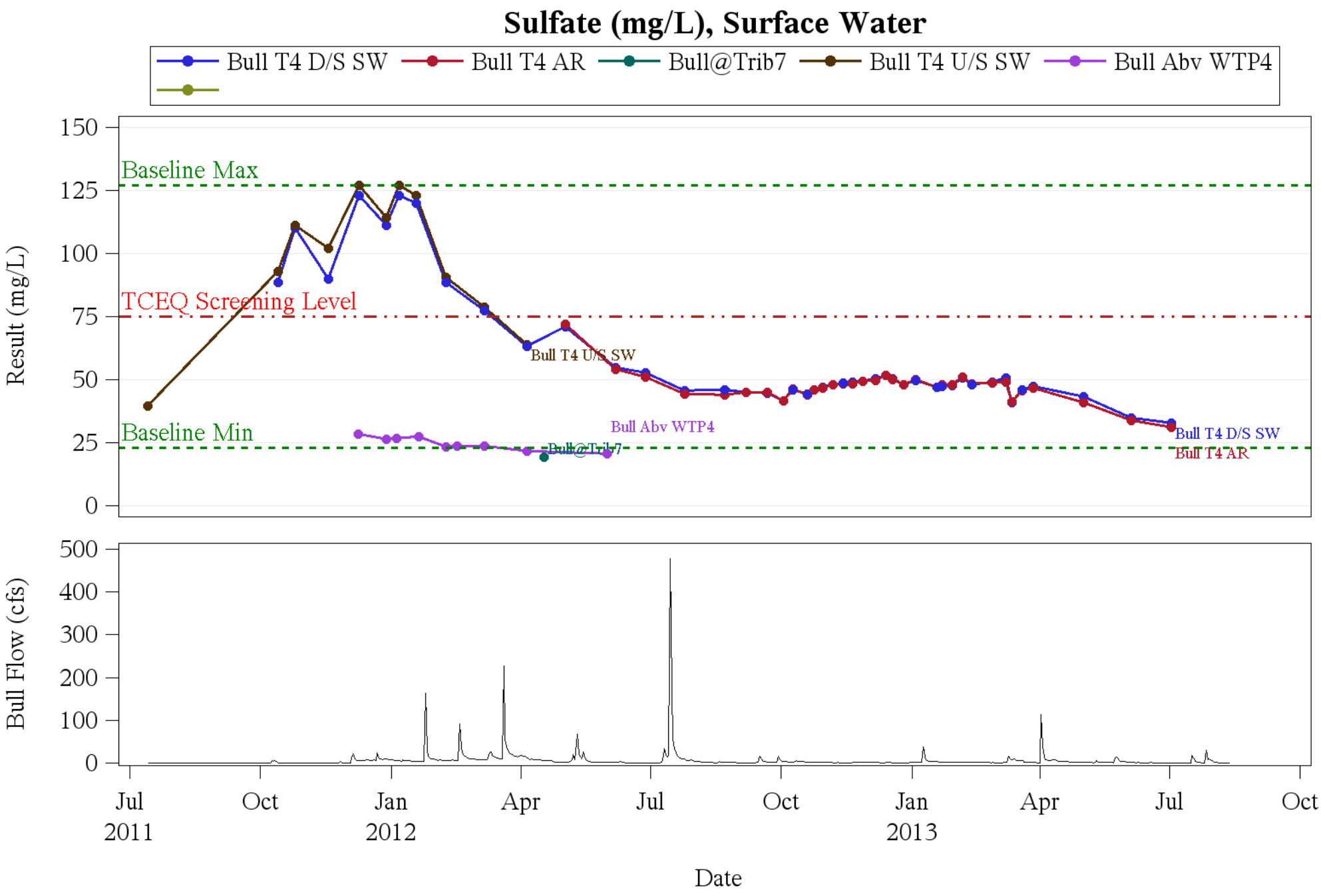

pH, Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (pH)
9
8
7
6
JT-112 Base Max
JT-127 Base Max
JTMEC Well JT-112
JTMEC Well JT-127
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

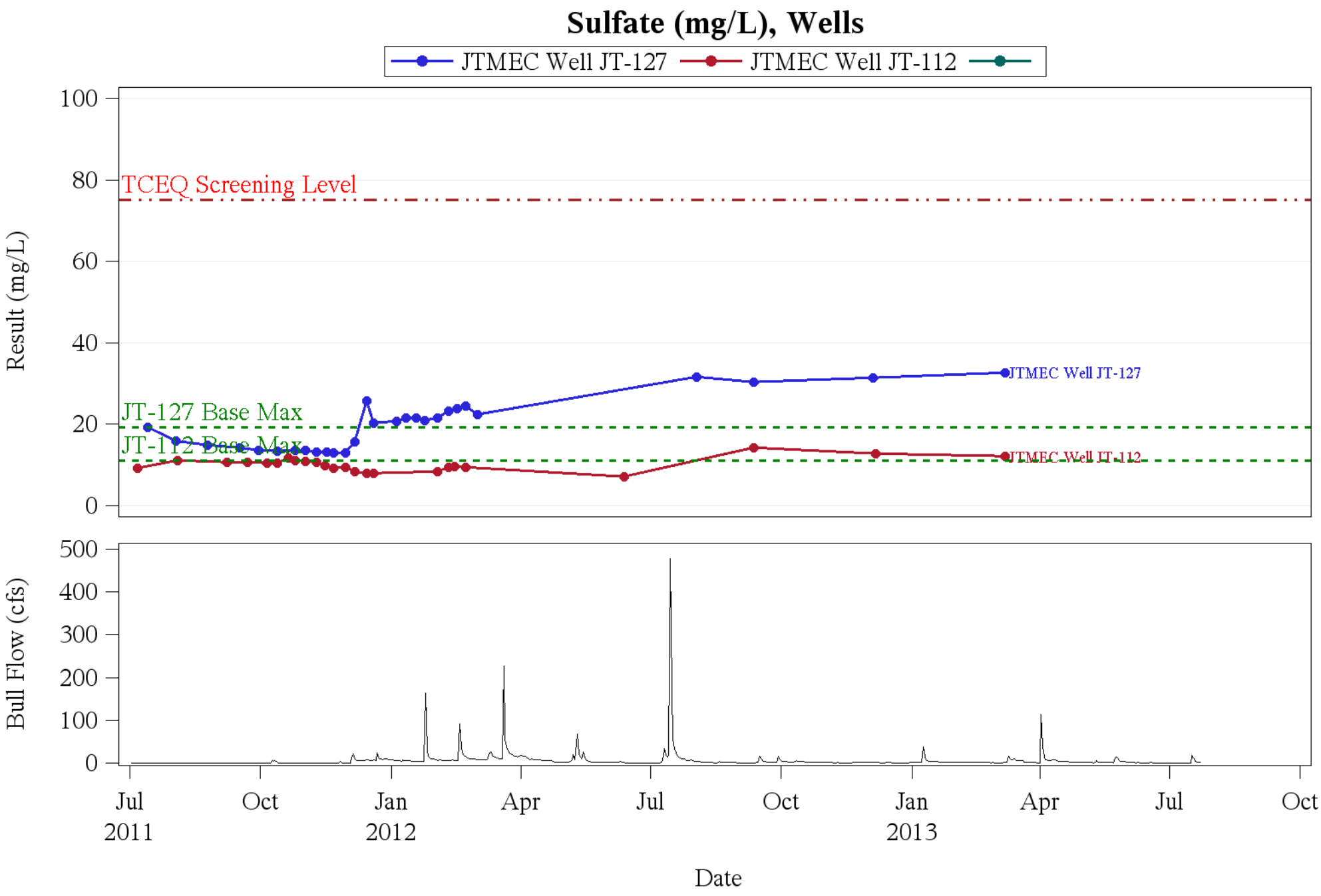

pH, Springs
Tanglewood
Ribelin
Lanier
Result (pH)
9
8
7
6
Baseline Max
Baseline Min
Ribelin
Tanglewood
Lanier
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

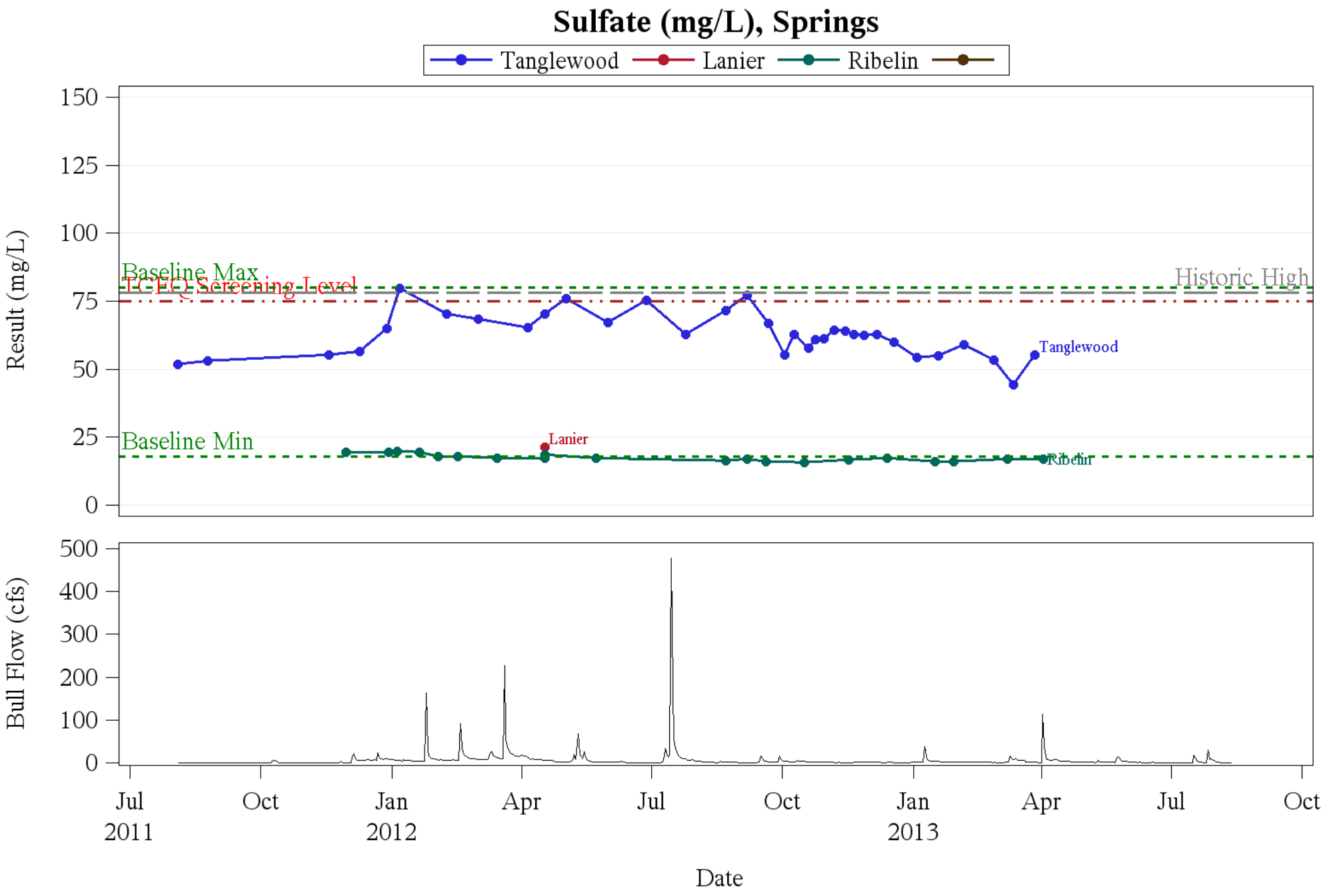

Sodium (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull@Trib7
Bull Abv WTP4
Bull T4 U/S SW
Result (mg/L)
100
80
60
40
20
0
Baseline Max
Baseline Min
Bull T4 U/S SW
Bull T4 AR
Bull T4 D/S SW
Bull Abv WTP4
Bull@Trib7
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

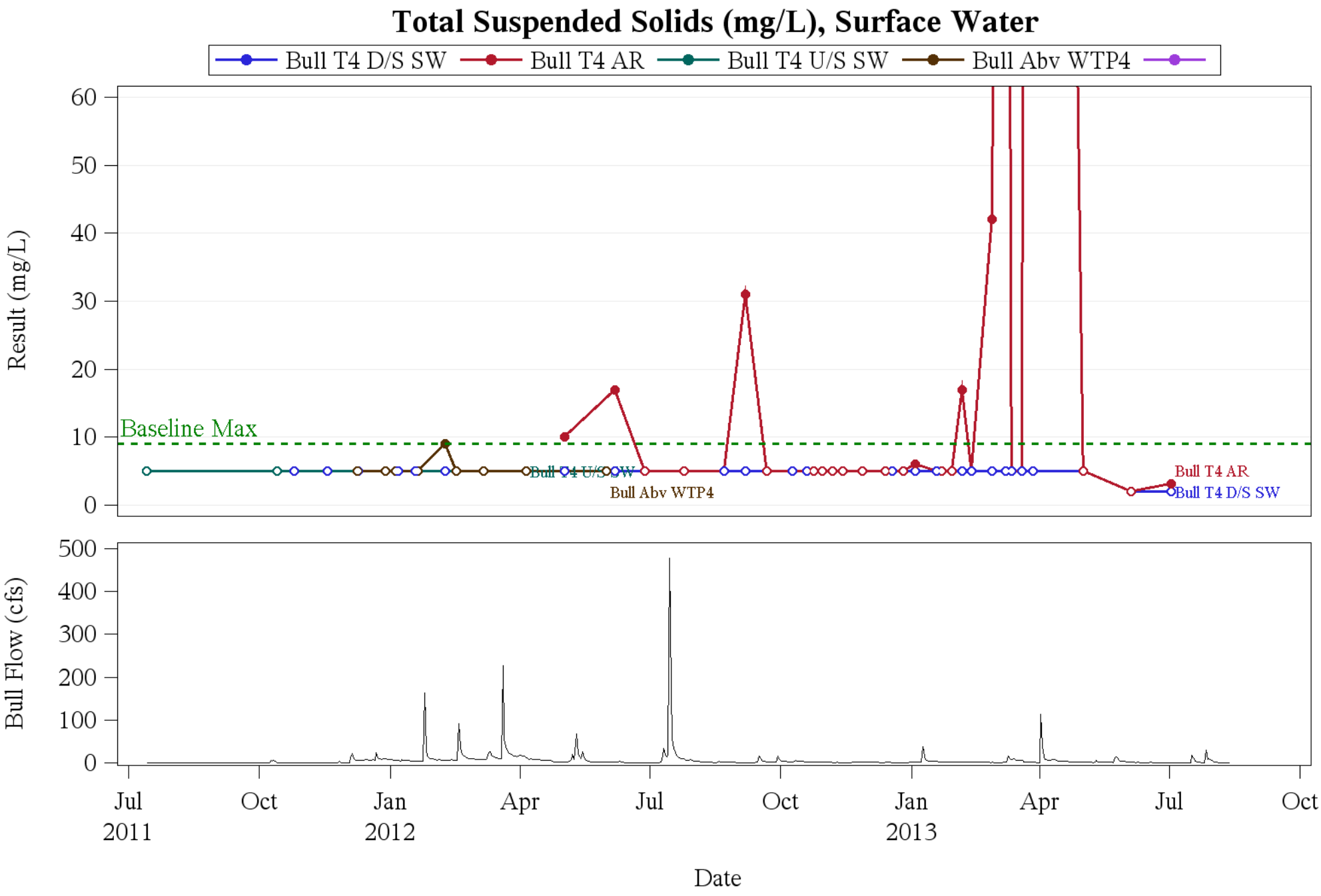

Sodium (mg/L), Wells
JTMEC Well JT-127
JTMEC Well JT-112
Result (mg/L)
100
80
60
40
20
0
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

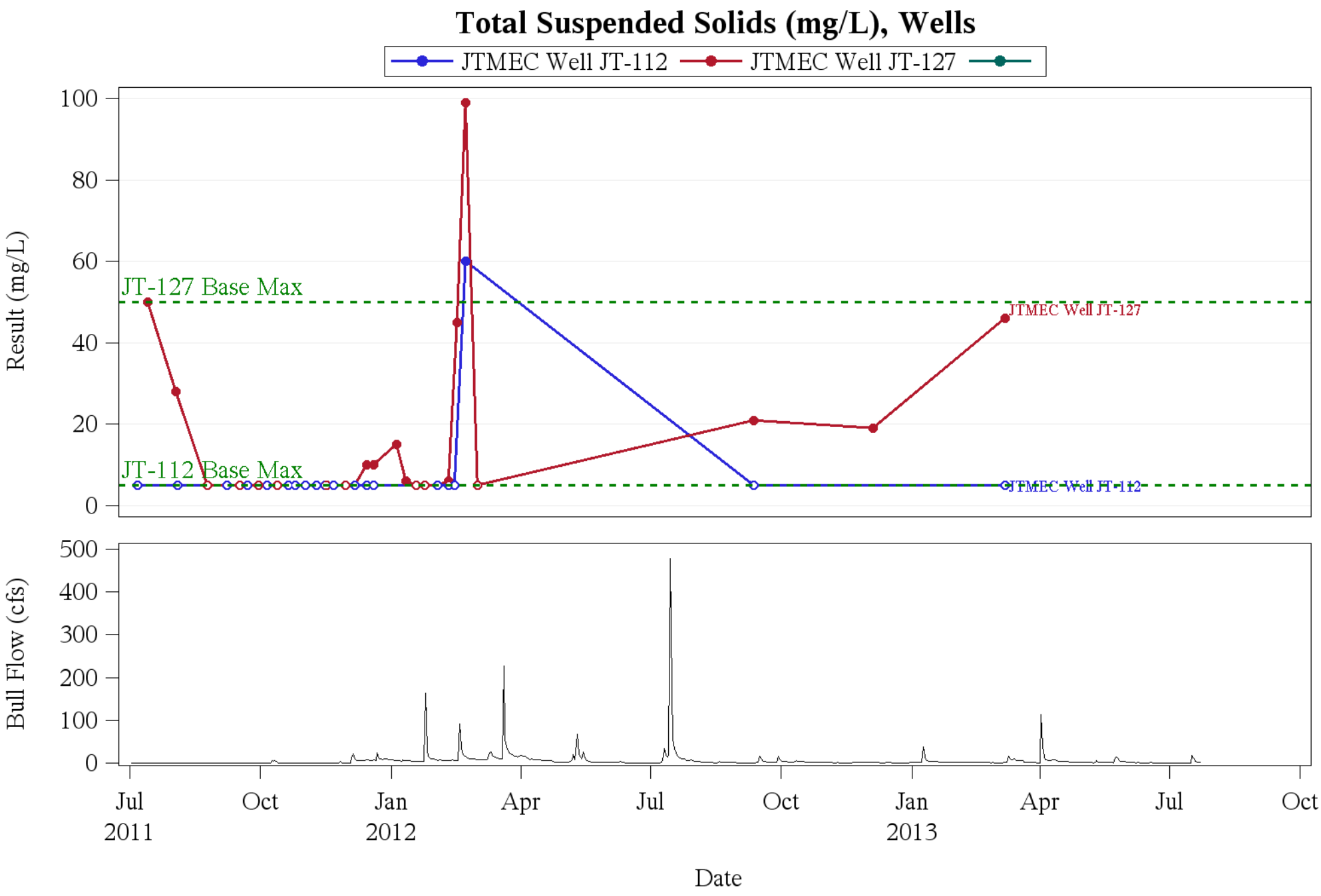

Sodium (mg/L), Springs
Tanglewood
Ribelin
Lanier
Result (mg/L)
100
80
60
40
20
0
Baseline Max
Baseline Min
Historic High
Tanglewood
Lanier
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

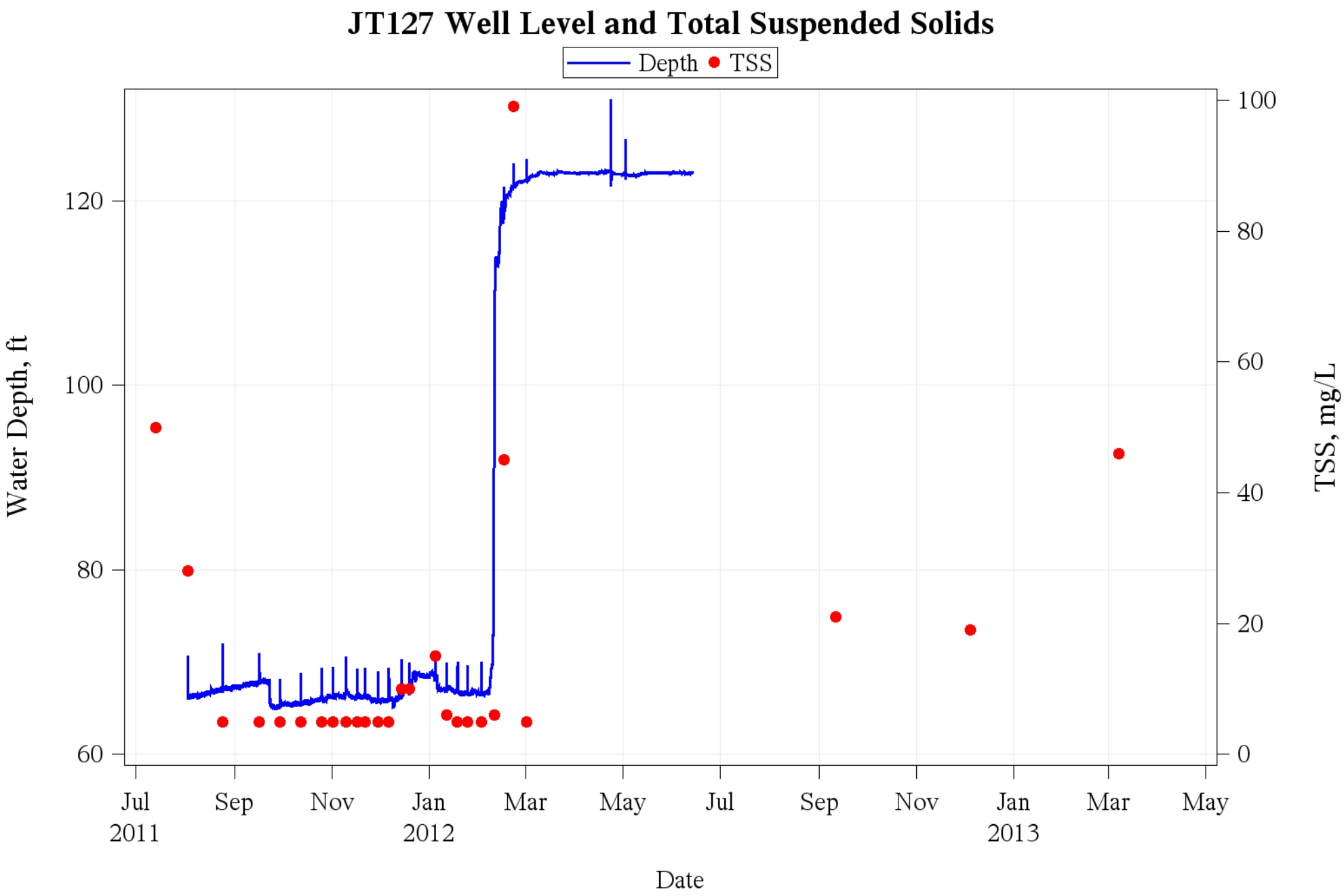

Sulfate (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull@Trib7
Bull T4 U/S SW
Bull Abv WTP4
Baseline Max
TCEQ Screening Level
Baseline Min
Result (mg/L)
150
125
100
75
50
25
0
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date


Sulfate (mg/L), Wells
JTMEC Well JT-127
JTMEC Well JT-112
100
80
60
40
20
0
Result (mg/L)
TCEQ Screening Level
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
500
400
300
200
100
0
Bull Flow (cfs)
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

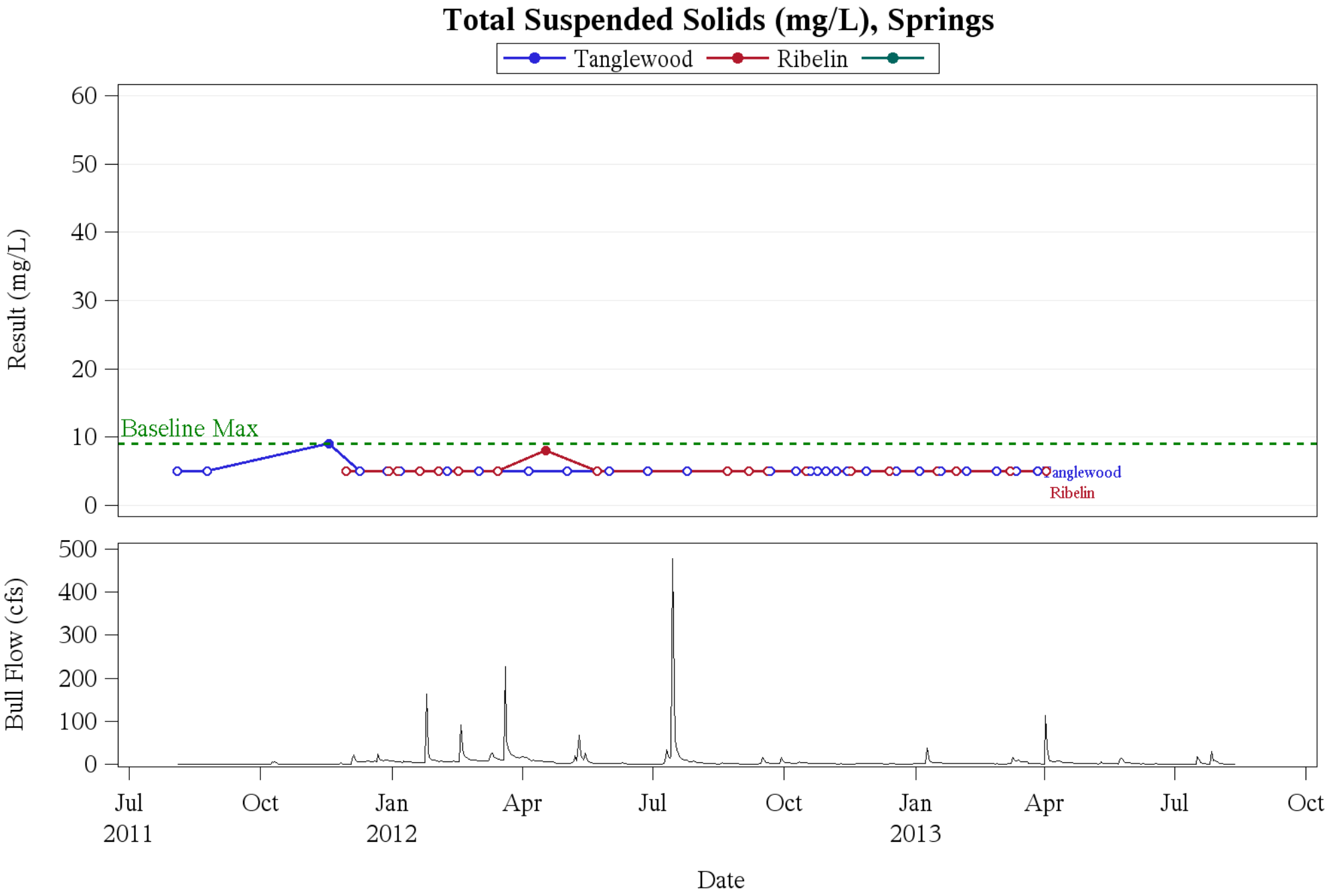

Sulfate (mg/L), Springs
Tanglewood
Lanier
Ribelin
Result (mg/L)
150
125
100
75
50
25
0
Baseline Max
LC EQ Screening Level
Historic High
Tanglewood
Baseline Min
Lanier
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

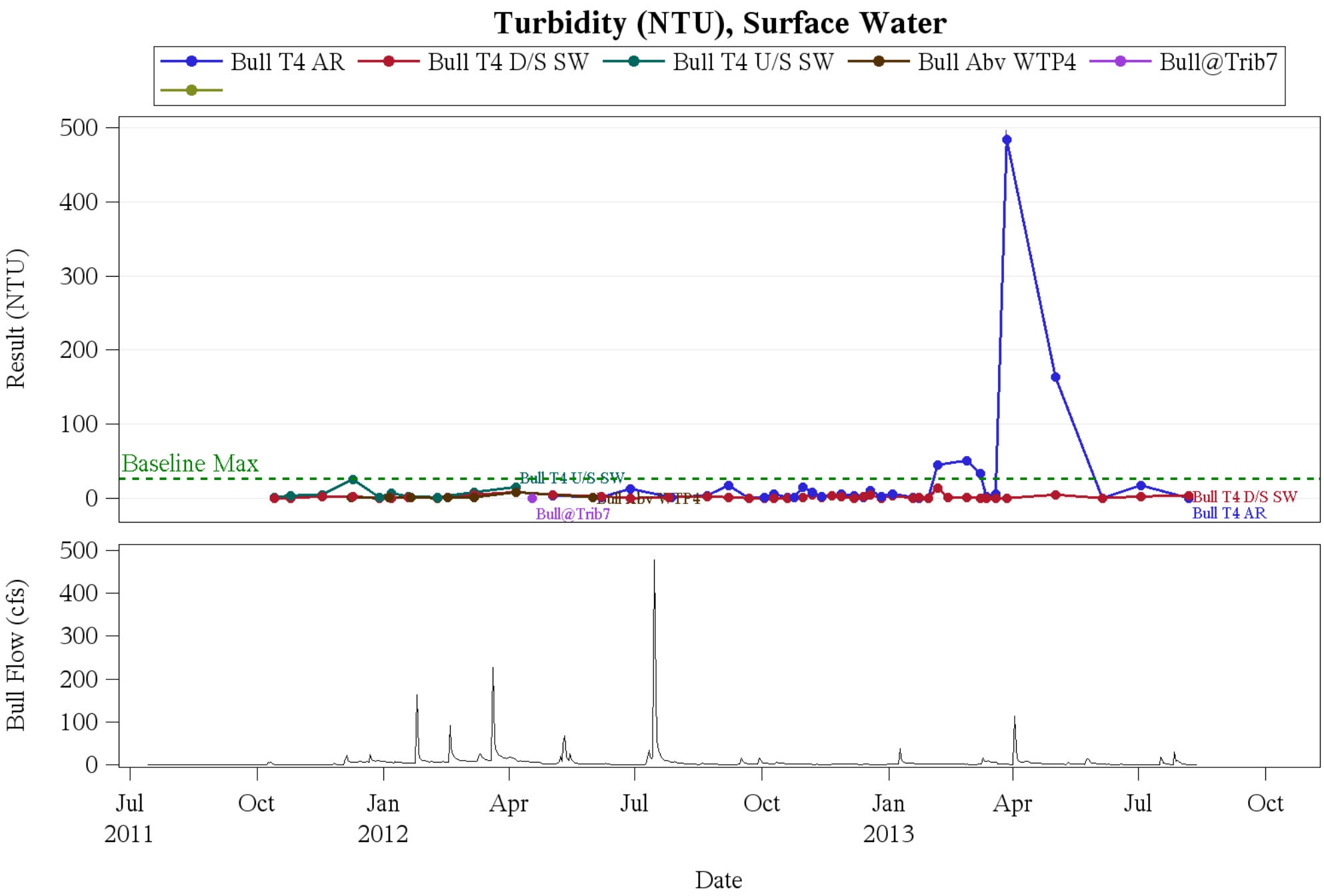

Total Suspended Solids (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
Result (mg/L)
60
50
40
30
20
10
0
Baseline Max
Bull T4 U/S SW
Bull Abv WTP4
Bull T4 AR
Bull T4 D/S SW
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

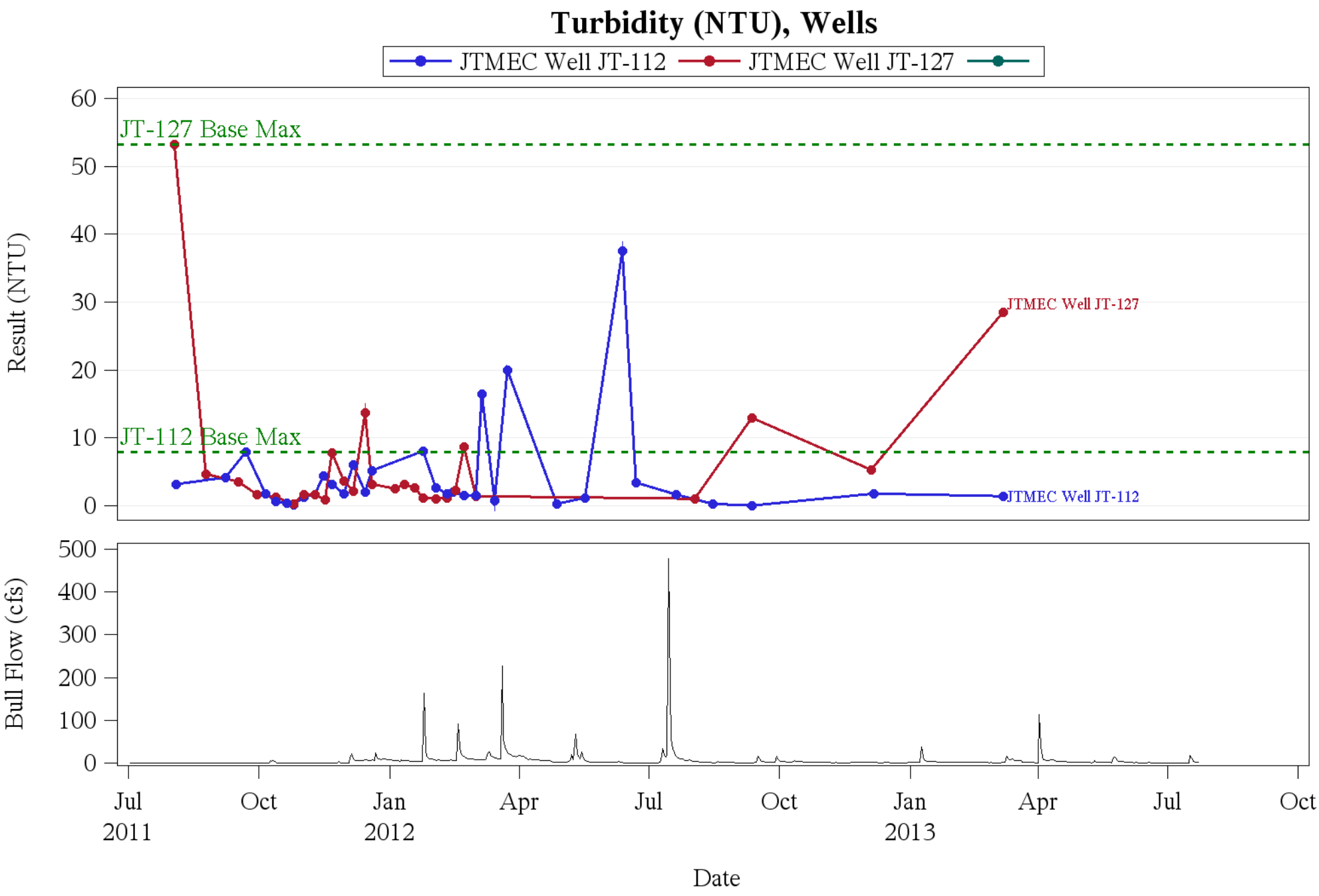

Total Suspended Solids (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
Result (mg/L)
100
80
60
40
20
0
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

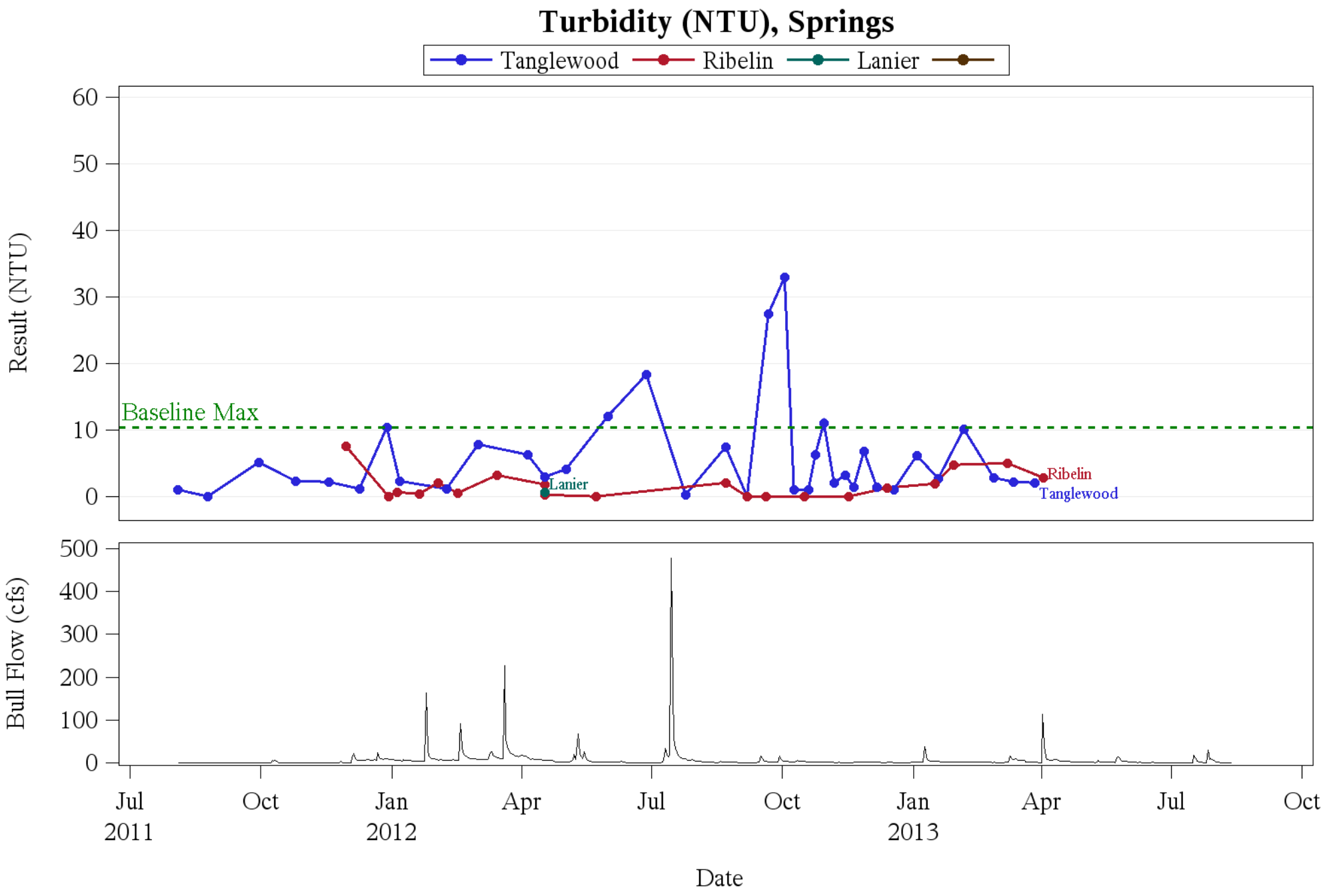


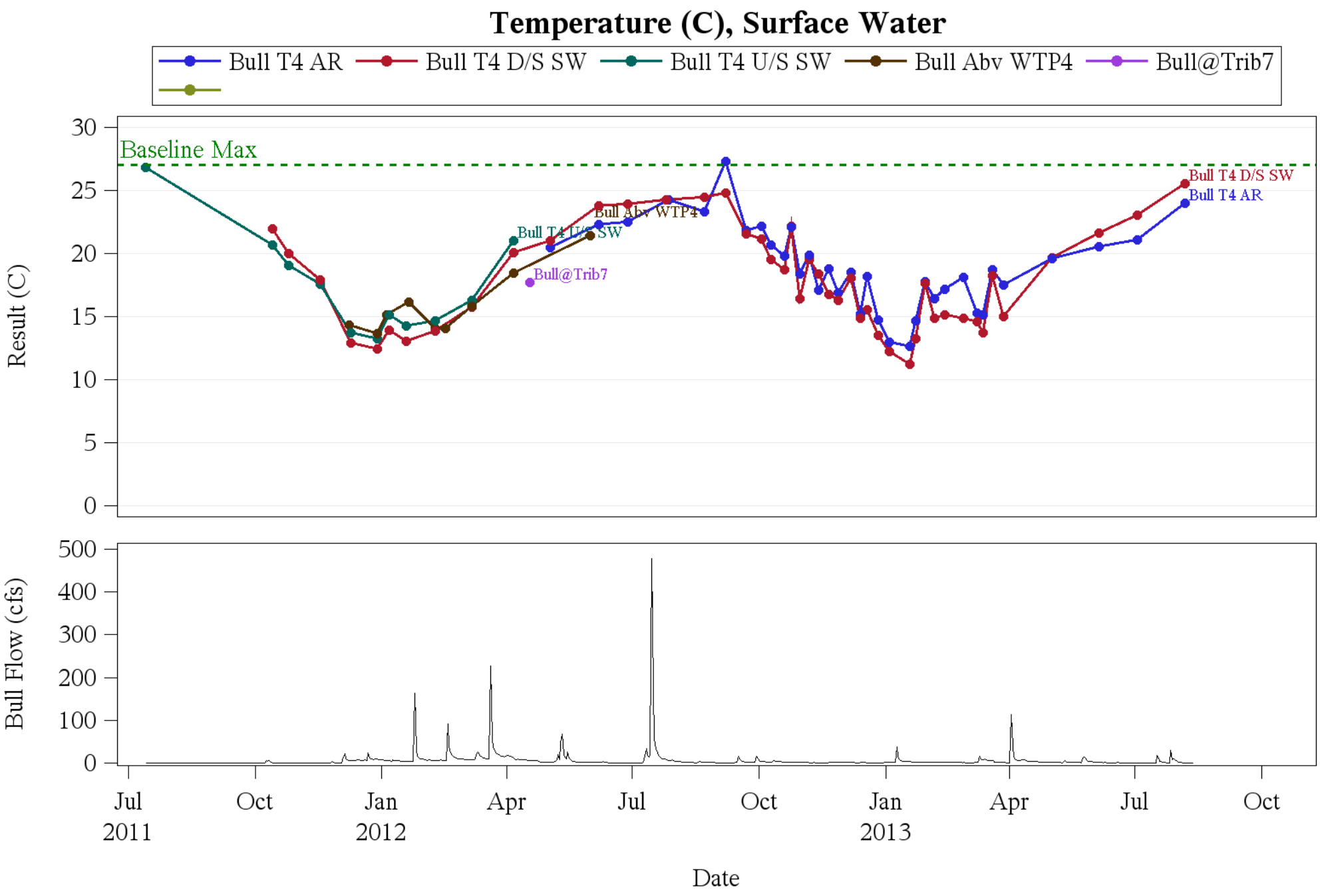
City of Austin DRAFT: QA/QC review pending

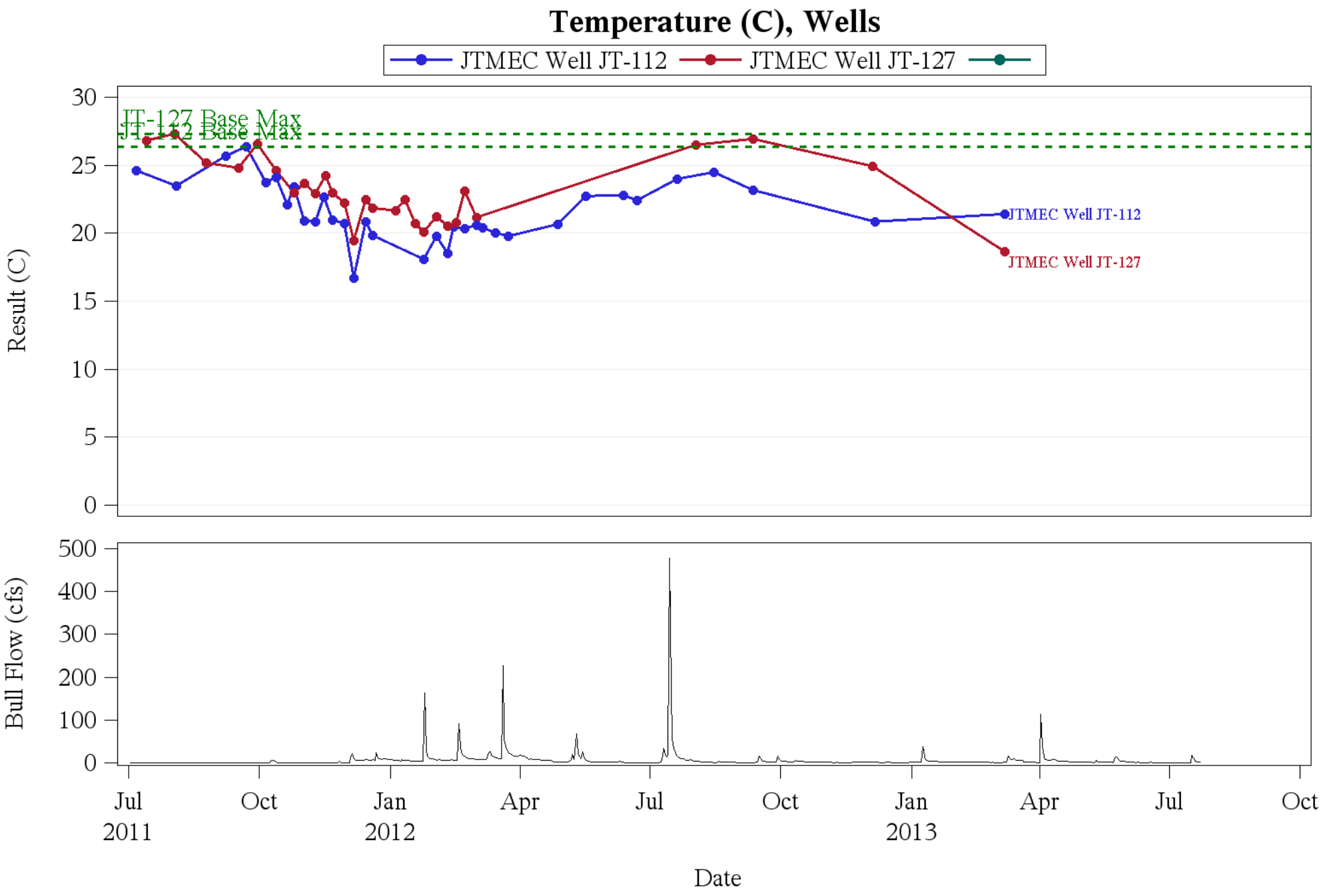

Total Suspended Solids (mg/L), Springs
Tanglewood
Ribelin
Result (mg/L)
60
50
40
30
20
10
0
Baseline Max
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

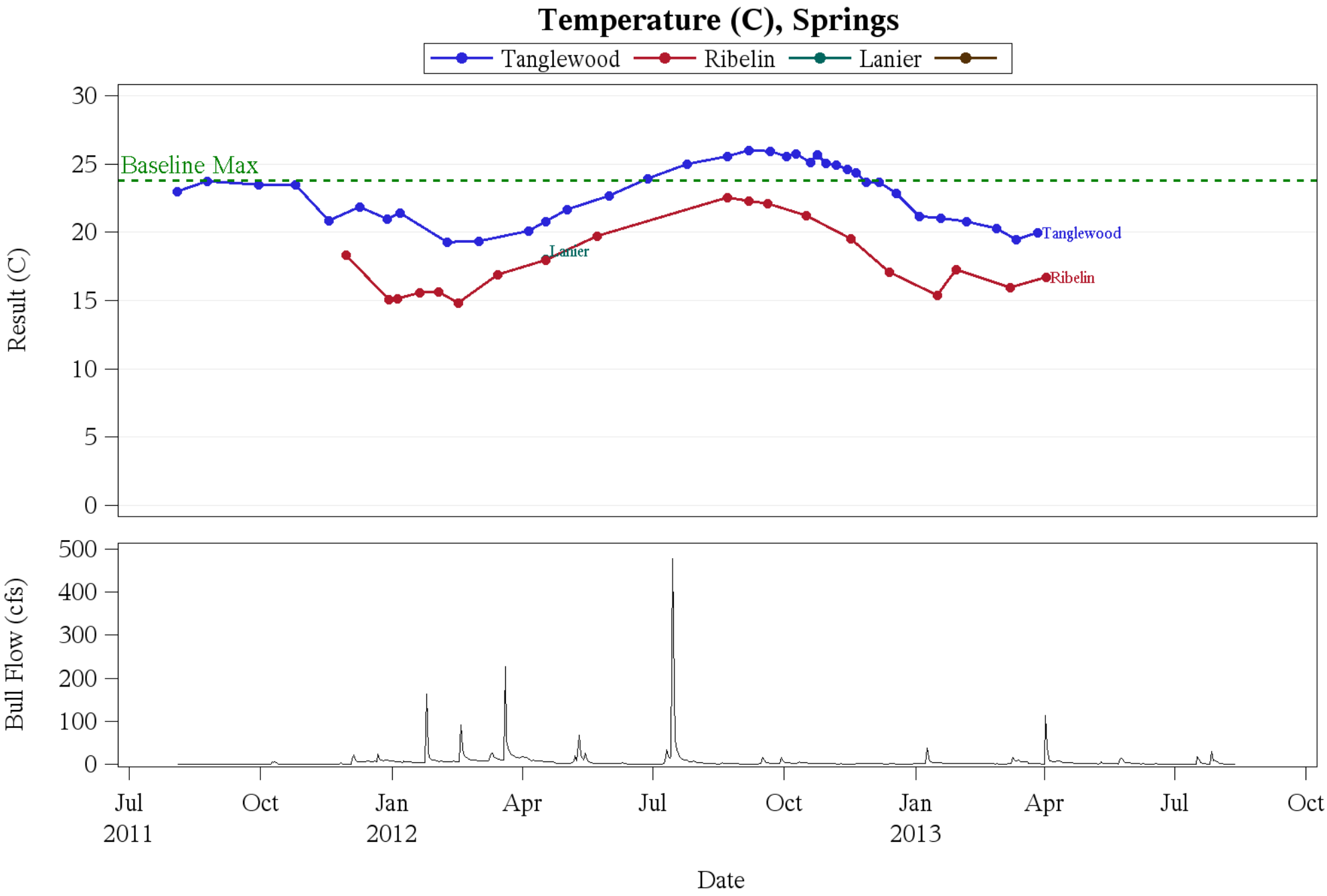

Turbidity (NTU), Surface Water
Bull T4 AR
Bull T4 D/S SW
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Result (NTU)
500
400
300
200
100
0
Baseline Max
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

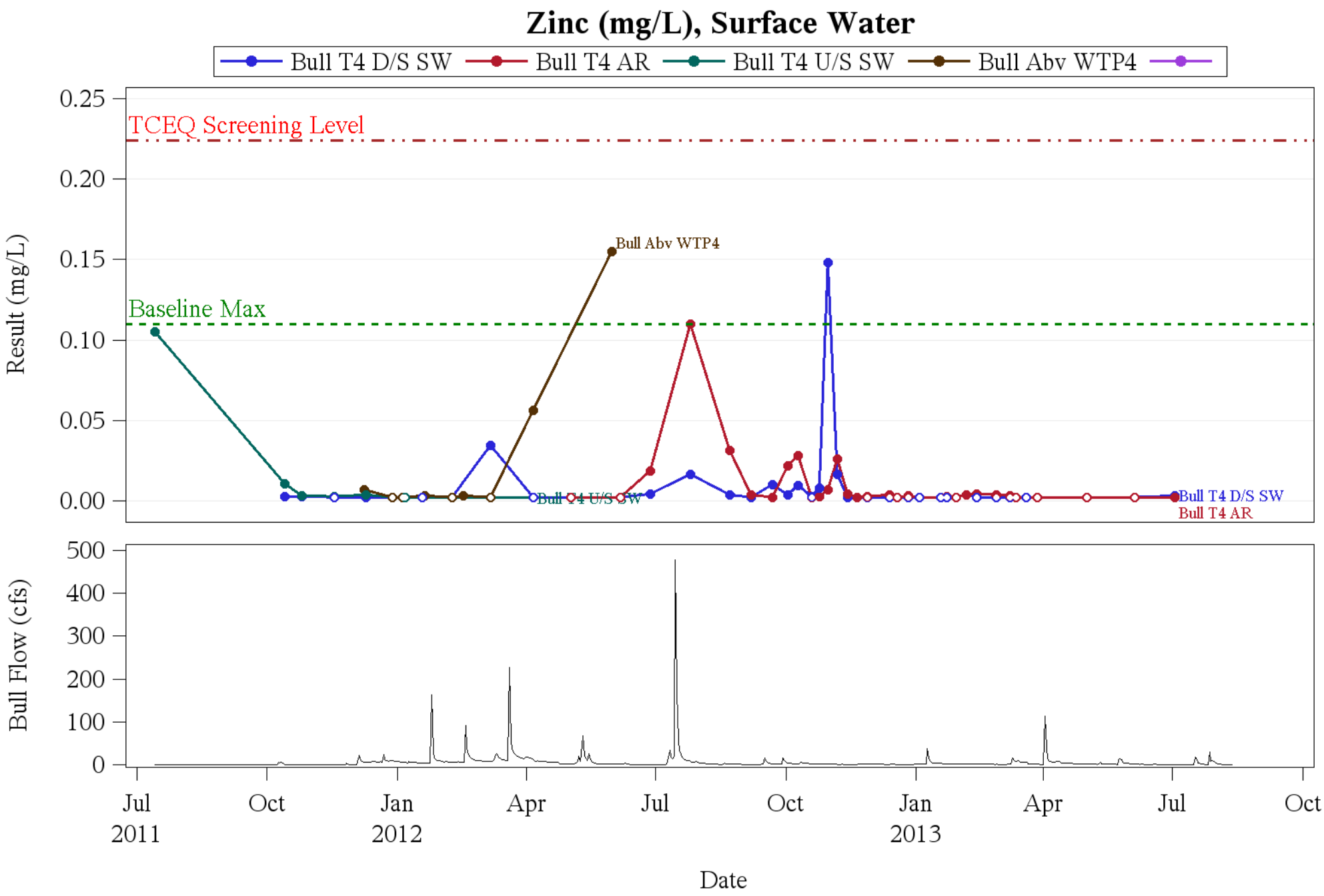

Turbidity (NTU), Wells
JTMEC Well JT-112
JTMEC Well JT-127
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-127
JTMEC Well JT-112
Result (NTU)
Bull Flow (cfs)
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date

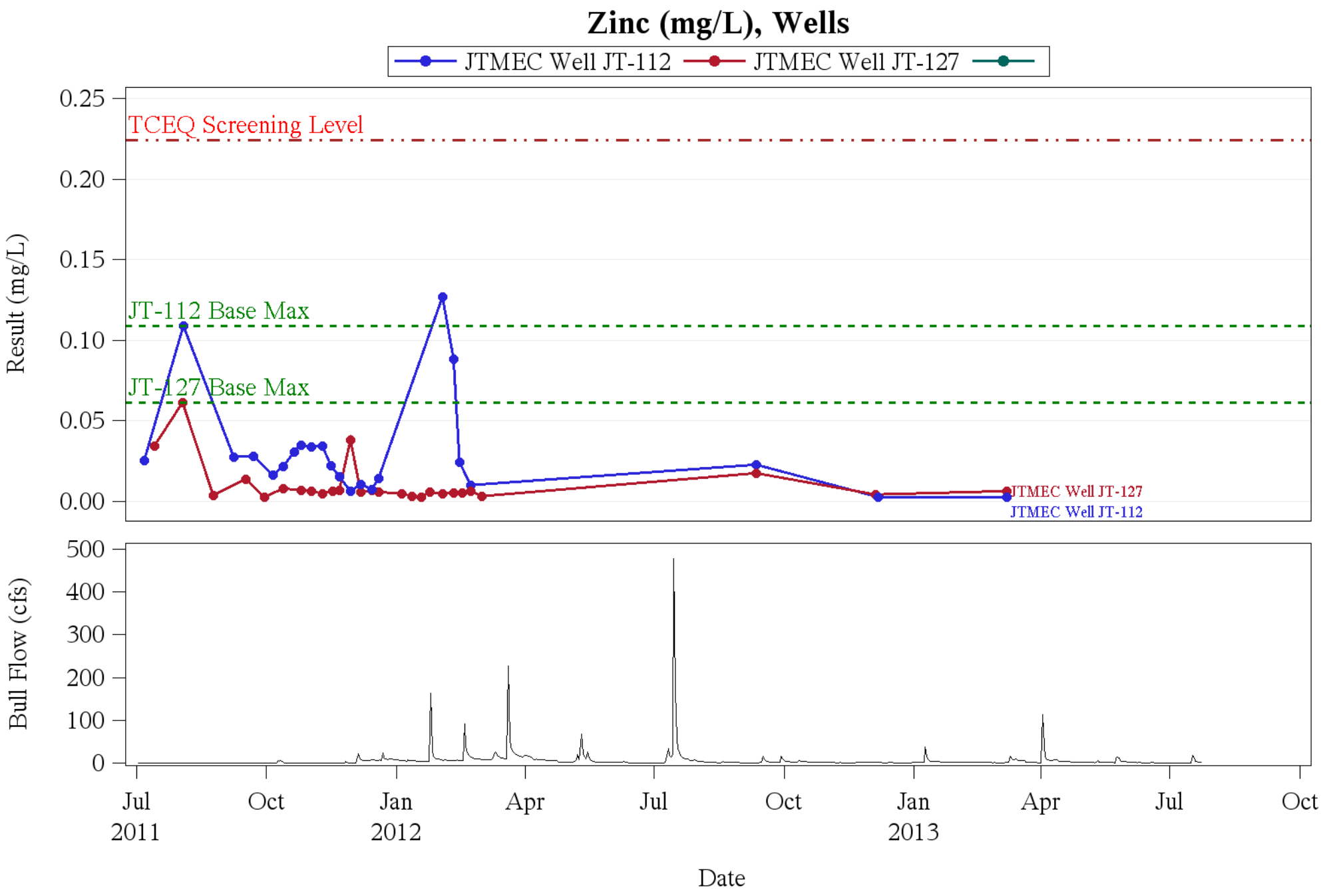

Turbidity (NTU), Springs
Tanglewood
Ribelin
Lanier
Result (NTU)
60
50
40
30
20
10
0
Baseline Max
Lanier
Ribelin
Tanglewood
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date

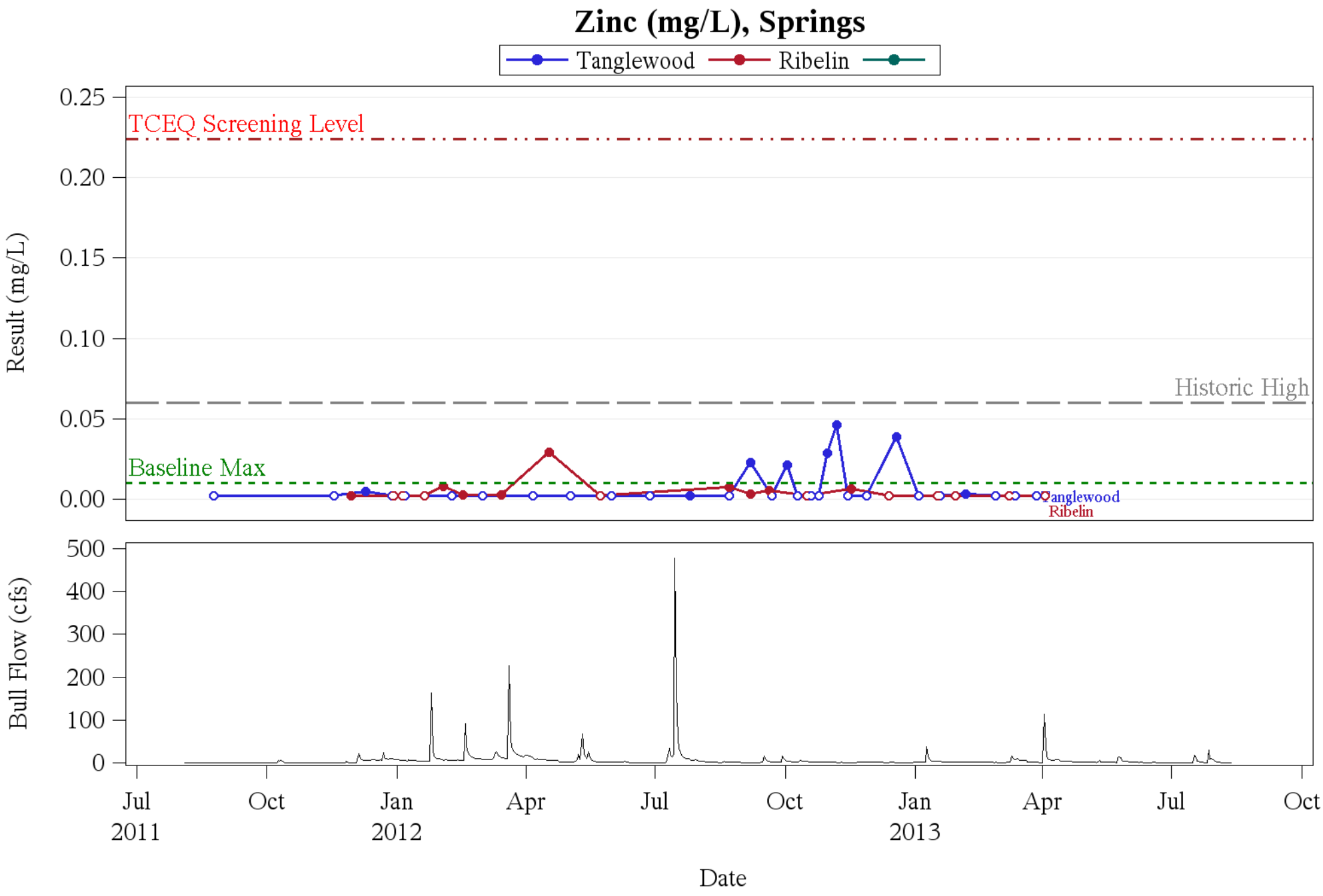

Temperature (C), Surface Water
Bull T4 AR
Bull T4 D/S SW
Bull T4 U/S SW
Bull Abv WTP4
Bull@Trib7
Baseline Max
Result (C)
30
25
20
15
10
5
0
Bull T4 D/S SW
Bull T4 AR
Bull Abv WTP4
Bull T4 U/S SW
Bull@Trib7
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date


Temperature (C), Wells
JTMEC Well JT-112
JTMEC Well JT-127
JT-127 Base Max
JT-112 Base Max
JTMEC Well JT-112
JTMEC Well JT-127
Result (C)
30
25
20
15
10
5
0
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date


Temperature (C), Springs
Tanglewood
Ribelin
Lanier
Baseline Max
Result (C)
30
25
20
15
10
5
0
Tanglewood
Lanier
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date


Zinc (mg/L), Surface Water
Bull T4 D/S SW
Bull T4 AR
Bull T4 U/S SW
Bull Abv WTP4
TCEQ Screening Level
Baseline Max
Result (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Bull Abv WTP4
Bull T4 U/S SW
Bull T4 D/S SW
Bull T4 AR
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date


Zinc (mg/L), Wells
JTMEC Well JT-112
JTMEC Well JT-127
TCEQ Screening Level
JT-112 Base Max
JT-127 Base Max
Result (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
JTMEC Well JT-127
JTMEC Well JT-112
Bull Flow (cfs)
500
400
300
200
100
0
Jul 2011
Oct
Jan 2012
Apr
Jul
Oct
Jan 2013
Apr
Jul
Oct
Date


Zinc (mg/L), Springs
Tanglewood
Ribelin
TCEQ Screening Level
Historic High
Baseline Max
Result (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Tanglewood
Ribelin
Bull Flow (cfs)
500
400
300
200
100
0
Jul
2011
Oct
Jan
2012
Apr
Jul
Oct
Jan
2013
Apr
Jul
Oct
Date