What is turbidity?

(Credit: NASA Johnson (Flickr), NASA. Public domain.)

Why does anyone measure turbidity?

- All by themselves, turbidity measurements aren't especially useful.
  - Turbidity directly tells us about the amount of light available to plant for photosynthesis
- **BUT..** The turbidity measurements can be **a very valuable surrogate** giving us a **lot** of information about other water quality parameters that are very difficult to measure directly or continuously, such as:
  - Sediment concentrations and local erosion rates
  - Heavy metal concentrations
  - Concentrations of multiple types of pathogens

Why do YOU measure turbidity?

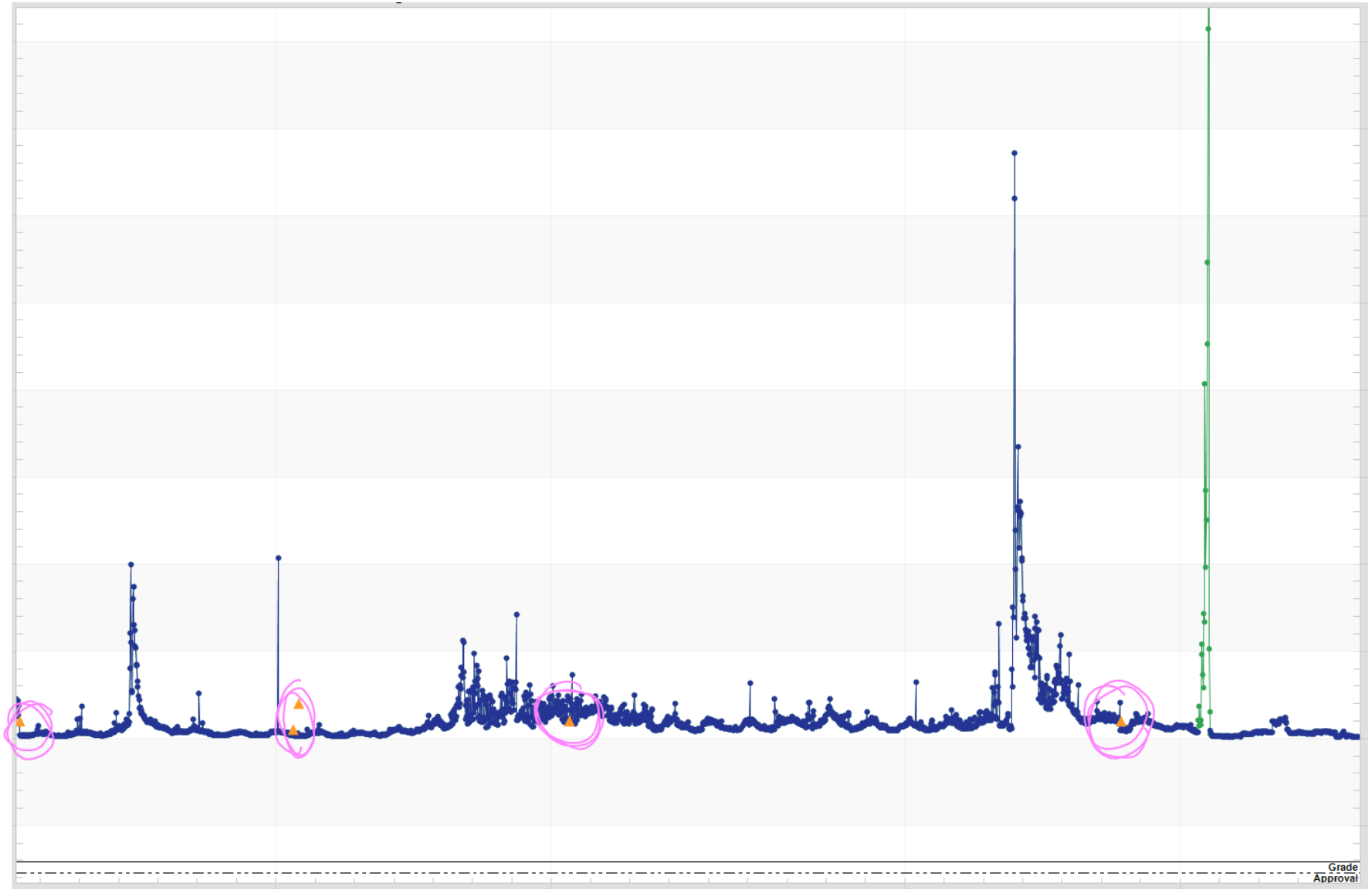
- The turbidity sensors are both the most expensive and the most difficult to maintain of the sensors most of the DRWI groups have.
- So – if you have one – you should know **why** you're going through the trouble of having it.
- Some possible reasons:
  - As an educational tool
  - Sediment or nutrient TMDL (total maximum daily load)
  - Verify the effectiveness of remediation or restoration project
  - Contribute to Stroud and William Penn Foundation research

How “good” does my turbidity data need to be?

- The level of data quality you need really depends on **why** you’re measuring turbidity in the first place.
- If your primary reason to have a monitoring station is to use it as a teaching tool, you can have a much higher tolerance for bad data.
- If you really want to calculate sediment loads or if your monitoring is legally mandated in relation to a TMDL, you will have much lower tolerance for bad data.

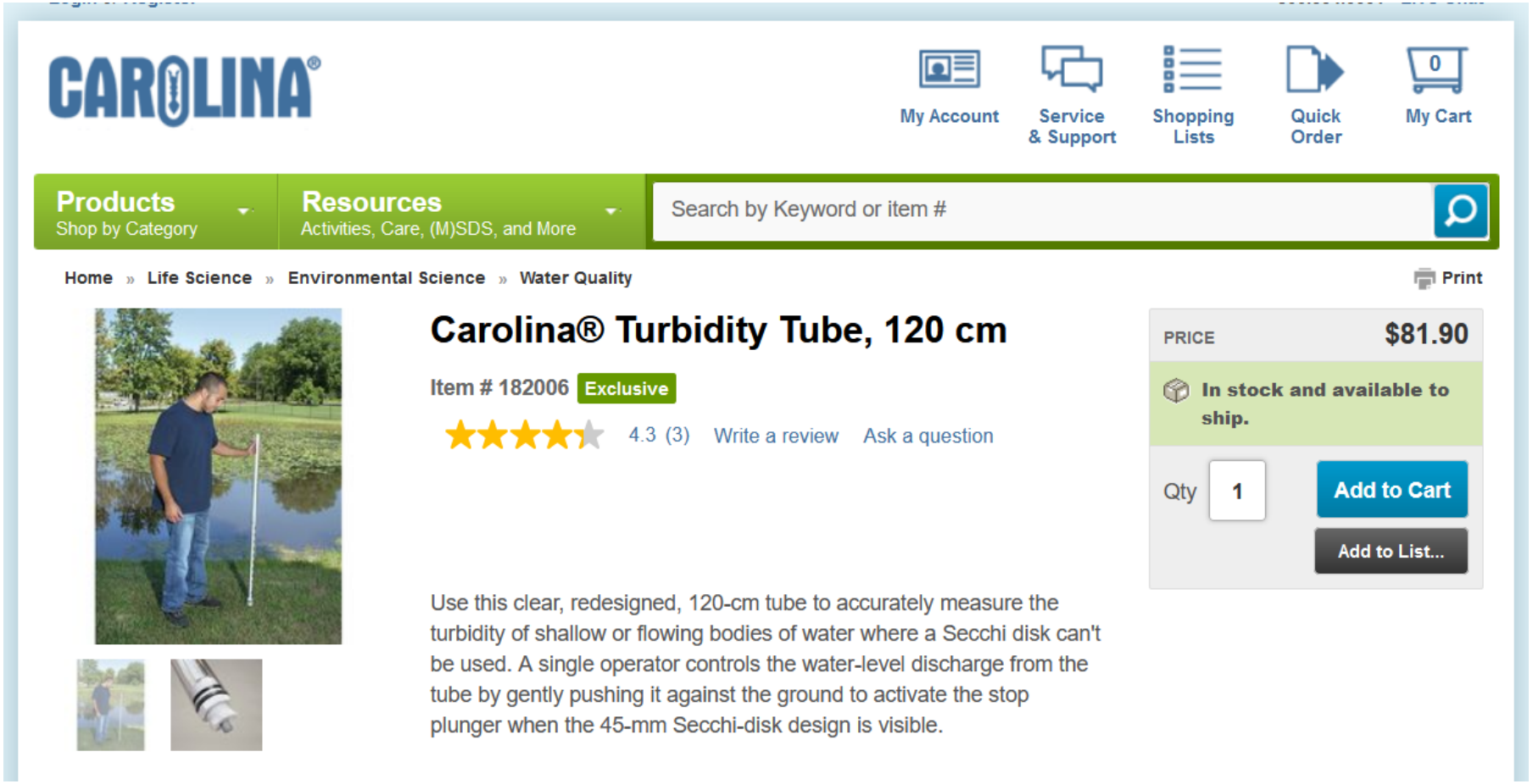
So, how do I know if my data is “good?”

- Ideally, regularly measure the stream with a second **independently certified turbidity meter** that is **calibrated** against a known certified standard. Your sensor’s values should match.



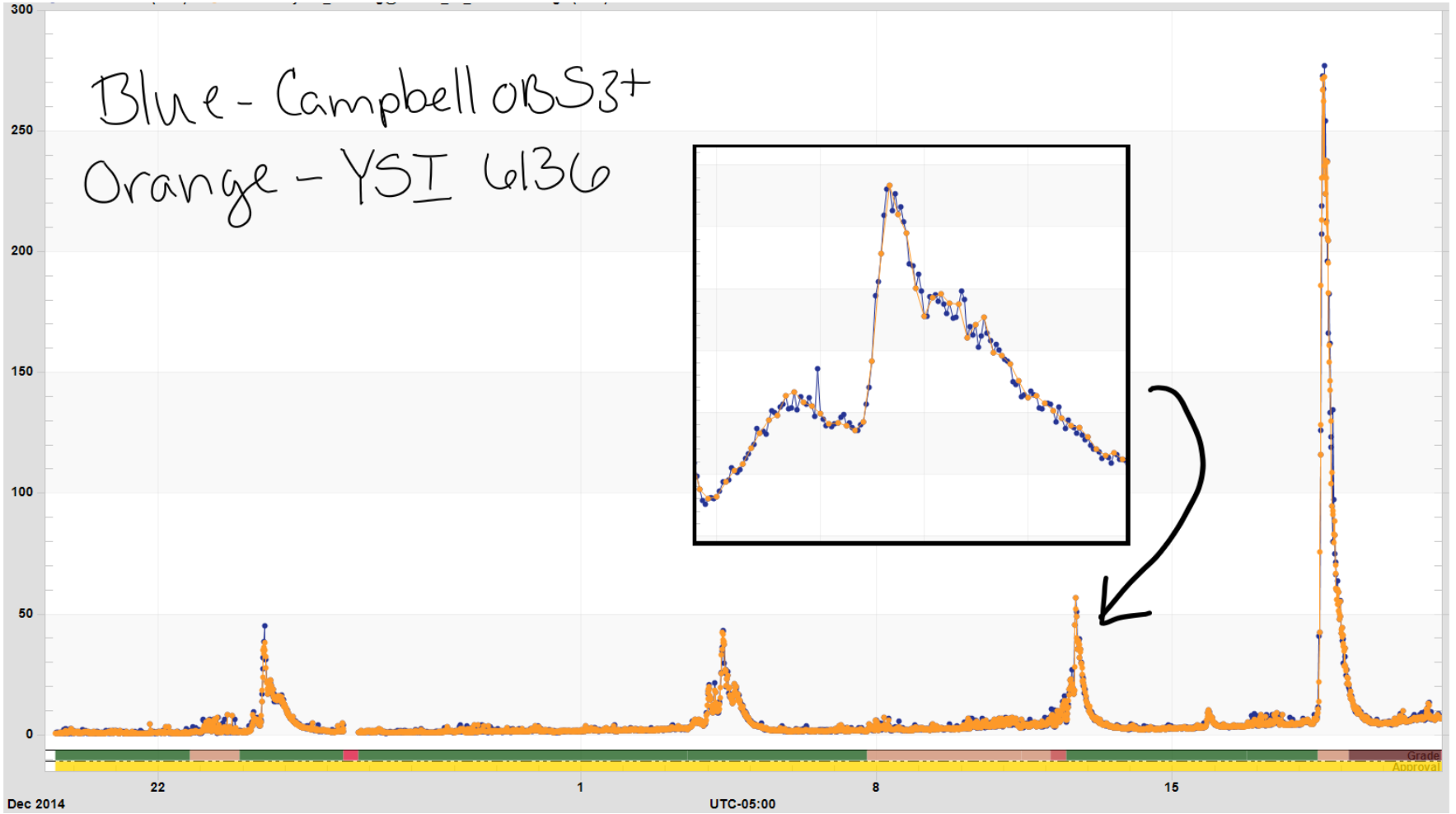
So, how do I know if my data is “good?”

- In addition to hand-held meters, there are (relatively) inexpensive turbidity tubes or Secchi-disks that can be used at moderate turbidities.



So, how do I know if my data is “good?”

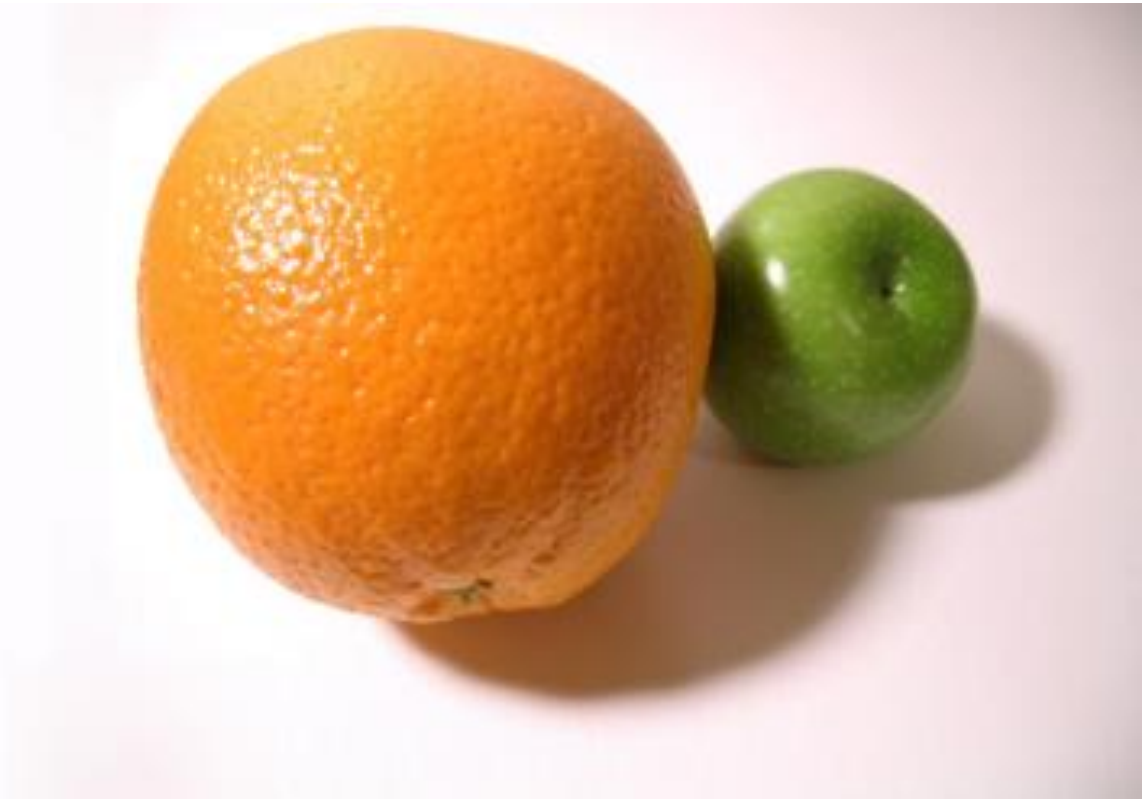
- You could also install two completely independent sensors in the stream to ensure they match each other.



So, how do I know if my data is “good?”

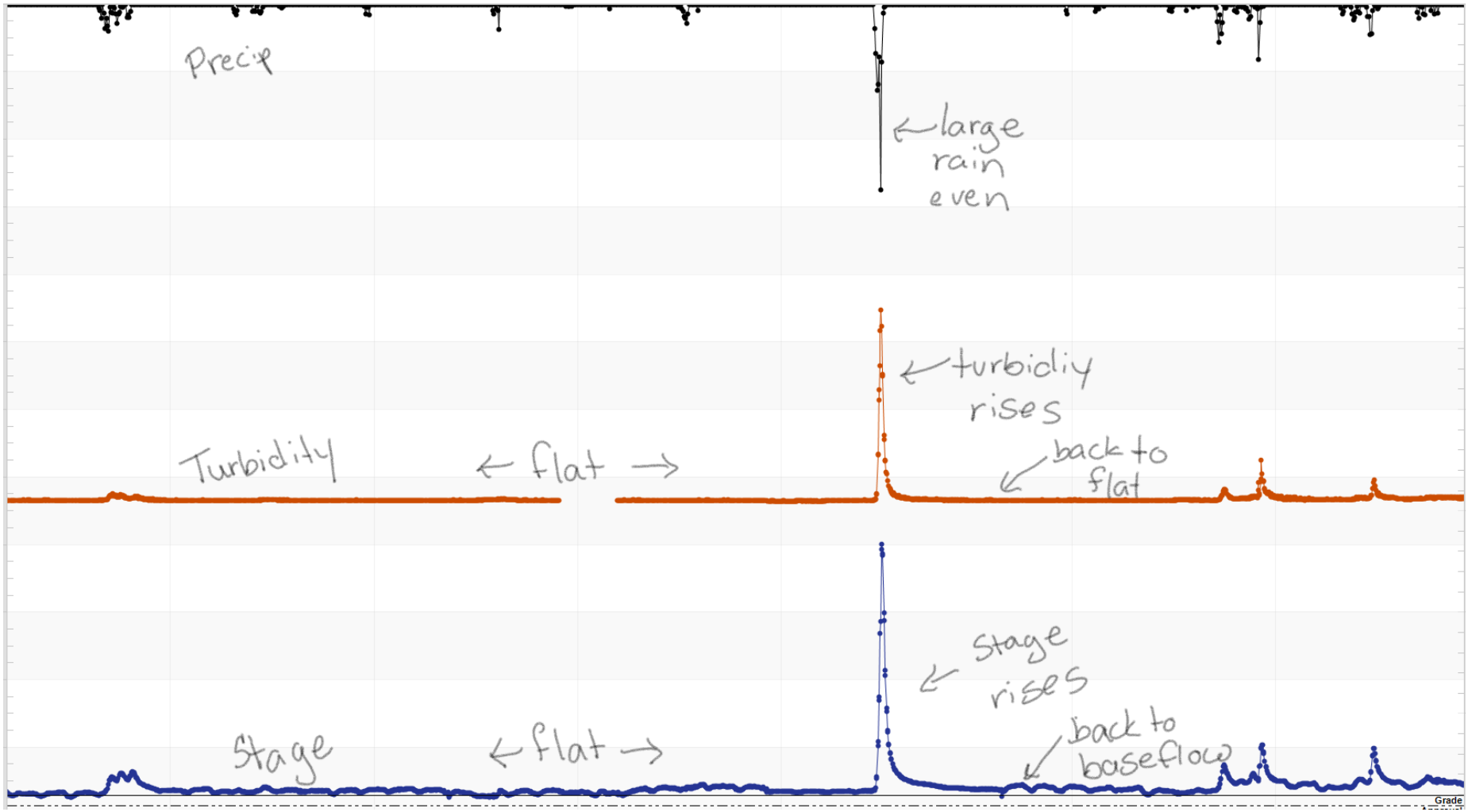
- In addition to independent measurements, we know fairly well how most stream’s turbidity changes day-to-day so we follow to make sure the sensor values **match expectations**.

Close Enough?



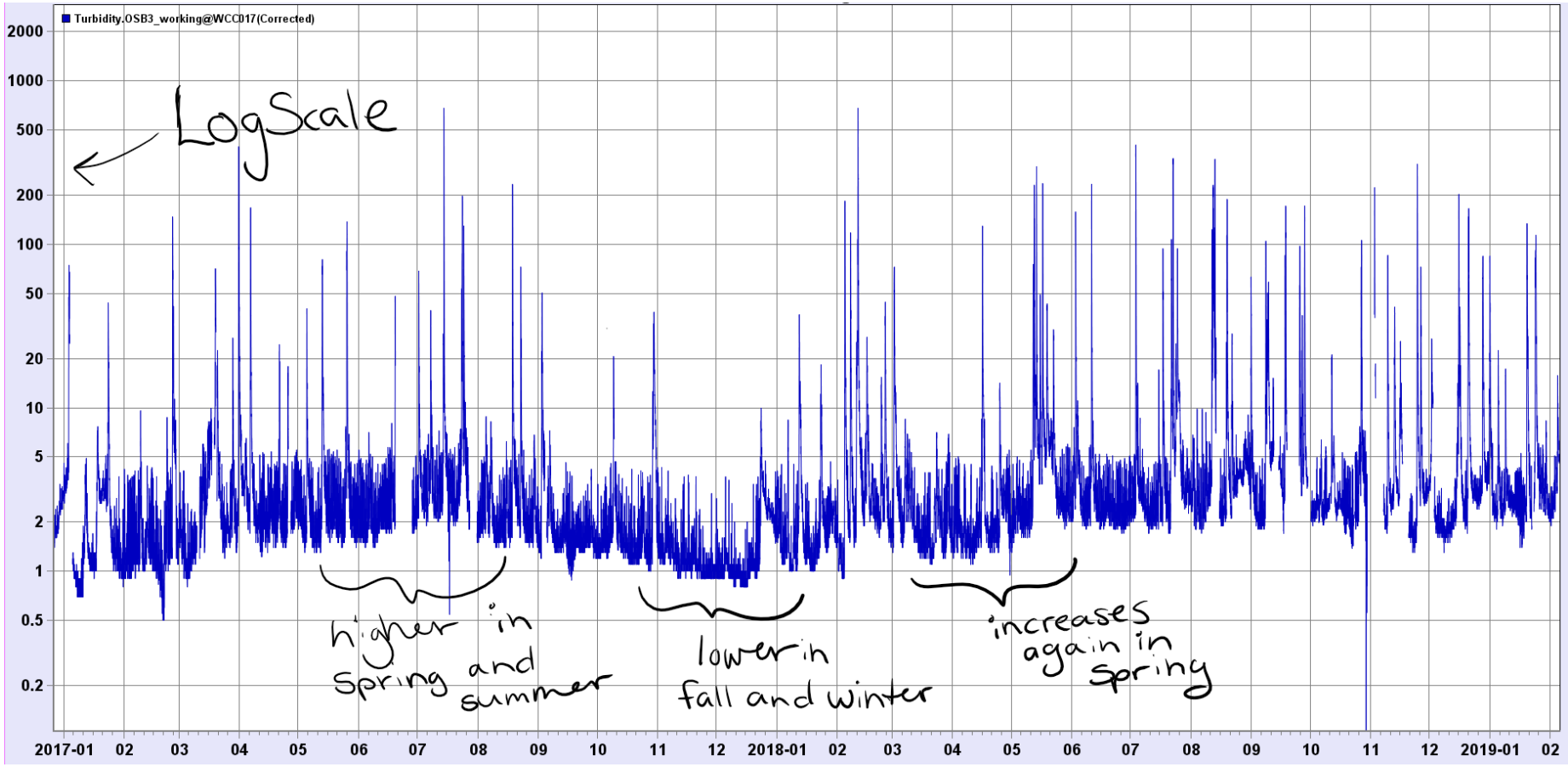
Well, what are some of the expected turbidity patterns?

- We expect stream turbidity to be **low at baseflow**, to **rise in storms** with rising waters, and to **fall back** to approximately the initial value after a storm.



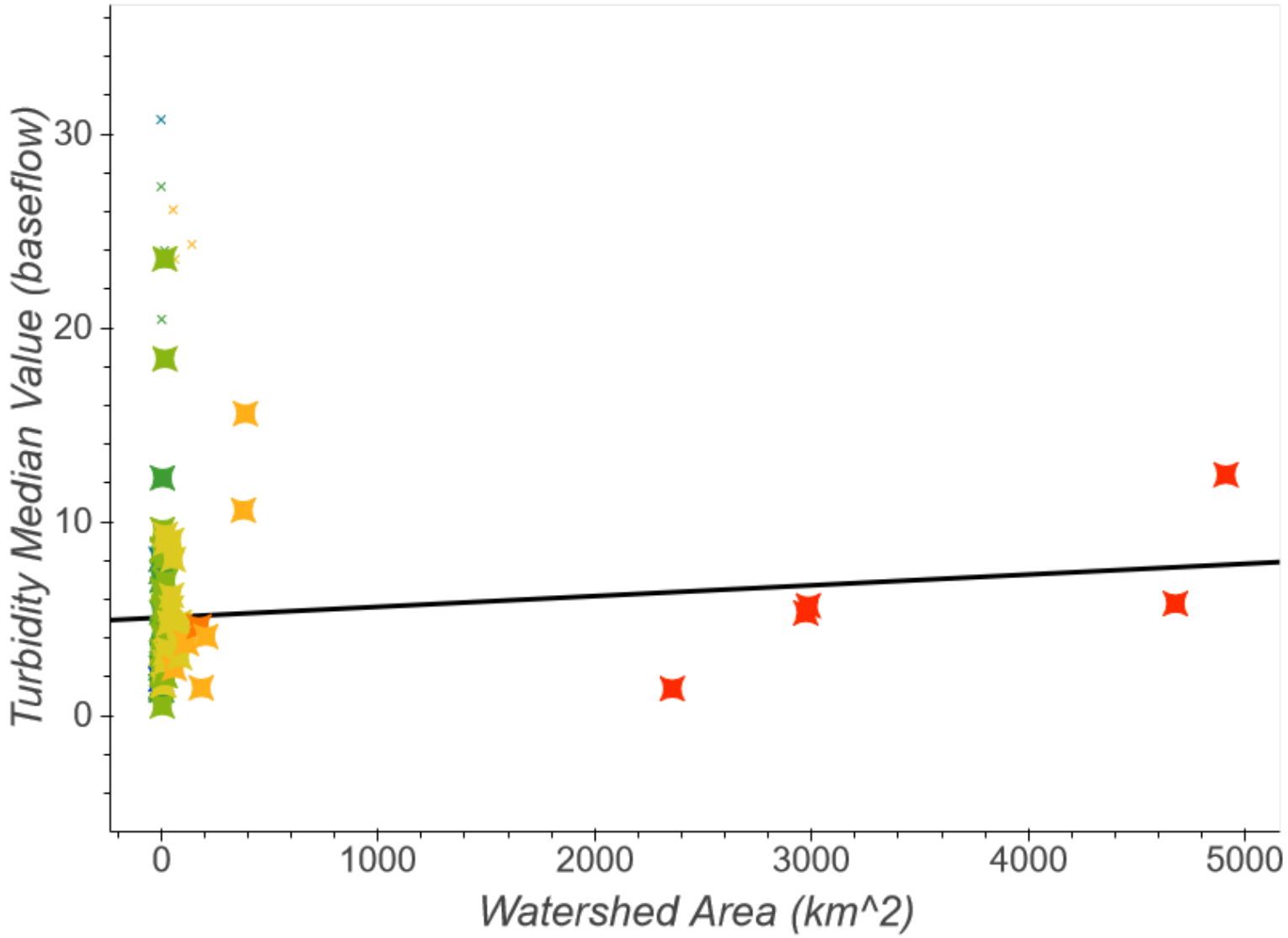
Well, what are some of the expected turbidity patterns?

- There may be some **seasonal variation** – higher in the summer, lower in the fall – but in our area this is generally much less than the variation caused by storms.



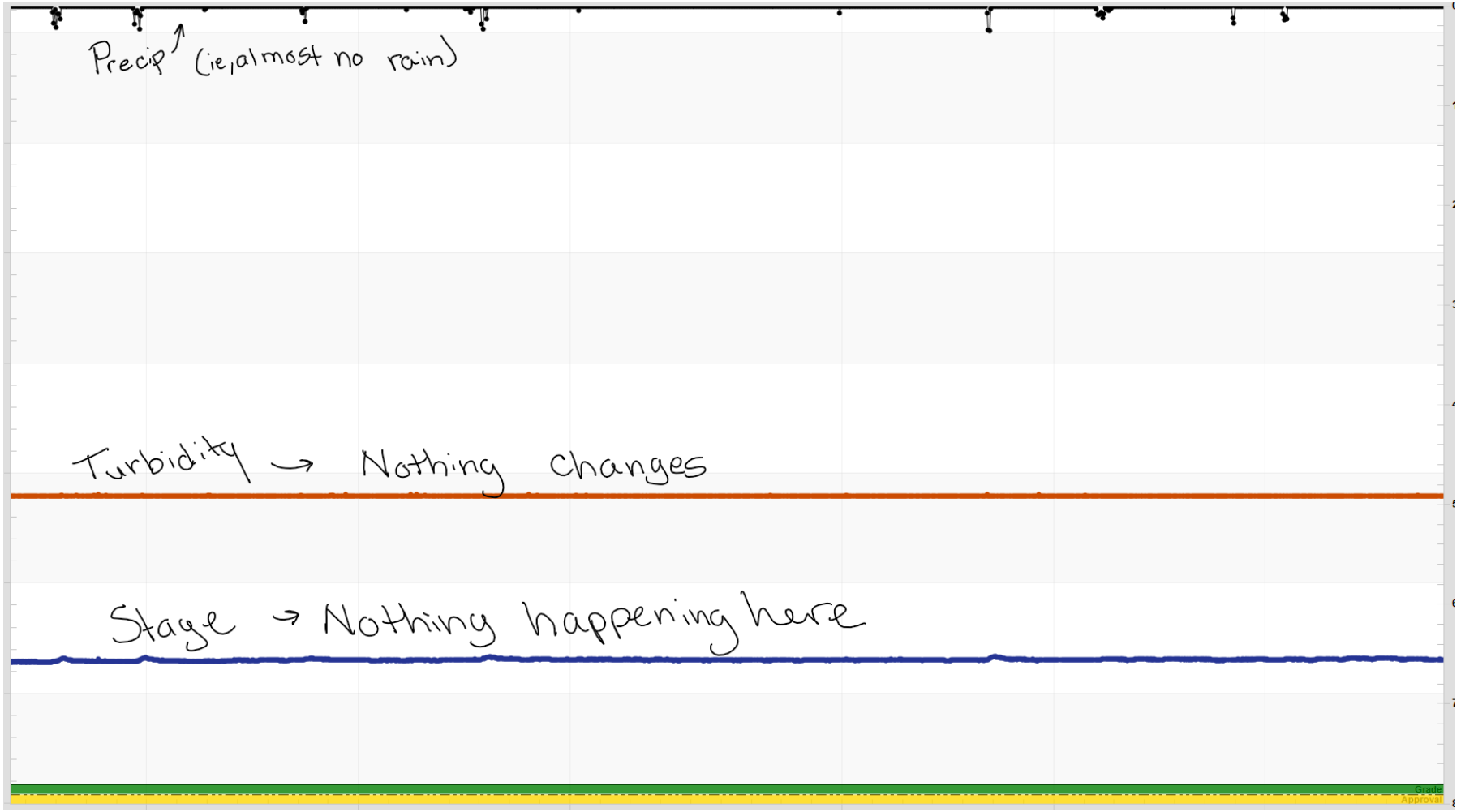
Well, what are some of the expected turbidity patterns?

- Larger streams *may* have higher baseflow turbidity than small streams.
- Again, this is a much smaller influence than storms.



Well, what are some of the expected turbidity patterns?

- If the stream **isn't changing** much, the turbidity should be pretty **constant**.

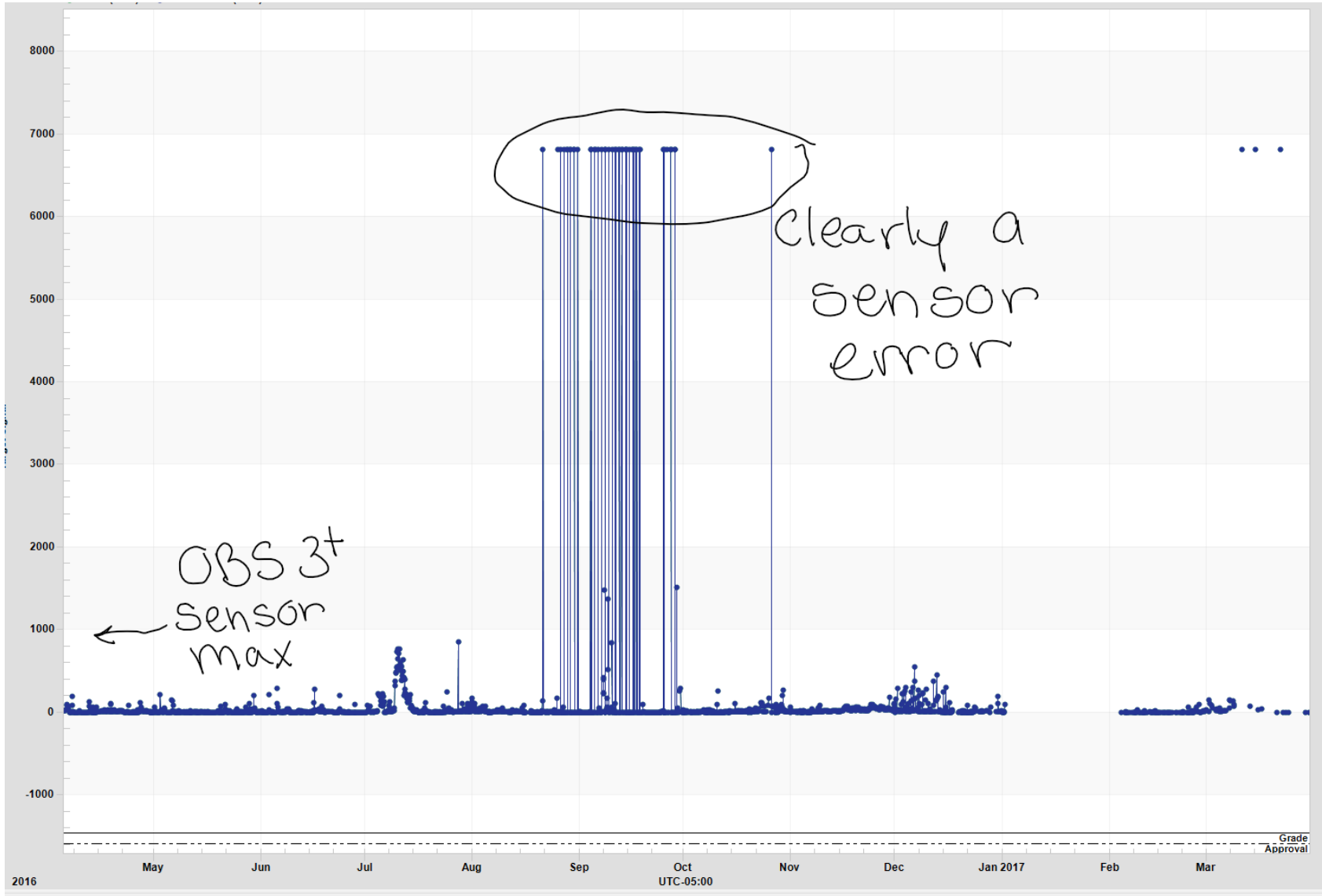


What do I do when my turbidity doesn't match with standards and expectations?

- You clean it up! Delete bad or suspect data and correct for drift and fouling when possible.
- Internally, Stroud uses software called Aquarius made by Aquatic Informatics.

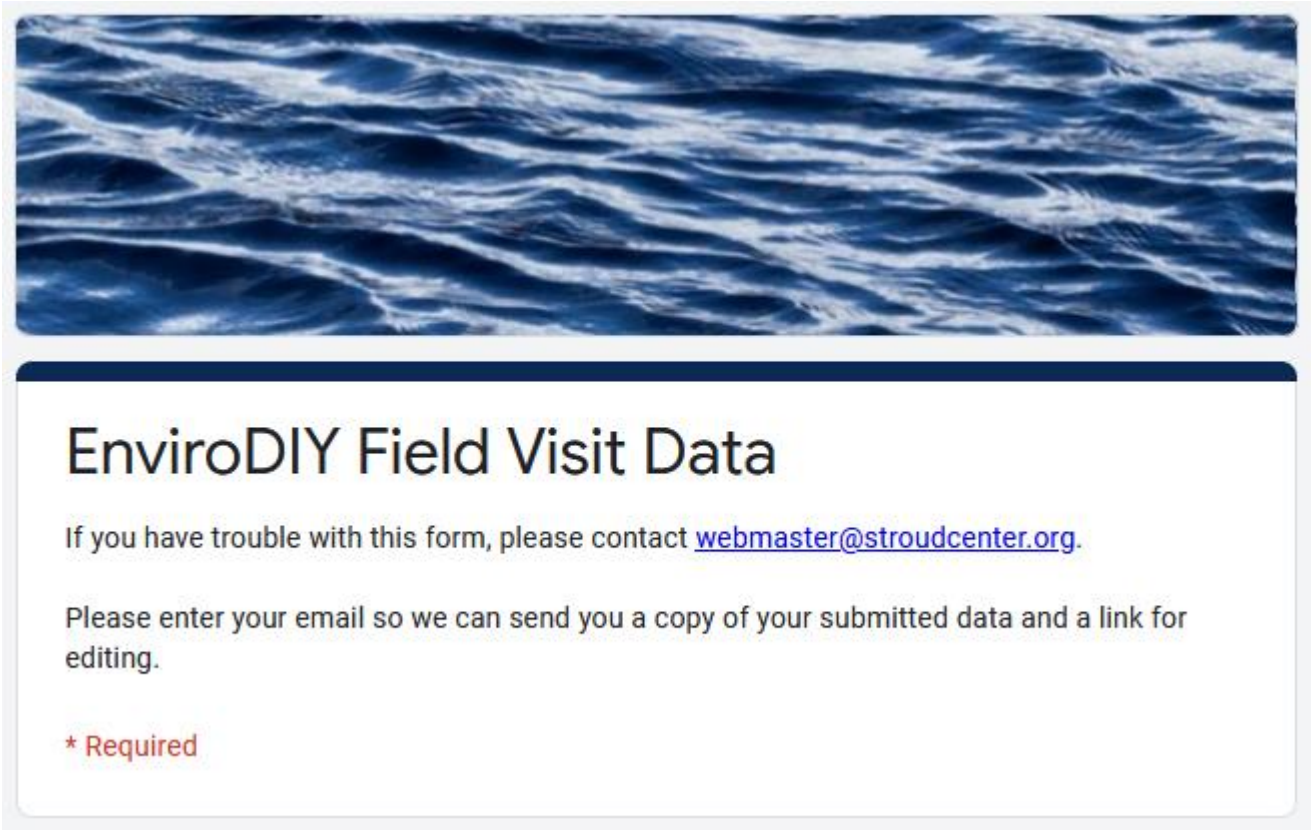
Remove obvious errors – sensor malfunctions

- We know that turbidity **cannot be less than 0** and that the turbidity sensor almost everyone has cannot measure higher than 1000 NTU. So we can immediately delete any points that are < 0 or > 1000 NTU.



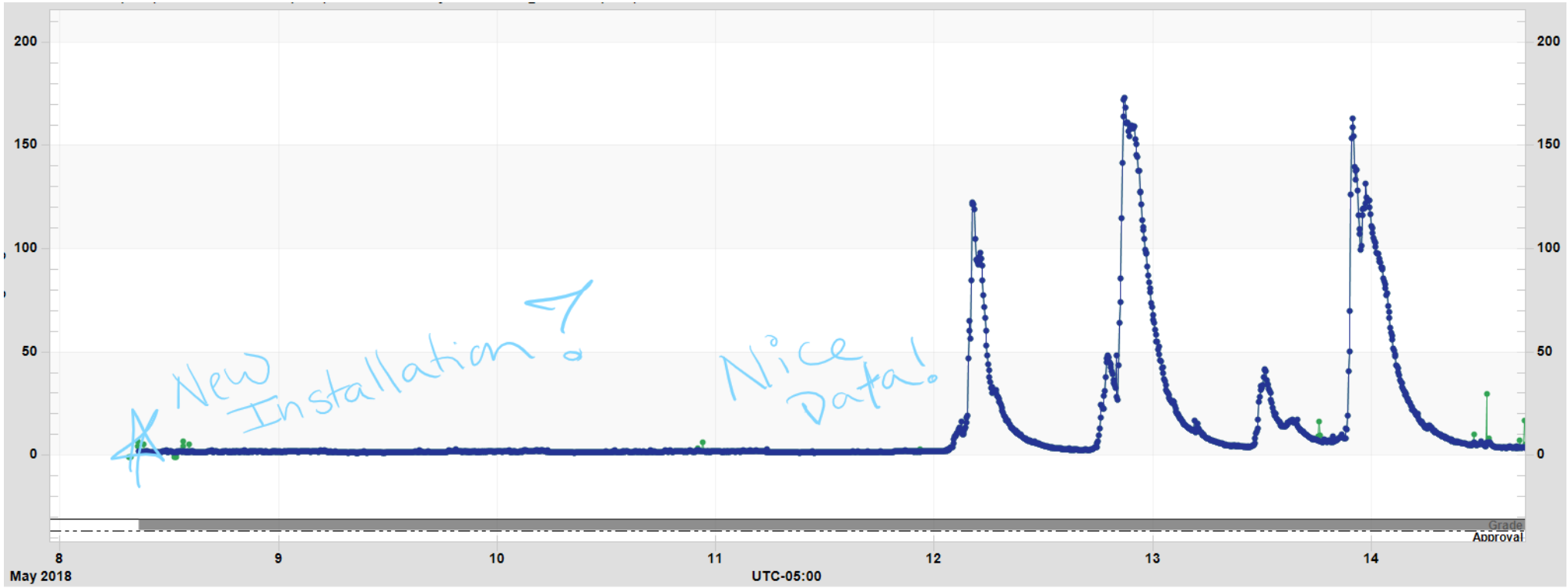
Remove obvious errors – station notes

- **If we know from station maintenance visits** that there was a period that the sensor was either dry or buried, that data can be immediately deleted.
- *Usually* a buried sensor will report >1000 NTU and a dry sensor will report near 0 or slightly negative.



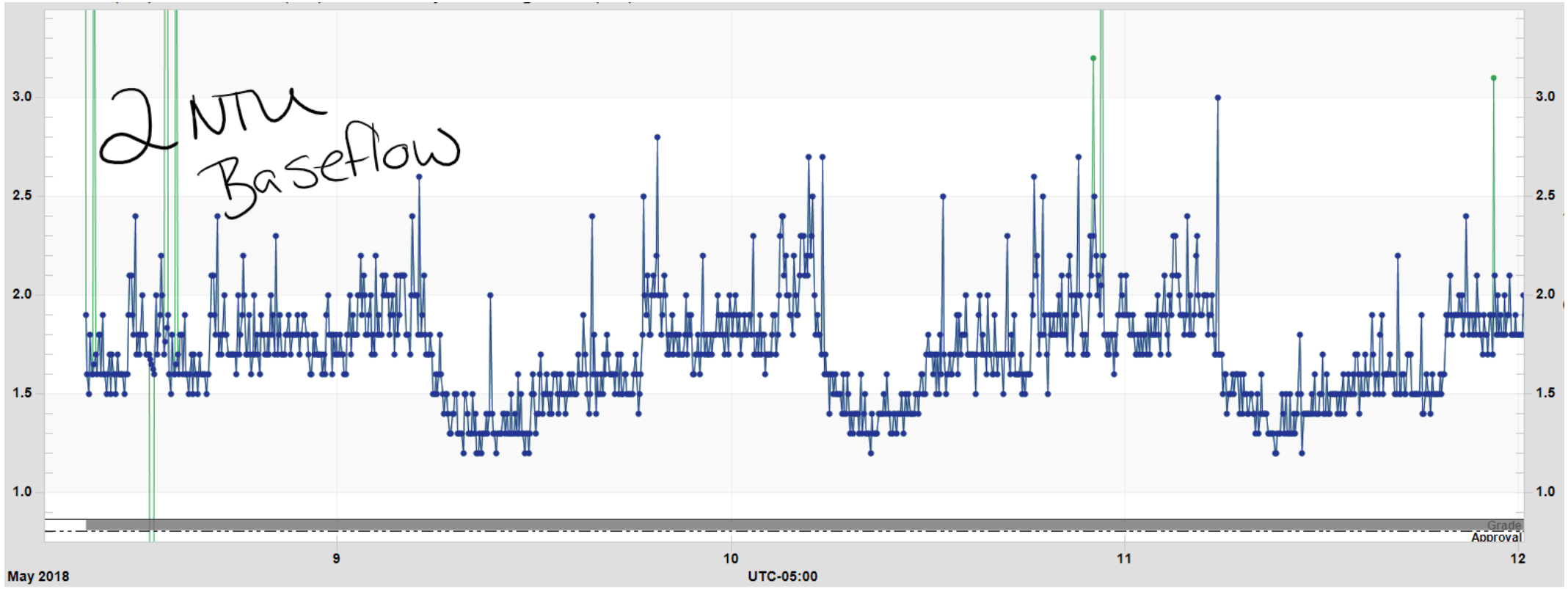
Calibrate your eyes to what good data looks like at your site

- Focus in on a period of a week or so when you know the sensor was completely clean and operating properly – likely right after installation.



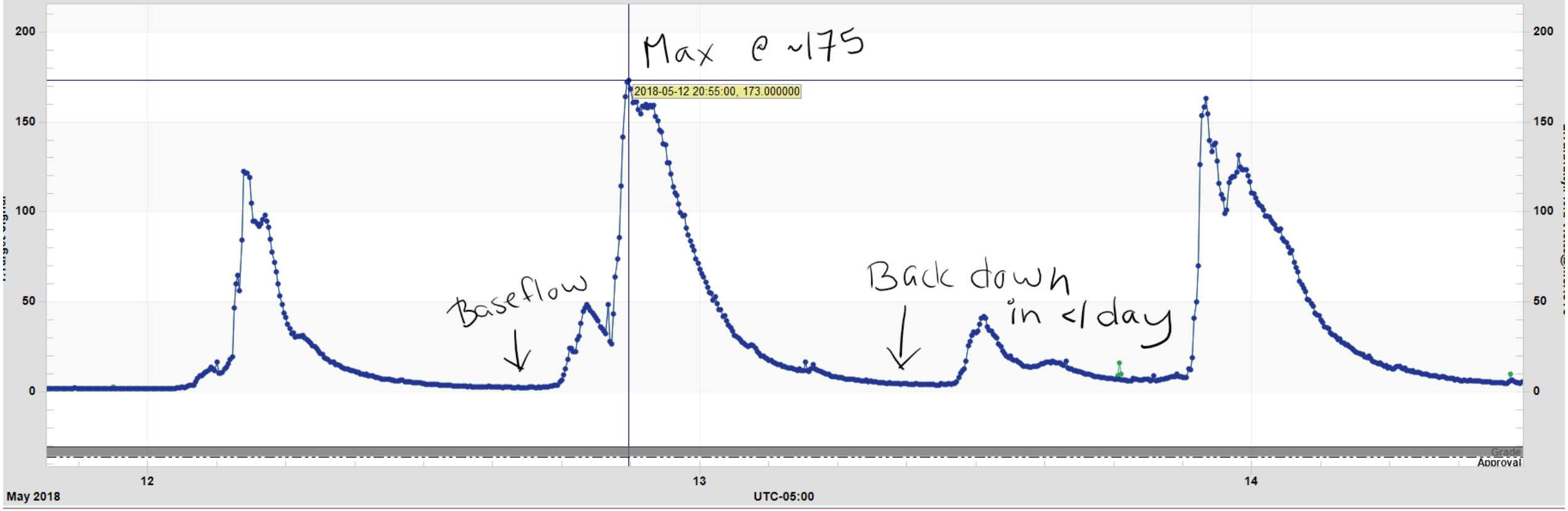
Calibrate your eyes – baseflow

- Make note of what the baseflow turbidity was in that ideal period. Was it 2, 5, or 30? That is (approximately) the number your should be seeing at all times except during storms.



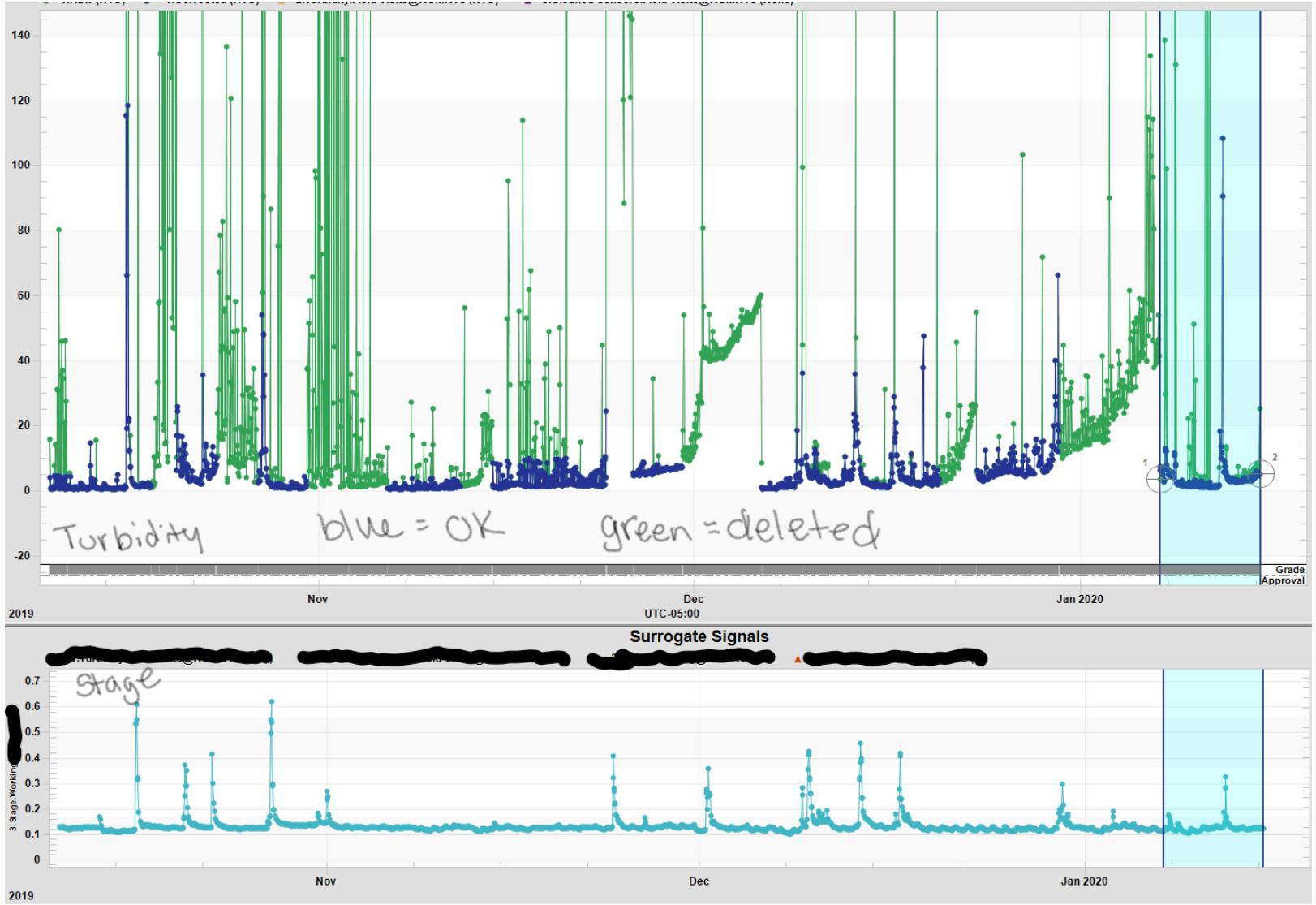
Calibrate your eyes – storm flow

- If you had a small (or large) storm during this period, make note of **how high** the turbidity rose and whether it topped out before or after the flow data.



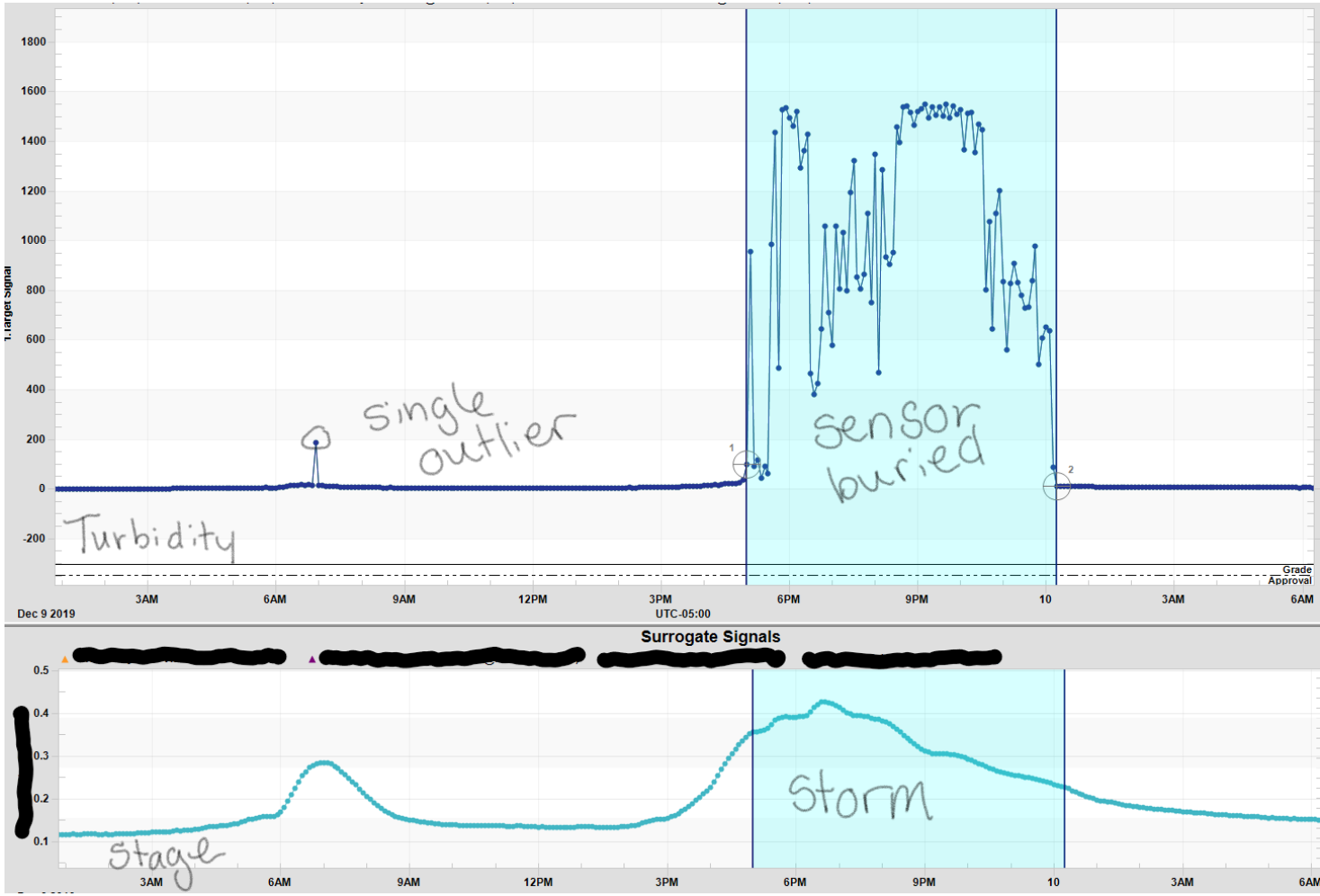
Comb through the data

- Once we've removed blatant errors and have a good idea what good data at our site should be, the next step is to plot turbidity and water depth (or preferably stage, or ideally discharge) and to scroll through day-by-day to look for anything that doesn't follow the pattern.



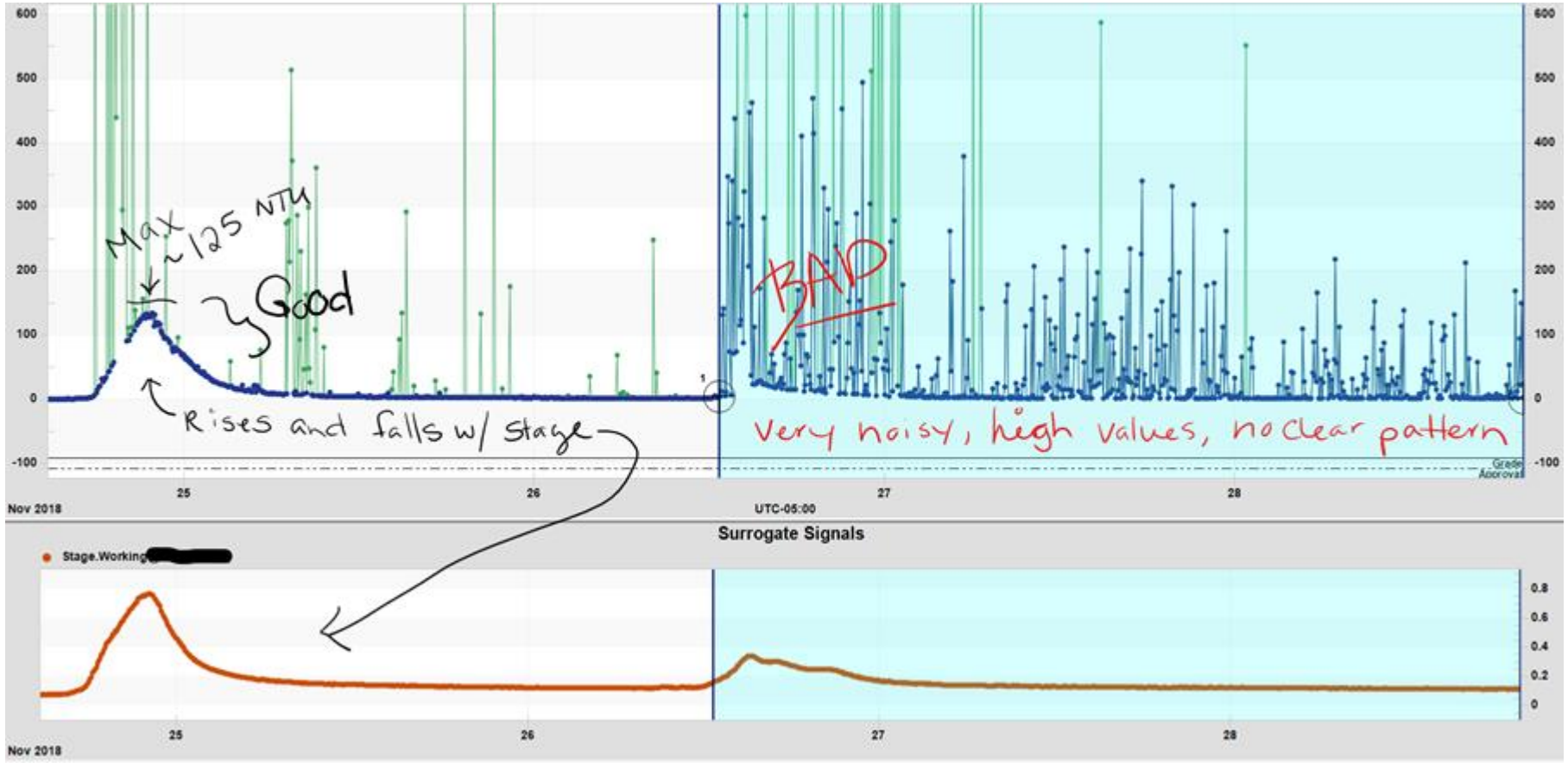
What am I looking for? Outliers.

- Single or small numbers of **points much higher (or lower) than the points before or after them**. Usually this is caused by a fish or leaf or electrical noise. Delete these points.



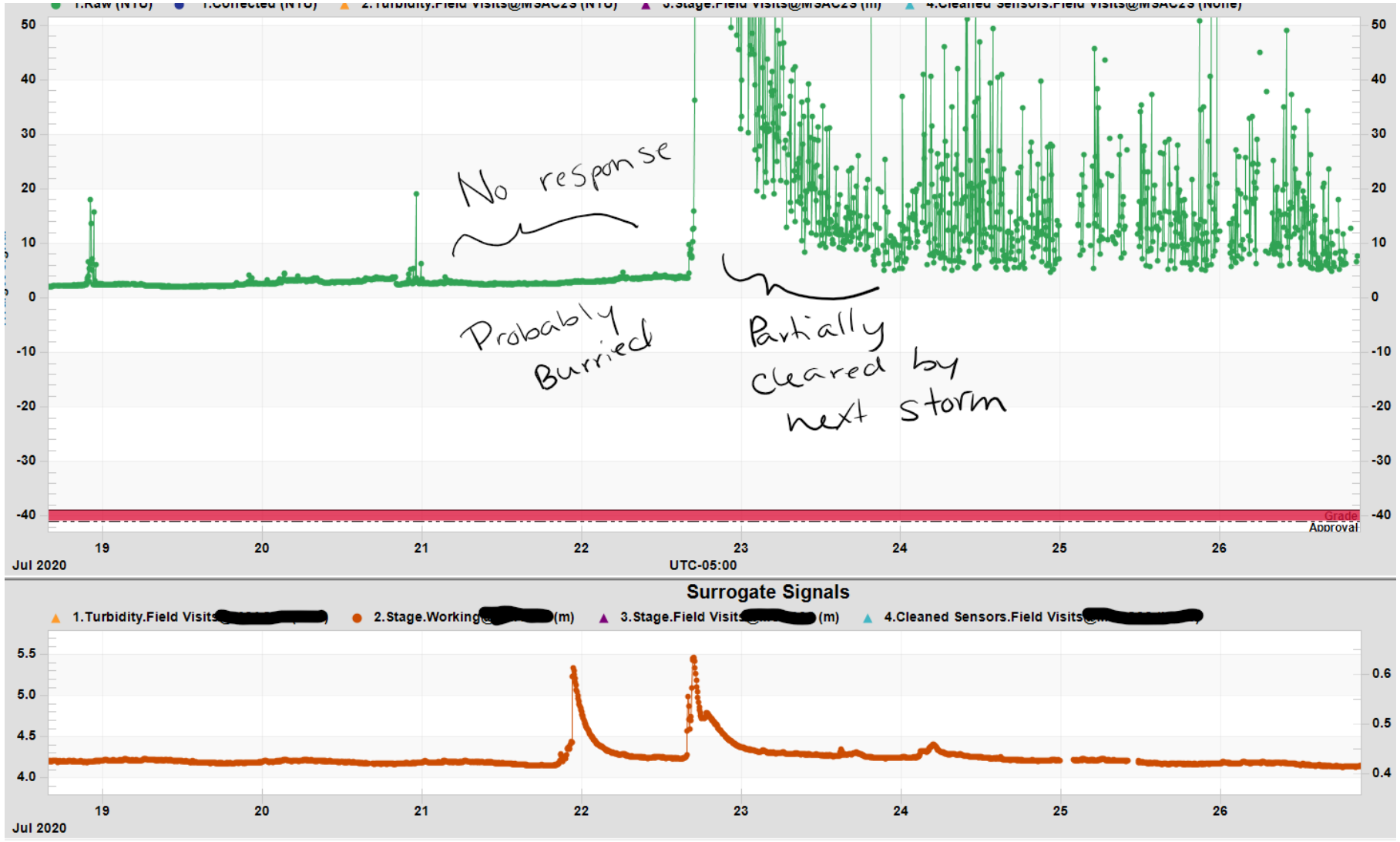
What am I looking for? Buried sensor.

- Turbidity that goes up during a storm but **doesn't go back down** when the flow goes back down.
- This usually means the sensor got a layer of dirt (or was completely buried) during the storm.
- **Delete this data**.



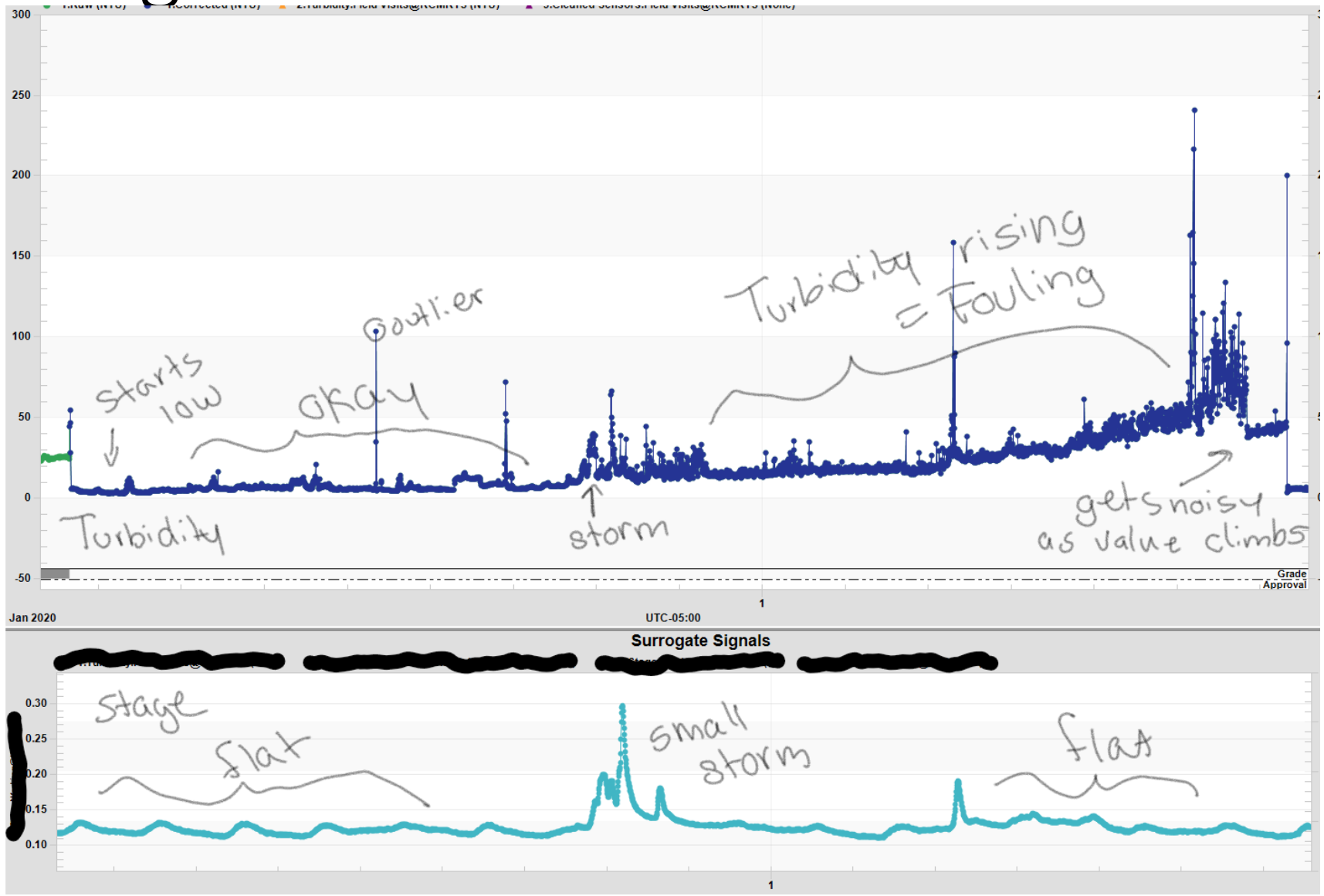
What am I looking for? Non-responsive sensor.

- Turbidity data that is very low or non-responsive when the stream stage changes.
- Usually this means the sensor is either dry or buried.
- **Delete this data**.



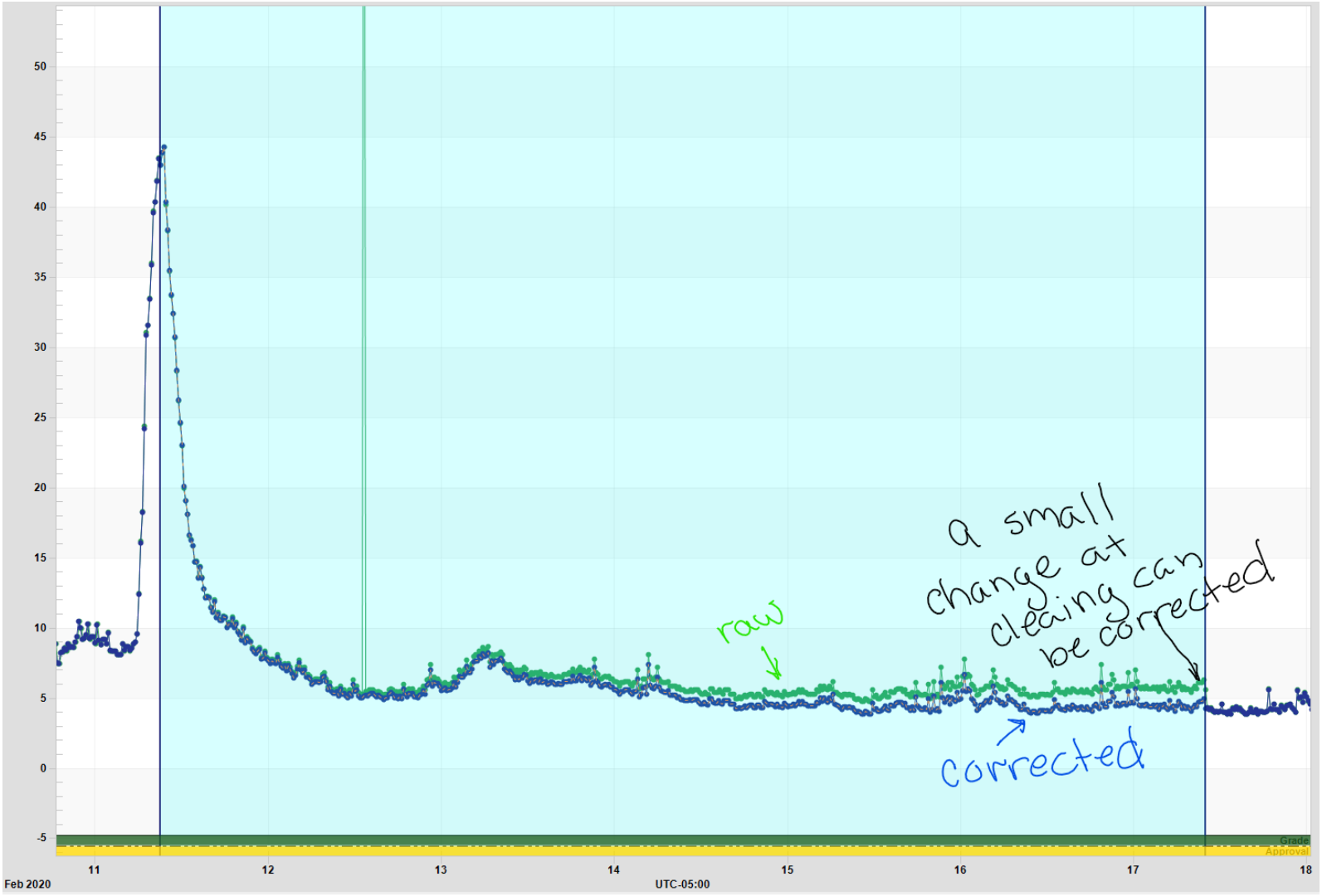
What am I looking for? FOULING!

- Data that begins to **creep upward** when the stream depth does not change. This is the sensor "fouling." This upward creep is caused by algae growing and dirt depositing on the sensor.
- **This is, by far, the biggest reason I delete data**.
  - In some stations, fouling happens very, very quickly – within a day or so. Others may be OK for months.



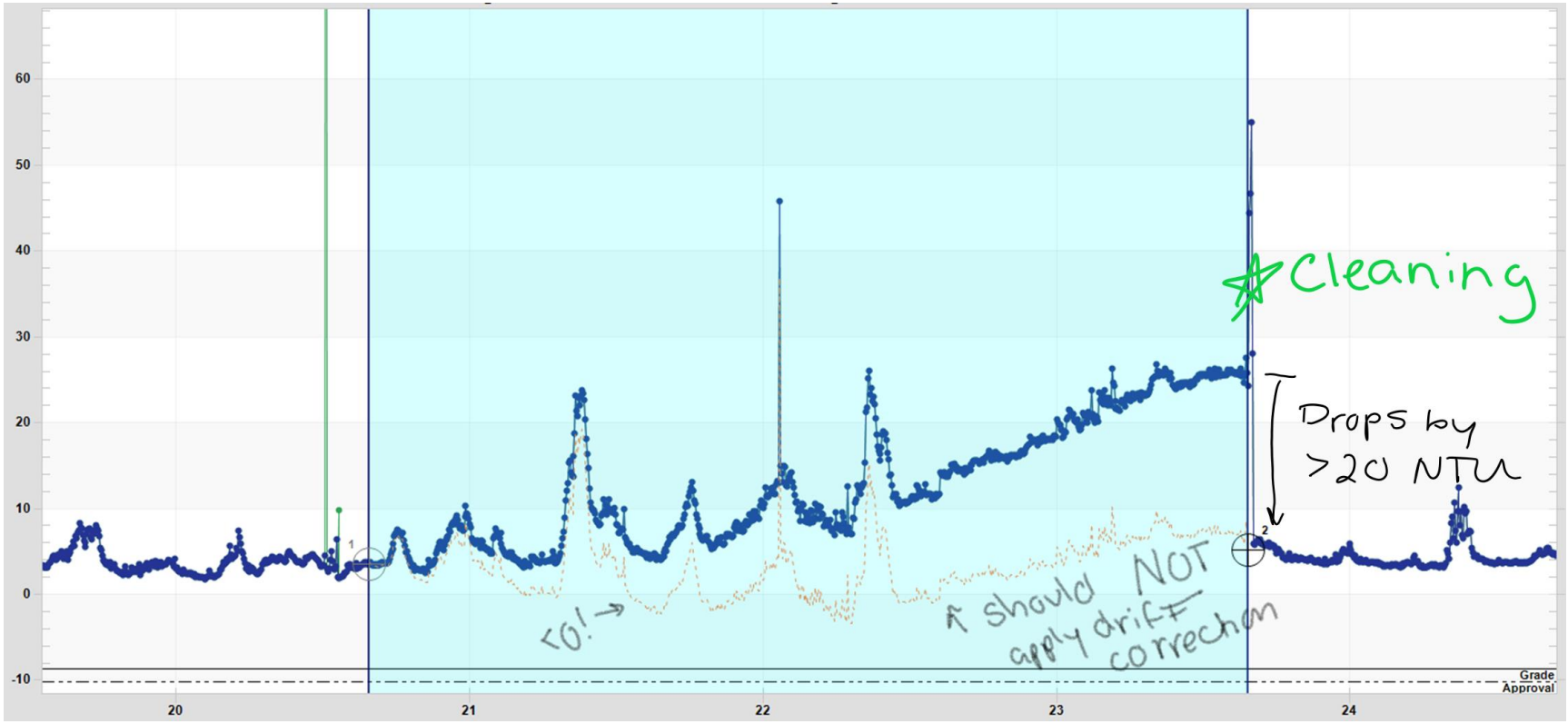
What am I looking for? Minor fouling.

- If you see a drift upwards of less than 10-15 NTU between cleanings you can apply a linear drift correction to pull the data back down.



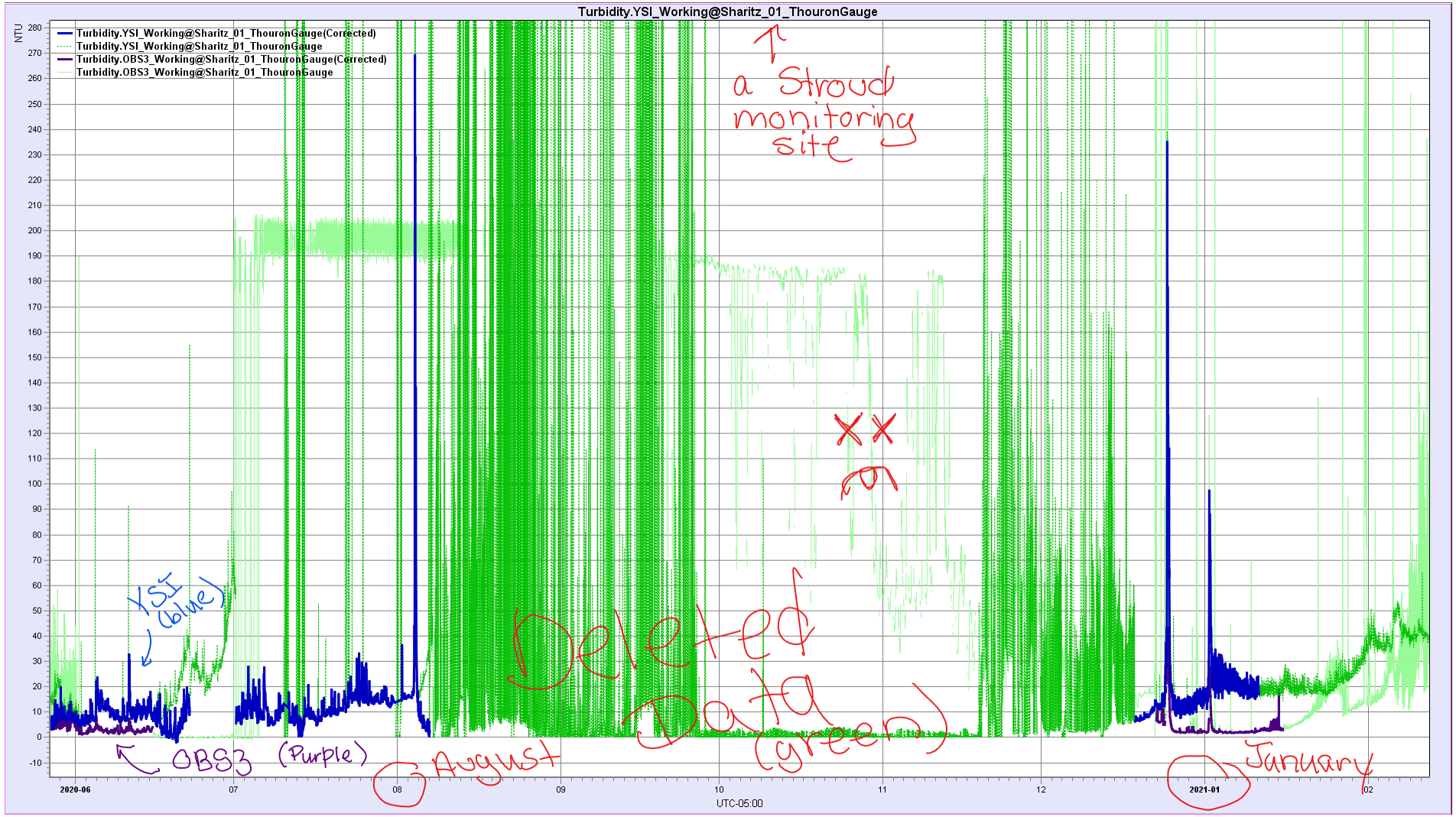
What am I looking for? Major fouling.

- If you see a larger drift upwards or don't know when the next cleaning is, **delete the whole section**.
- This is by far the biggest reason I delete data.



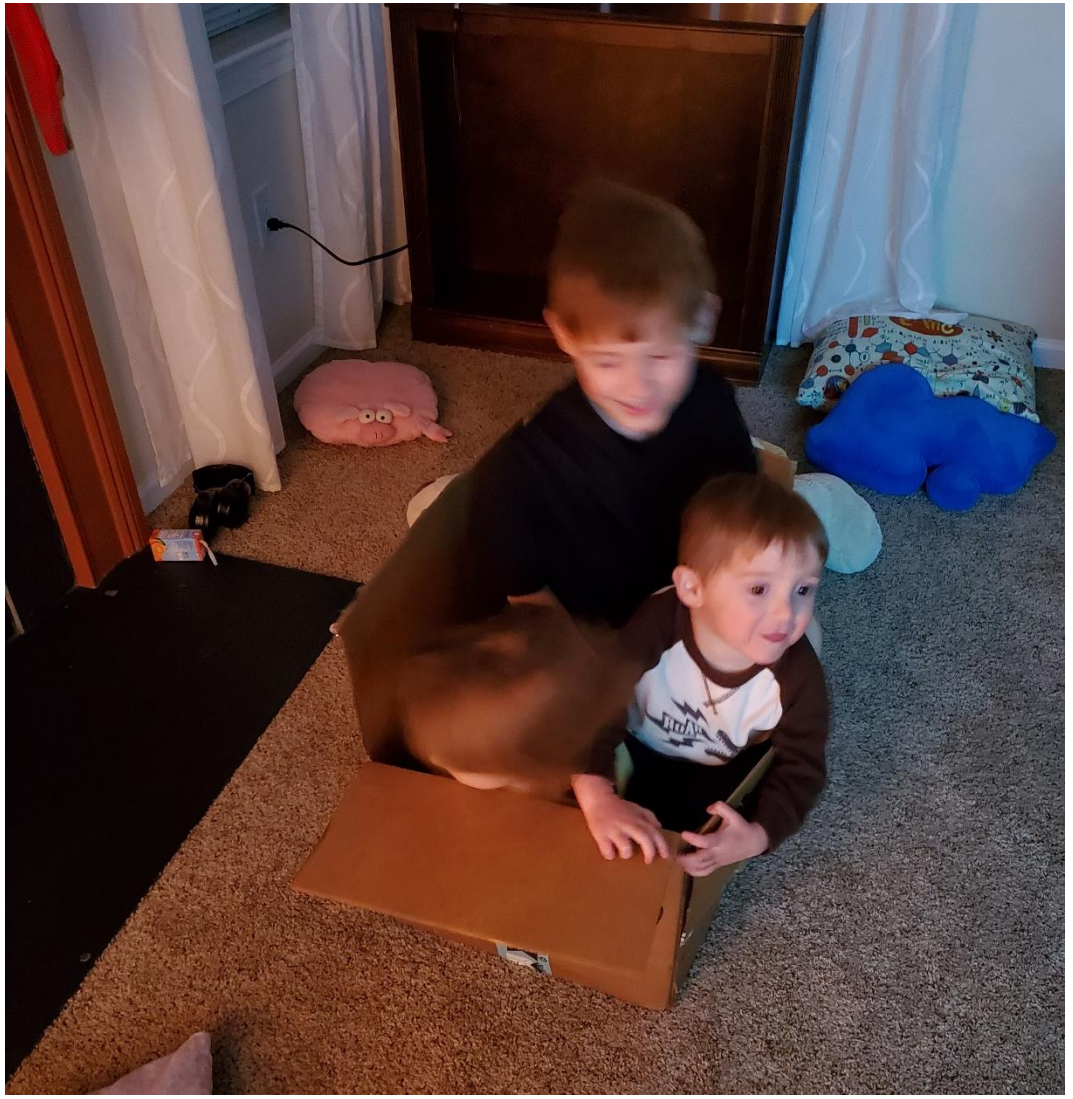
Yikes! I'm deleting TONNES of data!

- Trust us, it happens to the best of us!
- This site has TWO sensors and we still lost months of data!



How do I make my data better in the future?

- First, **know how good your data needs to be**; that is, know why you're collecting the data in the first place!
- All your data cleaning and quality control will be **much, much easier** if the data you collect is better to start with.
- Photo editing is no substitute for photography technique!



How do I make my data better? Maintenance.

- The best way to get better data is to visit your station and **clean the sensor more frequently**. There's really no getting around this. If you want better data, you must be there more often.

How do I make my data better? Prioritize.

- With finite person-power, focus your visits to the station on times when the sensor is most likely to need cleaning:
  - **Right *before* a storm** – storms are where the excitement is; be ready!
  - **Right *after* a storm** – storms often dirty or bury sensors. Visit and clean your sensor once the water has gone down and it's safe to get in.
  - **In the spring time** – as the weather (and stream water) get warmer, algae starts to grow faster. Before the trees leaf-out the stream gets extra sunlight accelerating algal growth on your sensor.
  - **In the fall** – leaves in the stream can collect and pile up on your sensor.
  - **Any time** you see your data creeping upward or stuck at a high value in your online plots. **Check Monitor My Watershed frequently!**

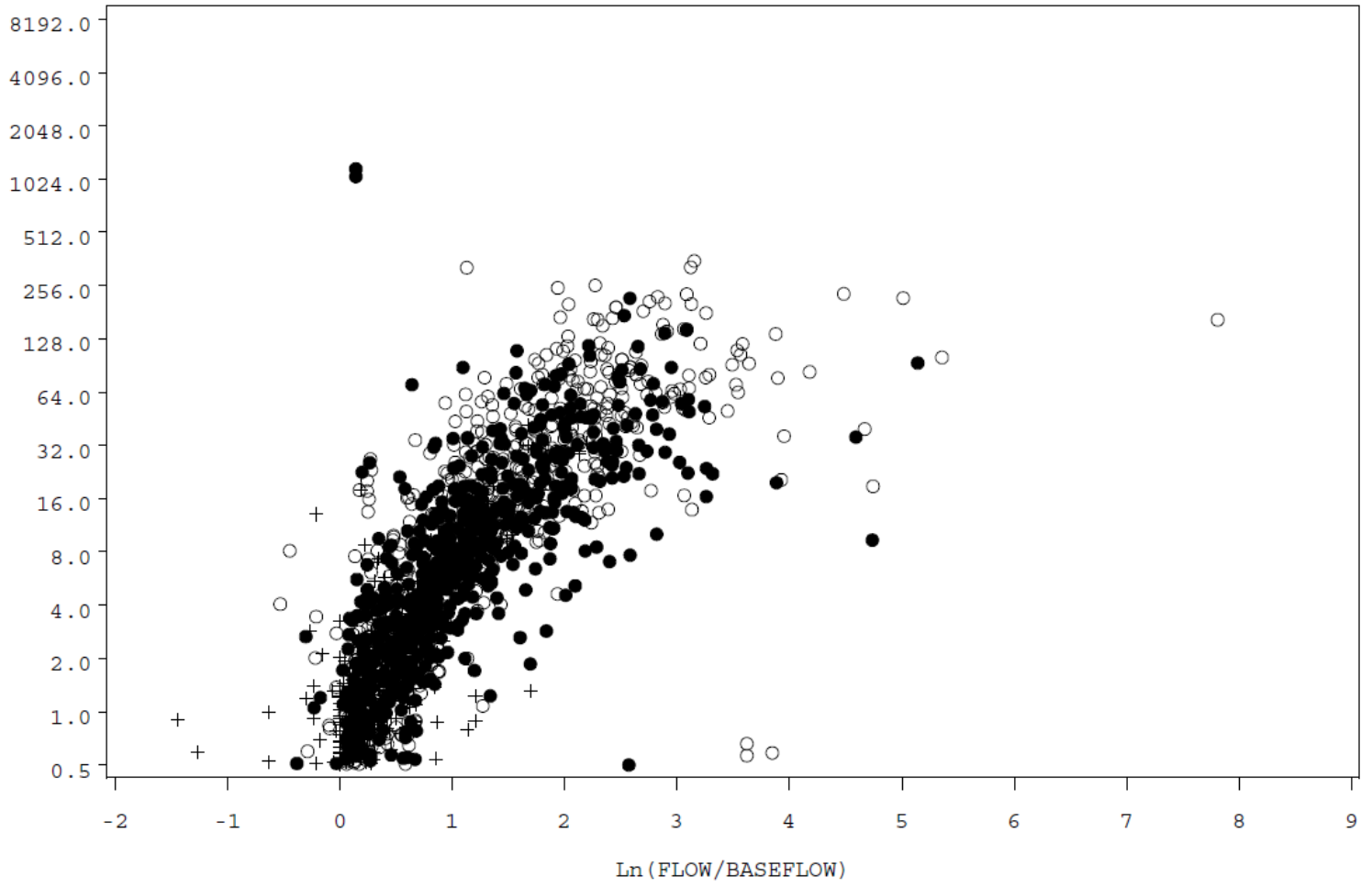
Woah, I'm not sure we can do that, what are my options?

- **Recruit help** – more workers or volunteers
- Purchase **more expensive equipment** with compressed air cleaning, wipers, covers, screens, or other fouling protection.
- Get a sensor with a shorter field of vision.

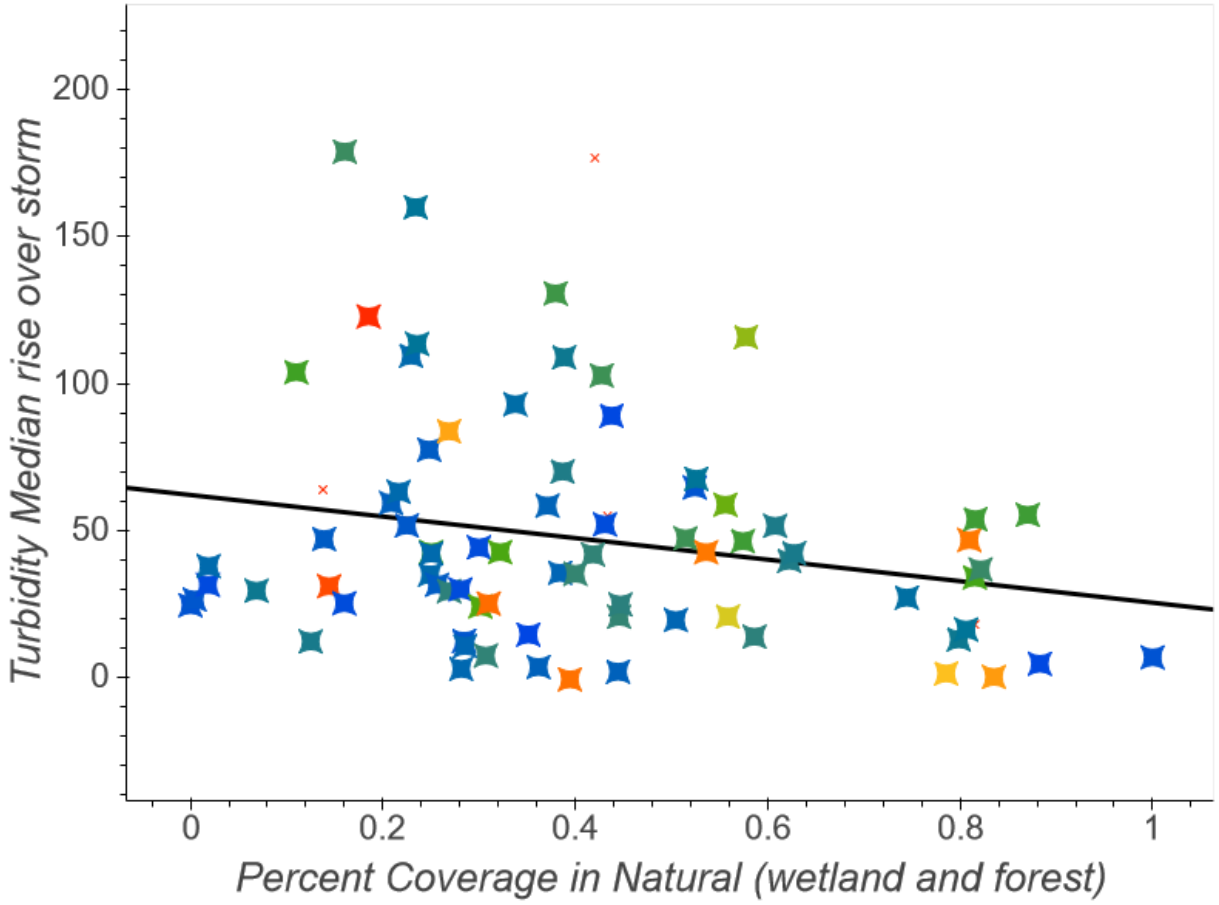
- *No matter how fancy your equipment and fouling protection is, you will still need to make maintenance visits to your station!*

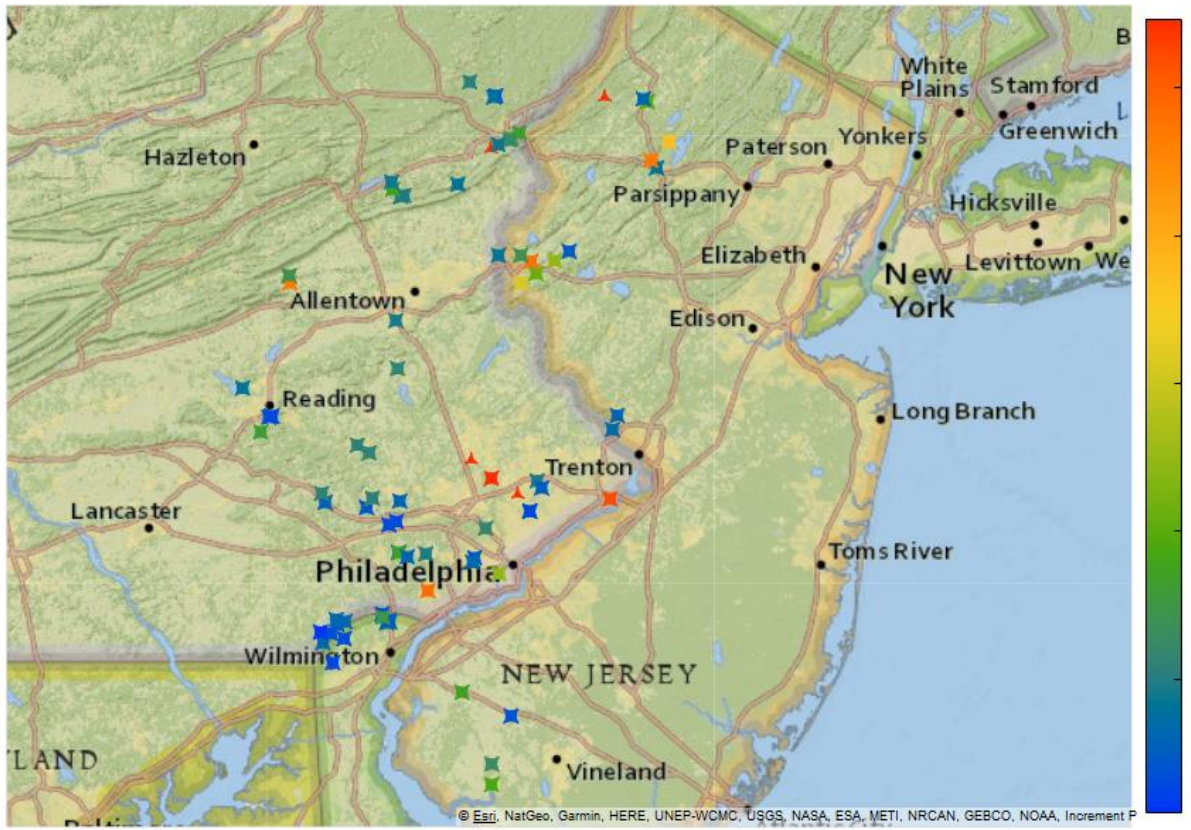
More options?

- Consider temporary deployments aiming to capture a single storm.
  - If you can quantify the relationship between flow and turbidity in a small number of storms, you can use that to estimate turbidity for the ones you miss.
- *As a last resort*, re-consider whether you truly need to measure turbidity and, if not, remove the sensor.



Okay, so you've showed how you're evaluating the turbidity data. Do you have any results?





Where do I go for more information?