GWPD 13—Measuring water levels by use of an air line

VERSION: 2010.1

PURPOSE: To measure the depth to the water surface below a measuring point using the submerged air line method.

Materials and Instruments

1. 1/8 or 1/4-inch diameter, seamless copper tubing, brass tubing, or galvanized pipe with a suitable pipe tee for connecting an altitude or pressure gauge. Flexible plastic tubing also can be used, but is less desirable.
2. Calibrated altitude or pressure gauge, and spare gauges. Gauges that are filled with either oil or silicone work best and are most durable.
3. Compressed air source and corresponding valve stem, usually a Schrader valve. A tire pump can be used on shallow wells and piezometers, but a more substantial source of compressed air is needed where depth to water is hundreds of feet.
4. Small open-end wrench
5. Wire or electrician's tape
6. A steel tape graduated in feet, tenths and hundredths of feet
7. Blue carpenter's chalk
8. Clean rag
9. Field notebook
10. Pencil or pen, blue or black ink. Strikethrough, date and initial errors; no erasures
11. Water-level measurement field form

Data Accuracy and Limitations

1. Accuracy of the water-level measurement is a function of the quality and range of the gauge and the precision to which the length of the air line is known.
2. Water-level measurements using an altitude or pressure gauge can be as accurate as 0.1 foot, but may only be accurate to 1 foot or more, depending on the gauge accuracy and range.
3. Water-level measurements using a pressure gauge are approximate and should not be considered accurate to more than the nearest foot.
4. When measuring deep water levels, corrections for fluid temperatures and vertical differences in air density are additional considerations (Garber and Koopman, 1968).

Advantages

1. Especially useful in pumped wells where water turbulence may preclude using a more precise method.
2. Method can be used while the well is being pumped, when splashing of water makes the wetted-tape method useless.
3. Bends or spirals in the air line do not influence the accuracy of this method as long as the position of the tubing opening is not changed.
4. Can be convenient and is nonintrusive.
5. Air line can be installed once and left in the well for future measurements.

Disadvantages

1. Less accurate than the wetted tape or the electric tape methods.
2. Requires time to install the air line and equipment.
3. Requires careful calculations.

Assumptions

1. An established measuring point (MP) exists and the MP correction length (distance from MP to land-surface datum (LSD)) is known. See GWPD 3 for the technical procedure on establishing a permanent MP.
2. The MP is clearly marked and described so that a person who has not measured the well will be able to recognize it.
3. The air line already is installed, your agency owns the well, or your agency has permission to install the air line.
4. The air line extends far enough below the water level that the lower end remains submerged during pumping of the well.
5. The altitude or pressure gauge and steel tape are calibrated.
6. The same procedure is used for measurements referenced to altitude or measuring points, but with a different datum correction.

Instructions

Figure 1 shows a typical installation for measuring water levels by the air line method.

1. Install an air line pipe or tube in the well. The air line can be installed by either lowering it into the annular space between the pump column and casing after the pump has been installed in the well or by securing it to sections of the pump and pump column with wire or tape as it is lowered into the well.
2. Attach a pipe tee to the top end of the air line. On the opposite end of the pipe tee, attach a Schrader valve stem.
3. Use a wrench to connect an altitude gauge that reads in feet or a pressure gauge that reads in pounds per square inch (psi) to the fitting on top of the pipe tee.
4. Connect a compressed air source to the Schrader valve stem fitting on the pipe tee.
5. Preparatory steps: When pressurizing the air line system (step 8 below), ensure that you supply enough air pressure to purge the water from the air line tubing before a reading is recorded. This can be done by observing the gauge readings while pressurizing the system. After application of pressure, the gauge reading initially will increase to a certain pressure, and when the pressure source is removed, the gauge reading will decrease to a certain pressure. Repeat this process two or three times to ensure that the gauge reads consistently. If the tubing is plugged or crushed, the gauge reading will not decrease after the pressure source is removed. If the tubing is cut or severed, the gauge reading will decrease quickly to zero after the pressure source is removed. In either case, the air line readings will be in error. Also, do not assume that the air line tubing length reported to you is valid. Instead, make water-level measurements by use of steel tape and air line reading simultaneously. This step provides a verified water-level measurement that is relative to the pressure gauge reading. If the two measurements differ, then a correction factor can be calculated. The correction factor will be unique to the well and the gauge.
6. As the water level in the well changes, the guage reading (h) and the water level below MP (d; fig. 1) must change in a manner such that their sum remains the same. Their sum is a constant (k), which is determined at the same time as a simultaneous wetted-steel tape and pressure gauge measurement is made.
7. To calibrate the air line system, make an initial depth-to-water (d) measurement, with a wetted-steel tape, and an initial air gauge reading (h). Apply any needed correction to the wetted-steel tape measurement. Add d and h to determine the constant value for k. Use the compressed air source to force air into the air line until all the water is expelled from the line. Once all water is displaced from the air line, record the maximum gauge reading.
   - Example 1.—Using an altitude gauge. The initial measured depth to the water level, d, is 25.86 ft; the initial altitude gauge reading, h, is 75.5 ft. Then the constant k = 25.9 ft + 75.5 ft = 101.4 ft (fig. 1).
   - Example 2.—Using a pressure gauge. The initial measured depth to the water level, d, is 85.85 ft; the initial pressure gauge reading, h, is 28 psi. Then the constant k = 86 ft + (2.307 ft/psi x 28 psi) = 86 ft + 64 ft = 150 ft (fig. 1).
8. To measure the water-level depth in a well with an air line, subsequent air line readings are subtracted from the constant k to determine the depth to the water level below the MP. Use a compressed air source to pump compressed air into the air line until all the water is expelled from the line, and record the maximum gauge reading. Apply any correction factor resulting from the calibration process.
   - Example 1.—Depth to the water level in a well using an altitude gauge with a constant k of 101.4 ft. During a later pumping period, the maximum altitude gauge h reads 50.0 ft; therefore, the water level, d, is 101.4 ft – 50.0 ft = 51.4 ft (fig. 2).

- Example 2.—Depth to the water level in a well using a pressure gauge with a constant k of 150 ft. During a later pumping period, the maximum pressure gauge h reads 18 psi; therefore, the water level, d, is 150 ft – (2.307 ft/psi x 18 psi) = 150 ft – 41 ft = 109 ft (fig. 3).

9. Apply the MP correction to get the depth to water below or above LSD.

Data Recording

All data are recorded in the field notebook and on the water-level measurement field forms (fig. 2 or 3) to the appropriate accuracy.

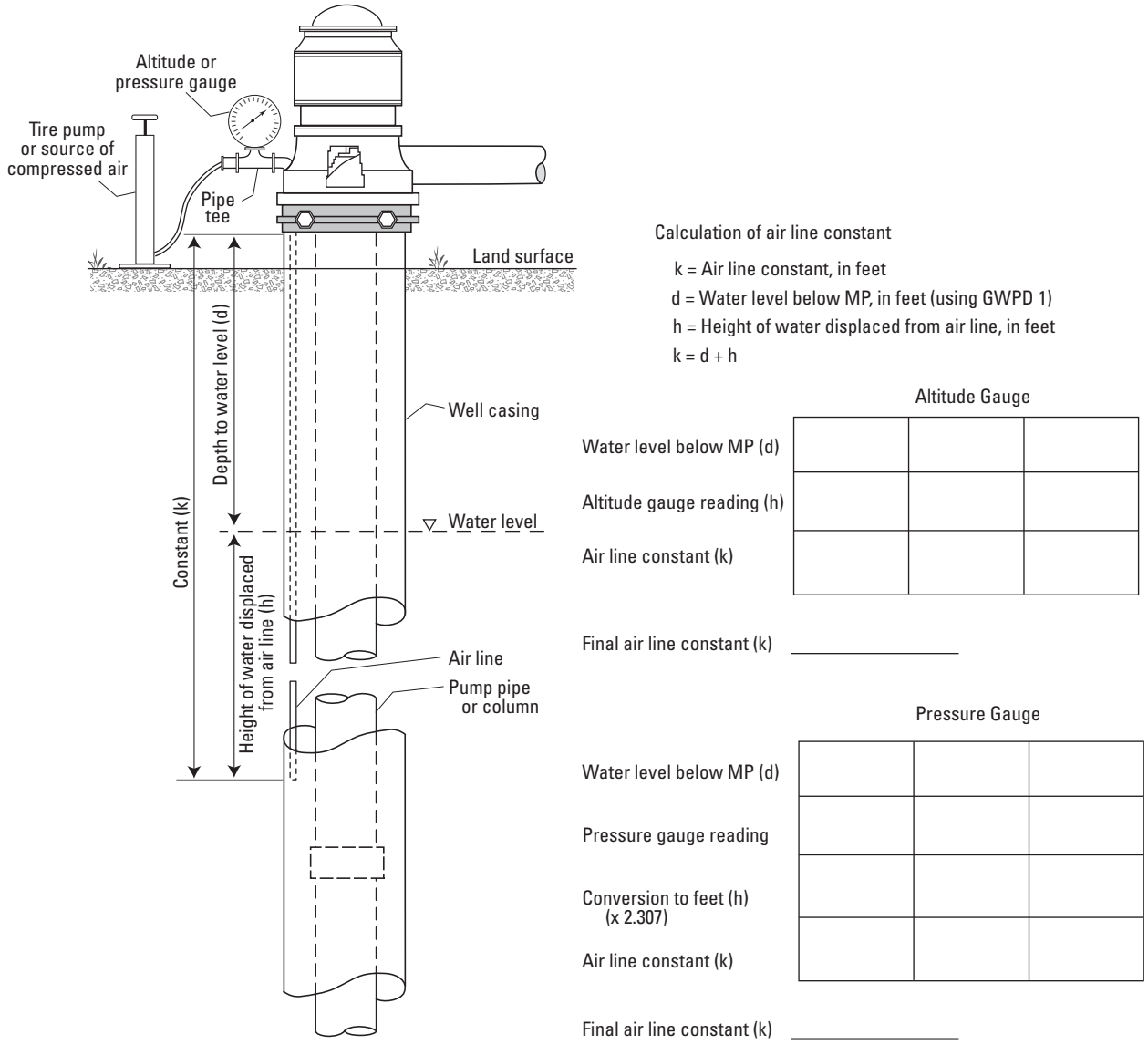

Figure 1. Typical installation for measuring water levels by the air line method and relation of measured depth to water level (d), height of water displaced from air line (h), and constant (k). Constant is calculated by use of altitude gauge or pressure gauge.

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WATER-LEVEL MEASUREMENT FIELD FORM

Air Line Measurement: Altitude Gauge

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SITE INFORMATION

Equipment ID & Altitude Range

k = Air-line Constant (k)

Date of Field Visit

SITE ID (C1)

Station name (C12)

WATER-LEVEL DATA	1	2	3	4	5
Time					
Gauge Reading					
Gauge Correction					
Corrected Gauge Reading					
Air-Line Constant, K					
WL Below MP					
MP Correction					
WL Above LSD					

Measured by _____ COMMENTS*_____

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321) — month – day – year

ENDING DATE (C322) — month – day – year

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243): L M S (below land surface, below meas. pt., sea level)

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	TIME DATUM (C402)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
month – day – year				A		.

METHOD OF WATER-LEVEL MEASUREMENT(C239) — GWPD 13

A airline, B analog, C calibrated airline, E estimated, G pressure gage, H calibrated press. gage, L geophysical logs, M manometer, N non-rec. gage, R reported, S steel tape, T electric tape, V calibrated elec. tape, Z other

SITE STATUS FOR WATER LEVEL (C238)

D dry, E recently flowing, F flowing, G nearby flowing, H nearby recently flowing, I injector site, J injector site monitor, M plugged, N measurement discon., O obstruction, P pumping, R recently pumped, S nearby pumping, T nearby recently pumped, V foreign substance, W well destroyed, X surface water effects, Z other, BLANK static

Figure 2. Water-level measurement field form for air line measurement using an altitude gauge. This form, or an equivalent custom-designed form, should be used to record field measurements.

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WATER-LEVEL MEASUREMENT FIELD FORM

Air Line Measurement: Pressure Gauge

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SITE INFORMATION

Equipment ID & Pressure Range

k = Air-line Constant (k)

Date of Field Visit

SITE ID (C1)

Station name (C12)

WATER-LEVEL DATA	1	2	3	4	5
Time					
Gauge Reading					
Gauge Correction					
Corrected Gauge Reading					
Conversion to Feet (x 2.307)					
Air-Line Constant, K					
WL Below MP					
MP Correction					
WL Above LSD					

Measured by _____ COMMENTS*_____

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321) — month – day – year

ENDING DATE (C322) — month – day – year

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243): L (below land surface) M (below meas. pt.) S (sea level)

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
month – day – year			A		

GWPD 13

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S	T	V	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysical logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently	flowing,	nearby	nearby	injector	injector	plugged,	measure-	obstruc-	pumping,	recently	nearby	nearby	foreign	well	surface	other	static

Figure 3. Water-level measurement field form for air line measurement using a pressure gauge. This form, or an equivalent custom-designed form, should be used to record field measurements.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Minnesota, Johnson Filtration Systems, Inc., 1089 p.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, p. 6–11.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Lohman, S.W., 1953, Measurement of ground-water levels by air-line method: U.S. Geological Survey Open-File Report 53–159, 5 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, p. 2-10.