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Date: JAN 3 0 2017
Refer To: ADEM-17-0014
LAUR: 17-20200
Locates Action No.: n/a

John Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Field Summary Report for Alluvial Piezometers in Sandia Canyon

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Field Summary Report for Alluvial Piezometers in Sandia Canyon.

If you have any questions, please contact Ted Ball at (505) 665-3996 (tedball@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

David S. Rhodes, Director
Office of Quality and Regulatory Compliance
Environmental Management
Los Alamos Field Office

BR/DR/TB:sm

Enclosures: Two hard copies with electronic files – Field Summary Report for Alluvial Piezometers in Sandia Canyon (EP2017-0001)

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January 2017
EP2017-0001

Field Summary Report for Alluvial Piezometers in Sandia Canyon

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Associate Directorate for Environmental Management

EP2017-0001

Field Summary Report for Alluvial Piezometers in Sandia Canyon

January 2017

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David S. Rhodes	[signature]	Office Director	Quality and Regulatory Compliance	1-27-2017
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EXECUTIVE SUMMARY

This field summary report describes the drilling, hand-augering, and installation of 17 piezometers, located within Technical Area 72 at Los Alamos National Laboratory, New Mexico. As stated in the July 2015 "Work Plan for Chromium Plume Center Characterization," the purpose of the piezometers is to evaluate infiltration over the portion of Sandia Canyon where the majority of historical and present-day infiltration is suspected to occur, as required by the New Mexico Environment Department's "Approval with Modifications, Drilling Work Plan for Alluvial Piezometers in Sandia Canyon."

Fifteen piezometers were drilled with an auger rig and installed in five north-south trending transects spanning the alluvial fill portion of the bottom of Sandia Canyon. The remaining two piezometers were hand-augered and installed upgradient of the five transects with stainless-steel hand-augers and stainless-steel extension rods. The alluvial piezometers were constructed with vibrating wire transducers set above the alluvium/bedrock contact or within the alluvium where the contact was not reached. The geologic formations encountered were alluvium (Qal), Otowi Member of the Bandelier Tuff (Qbo), Tshirege Member of the Bandelier Tuff (Qbt 1g), and the Cerro Toledo interval (Qct).

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ACRONYM LIST

amsl	above mean sea level
bgs	below ground surface
Consent Order	Compliance Order on Consent
DOE	Department of Energy (U.S.)
DTW	depth to water
EM	Environmental Management
ESH	Environment, Safety, and Health
FTL	field team leader
HSA	hollow-stem auger
I.D.	inside diameter
IDW	investigation-derived waste
LANL	Los Alamos National Laboratory
NAD	North American Datum
NR	not recorded
NMED	New Mexico Environment Department
O.D.	outside diameter
RCT	radiological control technician
STR	subcontractor technical representative
TA	technical area
TD	total depth
VWT	vibrating wire transducer
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This field summary report summarizes borehole drilling, hand-augering, and installation of 17 alluvial piezometers in Sandia Canyon. The report is written in accordance with the requirements in Appendix F, Section II, of the June 2016 Compliance Order on Consent (the Consent Order) and the New Mexico Environment Department's (NMED's) "Approval with Modification, Drilling Work Plan for Alluvial Piezometers in Sandia Canyon" (NMED 2016, 601327). The alluvial piezometers were installed between May 17 and July 8, 2016, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Management (EM) Directorate.

The alluvial piezometers are located within the Laboratory's Technical Area 72 (TA-72) in Los Alamos County, New Mexico (Figure 1.0-1). As stated in the July 2015 "Work Plan for Chromium Plume Center Characterization" (LANL 2015, 600615), the purpose of the piezometers is to evaluate infiltration over the portion of Sandia Canyon where it is believed the majority of historical and present-day infiltration has occurred. The overall objective of the piezometer configuration is to evaluate the integrated area of infiltration over the subject area. The general approach will be to obtain pressure data at varying depths throughout the saturated portion of the alluvium. The pressure data will be used to refine the current hydrologic model for infiltration of effluent and other surface water sources in Sandia Canyon. The data will also be used to establish a baseline to compare with potential future changes that may occur either because of operational changes in effluent volumes or future remediation strategies that may include discharge of treated groundwater to Sandia Canyon above the infiltration zone monitored by the piezometers. An additional objective is to further constrain the upgradient extent of infiltration in Sandia Canyon.

A total of 15 piezometers, SCPZ-15 through SCPZ-29, were installed in 5 north-south trending transects, spanning the alluvial fill portion of the bottom of Sandia Canyon. A CME-75 tracked hollow-stem auger (HSA) drill rig with 4.25-in.–inside diameter (I.D.)/8-in.–outside diameter (O.D.) HSAs was used to drill the piezometers. A modified split-spoon sampler was used for geologic logging.

The remaining two piezometers, SCPZ-13 and SCPZ-14, were hand-augered upgradient of the five transects with 3.25-in. stainless-steel hand-augers and stainless-steel extension rods. Piezometers SCPZ-1 through SCPZ-12 were installed previously in the wetland upcanyon and are not discussed in this report (LANL 2014, 257590).

After the piezometers were drilled and hand-augered, vibrating wire transducers (VWT) were installed in the boreholes during placement of construction materials.

Post-installation activities included surface completion installation, data logger programming, and geodetic surveying. Future activities will include waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the EM Records Processing Facility. This report contains a summary description of activities and supporting figures, tables, and appendixes associated with the project. Appendix A is the instruction manual for the Geokon Model LC-2×4 4 Channel VW Datalogger, Appendix B is the instruction manual for the Geokon Model 4500 Series Vibrating Wire Piezometers, Appendix C is the Geokon LogView User's Guide, and Appendix D includes the VWT calibration reports.

2.0 ADMINISTRATIVE PLANNING

The following documents were prepared to guide activities associated with the drilling and installation of the alluvial piezometers in Sandia Canyon:

- The approved "Drilling Work Plan for Alluvial Piezometers in Sandia Canyon" (LANL 2015, 601047; NMED 2016, 601327);
- "Field Implementation Plan for Alluvial Piezometers in Sandia Canyon" (TerranearPMC 2016, 601928);
- "IWD [Integrated Work Document] for Drilling and Installation of Alluvial Piezometers in Sandia Canyon" (TerranearPMC 2016, 601927); and
- "Waste Characterization Strategy Form for Drilling Work Plan for Alluvial Piezometers in Sandia Canyon" (LANL 2016, 601275).

3.0 FIELD ACTIVITIES

Field activities, including borehole drilling, lithologic logging, VWT system installation, surface completions, geodetic surveying and waste management followed an approved IWD. The approved "Drilling Work Plan for Alluvial Piezometers in Sandia Canyon" (LANL 2015, 601047; NMED 2016, 601327) was used to guide field operations and ensure all objectives were met.

3.1 Mobilization

The CME-75 tracked HSA drill rig, drilling equipment, and supplies were mobilized to a well pad (R-43) in proximity to the piezometer locations on May 17 and May 19, 2016. The equipment and tooling were decontaminated before mobilization to the site and were screened by a Laboratory radiological control technician (RCT) and inspected by the Laboratory project Environment, Safety, and Health representative and subcontractor technical representative (STR) before drilling activities commenced.

3.2 Drilling Methods

Fifteen of the 17 boreholes were drilled with the CME 75 tracked HSA rig, downhole tooling, and support equipment. HSAs using auger flights with 4.25-in. I.D./8-in. O.D. were used to drill the boreholes. After advancement of each auger flight, a standard penetration test hammer run downhole on rods was used to advance drive samplers over 1.5-ft-long sample intervals, with blow counts documented for each 6-in. drive interval.

Two piezometer boreholes, located farther upcanyon, were installed with nominal 3.25-in. stainless-steel hand-augers and stainless-steel extension rods.

3.3 Lithologic Logging

Drive samples were collected during drilling to determine lithologic characteristics as well as to examine the contact between the alluvium and underlying bedrock. In general, blow counts were documented during drive sampling to determine alluvial sediment consolidation as well as to aid in determining when Quaternary alluvium (Qal)/Tshirege Member Unit 1g of the Bandelier Tuff (Qbt 1g) bedrock contact or the Qal/Cerro Toledo (Qct) contact was encountered. However, because the Cerro Toledo (Qct) formation lacks cementation, blow counts were not useful in determining the Qal/Qct contact. During the installation of borehole SCPZ-17, the first location drilled for this project, blow counts were not recorded until the anticipated depth of the alluvium/bedrock contact was reached. After SCPZ-17 was drilled, blow counts were recorded during drive sampling at approximate 5-ft intervals. During hand-augering, lithology was based on characteristic changes in the quality of augering as well as on the recovered auger materials. Lithologic characteristics and relative moisture were recorded on lithologic logs.

3.4 Decontamination

Following completion of drilling activities, augers and sampling tools were decontaminated with a wire brush, followed by spraying with Fantastik and wiping clean with paper towels. Investigation-derived waste (IDW) accumulated during decontamination activities was staged and managed on-site and characterized according to the waste characterization strategy form (WCSF).

3.5 Piezometer Installation and Construction

As originally designed, the piezometers comprising the five transects were to include three Geokon model 4500AL-170-kPa VWT sets in each borehole, with each VWT installed in a 2-ft interval of 10/20 silica sand, separated by a 1-ft interval of hydrated bentonite chips. The deepest of the three VWTs and the sand interval were to be placed at the alluvium/bedrock contact. The middle and upper VWTs were to be installed above and backfill materials emplaced as augers were removed.

The two hand-augered piezometer boreholes consisted of two VWT sets in each borehole. Each VWT was installed in a 2-ft interval of 10/20 Colorado silica sand, separated by a 1-ft interval of hydrated bentonite chips. The first (lowermost) VWT and sand interval were placed at the alluvium/bedrock contact.

A separate, unique data cable was connected to each VWT that extended upward, beyond the surface of the borehole. The VWTs were clearly labeled and lowered into the borehole using the manufactured communication cable, with moderate tension maintained on the cable throughout installation. Before installation, an initial zero pressure reading was obtained for each piezometer in a thermally stable water bath. Proper function of the VWTs was confirmed before initial backfilling. Material volumes were calculated before emplacement and were measured to verify depths as necessary throughout backfilling as the augers were removed. Measurements were made with a sounding line to document backfill emplacement depths. Bentonite seals were carefully hydrated to prevent infiltration into the filter pack sand. After the upper VWT was emplaced and the uppermost sand pack installed, the boreholes were backfilled with hydrated bentonite chips to 0.5 ft below ground surface (bgs).

The alluvium/bedrock interface (Qbt 1g or Qct) was to be used to establish the total depth (TD) of the piezometer boreholes. In each of the boreholes, the goal was to identify the top of bedrock at each location, then backfill the boreholes with hydrated bentonite to the base of alluvium to create a seal to ensure no preferential seepage occurred across the lithologic contact. However, at the locations of SCPZ-15, SCPZ-22, SCPZ-23b, and SCPZ-27, bedrock was not encountered, and the piezometers were installed as deep as was practical.

Transect 1

Piezometers SCPZ-15, SCPZ-16, and SCPZ-17 were installed as transect 1.

Piezometer SCPZ-15 was drilled to a TD of 69 ft bgs, encountering moist sediment at 40.5 ft bgs, although no bedrock was encountered during drilling. Because the augers were getting tight in the borehole, they were pulled back to 54 ft bgs so sediment could settle out. Following consultation with the Laboratory technical lead, SCPZ-15 was completed above the slough, with a TD of 53.7 ft bgs. Construction details for SCPZ-15 are shown in Figure 3.5-1, and borehole lithologic details are presented in Table 3.5-1.

Piezometer SCPZ-16 was drilled to a TD of 29.5 ft bgs, encountering Qbt 1g bedrock at 28.5 ft bgs. No moisture was observed in sediments during drilling. Construction details for SCPZ-16 are shown in Figure 3.5-2, and borehole lithologic details are presented in Table 3.5-2.

During installation of piezometer SCPZ-17, difficult drilling conditions were encountered at 29.5 ft bgs, although the borehole was advanced to a TD of 35.5 ft bgs to ensure Qbt 1g bedrock was located and the auger head was not drilling on top of cobble or boulders. No moisture was observed in sediments during drilling. Construction details for SCPZ-17 are shown in Figure 3.5-3, and borehole lithologic details are presented in Table 3.5-3.

Transect 2

Piezometers SCPZ-18, SCPZ-19, and SCPZ-20 were installed as transect 2.

Piezometer SCPZ-18 was drilled to a TD of 30.5 ft bgs, encountering Qct bedrock at 29.3 ft bgs. No moisture was observed in sediments during drilling. Construction details for SCPZ-18 are shown in Figure 3.5-4, and borehole lithologic details are shown in Table 3.5-4.

During installation of piezometer SCPZ-19, lithologic changes at 29.2 ft bgs led the geologist/field team lead (FTL) to believe Qct bedrock was encountered at 29.2 ft bgs. However, the borehole was advanced to a TD of 35.5 ft bgs to ensure the alluvium/bedrock contact had been located. No moisture was observed in sediments during drilling. Construction details for SCPZ-19 are shown in Figure 3.5-5, and borehole lithologic details are presented in Table 3.5-5.

During installation of piezometer SCPZ-20, the initial Qal/Qct contact was difficult to determine, and it was not until Qbo was encountered at 40 ft bgs that upon further evaluation of drill cuttings and drive samples the FTL determined Qct bedrock occurred at 20 ft bgs. Moisture was observed in sediments at 24 ft bgs during drilling. Construction details for SCPZ-20 are shown in Figure 3.5-6, and borehole lithologic details are presented in Table 3.5-6.

Transect 3

Piezometers SCPZ-21, SCPZ-22, and SCPZ-23 were installed as transect 3.

Piezometer SCPZ-21 was drilled to a TD of 25.5 ft bgs, encountering Qct bedrock at 24.3 ft bgs. No moisture was observed in sediments just above the Qct contact during drilling. Construction details for SCPZ-21 are shown in Figure 3.5-7, and borehole lithologic details are presented in Table 3.5-7.

Piezometer SCPZ-22 was drilled to a TD of 56 ft bgs, encountering moist sediment at approximately 30.5 and 39–40.5 ft bgs, and wet sediment beginning at 44 ft bgs, although no bedrock was encountered during drilling. Following consultation with Laboratory technical lead, water levels were monitored for approximately 2.75 h, with depth to water (DTW) ranging from 47.6 to 50.4 ft bgs, with about 0.5 ft of sediment in the bottom of the augers. SCPZ-22 was completed above slough, with a TD of 56 ft bgs. Construction details for SCPZ-22 are shown in Figure 3.5-8, and borehole lithologic details are presented in Table 3.5-8.

The remaining piezometer(s) in transect 3, SCPZ-23a and SCPZ-23b, were completed in two boreholes. During borehole advancement for SCPZ-23a, Qbt 1g bedrock was encountered at 55.0 ft bgs. After the borehole was advanced to 58 ft bgs, to facilitate piezometer construction and installation of the lower VWT, backfill materials were bridged inside the augers, resulting in upward displacement of the middle VWT while the augers were being removed. Following discussion with the Laboratory technical lead, a second borehole, SCPZ-23b, was drilled to 50 ft bgs approximately 3.5 ft away from SCPZ-23a.The middle and upper VWTs were installed in SCPZ-23b. No bedrock was encountered during borehole advancement of SCPZ-23b. Construction details for SCPZ-23a and SCPZ-23b are shown in Figures 3.5-9 and 3.5-10, respectively, and borehole lithologic details for SCPZ-23a are presented in Table 3.5-9. Lithologic details were not recorded for SCPZ-23b because of its proximity to SCPZ-23a.

Transect 4

Piezometers SCPZ-24, SCPZ-25, and SCPZ-26 were installed as transect 4.

Piezometer SCPZ-24 was drilled to a TD of 20.5 ft bgs, encountering Qbt 1g bedrock at 14.5 ft bgs. Because the alluvium/bedrock contact is shallow, the borehole was advanced another 6 ft to ensure bedrock was encountered, and the auger head was not drilling on a cobble or boulder. No moisture was observed in sediments during drilling. Construction details for SCPZ-24 are shown in Figure 3.5-11, and borehole lithologic details are presented in Table 3.5-10.

Piezometer SCPZ-25 was drilled to a TD of 56 ft bgs, and Qbt 1g bedrock was encountered at 55 ft bgs. During well construction, DTW was measured at 42.4 ft bgs. Construction details for SCPZ-25 are shown in Figure 3.5-12, and borehole lithologic details are presented in Table 3.5-11.

Piezometer SCPZ-26 was drilled to a TD of 30.5 ft bgs, and Qct bedrock was encountered at 24.3 ft bgs. Because the alluvium/bedrock contact is shallow, the borehole was advanced another 6 ft to ensure bedrock had been located. No moisture was observed in sediments during drilling. Construction details for SCPZ-26 are shown in Figure 3.5-13, and borehole lithologic details are presented in Table 3.5-12.

Transect 5

Piezometers SCPZ-27, SCPZ-28, and SCPZ-29 were installed as transect 5.

Two boreholes were drilled to install SCPZ-27, the first of which, designated as SCPZ-27-PA, was abandoned when Qbt 1g bedrock was encountered at 10.4 ft bgs. Borehole abandonment details are shown in Figure 3.5-14, and borehole lithologic details are presented in Table 3.5-13. Because the terrain near the SCPZ-27-PA location is not flat, the second borehole for SCPZ-27 had to be located across the stream channel on the north bank, approximately 30 ft from SCPZ-29. Piezometer SCPZ-27 was advanced to 56 ft bgs, with no bedrock encountered during drilling. After drilling to TD, the augers were pulled up 2 ft to allow sediment to settle out. Water levels were monitored at the direction of the Laboratory technical lead for approximately 1.5 h. During this monitoring, water levels changed from 52.3 ft bgs at the onset of monitoring to 47.3 ft bgs before piezometer construction. Construction details for SCPZ-27 are shown in Figure 3.5-15, and borehole lithologic details are presented in Table 3.5-14.

Piezometer SCPZ-28 was drilled to a TD of 46 ft bgs, and Qbt 1g bedrock was encountered at 44.8 ft bgs. Moist and wet sediments were observed during drilling; however, no standing water was measured in the borehole before the VWT was installed. Construction details for SCPZ-28 are shown in Figure 3.5-16, and borehole lithologic details are presented in Table 3.5-15.

Piezometer SCPZ-29 was drilled to a TD of 51 ft bgs, and Qbt 1g bedrock was encountered at 49.1 ft bgs. Before well construction, DTW was measured at 49.5 ft bgs. Construction details for SCPZ-29 are shown in Figure 3.5-17, and lithologic details are presented in Table 3.5-16.

Upgradient Piezometers

Piezometers SCPZ-13 and SCPZ-14 were installed upgradient of transects 1–5, approximately 2471 ft and 1699 ft, respectively, west-northwest of transect 1.

Piezometer SCPZ-13 was hand-augered to a TD of 8.2 ft bgs, and Qbt 1g bedrock was encountered at 8.1 ft bgs. Moist sediments were observed during installation of SCPZ-13; however, no standing water was encountered. Construction details for SCPZ-13 are shown in Figure 3.5-18, and borehole lithologic details are presented in Table 3.5-17.

Piezometer SCPZ-14 was hand-augered to a TD of 10.1 ft bgs, and Qbt 1g bedrock was encountered at 10 ft bgs. No moisture was observed in sediments during installation of SCPZ-14. Construction details for SCPZ-14 are shown in Figure 3.5-19, and borehole lithologic details are presented in Table 3.5-18.

3.6 Groundwater Detection

Based on existing alluvial wells and piezometers in the area, the saturated thickness of alluvial groundwater has been shown to be highly variable. Water-level variability is driven by hydraulic response to the daily variations in effluent discharge, periodic storm flows, and seasonal precipitation. The alluvial water level was anticipated to occur near the alluvium/bedrock interface. Alluvial water was found at the alluvium/bedrock interface at SCPZ-25 and SCPZ-29. Moist or wet sediments were observed in many boreholes while drilling above the alluvium/bedrock interface, and measurable standing water was recorded at SCPZ-15, SCPZ-22, SCPZ-25, SCPZ-27, and SCPZ-29. Water levels measured in boreholes before piezometer construction as well as depth to bedrock, where applicable, are presented in Table 3.6-1 as well as on as-built figures for the piezometers.

3.7 Surface Completion

The surface completions included a 4-ft long 16-in.-I.D. steel outer protective casings to protect the data cables and data logger. The protective casings extend to approximately 2 ft bgs and were filled with 3 ft of pea gravel, with a weep hole installed at the base of the steel casings above ground level to prevent water buildup inside. Subsequent to piezometer installation, the steel protective casings were set in 3-ft by 3-ft by 0.5-ft-thick concrete pads. The tops of the protective casings were fitted with tamper-proof aluminum cover plates and fitted with Laboratory-supplied locks. A brass survey monument, imprinted with well identification information, was placed in the northwest corner of each concrete pad.

SCPZ-23b and SCPZ-27-PA were completed at the surface with a mounded concrete cap and an aluminum survey marker imprinted with the location identification information.

3.8 Demobilization

Demobilization activities included the following:

- Final decontamination and screening for radioactivity by an RCT of the drill rig, tools, and support equipment
- Loading and removal of the drilling tools, including alternative tools, from the site
- Removal of the drill rig and support vehicles from the site
- Staging and securing of IDW for future disposition
- Removal of municipal waste (e.g., materials packaging)
- Final site cleanup

3.9 IDW

A WCSF was prepared by the Laboratory in accordance with EP-DIR-SOP-10021, Characterization and Management of Project Waste, and all IDW was managed in accordance with an approved WCSF. This procedure incorporated the requirements of all applicable U.S. Environmental Protection Agency, and NMED regulations, U.S. Department of Energy orders, and Laboratory requirements. The waste streams included drill cuttings and contact waste. Drill cuttings were managed in accordance with the NMED-approved Decision Tree for the Land Application of Drill Cuttings (April 2016). Drilling, purge, and development waters were managed in accordance with the NMED-approved Notice of Intent Decision Tree for Drilling, Development, Rehabilitation, and Sampling Purge Water (March 2010). Drill cuttings were containerized and characterized with direct sampling. If they could not be land-applied, the cuttings were sent to an authorized treatment, storage, or disposal facility. Contact waste was containerized and characterized based on the waste determination of the drill cuttings.

3.10 Data Logger Installation

Following completion of piezometer installation, Geokon model LC-2×4 channel data loggers were installed at each piezometer location. The VWTs were connected to the data loggers and programmed to collect data readings at 1-h intervals. Following data logger installation and programming, the data loggers were secured at each piezometer location inside 16-in. protective casings with locking covers. Data logger and VWT serial numbers, along with VWT initial zero pressure readings and thermal bath temperature readings before installation, are presented in Table 3.10-1.

3.11 Surveying

A New Mexico licensed professional land surveyor conducted a geodetic survey on July 8, 2016 (Table 3.11-1). The survey data conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and Facility Management.” All coordinates are expressed relative to the New Mexico State Plane Coordinate System Central Zone (North American Datum [NAD] 83); elevation is expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points include ground surface elevation near concrete pads/mounds, the top of the pins in the concrete pads/mounds, and the top of the protective casings.

4.0 ACKNOWLEDGMENTS

Cascade Drilling drilled and installed piezometers SCPZ-15 through SCPZ-29.

TerranearPMC provided oversight on all preparatory and field-related activities. TerranearPMC field personnel hand-augered and installed piezometers SCPZ-13 and 14.

5.0 REFERENCES AND MAP DATA SOURCES

5.1 References

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the Environment, Safety, and Health (ESH) Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), June 2014. "Sandia Wetland Performance Report, Baseline Conditions 2012–2014," Los Alamos National Laboratory document LA-UR-14-24271, Los Alamos, New Mexico. (LANL 2014, 257590)

LANL (Los Alamos National Laboratory), July 2015. "Work Plan for Chromium Plume Center Characterization," Los Alamos National Laboratory document LA-UR-15-24861, Los Alamos, New Mexico. (LANL 2015, 600615)

LANL (Los Alamos National Laboratory), December 2015. "Drilling Work Plan for Alluvial Piezometers in Sandia Canyon," Los Alamos National Laboratory document LA-UR-15-29446, Los Alamos, New Mexico. (LANL 2015, 601047)

LANL (Los Alamos National Laboratory), March 1, 2016. "Waste Characterization Strategy Form for Drilling Work Plan for Alluvial Piezometers in Sandia Canyon," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2016, 601275)

NMED (New Mexico Environment Department), March 17, 2016. "Approval with Modification, Drilling Work Plan for Alluvial Piezometers in Sandia Canyon," New Mexico Environment Department letter to D. Hintze (DOE-EM-LA) and M. Brandt (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2016, 601327)

TerranearPMC, May 2016. "Field Implementation Plan for Alluvial Piezometers in Sandia Canyon," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2016, 601928)

TerranearPMC, May 9, 2016. "IWD [Integrated Work Document] for 2016 Drilling and Installation of Alluvial Piezometers in Sandia Canyon," Los Alamos, New Mexico. (TerranearPMC 2016, 601927)

5.2 Map Data Sources

Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109; 12 April 2010.

Hypsography, 100 and 20 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Surface Drainages, 1991; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0591; 1:24,000 Scale Data; Unknown publication date.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 4 December 2009.

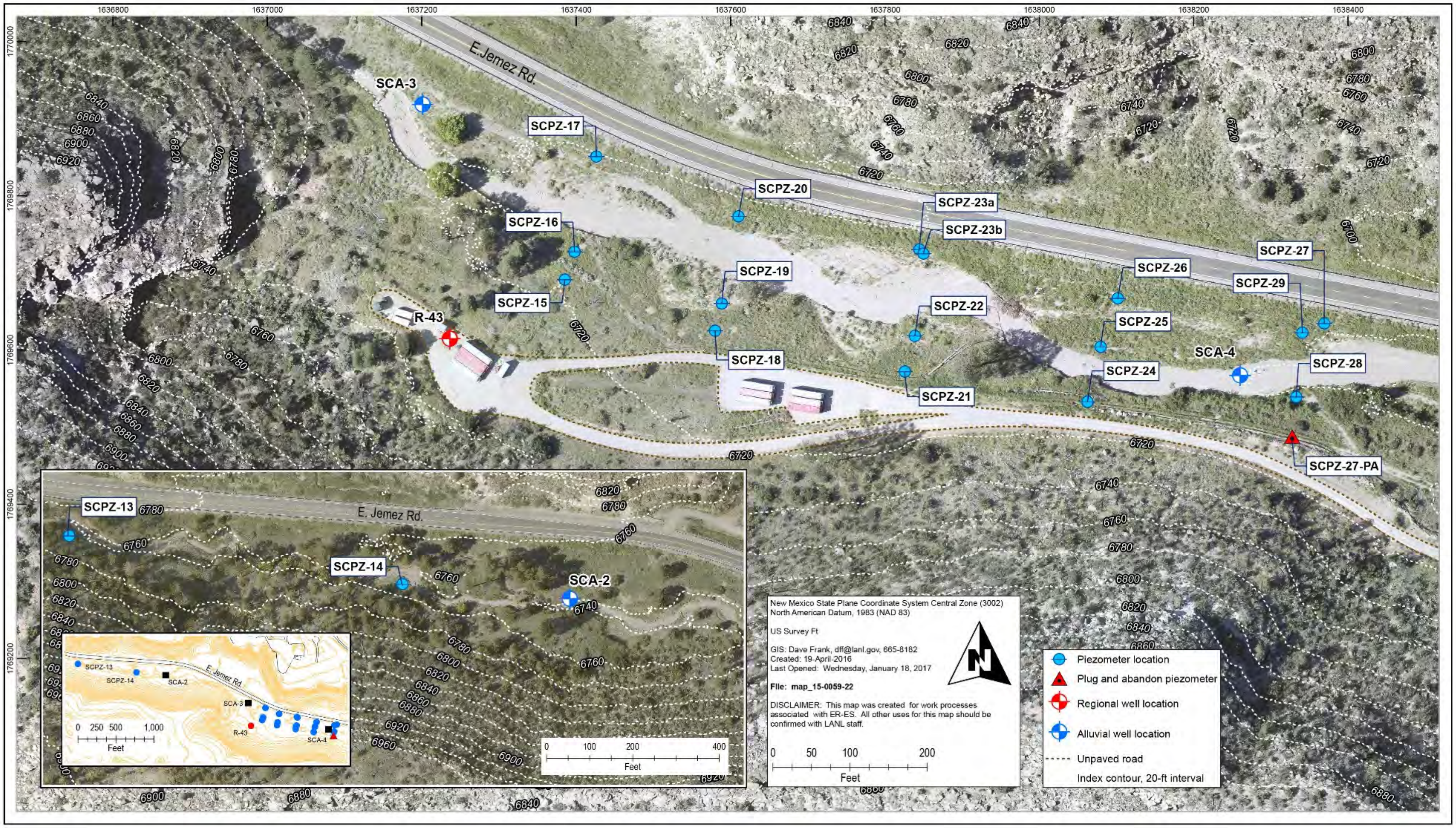


Figure 1.0-1 Locations for alluvial piezometer transects and upgradient alluvial piezometers

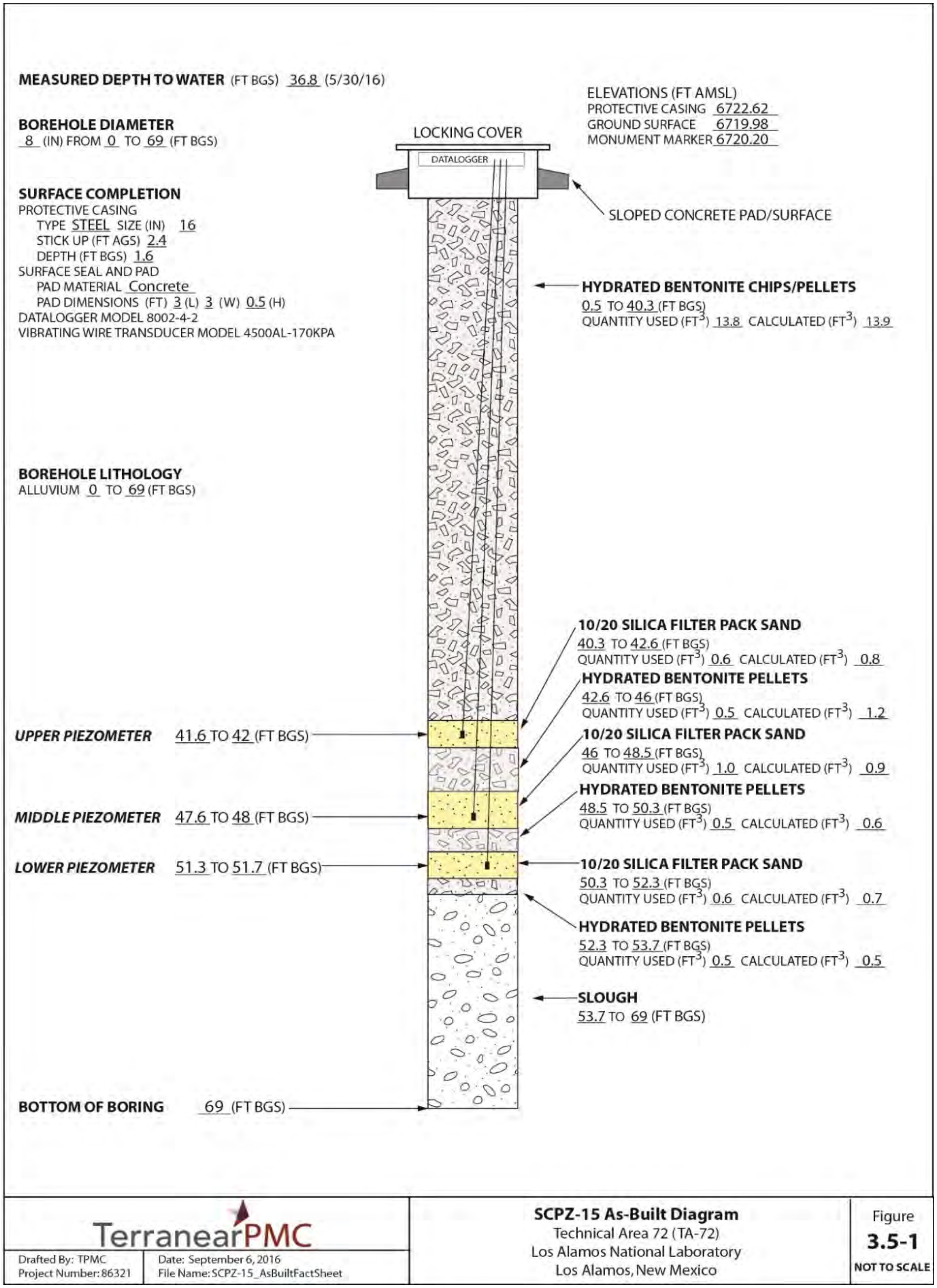


Figure 3.5-1 As-built diagram of SCPZ-15

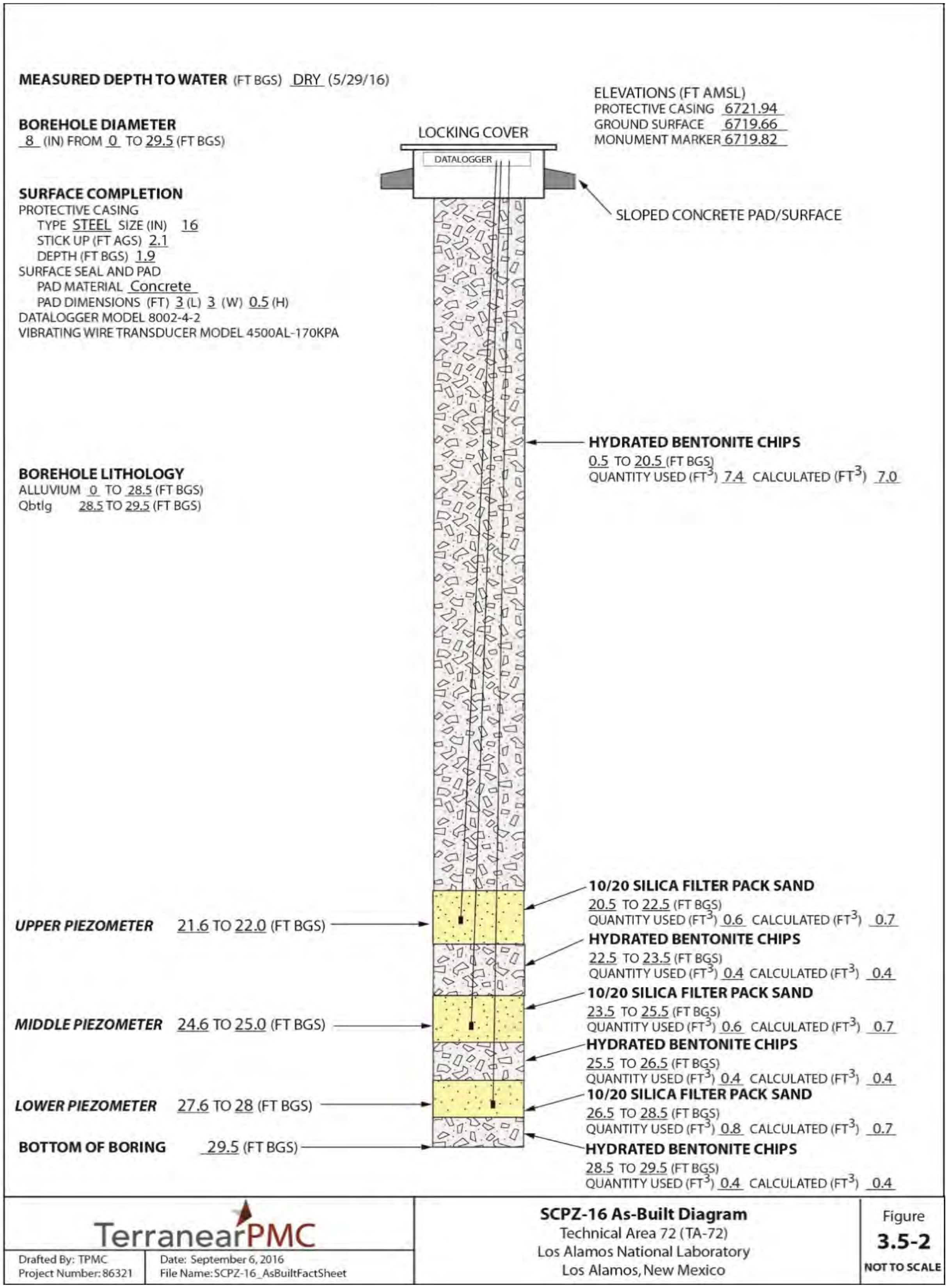
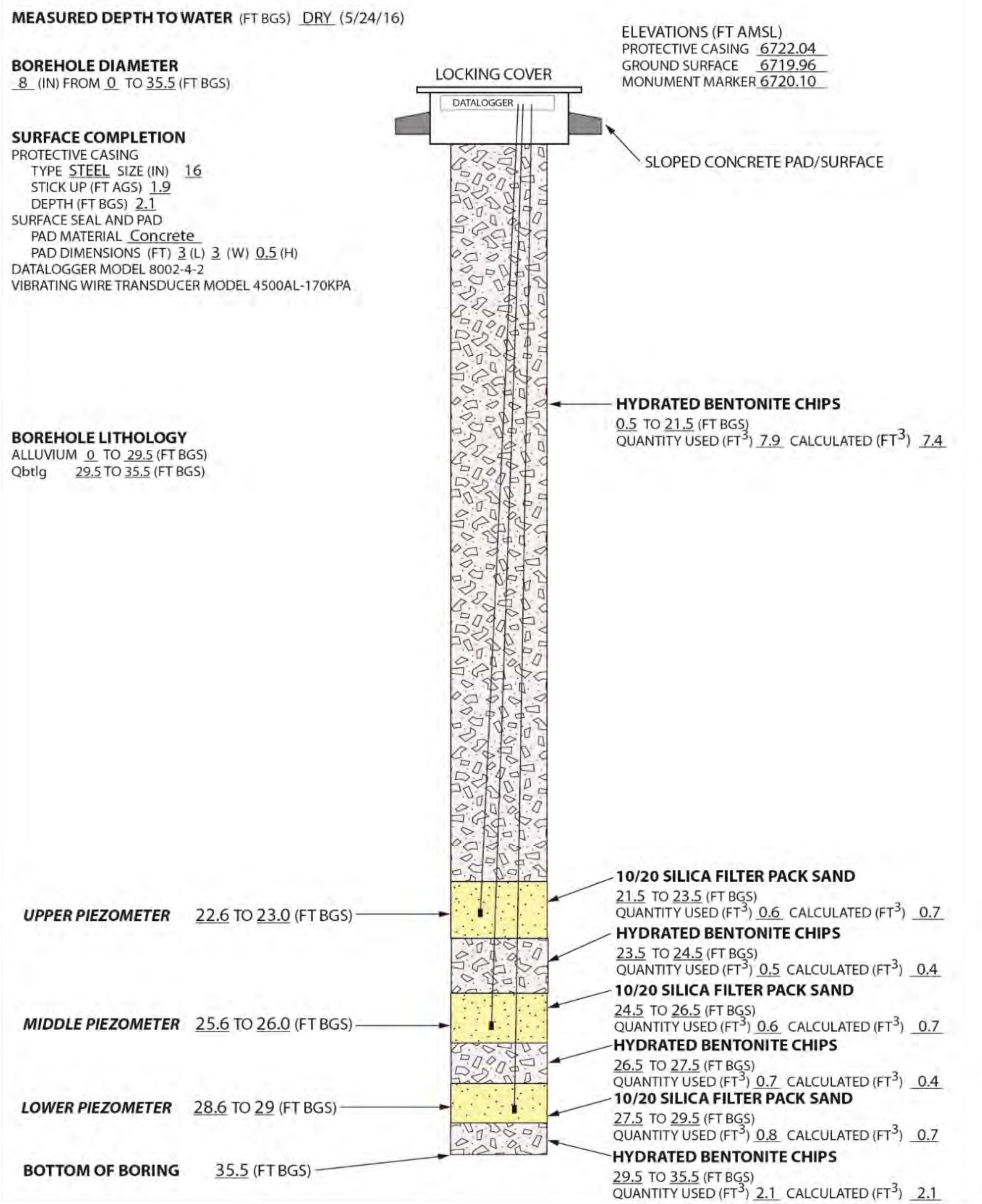


Figure 3.5-2 As-built diagram of SCPZ-16



TerranearPMC Drafted By: TPMC Project Number: 86321	Date: September 6, 2016 File Name: SCPZ-17_AsBuiltFactSheet	**SCPZ-17 As-Built Diagram** Technical Area 72 (TA-72) Los Alamos National Laboratory Los Alamos, New Mexico	Figure **3.5-3** NOT TO SCALE

Figure 3.5-3 As-built diagram of SCPZ-17

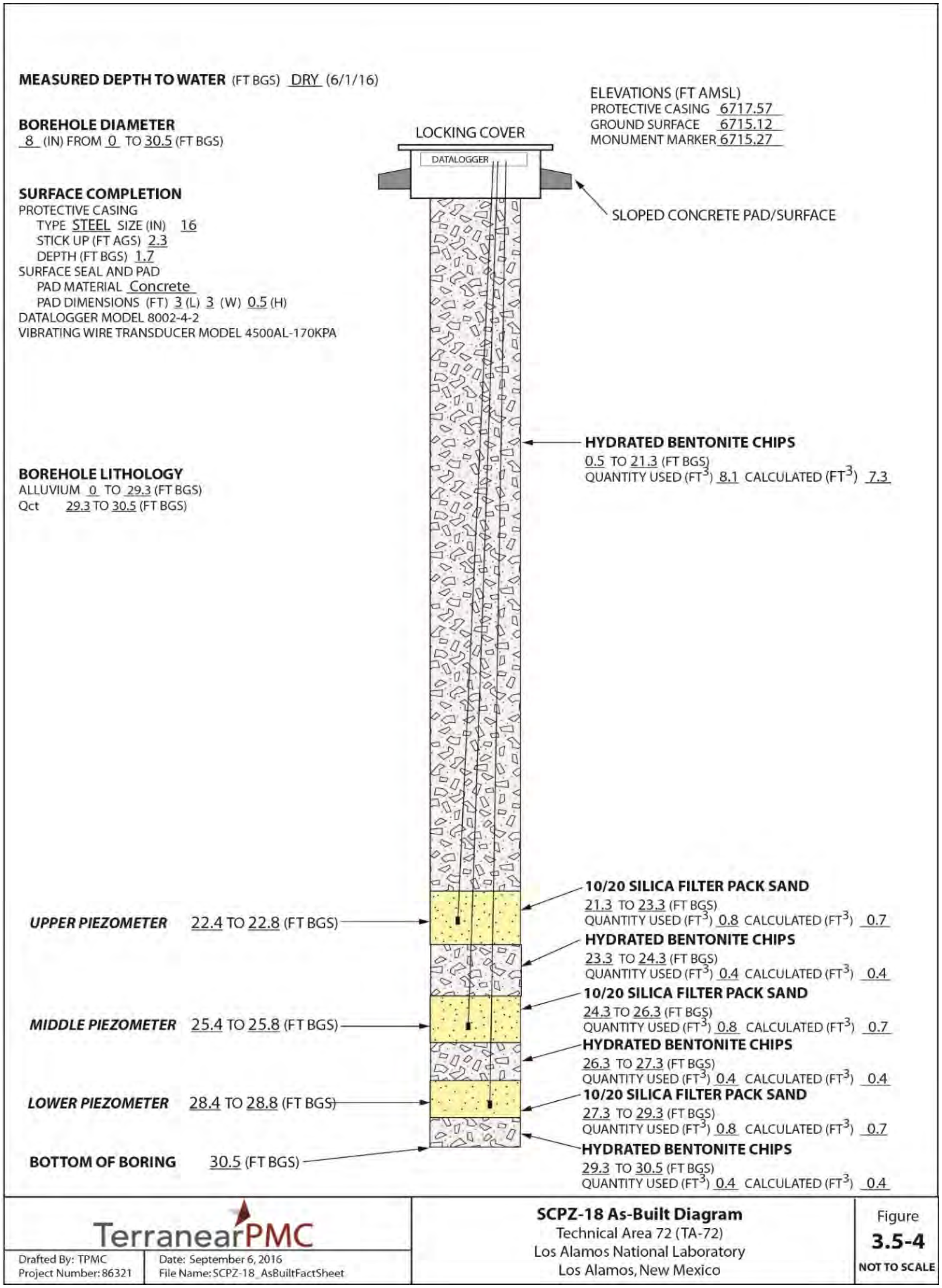


Figure 3.5-4 As-built diagram of SCPZ-18

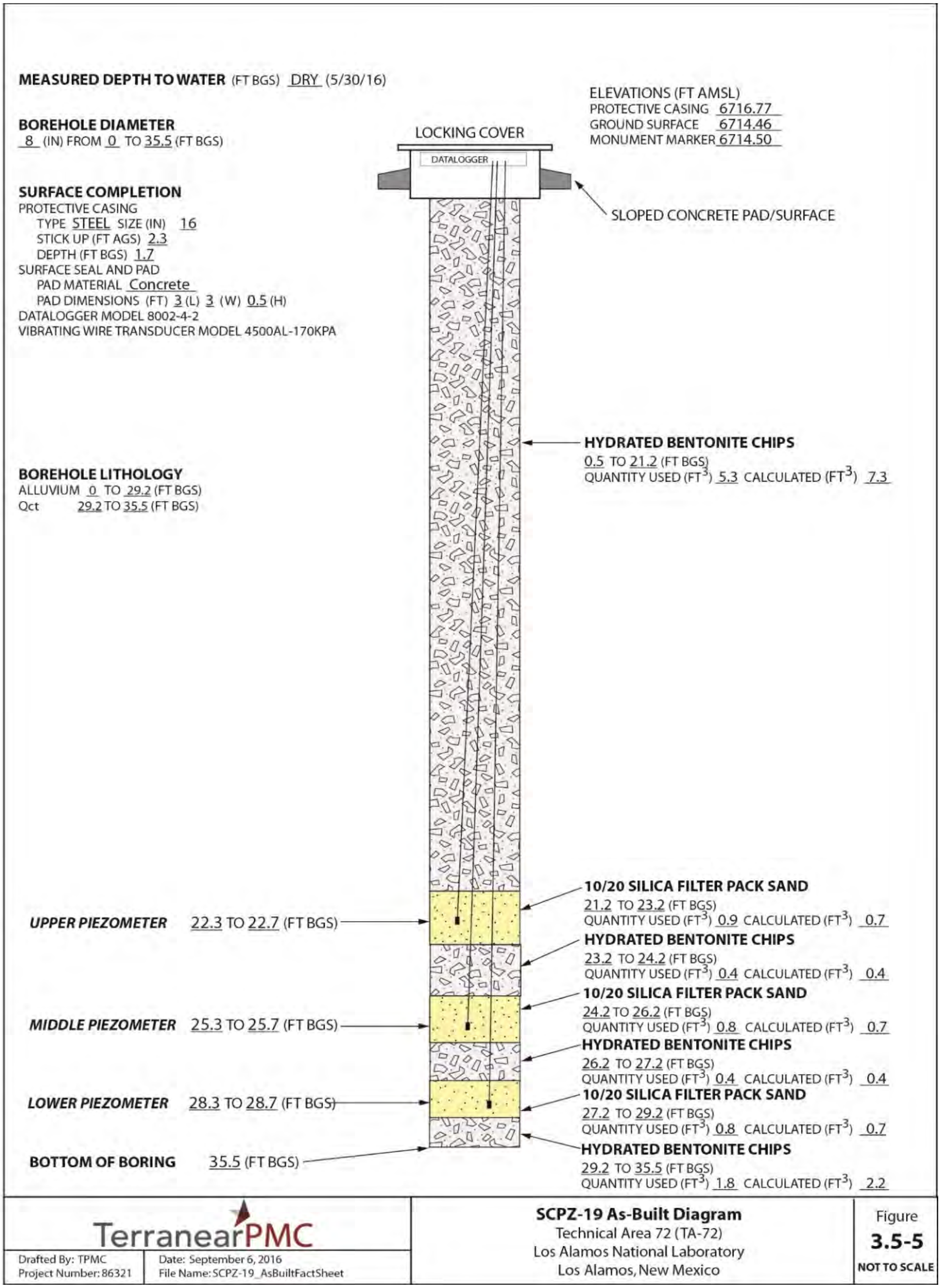


Figure 3.5-5 As-built diagram of SCPZ-19

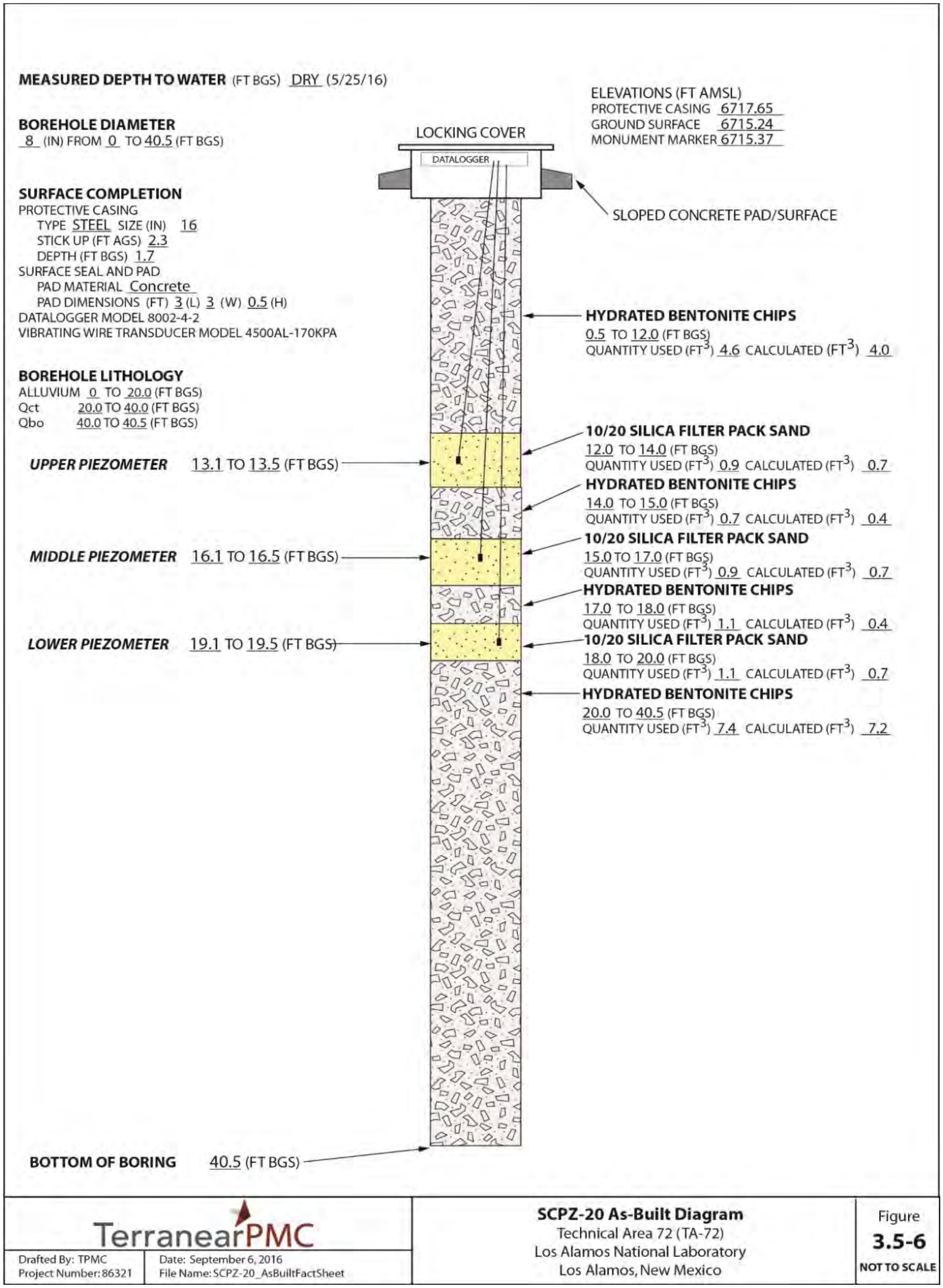


Figure 3.5-6 As-built diagram of SCPZ-20

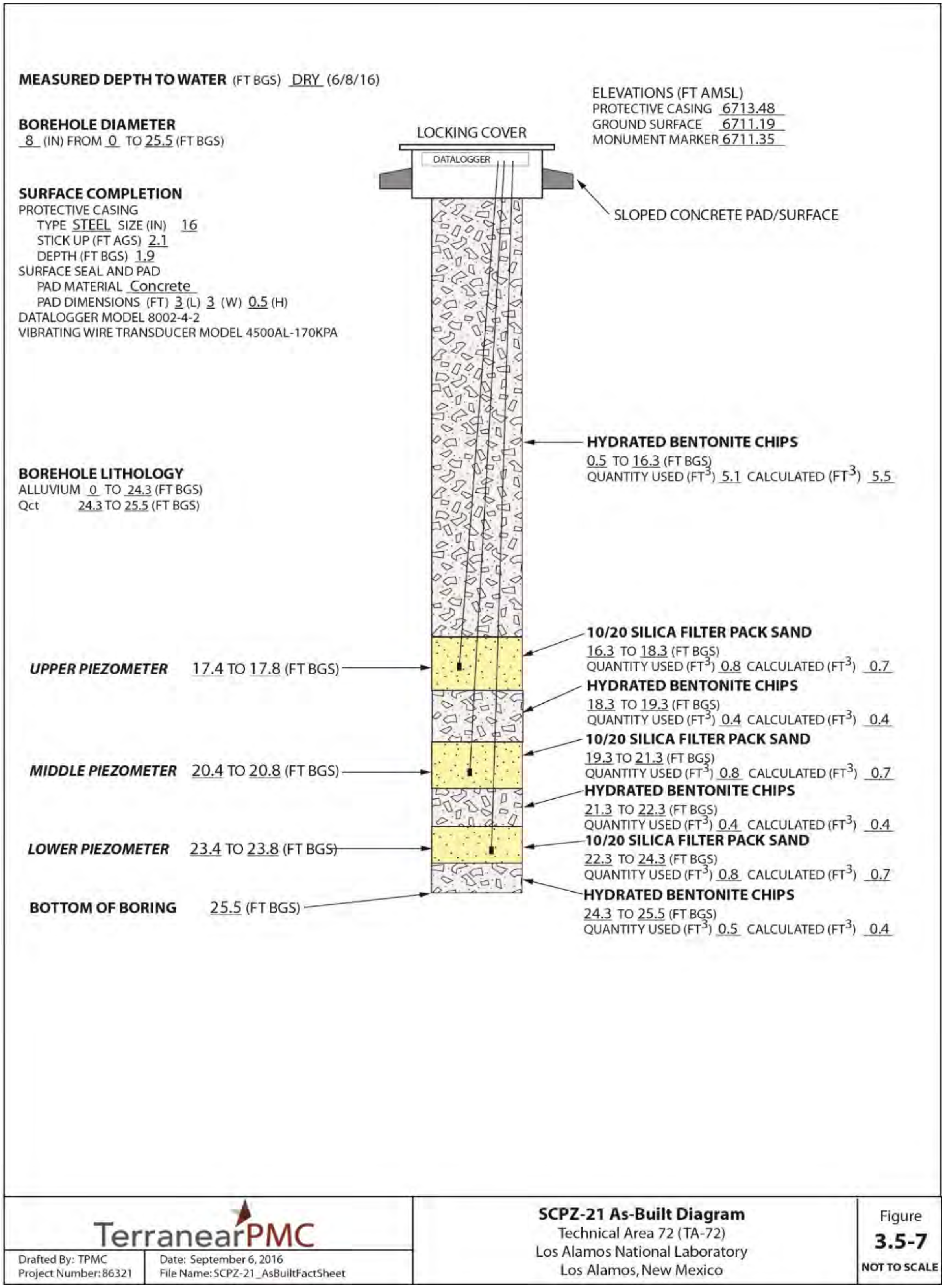


Figure 3.5-7 As-built diagram of SCPZ-21

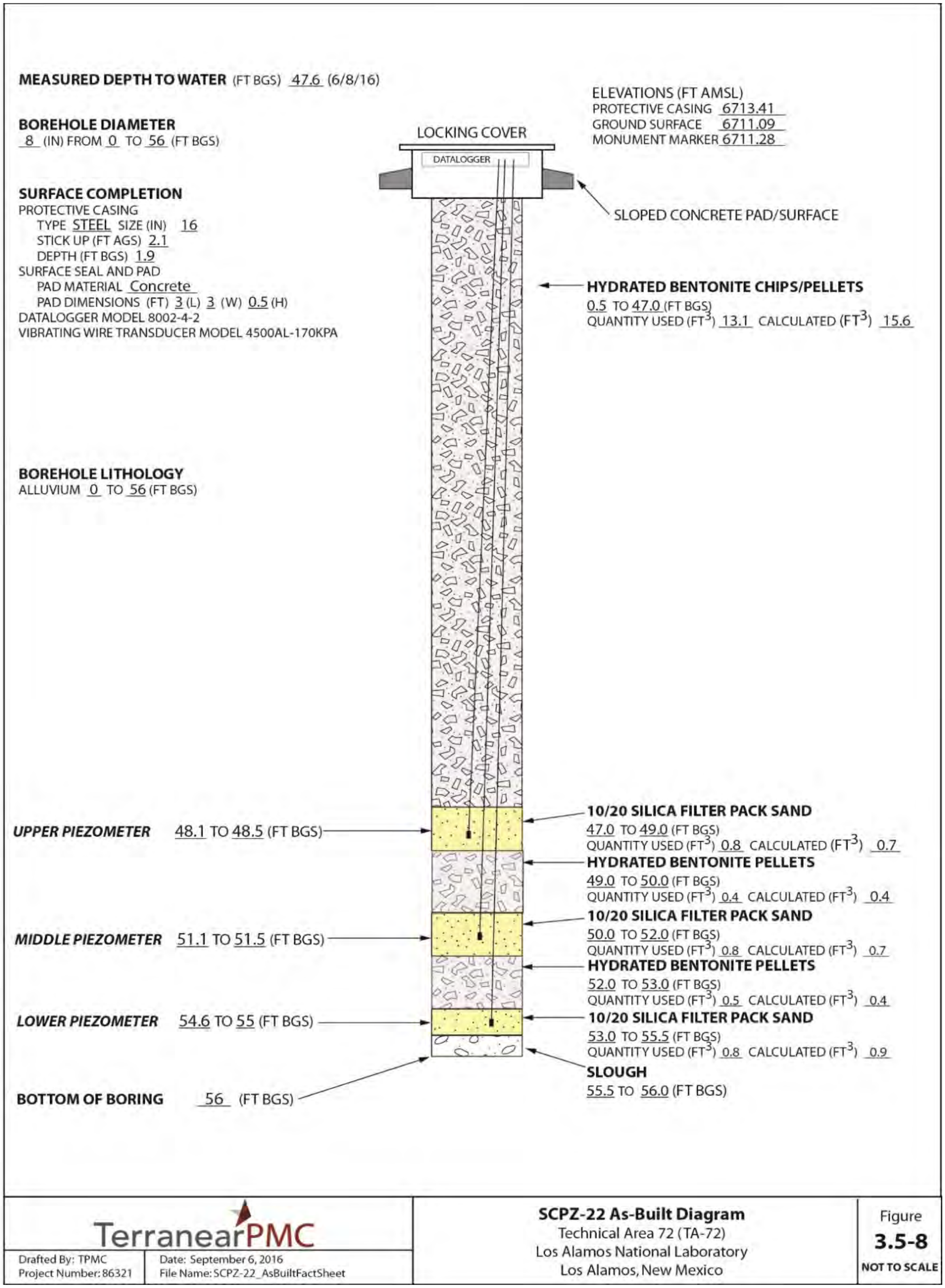


Figure 3.5-8 As-built diagram of SCPZ-22

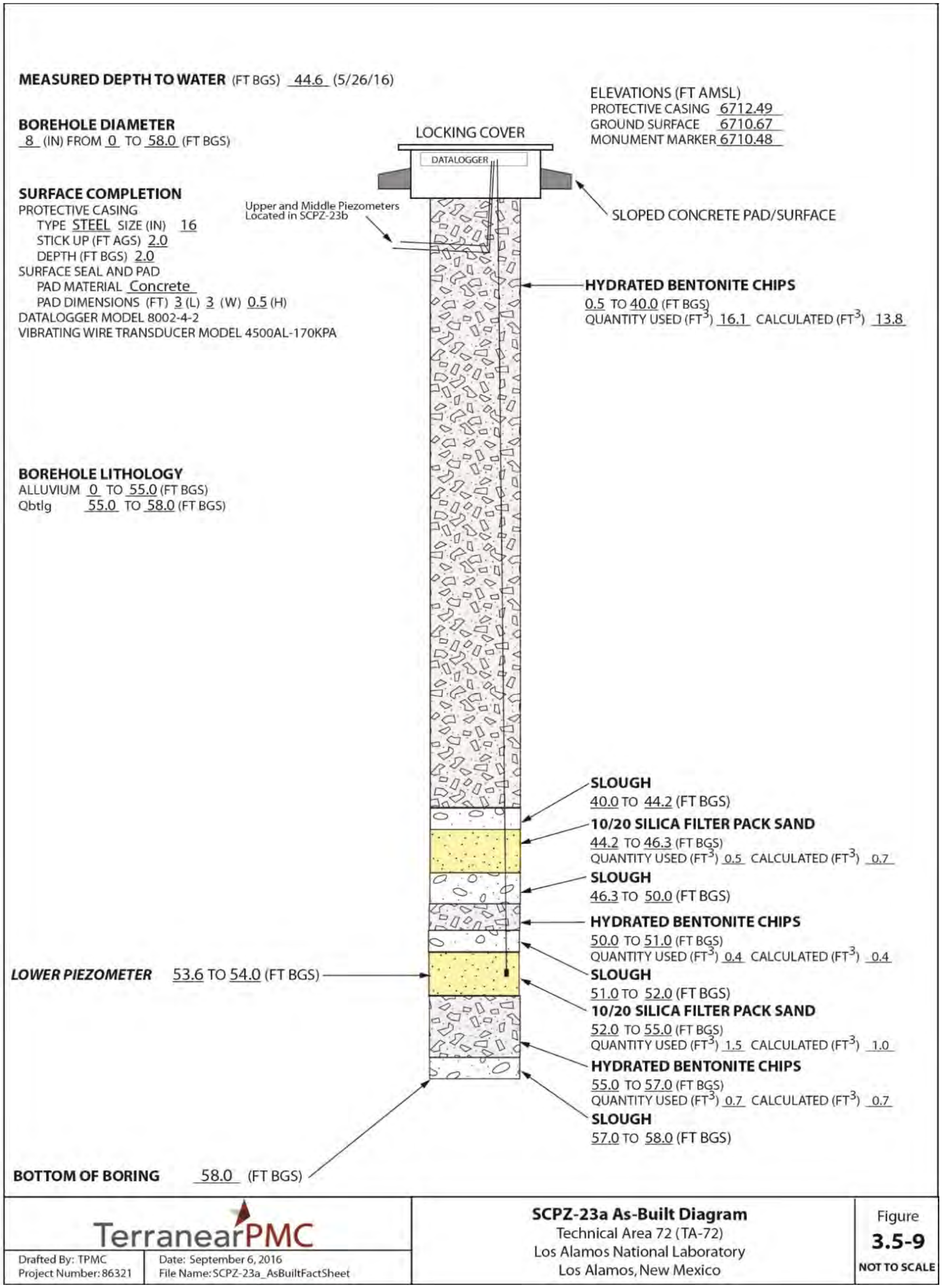
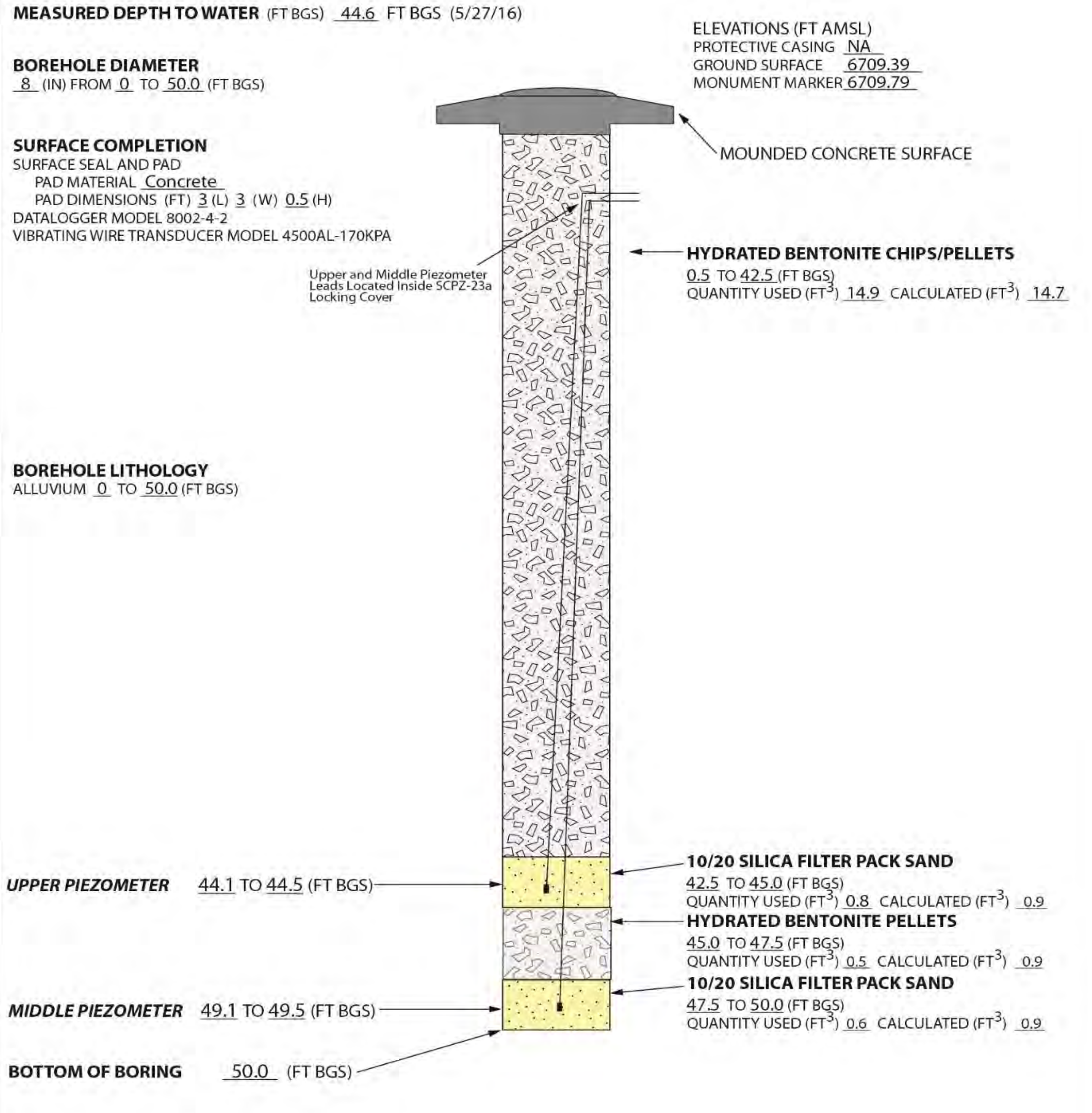


Figure 3.5-9 As-built diagram of SCPZ-23a



TerranearPMC

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Project Number: 86321

Date: September 6, 2016
File Name: SCPZ-23b_AsBuiltFactSheet

SCPZ-23b As-Built Diagram
Technical Area 72 (TA-72)
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure **3.5-10**
NOT TO SCALE

Figure 3.5-10 As-built diagram of SCPZ-23b

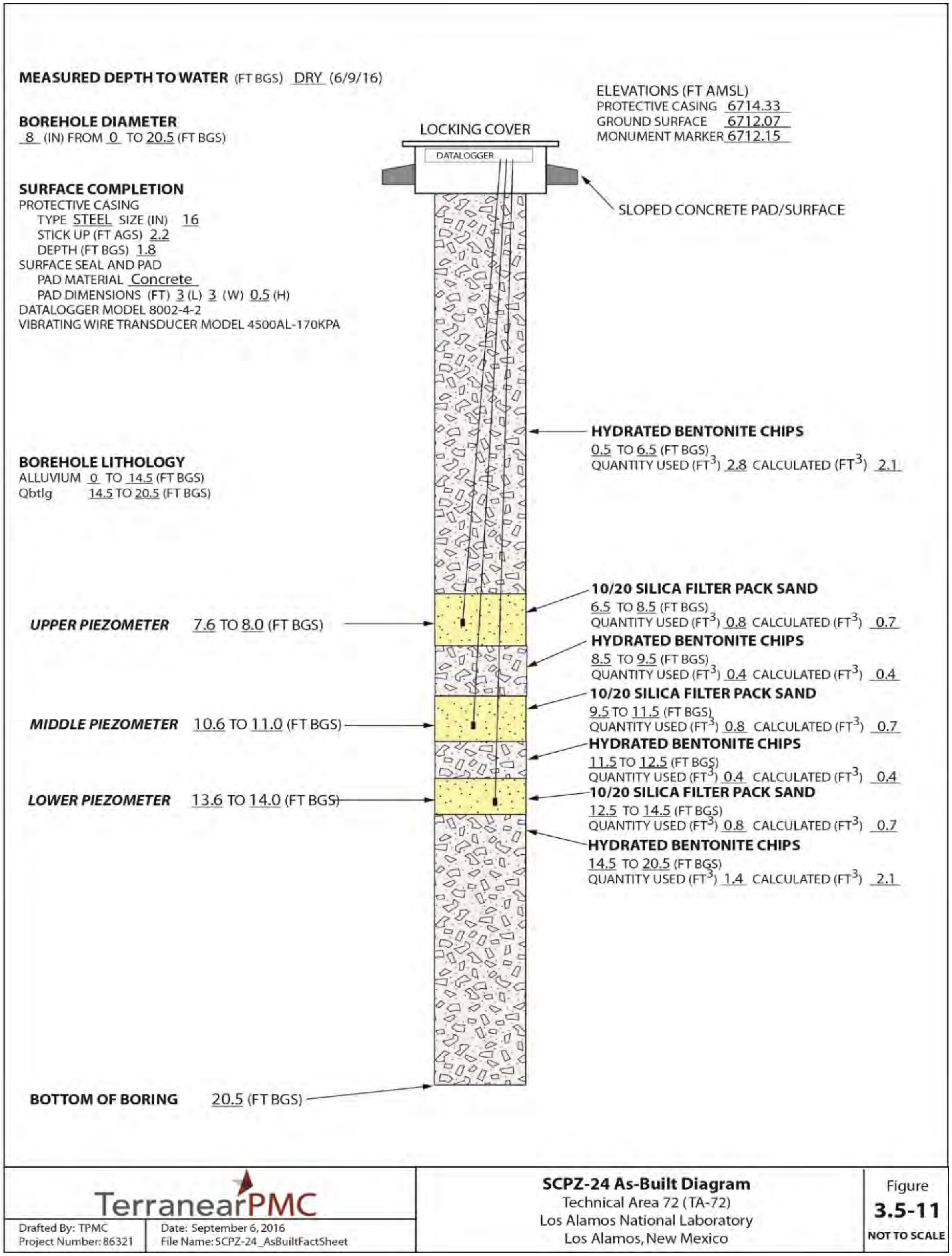

Figure 3.5-11 As-built diagram of SCPZ-24

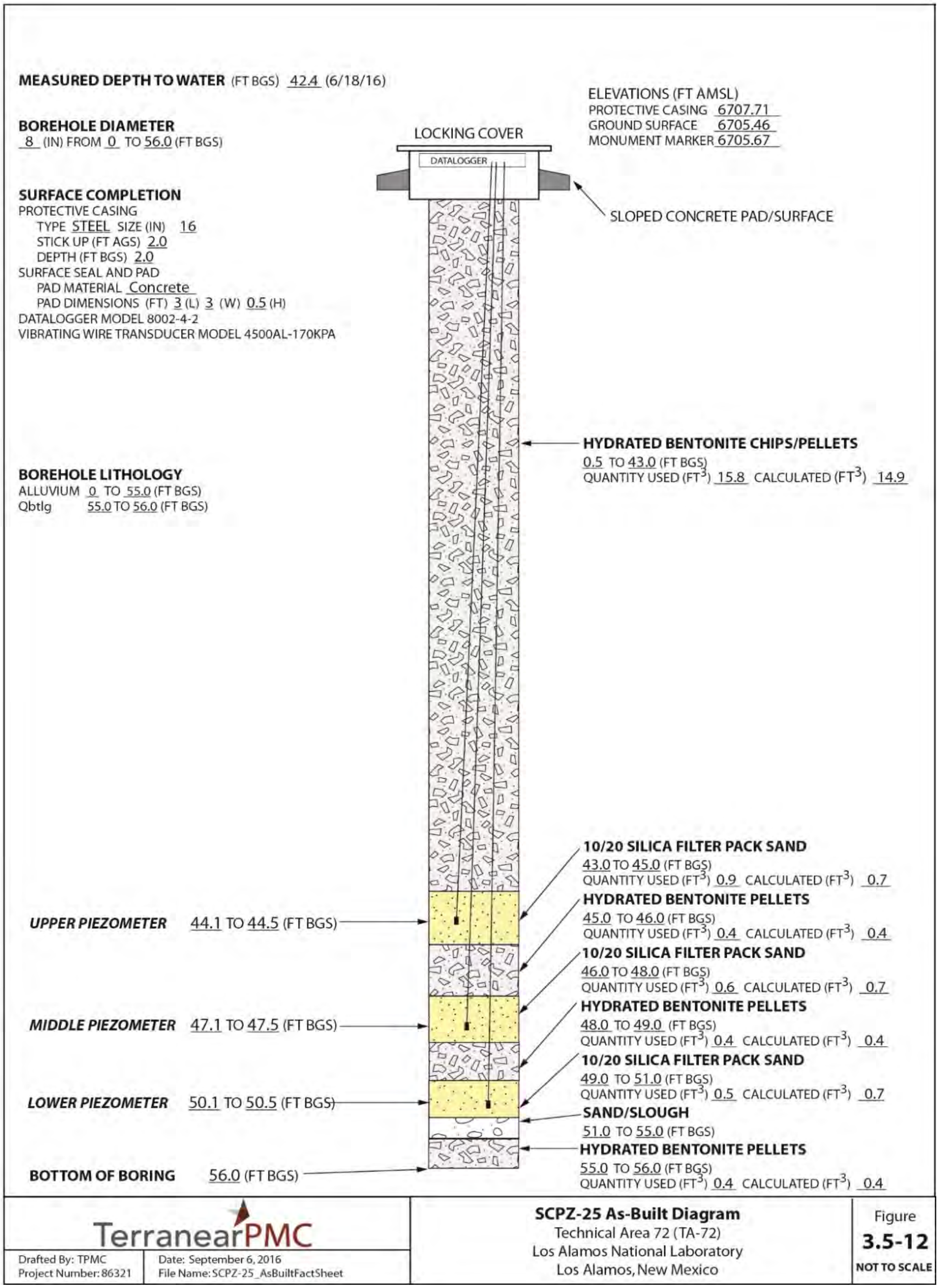

Figure 3.5-12 As-built diagram of SCPZ-25

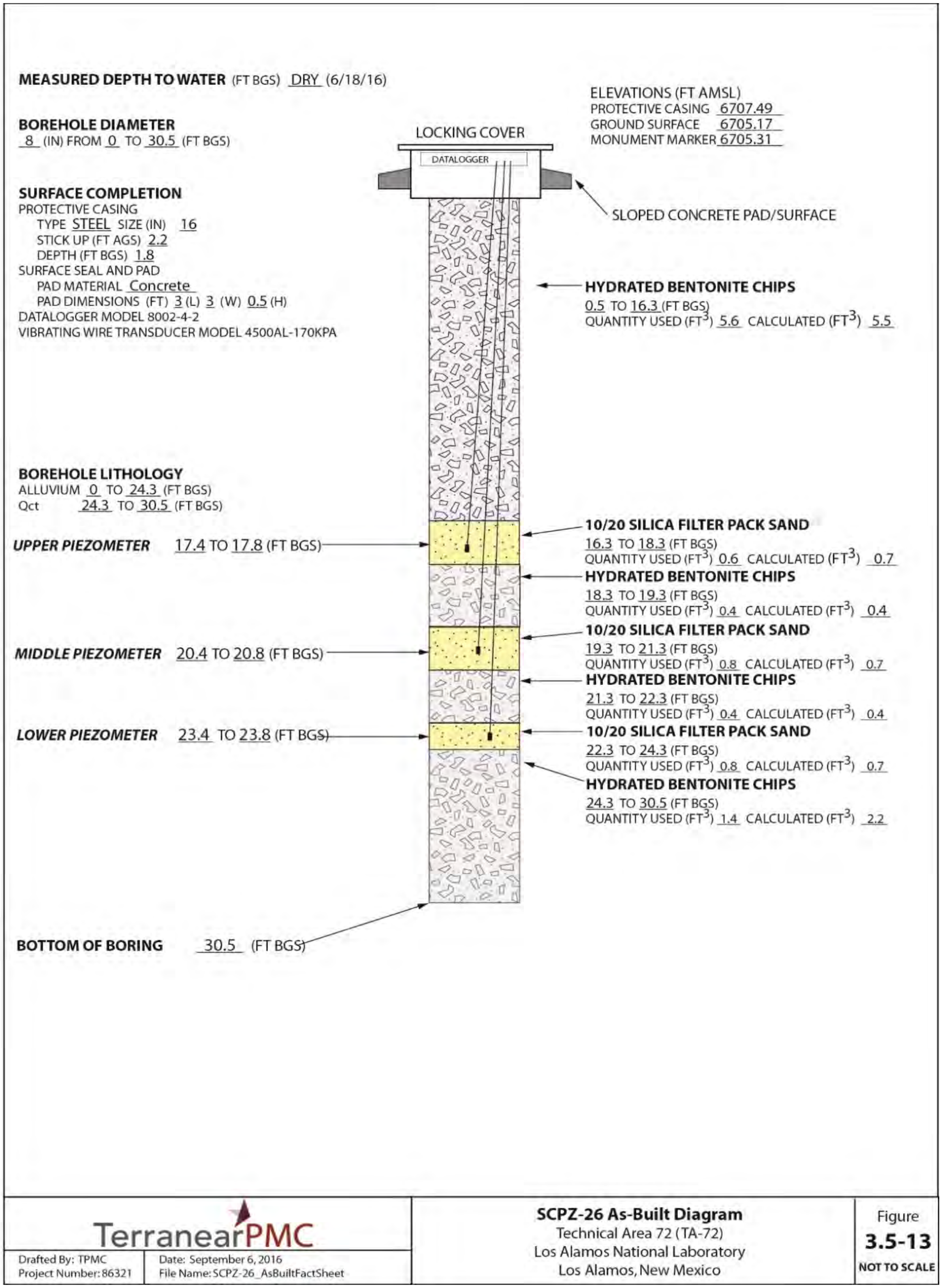

Figure 3.5-13 As-built diagram of SCPZ-26

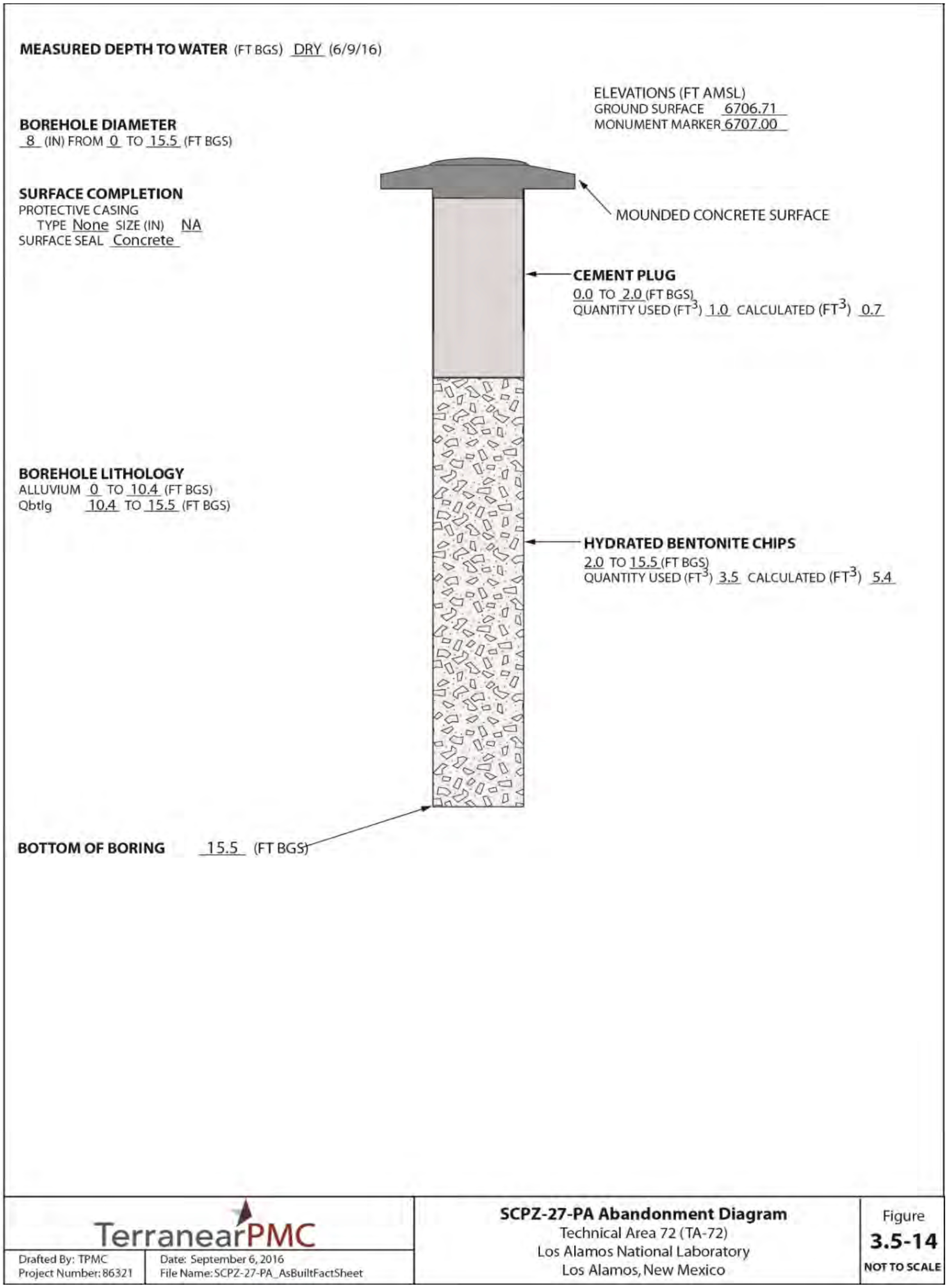

Figure 3.5-14 Abandonment diagram for SCPZ-27-PA

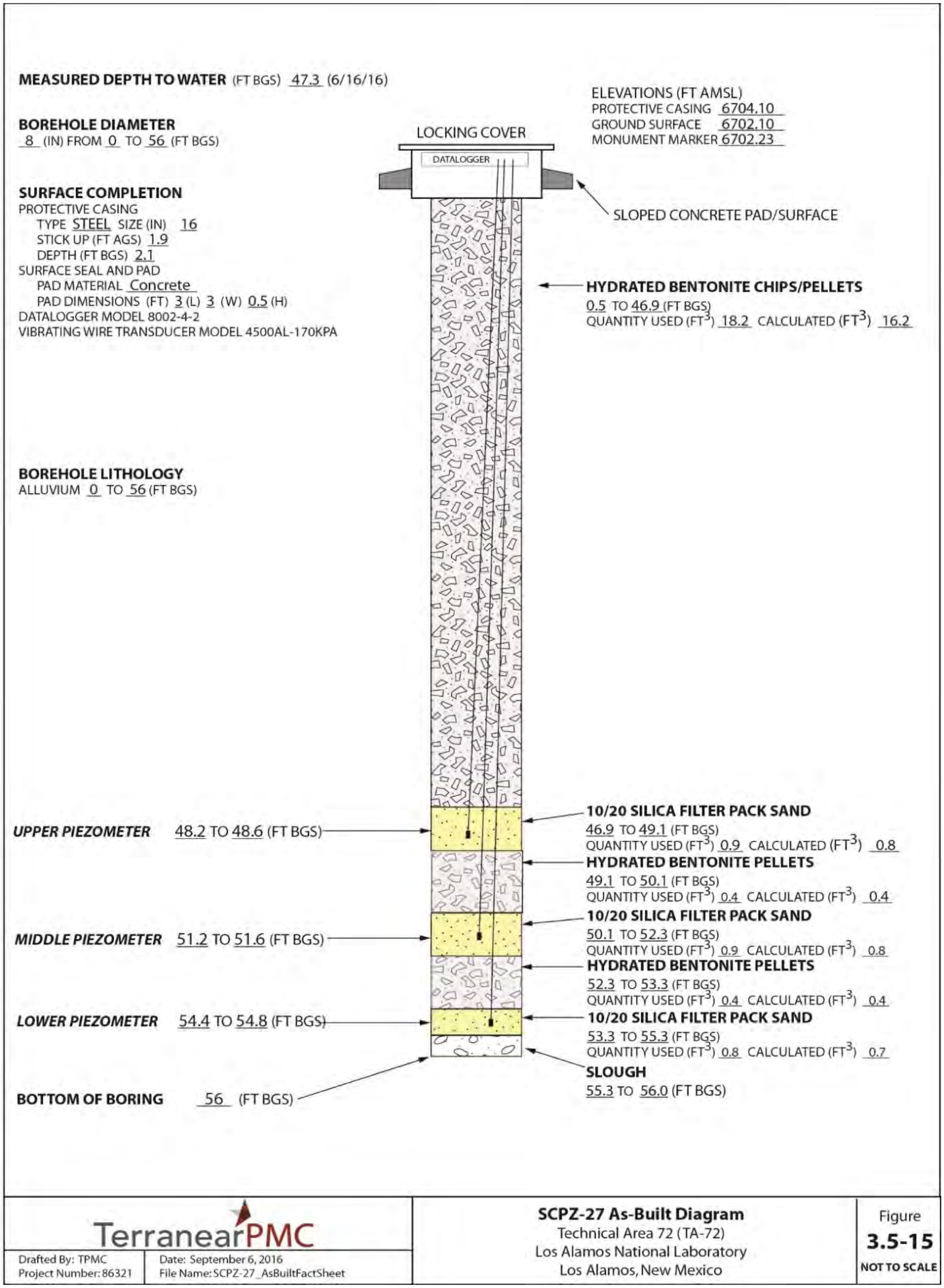

Figure 3.5-15 As-built diagram of SCPZ-27

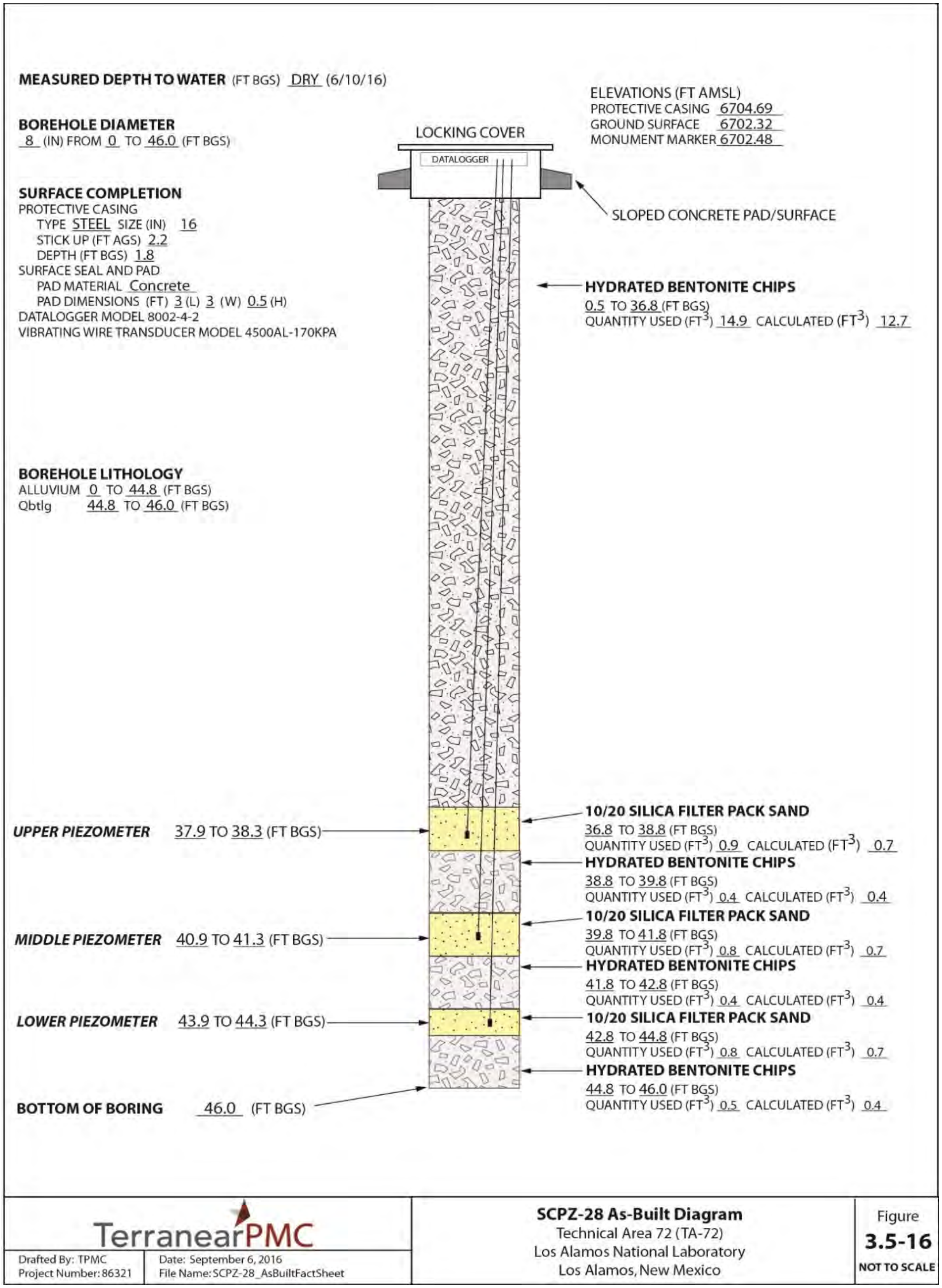

Figure 3.5-16 As-built diagram of SCPZ-28

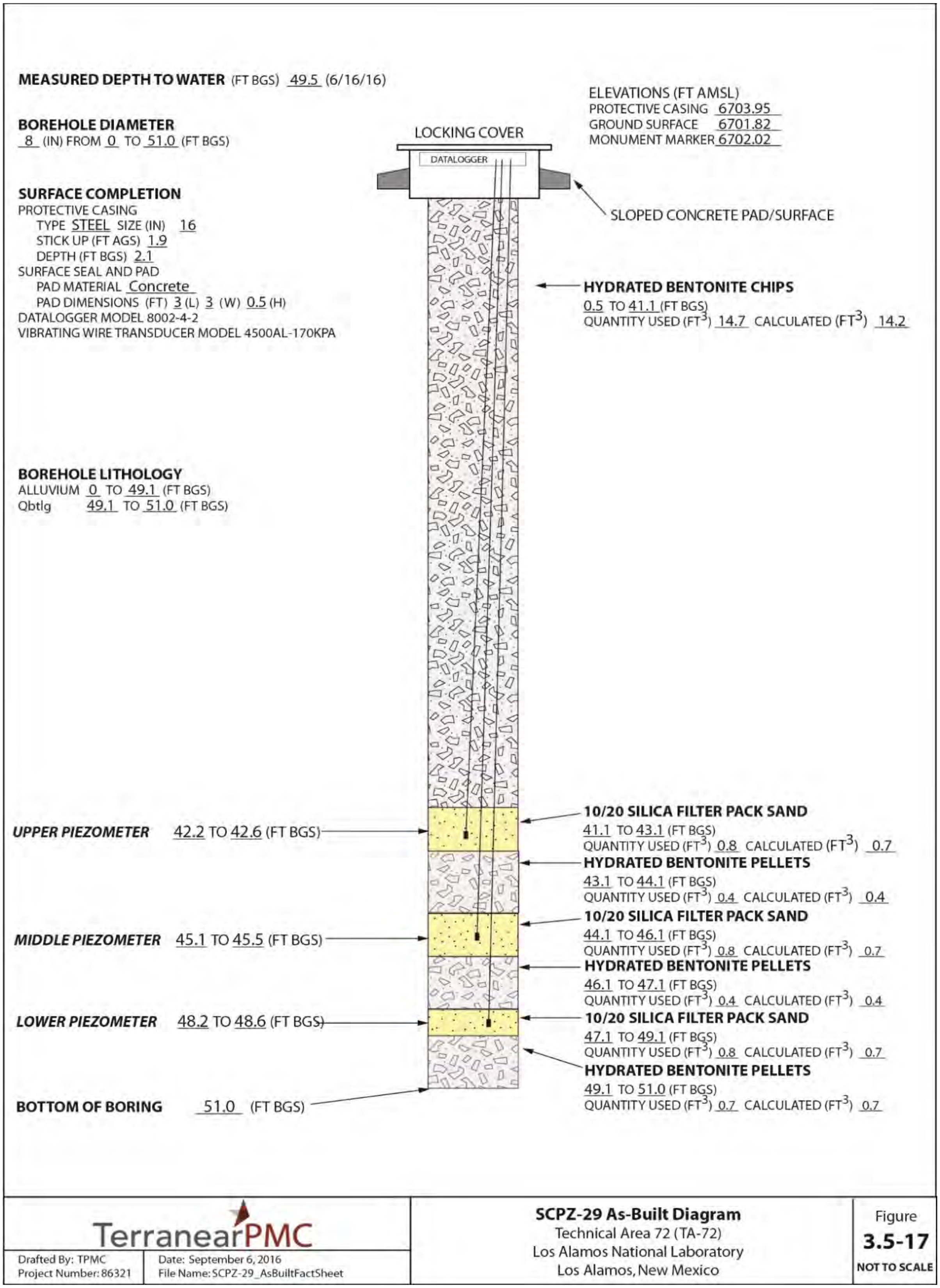

Figure 3.5-17 As-built diagram of SCPZ-29

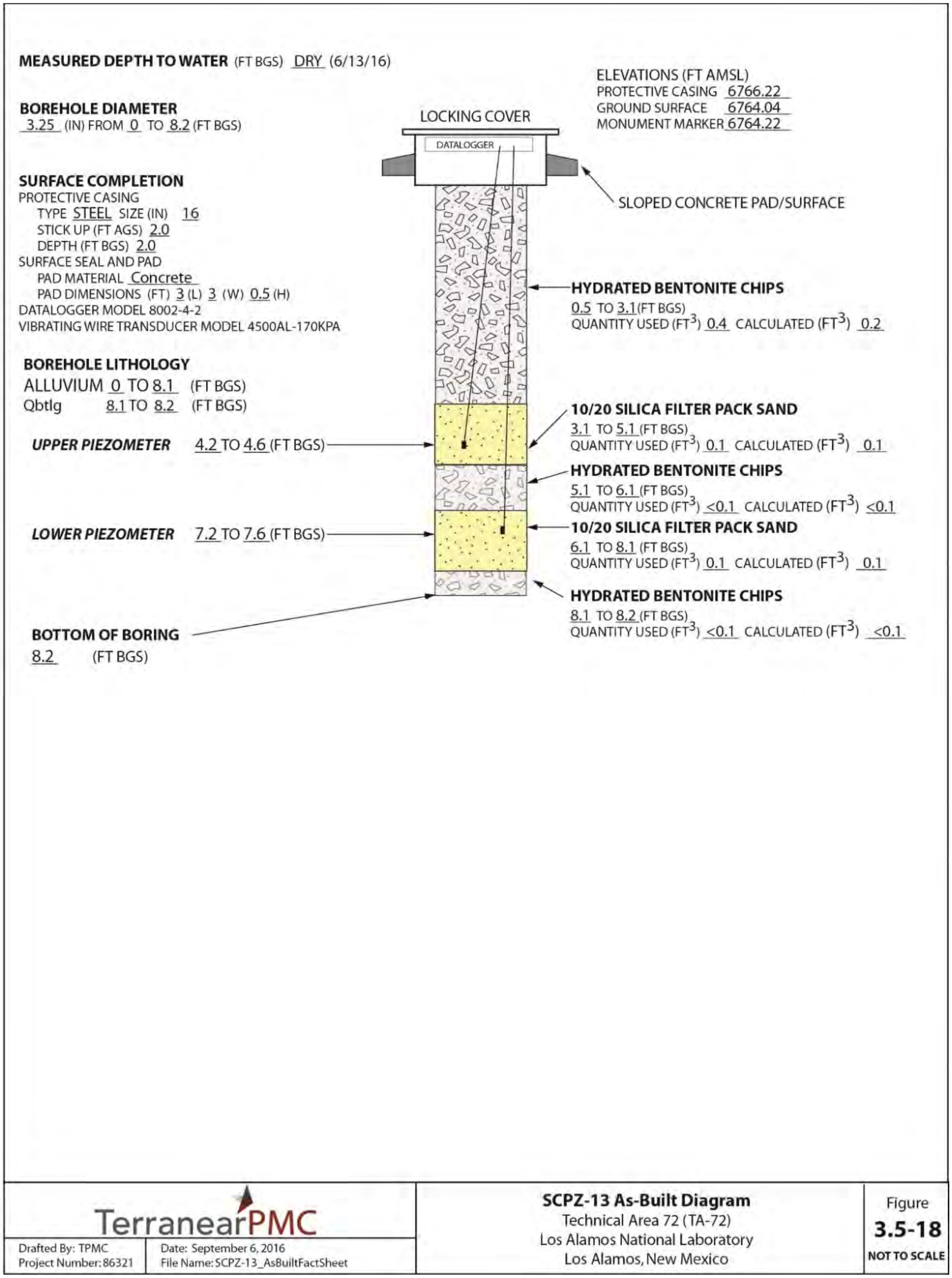

Figure 3.5-18 As-built diagram of SCPZ-13

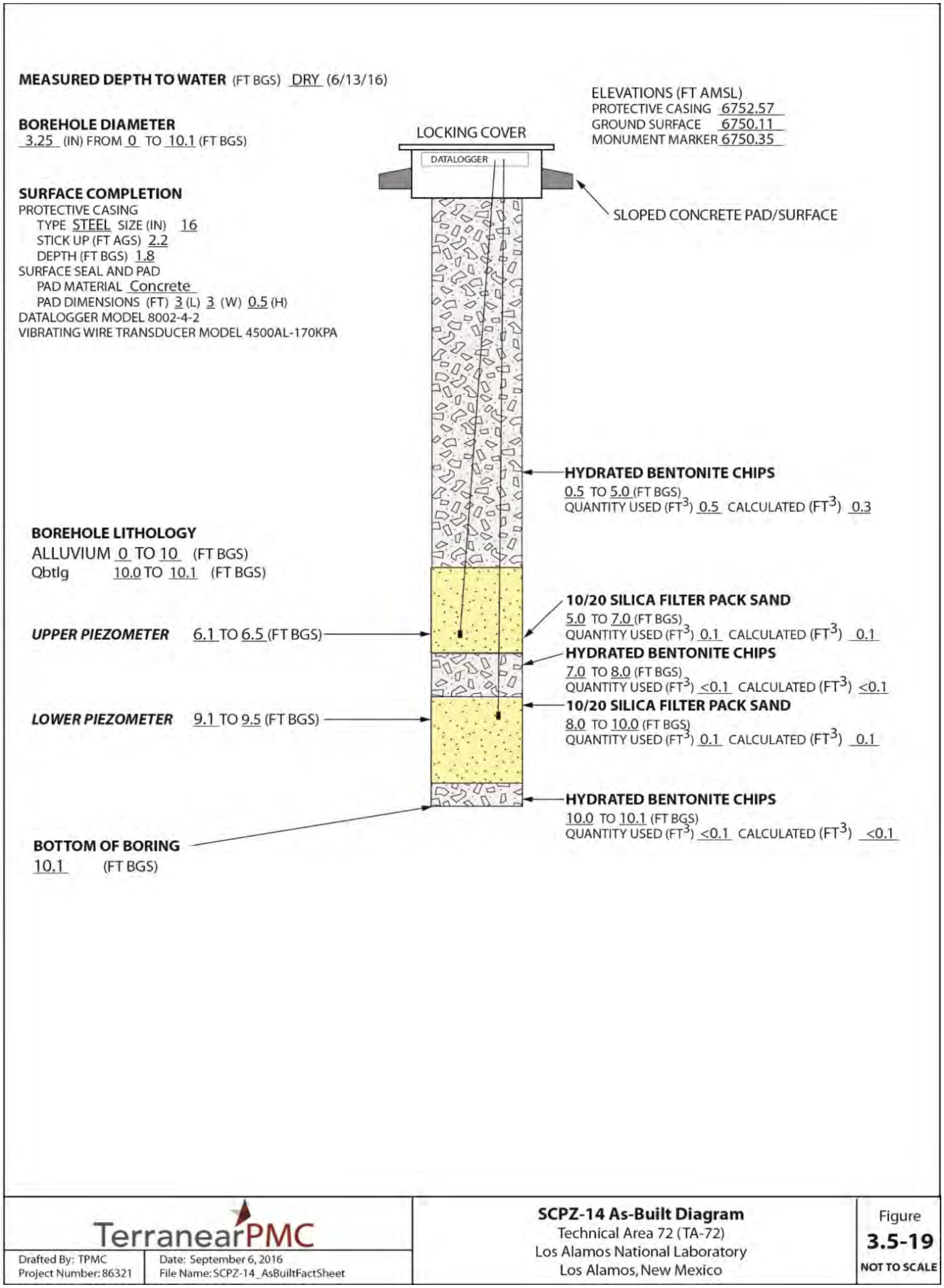

Figure 3.5-19 As-built diagram of SCPZ-14

Table 3.5-1
SCPZ-15 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	3-4-8	100	Tan to light brown silt and fine sand, unconsolidated, poorly sorted	Qal	Dry
9–10.5	4-4-4	100	Same as above	Qal	Dry
14–15.5	8-8-11	100	Light to medium brown, silt and fine sand, unconsolidated, poorly sorted	Qal	Dry
19–20.5	11-21-24	100	Same as above	Qal	Dry
24–25.5	10-10-25	100	Same as above	Qal	Dry
29–30.5	10-12-34	100	Same as above	Qal	Dry
34–35.5	15-26-28	100	Same as above	Qal	Dry
39–40.5	11-12-22	100	Same as above	Qal	Bottom few inches moist
44–45.5	8-12-26	100	Same as above	Qal	Wet
49–50.5	50	100 (slough)	Same as above	Qal	Wet
54–69.0	Drive samples not attempted because of slough in augers	n/a*	n/a	No indication of bedrock contact during drilling	n/a

*n/a = Not applicable.

Table 3.5-2
SCPZ-16 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4-8-9	75	Light brown fine sand/silt	Qal	Dry
9–10.5	6-7-9	25	Same as above	Qal	Dry
14–15.5	5-5-9	100	Light to dark brown, fine sand/silt, minor clay, trace gravel	Qal	Dry to moist near bottom of sampler
19–20.5	7-8-10	25	Light brown, fine sand/silt	Qal	Dry
24–25.5	7-9-16	25	Same as above	Qal	Dry
28–29.5	10-11-19	100	Poorly to moderately welded, light pinkish-white, pumice-rich	Qbt 1g contact at 28.5 ft bgs	Dry

Table 3.5-3
SCPZ-17 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	NR[a]	100	Pinkish-gray to light brown, fine sand, poorly sorted, with coarse gravel (weathered tuff)	Qal	Dry
9–10.5	NR	100	Same as above; also abundant quartz and sanidine	Qal	Dry
14–15.5	NR	100	Same as above; also weathered tuff and dacite gravel	Qal	Dry
19–20.5	NR	25	Same as above; also less gravel	Qal	Dry
24–25.5	NR	100	Same as above; also reddish-brown, minor clay	Qal	Moist
29–30.5	50/6	30	light brown to pink, pumice-rich	Qbt 1g contact at 29.5 ft bgs	Dry
30.5–35.5[b]	Drive samples not collected	n/a[c]	Same as above	Qbt 1g; no indication of lithology change during drilling	Dry

[a] NR = Not recorded.

[b] Borehole advanced to 35.5 ft bgs to ensure bedrock was encountered.

[c] n/a = Not applicable.

Table 3.5-4
SCPZ-18 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	5, 5, 5	50	Tan to light brown, fine sand with silt, poorly sorted, unconsolidated, minor gravel	Qal	Dry
9–10.5	5, 5, 8	100	Tan, medium to coarse silty sand, quartz and sanidine, moderately sorted	Qal	Dry
14–15.5	10, 16, 22	100	Same as above; also minor gravel	Qal	Dry
19–20.5	9, 10, 16	100	Same as above	Qal	Dry
24–25.5	14, 18, 19	100	Light brown, fine sand and silt, moderately sorted, consolidated	Qal	Moist in bottom 1 in. of sampler
29–30.5	5, 6, 12	100	Reddish-brown to pink, well stratified above contact, medium to dark brown poorly sorted sand and silt, with fibrous pumice in layers of tuff	Qct contact at 29.3 ft bgs	Moist above lithologic contact

Table 3.5-5
SCPZ-19 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 4, 4	25	Tan to light brown, fine sand with silt, minor gravel, subangular to rounded	Qal	Dry
9–10.5	7, 8, 11	75	Same as above	Qal	Dry
14–15.5	7, 10, 5	100	Same as above; also less gravel, medium-coarse sand towards bottom of sample, quartz and sanidine	Qal	Dry
19–20.5	9, 12, 25	100	Light brown to tan, medium-coarse sand	Qal	Dry
24–25.5	11, 13, 15	100	Same as above	Qal	Dry
29–30.5	7, 8, 16	100	Reddish-brown to brown, silt and tuffaceous materials, layers of fine sanidine crystals, well stratified	Qct contact at 29.2 ft bgs	Dry
34–35.5	15, 16, 24	100	Same as above	Qct	Dry to moist

Table 3.5-6
SCPZ-20 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	10, 12, 19	25	Light brown, poorly sorted fine sand and silt, with dacite gravel and weathered tuff	Qal	Dry
9–10.5	5, 6, 9	50	Light brown, fine sand, less gravel, abundant quartz and sanidine, weather tuff fragments	Qal	Dry
14–15.5	5, 8, 7	50	Same as above	Qal	Dry
19–20.5	9, 9, 9	100	Medium to dark brown sand and silt, with quartz and sanidine, glassy-fibrous pumice, clay towards bottom of sampler	Qct contact at 20 ft bgs	Dry to moist
24–25.5	5, 6, 10	100	Medium brown, fine sand, well sorted, abundant quartz and sanidine	Qct	Moist
29–30.5	12, 15, 16	100	Medium to dark brown, fine sand, abundant quartz	Qct	Moist
34–34.5	10, 15, 16	100	Reddish-dark brown, fine sand and silt, well sorted, with gravel	Qct	Moist
39–40.5	18, 22, 37	100	Pale red to pinkish-gray, crystal-bearing, lithic-rich, vitric pumice	Qct/Qbo at 40 ft bgs	Moist

Table 3.5-7
SCPZ-21 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 5, 7	50	Tan, fine to medium sand, poorly sorted, with silt, unconsolidated	Qal	Dry
9–10.5	3, 7, 7	75	Same as above	Qal	Dry
14–15.5	6, 7, 10	100	Light-medium brown, fine sand and silt, moderately sorted, unconsolidated	Qal	Dry
19–20.5	5, 10, 13	100	Light brown, medium sand and silt, poorly sorted, unconsolidated	Qal	Dry
24–25.5	3, 5, 10	100	Light brown, well stratified as above, layered pumice-rich sediment, abundant quartz and sanidine, crystal rich tuffaceous layers	Qct contact at 24.3 ft bgs	Moist above contact, dry below

Table 3.5-8
SCPZ-22 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 5, 6	25	Tan, fine sand, poorly sorted, with silt, unconsolidated	Qal	Dry
9–10.5	5, 6, 15	50	Same as above	Qal	Dry
14–15.5	12, 50/6	100	Same as above; also minor gravel	Qal	Dry
19–20.5	15, 16, 17	100	Same as above	Qal	Dry
24–25.5	14, 17, 18	75	Tan, medium sand, unconsolidated	Qal	Dry
29–30.5	6, 10, 20	100	Same as above	Qal	Bottom 1 in. of sampler moist
34–35.5	9, 10, 12	100	Tan, stratified fine-coarse sand, crystal rich, down to reddish-brown, tuff layers	Qal	Dry
39–40.5	9, 15, 30	100	Light brown, medium sand, silt, minor gravel, poorly sorted	Qal	Moist
44–45.5	10, 19, 20	100	Same as above; also increasing gravel size	Qal	Wet
49–50.5	14, 19, 20	100	Same as above and consolidated	Qal	Wet
54–55.5	5, 6, 10	100	Same as above	Qal	Wet
55.5–56.0	Drive samples not collected	n/a*	Same as above	Qal	Wet

*n/a = Not applicable.

Table 3.5-9
SCPZ-23a Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 5, 5	100	Light brown, fine sand and silt, minor quartz and sanidine	Qal	Dry
9–10.5	7, 8, 9	50	Light to medium brown, fine sand and silt, increasing quartz and sanidine, minor gravel	Qal	Dry
14–15.5	5, 6, 7	100	Same as above; also transition to coarse sand at 15 ft, abundant quartz and sanidine	Qal	Dry
19–20.5	6, 10, 20	100	Light brown, pink, weathered tuff, with less quartz and sanidine, transitioning to coarse sand, well sorted	Qal	Dry
24–25.5	10, 12, 15	100	Dark brown, fine sand, silt and minor clay, weathered tuff, small quartz and sanidine crystals	Qal	Dry
29–30.5	4, 5, 8	100	Dark brown, silty clay, minor lithics and gravels	Qal	Moist
34–35.5	11, 17, 18	100	Same as above; also dacite and pumice gravels/clasts	Qal	Very moist
39–40.5	6, 10, 11	100	Same as above	Qal	Moist
44–45.5	18, 21, 22	100	Same as above	Qal	Wet
49–50.5	7, 12, 27	100	Same as above	Qal	Wet
54–55.5	24, 50/6	100	Same as above; also to glassy pumice, homogenous	Qbt 1g contact at 55 ft bgs.	Wet
55.5–58.0[a]	Drive samples not collected	n/a[b]	Same as above	Qbt 1g	Wet

[a] Advanced to 58.0 ft bgs to remove slough and facilitate piezometer construction.

[b] n/a = Not applicable.

Table 3.5-10
SCPZ-24 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	5, 6, 5	50	Tan-light brown, fine sand and silt, poorly sorted, unconsolidated	Qal	Dry
9–10.5	5, 5, 7	75	Same as above; also minor gravel	Qal	Dry
14–15.5	23, 11, 8	100	Same as above; also transition to whitish-light pink ash flow tuff, poorly welded, crystal-bearing, with xenoliths	Qbt 1g contact at 14.5 ft bgs	Dry
19–20.5	15, 19, 29	100	Same as above; also moderately welded	Qbt 1g	Dry

Table 3.5-11
SCPZ-25 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	5, 5, 6	50	Tan, fine sand and silt, poorly sorted, unconsolidated	Qal	Dry
9–10.5	10, 11, 12	75	Same as above	Qal	Bottom 3-in of sampler moist
14–15.5	4, 7, 8	100	Light brown, medium sand and silt, moderately sorted, unconsolidated	Qal	Moist
19–20.5	10, 7, 12	100	Same as above	Qal	Moist
24–25.5	5, 5, 11	100	Same as above	Qal	Moist
29–30.5	6, 8, 10	100	Same as above; also minor gravel	Qal	Moist
34–35.5	3, 6, 5	100	Reddish-brown, fine sand and silt, well sorted, moderately consolidated	Qal	Bottom 4-in. of sampler wet
39–40.5	10, 10, 13	100	Light brown, medium sand and silt, moderately sorted, unconsolidated	Qal	Wet
44–45.5	5, 10, 15	100	Same as above	Qal	Wet
49–50.5	9, 13, 14	25	Same as above	Qal	Saturated
54–55.5	20, 50/6	100	Same as above to light orange tuff with white to light gray pumice lapilli	Qbt 1g contact at 55 ft bgs	Wet above contact
55.5–56.0[a]	Drive samples not collected	n/a[b]	Same as above	Qbt 1g	Wet

[a] Advanced to 56.0 ft bgs to remove slough and facilitate piezometer construction.

[b] n/a = Not applicable.

Table 3.5-12
SCPZ-26 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 5, 5	50	Tan, fine sand and silt, poorly sorted, unconsolidated	Qal	Dry
9–10.5	5, 6, 7	75	Tan, fine sand and silt, minor gravel, moderately sorted, unconsolidated	Qal	Dry
14–15.5	6, 8, 9	100	Same as above	Qal	Dry
19–20.5	7, 8, 9	100	Same as above	Qal	Dry
24–25.5	4, 7, 10	100	Same as above; also well stratified, to layered silty, crystal-rich tuff	Qct contact at 24.3 ft bgs	Dry
29–30.5	9, 10, 20	100	Same as above	Qct	Dry

Table 3.5-13
SCPZ-27-PA Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 5, 5	50	Tan to light brown, fine sand and silt, poorly sorted, unconsolidated	Qal	Dry
9–10.5	10, 50/6	100	Same as above to light gray to pink ash flow tuff, crystal rich, pumice lapilli	Qbt 1g contact at 10.4 ft bgs	Dry
14–15.5	50/6	25	Same as above	Qbt 1g	Dry

Table 3.5-14
SCPZ-27 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	4, 5, 7	75	Tan to light brown, fine to medium sand and silt, moderately sorted, unconsolidated	Qal	Dry
9–10.5	5, 7, 9	100	Same as above	Qal	Dry
14–15.5	4, 6, 21	100	Same as above	Qal	Dry
19–20.5	4, 8, 12	100	Same as above	Qal	Dry
24–25.5	8, 16, 23	100	Same as above	Qal	Dry
29–30.5	19, 21, 29	100	Medium to dark brown, fine sand and silt, moderately sorted, unconsolidated	Qal	Moist at 30 ft bgs
34–35.5	9, 19, 20	100	Same as above	Qal	Moist
39–40.5	12, 15, 16	100	Same as above	Qal	Wet at 40 ft bgs
44–45.5	8, 8, 11	100	Same as above	Qal	Wet
49–50.5	9, 10, 12	100	Same as above	Qal	Wet
54–55.5	12, 15, 16	100	Same as above	Qal	Wet
55.5–56.0[a]	Drive samples not collected	n/a[b]	Same as above	Qal	Wet

[a] Advanced to 56.0 ft bgs to facilitate piezometer construction.

[b] n/a = Not applicable.

Table 3.5-15
SCPZ-28 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	6, 8, 10	75	Light brown, fine sand and silt, poorly sorted, unconsolidated	Qal	Dry
9–10.5	10, 15, 16	100	Same as above	Qal	Dry
14–15.5	10, 13, 14	100	Same as above, minor tuffaceous gravels	Qal	Dry
19–20.5	13, 15, 16	100	Same as above	Qal	Dry
24–25.5	5, 5, 8	100	Light brown, medium-coarse sand, moderately sorted, unconsolidated	Qal	Dry
29–30.5	20, 29, 35	100	Light gray, poorly welded tuff, crystal and sanidine rich	Qal	Wet at 29.9 ft bgs
34–35.5	12, 17, 18	100	Light brown, medium to coarse sand, minor gravel	Qal	Dry
39–40.5	10, 15, 17	100	Brown to pink tuff, fine sand and silt	Qal	Moist
44–45.5	9, 10, 22	100	Same as above to white, powdery, grayish-white, crystal-rich pumice lapilli (fibrous)	Qbt 1g contact at 44.8 ft bgs	Moist above contact
45.5-46.0[a]	Drive samples not collected	n/a[b]	Same as above	Qbt 1g	Moist

[a] Advanced to 46.0 ft bgs to facilitate piezometer construction.

[b] n/a = Not applicable.

Table 3.5-16
SCPZ-29 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description	Lithologic Unit	Relative Moisture
4–5.5	6, 7, 9	50	Tan fine sand and silt, poorly sorted, unconsolidated	Qal	Dry
9–10.5	4, 5, 6	50	Same as above	Qal	Dry
14–15.5	4, 5, 8	100	Light brown, fine to medium sand, moderately sorted, unconsolidated	Qal	Dry
19–20.5	4, 5, 9	100	Same as above	Qal	Dry
24–25.5	5, 5, 5	75	Same as above	Qal	Dry
29–30.5	9, 10, 12	100	Same as above to 30.1 ft bgs; medium to dark brown, fine sand and silt, moderately sorted, unconsolidated	Qal	Moist at 30.1 ft bgs
34–35.5	20, 50/6	50	Same as above	Qal	Moist
39–40.5	10, 15, 19	75	Same as above	Qal	Very moist at 38.8 ft bgs
44–44.5	7, 7, 11	50	Same as above	Qal	Wet
49–50.5	9, 12, 13	50	Same as above to 49.1 ft bgs; light orange tuff, with white-light gray pumice lapilli	Qbt 1g contact at 49.1 ft bgs	Dry
50.5–51.0[a]	Drive samples not collected	n/a[b]	Same as above	Qbt 1g	Dry

[a] Advanced to 51.0 ft bgs to facilitate piezometer construction.

[b] n/a = Not applicable.

Table 3.5-17
SCPZ-13 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description[a]	Lithologic Unit	Relative Moisture
0–8.1	n/a	n/a	Light brown, fine and silt, moderately sorted, unconsolidated	Qal	Moist at 6.1 ft bgs
8.1–8.2	n/a[b]	n/a	Tuff	Qbt 1g	Moist

[a] Logged from hand-auger cuttings.

[b] n/a = Not applicable.

Table 3.5-18
SCPZ-14 Borehole Log

Drive Sample Depth (ft bgs)	Blow Counts	% Recovery	Lithologic Description[a]	Lithologic Unit	Relative Moisture
0–10	n/a	n/a	Light brown, fine and silt, moderately sorted, unconsolidated	Qal	Dry
10–10.1	n/a[b]	n/a	Tuff	Qbt 1g	Dry

[a] Logged from hand-auger cuttings.

[b] n/a = Not applicable.

Table 3.6-1
DTW in Sandia Canyon Boreholes before Piezometer Construction

Piezometer Location	DTW (ft bgs)	Depth to Bedrock (Qbt 1g/Qct) (ft bgs)
SCPZ-15	36.8	Not encountered
SCPZ-22	47.6	Not encountered
SCPZ-25	42.4	55
SCPZ-27	47.3	Not encountered
SCPZ-29	49.5	49.1

Table 3.10-1
Sandia Canyon Piezometers Data Logger and VWT Serial Numbers and VWT Zero Readings and Temperature Readings

Identification	Data Logger Serial Numbers	VWT Serial Numbers	VWT Zero Readings	VWT Temperature Readings (°C)
SCPZ-13 Upper VWT	1614894	1612744	10378.190	27.6
SCPZ-13 Lower VWT	—*	1612745	10087.525	27.2
SCPZ-14 Upper VWT	1614895	1612746	10218.339	27.7
SCPZ-14 Lower VWT	—	1612747	10497.163	27.6
SCPZ-15 Upper VWT	1614896	1610327	10231.005	16.0
SCPZ-15 Middle VWT	—	1610328	10340.222	16.0
SCPZ-15 Lower VWT	—	1610329	10155.685	15.5
SCPZ-16 Upper VWT	1614897	1610330	10344.997	14.7
SCPZ-16 Middle VWT	—	1610331	10353.710	15.5
SCPZ-16 Lower VWT	—	1610332	10436.498	15.4
SCPZ-17 Upper VWT	1614898	1610333	10248.741	24.2
SCPZ-17 Middle VWT	—	1610335	10475.862	23.8
SCPZ-17 Lower VWT	—	1610336	10086.328	24.2
SCPZ-18 Upper VWT	1614899	1610337	10400.012	20.1
SCPZ-18 Middle VWT	—	1610338	10363.469	19.8
SCPZ-18 Lower VWT	—	1610339	10228.333	20.3
SCPZ-19 Upper VWT	1614900	1612710	10459.746	19.5
SCPZ-19 Middle VWT	—	1612711	10623.842	19.6
SCPZ-19 Lower VWT	—	1612712	10384.371	19.4
SCPZ-20 Upper VWT	1614901	1612713	10174.870	19.6
SCPZ-20 Middle VWT	—	1612714	10524.434	19.3
SCPZ-20 Lower VWT	—	1612715	10350.003	19.6
SCPZ-21 Upper VWT	1614902	1612716	10313.104	30.1
SCPZ-21 Middle VWT	—	1612717	10253.509	29.6
SCPZ-21 Lower VWT	—	1612718	10472.297	29.3
SCPZ-22 Upper VWT	1614903	1612719	10475.536	29.1
SCPZ-22 Middle VWT	—	1612720	10364.675	29.1
SCPZ-22 Lower VWT	—	1612721	10236.816	29.1
SCPZ-23b Upper VWT	1614904	1612722	10160.021	25.8
SCPZ-23b Middle VWT	—	1612723	10480.882	26.1

Table 3.10-1 (continued)

Identification	Data Logger Serial Numbers	VWT Serial Numbers	VWT Zero Readings	VWT Temperature Readings (°C)
SCPZ-23a Lower VWT	—	1612724	10504.913	26.1
SCPZ-24 Upper VWT	1614905	1612725	10555.665	21.8
SCPZ-24 Middle VWT	—	1612726	10271.530	21.7
SCPZ-24 Lower VWT	—	1612728	10391.126	21.6
SCPZ-25 Upper VWT	1614906	1612729	10343.736	26.4
SCPZ-25 Middle VWT	—	1612730	10179.236	26.5
SCPZ-25 Lower VWT	—	1612731	9158.264	26.6
SCPZ-26 Upper VWT	1614907	1612732	10366.034	23.3
SCPZ-26 Middle VWT	—	1612733	10462.978	23.3
SCPZ-26 Lower VWT	—	1612734	10198.188	23.2
SCPZ-27 Upper VWT	1614908	1612735	10191.866	19.3
SCPZ-27 Middle VWT	—	1612736	10321.530	19.3
SCPZ-27 Lower VWT	—	1612737	10392.526	19.3
SCPZ-28 Upper VWT	1614909	1612738	10213.386	18.7
SCPZ-28 Middle VWT	—	1612739	10293.143	18.7
SCPZ-28 Lower VWT	—	1612740	10369.769	18.9
SCPZ-29 Upper VWT	1614910	1612741	10428.328	18.8
SCPZ-29 Middle VWT	—	1612742	10596.849	19.2
SCPZ-29 Lower VWT	—	1612743	10500.931	19.1

* — = Only one data logger per piezometer location.

Table 3.11-1
Sandia Canyon Piezometers Survey Coordinates

Identification	Northing	Easting	Elevation
SCPZ-13 brass cap embedded in pad	1770428.6948	1634955.9897	6764.22
SCPZ-13 ground surface near pad	1770430.1237	1634955.5643	6764.04
SCPZ-13 protective casing	1770428.2661	1634956.4967	6766.22
SCPZ-14 brass cap embedded in pad	1770316.3836	1635727.5751	6750.35
SCPZ-14 ground surface near pad	1770317.8479	1635727.4759	6750.11
SCPZ-14 protective casing	1770314.9524	1635726.9231	6752.57
SCPZ-15 brass cap embedded in pad	1769690.4957	1637386.6216	6720.20
SCPZ-15 ground surface near pad	1769691.6385	1637385.4305	6719.98
SCPZ-15 protective casing	1769689.8164	1637386.9581	6722.62
SCPZ-16 brass cap embedded in pad	1769727.1688	1637397.2607	6719.82
SCPZ-16 ground surface near pad	1769727.8650	1637398.1232	6719.66
SCPZ-16 protective casing	1769726.7590	1637397.4791	6721.94
SCPZ-17 brass cap embedded in pad	1769850.5762	1637427.6662	6720.10
SCPZ-17 ground surface near pad	1769851.1542	1637426.3385	6719.96
SCPZ-17 protective casing	1769849.6866	1637427.5164	6722.04
SCPZ-18 brass cap embedded in pad	1769624.9441	1637581.2525	6715.27
SCPZ-18 ground surface near pad	1769625.3319	1637580.3275	6715.12
SCPZ-18 protective casing	1769624.0080	1637581.4669	6717.57
SCPZ-19 brass cap embedded in pad	1769659.2075	1637589.6891	6714.50
SCPZ-19 ground surface near pad	1769660.4075	1637588.8040	6714.46
SCPZ-19 protective casing	1769658.4099	1637589.6570	6716.77
SCPZ-20 brass cap embedded in pad	1769771.8010	1637610.9222	6715.37
SCPZ-20 ground surface near pad	1769773.4422	1637610.4934	6715.24
SCPZ-20 protective casing	1769771.0009	1637611.1700	6717.65
SCPZ-21 brass cap embedded in pad	1769571.2304	1637826.3519	6711.35
SCPZ-21 ground surface near pad	1769572.2888	1637825.8690	6711.19
SCPZ-21 protective casing	1769570.4095	1637826.7888	6713.48
SCPZ-22 brass cap embedded in pad	1769617.3342	1637838.7288	6711.28
SCPZ-22 ground surface near pad	1769618.4864	1637839.0567	6711.09
SCPZ-22 protective casing	1769616.5850	1637838.6268	6713.41
SCPZ-23a brass cap embedded in pad	1769729.6960	1637845.9166	6710.48

Table 3.11-1 (continued)

Identification	Northing	Easting	Elevation
SCPZ-23a ground surface near pad	1769730.6690	1637844.8818	6710.67
SCPZ-23a protective casing	1769729.1073	1637846.3838	6712.49
SCPZ-23b brass cap embedded in pad	1769726.4493	1637849.8132	6709.79
SCPZ-23b ground surface near pad	1769725.2175	1637850.0875	6709.39
SCPZ-24 brass cap embedded in pad	1769532.3212	1638063.7958	6712.15
SCPZ-24 ground surface near pad	1769533.2057	1638062.7896	6712.07
SCPZ-24 protective casing	1769531.7524	1638063.8726	6714.33
SCPZ-25 brass cap embedded in pad	1769602.7992	1638080.9766	6705.67
SCPZ-25 ground surface near pad	1769604.2733	1638079.8373	6705.46
SCPZ-25 protective casing	1769602.1753	1638081.0447	6707.71
SCPZ-26 brass cap embedded in pad	1769665.3774	1638103.7642	6705.31
SCPZ-26 ground surface near pad	1769667.0857	1638102.1285	6705.17
SCPZ-26 protective casing	1769664.9882	1638103.5415	6707.49
SCPZ-27 brass cap embedded in pad	1769634.4635	1638370.7228	6702.23
SCPZ-27 ground surface near pad	1769634.6488	1638369.6326	6702.10
SCPZ-27 protective casing	1769633.6896	1638370.8445	6704.10
SCPZ-27 plugging and abandonment brass cap embedded in pad	1769489.1337	1638327.5256	6707.00
SCPZ-27 27 plugging and abandonment ground surface near pad	1769487.9666	1638327.7641	6706.71
SCPZ-28 brass cap embedded in pad	1769538.1862	1638333.7400	6702.48
SCPZ-28 ground surface near pad	1769539.2003	1638333.4881	6702.32
SCPZ-28 protective casing	1769538.1319	1638334.2588	6704.69
SCPZ-29 brass cap embedded in pad	1769622.1270	1638342.5159	6702.02
SCPZ-29 ground surface near pad	1769622.8494	1638341.3330	6701.82
SCPZ-29 protective casing	1769621.2938	1638342.8802	6703.95

Note: All coordinates are expressed as New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in ft amsl using the National Geodetic Vertical Datum of 1929.

Appendix A

Instruction Manual Model LC-2x4 4 Channel VW Datalogger

GEOKON The World Leader in Vibrating Wire Technology

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Instruction Manual

Model LC-2x4

4 Channel VW Datalogger

CE

(Doc Rev R, 04/14/2016)

Warranty Statement

Geokon, Inc. warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by Geokon, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of Geokon's control. Components which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

Geokon manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Geokon, Inc. is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by Geokon, Inc. or any breach of any warranty by Geokon, Inc. shall not exceed the purchase price paid by the purchaser to Geokon, Inc. for the unit or units, or equipment directly affected by such breach. Under no circumstances will Geokon reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, Geokon, Inc. neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

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LIST of FIGURES, TABLES and EQUATIONS

1. INTRODUCTION

The Model LC-2x4 4 Channel Datalogger is a low cost, battery powered and easy to use measurement instrument designed to read up to 4 vibrating wire sensors equipped with thermistors.

The 320K standard memory provides storage for 10666 data arrays. Each array consists of an optional datalogger ID string (16 characters maximum), a timestamp consisting of the year, date (julian day or month/day format), time (hhmm or hours/minutes format) and seconds when the reading was taken. Also included in the data is the internal 3V (or external 12V) battery voltage, the datalogger temperature, the vibrating wire readings, the transducer temperature and the Array #.

Internal math is calculated using 32 bit floating point notation (IEEE). Math operations on the instrument readings, such as application of zero readings, gage factors (or calibration factors) and offsets when using a linear conversion technique or polynomial coefficients when using the polynomial conversion, provide outputs directly in engineering units. The dataloggers internal configuration is defined through communication with a computer using the supplied RS-232 or USB (or optional RS-485) interface cable. The datalogger is configured and monitored using LogView, a Geokon proprietary Graphic User Interface (GUI) software application (See section 2). The datalogger can also be configured and monitored via text-based commands with any standard terminal emulator software, such as Microsoft Windows HyperTerminal™ (see section 3 - LC-2x4 Command Set).

The following three communications options are available for the LC-2x4:

LC-2x4 Model #	Communication
8002-4-1	RS-232
8002-4-2	USB
8002-4-3	RS-485

8002-4-1: Communication with the LC-2x4 is implemented via the host computer's RS-232 COM port. See section 2.3.6 for further information.

8002-4-2: Communication with the LC-2x4 is implemented via the host computer's USB 2.0 port. When connected to a computer via the USB port, the LC-2x4 appears to the computer as a "virtual" COM port. The LC-2x4 datalogger also receives all of its operating power from the computer, thus extending the internal 3V (or external 12V) battery life. When disconnected from the USB port, the datalogger automatically switches to the internal 3V (or external 12V) battery pack. See section 2.3.7 for further information.

8002-4-3: Communication with the LC-2x4 is implemented via RS-485. This allows for long communication cables (up to 4000') between the host computer and the LC-2x4. The ability to network two or more LC-2x4 dataloggers together is also available with this communication option. See section 2.3.8 and Appendix F Networking for further information.

All data, both readings and configuration, are stored in non-volatile EEPROM with a typical storage life of 10 years (minimum). The internal temperature compensated real-time clock, used to provide timekeeping and triggering of readings, is accurate to ± 2 minutes/year.

The comma delineated ASCII output format allows for easy importing into popular spreadsheet programs such as Lotus 1-2-3™ or Microsoft Excel™. See Appendix D for sample data files.

Figure 1 - LC-2x4 4-Channel VW Datalogger

2. GETTING STARTED

The following equipment will arrive with the Model LC-2x4 datalogger;

1. Set of (2) alkaline 'D' cell batteries.

2. Set of (4) desiccant packs packaged with the batteries.

3. Accessories:

   8002-4-1: P/N S-8001-6 (DB-9F to 10-pin Bendix Male) RS-232 Communication Cable

   8002-4-2: P/N COM-109 (USB-A to 10-pin Bendix Male) USB Communication Cable

   8002-4-3: Communications Cable dependant on S-8001-5 (RS-232) or S-8002-5 (USB) RS-485 computer interface

4. Model LC-2x4 4 Channel Datalogger Instruction Manual.

If any of these items are missing or damaged contact the factory for replacements. The following are optional accessories;

- RS-485 interface cable.
- S-8001-5 (RS-232) or S-8002-5 (USB) RS-485 computer interface.
- Vibrating Wire Sensor with built-in thermistor (4 maximum).

This section will outline the basic steps needed to install the communications software, establish communication with the Model LC-2x4 and configure the datalogger in the context of water level monitoring using a Geokon model 4500S Vibrating Wire Pressure Transducer.

Open up the LC-2x4 by unscrewing the 4 captive screws on the top of the enclosure. Make sure that no dirt, water or other contaminants are allowed to enter the LC-2x4 enclosure. Insert the 2 "D" cells straight down into the battery holder, with the positive end of each fitting into the red washer as shown in Figure 2. Note that there is a ziplock bag containing 4 desiccant packs shipped along with the batteries. As soon as the batteries are installed, take the desiccant packs out of the ziplock back and place them inside the enclosure. Immediately close and reseal the lid. This will help to prevent condensation of moisture within the enclosure.

Figure 2 – Battery Installation

2.1. Transducer Installation

Open up the LC-2x4 by unscrewing the 4 captive screws on the top of the LC-2x4 enclosure. Route the vibrating wire transducer cable(s) into the LC-2x4 enclosure through the bulkhead fittings. Referring to Table 1 (or Appendix B.1.) Transducer Cable Connections, connect the cable wires to the datalogger's 5 pin internal terminal strips, located on the LC-2x4's Multiplexer circuit board. Wire each cable's 5 conductors into the terminal strip per Table 1.

Terminal Strip Position	Channel Number	Description	Cable Wire Color
VW1+	1	Vibrating Wire +	RED
VW1-	1	Vibrating Wire -	BLACK
TH1+	1	Thermistor +	GREEN
TH1-	1	Thermistor -	WHITE
SHLD1	1	Analog Ground (shield)	BARE WIRE
VW2+	2	Vibrating Wire +	RED
VW2-	2	Vibrating Wire -	BLACK
TH2+	2	Thermistor +	GREEN
TH2-	2	Thermistor -	WHITE
SHLD2	2	Analog Ground (shield)	BARE WIRE
VW3+	3	Vibrating Wire +	RED
VW3-	3	Vibrating Wire -	BLACK
TH3+	3	Thermistor +	GREEN
TH3-	3	Thermistor -	WHITE
SHLD3	3	Analog Ground (shield)	BARE WIRE
VW4+	4	Vibrating Wire +	RED
VW4-	4	Vibrating Wire -	BLACK
TH4+	4	Thermistor +	GREEN
TH4-	4	Thermistor -	WHITE
SHLD4	4	Analog Ground (shield)	BARE WIRE

Table 1 Transducer Cable Connections

2.2. Earth Ground Installation

The LC-2x4 provides lightning protection in the form of gas tube surge arrestors. In order for these components to divert the energy from a lightning strike safely to ground, a good solid electrical connection to earth ground needs to be made. A grounding rod should be driven (or other suitable attachment to earth utilized) to ground the system and provide a path to earth in the event of a lightning strike. A 6' to 8' copper stake with appropriate large gauge wire (12 AWG or larger) connected to the LC-2x4 enclosure is suggested. The stake should be driven as close to the datalogger as possible, and to a depth of at least 3 feet (1m). A copper grounding lug is supplied on the exterior of the LC-2x4 enclosure to provide connection to this wire from the grounding rod.

2.3. Software Installation And Setup

LogView is Graphical User Interface (GUI) software is used to communicate with the datalogger using a personal computer running a Microsoft Windows® operating system. Other general purpose communication programs (i.e. Windows HyperTerminal™) can also be used to communicate with the Model LC-2x4 via text-based commands. The LogView and USB drivers install program can be downloaded at www.geokon.com/software.

Perform the following steps to install LogView software for each computer that will connect to an LC-2x4. These instructions are for computers running Windows XP. The installation procedure is very similar for computers running Windows7, Windows 2000 and Windows 98. This installation procedure needs to be performed just once for each computer that will run LogView to communicate with a LC-2x4 datalogger.

NOTE: The USB drivers are only required for LC-2x4 models 8002-4-2 and the 8002-5 RS-485 Interface

Make sure that the (2) 1.5V D-cell alkaline batteries are installed in the datalogger (See section 4.2 BATTERIES for instructions) and that the LC-2x4 datalogger is not connected to the computer at this time.

2.3.1. LogView Installation:

1. Using Windows Explorer, navigate to the extracted downloaded files and double click on the file "start.bat" to start the install process.
2. Click "**Next >**" when the **Welcome** window appears.
3. When the **Choose Install Location** window appears, choose a folder for the LogView installation then click "**Next>**".
4. When the **Choose Start Menu Folder** window appears, choose an appropriate folder (default is Geokon) then click "**Install**".
5. Click "**Next >**" when the **Java Installation Complete** window appears.
6. Click "**Finish**" when the **Completing the LogView Setup Wizard** window appears.

2.3.2 Launching LogView:

Launching LogView can be accomplished two different ways. Double clicking on the desktop icon:

Or via the Windows Start button: "Programs → Geokon → LogView"

2.3.3. LogView Workspaces:

When opening LogView for the first time, the user will be prompted to create a workspace name (see Figure 3). The workspace name can be any combination of letters and numbers and, ideally, will be descriptive in nature. See the LogView User's Guide for more information on workspaces.

Figure 3 - Select Workspace Name

Once the workspace name has been selected, clicking on "**Ok**" causes LogView to prompt the user to choose or create a folder where all the workspace elements will be stored (see Figure 4). The folder location may be entered directly, i.e., `C:\Workspaces\East Coast` or the **Browse** button may be used to navigate to a folder location or to create a new folder (see Figure 4). This workspace location will be stored in the LogView configuration for subsequent application access. Once workspaces are created, future user access is always by name.

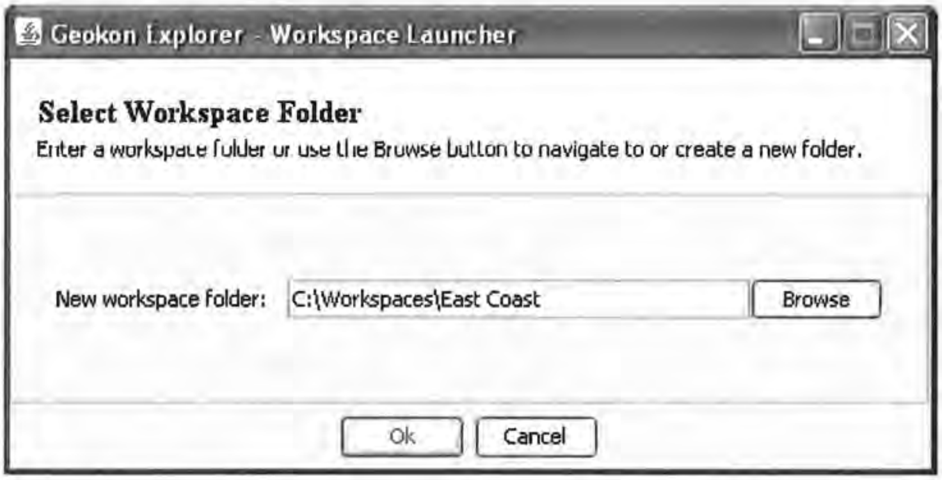

Figure 4 - Select Workspace Folder

If no other is specified, a default folder path is displayed based on the system default workspace path combined with the new workspace name. After the folder path has been specified, either the default or user selected (see Figure 4), clicking on "**Ok**" will display the main window of LogView (see Figure 5). On the left-hand side of the main window is the Project Explorer displaying the newly created workspace. The user can now add new project(s), datalogger(s) and sensor configurations to the workspace by right-clicking on the workspace and using the menu tools.

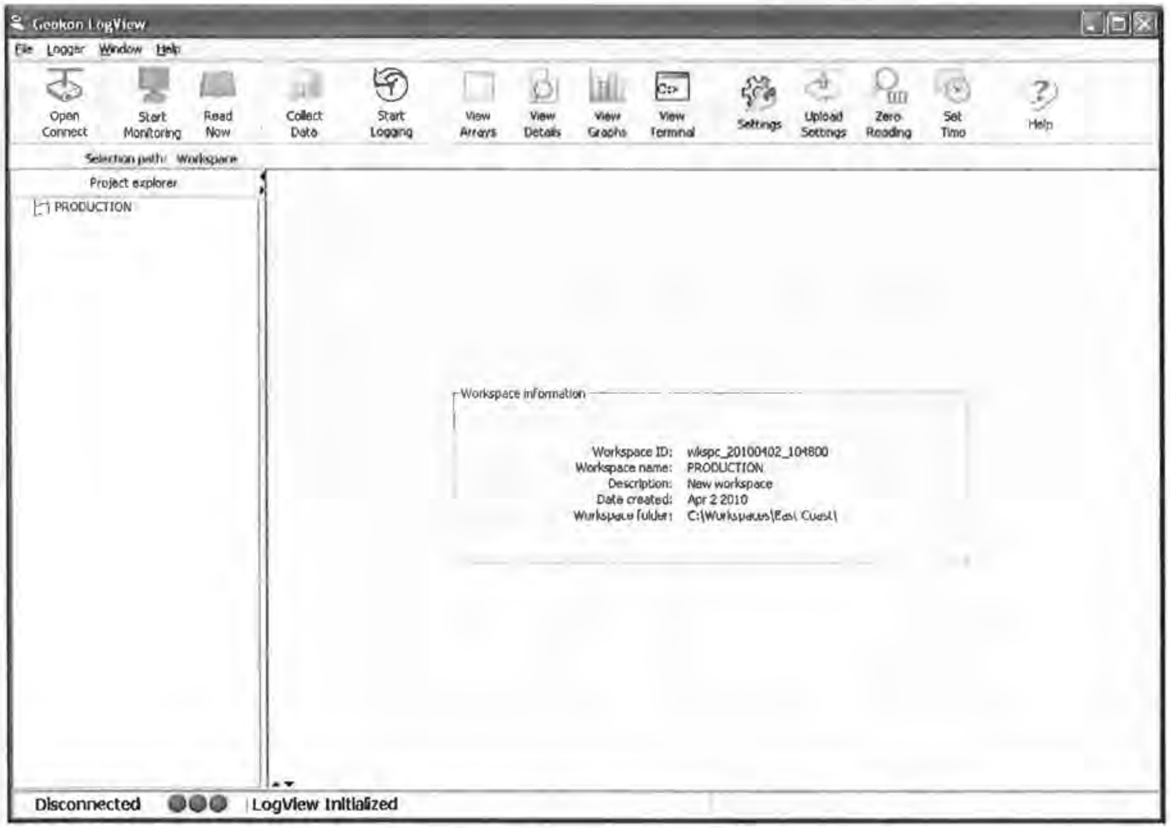

Figure 5 - LogView Main Window

2.3.4. Adding Projects to LogView Workspaces:

Right-clicking on the "**PRODUCTION**" workspace brings up a context sensitive menu that allows the user to add projects to this workspace (using the "**New→Project**" menu selection). Select a name that makes sense for the real-world project this program will be used for. In this example "TestLoggers" was chosen as the project name (see Figure 6 below).

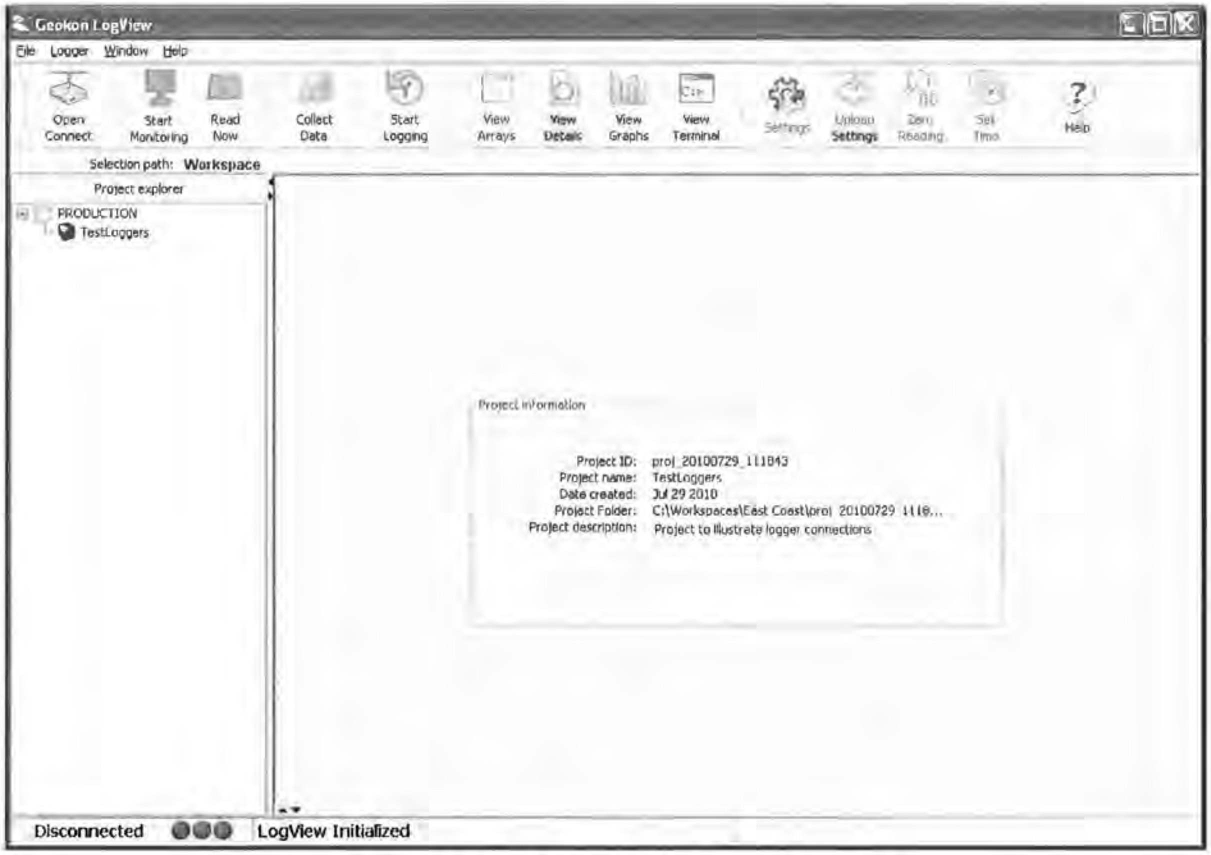

Figure 6 - LogView Main Window with new project

2.3.5. Adding Dataloggers to LogView Projects:

Right-clicking on the "**TestLoggers**" project brings up a context sensitive menu (see Figure 7) that allows users to add dataloggers to their projects. Selecting **New→Logger** from the context menu causes the "**Datalogger Settings**" dialog to be displayed. Like Workspaces and Projects, Dataloggers can be assigned a unique human-readable name. For this example, "MyLogger" was chosen for the Datalogger name. For a complete description of all datalogger settings please see the LogView Online Help section on Datalogger Settings. For connection purposes, the relevant tab in this dialog is "**Connection Options**" (see Figure 8).

After physically connecting to a PC, all LC-2x4 dataloggers require a COM port to be identified in the "**Connection Options**". Starting with firmware revision 3.1.X, LC-2x4 dataloggers can communicate at baud rates of 9600 and 115,200. Before this revision the datalogger baud rate was 9600 only so, for these dataloggers, the default setting should not be changed (See Figure 7).

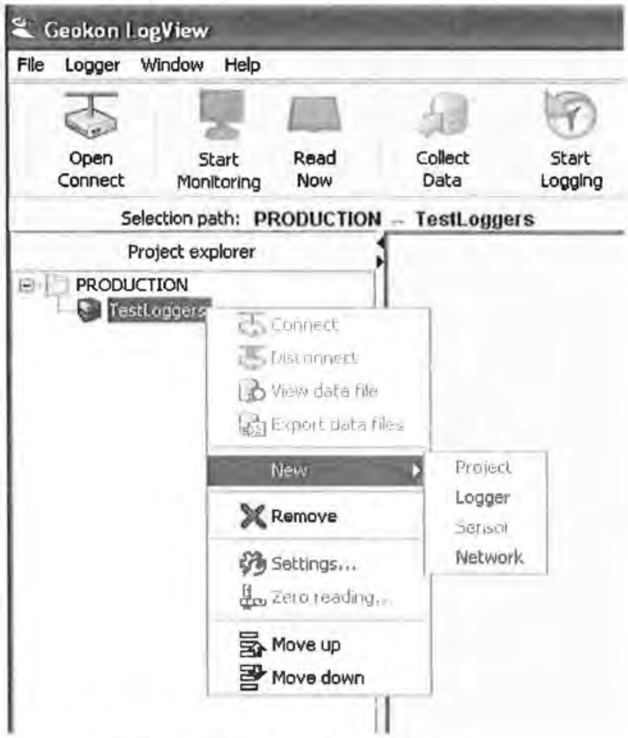

Figure 7 - LogView Context Menu

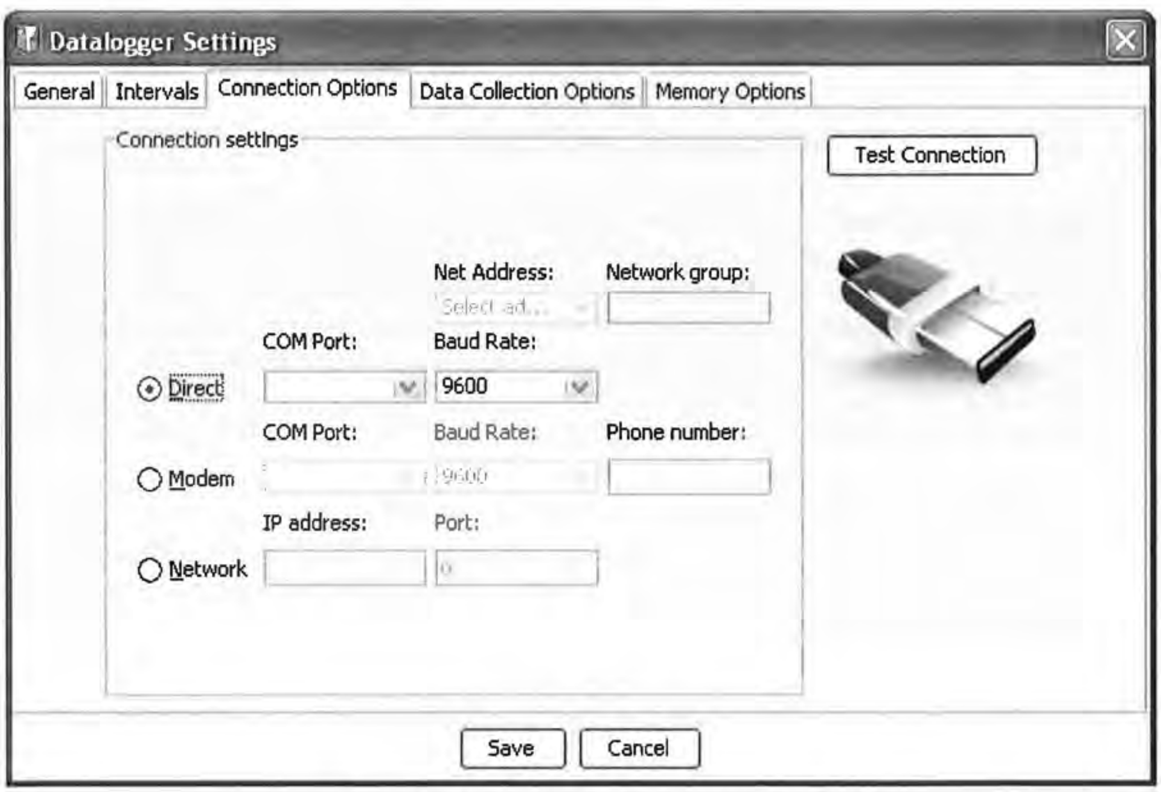

Figure 8 - Datalogger Settings, Connection Options

2.3.6. LC-2x4 Connection (8002-4-1, RS-232):

Connect the supplied LC-2x4 RS-232 Communications cable (S-8001-6) to the COM port of the LC-2x4 datalogger. The protective cap on the datalogger COM connector is removed by pushing in and turning. Plug the DB-9 end of the RS-232 Communications cable into the host computer's RS-232 port (either internal or external via a USB to Serial converter). Proceed to section 2.3.9, Connecting to a Datalogger with LogView.

2.3.7. LC-2x4 Connection (8002-4-2, USB) :

Connect the supplied LC-2x4 USB Communications cable (COM-109) to the USB port of the LC-2 datalogger. The protective cap on the datalogger USB connector is removed by pushing in and turning. Plug the USB-A end of the USB cable into an available USB-2.0 port on the host computer.

NOTE: On certain PCs with operating systems older than XP, Service Pack 3, the 8002-4-2 may require the installation of a driver to properly communicate with the PC. If the PC does not recognize the datalogger's internal USB to serial converter then the driver may need to be installed by executing the program, CDMv2_xxxx, from the LogView Install folder. Proceed to section 2.3.9, Connecting to a Datalogger with LogView.

2.3.8. LC-2x4 Connection 8002-4-3 (RS 485):

Make the COM port connection per section 2.3.6 (RS-232) or 2.3.7 (USB), and then refer to **Appendix F: Networking** to establish communications.

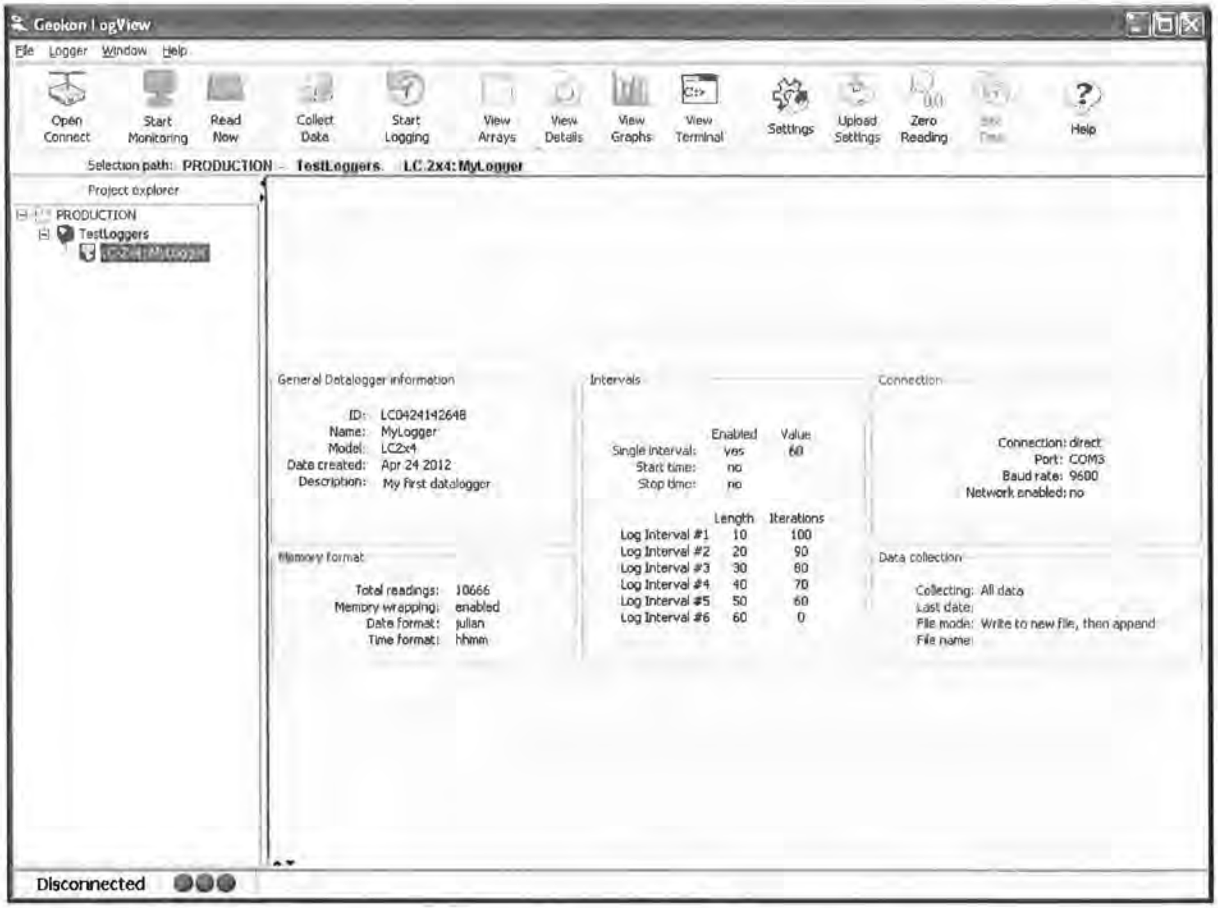

Figure 9 - Datalogger Highlighted, Not Connected

2.3.9. Connecting to a Datalogger with LogView:

1. With a Datalogger profile configured and selected in the Project Explorer (see Figure 9), click on the "**Open Connect**" button on the LogView Toolbar.
2. When connecting to a new Datalogger for the first time, the message below (see Figure 10) may be displayed after a few seconds. This is normal and is only an indication that the datalogger doesn't match the configuration created in the Project Explorer. Click on "Continue" to finish connecting to the datalogger.
3. Click on the "**Upload Settings**" button on the LogView Toolbar to synchronize the datalogger with the LogView configuration (see Figure 11).
4. LogView is now connected and configured correctly for the LC-2x4 datalogger. Sensors can now be added to the datalogger in a similar fashion as adding Dataloggers to Projects. Sensor settings are accessed via the context menu from the Project Explorer.
5. Always upload the new settings to the datalogger after changing its configuration in LogView.

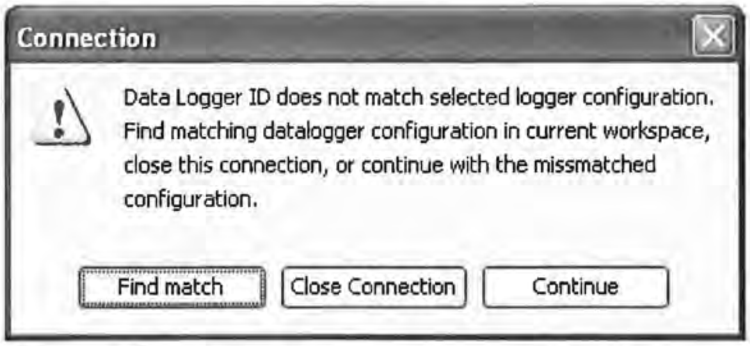

Figure 10 - Datalogger Connection Mismatch

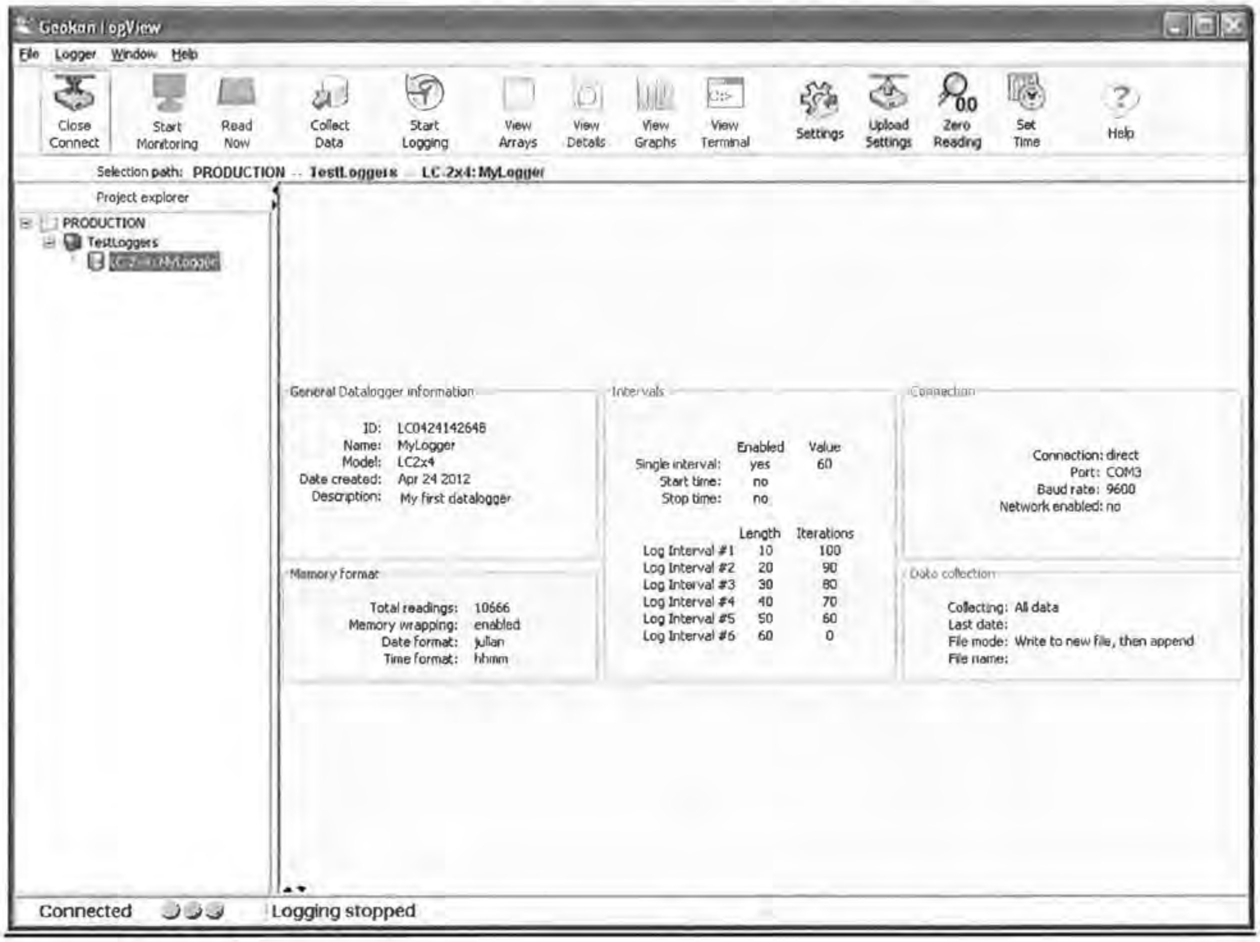

Figure 11 - Datalogger Connected

2.3.10. Determining COM Port Numbers:

When connecting an 8002-4-1 datalogger to a PC with an internal serial port(s) the COM Port number that LogView requires is usually COM1 or COM2 but, occasionally may be COM3 if the PC has more than one internal serial port. Figure 12 below illustrates that the PC has 2 serial ports, one internal (COM1) and the other via a USB to serial converter (COM13).

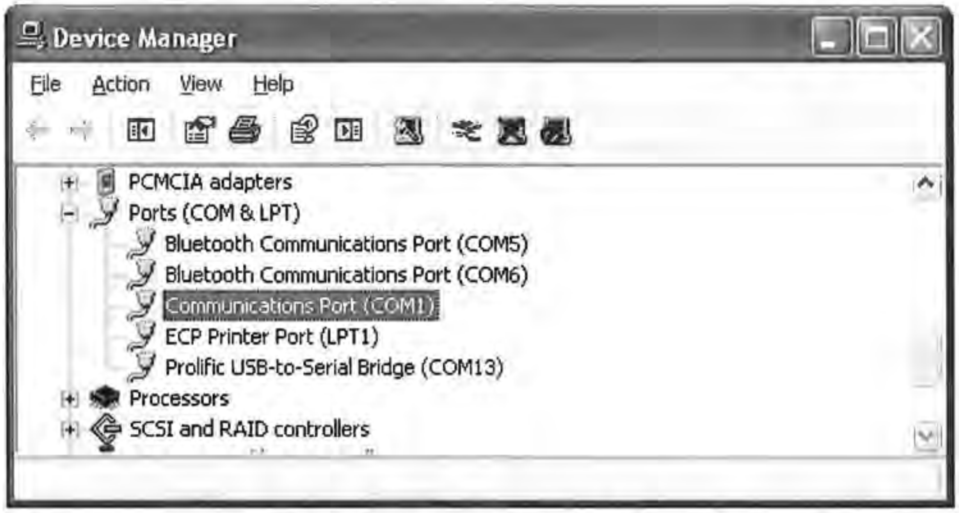

Figure 12 - PC Internal COM Port

When connecting an 8002-4-2 datalogger to a PC the COM Port number LogView requires can be any number and depends on how many other devices are attached to the PC like, internal serial ports and Bluetooth devices. Figure 13 below illustrates that the PC has 3 serial ports, one internal (COM1) and the other two via USB to serial converters (COM13 and COM3). One way to determine which COM port an 8002-4-2 datalogger is attached to is to disconnect the cable and see which COM device disappears from the Device Manager Ports list.

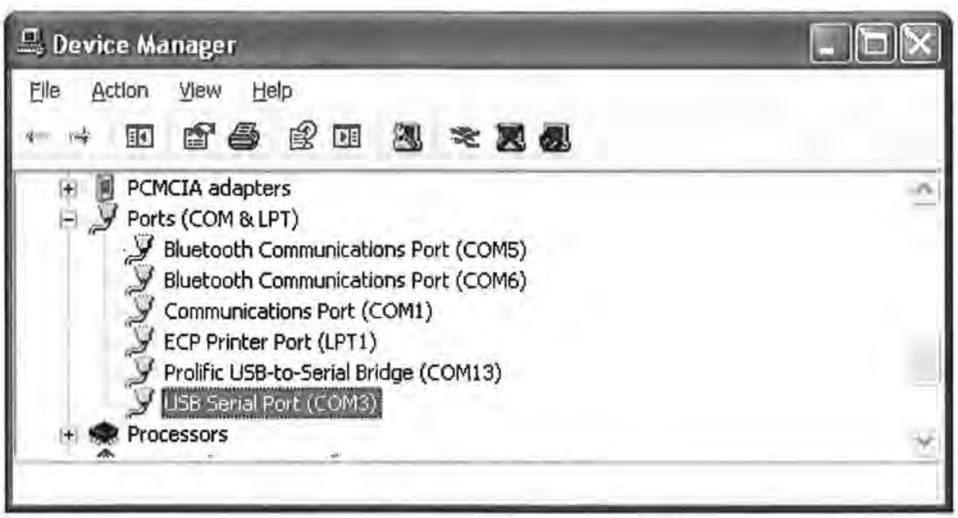

Figure 13 - Device Manager Ports List

In this case, COM3 is actually the 8002-4-2 datalogger and not a universally available serial port.

2.4. Communication Setup Example Using HyperTerminal

NOTE: If using a 8002-4-2 USB LC-2x4, it is important that the LC-2x4 first be connected to the computer's USB port before attempting to communicate so that the LC-2x4 can be recognized by the computer as a virtual COM port.

Proceed with the following steps to connect with the datalogger using a terminal emulator program such as Microsoft Windows HyperTerminal™:

1. Launch HyperTerminal (Start → All Programs → Accessories → Communications → HyperTerminal). If running under Vista or newer, contact Geokon for Geokon's Terminal Window Software.

2. Enter a name for the New Connection and click OK (see Figure 14):

Figure 14 - HyperTerminal Connection Description

3. In the Connect Using window, select the appropriate COM port (see Figure 15):

Figure 15 - COM Port Selection

4. In the COM Properties window, configure the COM port (see Figure 16):

Figure 16 - COM Port Settings

8002-4-1 (RS-232): Configure the COM port (typically COM1 or COM2) as 9600 Bits per second, 8 Data bits, no Parity, 1 Stop bit, no Flow control.

8002-4-2 (USB): Configure the new COM port that is added when the LC-2x4 is connected as 9600 Bits per second, 8 Data bits, no Parity, 1 Stop bit, no Flow control.

5. Click Apply then OK.
6. Press <ENTER> <ENTER> to wake the datalogger from sleep. The datalogger returns the power up prompt;

```
Hello. Press "?" for Help.
*
```

Note: If no characters are received in 15 seconds the datalogger (non-networked) will return to its low power sleep mode. Press <ENTER> <ENTER> to wake it again.

Note: When network commands are enabled and RS-485 is being used, the address must be sent before the respective datalogger will respond. See sections 3.21. thru 3.25. for additional information.

7. Type ? <ENTER> to display the Help list. See section 3 for detailed information on all the commands listed. **All commands must be entered in capital letters!** ;

*?

Command	Description
C	View current Clock
CSmm/dd/yy/hh:mm:ss	Clock Set
DEFAULT	Load factory DEFAULT gage settings
DF	Date Format(0=julian,1=month,day)
DL	Display DataLogger type
Dnnnnn	Display nnnnn arrays from pointer
E	End communications and go to sleep

Gnn/c/tt/szzzzzz/sffffff/soooooo
or
Gnn/c/tt/saaaaaa/sbbbbbb/scccccc

Gage information, where;

nn = Channel #
c = Conversion Type(L/P)
tt = Gage Type

For Linear (L) Conversion:
szzzzzz = zero reading with sign
sffffff = gage factor with sign
soooooo = offset with sign

For Polynomial (P) Conversion:
saaaaaa = polynomial coefficient A with sign
sbbbbbb = polynomial coefficient B with sign
scccccc = polynomial coefficient C with sign

IDdddddddddddddddd	View current ID,set to dddddddddddddddd
Ln/lllll/iii	View Log intervals/change n interval
	lllll = length
	iii = iterations of interval
LD,LE	Log intervals Disable, Enable
M,MD,ME	Monitor status, Disable, Enable
MXS	Display Multiplexer Setup
MX#	Select Multiplexer Configuration(4,16)
N	Display Next time to read
NAddd	Network Address (1-256)
NS,ND,NE	Network Status, Disable, Enable
Pnnnnn	Position array pointer to nnnnn
R	Reset memory
RESET	RESET processor
S,SS	Datalogger Status, System Status
SCnnnnn	View SCan interval/enter nnnnn interval
SPhh:mm	StoP logging, hh:mm = stop time
SR	Synchronize Readings(0=not synch'd,1=synch'd)
SThh:mm	STart logging, hh:mm = start time
SV	Software Version
TEST	System Test
TF	Time Format (0 = hhmm, 1 = hh,mm)
Tnn/t	Thermistor information, where;
	nn = Channel #
	t = Thermistor Type
	Thermistor type (0 = standard, 1 = high temp BR55A822J, 2 = high temp 103JL1A)
TR,TR0	display TRap count, zero TRap count
VL	display Lithium cell Voltage
V3	display 3V Battery Voltage
V12	display 12V Battery Voltage
WFn	Wrap Format(0=don't wrap memory,1=wrap memory
X	Single Reading - NOT stored

All of these commands are executed by typing with the correct syntax and pressing <ENTER>. If the command has not been entered correctly, the datalogger will respond with an asterisk only.
For example;

```
*L7/100/255
*
```

The datalogger will respond to correctly entered commands by displaying the modified values. The purpose and syntax of each of these commands are discussed in the following sections.

3. COMMAND LIST

3.1. BRnnn

This command is not displayed in the help text (?<ENTER>). Displays or sets the current baud rate. Valid numbers for "nnn" are 9 (9600 baud) or 115 (115,200 baud). The example below changes the baud rate to 9600 with no confirmation.

```
*BR9
```

3.2. C

Display the current datalogger real-time clock settings. The CS command section explains how to adjust the clock settings.

```
*C
Date: 02/21/07  Time: 10:43:08
*
```

3.3. CSmm/dd/yy/hh:mm:ss

Set the datalogger's internal real time clock; mm represents the month, dd the day of the month, yy the year, hh the hours, mm the minutes, and ss the seconds. Illegal combinations will be ignored (i.e. CS02/30/07 or CS///12:60). Fields can be left blank to avoid changing (i.e. CS//07 to just change the year).

```
*CS///10:45:00
Date: 02/21/07   Time: 10:45:00
*
```

Note: If logging is currently started and the clock is changed, a restart of the scan interval or log interval table will occur.

3.4. DEFAULT

The DEFAULT command will reload the datalogger's channel and gage settings to the factory default settings, along with the reading synchronization and memory wrap settings. This results in:

All channels Enabled
All Gage Types set to 1
All Zero Readings set to 0.00000
All Gage Factors set to 1.00000
All Gage Offsets set to 0.00000
All channels use linear conversion
Scan interval = 10S
All readings synchronized to the top of the hour
Memory will wrap when full and continue logging
All Thermistors set to standard temperature

***DEFAULT**
This will load all channels with factory default gage settings!
Are you sure(Y/N)?Y
All channels restored to factory default gage settings.

3.5. DF

Display or set the date format. This setting determines how the date information will be displayed in the array when the monitor mode is active or arrays are displayed from memory. Entering DF displays the current date format. Entering DF0 sets the date format to julian. Entering DF1 sets the date format to month,day. The default date format display is Julian (decimal) day.

```
*DF
Date format is julian.

*DF1
Date format is month,day.

*DF0
Date format is julian.
```

3.6. DL

Display the current datalogger mode setting.

```
*DL
LC-2x4
```

3.7. Dnnnnn

Use the D command to display arrays forward from the User Position for verification or collection. The updated memory pointers are displayed by this command.

*P1
MS:3146 OP:3147 UP:1
***D5**
2007,11,23,17,52,43,3.10,25.51,9039.950,-999999.0,-999999.0,-999999.0,23.2,-99.0,-99.0,-99.0,1
2007,11,23,17,53,43,3.10,24.77,9040.149,-999999.0,-999999.0,-999999.0,23.2,-99.0,-99.0,-99.0,2
2007,11,23,17,54,43,2.97,24.42,9040.319,-999999.0,-999999.0,-999999.0,23.2,-99.0,-99.0,-99.0,3
2007,11,23,17,55,43,2.98,24.22,9039.622,-999999.0,-999999.0,-999999.0,23.1,-99.0,-99.0,-99.0,4
2007,11,23,17,56,43,2.98,23.96,9038.542,-999999.0,-999999.0,-999999.0,22.7,-99.0,-99.0,-99.0,5

MS:3146 OP:3147 UP:6
*

MS represents the Memory Status of the datalogger. This number indicates how many arrays have been written to memory. In this example, **MS:3146** indicates that 3146 out of 10666 arrays have been written to memory. **OP:3147** indicates that the next memory location to be written to is location 3147. **UP:1** indicates that the memory location currently being pointed to (via the P command) is memory location 1. Use the D command to display arrays forward from the User Position, In this case, **D5** displays the arrays stored at memory locations 1,2,3,4 and 5, and leaves the memory pointer at memory location 6.

Figure 17 illustrates the ring memory scheme.

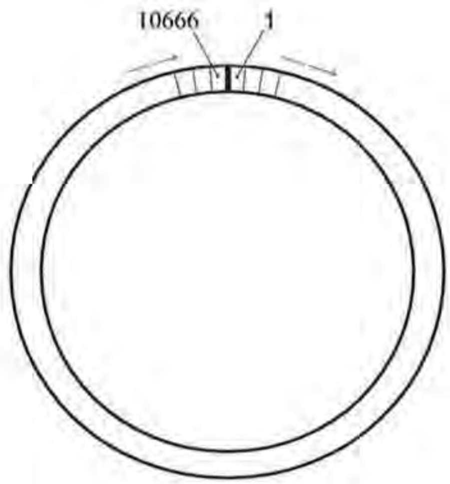

Figure 17 - Order of Array Usage

OP represents the Output Position that the next array will be written to.

UP represents the User Position. This value is updated by D and P commands. The user may display arrays from this position or re-position to another array.

The format is comma delineated ASCII, identical to that displayed when the Monitor mode is active. See Appendix D for a sample data file. See Appendix C in regards using the D command to collect data. When the array display is finished the memory pointers are displayed.

3.8. E

Returns the datalogger to its low power sleep mode (readings continue to be logged and displayed in this mode). **This command should always be used when finished communicating with the datalogger to ensure the lowest power consumption.** However, the datalogger (non-networked) will enter sleep mode regardless if no command is received in a period of approximately 15 seconds.

To return from the low power operating mode press <ENTER> <ENTER>. The datalogger responds;

```
Hello. Press "?" for Help.
*
```

Note: When network commands are enabled the address must be sent before the respective datalogger will respond. See the **NA, ND** and **NE** command sections for additional information.

3.9. Gnn/c/tt/szzzzzz/sffffff/soooooo or Gnn/c/tt/saaaaaa/sbbbbbb/scccccc

The **G** command is used to set up each of the 4 datalogger channels. All of the transducer parameters, including the type of conversion (linear or polynomial) and whether a channel is enabled or disabled are set with this command. Refer to Table 2 and Table 3 for a description of each gage type.

The syntax for this command is:

Linear Conversion:

Gnn/c/t/szzzzzz/sffffff/soooooo

Where:

nn = Channel # (Valid entries are 1,2,3 and 4 for the LC-2x4)
c = Conversion Type(L/P) where L=Linear and P=Polynomial
t = Gage Type:

0: Channel Disabled (will display "---")
1: VW Gage Type 1
2: VW Gage Type 2
3: VW Gage Type 3
4: VW Gage Type 4
5: VW Gage Type 5
6: VW Gage Type 6

szzzzzz = zero reading with sign
sffffff = gage factor with sign
soooooo = offset with sign

Example: To setup Channel 1 as a model 4000 VW Strain Gage with a Zero Reading of 490 digits, a Gage Factor of –0.0015 and a Gage Offset of 0, enter:

G1/L/3/490/-0.0015/0 <ENTER>

The LC-2x4 will return:

CH 1: ENABLED
GT: 3 ZR: 490.0000 GF: -0.00150 GO: 0.00000

__Note__: If selecting Gage Type 0 to disable the channel, the LC-2x4 will only return ''. Use the **MXS** command (section 3.18) to view the disabled channels.

When using linear conversion (L) of the instrument reading, the G command is used to select the gage type and enter the gage zero reading, gage factor, and gage offset.

Linear Conversion is described further as follows:
szzzzzz represents the zero reading for the transducer being read, **sffffff** represents the multiplier (calibration or gage factor) that will be applied to the reading to convert to engineering units and **soooooo** is the offset that will be applied to the gage reading. The zero reading, gage factor and offset can be entered with a sign and decimal point. The maximum number of digits, including sign and decimal point is 15. The entered value will display to a maximum of 5 places to the right of the decimal point.

For all vibrating wire instruments (Gage Types 1-6), manufactured after November 2, 2011 and for all dataloggers (8002-4-X) with a firmware revision of 3.1.X and up, the basic formula for calculation of displayed and stored values is as follows;

$$\text{Display} = ((\text{CurrentReading} - \text{ZeroReading}) \times \text{Multiplier}) + \text{Offset}$$

Equation 1 - Displayed Gage Reading using Linear Conversion

NOTE: It is possible that a new datalogger might be used with an older sensor or vice versa and because of equation differences the output might be negative. As of LogView version V2.1.1.X, an additional sensor configuration parameter is now required, allowing LogView to compensate for old versus new sensor/datalogger combinations. This new parameter: **Output Calculation**, determines whether the sensor was calibrated using the formula: **G x (R0 – R1)** or **G x (R1 – R0).** As with the gage factor, this information is available from the calibration certificate supplied with each sensor. Please see the LogView User's Guide or the online help section, "Sensor Settings" available while running LogView.

NOTE: In Equation 1 (above), the "**CurrentReading**" is frequently referred to as **R1** while the "**ZeroReading**" is referred to as **R0**

Polynomial Conversion:

Gnn/c/tt/saaaaaa/sbbbbbb/scccccc

Where:

nn = Channel # (Valid entries are 1,2,3 and 4 for the LC-2x4)
c = Conversion Type(L/P)
t = Gage Type:
- 0: Channel Disabled (will display "---")
- 1: VW Gage Type 1
- 2: VW Gage Type 2
- 3: VW Gage Type 3
- 4: VW Gage Type 4
- 5: VW Gage Type 5
- 6: VW Gage Type 6

saaaaaa = polynomial coefficient A with sign
sbbbbbb = polynomial coefficient B with sign
scccccc = polynomial coefficient C with sign

When using polynomial conversion (P) , the G command is used to select the gage type and enter the three polynomial coefficients, A, B and C.

Polynomial Conversion is described further as follows:
saaaa represents polynomial coefficient A, **sbbbb** represents polynomial coefficient B and **scccc** polynomial coefficient C. The polynomial coefficients can be entered with a sign and decimal point. The maximum number of digits, including sign and decimal point is 15. The entered value will display to a maximum of 5 places to the right of the decimal point.

For the vibrating wire instruments (Gage Types 1-6), the basic formula for calculation of displayed and stored values is:

$$\mathbf{Display = (CurrentReading^2 \times A) + (CurrentReading \times B) + C}$$

Equation 2 - Displayed Gage Reading using Polynomial Conversion

NOTE: When using the Polynomial conversion method, the default reading units for a vibrating wire instrument is the frequency squared multiplied by 10^{-6}. For example, an instrument reading 3000Hz will output a value of "9.000" when A is entered as "0", B is "1" and C is "0". However, typical calibration units for vibrating wire instruments are frequency squared multiplied by 10^{-3}. To adjust for this discrepancy between LC-2 expected units and calibration units **multiply the A coefficient by 1,000,000 and the B coefficient by 1000. The A and B coefficients can be found on the supplied calibration certificate.** The C coefficient should be calculated based on an actual field reading. The above multiplication is **only** necessary if the datalogger is being set up via text commands (see section 2.3) **AND** the gage conversion is set for polynomial. When using LogView to set up the datalogger configuration, the multiplication is performed by LogView. Refer to the appropriate sensor manual for more information on how to calculate the C coefficient.

Geokon Model	Gage Type	Description
4000	3	Strain Gage
4100	1	Strain Gage
4200	3	Strain Gage
4204	6	Strain Gage
4202/421X	1	Strain Gage
4300BX	1	BX Borehole Stressmeter
4300EX	5	EX Borehole Stressmeter
4300NX	1	NX Borehole Stressmeter
4400	1	Embedment Jointmeter
4420	1	Crackmeter
4450	1	Displacement Transducer
4500	1	Piezometer
4600/4651/4675	1	Settlement Systems
4700	1	Temperature Transducer
4800	1	Pressure Cell
4850	1	Low Pressure Piezometer
4900	1	Load Cell
4910/4911/4912	1	Load Bolts

Table 2 - Vibrating Wire Gage Types

Type	Measurement Type	Description	Output Units	Linear Range	Polynomial Range
0		Channel Disabled			
1	Vibrating Wire	Middle frequency sweep, 1400-3500 Hz	Digits	1960 to 12250	1.960 to 12.250
2	Vibrating Wire	High frequency sweep, 2800-4500 Hz	Digits	7840 to 20250	7.840 to 20.250
3	Vibrating Wire	Very low frequency sweep, 400-1200 Hz	Digits	160 to 1440	0.160 to 1.440
4	Vibrating Wire	Low frequency sweep, 1200-2800 Hz	Digits	1440 to 7840	1.440 to 7.840
5	Vibrating Wire	Very high frequency sweep, 2500-4500 Hz	Digits	6250 to 20250	6.250 to 20.250
6	Vibrating Wire	Low frequency sweep, 800-1600 Hz	Digits	640 to 2560	0.640 to 2.560

Table 3 - Gage Type Descriptions

The "Digits" calculation for the Vibrating Wire transducer output when using linear conversion is based on this equation;

$$\text{Digits} = \text{frequency}^2 \times 10^{-3}$$

Equation 3 - Digits Calculation using Linear Conversion

The "Digits" calculation for the Vibrating Wire transducer output when using polynomial conversion is based on this equation;

$$\text{Digits} = \text{frequency}^2 \times 10^{-6}$$

Equation 4 - Digits Calculation using Polynomial Conversion

Frequency, in the above equations, represents the resonant frequency of vibration of the wire in the transducer (in Hertz) as determined by the datalogger.

To convert calibration factors (pressure transducers are usually psi per digit) to other engineering units consult Table 4.

NOTE: In LogView Sensor Settings, when output units are set different than inputs units, a conversion factor (see Table 4) is automatically applied to the gage factor of each sensor. See the LogView User's Guide for more information on Sensor Settings.

From → To ↓	psi	"H_2O	'H_2O	mm H_20	m H_20	"HG	mm HG	atm	mbar	bar	kPa	MPa
psi	1	.036127	.43275	.0014223	1.4223	.49116	.019337	14.696	.014503	14.5039	.14503	145.03
"H_2O	27.730	1	12	.039372	39.372	13.596	.53525	406.78	.40147	401.47	4.0147	4016.1
'H_2O	2.3108	.08333	1	.003281	3.281	1.133	.044604	33.8983	.033456	33.4558	.3346	334.6
mm H_20	704.32	25.399	304.788	1	1000	345.32	13.595	10332	10.197	10197	101.97	101970
m H_20	.70432	.025399	.304788	.001	1	.34532	.013595	10.332	.010197	10.197	.10197	101.97
"HG	2.036	.073552	.882624	.0028959	2.8959	1	.03937	29.920	.029529	29.529	.2953	295.3
mm HG	51.706	1.8683	22.4196	.073558	73.558	25.4	1	760	.75008	750.08	7.5008	7500.8
atm	.06805	.0024583	.0294996	.0000968	.0968	.03342	.0013158	1	.0009869	.98692	.009869	9.869
mbar	68.947	2.4908	29.8896	.098068	98.068	33.863	1.3332	1013.2	1	1000	10	10000
bar	.068947	.0024908	.0298896	.0000981	.098068	.033863	.001333	1.0132	.001	1	.01	10
kPa	6.8947	.24908	2.98896	.0098068	9.8068	3.3863	.13332	101.320	.1	100	1	1000
MPa	.006895	.000249	.002988	.00000981	.009807	.003386	.000133	.101320	.0001	.1	.001	1

Table 4 - Engineering Units Multiplication Factors

3.10. IDdddddddddddddddd

Displays or sets the datalogger ID. The ID is a 16 character string that can be used to identify a datalogger and the data that is transmitted by it. If an ID is entered it will be transmitted as the first element in each array of data. For example;

```
*ID
Datalogger ID:
*ID
Datalogger ID:
*IDDatalogger#1
Datalogger ID:Datalogger#1
*ST
Logging started.
Datalogger#1,2007,11,25,11,25,16,2.92,20.93,9.020,-999999.0,-999999.0,
-999999.0,22.0,-99.0,-99.0,-99.0,1
Datalogger#1,2007,11,25,11,25,21,2.92,20.95,9.061,-999999.0,-999999.0,
-999999.0,22.0,-99.0,-99.0,-99.0,2
Datalogger#1,2007,11,25,11,25,26,2.92,21.04,9.045,-999999.0,-999999.0,
-999999.0,22.0,-99.0,-99.0,-99.0,3
Datalogger#1,2007,11,25,11,25,31,2.92,21.09,9.014,-999999.0,-999999.0,
-999999.0,22.0,-99.0,-99.0,-99.0,4
```

To clear the ID enter a <SPACE> character as the ID. When the ID is cleared the arrays from the logger will display beginning with the year. To display the current ID enter `ID` <ENTER>.

3.11. L

Display all 6 log intervals.

```
*L
Log Intervals List
----------------------------------------------

Interval #1  Length: 10    Iterations: 100

Interval #2  Length: 20    Iterations: 90

Interval #3  Length: 30    Iterations: 80

Interval #4  Length: 40    Iterations: 70

Interval #5  Length: 50    Iterations: 60

Interval #6  Length: 60    Iterations: 50


*
```

This command has no effect on the current interval (scan or log). If logging is started and log intervals are enabled the iterations value will be followed by the number of readings left at that interval. For example;

```
*L
Log Intervals List
----------------------------------------------

Interval #1  Length: 10    Iterations: 100/96

Interval #2  Length: 20    Iterations: 90/90

Interval #3  Length: 30    Iterations: 80/80

Interval #4  Length: 40    Iterations: 70/70

Interval #5  Length: 50    Iterations: 60/60

Interval #6  Length: 60    Iterations: 50/50


*
```

The above list indicates that there are 96 iterations of interval 1 left before interval 2 begins execution. See the `Ln/lllll/iii` command section to modify intervals.

3.12. Ln/lllll/iii

Define the length and iteration of any interval in the list; n refers to the number of the interval (1-6), lllll is the length (3-86400), and iii is the iterations (0-255), or the number of readings that will be taken at that interval. If 0 is entered for the iteration value that interval will execute indefinitely. Illegal entries will be ignored, i.e. `L7/10/100` or `L1/1000/500`. If the entry is correct the modified interval will display.

```
*L1/100/0
Interval #1  Length: 100   Iterations: 0
*
```

If log intervals are enabled and logging was started, any change to the interval list will result in a restart of the table!

Table 5 lists possible logarithmic interval lengths and iterations. Any combination of lengths and iterations is permissible.

Interval	Length	Iterations	Elapsed Time
1	10 seconds	6	1 minute
2	30 seconds	20	10 minutes
3	60 seconds	100	100 minutes
4	300 seconds	200	1000 minutes
5	2400 seconds	250	10000 minutes
6	3600 seconds	0	endless

Table 5 - Logarithmic Intervals List

3.13. LD

Disable use of log intervals. If logging is started (**ST** command) it will continue based on the scan interval entry (**SC** command).

```
*LD
Log intervals disabled.
*Datalogger#1,2007,11,25,11,41,17,2.92,20.63,9.055,-999999.0,-999999.0,
-999999.0,22.5,-99.0,-99.0,-99.0,549
*
```

3.14. LE

Enable use of log intervals. If logging is started (**ST** command) it will continue based on the interval lengths and iterations of the log list (**SC** command).

```
*LE
Log intervals enabled.
*Datalogger#1,2007,11,25,11,42,56,2.92,21.51,9.042,-999999.0,-
999999.0,-999999.0,22.5,-99.0,-99.0,-99.0,622
```

3.15. M

Display the current Monitor mode setting. The monitor mode will display arrays as they are stored in memory in the course of logging. This is useful where a test is being conducted and immediate display of logged values would be helpful. Use the **MD** and **ME** commands (next two sections) to disable or enable the use of the Monitor mode.

```
*M
Monitor mode enabled.
*
```

3.16. MD

Disable the Monitor mode. Arrays will not be sent to the host computer as they are logged.

```
*MD
Monitor mode disabled.
*
```

3.17. ME

Enable the Monitor mode. Arrays will be sent to the host computer as they are logged.

```
*ME
Monitor mode enabled.
*
```

3.18. MXS

Display the Multiplexer Status.

```
*MXS

LC-2MUX 4-Channel Multiplexer Setup:

CH 1: ENABLED
GT: 3  ZR: 0.00000  GF: 1.00000  GO: 0.00000  TH: 0

CH 2: ENABLED
GT: 1  ZR: 0.00000  GF: 1.00000  GO: 0.00000  TH: 0

CH 3: ENABLED
GT: 1  ZR: 0.00000  GF: 1.00000  GO: 0.00000  TH: 0

CH 4: ENABLED
GT: 1  ZR: 0.00000  GF: 1.00000  GO: 0.00000  TH: 0


*
```

3.19. MXn

Select the maximum number of channels (4 or 16) of the multiplexer. For a LC-2x4, this is 4 by default:

```
*MX4
4 Channel Multiplexer Selected.
*
```

3.20. N

Display the next time the datalogger will initiate a measurement cycle. If the start time (`ST` command) has been set this command will display when logging will begin.

```
*ST12:00
Logging will start at: 12:00:00
*N
Next time to read: 12:00:00
*
```

3.21. NA

Displays the current network address.

```
*NA
Network address: 1
*
```

When network recognition is enabled, this number (preceded by the # character) must be entered for the respective datalogger to respond. The following example illustrates communication with 2 different dataloggers on the RS-485 network.

```
<ENTER>
<ENTER>
#1<ENTER>
Network address: 1
*NA
Network address: 1
*E

<ENTER>
<ENTER>
#2<ENTER>
Network address: 2
*NA
Network address: 2
*E
```

3.22. NAddd

Sets the current network address to any address between 1 and 256.

```
*NA10
Network address: 10
*
```

When network recognition is enabled, this number (preceded by the # character) must be entered for the respective datalogger to respond. The following example illustrates communication with 2 different dataloggers on the RS-485 network.

```
<ENTER>
<ENTER>
#1<ENTER>
Network address: 1
*NA
Network address: 1
*E

<ENTER>
<ENTER>
#10<ENTER>
Network address: 10
*NA
Network address: 10
*E
```

NOTE: If connected directly to the datalogger via USB and networking is enabled, the datalogger will respond with the * prompt only.
NOTE: The network address may not be changed while networked. Direct connect to the datalogger via USB in order to change the network address.

3.23. ND

Network Disable the datalogger. Disables networking of 2 or more LC-2x4 dataloggers.

```
*ND
Network recognition disabled.
```

3.24. NE

Network Enable the datalogger. Enables networking of 2 or more LC-2x4 dataloggers.

```
*NE
Network recognition enabled.
```

Note: If a networked LC-2x4 is connected via the RS-232 or USB port, connection to the datalogger can be made directly without the need to enter the correct datalogger address. This can be helpful if the network address is unknown and the datalogger is network enabled.

3.25. NS

Display the current network status.

```
*NS
Network recognition disabled.
*
```

Or;

```
*NS
Network recognition enabled.
*
```

3.26. Pnnnn

Position the User Position memory pointer. Type **P** and a number between 1 and 10666 to position the pointer. Arrays can then be displayed (**D** command) from the new position. The updated pointers will display after entering a valid position.

```
*P1
MS:3200   OP:1567   UP:1
*
```

3.27. R

Reset memory pointers to default settings. Gage and interval settings, as well as the real-time clock settings, are not affected by this command. User will be asked to verify before executing. Press **Y** to continue, any other key to abort.

```
*R
Are you sure(Y/N)?Y
Memory cleared.
*
```

Note: This command does not erase memory. If the need arises to recover data that was previously taken, take 1 (or more) readings and then position the memory pointers via the **P** and **D** commands to recover previously taken readings.

3.28. RESET

RESET (re-boot) the LC-2 microprocessor. All stored readings and settings, as well as the ID and real-time clock settings are not affected by this command.

***RESET**
Resetting...
RESET COMPLETE
*****

3.29. S

Display the datalogger Status.

```
*S
MS:1004   OP:1005   UP:1004
4 Channel Multiplexer Selected.
Scan interval: 15 second(s).
Logging stopped.
Log intervals disabled.
Monitor mode enabled.
*
```

Line	Description	Manual Sections
1	Status of memory pointers	3.7, 3.26
2	Multiplexer Type	3.18
3	Scan interval setting	3.30
4	Start/Stop status	3.32, 3.34
5	Stop time (optional)	3.32
6	Log interval status	3.13, 3.14
7	Monitor mode status	3.15, 3.16, 3.17

Table 6 - S Command Information

3.30. SCnnnnn

Enter the SCan interval, in seconds. Range of entry is 3 to 86400 and is dependent on the number and type of transducers connected. Only whole numbers are accepted. Typing **SC** with no value returns the current setting only

```
*SC
Scan interval: 60 second(s).
*SC300
Scan interval: 300 second(s).

*
```

3.31. SS

Display the System Status of the datalogger.

```
*SS
Trap count: 0
Network address: 1
Network recognition disabled.
Time format is hh,mm.
Date format is month,day.
*
```

Line	Description
1	Trap Count (Communication errors counter)
2	Current network address
3	Current network status
4	Current time format configuration.
5	Current date format configuration.

Table 7 - SS Command Information

3.32. SPhh:mm

Sto**P** the datalogger logging values; hh is the hour (24 hour format) of the day to stop and mm the minutes. The time entry is optional.

```
*SC60
Scan interval: 60 second(s).
*ST
Logging started.
Datalogger#1,2007,11,25,14,10,05,2.94,23.99,9.071,---,---,---,22.9,---,
---,---,1


*SP12:00
Logging will start at: 15:13:46
Logging will stop at: 12:00:00
*
```

Note that when SPhh:mm is issued, the datalogger responds with the time of the next reading along with the time at which logging will stop.

3.33. SR

Synchronize **R**eadings to the top of the hour. If enabled (default) via the SR1 command, then all readings after the first reading will synchronize to the top of the hour:

```
*SR1
Readings are synchronized to the top of the hour.
*ST
Logging started.
2008,318,1314,41,3.50,24.45,-8961.077,-999999.0,-999999.0,
-8444.892,23.1,-99.0,23.8,23.9,6645

*2008,318,1314,45,3.50,24.57,-8961.276,-999999.0,-999999.0,
-8445.080,23.2,-99.0,23.8,23.9,6646
2008,318,1315,0,3.50,24.86,-8960.023,-999999.0,-999999.0,
-8445.035,23.2,-99.0,23.8,23.9,6647

*SR0
Readings are not synchronized to the top of the hour.
*ST
Logging started.
2008,318,1316,31,3.50,24.39,-8960.209,-999999.0,-999999.0,
-8445.080,23.3,-99.0,23.8,23.9,6648
```

```
*2008,318,1316,46,3.50,24.80,-8960.090,-999999.0,-999999.0,
-8445.092,23.3,-99.0,23.8,23.9,6649

*2008,318,1317,1,3.50,24.80,-8961.173,-999999.0,-999999.0,
-8445.302,23.4,-99.0,23.8,23.9,6650
```

3.34. SThh:mm

STart the datalogger logging values; hh is the hour of the day (24 hour format) to start and mm the minutes. The time entry is optional. Entry is ignored if logging is already started (unless a time is entered).

```
*ST
Logging already started!
*ST11:00
Logging will start at: 11:00:00
*
```

3.35. SV

Return the Software Version of the datalogger's operating system software. Consult the factory to check on latest versions available.

```
*SV
Software version: 3.7.0
*
```

3.36. TEST

TEST is a set of internal self tests that are performed at the factory during final test.

```
*TEST

LC-2MUX TEST MENU:

SELECTION         TEST

    0        INTERNAL EEPROM
    1        EXTERNAL EEPROM BANK 1
    2        EXTERNAL EEPROM BANK 2
    3        EXTERNAL EEPROM BANK 3
    4        EXTERNAL EEPROM BANK 4
    5        EXTERNAL EEPROM BANK 5
    6        EXTERNAL EEPROM BANK 6
    7        ALL EEPROM
    8        +5X_X
    9        RTC 32KHz
    A        EXTERNAL INPUT (GAGE TYPE 1)
    B        EXTERNAL INPUT (GAGE TYPE 2)
    C        EXTERNAL INPUT (GAGE TYPE 3)
    D        EXTERNAL INPUT (GAGE TYPE 4)
    E        EXTERNAL INPUT (GAGE TYPE 5)
    X        EXIT TEST MENU

ENTER SELECTION:
```

Selection	Description
0	Test the Configuration memory bank
1	Test Readings 1-1777 memory bank
2	Test Readings 1778-3554 memory bank
3	Test Readings 3555-5331 memory bank
4	Test Readings 5332-7108 memory bank
5	Test Readings 7109-8885 memory bank
6	Test Readings 8886-10666 memory bank
7	Test all memory banks
8	Turn on System power supplies
9	Test the 32.768 RTC timebase
A	External Input with Gage Type 1 filter configuration
B	External Input with Gage Type 2 filter configuration
C	External Input with Gage Type 3 filter configuration
D	External Input with Gage Type 4 filter configuration
E	External Input with Gage Type 5 filter configuration
X	Exit and return to normal operations

Table 8 – TEST Menu Information

3.37. TF

Display the current Time Format display option setting. This setting determines how the time information will be displayed in the array when the Monitor mode is active (see M command section) or arrays are being displayed from memory. Entering TF alone returns the current time format. Entering TF0 sets the time format to hhmm. Entering TF1 sets the time format to hh,mm. The default time format display is hhmm.

```
*TF
Time format is hh,mm.
*TF0
Time format is hhmm.
*TF1
Time format is hh,mm.
*
```

3.38. Tnn/t

Enter the channel's (nn) thermistor type (t). This command allows a specific thermistor to be assigned to each individual channel (generally the external thermistor that is incorporated into the VW gage). Entering T1/0 sets the external thermistor type of channel 1 to the standard 3KΩ@25°C NTC (default). For example, entering T2/1 sets the external thermistor type of channel 2 to the high temperature BR55KA822J 8.22KΩ@25°C NTC thermistor. Entering T3/2 sets the external thermistor type of channel 3 to the high temperature 103JL1A 10KΩ@25°C NTC thermistor.

```
T1/0:
CH 1: ENABLED
GT: 1   ZR: 0.00000   GF: 1.00000   GO: 0.00000   TH: 0

T2/1:
CH 2: ENABLED
GT: 1   ZR: 0.00000   GF: 1.00000   GO: 0.00000   TH: 1

T3/2:
CH 3: ENABLED
GT: 1   ZR: 0.00000   GF: 1.00000   GO: 0.00000   TH: 2
```

3.39. TR

Display the current **TR**ap Count. The trap counter is a register that keeps track of the number of times that the internal processor has detected a communications error. This is a useful register to check if communication problems are suspected.

3.40. TR0

Reset the **TR**ap count register to **0**.

3.41. VL

Display the Lithium Coin Cell Voltage. The internal 3V lithium coin-cell is used to supply power to the real-time clock circuit. The 3V lithium coin cell life is rated at 10 years minimum.

```
*VL
Lithium Cell Voltage = 2.92V
*
```

3.42. V3

Display the 3V D-cell battery pack voltage. Replace the batteries when this voltage is less than 1.8V

```
*V3
3V Battery Voltage = 2.93V
*
```

3.43. V12

Display the external 12V battery voltage. Replace or recharge the battery when this voltage is less than 6V

```
*V12
12V Battery Voltage = 12.33V
*
```

3.44. WF

Display the current Wrap Format. Memory "wrapping" means that once the memory has filled, the datalogger will continue taking readings and overwrite the stored values in a circular fashion (see section 3.7.Dnnnnn).

When the wrap format is set to 0, logging will stop once the memory becomes full. This is useful if critical data is stored and it must not be inadvertently overwritten and lost.

When the wrap format is set to 1, logging will continue when the memory becomes full and the original stored values will be overwritten. With this setting, logging will continue indefinitely until told to stop with the SP command, the programmed stop time has been reached, or the battery has fallen to 1.6V.

```
*WF
Logging will not stop when memory is full
*WF0
Logging will stop when memory is full
*WF1
Logging will not stop when memory is full
*
```

3.45. X

Take and display one reading, but do not store this reading in memory. Useful if interested in obtaining a reading at the moment, without interrupting or affecting the current logging schedule.

```
*D

MS:3  OP:4  UP:3
*X
Datalogger#1,2007,11,25,13,11,39,2.93,23.59,9.060,---,---,---,22.8,---,---,---

*D

MS:3  OP:4  UP:3
*
```

Note: In this example, channels 2,3 and 4 are disabled.

4. MAINTENANCE

While the Model LC-2x4 Datalogger is designed to operate in field environments, nevertheless there are some basic maintenance procedures that should be followed to insure maximum reliability and functionality.

4.1. Cleaning:

The outside of the box can be cleaned using a cloth dampened with soap and water. **DO NOT USE ANY TYPES OF SOLVENTS OR SCOURING AGENTS!**

The connector sockets can be cleaned using a small stiff brush (small painters brush) dipped in soap and water. The sockets are water resistant so the internal electronics will not be adversely affected by them filling with water or other liquids. Be aware however, readings could be affected by shorting or other effects of an improper connection due to fluids being present in the connector. Dry connections thoroughly before using.

4.2. Batteries:

When the unit is not in use, especially for extended periods of time, the 'D' cells should be removed to prevent damage due to leakage. **The warranty does not cover damage due to battery leakage.** The table below details approximate operating times for the various types of 'D' cell batteries that may be used with the Model LC-2x4.

Battery Type	Battery Capacity	4 Second Scan Rate	1 Minute Scan Rate	1 Hour Scan Rate	1 Day Scan Rate
Lithium	19 AHr	54 hours	128 days	≥1 year	≥4 years
Alkaline	14 AHr	20 hours	47 days	≥6 months	≥2 years
Carbon-Zinc	5 Ahr	6 hours	16.5 days	≥3 months	≥1 year

Table 9 - Approximate Operating Times

The above table assumes a constant temperature environment of 25°C (not field conditions!). Battery life is shortened by temperature extremes. If the datalogger is continuously connected to an active computer's USB port, all operating power will be supplied via the USB port. As soon as USB power is lost, the datalogger will immediately switch over to its internal 3V (or external 12V) battery pack.

Batteries should be replaced when the measured voltage drops below 1.8 VDC (internal 3V battery) or 6V (external 12V battery). The datalogger electronics will stop the datalogger from logging and disable RS-485 communications if the battery goes below 1.6 VDC (internal 3V battery) or 5.5V (external 12V battery). In this event, a new set of batteries must be installed (or USB connection must be made) before the datalogger becomes operable again. All data and operating parameters are retained when removing batteries, even for an extended period (years) of time due to non-volatile EEPROM memory. If the datalogger was logging when it stopped itself due to low battery voltage, it will resume logging as soon as new batteries are installed or as soon as it is connected to a USB port.

4.2.1. Battery replacement instructions:

1) Remove the 4 captive lock regular head screws on the top of the case and lift the cover off. Underneath the cover is the 'D' cell battery holder.

2) Remove the two batteries from the holder being careful not to bend the sides outward. Insert the new batteries straight down into the battery holder, with the positive end of each fitting into the red washer. Check for secure connection between the battery terminals and holder. If a gap exists, remove batteries and bend the holder sides inward.

Proper Battery installation

Faulty Battery installation

3) Re-install the cover. Check datalogger for proper operation.

5. TROUBLESHOOTING

Listed below are a few commonly experienced problems and remedial action. Contact the factory should a problem arise not explained herein or additional information be needed.

5.1. Unit will not respond to communications.

- ✓ Wrong COM port selected.
- ✓ The USB Drivers may not be properly installed. See Section 2.3.2 8002-4-2 (USB) Driver Installation.
- ✓ If RS-232 or RS-485 communications are being used, the internal batteries of the datalogger may be low, dead or have a faulty connection to the holder. Replace/check batteries according to the **"Battery replacement instructions:"** on the previous page.
- ✓ If RS-485 communications is being used, the **<ENTER>, <ENTER>, #,datalogger address, <ENTER>** key sequence is not being sent. Refer to Appendix F – NETWORKING for further information.

5.2. Vibrating wire gage measurement reads -999999.0

- ✓ Using an ohmmeter, check connections to the vibrating wire gage leads. Resistance should be between 90 and 180 ohms (pins A&B on the 10-pin connector, see Appendix B). Remember to correct for cable resistance (approximately 15 Ω/1000' or 50 Ω/km, double for both directions). If resistance reads less than 100 Ω the cable is probably shorted. If resistance reads infinite or in the megohms range the cable is probably cut.
- ✓ Check the datalogger with another known good transducer. If it still reads –999999.0, the datalogger may be malfunctioning.
- ✓ Check that the proper gage type is selected (see Tables 1&2).
- ✓ Check that the transducer shield wire is not shorted to either the red or black wire.

5.3. Gage measurement (analog or vibrating wire) reads -999999.9

- ✓ A mathematical over-range has occurred. Check the magnitude of the reading, zero reading, multiplier and offset. The result must be in the range of 1.0×10^{-7} to 1.0×10^{7}.

5.4. Vibrating wire gage reading is unstable

- ✓ Is there a source of electrical noise nearby? Likely candidates are generators, motors, arc welding equipment, high voltage lines, etc. If possible, move the datalogger and transducer cables away from the power lines or electrical equipment.
- ✓ Check if the proper gage type is selected (see Tables 1 & 2).

5.5. Thermistor measurement shows -99.9 degrees Celsius

- ✓ Indicates open circuit to thermistor leads. Check connections from datalogger to thermistor leads. If okay, check thermistor with ohmmeter. Appendix F details the resistance versus temperature relationship.

APPENDIX A - SPECIFICATIONS

A.1. Measurement Capability

- Vibrating Wire (all types).
- External temperature (thermistor).
- Internal temperature (thermistor).
- Main battery voltage (3V and 12V).
- RTC lithium battery voltage.

A.2. Power

Power supply:	Internal 3 VDC (7.5Vmax) or External 12 VDC (15Vmax)
Processing/communication current:	<100 mA
VW measurement current:	<250 mA
Quiescent current:	<600 μA
RTC battery type:	Panasonic CR2032 3V lithium coin cell: 20mm, 225 mAHr
RTC battery life:	>10 years
Operating temperature range:	–30 to +50° C

A.3. Memory

Data memory:	320K EEPROM
Program memory:	24K EEPROM
Array storage	10666
Data memory type:	ring (oldest over-write)
Array elements:	ID (optional) Year Julian day (or month,day) Time (hhmm or hh,mm) Seconds Battery voltage Datalogger temperature Channel 1 Transducer reading Channel 2 Transducer reading Channel 3 Transducer reading Channel 4 Transducer reading Channel 1 Transducer temperature Channel 2 Transducer temperature Channel 3 Transducer temperature Channel 4 Transducer temperature Array #

A.4. Clock

Features:	full calendar
Time format:	12 or 24 hour (selectable)
Date Format:	mm,dd or julian (selectable)
Accuracy:	±2 minutes per year

A.5. Serial Interface (all LC-2x4 models):

Speed:	9600 bps & 115,200 (version 3.1.X and later)
Parameters:	8 Data bits
	1 Stop bit
	no Parity
	no Flow control
Data output format:	ASCII text

A.6. RS-485 Network

Maximum nodes:	256
Maximum cable length:	4000', 1.22 km

A.7. Vibrating Wire Measurement

Excitation sweep range:	400 Hz to 4500 Hz
Frequency Measurement Technique:	Adaptive Multiple Period Averaging
Accuracy:	0.05% F.S.R. (450-4000 Hz)
Resolution:	0.001 digit

A.8. Internal/External Temperature Measurement

Thermistor:	Dale #1C3001-B3 (YSI 44005)	(Standard	0)
	Thermometrics BR55KAKA822J	(High Temp	1)
	U.S. Sensor 103JL1A	(High Temp	2)

Transducer accuracy:	±0.5° C
Measurement accuracy:	0.5% FSR
Resolution:	0.01° C (Internal)
	0.1° C (External)
Linearization error:	0.02% FSR
Temperature range:	–40 to +60° C Standard Thermistor
	0 to +200° C High Temp Thermistor
Overall accuracy:	1.0% FSR (±1°)

A.9. Main Battery Measurement

3V Battery:		12V Battery:	
Range:	0 to 7.5 VDC	Range:	0 to 15 VDC
Accuracy:	±1.83mV	Accuracy:	±3.662mV
Resolution:	0.01 VDC		

A.10. Multiplexer Relay

NAIS TXS2SA-4.5V

contact resistance:	0.1 ohm (max)
switching current:	1A (max)

APPENDIX B - CONNECTOR PINOUTS

B.1. Transducer Cable Connections:

Terminal Strip Position	Channel Number	Description	Cable Wire Color
VW1+	1	Vibrating Wire +	RED
VW1-	1	Vibrating Wire -	BLACK
TH1+	1	Thermistor +	GREEN
TH1-	1	Thermistor -	WHITE
SHLD1	1	Analog Ground (shield)	BARE WIRE
VW2+	2	Vibrating Wire +	RED
VW2-	2	Vibrating Wire -	BLACK
TH2+	2	Thermistor +	GREEN
TH2-	2	Thermistor -	WHITE
SHLD2	2	Analog Ground (shield)	BARE WIRE
VW3+	3	Vibrating Wire +	RED
VW3-	3	Vibrating Wire -	BLACK
TH3+	3	Thermistor +	GREEN
TH3-	3	Thermistor -	WHITE
SHLD3	3	Analog Ground (shield)	BARE WIRE
VW4+	4	Vibrating Wire +	RED
VW4-	4	Vibrating Wire -	BLACK
TH4+	4	Thermistor +	GREEN
TH4-	4	Thermistor -	WHITE
SHLD4	4	Analog Ground (shield)	BARE WIRE

Table B-1 Transducer Cable Connections

B.2. RS-232 Connector Pinout (8002-4-1):

The mating 10 pin Bendix plug is part number PT06F-12-10P.

10 Pin Bendix	Internal Wire Color	PCB connector J5 pin	Description
A	Brown	1	Ground
B	Red	2	Tx
C	Orange	3	Rx
D	Yellow	4	RTS
E	Green	5	CTS
F	Blue	6	N/C
G	Violet	7	DTR
H	Grey	8	+5V
J	White	9	N/C
K	Black	10	Ground

Table B-2 RS-232 Connector Pinout

B.3. USB Connector Pinout (8002-4-2):

The mating 10 pin Bendix plug is part number PT06F-12-10P.

10 Pin Bendix	Internal Wire Color	PCB connector J5 pin	Description
A	Brown	1	USB VCC
B	Red	2	USB DM
C	Orange	3	USB DP
D	Yellow	4	Digital Ground
E	Green	5	RS-485 RX
F	Blue	6	RS-485 /RX
G	Violet	7	RS-485 TX
H	Grey	8	RS-485 /TX
J	White	9	RS-485 +12V
K	Black	10	RS-485 Ground

Table B-3 USB Connector Pinout

B.4. RS-485 Connector Pinout (optional, 8002-4-3):

10 Pin Bendix	Internal Wire Color	PCB connector J6 pin	Description
A	Brown	1	No Connection
B	Red	2	No Connection
C	Orange	3	No Connection
D	Yellow	4	Digital Ground
E	Green	5	RS-485 RX
F	Blue	6	RS-485 /RX
G	Violet	7	RS-485 TX
H	Grey	8	RS-485 /TX
J	White	9	RS-485 +12V
K	Black	10	RS-485 Ground

Table B-4 RS-485 Connector Pinout

APPENDIX C - DATA FILE TRANSFER TO A WINDOWS PC

Data can be downloaded to the PC either via LogView software (refer to the LogView Online Help) or via Windows HyperTerminal, which, prior to Windows Vista, was supplied with most personal computers. The steps to download the data using LogView are as follows:

C.1. Downloading Data using LogView

The steps below assume that a successful connection has been previously established between LogView and the datalogger. (See section 2.3.8 of this manual)

Click on the Collect Data button from the Main Toolbar. See Figure 18 below:

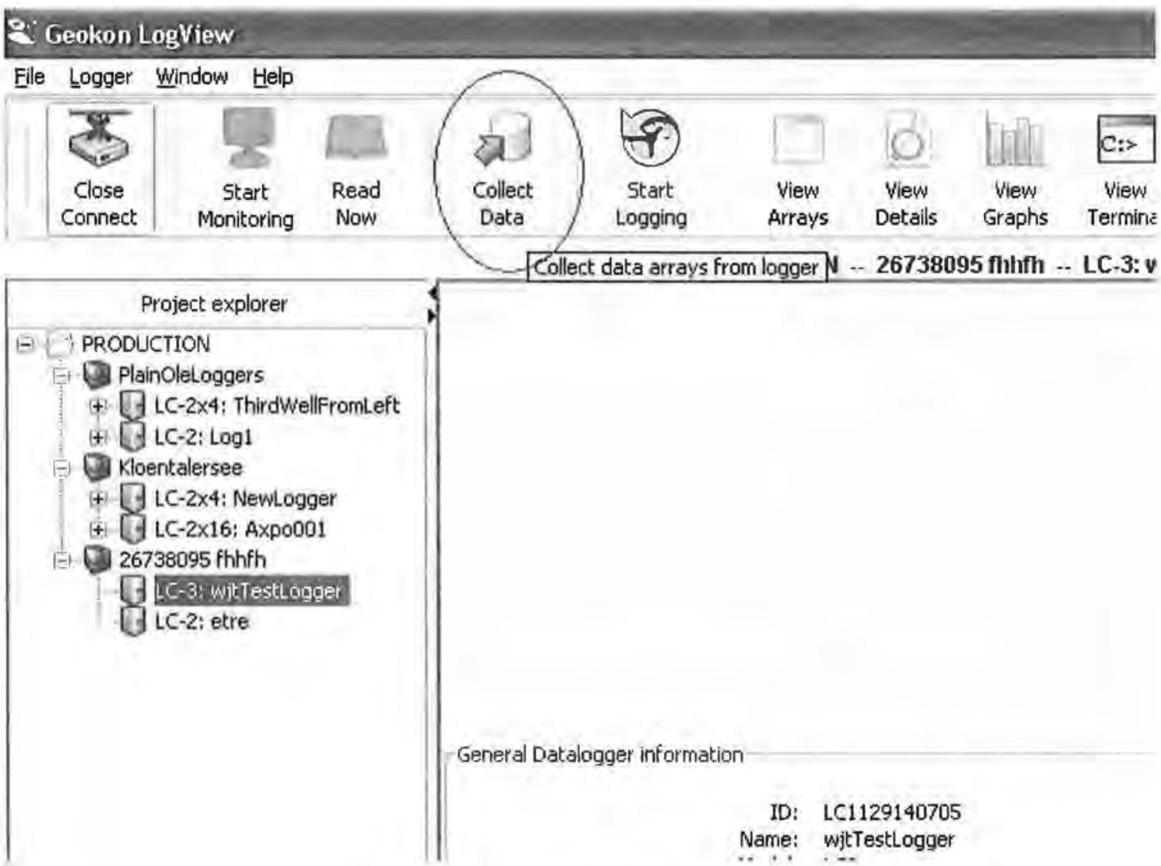

Figure 18 - LogView Collect Data Button

If the datalogger configuration is set for "Collect all data" in "Datalogger Settings→Data Collection Options" (see the LogView on-line help menu covering datalogger settings) then LogView will issue commands to the datalogger to initiate a download of all arrays logged on the datalogger. If the memory has wrapped then 10666 arrays will be downloaded starting at the current User Pointer (See sections 3.7 and 3.26 of this manual).

If the datalogger configuration is set for "Collect new data since last download" in "Datalogger Settings→Data Collection Options" then LogView will issue commands to the datalogger to initiate a download of all arrays since the last time data was downloaded.

Once the data collection has been initiated, the following progress bar (see Figure 19) will be displayed until the collection has completed:

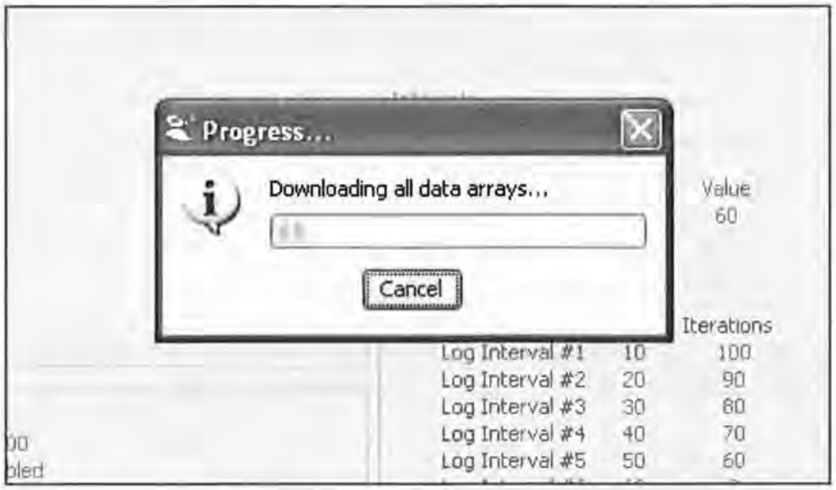

Figure 19 - Data Collection Progress Bar

After a data collection has finished LogView will display the message shown in Figure 20:

Figure 20 - Data Collection Complete Message

C.2. Downloading Data using HyperTerminal (or equivalent)

The steps to download the data using HyperTerminal are as follows:

Launch HyperTerminal: Start → Programs → Accessories → Communications → HyperTerminal

1. Enter a name for the New Connection – Select OK (see section 2.4, Figure 14, HyperTerminal Connection Description).

2. Change the Connect using setting to the appropriate COM port (in this case COM1 - see section 2.4, Figure 15, HyperTerminal Connection Selection) – Select OK.

3. In the COM Properties Dialog, enter the "Port Settings". Select Apply. Select OK (see section 2.4, Figure 16, HyperTerminal COM Port Settings).

4. With the cursor in the display screen, press the Enter key a few times to verify that communications has been established. The datalogger should return the power up prompt:

```
Hello. Press "?" for Help.
*
```

5. Upon confirmation of communications, select Transfer | Capture Text (see Figure 21):

Figure 21 - HyperTerminal Transfer Menu

6. Enter the path and name of the file you wish to create, either directly or with the Browse button, then click on the Start button (see Figure 22).

   Hint: It may be helpful to specify ".CSV" as the file extension to allow for direct formatted entry into a spreadsheet program.

Figure 22 - Specify Data Capture File

7. With the cursor in the display screen, push the <Enter> key a few times to wake-up the datalogger, then:

   Type "S" to get the Status of the datalogger.
   Type "P1" to position the data array Pointer at location 1.
   Type "D5" to Display the readings stored in memory (see Figure 23).
   Select Transfer | Capture Text | Stop.

```
*
*S
MS:5   OP:6   UP:0
4 Channel Multiplexer Selected.
Scan interval: 5 second(s).
Logging stopped.
Log intervals disabled.
Monitor mode enabled.
*P1
MS:5   OP:6   UP:1
*D5
Datalogger#1,2007,11,25,13,38,52,2.93,23.87,-9040.338,---,---,---,23.2,---,---,-
--
Datalogger#1,2007,11,25,13,38,57,2.93,23.93,-9040.222,---,---,---,23.2,---,---,-
--
Datalogger#1,2007,11,25,13,39,2,2.93,24.02,-9039.823,---,---,---,23.2,---,---,--
-
Datalogger#1,2007,11,25,13,39,7,2.93,24.10,-9040.090,---,---,---,23.2,---,---,--
-
Datalogger#1,2007,11,25,13,39,12,2.93,24.16,-9039.834,---,---,---,23.2,---,---,-
--

MS:5   OP:6   UP:6
*
```

Figure 23 - HyperTerminal/Datalogger Communication

8. The data are now stored in the specified file.

APPENDIX D - SAMPLE DATA FILE

D.1. Sample Raw Data File

Datalogger#1,2007,329,1421,0,2.93,25.01,-9040.265,---,---,---,23.7,---,---,---,1
Datalogger#1,2007,329,1421,10,2.93,25.13,-9039.986,---,---,---,23.7,---,---,---,2
Datalogger#1,2007,329,1421,20,2.93,25.42,-9039.950,---,---,---,23.7,---,---,---,3
Datalogger#1,2007,329,1421,30,2.93,25.30,-9041.042,---,---,---,23.7,---,---,---,4
Datalogger#1,2007,329,1421,40,2.93,25.16,-9040.502,---,---,---,23.7,---,---,---,5
Datalogger#1,2007,329,1421,50,2.93,25.07,-9039.458,---,---,---,23.7,---,---,---,6
Datalogger#1,2007,329,1422,0,2.93,25.04,-9040.303,---,---,---,23.7,---,---,---,7

Column: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

where;

Column 1 represents the datalogger id
Column 2 represents the year when the array was stored.
Column 3 represents the julian day (or day, month format, see section 3.5.).
Column 4 represents the time (or hh,mm format, see section 3.26.).
Column 5 represents the seconds.
Column 6 represents the main battery voltage (alkaline batteries, nominal 3.0 VDC).
Column 7 represents the internal temperature in degrees Celsius.
Column 8 represents the Channel 1 vibrating wire reading.
Column 9 represents the Channel 2 vibrating wire reading. (disabled)
Column 10 represents the Channel 3 vibrating wire reading. (disabled)
Column 11 represents the Channel 4 vibrating wire reading. (disabled)
Column 12 represents the Channel 1 external temperature in degrees Celsius.
Column 13 represents the Channel 2 external temperature in degrees Celsius. (disabled)
Column 14 represents the Channel 3 external temperature in degrees Celsius. (disabled)
Column 15 represents the Channel 4 external temperature in degrees Celsius. (disabled)
Column 16 represents the Array #

APPENDIX E - THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Resistance to Temperature Equation:

$$\mathbf{T} = \frac{1}{\mathbf{A} + \mathbf{B}(\mathbf{LnR}) + \mathbf{C}(\mathbf{LnR})^3} - 273.2$$

Equation E-1 - Convert Thermistor Resistance to Temperature

Where: T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3} (coefficients calculated over the −50 to +150° C. span)
B = 2.369×10^{-4}
C = 1.019×10^{-7}

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table E-1 - Standard Thermistor Resistance versus Temperature

Thermistor Type: Thermometrics BR55KA822J

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Equation E-2 - Convert Thermistor, Type BR55KA822J, Resistance to Temperature

Where: T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance

A = 1.02569×10^{-3}

B = 2.478265×10^{-4}

C = 1.289498×10^{-7}

Note: Coefficients calculated over -30° to +260° C. span.

Temp	R (ohms)	LnR	LnR^3	Calculated Temp	Diff	FS Error	Temp	R (ohms)	LnR	LnR^3	Calculated Temp	Diff	FS Error
-30	113898	11.643	1578.342	-30.17	0.17	0.06	120	407.62	6.010	217.118	120.00	0.00	0.00
-25	86182	11.364	1467.637	-25.14	0.14	0.05	125	360.8	5.888	204.162	125.00	0.00	0.00
-20	65805	11.094	1365.581	-20.12	0.12	0.04	130	320.21	5.769	191.998	130.00	0.00	0.00
-15	50684.2	10.833	1271.425	-15.10	0.10	0.03	135	284.95	5.652	180.584	135.00	0.00	0.00
-10	39360	10.581	1184.457	-10.08	0.08	0.03	140	254.2	5.538	169.859	140.01	-0.01	0.00
-5	30807.4	10.336	1104.068	-5.07	0.07	0.02	145	227.3	5.426	159.773	145.02	-0.02	-0.01
0	24288.4	10.098	1029.614	-0.05	0.05	0.02	150	203.77	5.317	150.314	150.03	-0.03	-0.01
5	19294.6	9.868	960.798	4.96	0.04	0.01	155	183.11	5.210	141.428	155.04	-0.04	-0.01
10	15424.2	9.644	896.871	9.98	0.02	0.01	160	164.9	5.105	133.068	160.06	-0.06	-0.02
15	12423	9.427	837.843	14.98	0.02	0.01	165	148.83	5.003	125.210	165.08	-0.08	-0.03
20	10061.4	9.216	782.875	19.99	0.01	0.00	170	134.64	4.903	117.837	170.09	-0.09	-0.03
25	**8200**	9.012	731.893	25.00	0.00	0.00	175	122.1	4.805	110.927	175.08	-0.08	-0.03
30	6721.54	8.813	684.514	30.01	-0.01	0.00	180	110.95	4.709	104.426	180.07	-0.07	-0.02
35	5540.74	8.620	640.478	35.01	-0.01	0.00	185	100.94	4.615	98.261	185.10	-0.10	-0.04
40	4592	8.432	599.519	40.02	-0.02	-0.01	190	92.086	4.523	92.512	190.09	-0.09	-0.03
45	3825.3	8.249	561.392	45.02	-0.02	-0.01	195	84.214	4.433	87.136	195.05	-0.05	-0.02
50	3202.92	8.072	525.913	50.01	-0.01	-0.01	200	77.088	4.345	82.026	200.05	-0.05	-0.02
55	2693.7	7.899	492.790	55.02	-0.02	-0.01	205	70.717	4.259	77.237	205.02	-0.02	-0.01
60	2276.32	7.730	461.946	60.02	-0.02	-0.01	210	64.985	4.174	72.729	210.00	0.00	0.00
65	1931.92	7.566	433.157	65.02	-0.02	-0.01	215	59.819	4.091	68.484	214.97	0.03	0.01
70	1646.56	7.406	406.283	70.02	-0.02	-0.01	220	55.161	4.010	64.494	219.93	0.07	0.02
75	1409.58	7.251	381.243	75.01	-0.01	0.00	225	50.955	3.931	60.742	224.88	0.12	0.04
80	1211.14	7.099	357.808	80.00	0.00	0.00	230	47.142	3.853	57.207	229.82	0.18	0.06
85	1044.68	6.951	335.915	85.00	0.00	0.00	235	43.673	3.777	53.870	234.77	0.23	0.08
90	903.64	6.806	315.325	90.02	-0.02	-0.01	240	40.533	3.702	50.740	239.69	0.31	0.11
95	785.15	6.666	296.191	95.01	-0.01	0.00	245	37.671	3.629	47.788	244.62	0.38	0.13
100	684.37	6.528	278.253	100.00	0.00	0.00	250	35.055	3.557	45.001	249.54	0.46	0.16
105	598.44	6.394	261.447	105.00	0.00	0.00	255	32.677	3.487	42.387	254.44	0.56	0.19
110	524.96	6.263	245.705	110.00	0.00	0.00	260	30.496	3.418	39.917	259.34	0.66	0.23
115	461.91	6.135	230.952	115.00	0.00	0.00							

Table E-2 - BR55KA822J Thermistor Resistance versus Temperature

Thermistor Type: U.S. Sensor 103JL1A

Resistance to Temperature Equation:

$$T = \frac{1}{A+B(LnR)+C(LnR)^3+D(LnR)^5} - 273.2$$

Equation E-3 - Convert Thermistor, Type 103JL1A, Resistance to Temperature

Where: T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
A = $1.12766979300187 \times 10^{-3}$
B = $2.34444184128213 \times 10^{-4}$
C = $8.47692130592308 \times 10^{-8}$
D = $1.17512193579615 \times 10^{-11}$

Temp	Ohms	Temp	Ohms
-30	176974	120	389.6
-25	130421	125	341.9
-20	97081	130	301
-15	72957	135	265.8
-10	55329	140	235.3
-5	42327	145	208.9
0	32650	150	186.1
5	25392	155	165.96
10	19901	160	148.36
15	15712	165	132.95
20	12493	170	119.43
25	**10000**	175	107.52
30	8057	180	97.02
35	6531	185	87.72
40	5326	190	79.49
45	4368	195	72.17
50	3602	200	65.66
55	2986	205	59.85
60	2488	210	54.65
65	2083	215	50
70	1752	220	45.82
75	1480	225	42.06
80	1255	230	38.68
85	1070	235	35.62
90	915.5	240	32.86
95	786.6	245	30.36
100	678.6	250	28.09
105	587.6	255	26.03
110	510.6	260	24.15
115	445.3		

Table E-3 - 103JL1A Thermistor Resistance versus Temperature

APPENDIX F - NETWORKING

F.1. Description

The Model LC-2x4 Datalogger is capable of being networked by way of a single, optically-isolated RS-485 communications cable. Utilizing one 8001-5 (RS-232) or 8002-5 (USB) RS-485 interface adapter at the computer (data collection) end, up to 256 Model LC-2x4 Dataloggers* may be networked. Also, the maximum network length* can be up to 4000 feet (1.22 km). RS-485 is chosen as the transmission medium due to its inherent noise immunity and it's capability to support a bus type of network architecture. The 8001-5 RS-485 interface adapter is battery powered to allow for collection of data in the field. An AC adapter is also provided if mains power is available. The 8002-5 draws its operating power from the host computer's USB 2.0 port.

Each datalogger appears as a "node" on the RS-485 bus, with its own unique address. In order to communicate with a specific datalogger, the user transmits the address of the datalogger via the #nnn command, where nnn represents the network address of the datalogger. Valid addresses are 1 thru 256.

In a RS-485 system, it is important to locate the "termination" device at the end of the bus. Make sure that circuit board jumper JP-2 (located adjacent to J5 – the COM connector cable termination on datalogger the circuit board) is positioned between pins 1 & 2 on the datalogger that is located at the farthest point on the bus from the RS-485 Interface Adapter and data collection computer. Refer to section F.2. an example of a typical communications session.

Finally, it is helpful to set the datalogger ID# to agree with the network address. This will tend to eliminate any confusion when collecting data.

For further information, refer to sections 3.10(ID), 3.21(NA), 3.22(NAddd), 3.23(ND), 3.24(NE) & 3.25(NS).

*** The total number of networked dataloggers is limited by the total network cable length. Contact a Geokon Sales Engineer for further information.**

F.2. Example of a 4 Datalogger Networking Session

1. This session assumes that there are 4 dataloggers running at 5 second scan intervals, and that each datalogger has only one channel enabled.

2. Press <ENTER> <ENTER> to wake the dataloggers from sleep. At this point, each datalogger is "listening" for its network address to be transmitted down the RS-485 bus.

3. To communicate with Datalogger #1 and observe several readings, type #1<ENTER>. Datalogger #1 returns:

```
Network address: 1
*
1,2007,11,25,16,25,0,2.98,24.6,-9040.265,---,---,---,20.5,---,---,---,34
1,2007,11,25,16,25,5,2.98,24.7,-9039.886,---,---,---,20.4,---,---,---,35
1,2007,11,25,16,25,10,2.98,24.7,-9040.028,---,---,---,20.5,---,---,---,36
*E
```

   Note that the datalogger ID, which is the first entry for each ASCII character string, corresponds to the network address. **This should be set by the user during initial datalogger setup via the ID command.**

   Typing E<ENTER> puts the datalogger back to sleep and disconnects it from the RS-485 bus. The datalogger will continue to wake up periodically (scan rate setting) to take a data reading. **The E command must be used in order to disconnect from the current datalogger and allow connection to the next datalogger.**

4. To communicate with Datalogger #2 and observe several readings, type <ENTER> <ENTER>to wake the dataloggers and then type #2<ENTER>. Datalogger #2 returns:

```
Network address: 2
*
2,2007,11,25,16,25,25,2.95,24.7,-360.112,---,---,---,20.4,---,---,---,27
2,2007,11,25,16,25,30,2.96,24.7,-360.155,---,---,---,20.4,---,---,---,28
*E
```

5. Doing the same for Datalogger numbers 3 & 4 results in:

```
Network address: 3
*
3,2007,11,25,16,30,0,2.98,24.7,9091.346,---,---,---,20.5,---,---,---,25
3,2007,11,25,16,30,5,2.98,24.7,9091.400,---,---,---,20.5,---,---,---,26
*E

Network address: 4
*
4,2007,11,25,16,31,26,2.96,24.8,-8457.811,---,---,---,20.4,---,---,---,20
4,2007,11,25,16,31,31,2.96,24.8,-8456.978,---,---,---,20.4,---,---,---,21
*E
```

APPENDIX G – Lithium Coin Cell

G.1. Description:

Under normal operating conditions, the 1.5V 'D' cells provide all the power required to operate the LC-2x4 datalogger. In order to maintain the correct date and time settings for those periods when the 'D' cells are removed, the LC-2x4 datalogger incorporates a 3V lithium coin cell (Panasonic CR2032) to supply operating current to the internal Real Time Clock.

Since the power requirements of the Real Time Clock circuit are minimal (3μA max.), the clock will continue to operate for up to 10 years under these conditions.

However, if the lithium cell voltage falls to 2.5V or less, it should be replaced using the following replacement procedure.

G.2. Replacement Procedure:

Materials Required:

1/4" Slotted Screwdriver
1/8" Slotted Screwdriver
1/4" Nutdriver
CR2032 Lithium Coin Cell (Geokon P/N BAT-115)
Disposable Grounding Wrist Strap (3M P/N 2209 or equivalent)

Procedure:

1. Put on the disposable grounding wrist strap and connect to a good earth ground.
2. Using the 1/4" slotted screwdriver, loosen the (4) captive screws and remove the datalogger cover.
3. Remove the two 'D' cells.
4. Using the 1/4" slotted screwdriver, remove the (4) 3/8" 6x32 battery plate mounting screws.
5. Lift up the battery plate and disconnect the 2 wire Molex connector from the header labeled "3V" ("12V" if applicable)
6. Using the 1/4" nutdriver, remove the (4) standoffs securing the printed circuit board to the case.
7. Lift the printed circuit board up to expose the bottom of the circuit board.
8. Using the 1/8" slotted screwdriver, gently pry the lithium coin cell battery from the battery holder.
9. Insert the replacement lithium coin cell into the battery holder (+ side facing out).
10. Re-install the printed circuit board back into the case.
11. Thread the (4) standoffs onto the set screws, using the nutdriver to gently tighten the standoffs.

12. Reconnect the 2 wire Molex connector to the header labeled "3V" ("12V" if applicable).
13. Position the battery plate over the standoffs and re-install using the (4) 3/8" 6x32 battery plate mounting screws.
14. Re-install the 'D' cells.
15. Re-install the datalogger cover.

Lithium coin cell replacement complete.

Appendix B

Instruction Manual Model 4500 Series
Vibrating Wire Piezometers

GEOKON The World Leader in Vibrating Wire Technology

48 Spencer Street
Lebanon, NH 03766, USA
Tel: 603•448•1562
Fax: 603•448•3216
E-mail: geokon@geokon.com
http://www.geokon.com

Instruction Manual

Model 4500

series
Vibrating Wire Piezometers

(Doc Rev Z 2/16)

Warranty Statement

Geokon, Inc. warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by Geokon, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of Geokon's control. Components which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

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LIST of FIGURES, TABLES and EQUATIONS

1. THEORY OF OPERATION

Geokon Model 4500 Vibrating Wire Piezometers are intended primarily for long-term measurements of fluid and/or pore pressures in standpipes, boreholes, embankments, pipelines and pressure vessels. Several models of the 4500 series are available (see Appendix A). Contact Geokon sales engineers for specific application information.

The instrument utilizes a sensitive stainless steel diaphragm to which a vibrating wire element is connected. See Figure 1-1. In use, changing pressures on the diaphragm cause it to deflect, and this deflection is measured as a change in tension and frequency of vibration of the vibrating wire element. The square of the vibration frequency is directly proportional to the pressure applied to the diaphragm. Two coils, one with a magnet, another with a pole piece, are located close to the wire. In use, a pulse of varying frequency (swept frequency) is applied to the coils and this causes the wire to vibrate primarily at its resonant frequency. When excitation ends the wire continues to vibrate and a sinusoidal AC electrical signal, at the resonant frequency, is induced in the coils and transmitted to the readout box where it is conditioned and displayed.

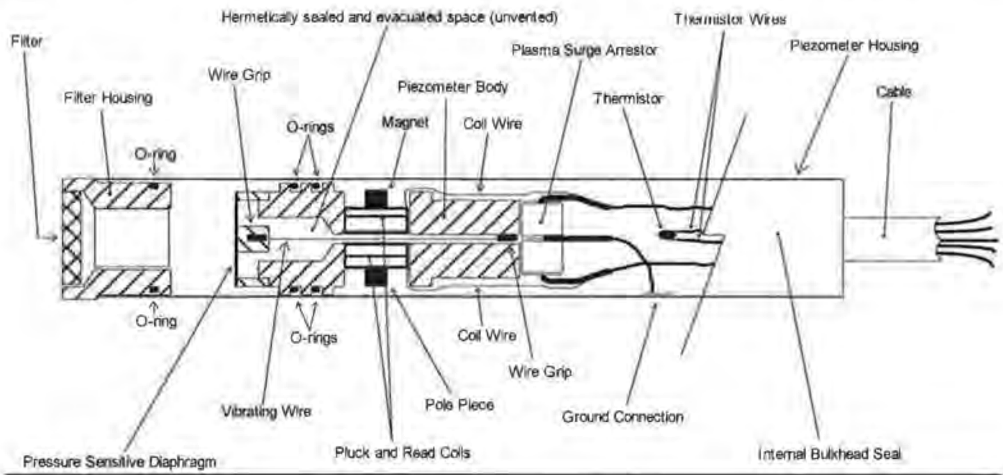


Figure 1-1 Vibrating Wire Piezometer

To prevent damage to the sensitive diaphragm a filter is used to keep out solid particles. Figure 1-1 illustrates. Standard filters are 50 micron stainless steel; high air entry value tips are available on request.

All exposed components are made of corrosion resistant stainless steel and, if proper installation techniques are used, the device should have an unlimited life. In salt water it may be necessary to use special materials for the diaphragm and housing.

Portable readout units are available to provide the excitation, signal conditioning and readout of the instrument. Datalogging systems are also available for remote unattended data collection of multiple sensors. Contact Geokon for additional information.

Calibration data are supplied with each piezometer for conversion of gage readings to engineering units such as pressure or level. See Section 4.

2. INSTALLATION

(For Quick Installation Instructions see AppendixE)

2.1 Preliminary Tests

Upon receipt of the piezometer the zero reading should be checked and noted (see Sections 3.1 to 3.3 for readout instructions). A thermistor is included inside the body of the piezometer (Figure 1-1) for the measurement of temperature (see Section 3.4 for instructions).

Calibration data are supplied with each gage and a zero reading, at a specific temperature and barometric pressure, is included. Zero readings at the site should coincide with the calibration zero readings within +/- 50 digits after barometric and temperature corrections are made. The factory elevation is +580 ft. all stated barometric readings represent absolute pressure uncorrected for height above sea level. (Barometric pressure changes with elevation at a rate of ≈½ psi per 1,000 ft.) See Figure 4, for a sample calibration sheet.

2.1.1 Establishing an Initial Zero Reading

Vibrating Wire Piezometers differ from other types of pressure sensors in that they indicate a reading at zero pressure. **Therefore it is imperative that an accurate initial zero pressure reading be obtained for each piezometer as this reading will be used in all subsequent data reduction.**

There are different ways of doing this but the essential element in all methods is that the piezometer be allowed to thermally stabilize in a constant temperature environment while the pressure on the piezometer is barometric only. Because of the way the piezometer is constructed it takes about 5 to 15 minutes for the temperature of all the different elements to equalize.

It will be necessary to measure the barometric pressure only if the piezometer is un-vented and if it will be installed in a location that is subject to barometric pressure changes that require correction, such as in an open well. *A piezometer sealed in place at depth could be recording pressures in groundwater that is not hydraulically connected to the atmosphere, and, for which, barometric pressure compensation would be inappropriate.*

The recommended way to take a zero reading and achieve temperature stability is to first pull off the standard filter stone and fill the inside of the piezometer with water then replace the filter stone. (In the case of HAE filter stones see section 2.6). Hang the piezometer in the borehole at a point just above the water and wait until the piezometer reading has stopped changing. Now take the zero reading and read the temperature, indicated by the thermistor inside the piezometer.

Another way is to place the piezometer under water in a bucket and allow 5 to 15 minutes for the temperature to stabilize, then lift the piezometer out of the water and immediately take a reading. When doing this, lift the piezometer by the cable only, do not handle the piezometer housing as body heat from the hand could cause temperature transients. Use the thermistor inside the piezometer to measure the water temperature.

Another way is to simply read the piezometer while in the air while making sure that the temperature has had time to stabilize. If this method is chosen be sure that the piezometer is protected from sunlight or sudden changes of temperature: Wrapping it in some insulating material is recommended.

Yet another way is to lower the piezometer to a known depth as marked out on the piezometer cable, (The diaphragm inside the piezometer is located approximately ¾ inch (15mm), from the tip. Then use a dip meter to accurately measure the depth to the water surface. Now, after temperature stabilization, read the piezometer pressure and, using the factory calibration constants and a knowledge of the pressure (height x density) of the water column above the piezometer, calculate either the equivalent zero pressure reading, if the linear regression is used, or the factor, C, if the second order polynomial is used.

A question may arise as to what to do with the filter stone while taking zero readings. If a standard stainless steel filter is being used, it will not matter if the filter stone is saturated or not. But if ceramic high air entry filter stone is in use then it must be saturated while taking the zero readings and must not be allowed to dry out to the extent that surface tension effects can affect the zero reading. For more details see section 2.6.

Caution. – do not allow the piezometer to freeze once it has been filled with water.

2.1.2 checking the piezometer performance

If a rough check on the piezometer performance is needed then the following procedure is recommended

1. Lower the piezometer to a point near the bottom of a water-filled borehole, or below the surface of a body of water.

2. Allow 15-20 minutes for the piezometer to come to thermal equilibrium. Using a readout box record the reading at that level.

3. Raise the piezometer by a measured depth increment. Record the reading on the readout box at the new depth..

4, Using the factory calibration factor calculate the change in water depth and compare the calculated change in depth with the measured depth increment. The two values should be roughly the same.

There are a couple of things that can affect this checking procedure:

- The density of the in-situ water may not be 1gm/cc if it is saline or turbid.
- **The water level inside the borehole may vary during the test due to the displacement of the water level as the cable is raised and lowered in the borehole**. This effect will be greater where the borehole diameter is smaller. For example, a Model 4500S-50 piezometer lowered 50 feet below the water column in a 1 inch (.875 inch ID) standpipe will displace the water level by more than 4 feet!
- Alternatively if a dip-meter is available, lower the piezometer tip to a measured depth below the water surface, allow the temperature to stabilize then take a reading. Calculate the elevation of the water surface using the given calibration factor. Compare this to the elevation measured using the dip-meter..

2.2 Installation in Standpipes or Wells

- A zero reading is first established (follow the procedures outlined in Section 2.1.1). The filter stone is saturated (follow the procedures in Section 2.6). Make a mark on the cable which will lie opposite the top of the standpipe, (well), when the piezometer has reached the desired depth. (The piezo diaphragm lies ¾ inch above the tip of the piezo).

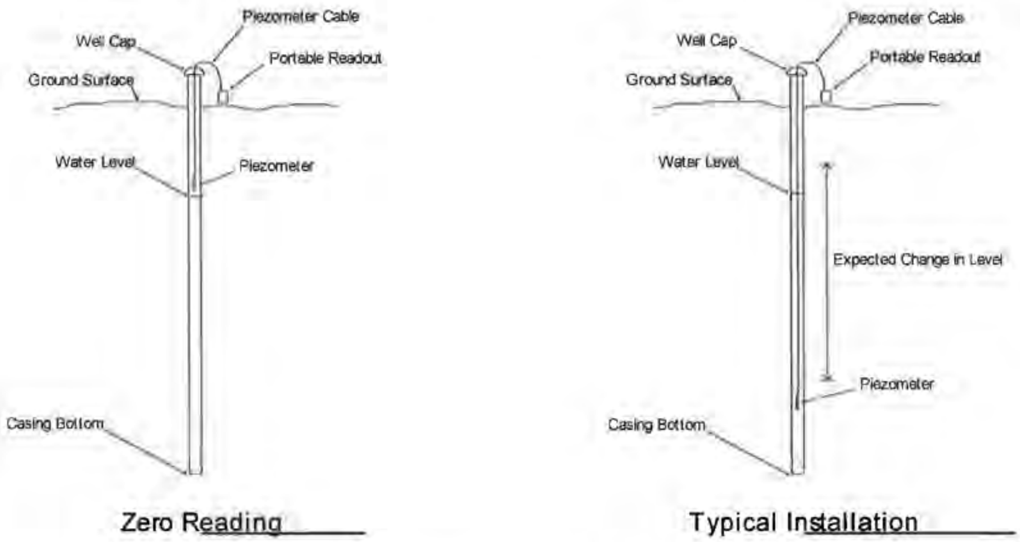


Figure 2-1 Typical Level Monitoring Installations

Be sure the cable is securely fastened at the top of the well or readings could be in error due to slippage of the piezometer into the well.

It is not recommended that piezometers be installed in wells or standpipes where an electrical pump and/or cable is present or nearby. Electrical interference from these sources can cause unstable readings. If unavoidable, it is recommended that the piezometer be placed inside a piece of steel pipe.

In situations where packers are used in standpipes the same sequence as above should be noted and special care should be taken to avoid cutting the cable jacket with the packer since this could introduce a possible pressure leakage path.

2.3 Installation in Boreholes

Geokon piezometers can be installed in boreholes in either single or multiple installations per hole, in cased or uncased holes. See Figure 2-2. Careful attention must be paid to borehole sealing techniques if pore pressures in a particular zone are to be monitored.

Boreholes should be drilled either without drilling mud or with a material that degrades rapidly with time, such as Revert™. The hole should extend from 6 inches to 12 inches below the proposed piezometer location and should be washed clean of drill cuttings. The bottom of the borehole should then be backfilled with clean fine sand to a point 6 inches below the piezometer tip. The piezometer can then be lowered, as delivered, into position. Preferably, the piezometer may be encapsulated in a canvas-cloth bag containing clean, saturated sand and then lowered into position. While holding the instrument in position (a mark on the cable is helpful) clean sand should be placed around the piezometer and to a point 6 inches above it. Figure 2-2 details two methods of isolating the zone to be monitored.

Installation A

Immediately above the "collection zone" the borehole should be sealed with either alternating layers of bentonite and sand backfill tamped in place for approximately 1 foot followed by common backfill or by an impermeable bentonite-cement grout mix. If multiple piezometers are to be used in a single hole the bentonite-sand plugs should be tamped in place below and above the upper piezometers and also at intervals between the piezometer zones. When designing and using tamping tools special care should be taken to ensure that the piezometer cable jackets are not cut during installation.

Installation B

Immediately above the "collection zone" the borehole should be filled with an impermeable bentonite grout.

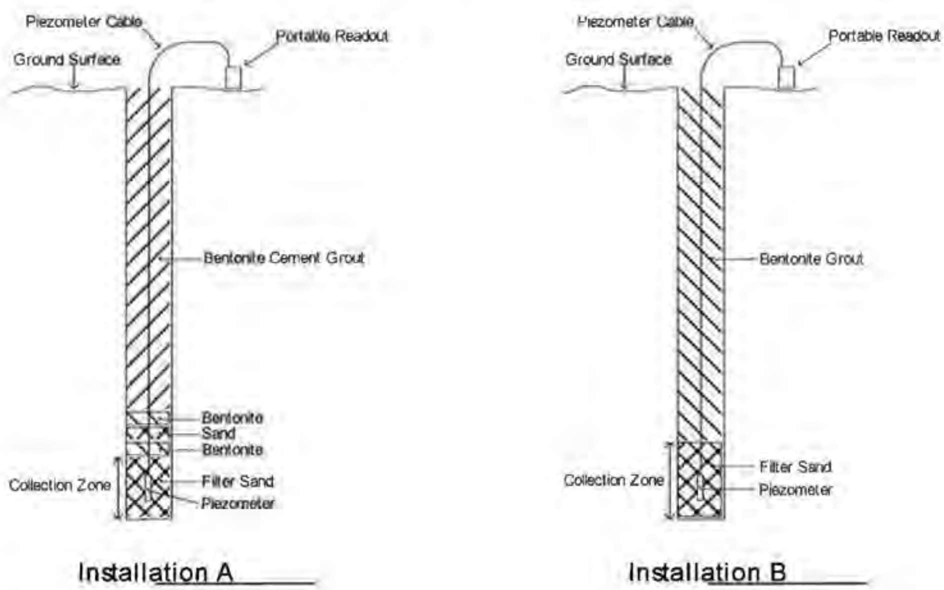


Figure 2-2 Typical Borehole Installations

Installation C

It should be noted that since the vibrating wire piezometer is basically a no-flow instrument, collection zones of appreciable size are not required and the piezometer can, in fact, be placed directly in contact with most materials provided that the fines are not able to migrate through the filter. The latest thinking, *(Mikkelson and Green, Piezometers in Fully Grouted Boreholes.Proceedings of FMGM 2003, Field Measurements in Geomechanics, Oslo, Norway, Sept. 2003. Contact Geokon for a copy of this paper)*, is that it is not necessary to provide sand zones and that the piezometer can be grouted directly into the borehole using a bentonite cement grout only. However, good results have been obtained by first placing the piezometer inside a canvas bag before grouting.

The general rule for installing piezometers in this way is to use a bentonite grout that mimics the strength of the surrounding soil. The emphasis should be on controlling the water-cement ratio. This is accomplished **by mixing the cement with the water first.** The most effective way of mixing is in a 50 to 200 gallon barrel or tub using the drill-rig pump to circulate the mix. Any kind of bentonite powder used to make drilling mud, combined with Type 1 or 2 Portland cement can be used. The exact amount of bentonite added will vary somewhat. The table below shows two possible mixes for strengths of 50 psi and 4 psi.
Add the measured amount of clean water to the barrel then gradually add the cement in the correct weight ratio. Next add the bentonite powder, slowly, so clumps do not form. Keep adding bentonite until the watery mix turns to an oily/slimy consistency. Let the grout thicken for another five to ten minutes. Add more bentonite as required until it is a smooth thick cream like pancake batter. It is now as heavy as it is feasible to pump. When pumping grout, unless the tremie-pipe is to be left in place, withdraw the tremie-pipe after each batch, by an amount corresponding to the grout level in the borehole. Caution: if the grout is pumped into the hole, rather than tremied, there is a danger that the piezometer will be over-ranged and damaged., So pumping direct into the bottom of the borehole should be avoided. It is good practice to read the piezometer while pumping.

Application	**Grout for Medium to Hard Soils**		**Grout for Soft Soils**	
Materials	Weight	Ratio by Weight	Weight	Ratio by Weight
Water	30 gallons	2.5	75 gallons	6.6
Portland Cement	94 lbs (1 sack)	1	94 lbs (1 sack)	1
Bentonite	25 lbs (as required)	0.3	39 lbs (as required)	0.4
Notes	The 28 day compressive strength of this mix is about 50 psi, similar to very stiff to hard clay. The modulus is about 10,000 psi		The 28 day strength of this mix is about 4psi, similar to very soft clay.	

Table 1 showing Cement/Bentonite/Water ratios for two grout mixes.

(For more details on this method of installation ask for a copy of the FMGM paper)

2.4 Installation in Fills and Embankments

Geokon piezometers are normally supplied with direct burial cable suitable for placement in fills such as highway embankments and dams, both in the core and in the surrounding materials.

In installations in non-cohesive fill materials the piezometer may be placed directly in the fill or, if large aggregate sizes are present, in a saturated sand pocket in the fill. If installed in large aggregate, additional measures may be necessary to protect the cable from damage.

In fills such as impervious dam cores where sub-atmospheric pore water pressure may need to be measured (as opposed to the pore air pressure) a ceramic tip with a high air entry value is often used which should be carefully placed in direct contact with the compacted fill material (see Installation A of Figure 2-3). In partially saturated fills if only the pore air pressure is to be measured, the standard tip is satisfactory. It should be noted that the coarse tip measures the air pressure when there is a difference between the pore air pressure and the pore water pressure, and that the difference between the two pressures is due to the capillary suction in the soil. The general consensus is that the difference is normally of no consequence to embankment stability. As a general rule the coarse (low air entry) tip is suitable for most routine measurements and, in fine cohesive soils, sand pockets should not be used around the piezometer tip (see Installation B of Figure 2-3). In high traffic areas and in material which exhibit pronounced "weaving", a heavy-duty armored cable should be used.

Cables are normally installed inside shallow trenches with the fill material consisting of smaller size aggregate. This fill is carefully hand compacted around the cable. Bentonite plugs are placed at regular intervals to prevent migration of water along the cable path.

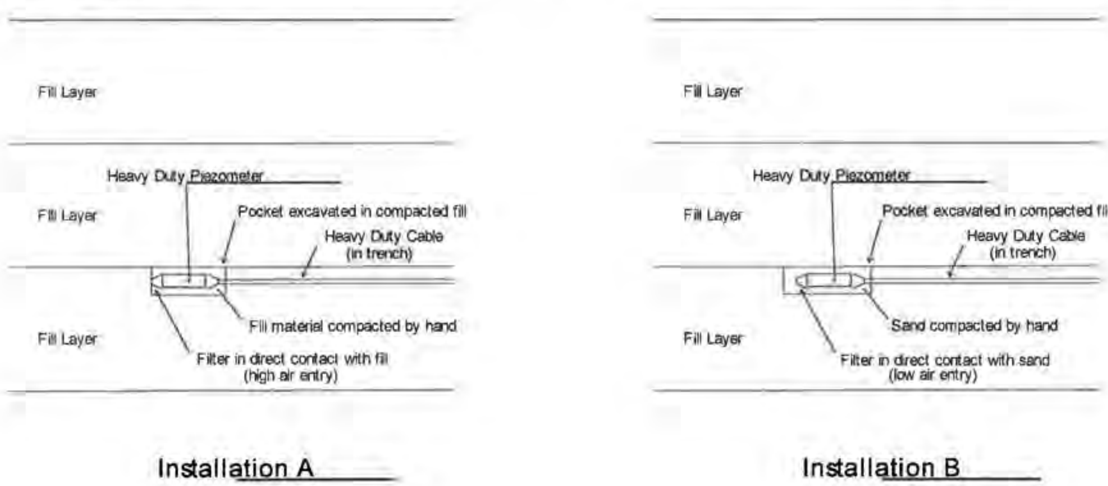


Figure 2-3 Typical Dam Installations

2.5 Installation by Pushing or Driving into Soft Soils

The Model 4500DP piezometer is designed for pushing into soft soils. See Figure 2-4. The unit is connected directly to the drill rod (AW, EW or other) and pressed into the ground either by hand or by means of the hydraulics on the rig. The units can also be driven but the possibility of a zero shift due to the driving forces exists.

A good rule of thumb is that the ground conditions need to be relatively soft for the 4500DP. Soft soils like clays or silts with SPT blow counts under 10 are suitable. The idea with push-in stuff is that in soft soils it can be difficult to keep a borehole open so the push-in may eliminate the need for a borehole. In stiffer soils one technique is to drill a hole and then push the 4500DP only a few feet below the bottom of the hole but again if the soil is stiff you risk breaking the sensor or at the very least over-ranging it.

The piezometer should be connected to the readout box and monitored during the driving process. If measurement pressures reach or exceed the calibrated range, the driving should be stopped and the pressures allowed to dissipate before continuing.

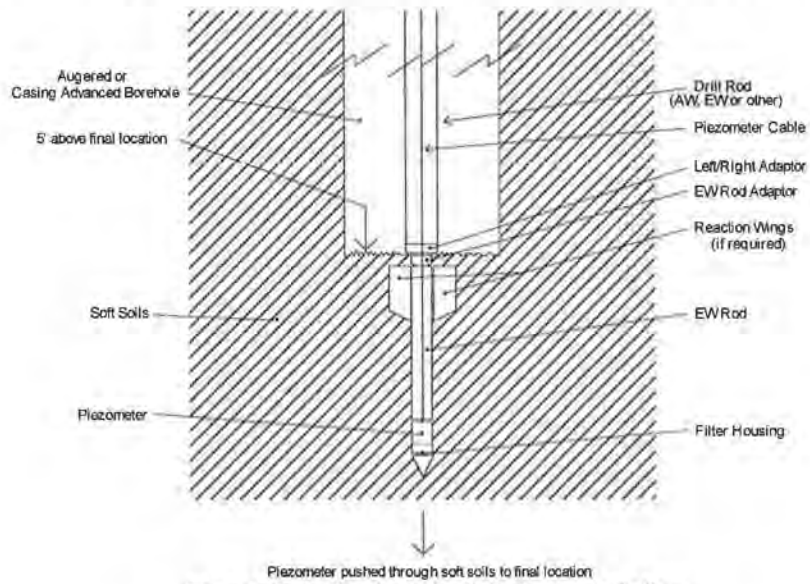


Figure 2-4 Typical Soft Soils Installation

The drill rod can be left in place or it can be removed. If it is to be removed then a special 5 foot section of EW (or AW) rod with wings and a left hand thread are attached directly to the piezometer tip. This section is detached from the rest of the drill string by rotating the string clockwise. The left hand thread will then loosen. The wings prevent the special EW rod from turning. A special LH/RH adapter is available from Geokon. The adapter is retrieved along with the drill string.

2.6 De-airing Filter Tips

Caution. – do not allow the piezometer to freeze once it has been filled with water. Most Geokon filter tips can be removed for saturating and re-assembly. The procedures are as follows:

2.6.1 Low Air Entry Filter, Model 4500S and 4500PN

For accurate results, total saturation of the filter is necessary. For the low air entry filter normally supplied, this saturation occurs as the tip is lowered into the water. Water is forced into the filter, compressing the air in the space between the filter stone and the pressure sensitive diaphragm. After a period of time, this air will dissolve into the water until the space and the filter is entirely filled with water. To speed up the saturation process, remove the filter assembly and fill the space above the diaphragm with water, then slowly replace the filter housing allowing the water to squeeze through the filter stone. With low pressure range piezometers (<10 psi) take readings with a readout box while pushing the filter housing on so as not to over-range the sensor.

To maintain saturation, the unit should be kept under water until installation.

If the 4500S piezometer is to be used in standpipes and raised and lowered many times the filter may loosen. A permanent filter assembly may be required. The removable filter may be fixed permanently by prick punching the piezometer tube approximately 1/16" to 1/8" behind the filter assembly joint.

Screens are also available for standpipe installations. Screens are less likely than standard filters to become clogged where salts in the water can be deposited if the filter is allowed to dry out completely.

2.6.2 Removable Ceramic Filter, Model 4500S

The ceramic filter on the 4500S piezometer is also removable for de-airing. Because of the high air entry characteristics, de-airing is particularly important for this filter assembly. Filters with different air entry values require different procedures.

1 Bar Filters

1. Remove the filter from the piezometer by carefully twisting and pulling on the filter housing assembly.
2. Boil the filter assembly in de-aired water.
3. Re-assemble the filter housing and piezometer under the surface of a container of de-aired water. Be sure that no air is trapped in the transducer cavity. While pushing the filter on use a readout box to monitor the diaphragm pressure. Allow over-range pressure to dissipate before pushing further.
4. To maintain saturation, the unit should remain immersed until installation.

2 Bar and Higher

The proper procedure for de-airing and saturating these filters is somewhat complex and should be done either at the factory by Geokon or by carefully following the instructions below:

1. Place the assembled piezometer, filter down, in a vacuum chamber with an inlet port at the bottom for de-aired water.
2. Close off the water inlet and evacuate the chamber. The transducer should be monitored while the chamber is being evacuated.
3. When the maximum vacuum has been achieved, allow de-aired water to enter the chamber and reach an elevation a few inches above the piezometer filter.
4. Close off the inlet port. Release the vacuum.
5. Observe the transducer output. It will take as long as 24 hours for the filter to completely saturate (5 bar) and the pressure to rise to zero.
6. After saturation the transducer should be kept in a container of de-aired water until installation. If de-aired at the factory a special cap is applied to the piezometer to maintain saturation.

2.6.3 Model 4500DP

The 4500 Drive Point is de-aired in the same way as the above models by first unscrewing the point of the piezometer assembly and then following the instruction for the 4500S.

2.7 Model 4500H and Model 4500HH Transducer

These transducers are for use with high temperatures up to 250 degrees C.

When connecting the Model 4500H transducer to external fittings, the fitting should be tightened into the ¼ - 18NPT female port., with a wrench on the flats provided on the transducer housing. Also, avoid tightening onto a closed system since the process of tightening the fittings could over-range and permanently damage the transducer. If in doubt, attach the gage leads to the readout box and take readings while tightening. Teflon tape on the threads makes for easier and more positive connection to the transducer. The maximum pressure is 3MPa.

The Model 4500HH is for extra high pressures and uses a 7/16-20, 60 degree, female, medium pressure fitting. The maximum pressure is 75MPa.

Both models, 4500H and 4500HH use a high temperature thermistor, (see Appendix C),

CAUTION: All high pressure sensors are potentially dangerous and care must be taken not to over-range them beyond their calibrated range. Sensors are tested to 150% of the range to provide a factor of safety.

2.8 Splicing and Junction Boxes

Because the vibrating wire output signal is a frequency rather than current or voltage, variations in cable resistance have little effect on gage readings and, therefore, splicing of cables has no effect either and, in some cases, may be beneficial. For example, if multiple piezometers are installed in a borehole, and the distance from the borehole to the terminal box or datalogger is great, a splice (or junction box, see Figure 2-6) could be made to connect the individual cables to a single multi-conductor cable. This multi-conductor cable would then be run to the readout station. For such installations it is recommended that the piezometer be supplied with enough cable to reach the installation depth plus extra cable to pass through drilling equipment (rods, casing, etc.). The cable used for making splices should be a high quality twisted pair type with 100% shielding (with integral shield drain wire). When splicing, it is very important that the shield drain wires be spliced together! Splice kits recommended by Geokon incorporate casts placed around the splice then filled with epoxy to waterproof the connections. When properly made, this type of splice is equal or superior to the cable itself in strength and electrical properties. Contact Geokon for splicing materials and additional cable splicing instructions.

Junction boxes and terminal boxes are available from Geokon for all types of applications. In addition, portable readout equipment and datalogging hardware are available. See Figure 2-5. Contact Geokon for specific application information.

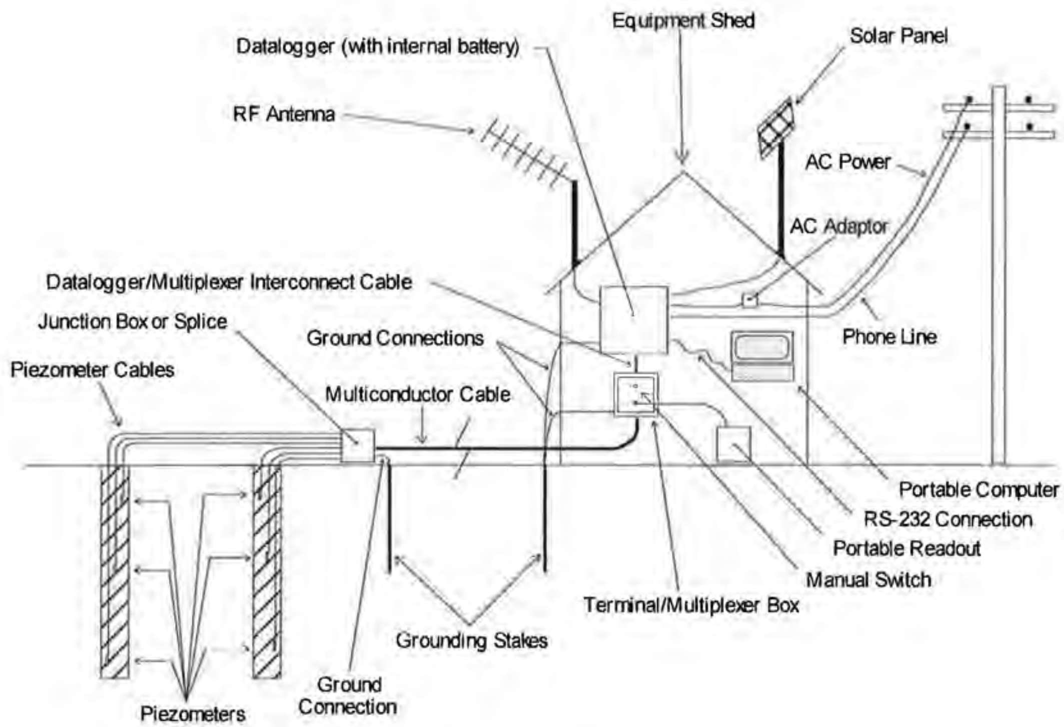


Figure 2-5 Typical Multi-Piezometer Installation

2.9 Lightning Protection

In exposed locations it is vital that the piezometer be protected against lightning strikes.

A tripolar plasma surge arrestor (Figure 1-1) is built into the body of the piezometer and protects against voltage spikes across the input leads. Following are additional lightning protection measures available;

1. If the instruments will be read manually with a portable readout (no terminal box) a simple way to help protect against lightning damage is to connect the cable leads to a good earth ground when not in use. This will help shunt transients induced in the cable to ground thereby protecting the instrument.

2. Terminal boxes available from Geokon can be ordered with lightning protection built in. There are two levels of protection;

   - The terminal board used to make the gage connections has provision for installation of plasma surge arrestors (similar to the device inside the piezometer).

   - Lightning Arrestor Boards (LAB-3) can be incorporated into the terminal box. These units utilize surge arrestors and transzorbs to further protect the piezometer.

   In the above cases the terminal box would be connected to an earth ground.

3. Improved protection using the LAB-3 can be had by placing the board in line with the cable as close as possible to the installed piezometer (see Figure 2-6). This is the recommended method of lightning protection.

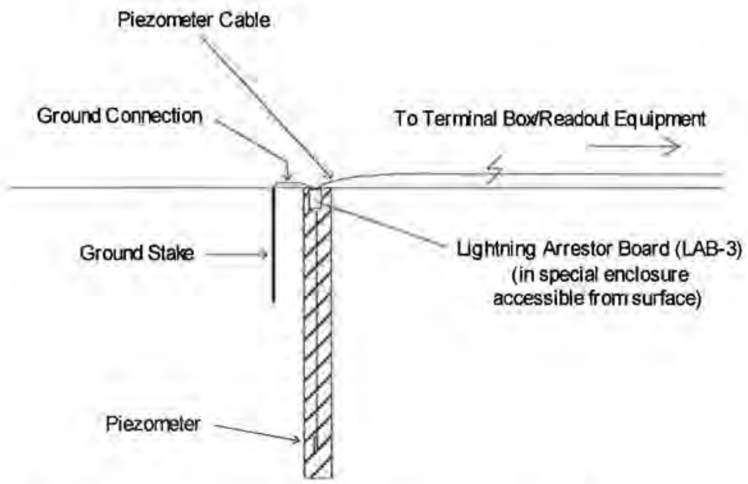


Figure 2-6 Recommended Lightning Protection Scheme

3. TAKING READINGS

3.1 Operation of the GK-403 Readout Box

The GK-403 can store gage readings and also apply calibration factors to convert readings to engineering units. Consult the GK-403 Instruction Manual for additional information on Mode "G" of the Readout. The following instructions will explain taking gage measurements using Modes "B" and "F" (similar to the GK-401 switch positions "B" and "F").

Connect the Readout using the flying leads or in the case of a terminal station, with a connector. The red and black clips are for the vibrating wire gage, the white and green leads are for the thermistor and the blue for the shield drain wire.

1. Turn the display selector to position "B" (or "F"). Readout is in digits (Equation 4-1).

2. Turn the unit on and a reading will appear in the front display window. The last digit may change one or two digits while reading. Press the "Store" button to record the value displayed. If the no reading displays or the reading is unstable see section 5 for troubleshooting suggestions. The thermistor will be read and output directly in degrees centigrade.

3. The unit will automatically turn itself off after approximately 2 minutes to conserve power.

3.2 Operation of the GK-404 Readout Box

The GK404 is a palm sized readout box which displays the Vibrating wire value and the temperature in degrees centigrade.
The GK-404 Vibrating Wire Readout arrives with a patch cord for connecting to the vibrating wire gages. One end will consist of a 5-pin plug for connecting to the respective socket on the bottom of the GK-404 enclosure. The other end will consist of 5 leads terminated with alligator clips. Note the colors of the alligator clips are red, black, green, white and blue. The colors represent the positive vibrating wire gage lead (red), negative vibrating wire gage lead (black), positive thermistor lead (green), negative thermistor lead (white) and transducer cable drain wire (blue). The clips should be connected to their respectively colored leads from the vibrating wire gage cable.

Use the **POS** (Position) button to select position **B** and the MODE button to select **Dg** (digits).
Other functions can be selected as described in the GK404 Manual.

The GK-404 will continue to take measurements and display the readings until the OFF button is pushed, or if enabled, when the automatic Power-Off timer shuts the GK-404 off.
The GK-404 continuously monitors the status of the (2) 1.5V AA cells, and when their combined voltage drops to 2V, the message **Batteries Low** is displayed on the screen. A fresh set of 1.5V AA batteries should be installed at this point

3.3 Operation of the GK-405 Readout Box

The GK-405 Vibrating Wire Readout is made up of two components:

- the Readout Unit, consisting of a Windows Mobile handheld PC running the GK-405 Vibrating Wire Readout Application
- the GK-405 Remote Module which is housed in a weather-proof enclosure and connects to the vibrating wire sensor by means of:

1) Flying leads with alligator type clips when the sensor cable terminates in bare wires or,
2) by means of a 10 pin connector..

The two components communicate wirelessly using Bluetooth®, a reliable digital communications protocol. The Readout Unit can operate from the cradle of the Remote Module (see Figure 3.1) or, if more convenient, can be removed and operated up to 20 meters from the Remote Module

Figure 3-1 GK405 Readout Unit

For further details consult the GK405 Instruction Manual.

3.4 Measuring Temperatures

Each vibrating wire piezometer is equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. Usually the white and green leads are connected to the internal thermistor. High temperature versions use a different thermistor than the standard versions.
The GK-403, GK404 and GK 405 readout boxes when used with the **standard** temperature thermistor will display the temperature in °C automatically. They will **not** do this with high temperature thermistors. The GK 401 readout box will not read temperatures directly, instead an ohmmeter must be used.

1. Connect the ohmmeter to the two thermistor leads coming from the piezometer. (Since the resistance changes with temperature are so large, the effect of cable resistance is usually insignificant. For long cables a correction can be applied – equal to 16 ohms per thousand feet.)

2. For standard temperature models, look up the temperature for the measured resistance in Table B-1.Page 21 Alternately the temperature could be calculated using Equation B-1. For high temperature models use Table C1 or the equation C1 given on page 22.

4. DATA REDUCTION

4.1 Pressure Calculation

The digits displayed by the Geokon Models GK-403, GK-404 or GK-405 Readout Boxes on channel B are based on the equation

$$\text{Digits} = \left(\frac{1}{\text{Period}}\right)^2 \times 10^{-3} \quad \text{or} \quad \text{Digits} = \frac{\text{Hz}^2}{1000}$$

Equation 4-1 Digits Calculation

For example, a piezometer reading 8000 digits corresponds to a period of 354μs and a frequency of 2828 Hz. Note that in the above equation, the period is in seconds: the readout boxes display microseconds.
Since digits are directly proportional to the applied pressure,

Pressure = (Current Reading - Initial Reading) × Linear Calibration Factor

or

$$\mathbf{P = (R_1 - R_0) \times G}$$

Equation 4-2 Convert Digits to Pressure

Since the linearity of most sensors is within □ 0.2% FS the errors associated with non-linearity are of minor consequence. However, for those situations requiring the highest accuracy it may be desirable to use a second order polynomial to get a better fit of the data points. The use of a second order polynomial is explained in Appendix D.

The calibration sheet, a typical example of which is shown in Figure 4, shows the data from which the linear gage factor and the second order polynomial coefficients are derived. Columns on the right show the size of the error incurred by assuming a linear coefficient and the improvement which can be expected by going to a second order polynomial . In many cases the difference is minor. The calibration sheets gives the pressure in certain engineering units. These can be converted to other engineering units using the multiplication factors shown in Table 4-1 below.

From → To ↓	psi	"H_2O	'H_2O	mm H_20	m H_20	"HG	mm HG	atm	mbar	bar	kPa	MPa
psi	1	.036127	.43275	.0014223	1.4223	.49116	.019337	14.696	.014503	14.5039	.14503	145.03
"H_2O	27.730	1	12	.039372	39.372	13.596	.53525	406.78	.40147	401.47	4.0147	4016.1
'H_2O	2.3108	.08333	1	.003281	3.281	1.133	.044604	33.8983	.033456	33.4558	.3346	334.6
mm H_20	704.32	25.399	304.788	1	1000	345.32	13.595	10332	10.197	10197	101.97	101970
m H_20	.70432	.025399	.304788	.001	1	.34532	.013595	10.332	.010197	10.197	.10197	101.97
"HG	2.036	.073552	.882624	.0028959	2.8959	1	.03937	29.920	.029529	29.529	.2953	295.3
mm HG	51.706	1.8683	22.4196	.073558	73.558	25.4	1	760	.75008	750.08	7.5008	7500.8
atm	.06805	.002458	.029499	.0000968	.0968	.03342	.001315	1	.000986	.98692	.009869	9.869
mbar	68.947	2.4908	29.8896	.098068	98.068	33.863	1.3332	1013.2	1	1000	10	10000
bar	.068947	.002490	.029889	.0000981	.098068	.033863	.001333	1.0132	.001	1	.01	10
kPa	6.8947	.24908	2.98896	.0098068	9.8068	3.3863	.13332	101.320	.1	100	1	1000
MPa	.006895	.000249	.002988	.0000098	.009807	.003386	.000133	.101320	.0001	.1	.001	1

Table 4-1 Engineering Units Multiplication Factors

Note: Due to changes in specific gravity with temperature the factors for mercury and water in the above table are approximations!

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500INS-700 kPa

Serial Number: 1043811

Date of Calibration: September 14, 2011

Temperature: 21.7 °C

Barometric Pressure: 994.7 mbar

Technician: [illegible]

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9073	9074	9074	1.526	0.22	0.028	0.00
140.0	8303	8304	8304	139.7	-0.04	140.0	-0.01
280.0	7528	7528	7528	278.9	-0.15	280.0	0.00
420.0	6748	6749	6749	418.8	-0.16	420.0	-0.01
560.0	5963	5963	5963	559.8	-0.02	560.1	0.01
700.0	5174	5174	5174	701.5	0.21	700.0	-0.01

(kPa) Linear Gage Factor (G): -0.1795 (kPa/ digit) **Regression Zero: 9082**

Polynomial Gage factors: A: -7.113E-07 B: -0.1694 C: ______

Thermal Factor (K): 0.1319 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02603 (psi/ digit)

Polynomial Gage Factors: A: -1.032E-07 B: -0.02456 C: ______

Thermal Factor (K): 0.01913 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures: Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

Figure 4 – A Typical Calibration Sheet

4.2 Temperature Correction

Careful selection of materials is made in constructing the vibrating wire piezometer to minimize thermal effects, however, most units still have a slight temperature coefficient. Consult the supplied calibration sheet to obtain the coefficient for a given piezometer.

Since piezometers are normally installed in a tranquil and constant temperature environment, corrections are not normally required. If however, that is not the case for a selected installation, corrections can be made using the internal thermistor (Figure 1-1) for temperature measurement. See Section 3.4 for instructions regarding obtaining the piezometer temperature.

Temperature correction equation is as follows;

Temperature Correction = (Current Temperature - Initial Temperature) × Thermal Factor

or

$$P_T = (T_1 - T_0) \times K$$

Equation 4-3 Temperature Correction

The calculated correction would then be **added** to the Pressure calculated using Equation 4-2. If the engineering units were converted remember to apply the same conversion to the calculated temperature correction!

For example, assume the initial temperature was 22° C, the current temperature is 15° C, and the thermal coefficient is +0,1319 kPa per °C rise (Figure 2-1). The temperature correction is +0.1319(15-22) = -0.92 kPa.

4.3 Barometric Correction (required only on un-vented transducers)

Since the standard piezometer is hermetically sealed and un-vented, it responds to changes in atmospheric pressure. That being the case, corrections may be necessary, particularly for the sensitive, low pressure models. For example, a barometric pressure change from 29 to 31 inches of mercury would result in ≈1 PSI of error (or ≈2.3 feet if monitoring water level in a well!). Thus it is advisable to read and record the barometric pressure every time the piezometer is read. A separate pressure transducer (piezometer), kept out of the water, may be used for this purpose.
Barometric correction equation is as follows;

Barometric Correction = (Current Barometer - Initial Barometer) × Conversion Factor

or

$$P_B = (S_1 - S_0) \times F$$

Equation 4-4 Barometric Correction

Since barometric pressure is usually recorded in inches of mercury a Conversion Factor is necessary to convert to PSI. The Conversion Factor for inches of mercury to PSI is .491. Table 4-1 lists other common Conversion Factors.

The calculated correction is usually **subtracted** from the Pressure calculated using Equation 4-2. If the engineering units were converted remember to apply the same conversion to the calculated barometric correction!

The user should be cautioned that this correction scheme assumes ideal conditions. In reality, conditions are not always ideal. For example, if the well is sealed, barometric effects at the piezometer level may be minimal or attenuated from the actual changes at the surface. Thus errors may result when applying a correction which is not required. We recommend, in these cases, to independently record barometric pressure changes and correlate these with observed pressure changes to arrive at a correction factor.

> An alternative to making barometric correction is to use piezometers that are vented to the atmosphere as noted section 4.3.1. However, vented piezos only make sense if the piezo is in an open well or standpipe and the user is only interested in the water level. Otherwise, if the piezo is buried it is not certain that the full effect of the barometric change will be felt immediately at the piezo and is more likely to be attenuated and delayed, in which case a vented piezo would automatically apply a correction that is too large and too soon. Having an on-site barometer with un-vented piezos also has the advantage that you can see the barometric change and judge to what extent it may have affected the piezo reading.

Equation 4-5 describes the pressure calculation with temperature and barometric correction applied.

$$P_{corrected} = ((R_1 - R_0) \times G) + ((T_1 - T_0) \times K) - ((S_1 - S_0) \times F)$$

Equation 4-5 Corrected Pressure Calculation

4.3.1 Vented Piezometers

Vented piezometers are designed to eliminate barometric effects. The space inside the transducer is not hermetically sealed and evacuated (see Figure 1-1), but is connected via a tube (integral with the cable) to the atmosphere. A chamber containing desiccant capsules is attached to the end of the tube to prevent moisture from entered the transducer cavity. Vented piezometers require more maintenance then non-vented types, and there is always a danger that water can find its way into the inside of the transducer and ruin it.

As supplied, the outer end of the desiccant chamber is closed by means of a seal screw to keep the desiccant fresh during storage and transportation. **THE SEAL SCREW MUST BE REMOVED BEFORE THE PIEZOMETER IS PUT INTO SERVICE!** The desiccant capsules are blue when fresh, they will gradually turn pink as they absorb moisture. When they have turned light pink in color they should be replaced. Contact Geokon for replacement capsules.

4.4 Environmental Factors

Since the purpose of the piezometer installation is to monitor site conditions, factors which may affect these conditions should always be observed and recorded. Seemingly minor effects may have a real influence on the behavior of the structure being monitored and may give an early indication of potential problems. Some of the factors include, but are not limited to; blasting, rainfall, tidal levels, excavation and fill levels and sequences, traffic, temperature and barometric changes (and other weather conditions), changes in personnel, nearby construction activities, seasonal changes, etc.

5. TROUBLESHOOTING

Maintenance and troubleshooting of vibrating wire piezometers is confined to periodic checks of cable connections and maintenance of terminals. The transducers themselves are sealed and not user serviceable. Following are typical problems and suggested remedial action.

- **Piezometer fails to give a reading**

1. Check the resistance of the coils by connecting an ohmmeter across the gage terminals. Nominal resistance is 180Ω (±5%), plus cable resistance at approximately 16Ω per 1000' of 22 AWG wire. If the resistance is very high or infinite the cable is probably broken or cut. If the resistance is very low the gage conductors may be shorted. If a cut or a short is located in the cable, splice according to instructions in Section 2.8.
2. Check the readout with another gage.
3. The Piezometer may have been over-ranged or shocked. Inspect the diaphragm and housing for damage. Contact the factory.

- **Piezometer reading unstable**

1. Connect the shield drain wire to the readout using the green (GK-401) or the blue (GK-403) clip.
2. Isolate the readout from the ground by placing it on a piece of wood or similar non-conductive material.
3. Check for sources of nearby noise such as motors, generators, antennas or electrical cables. Move the piezometer cables if possible. Contact the factory for filtering and shielding equipment available.
4. The Piezometer may have been damaged by over-ranging or shock.
5. The body of the Piezometer may be shorted to the shield. Check the resistance between the shield drain wire and the Piezometer housing.

- **Thermistor resistance is too high**

1. Likely there is an open circuit. Check all connections, terminals and plugs. If a cut is located in the cable, splice according to instructions in Section 2.8.

- **Thermistor resistance is too low**

1. Likely there is a short. Check all connections, terminals and plugs. If a short is located in the cable, splice according to instructions in Section 2.8.
2. Water may have penetrated the interior of the piezometer. There is no remedial action.

APPENDIX A - SPECIFICATIONS

Model	4500S	4500AL[1]	4500AR	4500B	4500C	4500DP	4580[2]
Available Ranges (psi)	0-50 0-100 0-150 0-250 0-500 0-750 0-1000 0-1500 0-3000 0-5000 0-10000 0-15000	0-10 0-25		0-50 0-100 0-250	0-50 0-100 0-250	0-10 0-25 0-50 0-150 0-250 0-500 0-750 0-1000 0-1500 0-3000 0-5000 0-10000	0-1 0-5
Resolution	0.025% FS	0.025% FS	0.025% FS	0.025% FS	0.05% FS	0.025% FS	0.01% FS
Linearity	< 0.5% FS[3]	< 0.5% FS[3]	< 0.5% FS[3]	< 0.5% FS[3]	< 0.5% FS[3]	< 0.5% FS[3]	< 0.5% FS[3]
Accuracy	0.1% FS[4]	0.1% FS[4]	0.1% FS[4]	0.1% FS[4]	0.1% FS[4]	0.1% FS[4]	0.1% FS
Over-Range	2 × FS	2 × FS	2 × FS	2 × FS	2 × FS	2 × FS	2 × FS
Thermal Coefficient	<0.025% FS/ °C	<0.05% FS/ °C	<0.05% FS/ °C	<0.025% FS/ °C	<0.05% FS/ °C	<0.025% FS/ °C	<0.025% FS/ °C
Temperature Range	-20°C to +80°C	-20°C to +80°C	-20°C to +80°C	-20°C to +80°C	-20°C to +80°C	-20°C to +80°C	-20°C to +80°C
OD	.75" 19.05 mm	1" 25.40 mm	.75" 19.05 mm	.687" 17.45 mm	.437" 11.10 mm	1.3" 33.3mm	1.5" 38.10 mm
Length	5.25" 133 mm	5.25" 133 mm	10" 254 mm	5.25" 133 mm	6.5" 165 mm	7.36" 187 mm	6.5" 165 mm

Table A-1 Vibrating Wire Piezometer Specifications

Accuracy of Geokon test apparatus: 0.1%

Contact Geokon for specific application information.

Notes:

1 Accuracy of test apparatus: 0.05%

2 Other ranges available upon request.

3 0.1% FS linearity available upon request.

4 Derived using 2nd order polynomial.

APPENDIX B–STANDARD TEMPERATURE THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Resistance to Temperature Equation B1:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Where; T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
$A = 1.4051 \times 10^{-3}$ (coefficients calculated over the -50 to +150° C. span)
$B = 2.369 \times 10^{-4}$
$C = 1.019 \times 10^{-7}$

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table B-1 STANDARD TEMPERATURE Thermistor Resistance versus Temperature

APPENDIX C – HIGH TEMPERATURE THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: Thermometrics BR55KA822J

Basic Equation, C1

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Where: T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance

$A = 1.02569 \times 10^{-3}$

$B = 2.478265 \times 10^{-4}$

$C = 1.289498 \times 10^{-7}$

Note: Coefficients calculated over -30° to +260° C. span.

Table B2

Temp	R (ohms)	LnR	LnR^3	Calculated Temp	Diff	FS Error	Temp	R (ohms)	LnR	LnR^3	Calculated Temp	Diff	FS Error
-30	113898	11.643	1578.342	-30.17	0.17	0.06	120	407.62	6.010	217.118	120.00	0.00	0.00
-25	86182	11.364	1467.637	-25.14	0.14	0.05	125	360.8	5.888	204.162	125.00	0.00	0.00
-20	65805	11.094	1365.581	-20.12	0.12	0.04	130	320.21	5.769	191.998	130.00	0.00	0.00
-15	50684.2	10.833	1271.425	-15.10	0.10	0.03	135	284.95	5.652	180.584	135.00	0.00	0.00
-10	39360	10.581	1184.457	-10.08	0.08	0.03	140	254.2	5.538	169.859	140.01	-0.01	0.00
-5	30807.4	10.336	1104.068	-5.07	0.07	0.02	145	227.3	5.426	159.773	145.02	-0.02	-0.01
0	24288.4	10.098	1029.614	-0.05	0.05	0.02	150	203.77	5.317	150.314	150.03	-0.03	-0.01
5	19294.6	9.868	960.798	4.96	0.04	0.01	155	183.11	5.210	141.428	155.04	-0.04	-0.01
10	15424.2	9.644	896.871	9.98	0.02	0.01	160	164.9	5.105	133.068	160.06	-0.06	-0.02
15	12423	9.427	837.843	14.98	0.02	0.01	165	148.83	5.003	125.210	165.08	-0.08	-0.03
20	10061.4	9.216	782.875	19.99	0.01	0.00	170	134.64	4.903	117.837	170.09	-0.09	-0.03
25	8200	9.012	731.893	25.00	0.00	0.00	175	122.1	4.805	110.927	175.08	-0.08	-0.03
30	6721.54	8.813	684.514	30.01	-0.01	0.00	180	110.95	4.709	104.426	180.07	-0.07	-0.02
35	5540.74	8.620	640.478	35.01	-0.01	0.00	185	100.94	4.615	98.261	185.10	-0.10	-0.04
40	4592	8.432	599.519	40.02	-0.02	-0.01	190	92.086	4.523	92.512	190.09	-0.09	-0.03
45	3825.3	8.249	561.392	45.02	-0.02	-0.01	195	84.214	4.433	87.136	195.05	-0.05	-0.02
50	3202.92	8.072	525.913	50.01	-0.01	-0.01	200	77.088	4.345	82.026	200.05	-0.05	-0.02
55	2693.7	7.899	492.790	55.02	-0.02	-0.01	205	70.717	4.259	77.237	205.02	-0.02	-0.01
60	2276.32	7.730	461.946	60.02	-0.02	-0.01	210	64.985	4.174	72.729	210.00	0.00	0.00
65	1931.92	7.566	433.157	65.02	-0.02	-0.01	215	59.819	4.091	68.484	214.97	0.03	0.01
70	1646.56	7.406	406.283	70.02	-0.02	-0.01	220	55.161	4.010	64.494	219.93	0.07	0.02
75	1409.58	7.251	381.243	75.01	-0.01	0.00	225	50.955	3.931	60.742	224.88	0.12	0.04
80	1211.14	7.099	357.808	80.00	0.00	0.00	230	47.142	3.853	57.207	229.82	0.18	0.06
85	1044.68	6.951	335.915	85.00	0.00	0.00	235	43.673	3.777	53.870	234.77	0.23	0.08
90	903.64	6.806	315.325	90.02	-0.02	-0.01	240	40.533	3.702	50.740	239.69	0.31	0.11
95	785.15	6.666	296.191	95.01	-0.01	0.00	245	37.671	3.629	47.788	244.62	0.38	0.13
100	684.37	6.528	278.253	100.00	0.00	0.00	250	35.055	3.557	45.001	249.54	0.46	0.16
105	598.44	6.394	261.447	105.00	0.00	0.00	255	32.677	3.487	42.387	254.44	0.56	0.19
110	524.96	6.263	245.705	110.00	0.00	0.00	260	30.496	3.418	39.917	259.34	0.66	0.23
115	461.91	6.135	230.952	115.00	0.00	0.00							

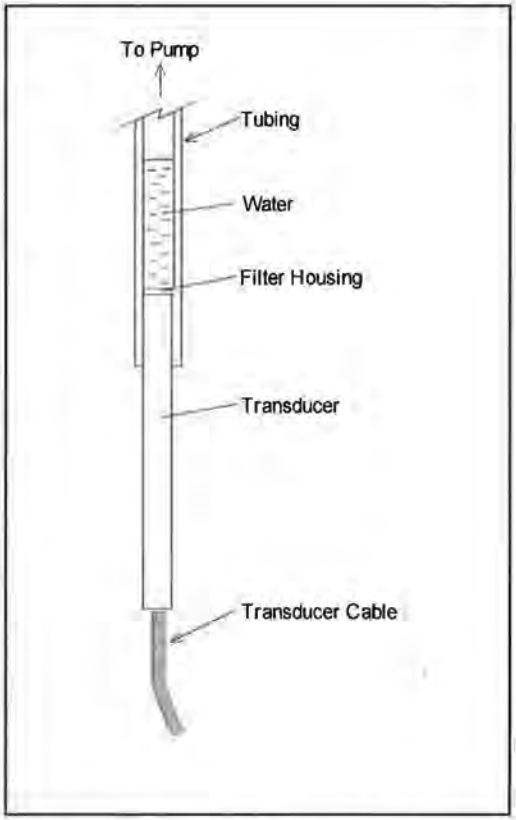
Table C-1 High Temperature. Temperature v Thermistor Resistance

APPENDIX D - NOTES REGARDING THE MODEL 4500C

Installation

The construction of this very slender vibrating wire transducer, requires a miniaturization of the internal parts and consequently they are somewhat delicate. Despite every precaution it is possible for the zero to shift during shipment due to rough handling. However, tests have shown that the zero may shift but the calibration factors do not change. Therefore it is doubly important that the initial no load zero reading be taken prior to installation. **And it is also important to handle the transducer gently during the installation procedure.**

If the pressures to be measured are less than 5 psi the filter stone in the filter housing must be saturated. ***However, the filter stone and housing are not removable in the 4500C. Any attempt to remove the filter stone or the housing will destroy the transducer!***



To saturate the filter a hand vacuum pump and short length of tubing (½" surgical tubing) is required. Attach the tube to the transducer as shown in the figure. Fill the tubing with approximately 2" (5 cm) of water. Hold the transducer so that the water rests on the filter. Attach the other end of the tube to the hand vacuum pump. While holding the transducer so that the water rests on the filter (and doesn't enter the pump!), squeeze the hand pump to initiate vacuum in the tubing. This will draw the air out of the filter and the space behind it. The water will replace it. A vacuum of 20-25" Hg. (50-65 cm Hg.) is sufficient for proper evacuation.

A hand pump that has been used successfully is the mityvacII® by Neward Enterprises, Inc. of Cucamonga, CA, USA. Hand pumps and tubing are available from the factory.

Data Reduction

Data reduction follows the same procedures as outlined in Section 4 of this manual.. Use Table 4-1 to convert psi to other engineering units.

APPENDIX E - NON LINEARITY AND THE USE OF A SECOND ORDER POLYNOMIAL TO IMPROVE THE ACCURACY OF THE CALCULATED PRESSURE

Most vibrating wire pressure transducers are sufficiently linear (± 0.2 % FS) that use of the linear calibration factor satisfies normal requirements. However, it should be noted that the accuracy of the calibration data, which is dictated by the accuracy of the calibration apparatus, is always ± 0.1 % FS.

This level of accuracy can be recaptured, even where the transducer is non-linear, by the use of a second order polynomial expression which gives a better fit to the data then does a straight line. The polynomial expression has the form:

$$\text{pressure} = AR^2 + BR + C$$

where R is the reading (digits channel B) and A,B,C, are coefficients. The figure 4 on page 16 shows a typical calibration sheet of a transducer which has a fairly normal non-linearity. The figure under the "Linearity (%FS)" column is

$$\frac{\text{Calculated pressure- True pressure}}{\text{Full-scale Pressure}} \times 100\% = \frac{G(R_1 - R_0) - P}{F.S} \times 100\%$$

Note The linearity is calculated using the regression zero for R_0 shown on the sheet.

For example when P= 420 kPa, G $(R_1 - R_0)$ = - 0.1795(6749-9082), gives a calculated pressure of 418.8 kPa. The error is 1.2 kPa equal to 122mm of water.

Whereas the polynomial expression gives a calculated pressure of A $(6749)^2$ + B (6749) + 1595.7 = 420.02 kPa and the actual error is only 0.02 kPa or 2mm of water.

Note. If the polynomial equation is used it is important that the value of C, in the polynomial equation, be taken in the field, following the procedures described in section 2.1.1. The field value of C is calculated by inserting the initial field zero reading into the polynomial equation with the pressure, P, set to zero.

If the field zero reading is not available calculate C using the zero pressure reading on the calibration sheet. (not the regression zero) In the above example the value of C would be derived from the equation 0 = A$(9074)^2$ + B(9074) from which C = 1595.7

It should be noted that where changes of water levels are being monitored it makes little difference whether the linear coefficient or the polynomial expression is used.

APPENDIX F - QUICK INSTRUCTIONS FOR INSTALLING A VIBRATING WIRE PIEZOMETER.

- Take a zero reading at zero, (atmospheric), pressure. Make sure that the temperature has not changed for 15 minutes previously. (Or until the piezo reading has stabilized). Check that this zero reading is compatible with the zero on the calibration sheet

- Record the barometric pressure and the temperature at the time the zero reading is taken.

- Carefully measure the length of the cable and make a mark on the cable which will lie opposite the top of the borehole, well, or standpipe when the piezometer has reached the desired depth. (The piezo diaphragm lies ¾ inch above the tip of the piezo).

- Saturate the piezometer filter. (Section 2.6)

- Follow the instruction of Section 2.2 for installation in standpipes or wells or Section 2.3 for boreholes.

APPENDIX G - Model 4500AR piezometer

The Model 4500 AR piezometer is designed to be used with readouts systems that can read frequency but do not have the capability to "pluck' the VW gage. This sensor has built-in electronics that cause the gage wire to vibrate in a continuous mode at its resonant frequency. The output from the sensor is a 5 volt DC square wave at this frequency.

A DC input voltage in the range of 6- 24 volts is required to operate the gage. The current consumption is approximately 21 mA at 12VDC. The gage output is independent of the input voltage. Multiple sensors powered simultaneously can be read at quite fast rates, up to 5 sensors per second and dynamic measurements on a single sensor can be made up to about 20Hz.

The gage is installed in the field in the same way that the Model 4500 standard piezometer is installed. (See Section 2)

Piezometer Wiring: The 3-pair cable is wired in pairs with each pair comprising one colored and one black lead.

Red	**+6-24 VDC Power**
Red's black	**Ground**
White	**Output**
White's black	**Output Ground**
Green	**Thermistor +**
Green's black	**Thermistor –**
Bare	**Shield**

Upon power up the gage will immediately start to "ring" at the resonant frequency and will continue to do so until the power is removed. Continuous operation will have no effect on the gage life.

Note

The sensor comprises two transducers, the VW pressure sensor and a thermistor for measuring temperature. The signals from the VW transducer are high level frequency and will interfere with the thermistor output if left powered during the period that the thermistor is being read. If the temperature reading is important the power to the pressure sensor should be switched off while the reading is taken.

Appendix C

LogView User's Guide

GEOKON
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LogView

User's Guide

(Rev E, 12/15)

Warranty Statement

Geokon, Inc. warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by Geokon, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of Geokon's control. Components which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

Geokon manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Geokon, Inc. is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by Geokon, Inc. or any breach of any warranty by Geokon, Inc. shall not exceed the purchase price paid by the purchaser to Geokon, Inc. for the unit or units, or equipment directly affected by such breach. Under no circumstances will Geokon reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, Geokon, Inc. neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

Table of Contents:

Table of Figures:

1. Installing LogView

This manual is intended to facilitate the installation, launching and configuration of LogView. It is not intended to be a substitute for the on-line manual or for the datalogger user's manuals.

Please consult the LogView Online Help and the individual datalogger's manuals for more detailed information regarding the operation of LogView and the LC-n series dataloggers.

1.1 Installing LogView

The LogView installer is only available as a .zip file which can be downloaded from our website. The latest version will be available there, as well as a "New Features and Fixes" page where you can view its development.

Please visit the following webpage to download it: http://www.geokon.com/software.

When prompted, choose to "Save file." When download is complete, right click on your new "LogViewSetup.zip" file and select "Extract all." This will display a message asking you to "Select a Destination and Extract Files" (Figure 1.) By default, it will create a new folder in the same location you saved it to. After choosing the destination folder, click the "Extract" button at the bottom of the window.

TIP: Make sure the box to "Show extracted files when complete," is checked. This opens the folder right up so you do not have to look for it.

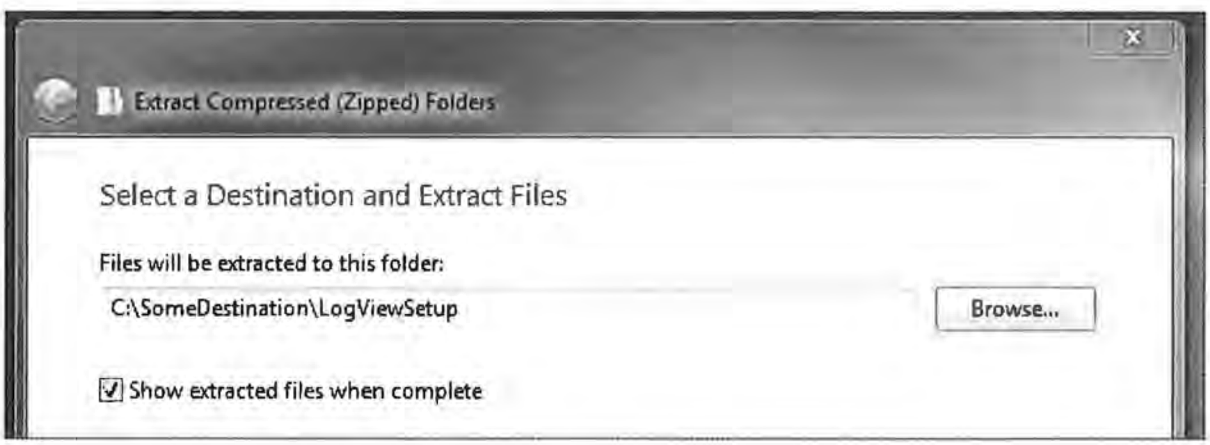

Figure 1 - Extract File Dialog

If you are installing LogView for the first time, you will need the USB drivers used to communicate with the 8003-2-2. By double clicking on the "start.bat" file, both the drivers and LogView will be installed. Follow the prompts for each installer.

To install the latest version of LogView only, double click on the file "setupLV_3_0_0_0000.exe" and follow the prompts, (the numbers may be different depending on the version number.)

NOTE: The LogView Installer checks to see if there is any other version installed and, if so, the following dialog box is displayed:

Figure 2- LogView Already Installed Warning

To install the drivers only, double click on the "CDMv2_12_00_WHQLCertified.exe" and follow the prompts, (the numbers may be different depending on the version number.)

NOTE: The USB drivers are only required for LC-2xN models 8002-N-2, 8002-5 (RS-485 interface) and LC-3x2 model 8003-2-2. Communication with an 8002-N-1 and 8003-2-1 requires either an internal COM port or a USB-to-Serial converter (which may require its own drivers). A PC re-boot may be required before the new drivers will take effect.

2. Starting LogView for the first time

Launching LogView is easy and can be accomplished two different ways. Double clicking on the desktop icon:

Or via the Start button:

Programs -> Geokon -> LogView

When you open LogView for the first time, you will be prompted to create a workspace. A workspace is a place where all other LogView resources are stored and contains one or more projects along with dataloggers, sensors and data files. LogView allows multiple workspaces to be defined so that projects may be logically grouped together, i.e., a company may have multiple work-sites and for each work-site there may be multiple projects under way.

Workspaces can also be used to allow different users to keep their projects and data separate from others when sharing a PC.

The first dialog prompt is for the workspace name. The name can be any combination of letters and numbers and, ideally, will be descriptive in nature (see Figure 3).

Figure 3 - Workspace Name

Once the workspace name has been selected, the next prompt will be to choose or create a folder where all the workspace elements will be stored. As can be seen in Figure 4 below, the default workspace location is in a folder name the same as the workspace name under a special shared folder reserved for workspaces. In Windows XP this folder is located at:

C:\Documents and Settings\All Users\Shared Documents\Geokon\LogView\Workspaces

For Vista and Windows 7 the default folder is located at:

C:\Users\Public\Public Documents\Geokon\LogView\Workspaces

LogView appends the name of the new workspace to this shared folder and uses it as the default location for the new workspace. The user is free to select a different location, either by entering it directly, or the Browse button may be used to navigate to a different folder location or to create a new folder. This workspace location will be stored in the LogView configuration file for subsequent application access. After workspaces are created, all future user access to a workspace is always by name.

Figure 4 - Workspace Folder

That's all that is required to create an initial workspace. Figure 5 below illustrates LogView's main window and shows the new workspace, PRODUCTION, in the Project Explorer:

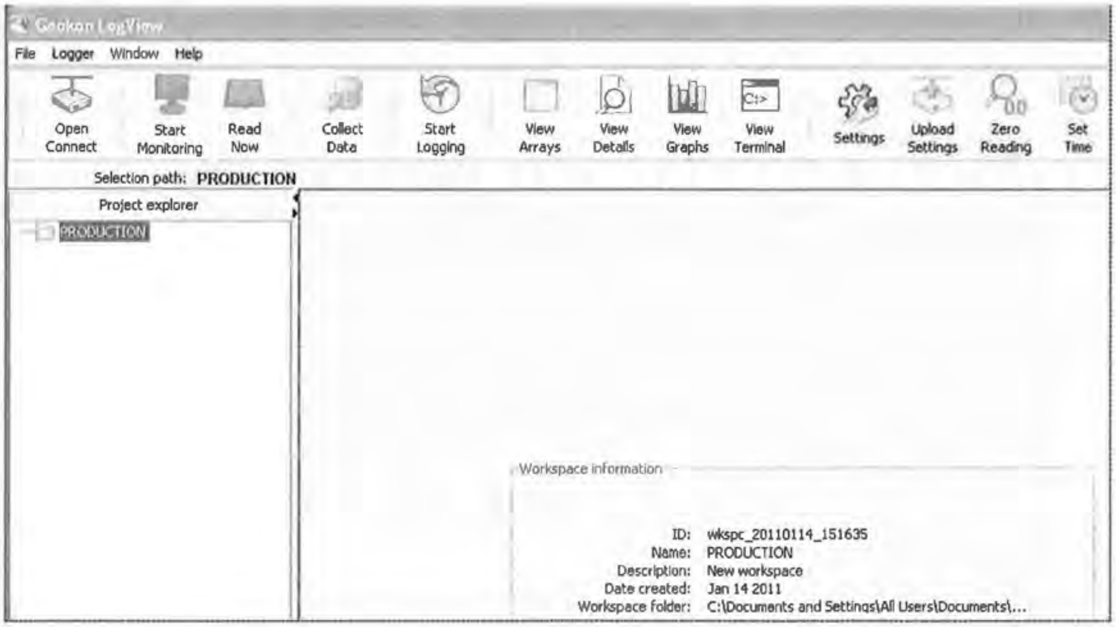

Figure 5 - Main Window

LogView "Project" objects can be added to a workspace by right-clicking on the workspace and using the menu tools (see Figure 6).

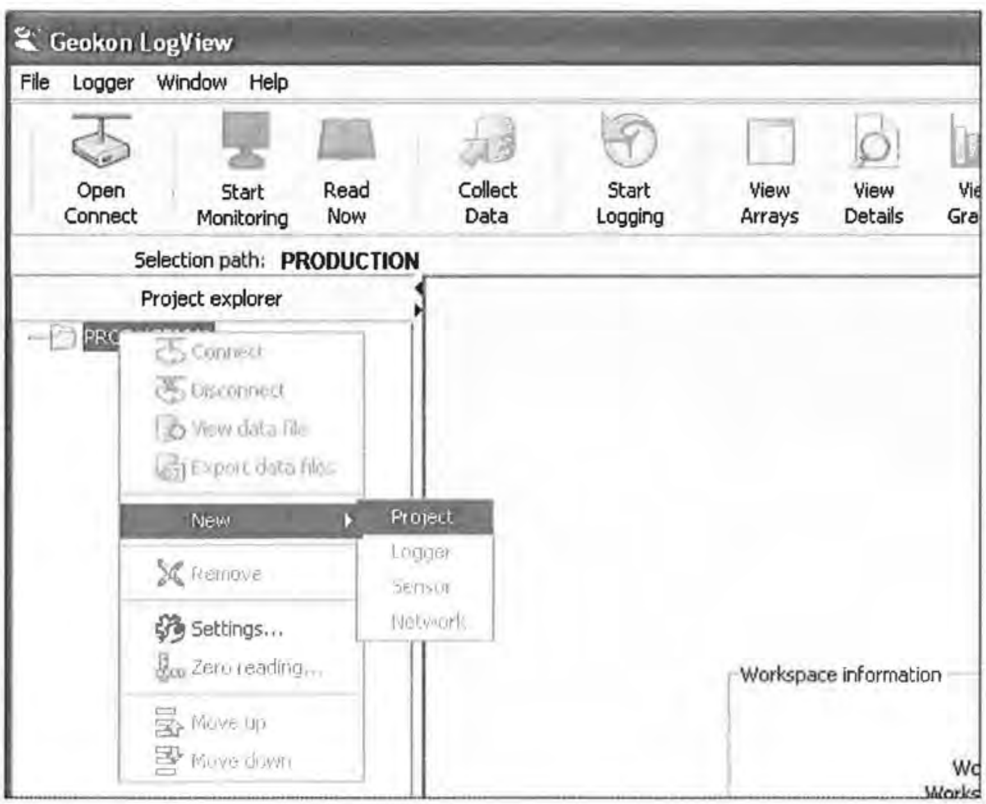

Figure 6 - Context Menu

When adding new projects, a dialog box is displayed, giving the user an opportunity to name and add a description for the new project (see Figure 7):

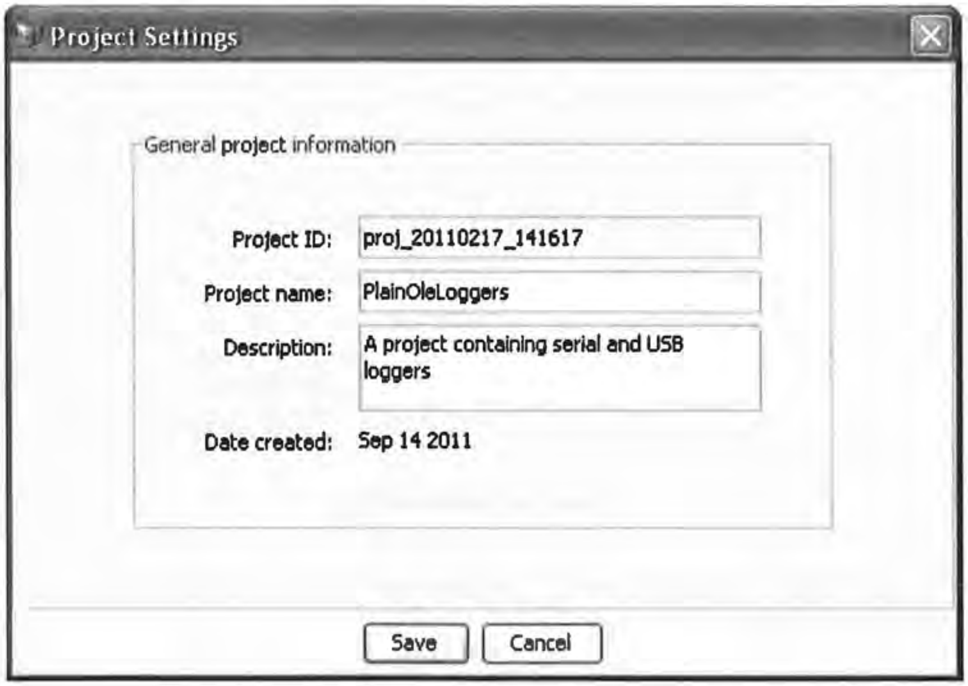

Figure 7 - Project Settings

Figure 8 below shows an example of the Project Explorer after a project has been added:

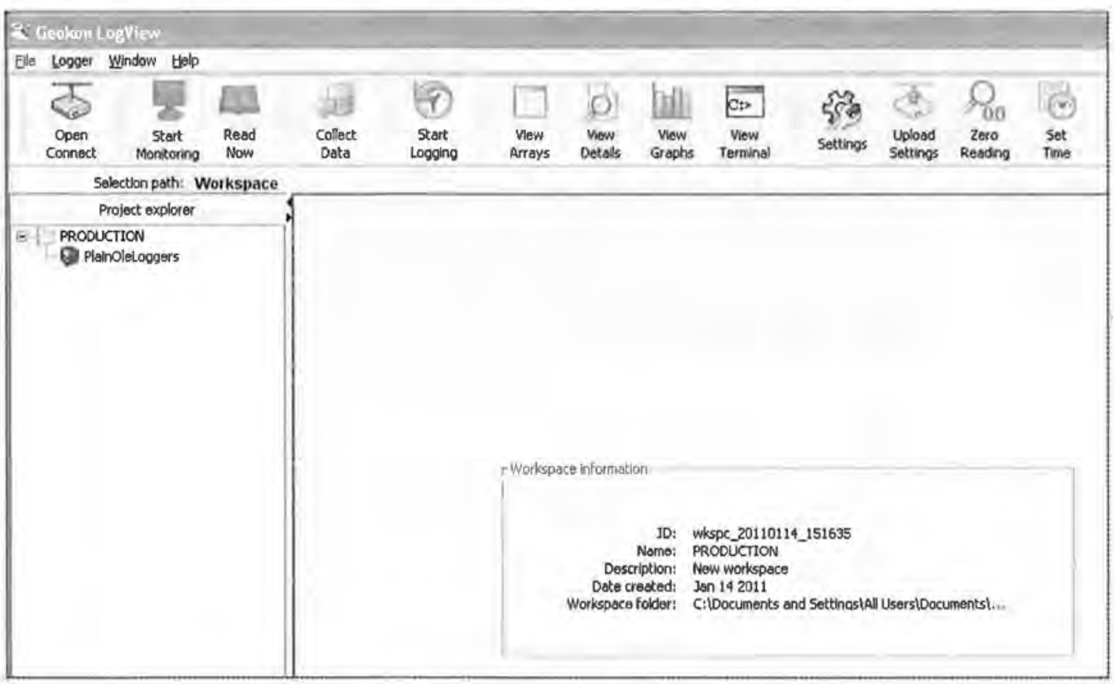

Figure 8 - Project Explorer with Project Added

In a similar fashion to adding Projects to Workspaces, Dataloggers can be added to Projects by right-clicking on the Project icon in the Project Explorer and clicking on "New", then "Logger" from the resulting context menu. This causes the Datalogger Settings window to be displayed (see figure 9). See section 2.3.5 (8002-4-3 and 8002-16-3) or 3.3.5 (8002-1-3) in the Geokon Datalogger Instruction Manual as well as the on-line help topic "Working with Dataloggers" for more details on adding dataloggers to projects.

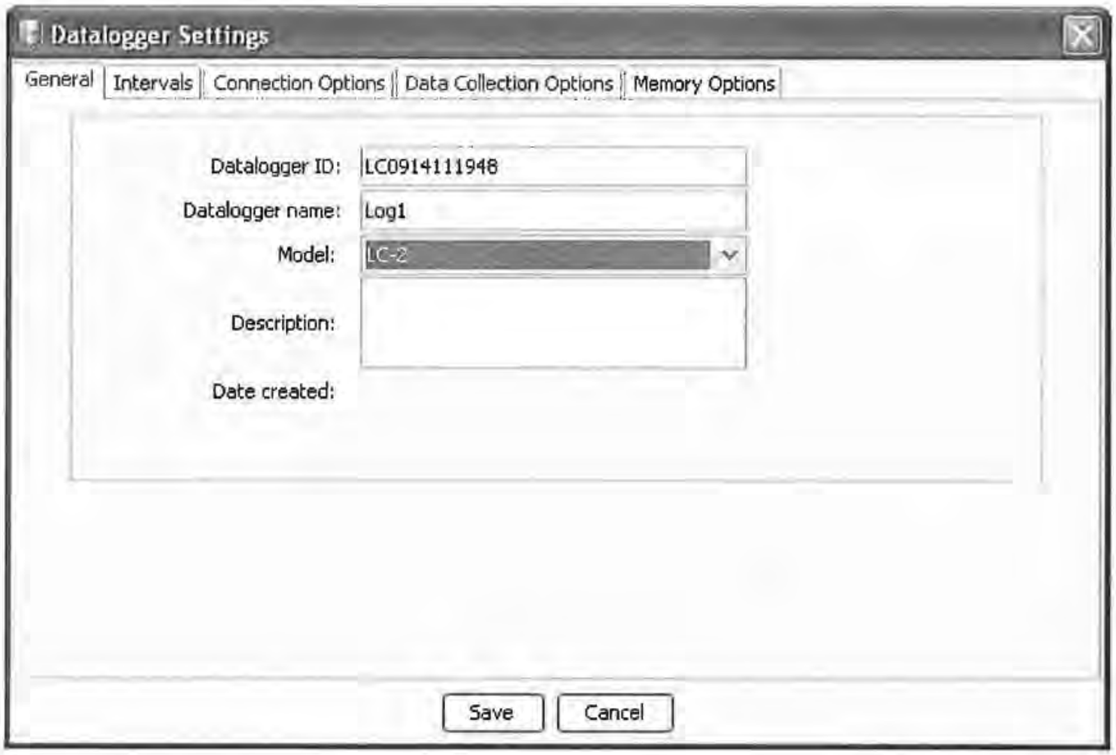

Figure 9 - Datalogger Settings

Figure 9 illustrates the General Setting tab and allows entry of various settings such as, name, model and description. All of the settings for a datalogger are broken up into sections accessed by clicking on the appropriate tab. See the on-line help topic "Configuration, Datalogger Settings" for more details on configuring a new datalogger. After the settings from all the tabs have been entered, click on "Save" to create the new logger.

As of LogView version 3.0.1.X, when the settings are saved for a **new** datalogger, the Sensor Setting dialog is automatically displayed allowing the settings for the available sensors to be configured. If your LogView version is greater than or equal to V3.0.1.X then you may skip the following paragraphs and proceed directly to Section 2.1 of this manual. If the Sensor Settings dialog is cancelled before saving, the following paragraphs pertain (See Figure 10).

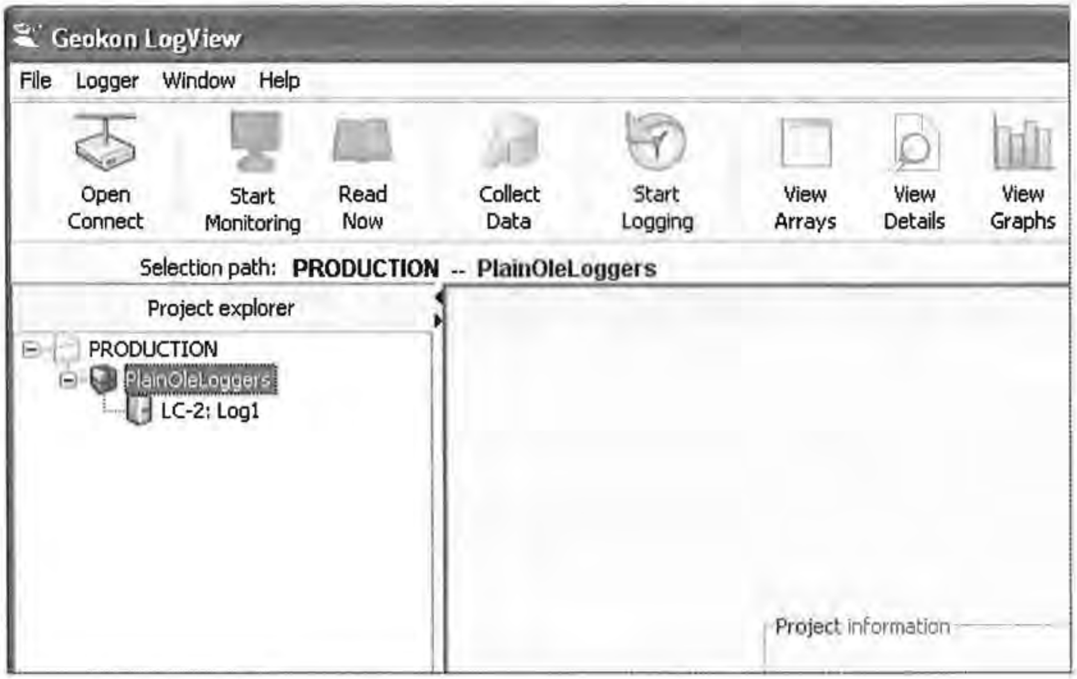

Figure 10 - Workspace, Project and Datalogger

A Sensor is the final element that needs to be added to define the complete configuration of a data logging system. Just as Dataloggers were added to Projects, Sensors can be added to Dataloggers by right-clicking on the Datalogger icon in the Project Explorer and clicking on "New", then "Sensor" from the resulting context menu (see Figure 11). This causes the Sensor Settings window to be displayed (see Figure 12).

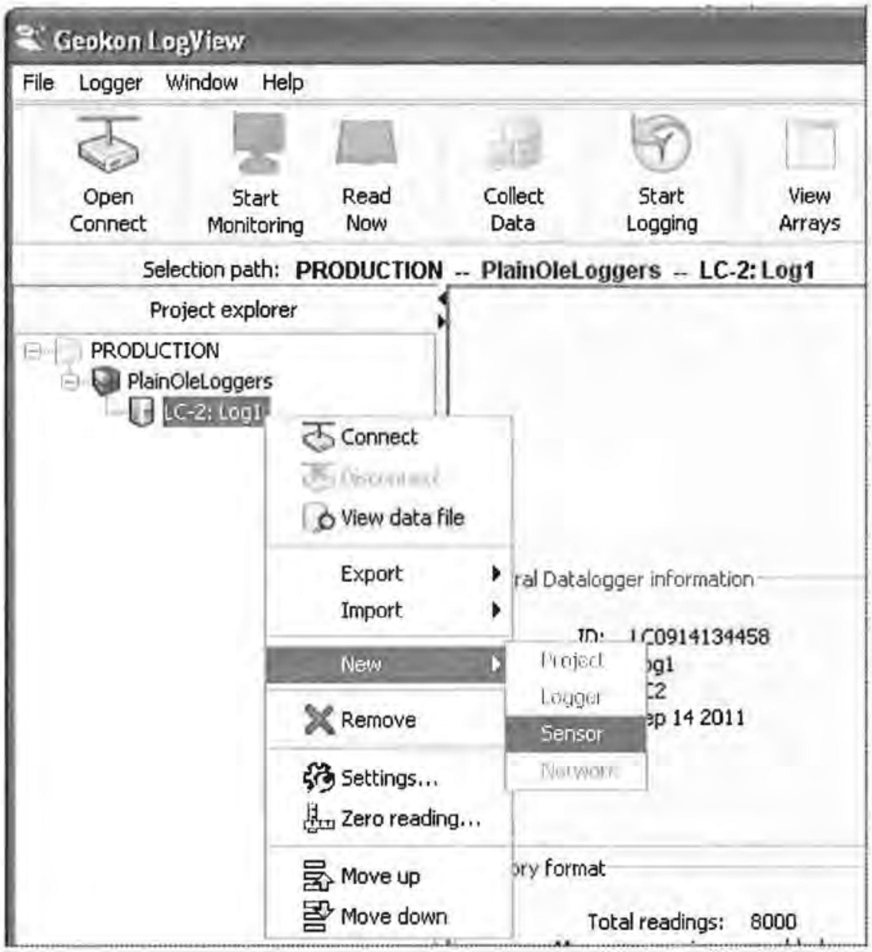

Figure 11 - Adding a Sensor

2.1 Adding Sensor(s) to a Datalogger

The Sensor Settings window (see Figure 12) allows one or multiple sensor's parameters to be modified. The number of channel selection "buttons" on the left hand side of the window depends on the type of datalogger that the sensor(s) are being added to. See section 3.8 (8002-4-X and 8002-16-X) or 4.6 (8002-1-X) in the Geokon Datalogger Instruction Manual as well as the on-line help topic "Working with Sensors" for more details on adding sensors to dataloggers.

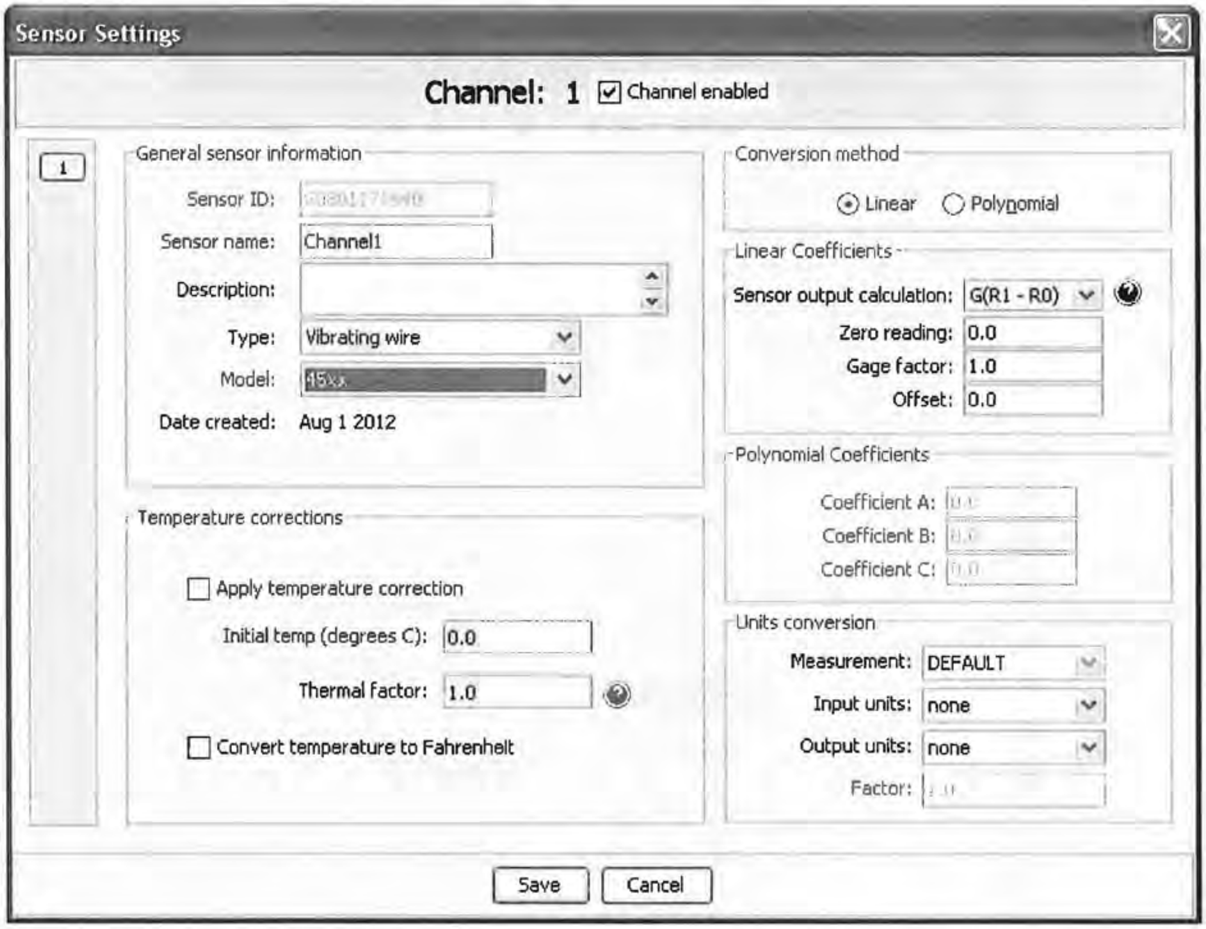

Figure 12 - Sensor Settings

Note the blue round "button" next to the Output calculation drop-down box in the Linear Coefficients section of the Sensor Settings. Clicking the button will display the following dialog box (see Figure 13):

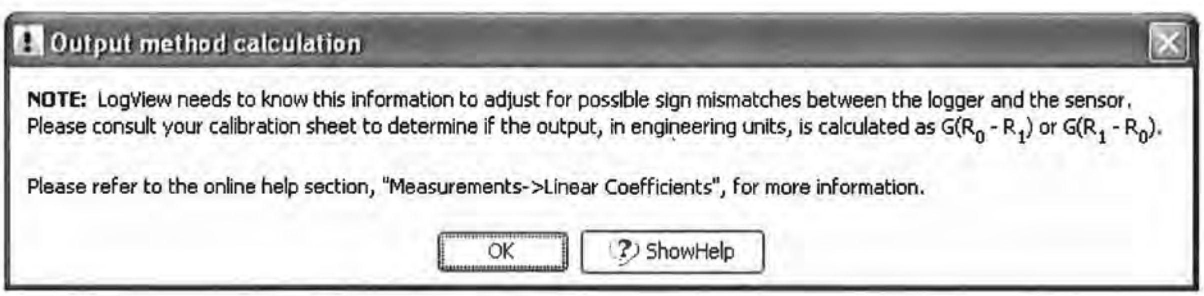

Figure 13 - Output Calculation Method Help Dialog

This dialog box is shown to inform the user that the output calculation method must be selected based on information contained in the calibration sheet. For all sensors calibrated after 11-02-2011, the change (from the zero value) in digits, multiplied by the gage factor to get engineering units, is calculated as the Current Reading (**R1**) minus the Initial Reading (**R0**).

For some sensors, prior to the above date, the calculation was performed as **R0 - R1**.

Based on the entered calculation method, LogView can adust the sign of the gage factor accordingly, allowing the user to directly enter the gage factor from the calibration sheet.

In the Temperature corrections section of Sensor Settings, if "Apply temperature corrections" is checked, the blue round "?" button is enabled and if clicked displays the following (see Figure 14):

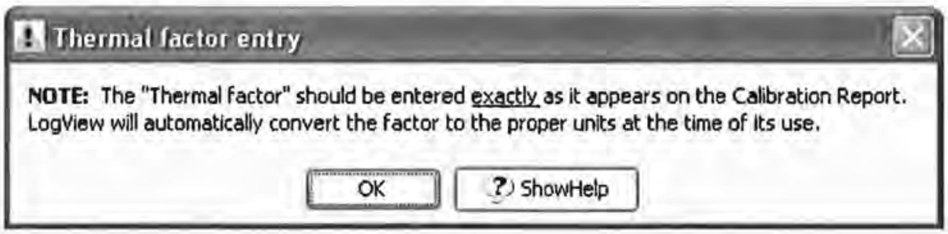

Figure 14 - Thermal Factor Help Dialog

In previous versions of LogView, the Thermal factor needed to be converted to Fahrenheit units if the "Convert temperature to Fahrenheit" checkbox was checked. After LogView 2.1.1.0029, this is no longer necessary.

If "Apply temperature corrections" is checked AND a "Units conversion factor" greater than 1.0 is displayed then the following warning will be displayed in the Temperature corrections section (see Figure 15):

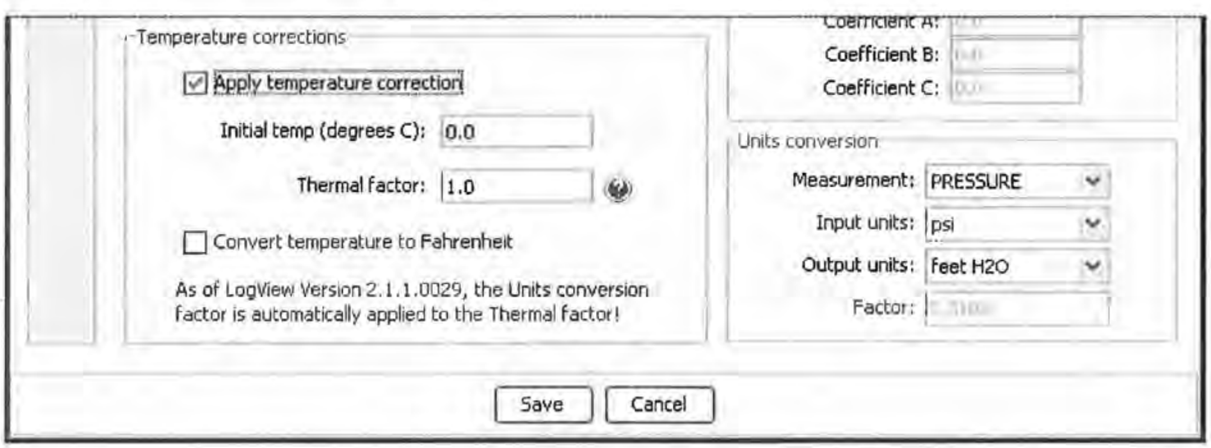

Figure 15 - Units Conversion Application Warning

In previous versions of LogView, the Thermal factor was not automatically multiplied by the "Units conversion factor" (see the Units conversion section). After LogView 2.1.1.0029, this will happen automatically.

Figure 16 illustrates the "PRODUCTION" workspace with the project "PlainOleLoggers". In the Project Explorer, you can see that the "PlainOleLoggers" project is expanded and it contains a datalogger named "Log1" (LogView prefixes datalogger names with the datalogger type). Also notice that "Log1" has a sensor "Channel1" defined for it (LogView prefixes sensor names with the channel number CHn).

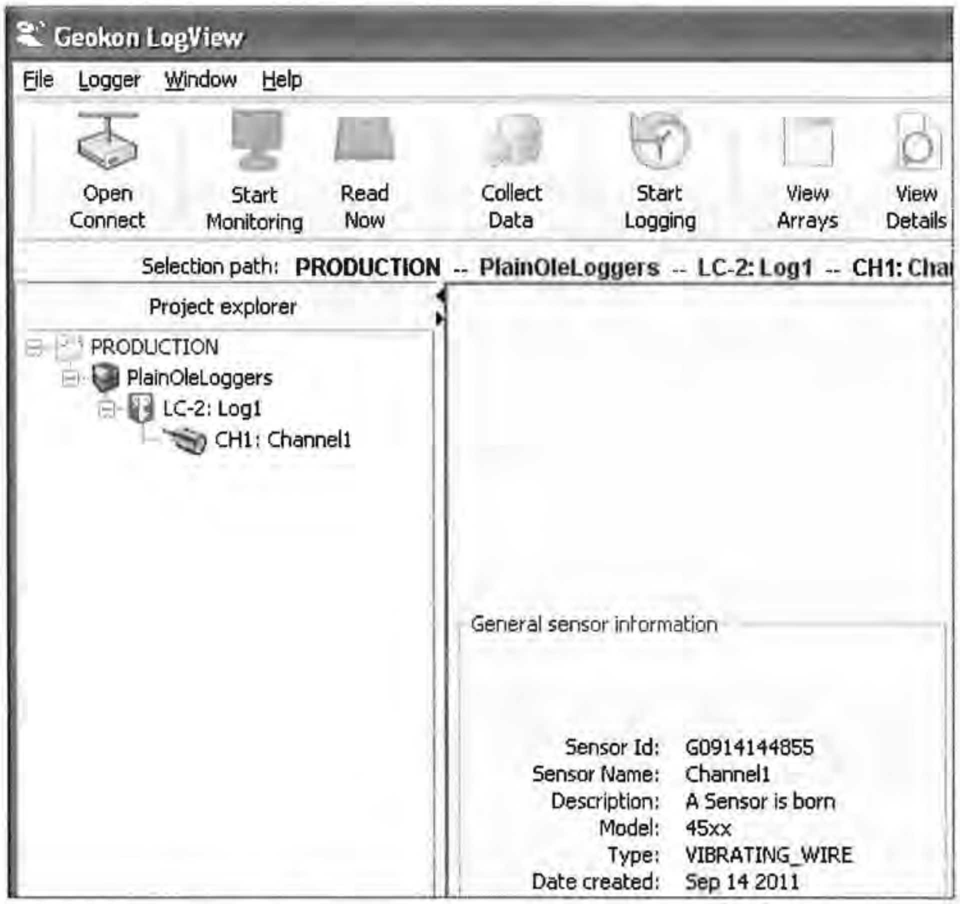

Figure 16 - Workspace, Project, Datalogger and Sensor

Each Project element, such as Dataloggers and Sensors, have "settings" associated with them. Once again, by right-clicking the element in the Project Explorer you can edit the Datalogger and Sensor settings - modifying parameters such as COM port settings, Gage Factors, etc.

LogView has a built-in help system which is available at all times by pressing the "Help" Toolbar button, the "F1" key or by accessing the "Help topics" menu item from the Main Menu.

3. Connecting to a Datalogger

The following sections describe the basic procedure to connect a datalogger to the user's PC and to establish communications with the datalogger via LogView. LC-2s with a USB connection will **not** maintain a PC "COM" port when the logger is disconnected. **For this reason, always, connect the datalogger to the PC before launching LogView.** If LogView is already open when the datalogger is connected (to the PC), close LogView and re-launch it after connecting the datalogger.

3.1 LC-2 RS-232 Connection (8002-1-1, 8002-1A-1, 8002-4-1, 8002-16-1):

Connect the supplied LC-2 RS-232 Communications cable (COM-108) to the COM port of the LC-2 datalogger. The protective cap on the datalogger COM connector is removed by pushing in and turning. Plug the DB-9 end of the RS-232 Communications cable into the host computer's RS-232 port (either internal or external via a USB to Serial converter).

3.2 LC-2 USB Connection (8002-1-2, 8002-1A-2, 8002-4-2, 8002-16-2):

Connect the supplied LC-2 USB Communications cable (COM-109) to the USB port of the LC-2 datalogger. The protective cap on the datalogger USB connector is removed by pushing in and turning. Plug the USB-A end of the USB cable into an available USB-2.0 port on the host computer.

NOTE: On some PCs, an 8002-X-2 may require the installation of a driver to properly communicate with the PC. If the PC does not recognize the datalogger's internal USB to serial converter then the driver may need to be installed by executing the program, CDMv2_xxxx, from the LogView Install folder.

3.3 Determining COM Port Numbers:

When connecting an 8002-1-1 or 8002-1A-1 datalogger to a PC with an internal serial port(s), the COM Port number that LogView requires is usually COM1 or COM2 but, occasionally may be COM3 if the PC has more than one internal serial port. Figure 17 below illustrates that the PC has 2 serial ports, one internal (COM1) and the other via a USB to serial converter (COM13).

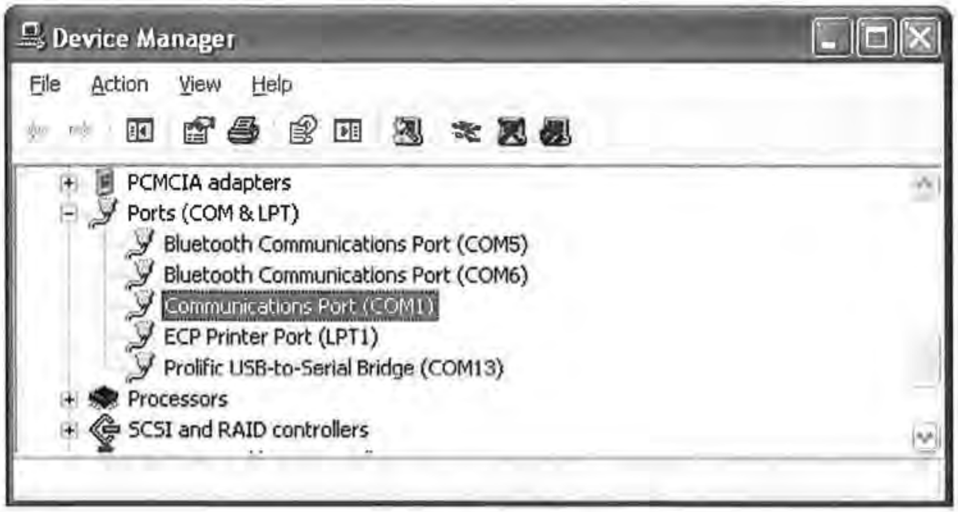

Figure 17 - RS-232 Serial COM Ports

When connecting an 8002-1-2 or 8002-1A-2 datalogger to a PC, the COM Port number that LogView requires can be any number and depends on how many other devices are attached to the PC such as, internal serial ports and Bluetooth devices.

The figure below (see Figure 18) illustrates that the PC has 3 serial ports, one internal, COM1 and the other two via USB to serial converters, COM13 and COM3.

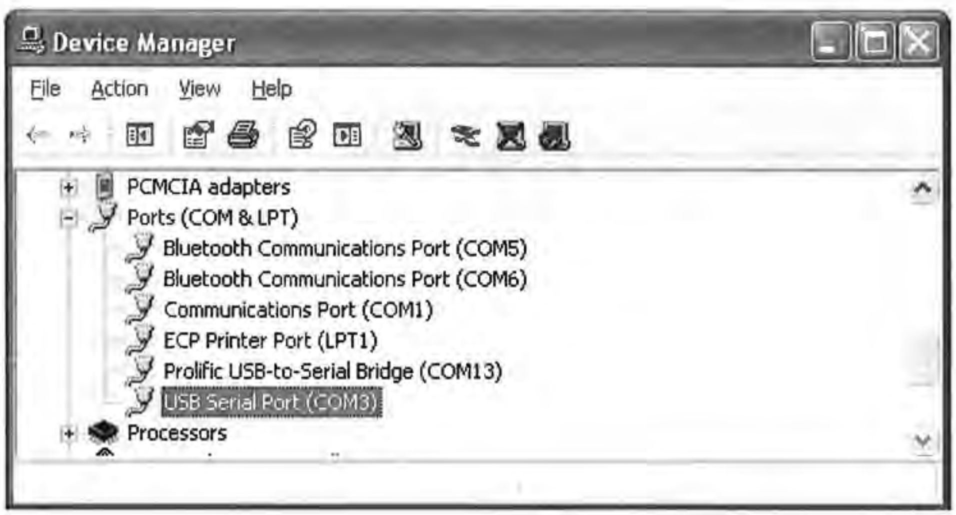

Figure 18 - USB COM Ports

HINT: With the Device Manager (above) open, an easy way to determine which COM port an 8002-1-2 datalogger is attached to is to disconnect the cable and see which COM device disappears from the Device Manager Ports list.

3.4 Establishing a Connection:

After determining the appropriate COM Port for a datalogger, a LogView connection can be established by following the steps below:

1. For USB dataloggers (8002-X-2), always make sure the USB end of the COM-109 cable is plugged into the PC and that the other end is attached to the datalogger.

2. Launch LogView.

3. Select a previously created Datalogger object from the Project Explorer and click on the "Settings" button from the LogView Toolbar. Alternately, a "new" Datalogger can be created by right-clicking a "Project" in the Project Explorer and selecting "New" then "Logger" from the resulting context menu. The Datalogger Settings dialog should be displayed (see Figure 19).

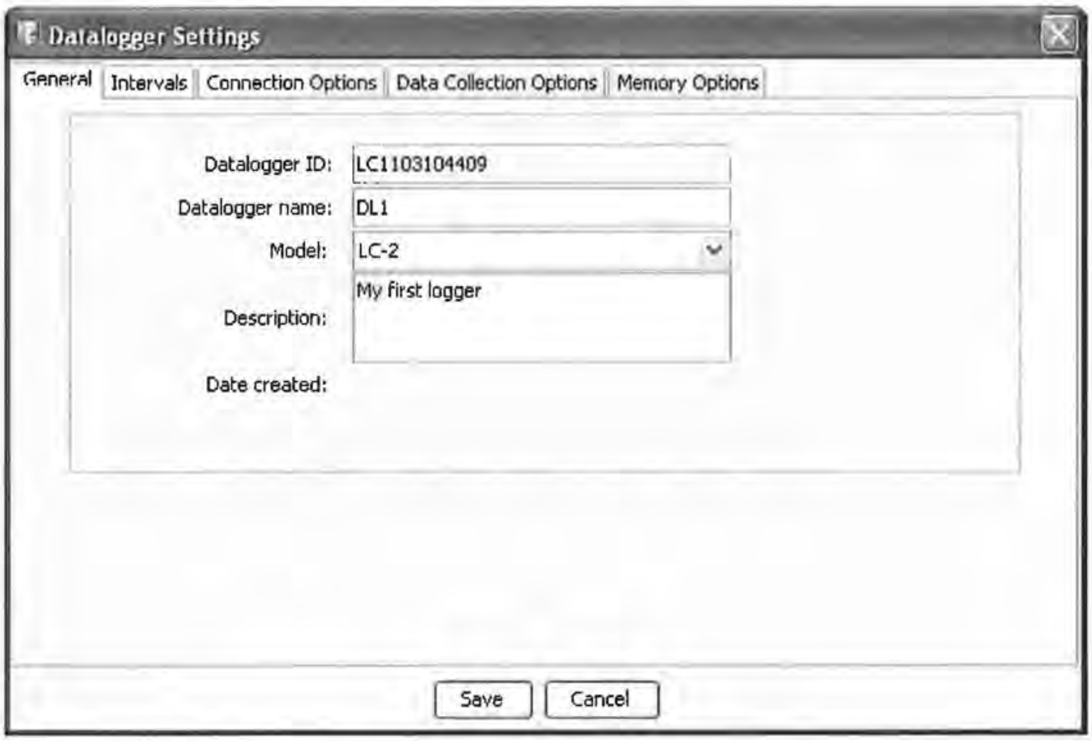

Figure 19 - Datalogger Settings

4. Click on the "Connection Options" tab to display the settings required to establish a datalogger connection (see Figure 20).

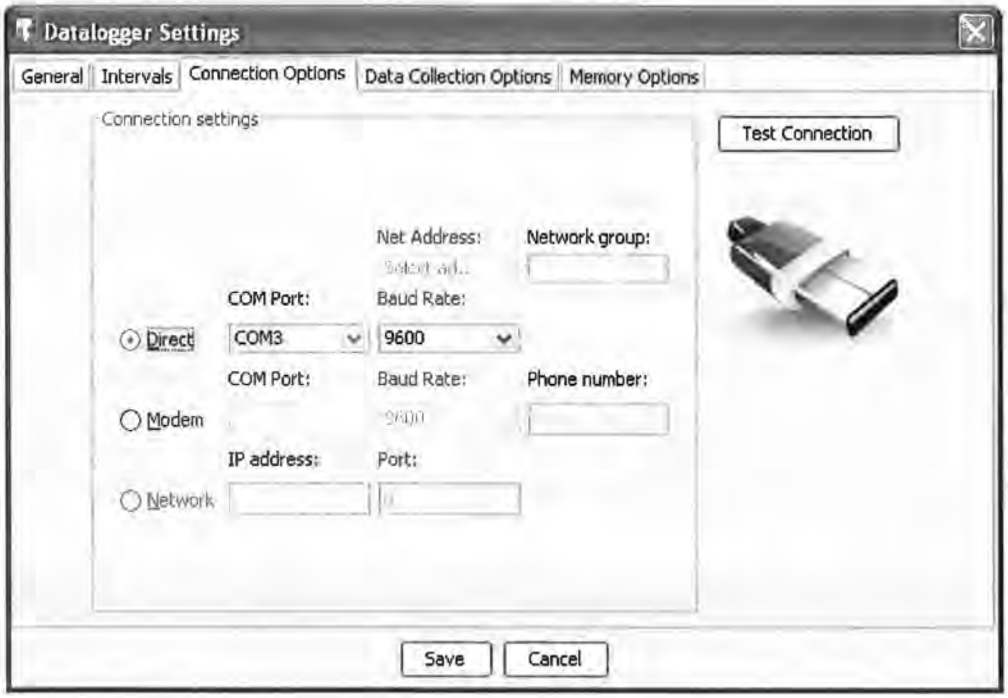

Figure 20 - Connection Options

5. Make sure the "Direct" radio button is enabled and select a COM port corresponding to the datalogger connection as determined in section 3.3. For single channel LC-2 dataloggers with firmware versions less than V5.0.X, the proper "Baud Rate" setting will be 9600. When done, click the "Save" button. (See the datalogger's user manual for more information regarding baud rate options.)

6. Click on the "Open Connect" button from the toolbar to create a connection from LogView to the selected datalogger. After several seconds, LogView should respond with a "Connected" status in the lower left hand corner of the screen.

   NOTE: It's very likely, when connecting for the first time to a new datalogger, that the following dialog box will be displayed (see Figure 21). This is normal and simply indicates that the Datalogger ID field that LogView assigns does not match the value in the physical datalogger. In most cases simply click on "Continue" to finish connecting to the datalogger.

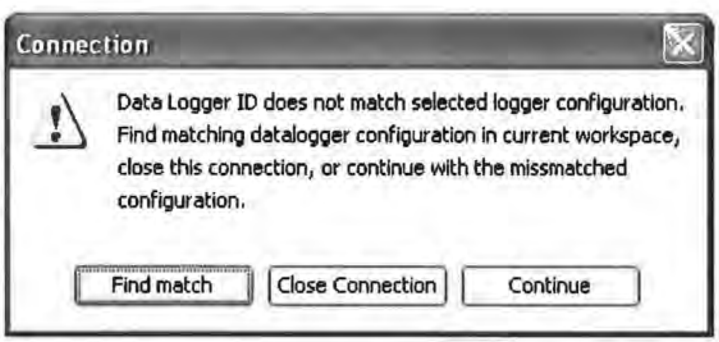

Figure 21 - Connection Warning Message

7. Upload the recently modified settings to the selected datalogger by clicking on the "Upload Settings" button from the toolbar.

8. Close the connection by clicking on the "Close Connect" button from the toolbar.

4. Collecting and viewing data

Before any data is collected, ensure your "Data Collection Options" have been configured for your project (Figure 22.). These can be found by selecting your datalogger and either right clicking, then selecting "Settings," or clicking the "Settings" button in the Toolbar. Choose the "Data Collection Options" tab to configure your settings.

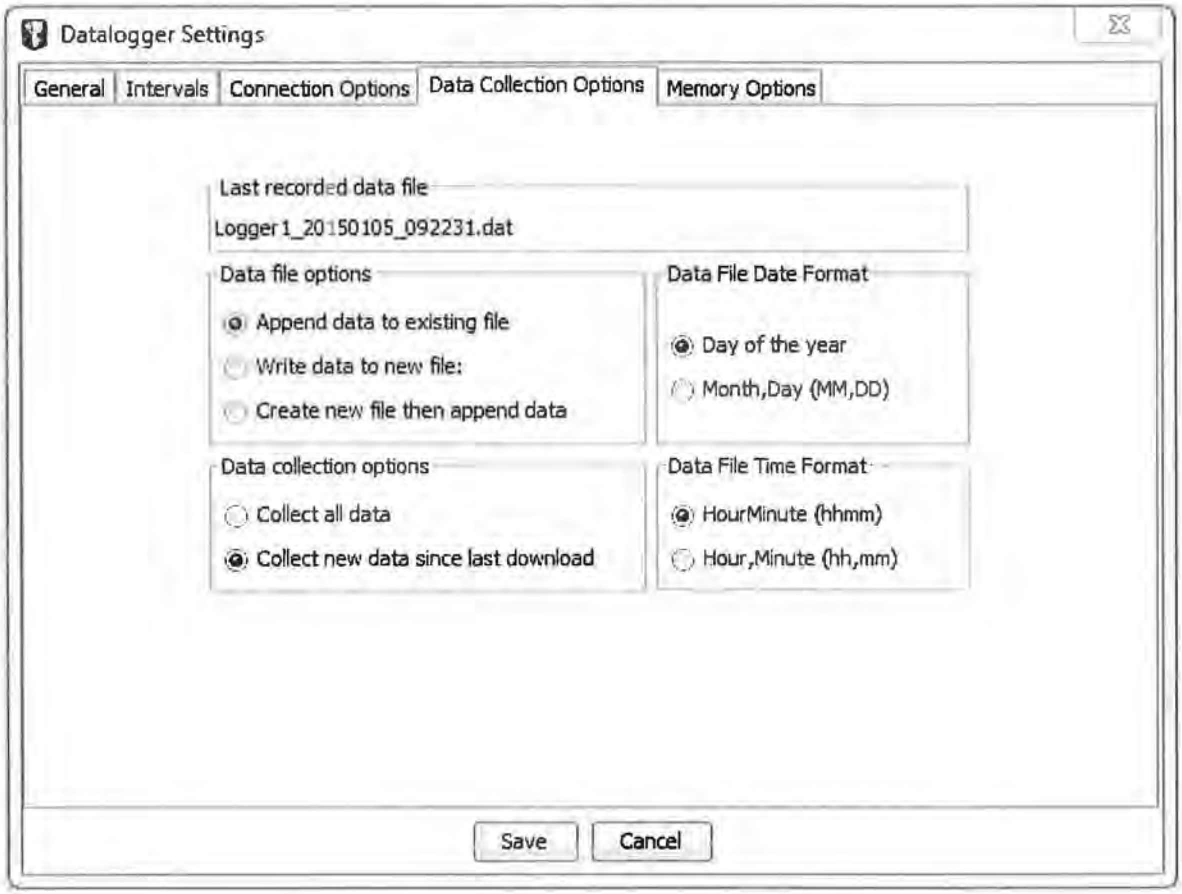

Figure 22 - Data Collection Options

Upon successful connection to a datalogger, the "Collect Data" button will be enabled in the toolbar, otherwise it is greyed out (Figure 23.)

NOTE: Once connected to a datalogger, you cannot select a different datalogger without first closing the active connection. Also, data cannot be collected from a logger that is not connected.

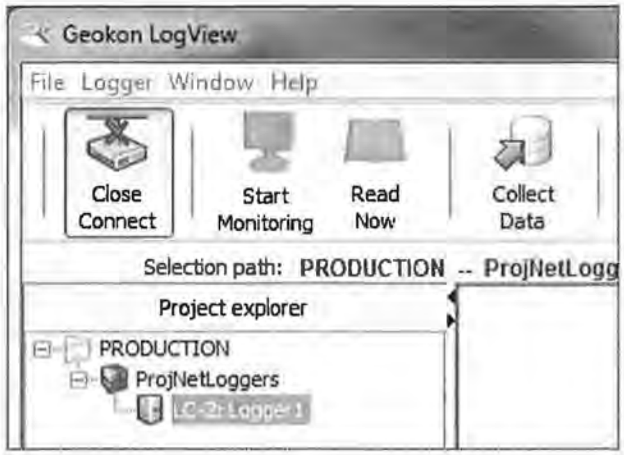

Figure 23 - Collect Data Button Enabled

When ready to collect your data, click the "Collect Data" button to begin collecting data. You will see a "Progress…" message indicating that new data is downloading (Figure 24.)

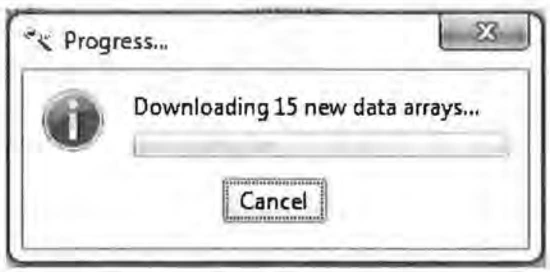

Figure 24 - New Data Downloading

Upon successful collection of data you will see the message displayed in Figure 25.

Figure 25 - Data Collection Complete Message

To view the collected data inside of LogView, right click on the desired datalogger and choose "View Data File." Next you will see a window showing "Available data files," choose the data file you want to view and click the "View" button. The data will be shown as a table with column headers and will also be shown as a graph below the table (Figure 26.)

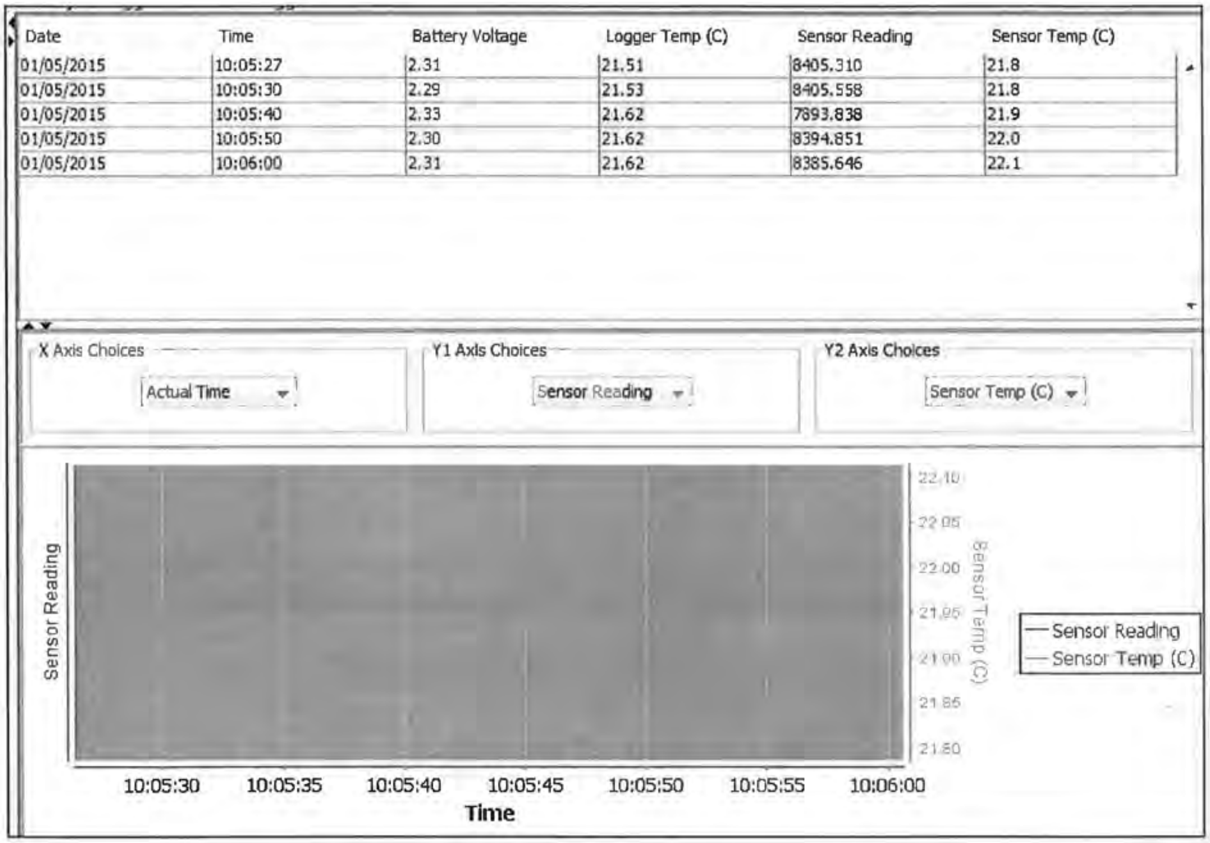

Figure 26 - Viewing Data Inside of LogView

To view the collected data outside of LogView, select the desired datalogger, right click on it, select "Export" > "Data Files" (Figure 27.)

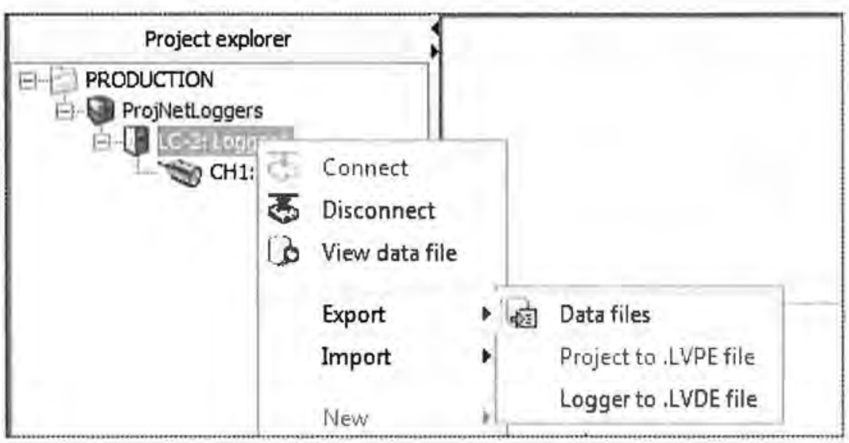

Figure 27 - Export Data Files Menu

A "Data Export" window will open where you can choose your export settings (Figure 28.) You must choose your "Export folder" and "Export File Format." The "Export Format Options" are optional. Next select a file from the "Available files:" pane and choose one of the arrow buttons to move the file to the "Selected for export" pane. When your settings are complete, click the "Export" button at the bottom of the window to finish the data export. You will see a message indicating the "Data export completed."

NOTE: When a file is selected it will be highlighted in blue. To see the functions of the arrow buttons, hover the mouse over them for a tool tip.

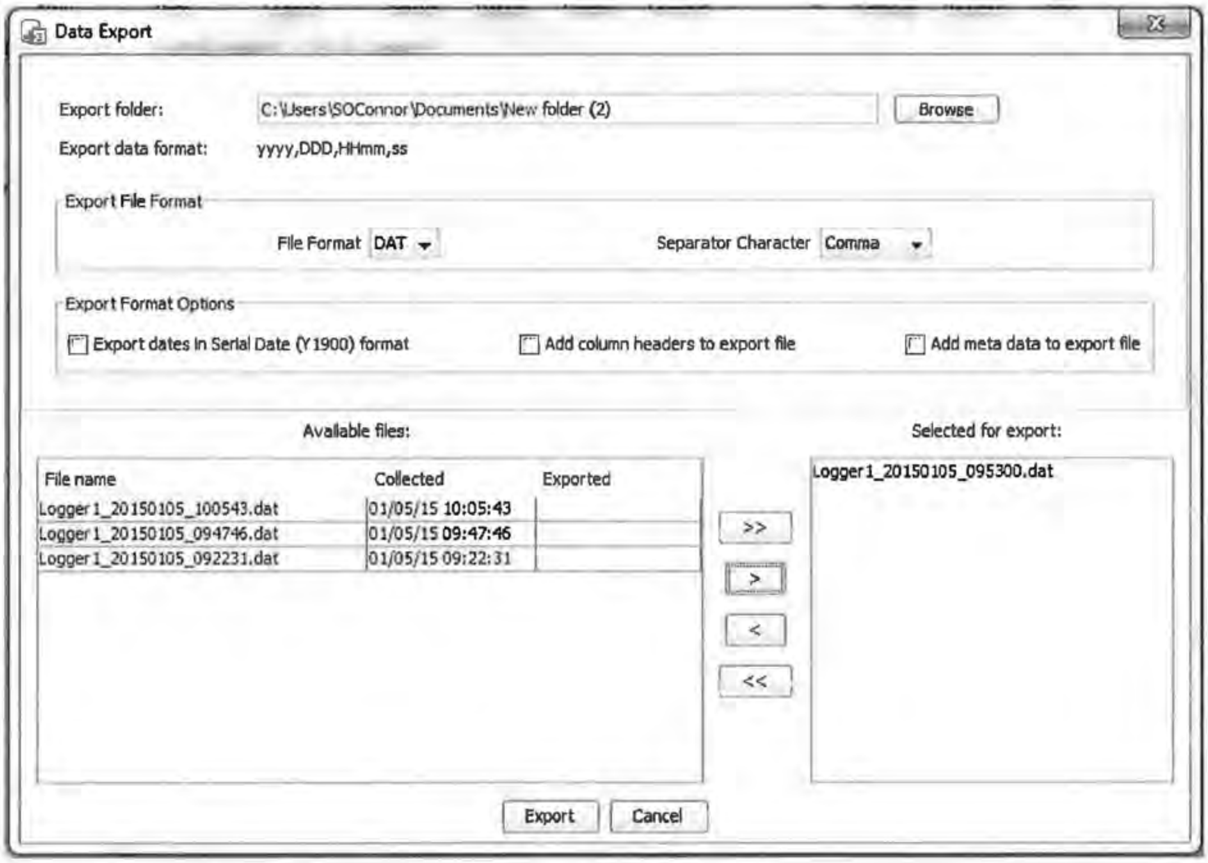

Figure 28 - Data Export Settings

You will now be able to view your collected data with your chosen settings in the program of your choice.

5. Creating a Datalogger Network (RS-485)

Under the project "ProjNetLoggers" is another type of project object: the Network Group object. A network group object contains all dataloggers that are to be "networked" together via an RS-485 communication link. As above, right-clicking a project object calls up a context menu, allowing a Network Group object to be added to the project.

Right-clicking a Network Group object calls up a context menu, allowing dataloggers to be added under the Network object.

Figure 29 below illustrates a typical datalogger "network". In the Project Explorer, you can see that the "ProjNetLoggers" project is expanded and contains a Network group object called "RS485 Loggers". Under "RS485 Loggers" are the networked dataloggers, "DL1" and "DL2". Also notice that both dataloggers have sensors defined.

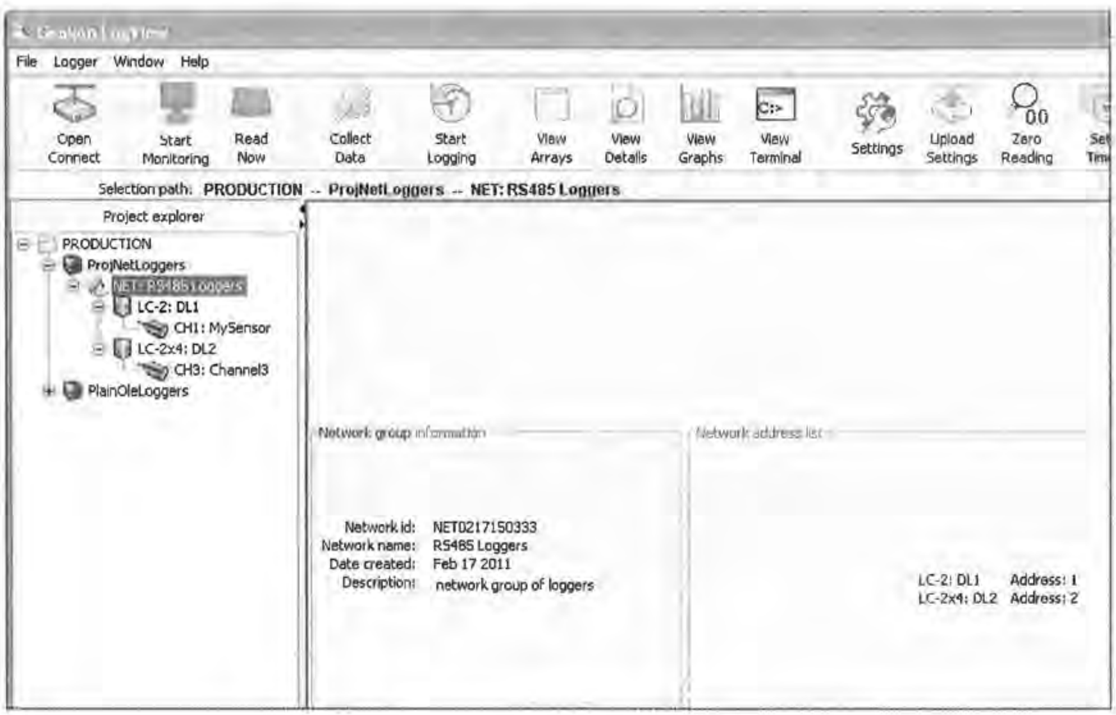

Figure 29 - Network Group

The sections below describe how to connect and communicate with networked dataloggers.

6. Connecting to Networked Dataloggers

A minimum of 6 components are required to create a network of (2) dataloggers:

Item	Description
1	8002-5: USB to RS-485 Conversion Module.
2	COM-109: USB cable needed communicate with item 1.
3	8002-1-3, 8002-4-3 or 8002-16-3: **Datalogger1** - One, four or sixteen channel datalogger with RS-485 option.
4	8002-1-3, 8002-4-3 or 8002-16-3: **Datalogger2** - One, four or sixteen channel datalogger with RS-485 option.
5	8002-1-3A: RS-485 Interconnect Cable. Connects item 1 with item 3.
6	8002-1-3A: RS-485 Interconnect Cable. Connects item 3 with item 4.

Table 1 – Minimum Components for RS-485 Logger Network

In LogView, after adding two Datalogger objects to the Network Group object, and before connecting the above components together as a network, each datalogger needs settings uploaded to it. This is accomplished using the following steps:

1) Connect one end of the COM-109 cable to the first datalogger's "Network In" connector and the other end to a free USB port on the PC. After selecting one of the networked Datalogger objects in the Project Explorer, click on the "Settings" button from the toolbar. The dialog box below will be displayed:

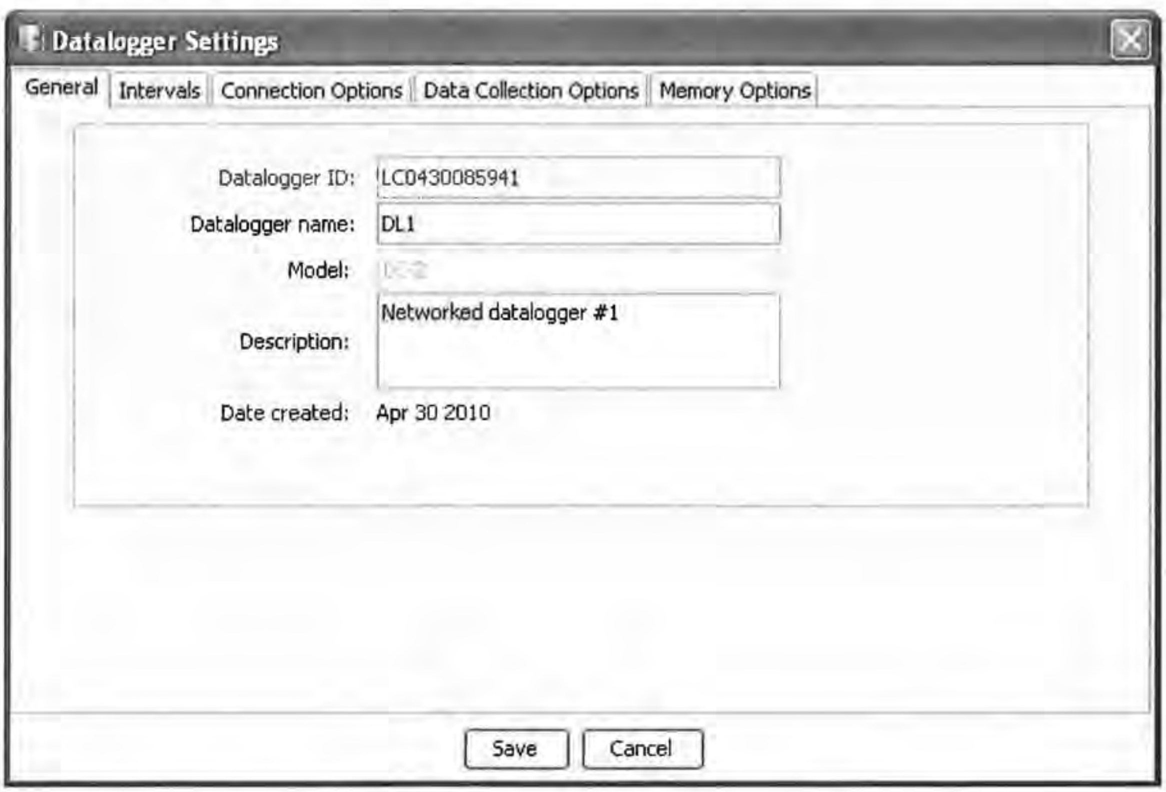

Figure 30 - Networked Datalogger Settings

2) Clicking on the "Connection Options" tab above will cause the dialog box below to be displayed:

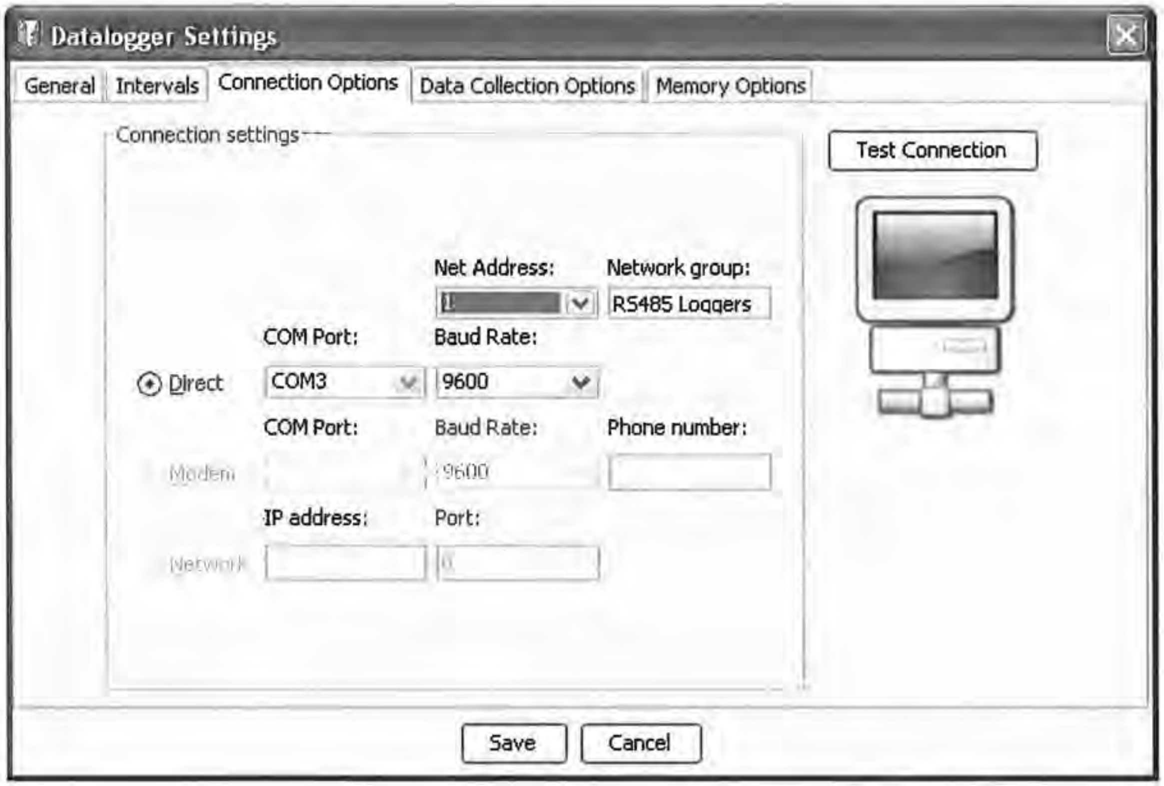

Figure 31 - Network Connection Options

3) Select a COM port corresponding to the datalogger connection - see section 2.3.10 (8002-4-3 and 8002-16-3) or 3.3.9 (8002-1-3) in the Geokon Datalogger Instruction Manual for more information on how to determine the appropriate COM port. Note that the network group for this datalogger has already been filled in.

4) The network address now needs to be set. Set the "Net Address" to the appropriate value; "1" for the first logger, "2" for the second, etc. It's a good idea to label the datalogger and also name it in such a way that it is easy to remember which Datalogger object matches with which physical datalogger. When done click on the "Save" button.

5) Click on the "Open Connect" button from the toolbar to create a connection from LogView to the selected datalogger. After several seconds, LogView should respond with a "Connected" status in the lower left hand corner of the screen.

NOTE: It's very likely, when connecting for the first time to a new datalogger, that a warning dialog box will be displayed (see Figure 21.) This is normal and simply indicates that the Datalogger ID field that LogView assigns does not match the value in the physical datalogger. In most cases simply click on "Continue" to finish connecting to the datalogger.

6) Upload the recently modified settings to the selected datalogger by clicking on the "Upload Settings" button from the toolbar.

7) Close the connection by clicking on the "Close Connect" button from the toolbar.

Now remove the COM-109 connection from the first data logger, attach it to the second and repeat steps 1 - 7 for next datalogger.

After the settings have been uploaded for all dataloggers in the network group, connect the components together as shown in the diagram below:

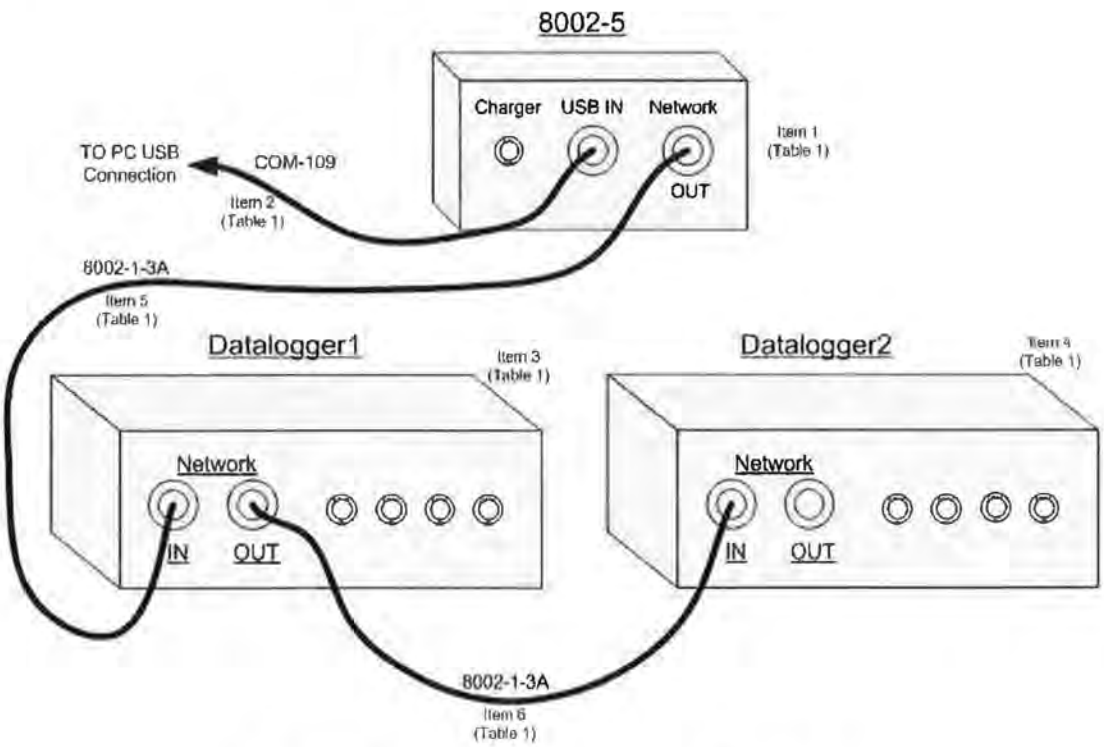

Figure 32 - Network Group Component Connections

The network group has now been setup and all attached dataloggers should be able to be accessed via LogView through the one USB connection.

NOTE: The last datalogger in the network must be terminated for proper operation. The termination procedure is described in the Datalogger Instruction Manual – Appendix F.

Appendix D

Vibrating Wire Pressure Transducer Calibration Reports

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610327

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9809	9811	9810	0.283	0.17	0.016	0.01
34.0	9096	9097	9097	33.95	-0.03	33.98	-0.01
68.0	8379	8381	8380	67.76	-0.13	67.94	-0.02
102.0	7657	7659	7658	101.8	-0.09	102.0	0.02
136.0	6934	6935	6935	136.0	-0.01	136.0	0.01
170.0	6208	6209	6209	170.2	0.14	169.9	-0.02

(kPa) Linear Gage Factor (G): -0.04718 (kPa/ digit)

Polynomial Gage factors: **A: -1.448E-07** **B: -0.04486** **C:** ____

Thermal Factor (K): 0.05671 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006843 (psi/ digit)

Polynomial Gage Factors: **A: -2.1E-08** **B: -0.006507** **C:** ____

Thermal Factor (K): 0.008226 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9840 **Temperature: 21.2 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610328

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9918	9920	9919	0.337	0.20	0.009	0.01
34.0	9220	9221	9221	33.96	-0.02	34.01	0.01
68.0	8519	8520	8520	67.70	-0.17	67.94	-0.02
102.0	7813	7814	7814	101.7	-0.18	101.9	-0.03
136.0	7099	7100	7100	136.0	0.04	136.1	0.07
170.0	6388	6390	6389	170.2	0.16	169.9	-0.04

(kPa) Linear Gage Factor (G): -0.04813 (kPa/ digit)

Polynomial Gage factors: **A: -1.909E-07** **B: -0.04502** **C: ________**

Thermal Factor (K): 0.01215 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006981 (psi/ digit)

Polynomial Gage Factors: **A: -2.769E-08** **B: -0.006529** **C: ________**

Thermal Factor (K): 0.001762 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9948 **Temperature: 21.4 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610329

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9720	9722	9721	0.321	0.19	0.003	0.00
34.0	8986	8987	8987	33.96	-0.02	34.00	0.00
68.0	8248	8250	8249	67.74	-0.14	67.96	-0.01
102.0	7506	7507	7507	101.7	-0.13	102.0	0.00
136.0	6759	6760	6760	136.0	-0.01	136.0	0.02
170.0	6010	6011	6011	170.3	0.17	170.0	-0.01

(kPa) Linear Gage Factor (G): -0.04580 (kPa/ digit)

Polynomial Gage factors: **A: -1.621E-07** **B: -0.04325** **C:**

Thermal Factor (K): 0.04562 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006643 (psi/ digit)

Polynomial Gage Factors: **A: -2.351E-08** **B: -0.006273** **C:**

Thermal Factor (K): 0.006616 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9748 **Temperature: 21.7 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610330

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9888	9890	9889	0.326	0.19	-0.013	-0.01
34.0	9166	9168	9167	33.96	-0.02	34.01	0.01
68.0	8441	8442	8442	67.75	-0.13	68.00	0.01
102.0	7712	7713	7713	101.7	-0.16	102.0	-0.01
136.0	6978	6979	6979	135.9	-0.04	136.0	-0.01
170.0	6239	6240	6240	170.3	0.20	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04658 (kPa/ digit)

Polynomial Gage factors: **A: -1.838E-07** **B: -0.04362** **C:**

Thermal Factor (K): -0.03585 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006756 (psi/ digit)

Polynomial Gage Factors: **A: -2.666E-08** **B: -0.006326** **C:**

Thermal Factor (K): -0.005200 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9916 **Temperature: 20.8 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610331

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9907	9908	9908	0.259	0.15	0.010	0.01
34.0	9192	9193	9193	33.94	-0.03	33.97	-0.02
68.0	8473	8474	8474	67.81	-0.10	67.98	0.00
102.0	7751	7752	7752	101.8	-0.09	102.0	0.01
136.0	7027	7028	7028	135.9	-0.03	136.0	-0.01
170.0	6299	6300	6300	170.2	0.14	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04711 (kPa/ digit)

Polynomial Gage factors: **A: -1.352E-07** **B: -0.04491** **C:** ______

Thermal Factor (K): 0.01687 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006832 (psi/ digit)

Polynomial Gage Factors: **A: -1.961E-08** **B: -0.006514** **C:** ______

Thermal Factor (K): 0.002447 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9936 **Temperature: 21.8 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610332

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10002	10003	10003	0.310	0.18	0.002	0.00
34.0	9297	9298	9298	33.92	-0.04	33.99	-0.01
68.0	8588	8589	8589	67.72	-0.15	67.98	0.00
102.0	7875	7876	7876	101.7	-0.15	102.0	0.00
136.0	7158	7159	7159	135.9	-0.04	136.0	0.00
170.0	6437	6438	6438	170.3	0.18	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04768 (kPa/ digit)

Polynomial Gage factors: **A: -1.854E-07** **B: -0.04463** **C:**

Thermal Factor (K): 0.03829 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006915 (psi/ digit)

Polynomial Gage Factors: **A: -2.689E-08** **B: -0.006473** **C:**

Thermal Factor (K): 0.005554 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10031 **Temperature: 20.9 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610333

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9827	9829	9828	0.284	0.17	-0.010	0.00
34.0	9117	9118	9118	33.95	-0.02	33.98	-0.01
68.0	8402	8403	8403	67.84	-0.08	68.03	0.03
102.0	7686	7687	7687	101.8	-0.12	102.0	-0.01
136.0	6966	6967	6967	135.9	-0.05	135.9	-0.03
170.0	6240	6241	6241	170.3	0.19	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04739 (kPa/ digit)

Polynomial Gage factors: A: -1.582E-07 B: -0.04485 C: ______

Thermal Factor (K): -0.008173 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006873 (psi/ digit)

Polynomial Gage Factors: A: -2.295E-08 B: -0.006504 C: ______

Thermal Factor (K): -0.001185 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9850 Temperature: 22.0 °C Barometer: 988.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Serial Number: 1610335

Calibration Instruction: VW Pressure Transducers

Cable Length: 60 feet

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Temperature: 21.60 °C

Barometric Pressure: 1001.3 mbar

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10044	10045	10045	0.260	0.15	-0.019	-0.01
34.0	9333	9334	9334	33.93	-0.04	34.01	0.01
68.0	8619	8620	8620	67.74	-0.14	68.01	0.02
102.0	7902	7903	7903	101.7	-0.16	102.0	-0.01
136.0	7181	7182	7182	135.8	-0.08	135.9	-0.03
170.0	6454	6455	6455	170.3	0.18	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04736 (kPa/ digit)

Polynomial Gage factors: **A: -1.751E-07** **B: -0.04447** **C:**

Thermal Factor (K): 0.02673 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006869 (psi/ digit)

Polynomial Gage Factors: **A: -2.54E-08** **B: -0.006449** **C:**

Thermal Factor (K): 0.003877 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10075 **Temperature: 20.9 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610336

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9677	9678	9678	0.320	0.19	0.002	0.00
34.0	8995	8996	8996	33.93	-0.04	33.98	-0.01
68.0	8309	8310	8310	67.74	-0.14	67.98	0.00
102.0	7619	7620	7620	101.7	-0.14	102.0	0.01
136.0	6926	6927	6927	135.9	-0.05	136.0	-0.01
170.0	6228	6229	6229	170.3	0.19	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04928 (kPa/ digit)

Polynomial Gage factors: **A: -1.975E-07** **B: -0.04614** **C:**

Thermal Factor (K): -0.03269 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007148 (psi/ digit)

Polynomial Gage Factors: **A: -2.864E-08** **B: -0.006692** **C:**

Thermal Factor (K): -0.004741 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9702 **Temperature: 21.2 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610337

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9960	9961	9961	0.258	0.15	-0.030	-0.02
34.0	9241	9243	9242	33.99	0.00	34.04	0.03
68.0	8522	8523	8523	67.78	-0.12	67.99	0.01
102.0	7799	7800	7800	101.7	-0.15	101.9	-0.02
136.0	7071	7072	7072	135.9	-0.04	136.0	-0.01
170.0	6339	6340	6340	170.3	0.18	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04695 (kPa/ digit)

Polynomial Gage factors: **A: -1.603E-07** **B: -0.04434** **C: ______**

Thermal Factor (K): 0.0009754 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006810 (psi/ digit)

Polynomial Gage Factors: **A: -2.324E-08** **B: -0.006431** **C: ______**

Thermal Factor (K): 0.0001415 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9992 **Temperature: 21.5 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610338

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9932	9933	9933	0.306	0.18	0.000	0.00
34.0	9218	9219	9219	33.95	-0.03	34.00	0.00
68.0	8501	8502	8502	67.74	-0.14	67.96	-0.01
102.0	7779	7780	7780	101.8	-0.13	102.0	0.01
136.0	7054	7055	7055	135.9	-0.03	136.0	0.00
170.0	6325	6326	6326	170.3	0.18	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04712 (kPa/ digit)

Polynomial Gage factors: A: -1.709E-07 B: -0.04434 C: ______

Thermal Factor (K): 0.02762 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006834 (psi/ digit)

Polynomial Gage Factors: A: -2.479E-08 B: -0.006431 C: ______

Thermal Factor (K): 0.004006 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9958 Temperature: 21.2 °C Barometer: 988.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 06, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1610339

Temperature: 21.60 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 1001.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9790	9792	9791	0.319	0.19	-0.019	-0.01
34.0	9053	9054	9054	33.98	-0.01	34.04	0.02
68.0	8314	8315	8315	67.70	-0.16	67.96	-0.01
102.0	7569	7571	7570	101.7	-0.17	101.9	-0.02
136.0	6819	6820	6820	135.9	-0.02	136.0	0.01
170.0	6066	6067	6067	170.3	0.19	170.0	-0.01

(kPa) Linear Gage Factor (G): -0.04564 (kPa/ digit)

Polynomial Gage factors: **A: -1.794E-07** **B: -0.04279** **C:**

Thermal Factor (K): 0.04082 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006619 (psi/ digit)

Polynomial Gage Factors: **A: -2.603E-08** **B: -0.006207** **C:**

Thermal Factor (K): 0.005921 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9819 **Temperature: 21.6 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612710

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10055	10057	10056	0.244	0.14	-0.023	-0.01
34.0	9364	9364	9364	33.95	-0.03	34.03	0.02
68.0	8670	8670	8670	67.76	-0.13	68.00	0.01
102.0	7974	7973	7974	101.7	-0.17	101.9	-0.03
136.0	7271	7271	7271	135.9	-0.04	136.0	0.00
170.0	6566	6566	6566	170.2	0.16	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04871 (kPa/ digit)

Polynomial Gage factors: **A: -1.758E-07** **B: -0.04579** **C:**

Thermal Factor (K): -0.05334 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007065 (psi/ digit)

Polynomial Gage Factors: **A: -2.55E-08** **B: -0.006641** **C:**

Thermal Factor (K): -0.007737 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10070 **Temperature: 21.5 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612711

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10220	10221	10221	0.316	0.19	-0.023	-0.01
34.0	9529	9529	9529	33.98	-0.01	34.02	0.01
68.0	8835	8835	8835	67.77	-0.13	68.00	0.01
102.0	8137	8137	8137	101.7	-0.14	102.0	0.00
136.0	7436	7436	7436	135.9	-0.06	135.9	-0.03
170.0	6728	6728	6728	170.3	0.22	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04868 (kPa/ digit)

Polynomial Gage factors: **A: -1.96E-07** **B: -0.04536** **C:** ______

Thermal Factor (K): -0.06979 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007061 (psi/ digit)

Polynomial Gage Factors: **A: -2.843E-08** **B: -0.006579** **C:** ______

Thermal Factor (K): -0.01012 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10233 **Temperature: 21.6 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612712

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9979	9980	9980	0.267	0.16	0.008	0.01
34.0	9285	9285	9285	33.97	-0.01	34.00	0.00
68.0	8589	8589	8589	67.75	-0.13	67.93	-0.03
102.0	7887	7887	7887	101.8	-0.09	102.0	0.01
136.0	7183	7183	7183	136.0	0.01	136.0	0.03
170.0	6478	6478	6478	170.2	0.14	169.9	-0.01

(kPa) Linear Gage Factor (G): -0.04853 (kPa/ digit)

Polynomial Gage factors: **A: -1.483E-07** **B: -0.04609** **C:**

Thermal Factor (K): -0.05916 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007039 (psi/ digit)

Polynomial Gage Factors: **A: -2.151E-08** **B: -0.006685** **C:**

Thermal Factor (K): -0.008581 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9998 **Temperature: 21.4 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612713

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9760	9761	9761	0.354	0.21	0.003	0.00
34.0	9048	9048	9048	33.95	-0.03	34.00	0.00
68.0	8332	8332	8332	67.70	-0.16	67.96	-0.01
102.0	7611	7611	7611	101.7	-0.17	102.0	-0.01
136.0	6884	6884	6884	136.0	0.00	136.0	0.03
170.0	6156	6156	6156	170.3	0.19	169.9	-0.01

(kPa) Linear Gage Factor (G): -0.04715 (kPa/ digit)

Polynomial Gage factors: **A: -1.959E-07** **B: -0.04403** **C:** ____

Thermal Factor (K): -0.02810 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006838 (psi/ digit)

Polynomial Gage Factors: **A: -2.841E-08** **B: -0.006386** **C:** ____

Thermal Factor (K): -0.004076 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9777 **Temperature: 21.7 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612714

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10112	10112	10112	0.285	0.17	-0.013	-0.01
34.0	9403	9403	9403	33.93	-0.04	34.01	0.01
68.0	8691	8691	8691	67.72	-0.15	67.99	0.01
102.0	7975	7975	7975	101.7	-0.16	102.0	0.00
136.0	7255	7255	7255	135.9	-0.06	136.0	-0.01
170.0	6530	6530	6530	170.3	0.18	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04746 (kPa/ digit)

Polynomial Gage factors: **A: -1.841E-07** **B: -0.04440** **C: ______**

Thermal Factor (K): -0.02065 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006883 (psi/ digit)

Polynomial Gage Factors: **A: -2.67E-08** **B: -0.006439** **C: ______**

Thermal Factor (K): -0.002995 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10125 **Temperature: 21.2 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612715

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9939	9940	9940	0.308	0.18	-0.019	-0.01
34.0	9228	9228	9228	33.98	-0.01	34.03	0.02
68.0	8515	8515	8515	67.73	-0.15	67.97	-0.01
102.0	7797	7797	7797	101.7	-0.16	102.0	-0.01
136.0	7074	7074	7074	135.9	-0.02	136.0	0.01
170.0	6348	6348	6348	170.3	0.19	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04733 (kPa/ digit)

Polynomial Gage factors: **A: -1.834E-07** **B: -0.04434** **C: ________**

Thermal Factor (K): -0.009594 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006865 (psi/ digit)

Polynomial Gage Factors: **A: -2.66E-08** **B: -0.006432** **C: ________**

Thermal Factor (K): -0.001392 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9952 **Temperature: 21.6 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612716

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9909	9910	9910	0.315	0.19	-0.022	-0.01
34.0	9214	9215	9215	33.97	-0.02	34.01	0.01
68.0	8516	8516	8516	67.79	-0.11	68.02	0.03
102.0	7815	7815	7815	101.7	-0.15	102.0	-0.01
136.0	7110	7110	7110	135.9	-0.06	135.9	-0.03
170.0	6398	6398	6398	170.3	0.22	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04842 (kPa/ digit)

Polynomial Gage factors: A: -1.938E-07 B: -0.04526 C: ________

Thermal Factor (K): -0.02196 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007023 (psi/ digit)

Polynomial Gage Factors: A: -2.81E-08 B: -0.006565 C: ________

Thermal Factor (K): -0.003185 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9925 Temperature: 21.6 °C Barometer: 988.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612717

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9832	9833	9833	0.347	0.21	0.020	0.01
34.0	9106	9106	9106	33.93	-0.04	33.98	-0.01
68.0	8375	8376	8376	67.69	-0.17	67.94	-0.02
102.0	7640	7640	7640	101.7	-0.17	101.9	-0.02
136.0	6897	6897	6897	136.0	0.04	136.1	0.07
170.0	6157	6157	6157	170.2	0.16	169.9	-0.03

(kPa) Linear Gage Factor (G): -0.04622 (kPa/ digit)

Polynomial Gage factors: **A: -1.785E-07** **B: -0.04337** **C:** ______

Thermal Factor (K): -0.009374 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006704 (psi/ digit)

Polynomial Gage Factors: **A: -2.589E-08** **B: -0.006290** **C:** ______

Thermal Factor (K): -0.001360 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9849 **Temperature: 21.6 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612718

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10076	10076	10076	0.241	0.14	-0.019	-0.01
34.0	9378	9378	9378	33.95	-0.03	34.03	0.02
68.0	8678	8679	8679	67.73	-0.15	67.98	0.00
102.0	7975	7975	7975	101.7	-0.16	102.0	-0.01
136.0	7267	7267	7267	135.9	-0.04	136.0	0.00
170.0	6556	6556	6556	170.2	0.16	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04829 (kPa/ digit)

Polynomial Gage factors: A: -1.713E-07 B: -0.04544 C:

Thermal Factor (K): -0.05661 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007005 (psi/ digit)

Polynomial Gage Factors: A: -2.485E-08 B: -0.006591 C:

Thermal Factor (K): -0.008210 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10086 Temperature: 21.2 °C Barometer: 988.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612719

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10056	10057	10057	0.259	0.15	0.008	0.01
34.0	9343	9343	9343	33.91	-0.05	33.98	-0.01
68.0	8626	8626	8626	67.73	-0.15	67.96	-0.01
102.0	7904	7904	7904	101.8	-0.11	102.0	0.02
136.0	7181	7181	7181	135.9	-0.05	136.0	-0.01
170.0	6453	6453	6453	170.2	0.15	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04717 (kPa/ digit)

Polynomial Gage factors: **A: -1.555E-07** **B: -0.04460** **C: ________**

Thermal Factor (K): -0.02882 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006841 (psi/ digit)

Polynomial Gage Factors: **A: -2.256E-08** **B: -0.006469** **C: ________**

Thermal Factor (K): -0.004181 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10080 **Temperature: 21.5 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612720

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9971	9971	9971	0.342	0.20	0.017	0.01
34.0	9283	9283	9283	33.92	-0.04	33.99	0.00
68.0	8591	8592	8592	67.67	-0.18	67.94	-0.02
102.0	7895	7895	7895	101.7	-0.19	101.9	-0.02
136.0	7191	7191	7191	136.0	0.03	136.1	0.07
170.0	6490	6490	6490	170.2	0.16	169.9	-0.03

(kPa) Linear Gage Factor (G): -0.04881 (kPa/ digit)

Polynomial Gage factors: **A: -2.057E-07** **B: -0.04542** **C: ________**

Thermal Factor (K): -0.05962 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007079 (psi/ digit)

Polynomial Gage Factors: **A: -2.984E-08** **B: -0.006588** **C: ________**

Thermal Factor (K): -0.008648 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9985 **Temperature: 21.4 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Serial Number: 1612721

Calibration Instruction: VW Pressure Transducers

Cable Length: 60 feet

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Temperature: 23.80 °C

Barometric Pressure: 996.8 mbar

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9828	9829	9829	0.258	0.15	0.006	0.01
34.0	9110	9110	9110	33.92	-0.05	34.00	0.00
68.0	8389	8389	8389	67.70	-0.16	67.94	-0.02
102.0	7662	7662	7662	101.8	-0.13	102.0	0.02
136.0	6933	6933	6933	135.9	-0.04	136.0	0.01
170.0	6201	6201	6201	170.2	0.14	170.0	-0.01

(kPa) Linear Gage Factor (G): -0.04685 (kPa/ digit)

Polynomial Gage factors: **A: -1.572E-07** **B: -0.04433** **C:** ____

Thermal Factor (K): -0.06496 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006795 (psi/ digit)

Polynomial Gage Factors: **A: -2.28E-08** **B: -0.006430** **C:** ____

Thermal Factor (K): -0.009422 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9840 **Temperature: 21.7 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612722

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9749	9750	9750	0.213	0.13	-0.032	-0.02
34.0	9037	9037	9037	33.99	0.00	34.06	0.04
68.0	8325	8325	8325	67.74	-0.14	67.97	-0.01
102.0	7608	7608	7608	101.7	-0.15	102.0	-0.01
136.0	6887	6887	6887	135.9	-0.04	136.0	0.00
170.0	6163	6163	6163	170.2	0.15	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04740 (kPa/ digit)

Polynomial Gage factors: **A: -1.529E-07** **B: -0.04497** **C:**

Thermal Factor (K): -0.02862 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006875 (psi/ digit)

Polynomial Gage Factors: **A: -2.218E-08** **B: -0.006522** **C:**

Thermal Factor (K): -0.004150 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9762 **Temperature: 21.2 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612723

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10078	10078	10078	0.246	0.15	-0.025	-0.01
34.0	9392	9393	9393	33.96	-0.02	34.04	0.02
68.0	8706	8706	8706	67.72	-0.15	67.98	0.00
102.0	8015	8015	8015	101.7	-0.16	102.0	-0.01
136.0	7320	7320	7320	135.9	-0.06	136.0	-0.01
170.0	6621	6621	6621	170.3	0.17	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04918 (kPa/ digit)

Polynomial Gage factors: **A: -1.855E-07** **B: -0.04608** **C:**

Thermal Factor (K): 0.003730 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007133 (psi/ digit)

Polynomial Gage Factors: **A: -2.691E-08** **B: -0.006683** **C:**

Thermal Factor (K): 0.0005410 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10095 **Temperature: 21.3 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612724

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10102	10102	10102	0.244	0.14	-0.020	-0.01
34.0	9410	9411	9411	33.98	-0.01	34.02	0.02
68.0	8717	8718	8718	67.78	-0.12	67.99	0.00
102.0	8021	8021	8021	101.8	-0.13	102.0	-0.01
136.0	7321	7321	7321	135.9	-0.04	136.0	-0.01
170.0	6617	6617	6617	170.3	0.17	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04878 (kPa/ digit)

Polynomial Gage factors: **A: -1.614E-07** **B: -0.04608** **C:** ______

Thermal Factor (K): -0.03734 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007075 (psi/ digit)

Polynomial Gage Factors: **A: -2.34E-08** **B: -0.006684** **C:** ______

Thermal Factor (K): -0.005415 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10118 **Temperature: 21.4 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612725

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10143	10144	10144	0.262	0.16	-0.031	-0.02
34.0	9435	9435	9435	33.99	0.00	34.04	0.02
68.0	8725	8725	8725	67.79	-0.11	68.01	0.02
102.0	8012	8012	8012	101.7	-0.14	102.0	-0.02
136.0	7294	7295	7295	135.9	-0.05	135.9	-0.02
170.0	6572	6572	6572	170.3	0.19	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04761 (kPa/ digit)

Polynomial Gage factors: **A: -1.658E-07** **B: -0.04484** **C: ________**

Thermal Factor (K): -0.02570 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006905 (psi/ digit)

Polynomial Gage Factors: **A: -2.405E-08** **B: -0.006503** **C: ________**

Thermal Factor (K): -0.003728 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10159 **Temperature: 22.0 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612726

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9866	9866	9866	0.241	0.14	-0.030	-0.02
34.0	9166	9166	9166	33.98	-0.01	34.03	0.02
68.0	8464	8465	8465	67.80	-0.11	68.01	0.02
102.0	7761	7761	7761	101.7	-0.16	101.9	-0.03
136.0	7051	7052	7052	135.9	-0.04	136.0	0.00
170.0	6339	6339	6339	170.3	0.17	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04821 (kPa/ digit)

Polynomial Gage factors: A: -1.626E-07 B: -0.04557 C: ________

Thermal Factor (K): -0.06400 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006992 (psi/ digit)

Polynomial Gage Factors: A: -2.358E-08 B: -0.006609 C: ________

Thermal Factor (K): -0.009283 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9878 Temperature: 21.6 °C Barometer: 987.7 mbar

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612728

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9975	9976	9976	0.258	0.15	0.012	0.01
34.0	9257	9258	9258	33.89	-0.06	33.92	-0.04
68.0	8531	8531	8531	67.93	-0.03	68.10	0.07
102.0	7808	7809	7809	101.8	-0.12	101.9	-0.02
136.0	7080	7080	7080	135.9	-0.04	135.9	-0.02
170.0	6347	6347	6347	170.2	0.16	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04685 (kPa/ digit)

Polynomial Gage factors: **A: -1.309E-07** **B: -0.04471** **C:**

Thermal Factor (K): -0.03973 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006795 (psi/ digit)

Polynomial Gage Factors: **A: -1.899E-08** **B: -0.006485** **C:**

Thermal Factor (K): -0.005762 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9987 **Temperature: 21.5 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612729

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9958	9959	9959	0.319	0.19	-0.017	-0.01
34.0	9273	9274	9274	33.95	-0.03	34.02	0.02
68.0	8586	8586	8586	67.70	-0.16	67.98	0.00
102.0	7894	7894	7894	101.7	-0.18	102.0	-0.01
136.0	7197	7197	7197	135.9	-0.05	136.0	0.00
170.0	6496	6496	6496	170.3	0.20	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04910 (kPa/ digit)

Polynomial Gage factors: **A: -2.148E-07** **B: -0.04556** **C:**

Thermal Factor (K): -0.04197 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007121 (psi/ digit)

Polynomial Gage Factors: **A: -3.115E-08** **B: -0.006608** **C:**

Thermal Factor (K): -0.006087 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9973 **Temperature: 21.6 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612730

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9794	9795	9795	0.270	0.16	-0.024	-0.01
34.0	9109	9110	9110	33.94	-0.04	34.02	0.02
68.0	8422	8422	8422	67.72	-0.15	68.00	0.01
102.0	7731	7731	7731	101.7	-0.17	102.0	-0.01
136.0	7036	7036	7036	135.8	-0.08	135.9	-0.02
170.0	6335	6335	6335	170.3	0.19	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04915 (kPa/ digit)

Polynomial Gage factors: A: -2.008E-07 B: -0.04591 C:

Thermal Factor (K): -0.008645 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007128 (psi/ digit)

Polynomial Gage Factors: A: -2.912E-08 B: -0.006658 C:

Thermal Factor (K): -0.001254 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers

Factory Zero Reading: 9804 Temperature: 21.8 °C Barometer: 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612731

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8743	8744	8744	0.391	0.23	-0.063	-0.04
34.0	8013	8014	8014	33.99	0.00	34.09	0.05
68.0	7282	7283	7283	67.64	-0.20	68.02	0.02
102.0	6546	6546	6546	101.5	-0.26	101.9	-0.03
136.0	5801	5802	5802	135.8	-0.10	135.9	-0.03
170.0	5048	5049	5049	170.5	0.30	170.0	0.03

(kPa) Linear Gage Factor (G): -0.04603 (kPa/ digit)

Polynomial Gage factors: **A: -2.538E-07** **B: -0.04253** **C:**

Thermal Factor (K): -0.02649 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006676 (psi/ digit)

Polynomial Gage Factors: **A: -3.681E-08** **B: -0.006168** **C:**

Thermal Factor (K): -0.003843 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8760 **Temperature: 22.0 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612732

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9964	9965	9965	0.313	0.19	-0.018	-0.01
34.0	9266	9266	9266	33.97	-0.02	34.02	0.01
68.0	8565	8565	8565	67.74	-0.14	67.99	0.01
102.0	7860	7860	7860	101.7	-0.16	102.0	-0.01
136.0	7150	7150	7150	135.9	-0.04	136.0	0.00
170.0	6436	6436	6436	170.3	0.20	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04818 (kPa/ digit)

Polynomial Gage factors: **A: -1.952E-07** **B: -0.04498** **C:**

Thermal Factor (K): -0.04336 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006988 (psi/ digit)

Polynomial Gage Factors: **A: -2.831E-08** **B: -0.006524** **C:**

Thermal Factor (K): -0.006289 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9989 **Temperature: 21.9 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612733

Temperature: 23.80 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.8 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10067	10068	10068	0.262	0.16	-0.002	0.00
34.0	9361	9361	9361	33.89	-0.06	33.96	-0.02
68.0	8648	8648	8648	67.83	-0.09	68.06	0.05
102.0	7936	7936	7936	101.7	-0.15	102.0	-0.01
136.0	7219	7219	7219	135.9	-0.07	135.9	-0.03
170.0	6496	6496	6496	170.3	0.17	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04760 (kPa/ digit)

Polynomial Gage factors: **A: -1.632E-07** **B: -0.04490** **C:** ______

Thermal Factor (K): -0.03740 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006904 (psi/ digit)

Polynomial Gage Factors: **A: -2.367E-08** **B: -0.006512** **C:** ______

Thermal Factor (K): -0.005424 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10081 **Temperature:** 22.0 °C **Barometer:** 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612734

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9813	9814	9814	0.270	0.16	0.006	0.00
34.0	9127	9127	9127	33.94	-0.04	34.01	0.00
68.0	8438	8439	8439	67.71	-0.16	67.95	-0.02
102.0	7745	7745	7745	101.7	-0.15	102.0	-0.01
136.0	7047	7048	7048	135.9	-0.02	136.0	0.02
170.0	6348	6349	6349	170.2	0.15	170.0	-0.01

(kPa) Linear Gage Factor (G): -0.04905 (kPa/ digit)

Polynomial Gage factors: A: -1.757E-07 B: -0.04621 C: ______

Thermal Factor (K): 0.001401 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007114 (psi/ digit)

Polynomial Gage Factors: A: -2.548E-08 B: -0.006702 C: ______

Thermal Factor (K): 0.0002032 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9838 Temperature: 22.0 °C Barometer: 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612735

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9788	9790	9789	0.243	0.14	0.015	0.01
34.0	9094	9095	9095	33.94	-0.04	33.98	-0.02
68.0	8396	8397	8397	67.82	-0.10	67.98	0.00
102.0	7695	7696	7696	101.8	-0.09	102.0	0.01
136.0	6993	6993	6993	135.9	-0.03	136.0	-0.01
170.0	6286	6287	6287	170.2	0.14	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04853 (kPa/ digit)

Polynomial Gage factors: **A: -1.339E-07** **B: -0.04637** **C: ______**

Thermal Factor (K): -0.03321 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007038 (psi/ digit)

Polynomial Gage Factors: **A: -1.942E-08** **B: -0.006726** **C: ______**

Thermal Factor (K): -0.004816 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9803 **Temperature: 22.0 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612736

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9923	9924	9924	0.271	0.16	0.007	0.00
34.0	9239	9240	9240	33.97	-0.02	34.01	0.00
68.0	8553	8554	8554	67.77	-0.12	67.96	-0.01
102.0	7863	7863	7863	101.8	-0.11	102.0	0.00
136.0	7169	7170	7170	136.0	-0.01	136.0	0.02
170.0	6474	6474	6474	170.2	0.15	170.0	-0.01

(kPa) Linear Gage Factor (G): -0.04927 (kPa/ digit)

Polynomial Gage factors: **A: -1.577E-07** **B: -0.04668** **C:**

Thermal Factor (K): -0.04286 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007146 (psi/ digit)

Polynomial Gage Factors: **A: -2.288E-08** **B: -0.006771** **C:**

Thermal Factor (K): -0.006216 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9940 **Temperature: 22.0 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612737

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10001	10002	10002	0.320	0.19	-0.017	-0.01
34.0	9318	9318	9318	33.97	-0.02	34.03	0.01
68.0	8632	8633	8633	67.71	-0.16	67.98	0.00
102.0	7941	7942	7942	101.7	-0.15	102.0	0.01
136.0	7248	7249	7249	135.8	-0.08	135.9	-0.04
170.0	6547	6548	6548	170.3	0.22	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04923 (kPa/ digit)

Polynomial Gage factors: A: -2.126E-07 B: -0.04571 C: ______

Thermal Factor (K): -0.05437 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007140 (psi/ digit)

Polynomial Gage Factors: A: -3.084E-08 B: -0.006629 C: ______

Thermal Factor (K): -0.007885 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10005 Temperature: 21.5 °C Barometer: 988.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612738

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9812	9813	9813	0.220	0.13	0.007	0.00
34.0	9123	9124	9124	33.94	-0.04	34.00	-0.01
68.0	8432	8432	8432	67.78	-0.12	67.97	0.00
102.0	7737	7737	7737	101.8	-0.11	102.0	0.01
136.0	7040	7040	7040	135.9	-0.04	136.0	0.00
170.0	6339	6340	6340	170.2	0.13	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04894 (kPa/ digit)

Polynomial Gage factors: **A: -1.401E-07** **B: -0.04668** **C:** ______

Thermal Factor (K): 0.01050 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007098 (psi/ digit)

Polynomial Gage Factors: **A: -2.032E-08** **B: -0.006770** **C:** ______

Thermal Factor (K): 0.001524 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9826 **Temperature: 21.4 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612739

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9889	9890	9890	0.262	0.15	-0.045	-0.03
34.0	9182	9183	9183	34.00	0.00	34.07	0.04
68.0	8475	8476	8476	67.74	-0.14	68.00	0.01
102.0	7764	7764	7764	101.7	-0.17	102.0	-0.01
136.0	7049	7049	7049	135.8	-0.09	135.9	-0.05
170.0	6325	6326	6326	170.3	0.21	170.0	0.03

(kPa) Linear Gage Factor (G): -0.04772 (kPa/ digit)

Polynomial Gage factors: **A: -1.885E-07** **B: -0.04466** **C: ________**

Thermal Factor (K): -0.01909 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006921 (psi/ digit)

Polynomial Gage Factors: **A: -2.735E-08** **B: -0.006478** **C: ________**

Thermal Factor (K): -0.002768 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9897 **Temperature: 21.4 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612740

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9958	9959	9959	0.261	0.15	0.001	0.00
34.0	9247	9248	9248	33.95	-0.03	34.00	0.00
68.0	8533	8534	8534	67.79	-0.11	67.99	0.01
102.0	7816	7817	7817	101.8	-0.12	102.0	0.00
136.0	7096	7096	7096	135.9	-0.04	136.0	-0.01
170.0	6371	6372	6372	170.2	0.16	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04739 (kPa/ digit)

Polynomial Gage factors: **A: -1.501E-07** **B: -0.04494** **C:**

Thermal Factor (K): -0.02792 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006873 (psi/ digit)

Polynomial Gage Factors: **A: -2.177E-08** **B: -0.006518** **C:**

Thermal Factor (K): -0.004049 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9972 **Temperature: 21.8 °C** **Barometer: 987.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612741

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10022	10023	10023	0.315	0.18	0.011	0.01
34.0	9328	9329	9329	33.93	-0.04	33.99	-0.01
68.0	8630	8631	8631	67.75	-0.14	67.98	0.00
102.0	7928	7929	7929	101.8	-0.13	102.0	0.01
136.0	7223	7224	7224	135.9	-0.04	136.0	0.00
170.0	6514	6514	6514	170.3	0.18	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04844 (kPa/ digit)

Polynomial Gage factors: **A: -1.815E-07** **B: -0.04544** **C:** ______

Thermal Factor (K): -0.05230 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007026 (psi/ digit)

Polynomial Gage Factors: **A: -2.632E-08** **B: -0.006591** **C:** ______

Thermal Factor (K): -0.007585 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10038 **Temperature: 21.4 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612742

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 60 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10206	10207	10207	0.273	0.16	0.005	0.00
34.0	9527	9528	9528	33.97	-0.02	34.00	0.00
68.0	8846	8846	8846	67.80	-0.11	67.98	0.00
102.0	8161	8161	8161	101.8	-0.11	102.0	0.00
136.0	7473	7473	7473	135.9	-0.01	136.0	0.00
170.0	6782	6782	6782	170.2	0.16	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04963 (kPa/ digit)

Polynomial Gage factors: **A: -1.584E-07** **B: -0.04694** **C:** ______

Thermal Factor (K): -0.06103 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007199 (psi/ digit)

Polynomial Gage Factors: **A: -2.298E-08** **B: -0.006808** **C:** ______

Thermal Factor (K): -0.008852 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10218 **Temperature: 21.6 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Serial Number: 1612743

Calibration Instruction: VW Pressure Transducers

Cable Length: 60 feet

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Temperature: 23.10 °C

Barometric Pressure: 996.3 mbar

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10108	10109	10109	0.223	0.13	0.050	0.03
34.0	9428	9428	9428	33.90	-0.06	33.95	-0.03
68.0	8743	8744	8744	67.77	-0.12	67.93	-0.03
102.0	8055	8056	8056	101.8	-0.09	102.0	0.00
136.0	7364	7364	7364	136.0	0.04	136.1	0.07
170.0	6676	6676	6676	170.1	0.07	169.9	-0.04

(kPa) Linear Gage Factor (G): -0.04949 (kPa/ digit)

Polynomial Gage factors: **A: -1.187E-07** **B: -0.04749** **C:** ____

Thermal Factor (K): -0.05486 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007177 (psi/ digit)

Polynomial Gage Factors: **A: -1.722E-08** **B: -0.006888** **C:** ____

Thermal Factor (K): -0.007957 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10119 **Temperature: 21.5 °C** **Barometer: 988.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612744

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 20 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9991	9992	9992	0.273	0.16	0.005	0.00
34.0	9313	9314	9314	33.93	-0.05	34.00	0.00
68.0	8632	8633	8633	67.74	-0.14	67.98	0.00
102.0	7947	7948	7948	101.7	-0.14	102.0	0.00
136.0	7259	7260	7260	135.9	-0.05	136.0	0.00
170.0	6567	6568	6568	170.2	0.16	170.0	0.00

(kPa) Linear Gage Factor (G): -0.04964 (kPa/ digit)

Polynomial Gage factors: **A: -1.812E-07** **B: -0.04664** **C:** ______

Thermal Factor (K): -0.05942 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.007200 (psi/ digit)

Polynomial Gage Factors: **A: -2.628E-08** **B: -0.006765** **C:** ______

Thermal Factor (K): -0.008618 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10002 **Temperature:** 22.3 °C **Barometer:** 988.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612745

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 20 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9674	9675	9675	0.308	0.18	0.010	0.00
34.0	8964	8965	8965	33.92	-0.05	33.98	-0.01
68.0	8250	8250	8250	67.75	-0.13	67.99	0.01
102.0	7532	7532	7532	101.7	-0.14	102.0	0.01
136.0	6811	6811	6811	135.9	-0.05	135.9	-0.01
170.0	6084	6085	6085	170.3	0.18	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04735 (kPa/ digit)

Polynomial Gage factors: **A: -1.743E-07** **B: -0.04460** **C: ______**

Thermal Factor (K): 0.01276 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006867 (psi/ digit)

Polynomial Gage Factors: **A: -2.528E-08** **B: -0.006469** **C: ______**

Thermal Factor (K): 0.001851 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9687 **Temperature: 21.9 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612746

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 20 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9815	9816	9816	0.216	0.13	0.001	0.00
34.0	9114	9114	9114	33.91	-0.06	33.97	-0.02
68.0	8407	8408	8408	67.84	-0.08	68.05	0.04
102.0	7701	7702	7702	101.8	-0.13	102.0	-0.01
136.0	6991	6992	6992	135.9	-0.07	135.9	-0.03
170.0	6276	6276	6276	170.2	0.15	170.0	0.02

(kPa) Linear Gage Factor (G): -0.04803 (kPa/ digit)

Polynomial Gage factors: **A: -1.4E-07** **B: -0.04578** **C: ________**

Thermal Factor (K): -0.02558 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006966 (psi/ digit)

Polynomial Gage Factors: **A: -2.031E-08** **B: -0.006639** **C: ________**

Thermal Factor (K): -0.003710 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9828 **Temperature: 22.3 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500AL-170 kPa

Date of Calibration: April 19, 2016

This calibration has been verified/validated as of 05/06/2016

Serial Number: 1612747

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 996.3 mbar

Cable Length: 20 feet

Technician: Kathy Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	10081	10082	10082	0.306	0.18	-0.010	-0.01
34.0	9367	9368	9368	33.94	-0.04	34.02	0.01
68.0	8650	8651	8651	67.72	-0.15	67.99	0.01
102.0	7929	7930	7930	101.7	-0.17	102.0	-0.01
136.0	7204	7204	7204	135.9	-0.06	135.9	-0.01
170.0	6473	6473	6473	170.3	0.20	170.0	0.01

(kPa) Linear Gage Factor (G): -0.04711 (kPa/ digit)

Polynomial Gage factors: **A: -1.886E-07** **B: -0.04399** **C: ______**

Thermal Factor (K): -0.02696 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.006833 (psi/ digit)

Polynomial Gage Factors: **A: -2.736E-08** **B: -0.006380** **C: ______**

Thermal Factor (K): -0.003910 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 10098 **Temperature: 21.9 °C** **Barometer: 988.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614894

Signed by: Date: May 06, 2016

Quality Assurance Manager

48 Spencer St. Lebanon, NH 03766 USA

Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614895

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

48 Spencer St. Lebanon, NH 03766 USA

Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614896

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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48 Spencer Street
Lebanon, NH 03766
USA

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Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614897

Signed by: Martin J. Gibson Date: May 06, 2016

Quality Assurance Manager

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GEOKON
48 Spencer Street
Lebanon, NH 03766
USA

48 Spencer St. Lebanon, NH 03766 USA

Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614898

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614899

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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GEOKON
48 Spencer Street
Lebanon, NH 03766
USA

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Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614900

Signed by: Date: May 06, 2016

Quality Assurance Manager

48 Spencer St. Lebanon, NH 03766 USA

Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614901

Signed by: Martin J. Gibson Date: May 06, 2016

Quality Assurance Manager

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Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614902

Signed by: Date: May 06, 2016

Quality Assurance Manager

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Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2   Serial Number: 1614903

Signed by: Martin J. Gibson   Date: May 06, 2016

Quality Assurance Manager

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Lebanon, NH 03766
USA

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Geokon, Inc. Statement of Calibration Practices

Geokon, Inc. certifies that this product has been calibrated and accepted using measurement standards traceable to the NIST in compliance with ANSI/NCSL Z540-1.

We further certify this product meets or exceeds Geokon, Inc. design and technical specifications for measurement accuracy.

Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614904

Signed by: Martin J. Gibson Date: May 06, 2016

Quality Assurance Manager

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Model Number: 8002-4-2   Serial Number: 1614905

Signed by: Martin J. Gilson   Date: May 06, 2016

Quality Assurance Manager

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Model Number: 8002-4-2 Serial Number: 1614906

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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Model Number: 8002-4-2 Serial Number: 1614907

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

48 Spencer St. Lebanon, NH 03766 USA

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Model Number: 8002-4-2 Serial Number: 1614908

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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Model Number: 8002-4-2 Serial Number: 1614909

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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Calibration operations are controlled using procedures that are a part of Geokon's certified ISO 9001:2008 quality system.

Model Number: 8002-4-2 Serial Number: 1614910

Signed by: Martin J. Gilson Date: May 06, 2016

Quality Assurance Manager

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