Tips on Water Level Monitoring with Pressure Transducers and Data Loggers in Hydrologic Testing, Monitoring, and Investigations

U.S. Office of Surface Mining Reclamation and Enforcement
05/30/2012

One of the more useful and cost effective tools of trade for a hydrologist is the pressure transducer with data logging capabilities. These instruments permit the collection of large amounts of water level data with minimal time and effort on the part of the hydrologist. Pressure transducers measure ambient pressure which when used in water can be converted to the height of the water over the transducer. Water levels in monitoring wells can be recorded over extended periods of time using these instruments. Pressure transducers can be used measure water levels in flow-measuring devices (e.g., weirs and flumes) and the readings can be converted to discharge rates.

There are two basic types of pressure transducers. The first has an integral air tube that is open to the atmosphere above the water which permits automatic compensation of barometric pressure changes. The second type is completely submerged. With the second type, an additional transducer is placed out of the water in the vicinity, so the barometric pressure is likewise recorded for the time interval as the water levels. Once both transducers are downloaded, the water level is corrected for the variations in barometric pressure generally using manufacturer-supplied software.

There are a multitude of pressure transducer manufacturers. While some are better than others, which brand and type you buy should be predicated on what your financial situation and needs.

Advantages of data logging pressure transducers:

- They allow the collection a large amount of data during long term monitoring with only periodic trips to the site. Most instruments will generally permit the storage of 60,000 to 100,000 data points before requiring downloading.
- Recording intervals can be as little as once per second (in some cases less than a second) or as broad as once every 30 days.
- Some transducers have log modes that permit data collection every 0.2 seconds initially and then the sampling interval will expand as time elapses. This mode works well for recording rapid changes in water levels like those that occur during aquifer slug injection or withdrawal tests.
- The data are generally downloaded to a laptop computer or a hand-held device and can be exported directly into commonly-used spreadsheet software for analysis and graphing.
- Most have replaceable batteries that will last several months to well over a year. Some units use commercially-available batteries (e.g., 9-volt) and can be swapped out in the field. Others have to be returned to the manufacturer for replacement of specialized batteries and recalibration. The latter are reported by at least one manufacturer to last between 2 and 10 years depending on the reading frequency.
- Most pressure transducers are constructed of durable materials (stainless steel and plastics) and in such a way that they are fairly robust and are not easily damaged by chemically aggressive waters and gases, shock from impacts, and weather-related influences.

Tips and Caveats:

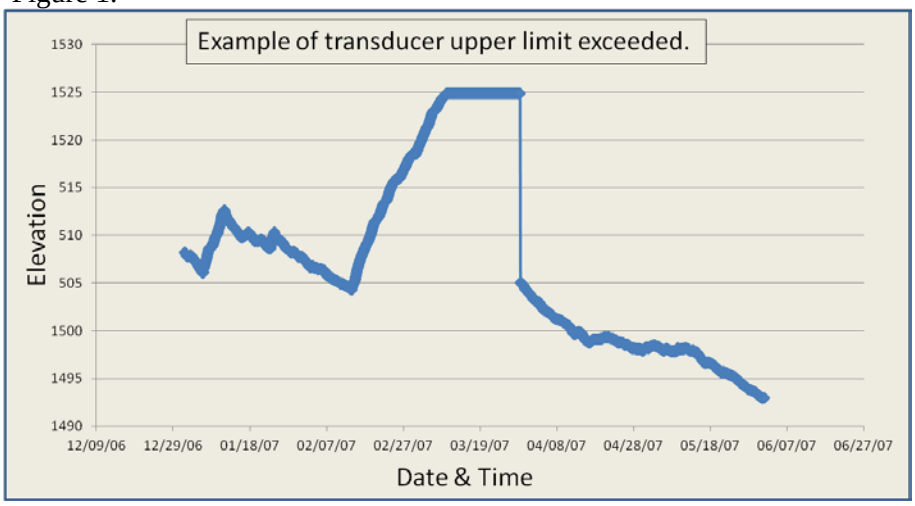
- It is best to select an instrument pressure range that fits your needs based on the range of water levels over the transducer you anticipate. To determine what pressure range you need, multiply the maximum anticipated water level over the transducer in feet by 0.433 lbs/ft to calculate the pressure in pounds per square inch (psi). If you unsure as to the range of fluctuation, it is best to go with a transducer rated for higher water levels (Table 1).

- If the upper limit of the transducer is exceeded the pressure reading will reach an upper limit (plateau) and flatten out. See Figure 1. Please note that if the pressure exceedance is great enough the transducer's sensor may be damaged requiring replacement or repair.

Table 1.

Transducer Pressure Upper Limit	Maximum Water Level
5 psi	11.5 ft. or 3.5 m
15 psi	35 ft or 11 m
20 psi	46 ft. or 14 m
30 psi	69 ft. or 21 m
50 psi	115 ft. or 35 m
100 psi	231 ft. or 70 m
250 psi	577 ft. or 176 m
500 psi	1153 ft. or 351 m

Figure 1.



- Bear-in-mind that with the higher upper pressure limit transducers there is usually reduced accuracy and resolution of the instrument.
- If possible the transducer needs to be placed at a level so that the water will not drop below it. If this happens, data will be lost and the only information obtained is that the water was less than the level of sensor on the transducer (Figure 2).
- Be aware that most vented transducers have the batteries and data logging unit housing at the opposite end of the cable. So, this housing is often hung near the top of the well and can be subject to temperature extremes and as well as other weather-related issues especially in the northern portions of the Appalachian Plateau. Batteries tend to respond poorly to cold weather. Therefore, the batteries may need changed more frequently during the winter season.
- Security is can also be an issue. These instruments are expensive and are often attractive targets for vandalism or theft (Figure 3). Securing the transducers within locking steel well casings is recommended. If the transducer cannot be locked down, it is recommended that they are sufficiently hidden or camouflaged to minimize potential harm. In areas where hunting and recreational shooting is common, casings can make inviting targets. So, it is suggested that the casing stick up be shortened or camouflaged as well.
- Take particular care with transducers with vented cables. If the cable is accidentally cut or kinked, it this will interfere with the barometric compensation. In all likelihood, the cable will have to be replaced if it is cut.

Figure 2.

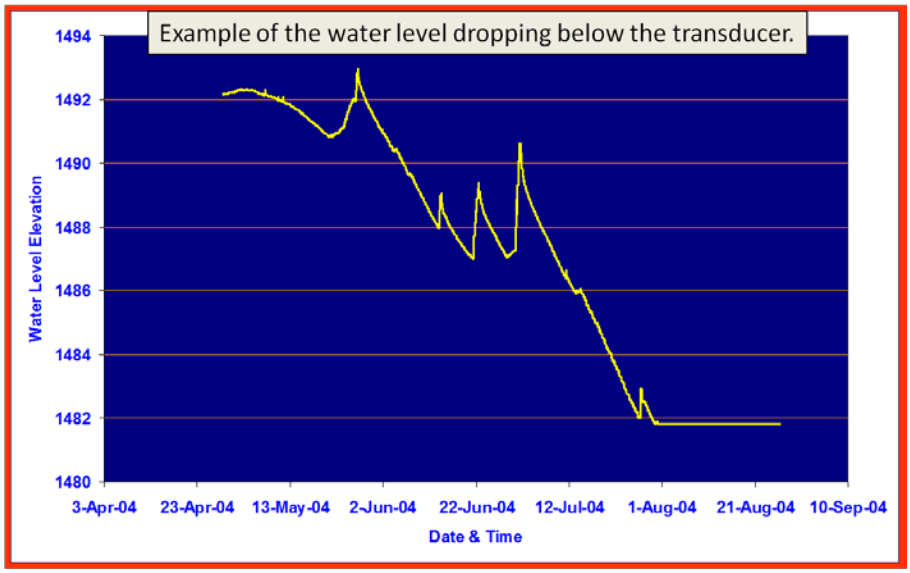


Figure 3.

- Use of transducers in weirs and flumes is often achieved with an integral stilling well. However, lacking a stilling well, the transducer can be placed in the bottom of the devise at the head measuring point. The flow measurement and water over the transducer will need to be calibrated, so the data can be converted to true flows. You may have to weigh down the transducer to prevent it from shifting or being lifted by the water movement.
- A potential problem with using a transducer directly on the bottom of a flow devise is that when the flow is very low there may be insufficient water over the sensor to register accurately.
- In areas of heavy siltation or those that receive considerable leaf litter in the fall, the flume or weir can become clogged and not work correctly. Thus, the transducer readings will be inaccurate.
- The readings of most transducers will drift slightly over time. So, it is good practice to manually read the water level each time that you down load the data logger Figure 4. That way the data can be adjusted to correct for any drift between readings.

Figure 4.

- Using pressure transducers in mining situations can present their own set of problems. Including but not limited to:
    - The precipitation of iron hydroxide or other materials can clog the transducer sensor and may affect the readings.
    - Acidic drainage environments can damage the pressure transducer casing (even stainless steel) and electronics causing it malfunction.
    - Some monitoring wells, especially in below drainage flooded underground mines produce hydrogen sulfide gas. This gas is quite corrosive and will attack the transducer and the housing with the data logger and batteries.
    - Monitoring wells in mining situations have been known to yield dangerous levels of methane. While the methane will not harm the transducer, it can be a hazard to anyone accessing the well and transducer. Caution needs to be practiced so that sparks or open flame is not generated within or near this methane-rich environment.

There are numerous different configurations by which to install pressure transducers in monitoring wells. Figure 5 is a typical example. The supporting cable that suspends the transducer is attached near the top of the monitoring well to provide access to the instrument. An eye bolt (Figure 6) fastened to the side of the steel casing works quite well. It is recommended that one nut is placed on the inside of the casing and two nuts are treaded to the outside. It is suggested to damage the treads on the outside once the nuts are on and tightened. It is also advised to position the eye bolt below ground level to conceal it. The cable can be attached with a carabiner type of clip for easy installation and removal.

Frequently, a universal cable is used which can be too long to allow placement of the sensor at the desired depth. So, the excess cable needs to be coiled within the casing and sufficiently secured to prevent movement once the instrument is set. If the sensor moves once the data logger is started the initial datum that was established will be incorrect. The cable can be laid out on the ground and measured to establish the correct length. Be sure the coils are not so tight that cables with an air tube as to pinch the tube. Electrical or duct tape works well to bind the cable and prevent subsequent movement.

Figure 5. Example of a pressure transducer installed in a monitoring well.

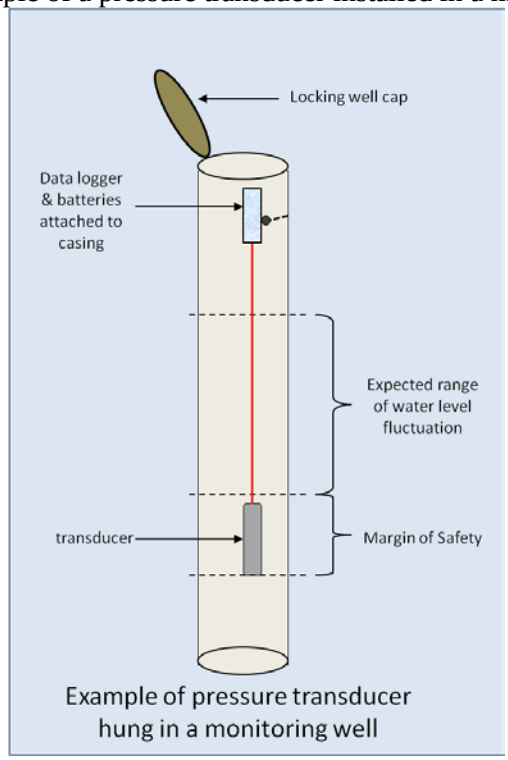


Figure 6. Eye bolt.

Additional Tips:

- Pressure transducers tend to be temperature sensitive. So, they need to be allowed adequate time to equilibrate to the water temperature prior to the start of logging. This will help minimize inaccuracies.
- When you first use a new transducer, it a good idea to manually check the water level over the sensor and compare it to the sensor reading to be sure it is functioning properly.
- Be sure to establish a recording frequency that fits your data needs. For example:

  - If you need to determine lag time between a substantial precipitation event and the water level response of a mine pool, then it is suggested that you program the recording for no less than once per hour. The spikes shown on the hydrograph in Figure 2 are in response to substantial precipitation events. The readings were collected once per hour and are so close together in the graph no connecting line was needed.
  - If you are monitoring a well during a three-hour pumping test, a sampling frequency of once per minute would be appropriate.
  - For a slug injection test once per second may be needed in highly transmissive units such as mine spoil. The log mode recording frequency, where the initial readings are taken in less than one second intervals, works well for these types of tests.
- Until you are familiar with how long the batteries will remain viable, it is suggested that you check them frequently (e.g., once every one or two months). The frequency of readings will dictate to some extent the life of the batteries. As previously mentioned, batteries will need replaced more often during the winter months as well.
- While the construction and circuitry of these instruments is fairly robust, they do periodically malfunction. Therefore, in order to minimize data losses, it is suggested that they be visited at least once every three months in data critical situations.

There are a variety of water quality meters coupled with data loggers that can be used in monitoring wells or surface waters in a manner similar to pressure transducers. Some of the parameters currently available include: temperature, dissolved oxygen and other gases, specific conductance, salinity, total dissolved solids, pH, resistivity, nitrate, chloride, turbidity, and ammonia/ammonium.

If additional information is required, contact any of the hydrologists at the Appalachian Regional Office.