

Red Dog Mine Long-Term Permafrost and Groundwater Monitoring Program for the Tailing Impoundment 2019 Annual Report

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Introduction

The Long-term Permafrost and Groundwater Monitoring Program (the Monitoring Program) was established as an outcome of the Supplemental Environmental Project (SEP) and the Consent Decree between Cominco Alaska, Inc. (now Teck Alaska Incorporated) and the United States Environmental Protection Agency (EPA), entered on November 25, 1997 (US v. Cominco Alaska Incorporated, Civil Action A97-267CV). The Monitoring Program was developed to monitor and predict potential effects of the Tailings Impoundment on permafrost and groundwater in the areas of the tailings Main Dam, Overburden Stockpile, and background locations downgradient of the Tailings Impoundment within the Red Dog Creek and Bons Creek drainages. A specific contract deliverable is the submission of an annual report which includes a data collection summary, a quality assurance and quality control (QA/QC) summary, and a description of the status of the monitoring program.

A review of the data from 2019 did not show any significant changes in permafrost or groundwater elevation in the area of the Tailings Impoundment. Improved quality checks and maintenance are starting to show improvement in data acceptance rates.

Background

The Red Dog Mine is a lead-zinc mine located in northwestern Alaska approximately 50 miles northeast of Kotzebue, Alaska and 107 miles north of the Arctic Circle within the DeLong Mountains. The mine is owned by NANA Regional Corporation and operated by Teck Alaska (TAK). Figures 1 and 2 illustrate the regional setting and layout of the mine and its support facilities. As illustrated on Figure 2, the mine consists of two open pits and support facilities. The open pits are used for the extraction of zinc and lead bearing ore. The support facilities include an ore milling and a concentration facility, an employee housing area, a construction camp, an asphalt paved runway, a power generation facility, and a tailings area. There are approximately 300 acres of waste rock piles and a tailings pond behind two earthen dams. The pond receives drainage from the open pit areas, natural surface run-off, and process waters from the milling operation.

The tailings pond has the potential to affect both permafrost and groundwater in one or more adjacent drainages. To document this, a ground temperature/groundwater level monitoring program began in the mid-1990s as part of the Groundwater Monitoring Supplemental Environmental Project. Results from this project are documented in Water Management Consultants, Inc. (WMCI 2001) report and form the basis for the Long-Term Permafrost and Groundwater Monitoring Plan.

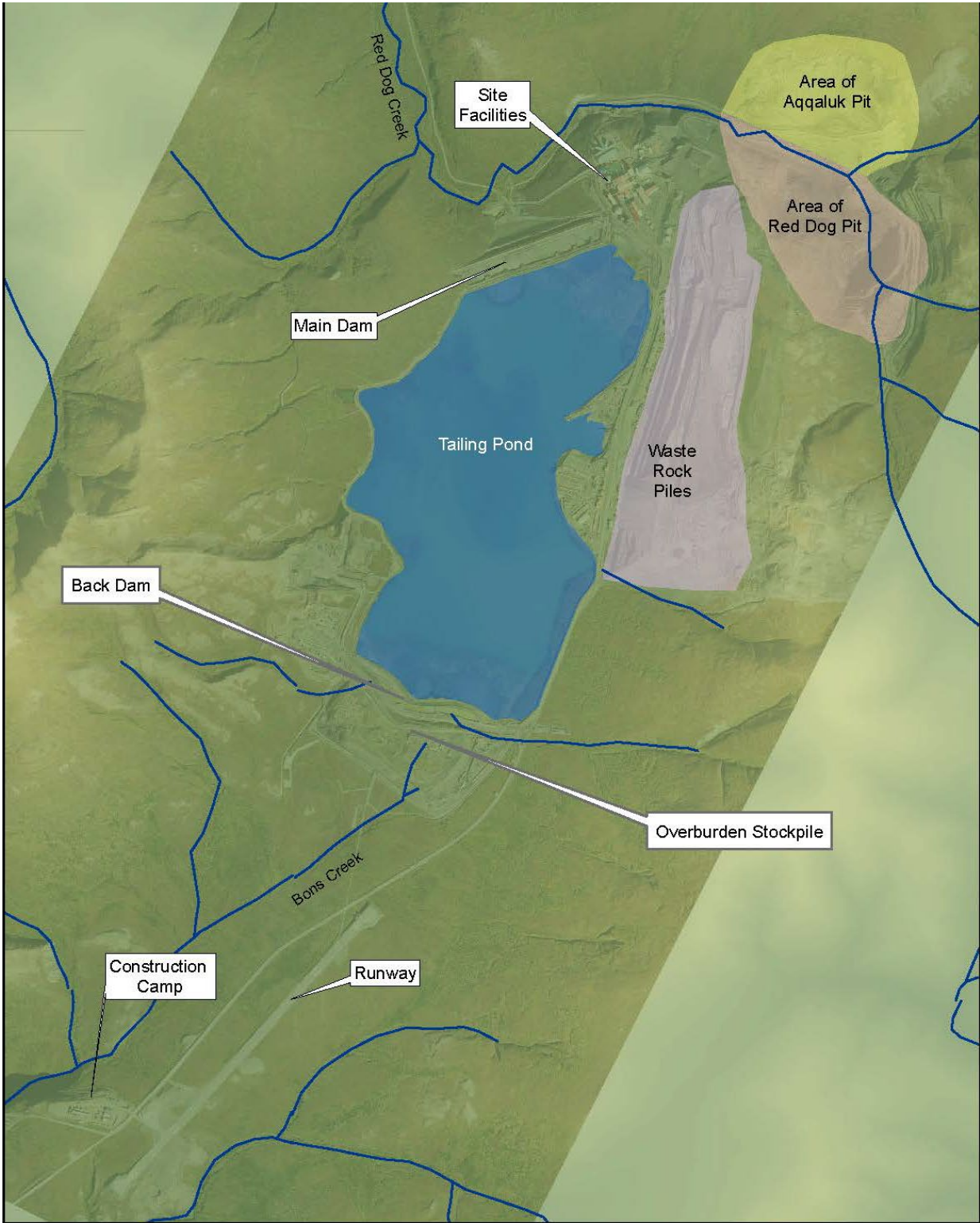
The key elements of the Monitoring Program are:




- The quarterly monitoring of sixteen thermistors at background sites, overburden stockpile, and main dam area;
- The quarterly monitoring of nine piezometers at background sites and main dam area;
- Data reduction, presentation, and management;
- Annual data reporting; and,
- Assessment of data trends on a five-year basis.

Figure 1 Red Dog Mine and Vicinity



Figure 2 Red Dog Mine Site Layout



  	DRAWING INFO		Red Dog Mine Site Layout Red Dog Mine, Alaska	Figure 2
	Scale: 1:25,000			
	Author: NJB			
	Job #: 165.030094			

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2019 Data Collection

TAK emailed Kuna Engineering (Kuna), the raw 2019 readings from the project thermistors and piezometers for data reduction, presentation, and management. A table of all the raw data is presented in Appendix A.

Ground temperatures and water levels were monitored beneath the main dam and overburden stockpile for graphical comparison to the background sites.

Thermistor Data

Kuna plotted the ground temperature measurements collected from the sixteen thermistor monitoring locations. The Red Dog Mine thermistor monitoring locations are illustrated on Figure 3 (northern portion), Figure 4 (central portion), and Figure 5 (southern portion).

The ground temperature monitoring data is depicted using two types of graphical plots which are presented in Appendix B, and summarized below:

- Temperature trumpet plot of data for all years (separate color for each year); and
- Temperature trumpet plot of data for 2019.

For each graphic plot, the measurements are presented as auto range and scale limited. The auto range plots represents all measurements which have passed the database QA/QC process described in the Data Management section of this report. For visual clarity, scale limited plots only include data within a limited range and excludes most outliers. Note the outliers are individual nodes that are likely caused by intermittent connections and therefore do not represent true changes in temperature at depth.

Table 1 Summary of the 2019 Quarterly Thermistor Data Collection

Thermistors	Associated Figure	General Location	Sampling Dates			
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
T-96-015	Figure 3	Red Dog Creek	1/23/19	4/27/19	7/17/19	10/16/19
T-95-005	Figure 3	Dam Area	1/23/19	Error	7/16/19	10/16/19
T-96-010	Figure 3	Dam Area	1/23/19	4/27/19	7/16/19	10/16/19
T-97-028	Figure 3	Dam Area	1/23/19	4/27/19	7/16/19	10/16/19
T-97-029	Figure 3	Dam Area	1/23/19	4/27/19	7/16/19	10/16/19
T-97-030	Figure 3	Dam Area	1/23/19	5/1/19	7/16/19	10/16/19
T-14-110	Figure 4	Tailing Impoundment	1/23/19	4/25/19	7/16/19	10/16/19
T-95-004	Figure 4	Dam area	1/23/19	Error	7/25/19	10/16/19
T-05-061	Figure 4	Dam area	1/23/19	4/27/19	7/16/19	10/16/19
T-95-008 #2	Figure 5	Overburden Stockpile	1/23/19	5/8/19	7/16/19	10/16/19
T-96-013	Figure 5	Overburden Stockpile	1/23/19	4/27/19	7/16/19	10/16/19
T-96-021	Figure 5	Overburden Stockpile	1/23/19	4/27/19	7/16/19	10/16/19
T-96-022	Figure 5	Overburden Stockpile	1/23/19	4/27/19	7/16/19	10/16/19
T-96-023	Figure 5	Overburden Stockpile	1/23/19	4/27/19	7/16/19	10/16/19
T-96-012	Figure 5	Bons Creek	1/23/19	4/27/19	7/16/19	10/16/19
T-96-012s	Figure 5	Bons Creek	1/23/19	4/27/19	7/16/19	10/16/19

Figure 3 Red Dog Mine Long-Term Thermistor and Piezometer Monitoring Locations
(Northern portion)

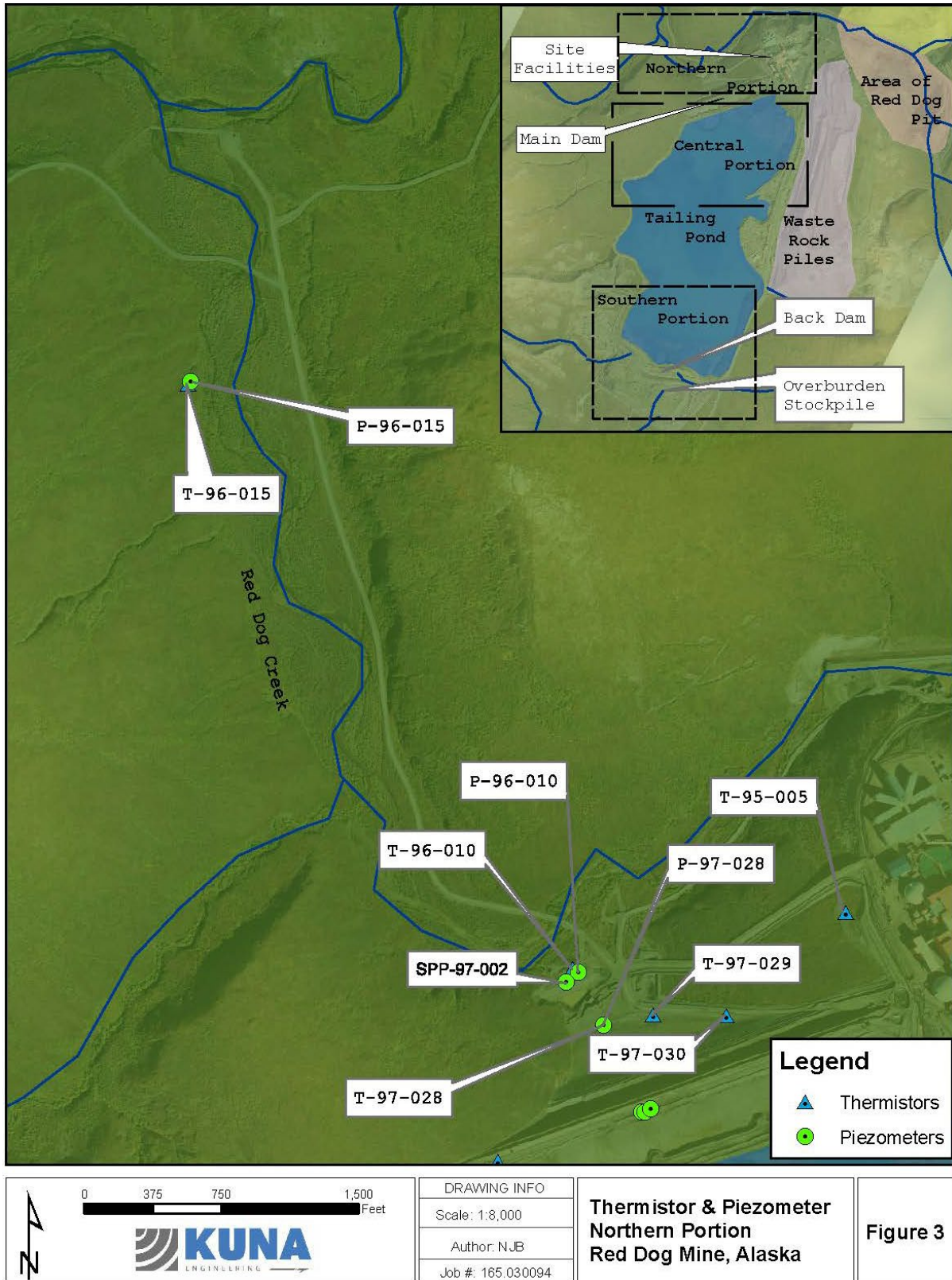


Figure 4 Red Dog Mine Long-Term Thermistor and Piezometer Monitoring Locations
(Central portion)

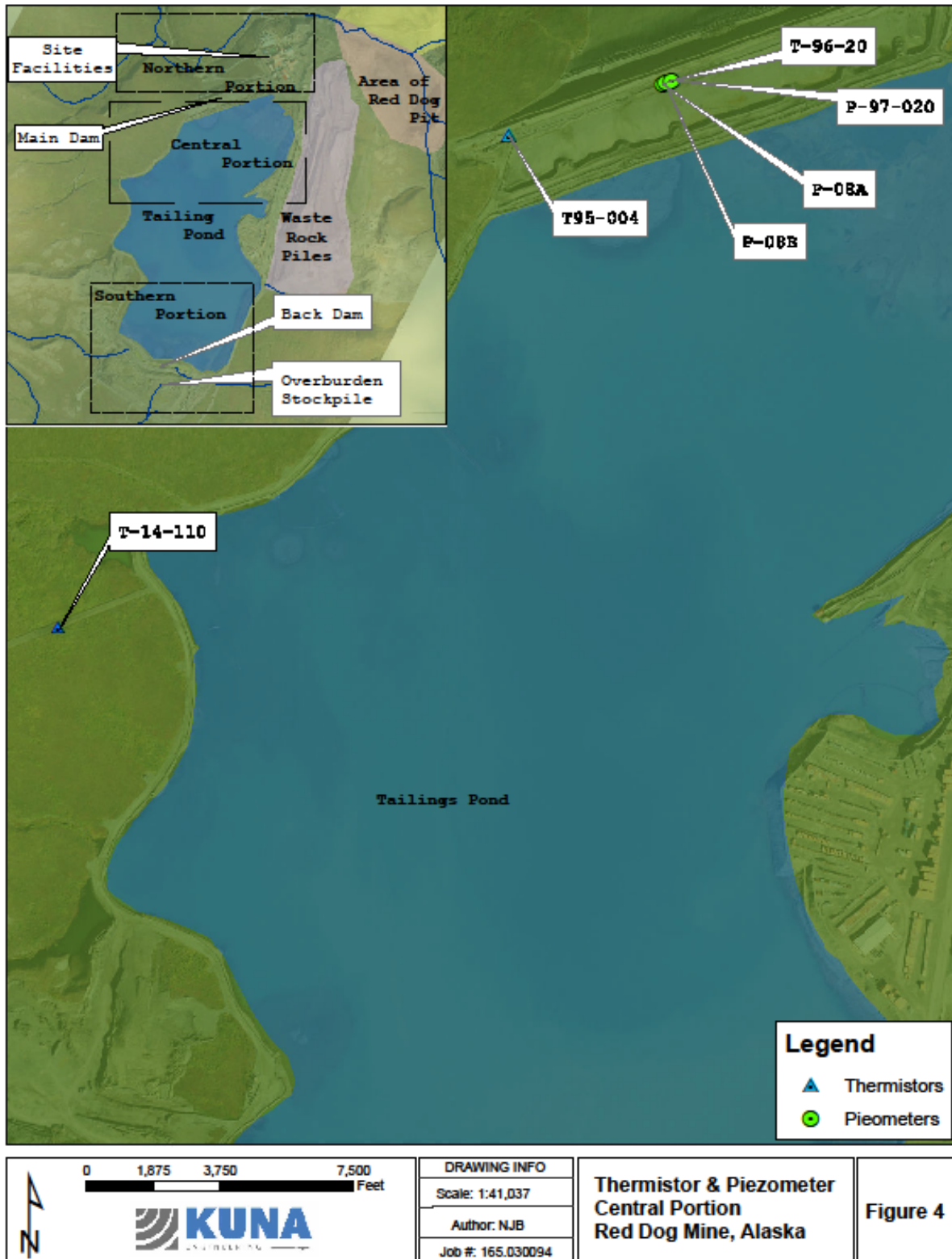
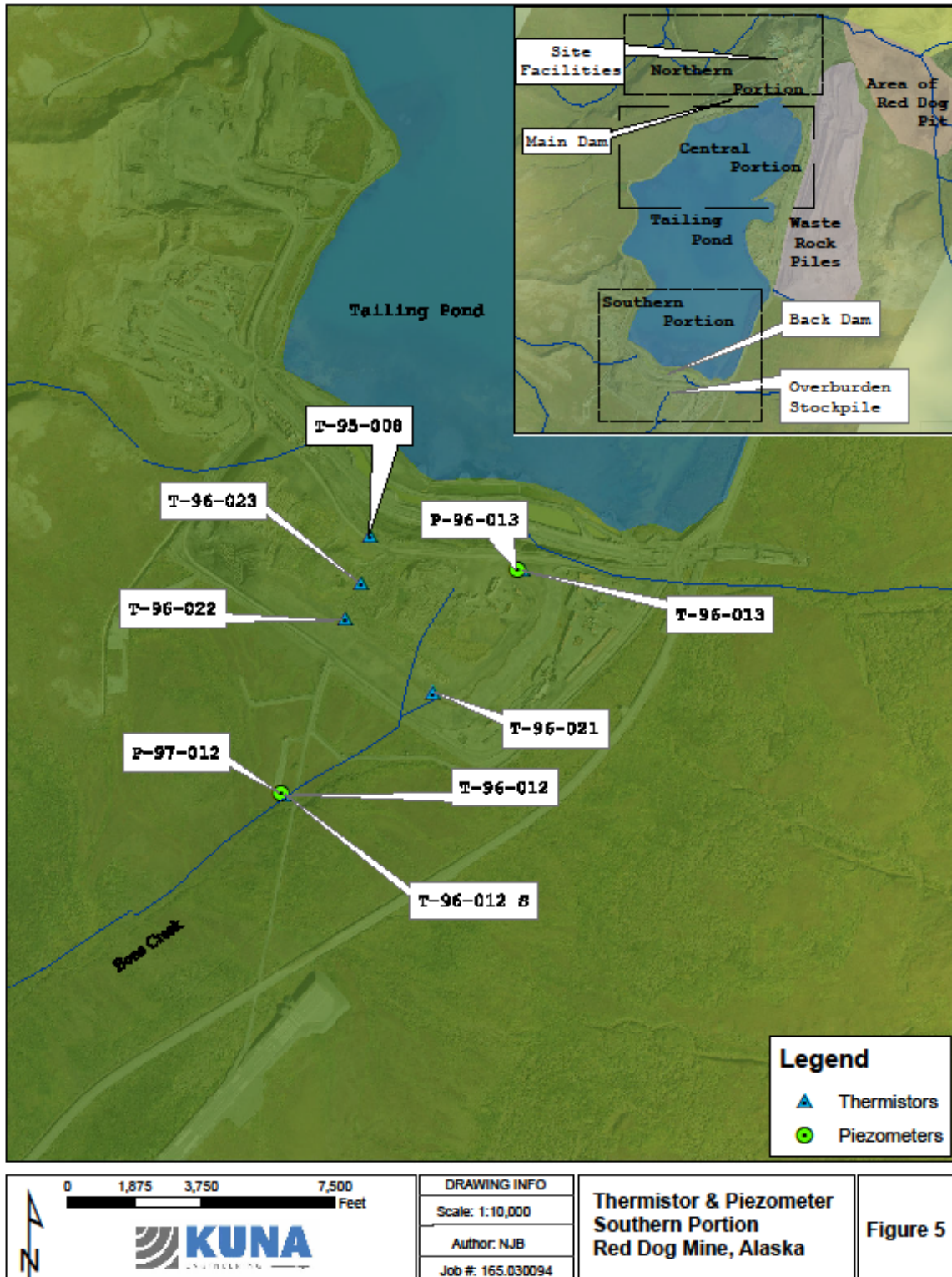


Figure 5 Red Dog Mine Long-Term Thermistor and Piezometer Monitoring Locations
(Southern portion)



Piezometer Data

The Red Dog Mine piezometers are illustrated on Figure 3 (northern portion), Figure 4 (central portion), and Figure 5 (southern portion). The 2019 quarterly piezometer data was collected by TAK and submitted to Kuna which prepared a graphical time series plots of groundwater elevation. This data is presented in Appendix C.

Table 2 Summary of the 2019 Quarterly Piezometer Data Collection

Piezometer	Associated Figure	General Location	Sampling Dates			
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
P-96-015	Figure 3	Red Dog Creek	1/23/19	4/27/19	7/12/19	-
P-96-010	Figure 3	Dam Area	1/23/19	4/27/19	-	10/30/19
P-97-028	Figure 3	Dam Area	1/23/19	4/27/19	7/17/19	10/30/19
SPP-97-002	Figure 3	Dam Area	1/23/19	4/27/19	7/17/19	10/30/19
P-08A	Figure 4	Dam Area	1/23/19	5/11/19	7/17/19	10/30/19
P-08B	Figure 4	Dam Area	1/13/19	4/27/19	7/17/19	10/30/19
P-97-020	Figure 4	Dam Area	1/23/19	4/27/19	7/17/19	10/30/19
P-96-013	Figure 5	Overburden Stockpile	1/23/19	4/27/19	7/12/19	10/30/19
P-97-012	Figure 5	Bons Creek	1/23/19	4/27/19	7/12/19	10/30/19

Note: Hyphen (-) denotes data was not collected

Data Management

The 2019 thermistors and piezometers data collection was performed by TAK personnel in accordance with the Red Dog Mine Long Term Groundwater Monitoring Plan's standard operating procedure (WMCI 2001). This data was provided to Kuna to update the TAK Red Dog Mine Database. Microsoft Access™ and Excel™ software were used to generate graphical plots of the data.

Data collected from the thermistor cables was measured in resistance as kilo-ohms (kohms) using a Dryden Instrumentation T5KMUK Automated Thermistor String Reader. The measured resistance values were converted to temperature using calibration coefficients for each thermistor sensor. A calibrated digital temperature acquisition cable was used to measure ground temperature at replacement site T-14-110. Data was reviewed for errors and omission, and then uploaded to the Red Dog Mine Database.

Ground temperature measurements that were not representative of true measurements (i.e., less than zero (0) kohms or greater than 300 kohms) were deleted before uploading to the Red Dog Mine Database. The deleted values are shaded red in the raw data table presented in Appendix A.

TAK provided Kuna the piezometer's vibrating wire measurements and barometric pressure measurements collected on-site. The vibrating wire transducer measurements were converted to groundwater elevation using the calibration coefficients, site elevation, and barometric pressure. Calibration of the vibrating wire transducers was determined during installation. The 2019 data was reviewed for errors and omissions and then uploaded to the Red Dog Mine Database.

Summary of Data QA/QC and System OM

Starting in 2017 Kuna developed and began using a "Quarterly Report Data Checklist", copies of which are included in Appendix D. The Checklist was developed to do a first order review of the data received from TAK. The completed checklists were transmitted to TAK to allow them to make corrections or if possible re-collect missing data. Standard operating procedures developed for the monitoring program included taking duplicate measurements to ensure different operators and or equipment would not impact representativeness of the data. QA/QC measurements for quarterly thermistors and piezometers data are attached in Appendix D.

Thermistor QA/QC

Duplicate measurements were collected from the Dryden Instrumentation T5KMUK data logger and the Dryden Switchbox Fluke multimeter system to ensure repeatability and concurrence with the automated data logger system. Variations in the thermistor measurements were also compared to previously collected data and trends. Thermistor QA/QC data is presented in Table 3.

Table 3 Summary of 2019, QA/QC Thermistors Data Collection

Quarter	Date	Thermistor	Multi-meter Start Time	Comments
1 st Quarter	1/23/19	T-97-28	-	Node 22 “jumpy”.
2 nd Quarter	4/27/19	T-97-29	1437 hours	Nodes 21 and 23 are bad, nodes 12-13 fluctuating.
3 rd Quarter	7/16/19	T-97-30	1723 hours	Nodes 2, 9-12, 17-18, 22-23 slowly climbing. Nodes 13, 14, 16, 20, 22, 24 are bad.
4 th Quarter	10/23/19	T-95-8	853 hours	

Piezometer QA/QC

Piezometer QA/QC data is presented in Table 4.

Table 4 Summary of 2019, QA/QC Piezometer Data Collection

Quarter	Date	Piezometer	Comments
1 st Quarter	1/23/19	P-97-012	QA/QC
2 nd Quarter	4/27/19	P-96-15	On row 4, 0 PSI on packer
3 rd Quarter	7/16/19	P-96-13	QA/QC on Row 5
4 th Quarter	10/16/19	P-96-15	

Thermistor System Maintenance

Thermistor measurements indicate that several are malfunctioning and require replacement. A program has been setup to replace surface connector cables as needed.

Piezometer System Maintenance

Vibrating wire transducers are functioning with few erroneous measurements collected from the sensors. Some of the piezometer wells have pneumatic packers installed in them to separate shallow from deep groundwater zones. It was noted in 2017, the pressure readings in some of these packers were very low so they were re-pressurized with nitrogen.

Piezometer P96-013 was planned to be replaced in 2019, but that has been deferred to 2020. EPA has been notified of this schedule change.

In October 2018, the following thermistors were modified by extending the top lead in preparation for the dam raise; T97-28, T97-29 and T97-30.

References

Water Management Consultants, Inc. (WMCI), 2001, Red Dog Mine – Long-Term Permafrost and Groundwater Monitoring Plan for the Tailing Impoundment, March, 2001.

Appendix A Raw Data

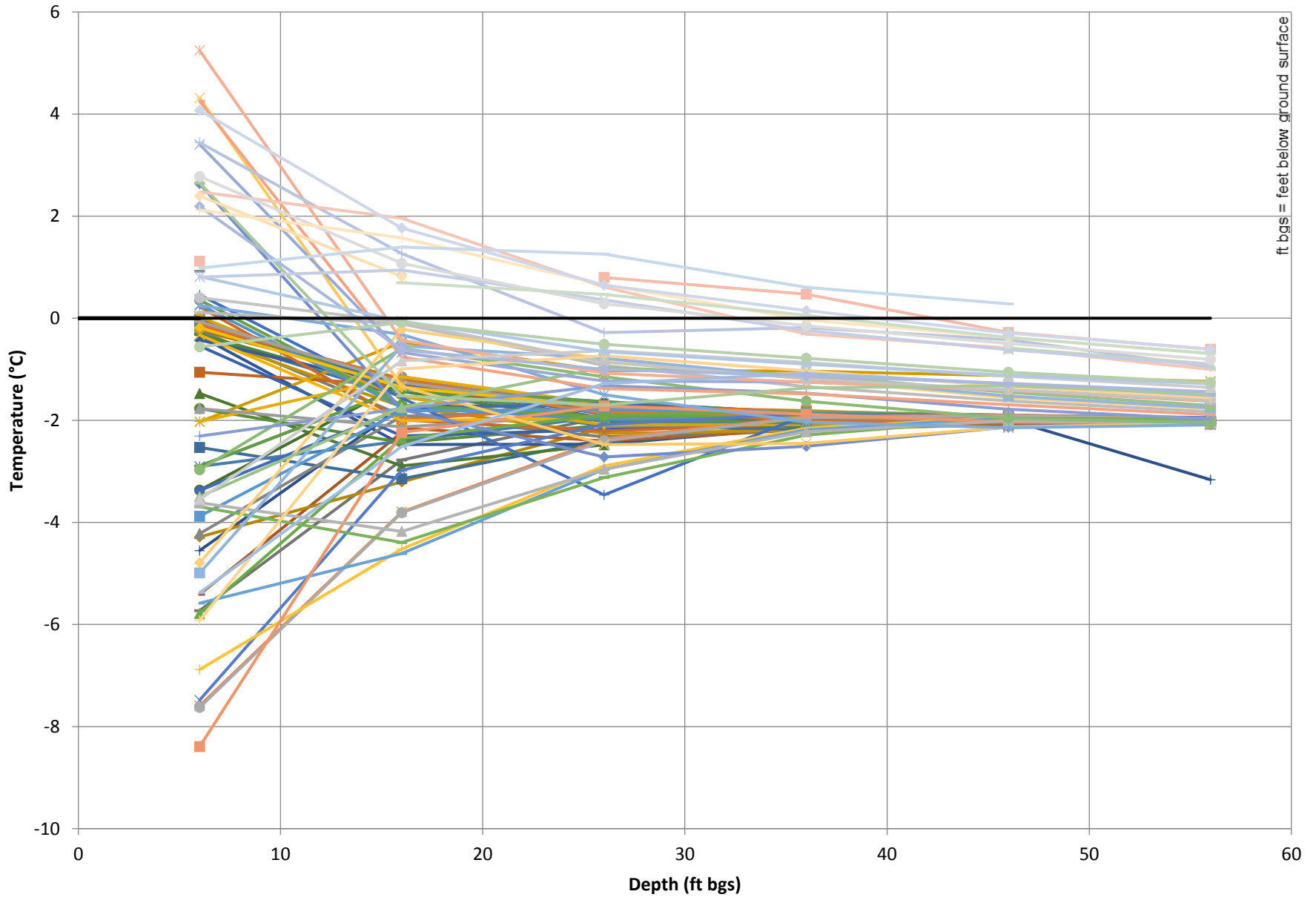
Raw Data Table (Thermistor)

Site ID	Num Therm	Date/Time	pt-01	pt-02	pt-03	pt-04	pt-05	pt-06	pt-07	pt-08	pt-09	pt-10	pt-11	pt-12	pt-13	pt-14	pt-15	pt-16	pt-17	pt-18	pt-19	pt-20	pt-21	pt-22	pt-23	pt-24		
T05-61	6	1/23/19 2:16 PM	14.715	15.121	15.747	16.398	16.668	16.943																				
T05-61	6	4/27/19 3:14 PM	15.589	15.257	15.274	15.872	16.114	16.543																				
T05-61	6	7/16/19 5:08 PM	-22.47	15.81	15.90	16.32	16.66	16.95																				
T05-61	6	10/16/19 10:30 AM	13.34	14.97	15.76	16.25	16.59	16.87																				
T95-4	24	1/23/19 2:20 PM	-12.45	13.991	-14.03	14.198	11.924	-97.38	16.099	15.312	-15.37	16.031	15.917	-14.92	15.869	15.993	-14.77	-14.92	-15.45	-14.69	15.248	15.257	15.39	-288.8	14.877	14.471		
T95-4	24	7/25/19 11:40 AM	-6.41	-16.64	15.64	-12.16	-11.29	-16.16	-16.42	-15.95	-17.12	-12.63	-10.07	-8.70	-13.31	-4.89	-5.30	-6.28	-5.05	-10.87	-12.89	-11.57	-12.46	-42.43	-11.69	-12.25		
T95-4	24	10/16/19 10:35 AM	12.71	13.67	14.61	-13.08	-12.84	-34.26	-10.62	-11.83	-11.02	-10.83	-8.74	-10.93	-12.84	15.28	-14.03	-12.06	-14.81	14.91	15.66	-10.01	-9999.00	-105.50	-9.68	-10.92		
T95-5	24	1/23/19 4:38 PM	15.64	15.246	16.082	16.531	16.596	16.788	16.79	16.794	16.812	16.708	16.598	16.75	16.708	16.728	16.67	16.63	16.473	16.361	16.67	16.67	16.07	15.881	15.73	15.54		
T95-5	24	7/16/19 5:31 PM	12.83	15.90	16.22	16.54	16.65	16.75	17.04	-17.28	16.88	16.99	16.87	16.83	9999.90	16.80	16.74	16.69	16.64	16.42	16.39	16.21	16.05	15.90	15.75	15.61		
T95-5	24	10/16/19 10:23 AM	13.00	14.51	16.07	16.51	16.61	16.73	16.79	16.81	16.84	16.85	16.87	16.82	16.81	16.78	16.73	16.67	16.63	16.49	16.37	16.19	16.09	15.89	15.74	15.57		
T95-8 #2	24	5/8/19 5:14 PM	17.625	16.771	16.785	16.93	16.94	16.957	16.942	16.922	17.008	17.012	17.017	16.983	17.003	17.062	17.014	17.048	17.056	17.042	17.067	17.094	17.088	17.08	17.138	17.168		
T95-8 #2	24	7/16/19 4:26 PM	9999.90	16.79	16.80	16.94	16.95	16.97	16.95	16.94	17.02	17.03	17.12	17.00	-9999.00	17.07	17.02	17.06	17.06	17.05	-9999.00	17.10	-9999.00	-9999.00	9999.90	9999.90		
T95-8 #2	7	10/16/19 10:05 AM	16.01	12.89	12.42	13.08	14.17	14.61	15.44																			
T95-8#2	24	1/23/19 3:38 PM	18.404	16.715	16.793	16.928	16.938	16.954	16.941	16.92	17.006	17.01	17.015	16.98	17	17.06	17.013	17.047	17.056	17.041	17.068	17.093	17.085	17.08	17.138	17.167		
T96-10	24	1/23/19 4:20 PM	15.863	15.716	30.816	16.052	16.002	15.981	15.989	15.829	15.863	15.791	15.682	15.581	16.85	19.985	14.989	15.21	16.65	14.719	-13.77	14.708	14.549	26.083	-1226			
T96-10	24	4/27/19 11:12 AM	-16.84	15.95	31.1	16.007	15.984	15.97	15.98	15.826	15.857	15.786	16.32	15.881	15.578	16.876	20.096	15.062	15.209	16.649	14.719	-13.77	14.719	14.548	26.233	-1206		
T96-10	24	7/16/19 5:36 PM	9999.90	16.10	31.54	-887.90	15.97	15.97	15.98	15.83	15.86	15.79	16.38	15.69	15.59	16.91	20.20	14.99	15.22	21.48	14.85	-13.79	14.74	14.55	26.37	-1184.00		
T96-10	24	10/16/19 10:49 AM	13.51	15.31	31.98	15.94	15.94	15.95	15.96	15.81	15.84	15.77	16.33	15.68	15.59	16.92	20.30	14.98	15.20	16.67	14.71	-13.76	14.78	14.56	26.54	-1177.00		
T96-12	24	1/23/19 10:46 AM	16.583	16.726	16.952	17.033	17.127	17.166	17.203	17.246	17.236	17.209	17.248	17.158	17.063	17.061	16.943	16.88	16.804	16.67	16.538	16.379	-9999	16.449	16.012	15.871		
T96-12	24	4/27/19 5:30 PM	16.412	16.704	16.932	17.018	17.116	17.156	17.195	17.239	-0.017	17.203	17.244	17.15	17.059	17.058	16.94	16.996	16.801	16.668	16.536	16.377	9999.9	16.148	16.011	15.87		
T96-12	24	7/16/19 11:06 AM	-40.65	16.70	16.93	17.01	17.12	17.16	17.20	17.25	17.25	17.21	17.25	17.16	17.07	16.95	16.89	16.81	16.668	16.54	16.39	-9999.00	16.11	16.02	15.88			
T96-12	24	7/16/19 11:09 AM	7.4967	7.9158	7.4699	7.7661	8.7526	12.013	15.462	22.73	-16.68	16.598	16.666	9999.9	-59.12	16.693	16.742	16.774	16.82	16.863	16.882	16.896	16.931	16.968	16.968	-53		
T96-12	24	10/16/19 9:51 AM	15.50	16.61	16.81	16.73	16.85	16.85	16.83	16.97	16.89	16.90	17.10	17.01	16.99	17.05	16.91	16.64	16.66	16.46	16.32	16.14	-1585.00	16.04	15.97	-14.62		
T96-12s	24	1/23/19 10:46 AM	23.948	25.864	24.259	20.782	18.168	16.742	16.39	16.425	16.493	16.666	16.665	16.692	16.728	16.716	16.763	16.792	16.843	16.882	16.887	16.908	16.956	16.983	17.01	16.95		
T96-12s	24	4/27/19 5:31 PM	16.285	17.616	17.021	16.736	16.759	16.495	16.405	16.442	16.487	16.59	16.642	16.647	16.708	16.695	16.742	16.838	16.823	16.862	16.867	16.817	16.933	16.967	16.944	16.944		
T96-12s	24	7/16/19 11:11 AM	9999.90	16.70	16.93	17.02	17.12	17.16	17.20	17.25	17.24	17.21	17.25	17.16	17.07	17.07	16.95	16.89	16.81	16.68	16.57	16.39	9999.90	16.16	16.02	-84.58		
T96-12s	24	10/16/19 9:50 AM	30.35	25.07	28.31	20.06	16.52	15.66	15.58	16.00	16.39	16.55	16.62	16.63	16.68	16.67	16.72	16.74	-9999.00	16.83	16.84	16.87	16.91	16.94	16.96	16.93		
T96-13	24	1/23/19 2:57 PM	15.715	15.794	15.471	16.546	16.739	16.844	17.115	16.952	17.159	17.171	17.171	17.207	18.591	18.844	18.712	19.913	17.181	17.221	17.037	18.883	16.763	16.643	16.556	16.382		
T96-13	24	4/27/19 4:19 PM	16.162	16.496	15.499	16.542	16.737	16.843	17.121	16.95	17.055	17.097	17.167	17.204	18.635	18.795	17.937	17.185	17.219	17.035	18.921	16.852	16.762	16.642	16.556	16.382		
T96-13	24	7/16/19 11:21 AM	9999.90	16.73	15.40	16.55	16.74	16.86	17.14	16.96	17.06	17.11	17.17	17.22	18.68	18.88	17.97	17.19	17.23	17.92	-19.08	16.86	-17.57	16.65	16.56	16.39		
T96-13	24	10/16/19 9:16 AM	25.78	23.70	23.71	24.14	22.28	17.90	15.81	14.84	14.42	13.58	13.04	12.74	12.50	12.22	12.02	11.88	11.82	11.78	11.75	11.78	11.85	11.88	9999.00	12.04		
T96-15	14	1/23/19 4:09 PM	16.705	16.945	16.923	16.905	16.805	16.718	16.668	16.582	16.537	16.519	16.425	16.348	16.293	16.237												
T96-15	14	4/27/19 3:04 PM	16.724	16.932	16.918	16.903	16.803	16.716	16.667	16.582	16.537	16.518	16.423	16.347	16.292	16.235												
T96-15	14	7/17/19 3:11 PM	16.74	16.993	16.972	16.91	16.81	16.73	16.67	16.59	16.54	16.53	16.43	16.36	16.30	16.25												
T96-15	14	10/16/19 2:55 PM	16.71	16.91	9999.90	9999.90	16.70	16.91	16.91	16.90	16.80	16.71	16.67	16.58	16.53	16.52												
T96-21	24	1/23/19 3:07 PM	22.407	22.591	15.853	13.989	13.247	13.449	13.264	13.484	13.724	14.036	14.333	14.718	15.14	15.567	15.794	16.124	16.512	16.617	16.682	16.773	16.82	16.858	16.897	16.959		
T96-21	24	4/27/19 4:31 PM	14.972	17.376	16.009	14.825	14.033	13.919	13.991	13.994	13.944	13.86	14.201	14.628	15.082	15.528	15.768	16.106	16.509	16.681	16.771	16.818	16.856	16.895	16.956			
T96-21	24	7/16/19 11:26 AM	-12.80	7.02	9999.00	12.37	13.50	14.15	13.72	13.64	13.71	13.97	14.28	9999.90	15.09	15.52	15.77	16.12	16.52	16.63	16.70	16.78	16.82	16.87	16.90	16.99		
T96-21	24	10/16/19 9:22 AM	24.29	15.33	12.19	11.51	11.75	12.69	13.01	13.43	13.72	14.02	14.32	14.67	15.11	15.50	15.78	16.13	16.51	16.62	16.68	16.77	16.82	16.86	16.89	16.95		
T96-22	24	1/																										

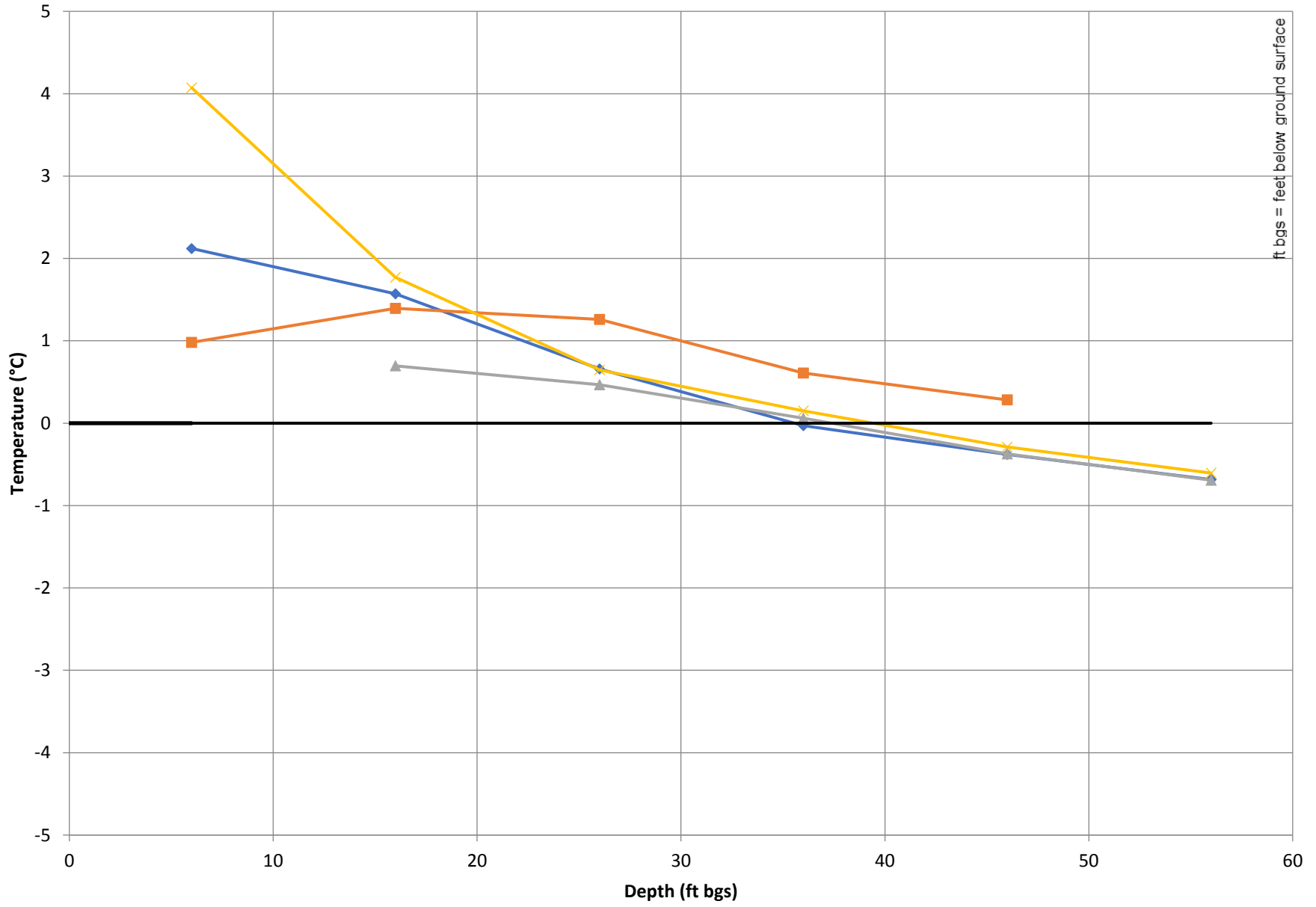
Appendix B

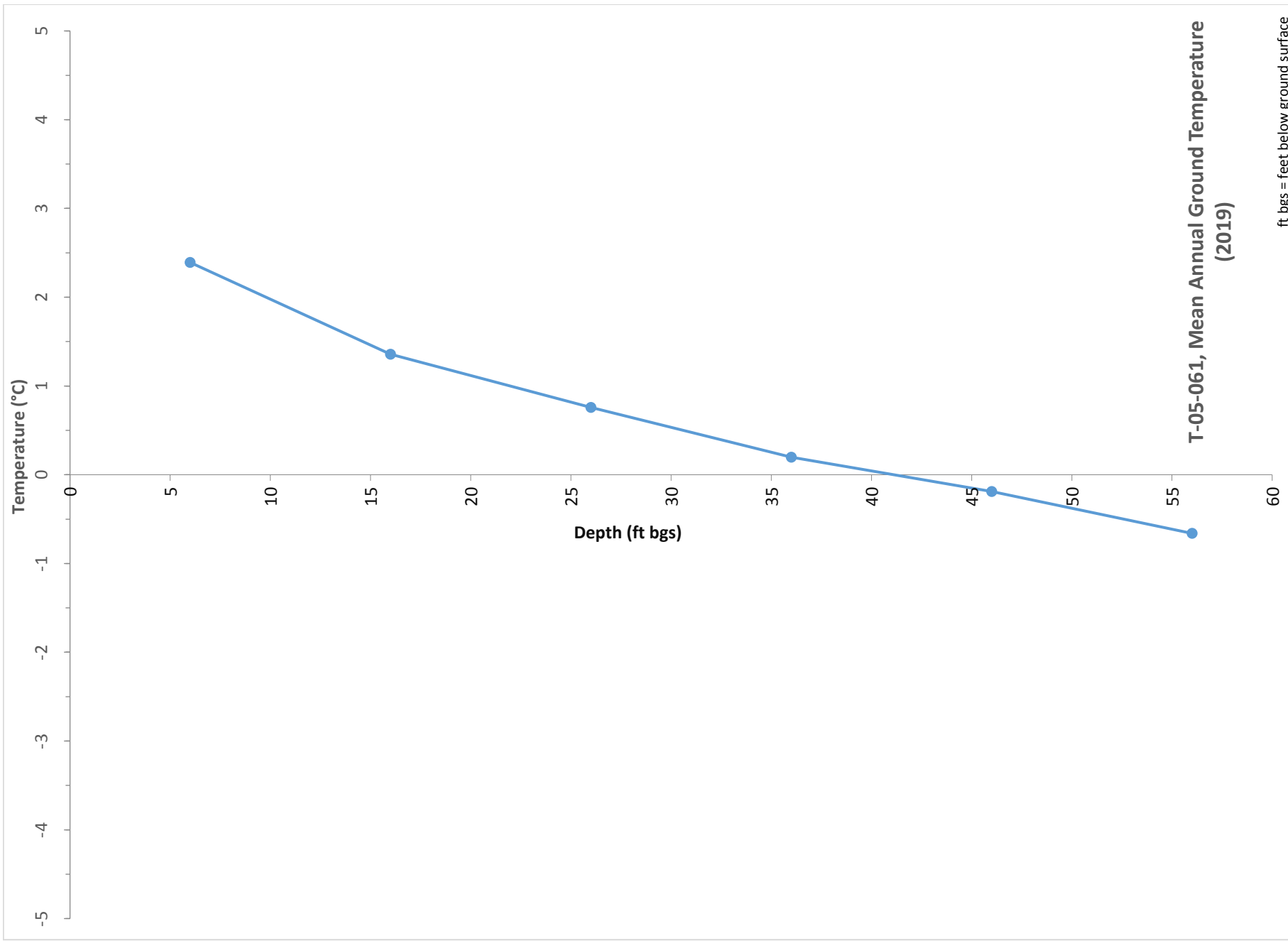
Thermistor Plots

Temperature Depth Plot for T-05-061



Temperature Depth Plot for T-05-061, 2019

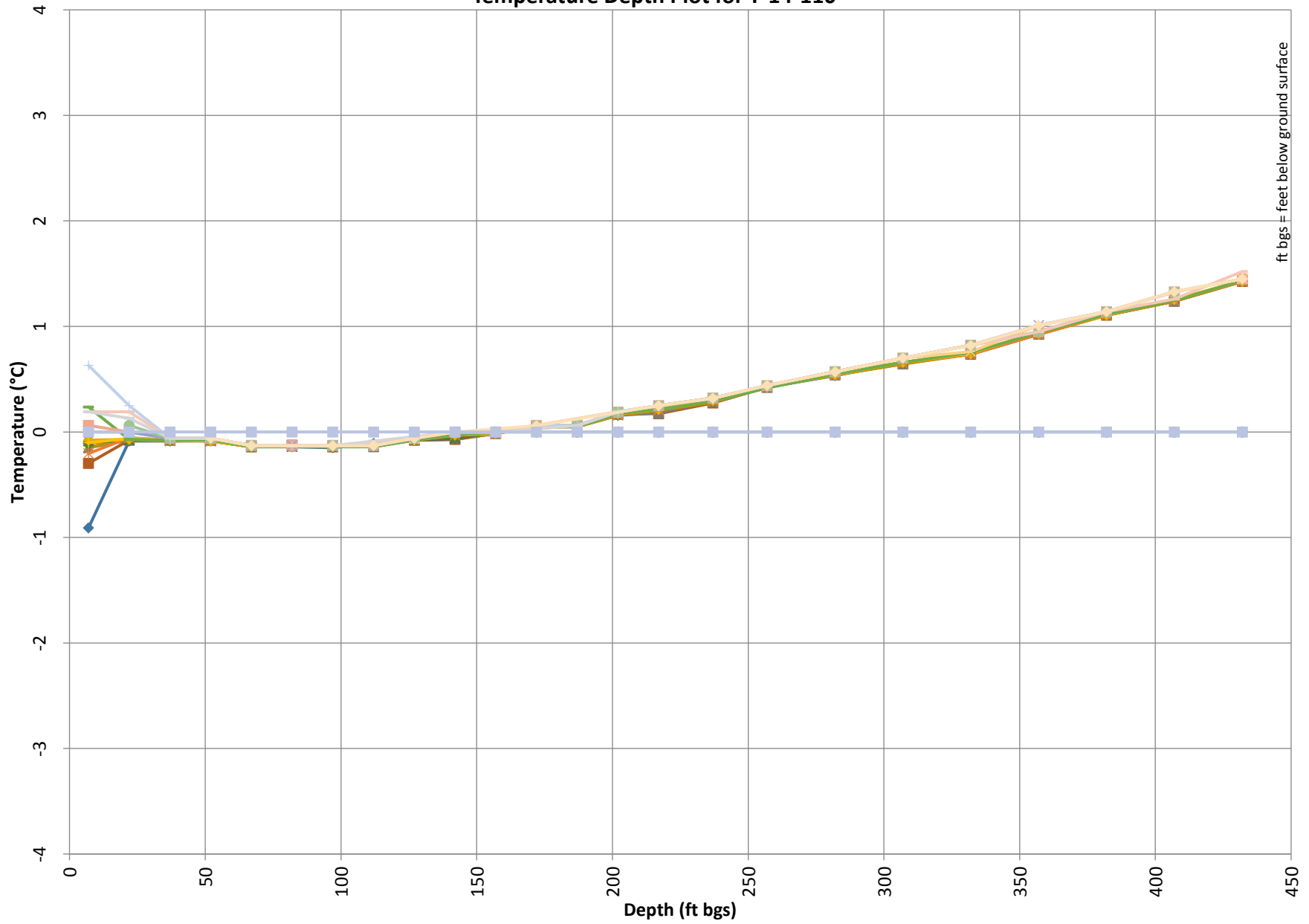




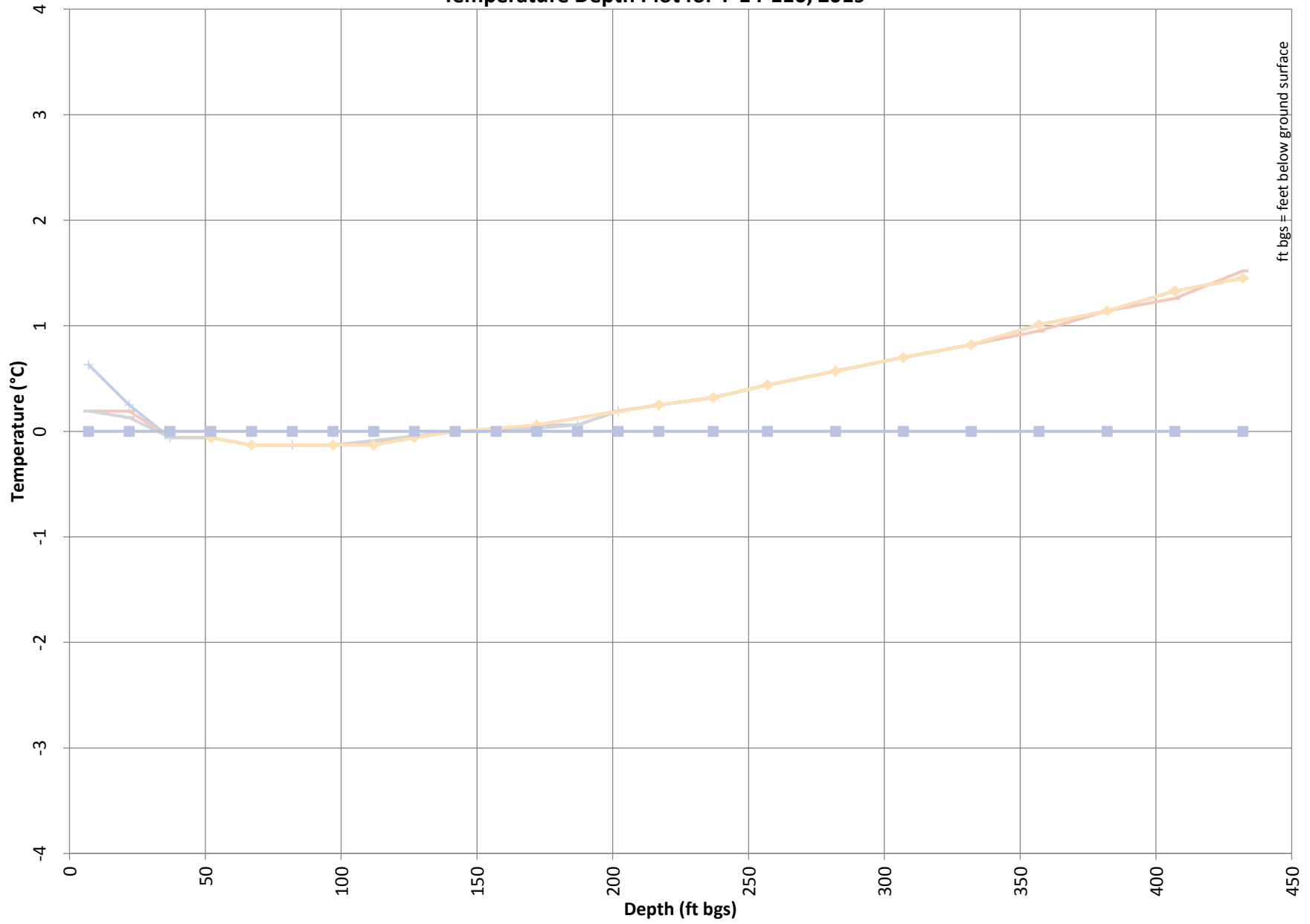
**T-05-061, Mean Annual Ground Temperature
(2019)**

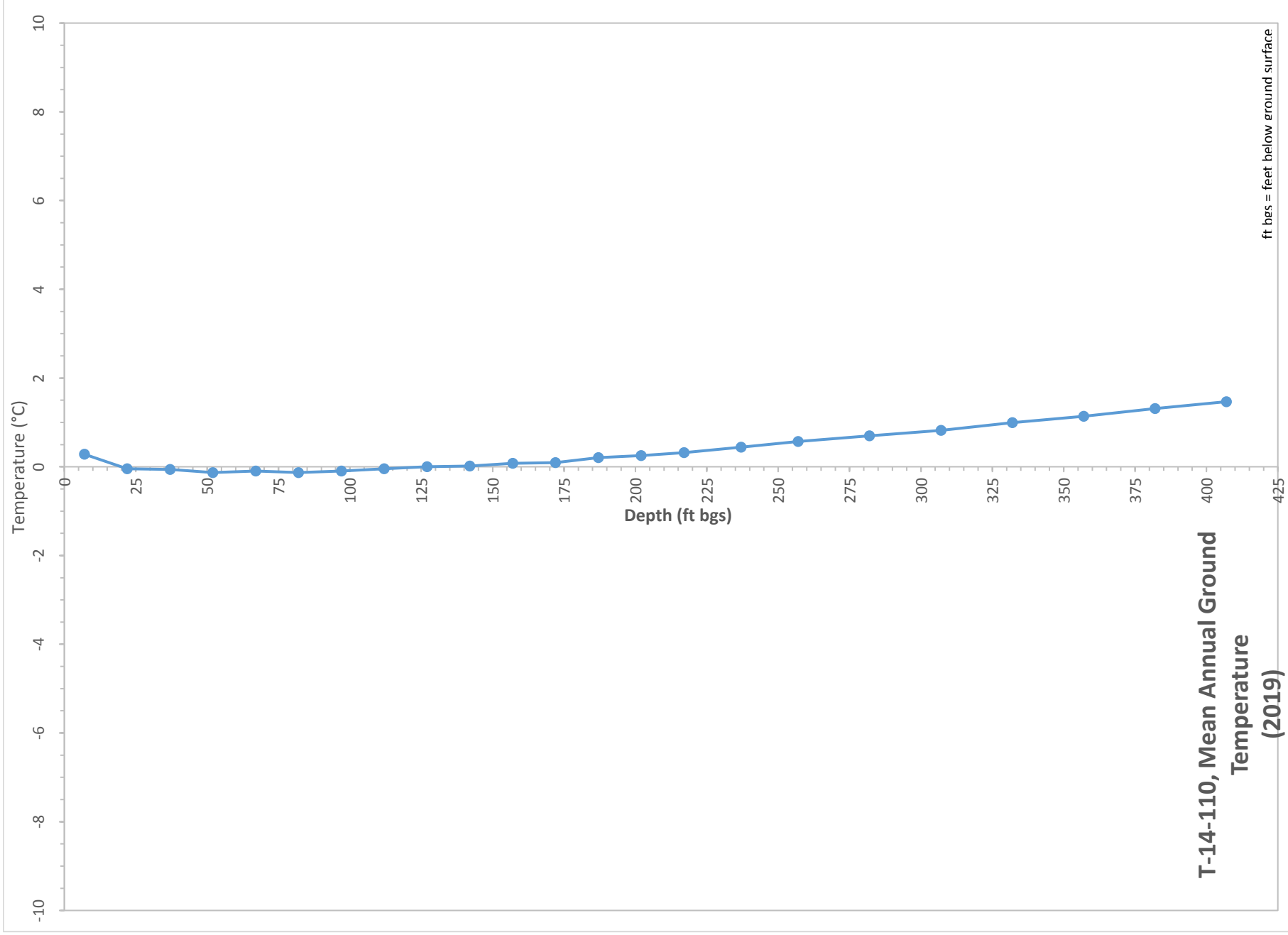
ft. bgs = feet below ground surface

Temperature Depth Plot for T-14-110



Temperature Depth Plot for T-14-110, 2019

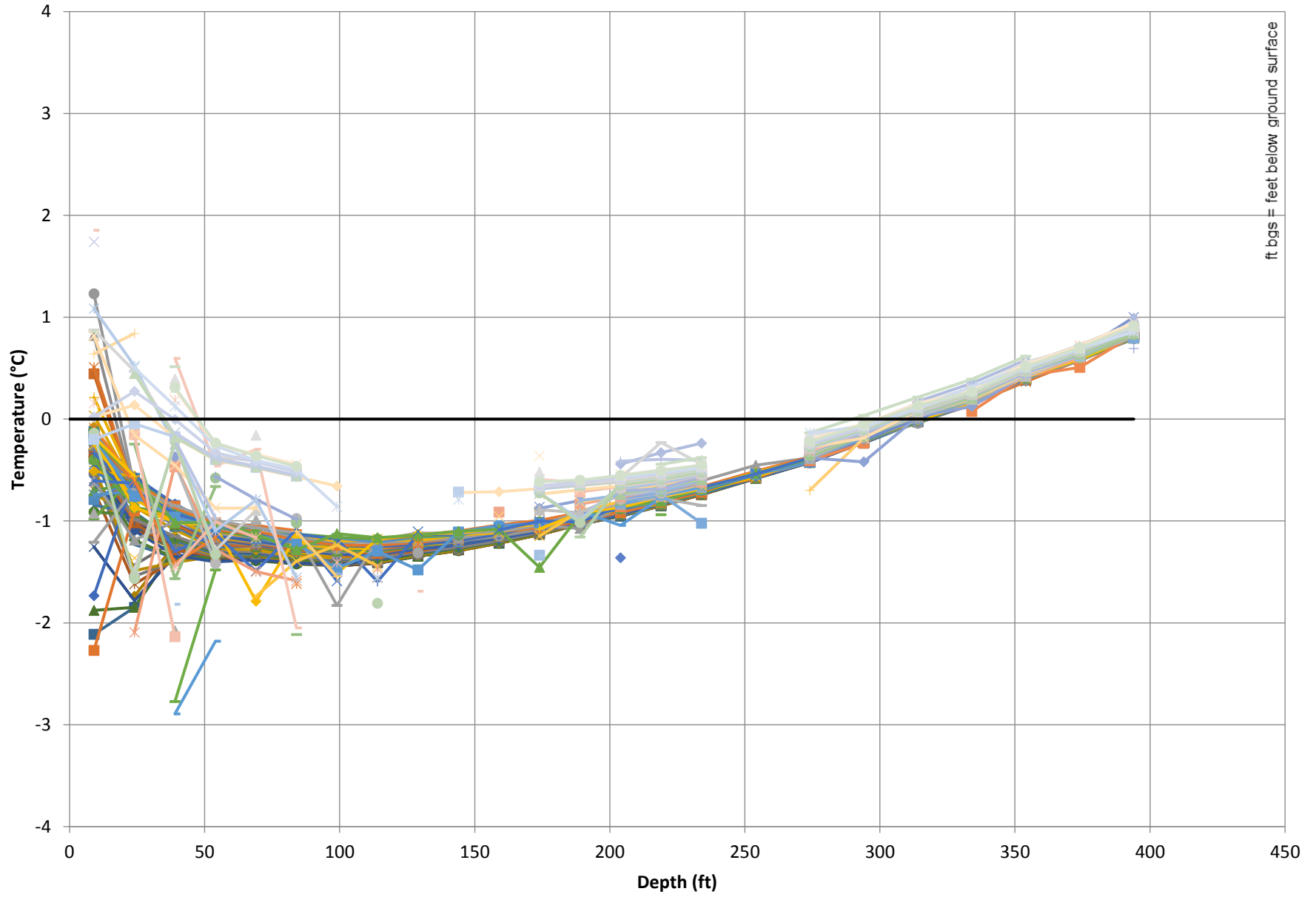




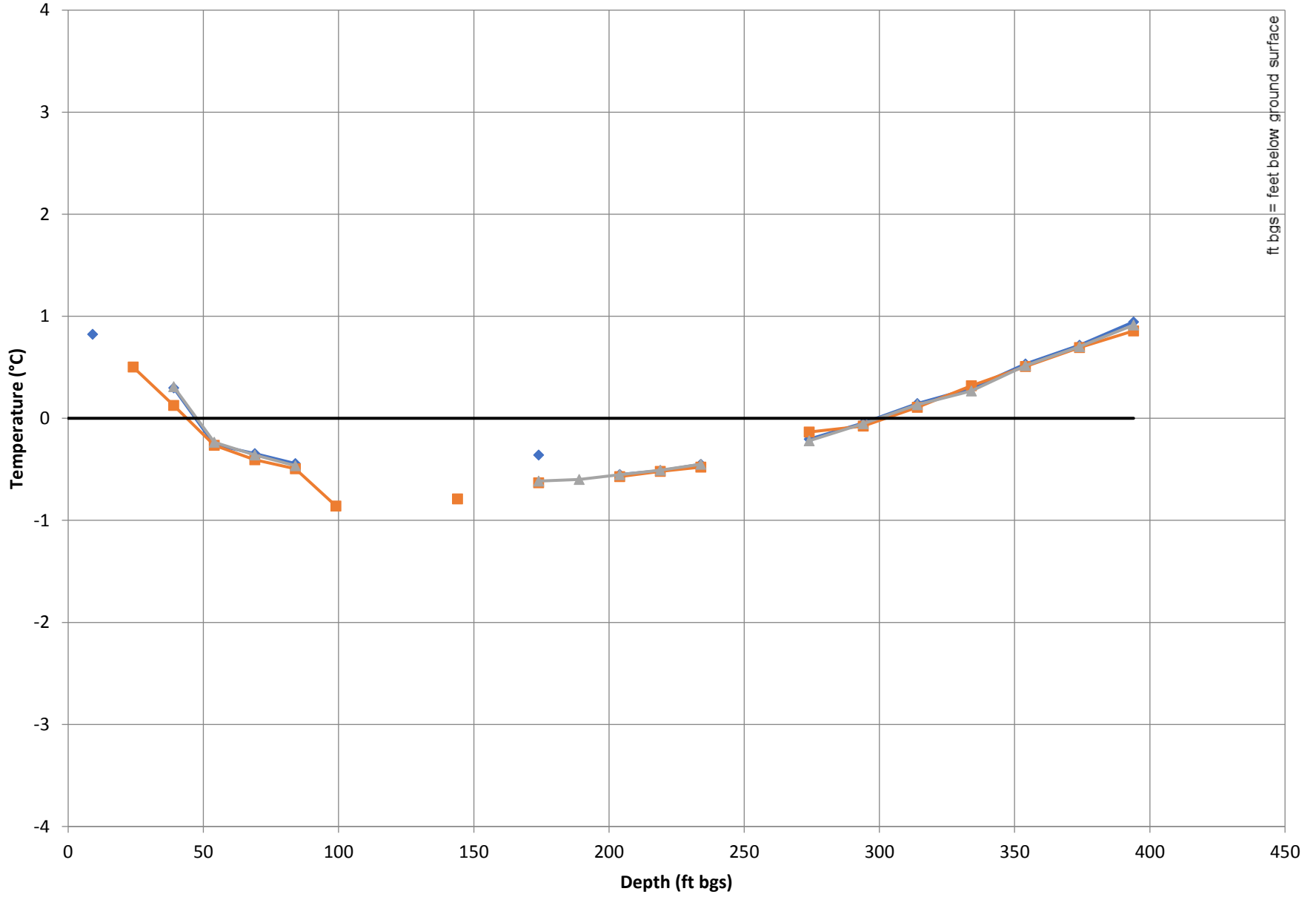
**T-14-110, Mean Annual Ground
Temperature
(2019)**

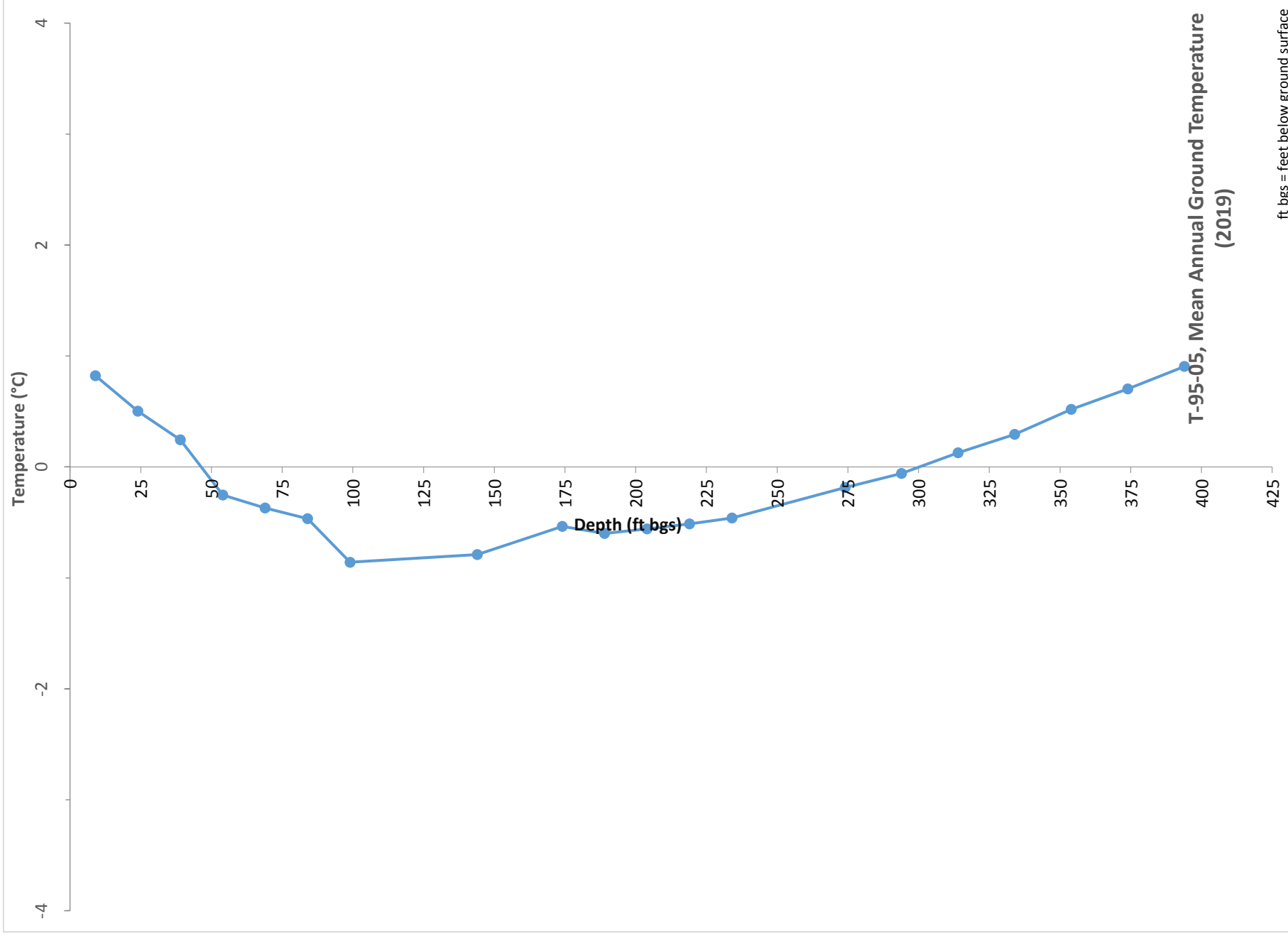
ft bgs = feet below ground surface

Temperature Depth Plot for T-95-005



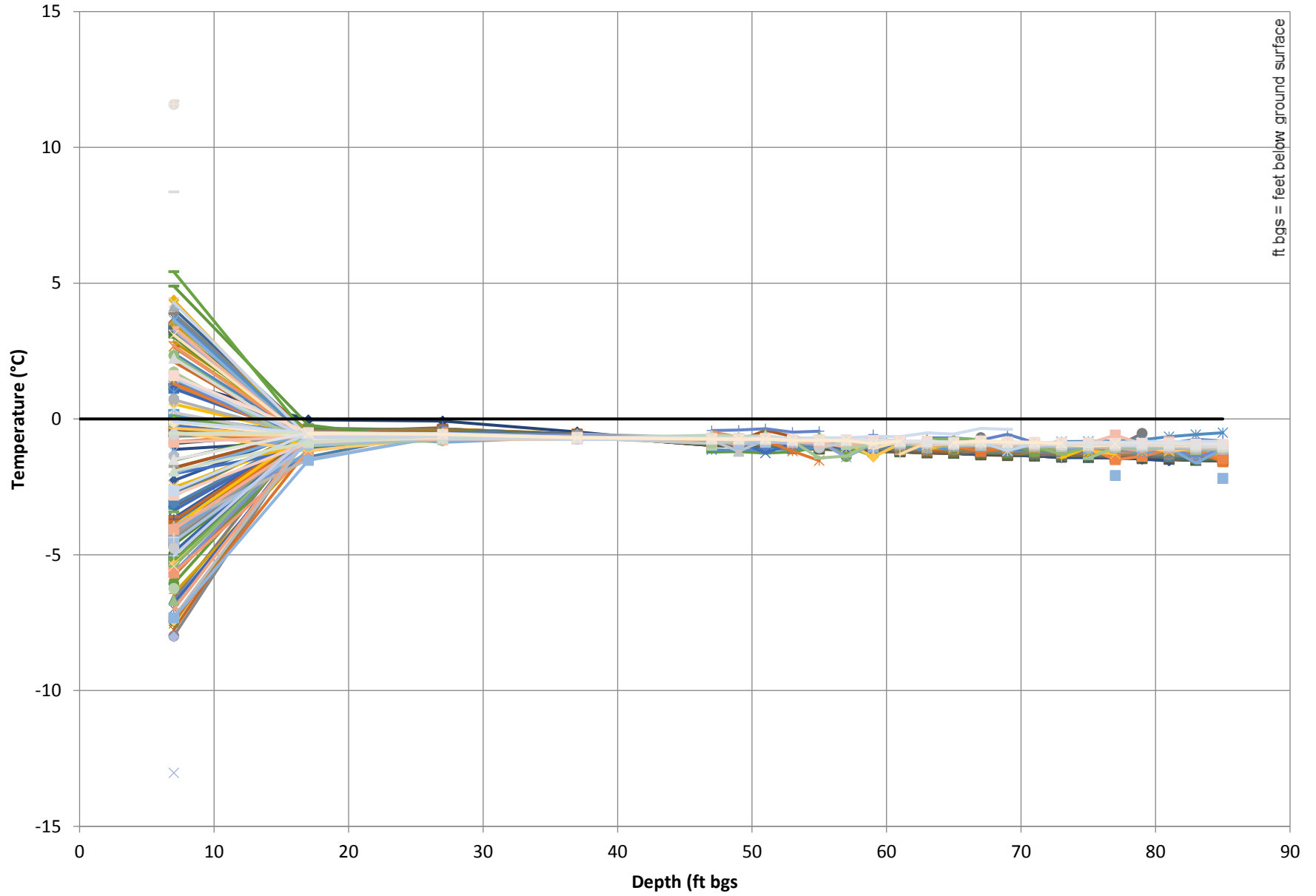
Temperature Depth Plot for T-95-005, 2019



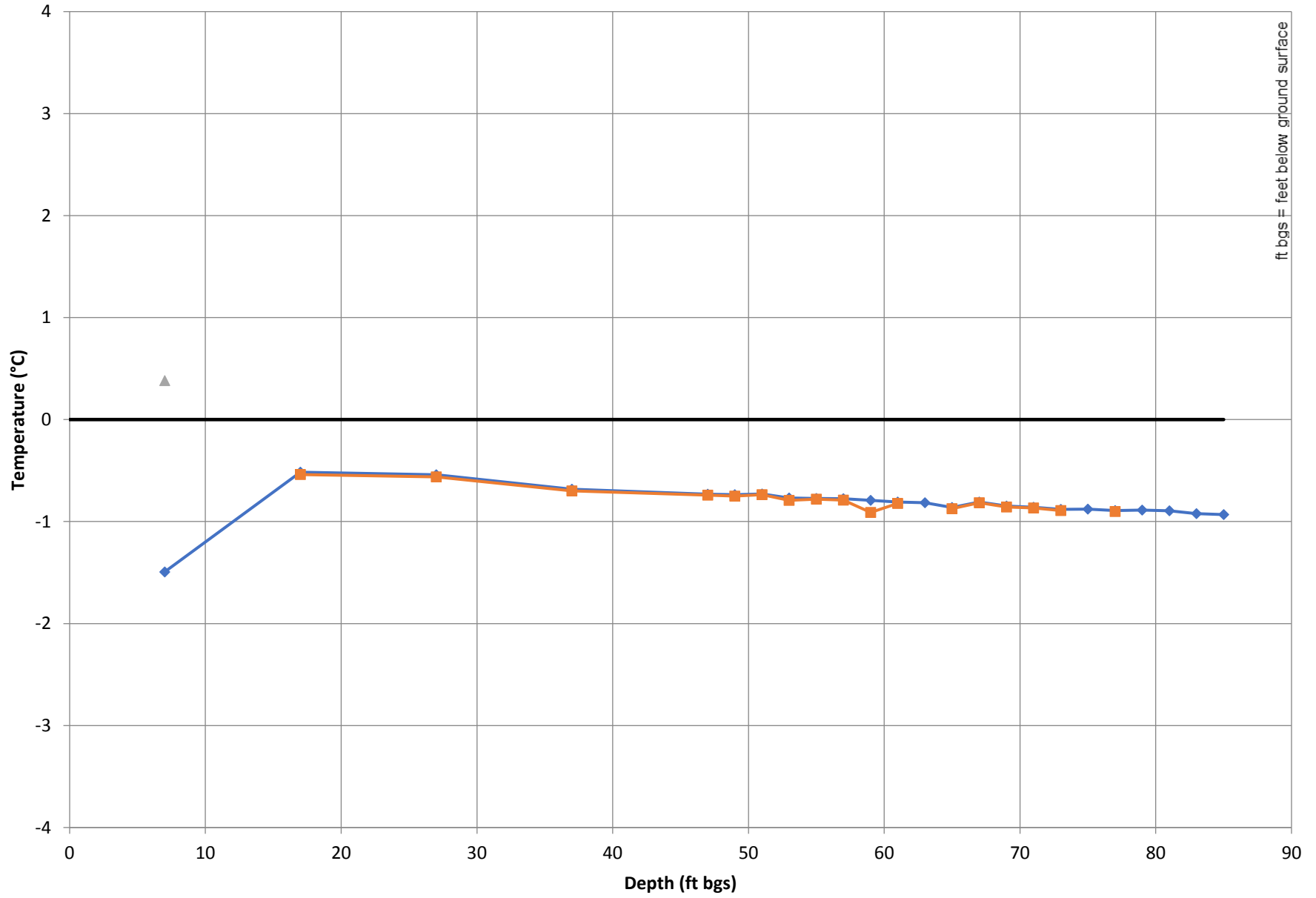


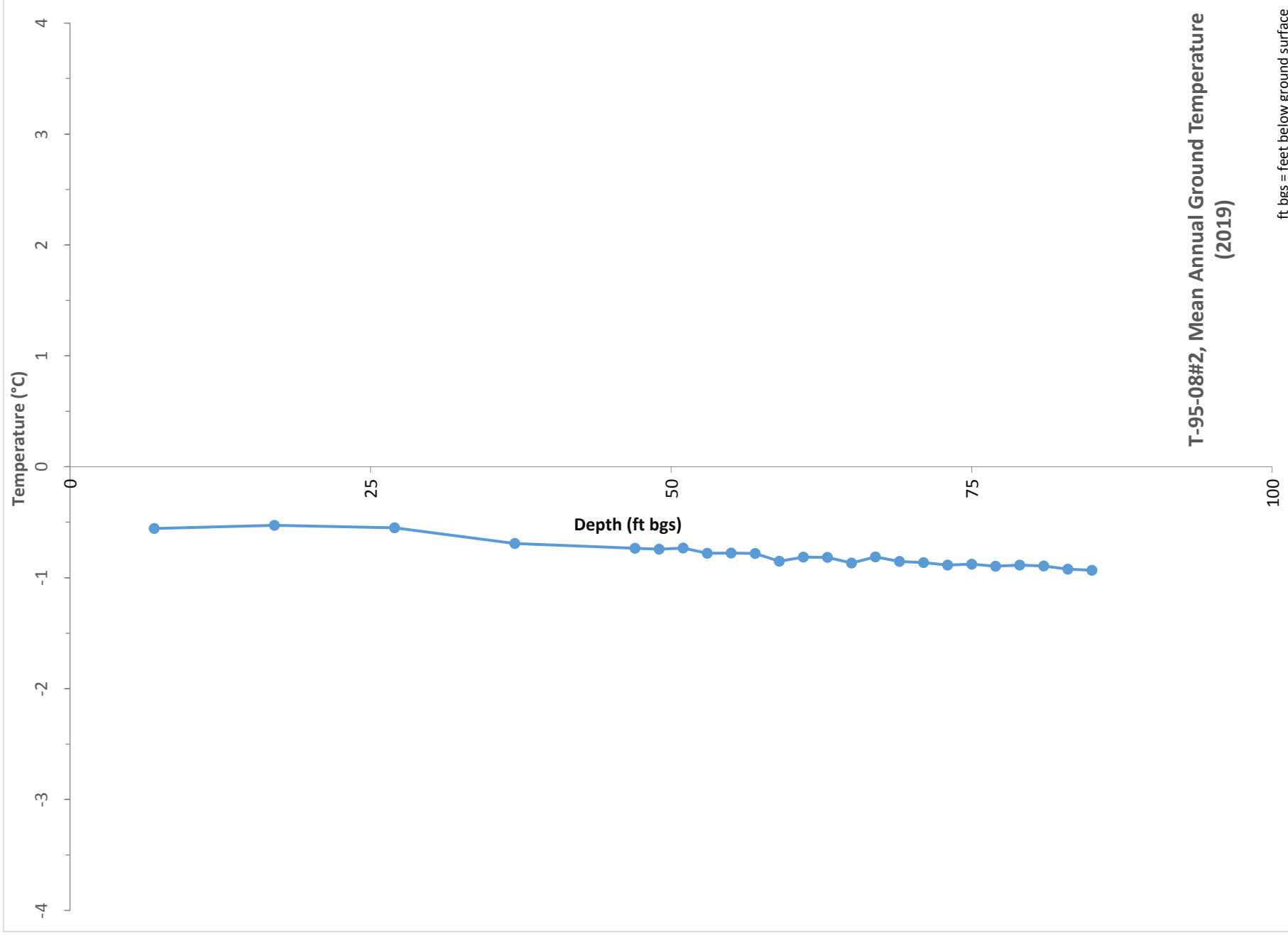
ft. bgs = feet below ground surface

Temperature Depth Plot for T-95-008 #2



Temperature Depth Plot for T-95-008 #2, 2019

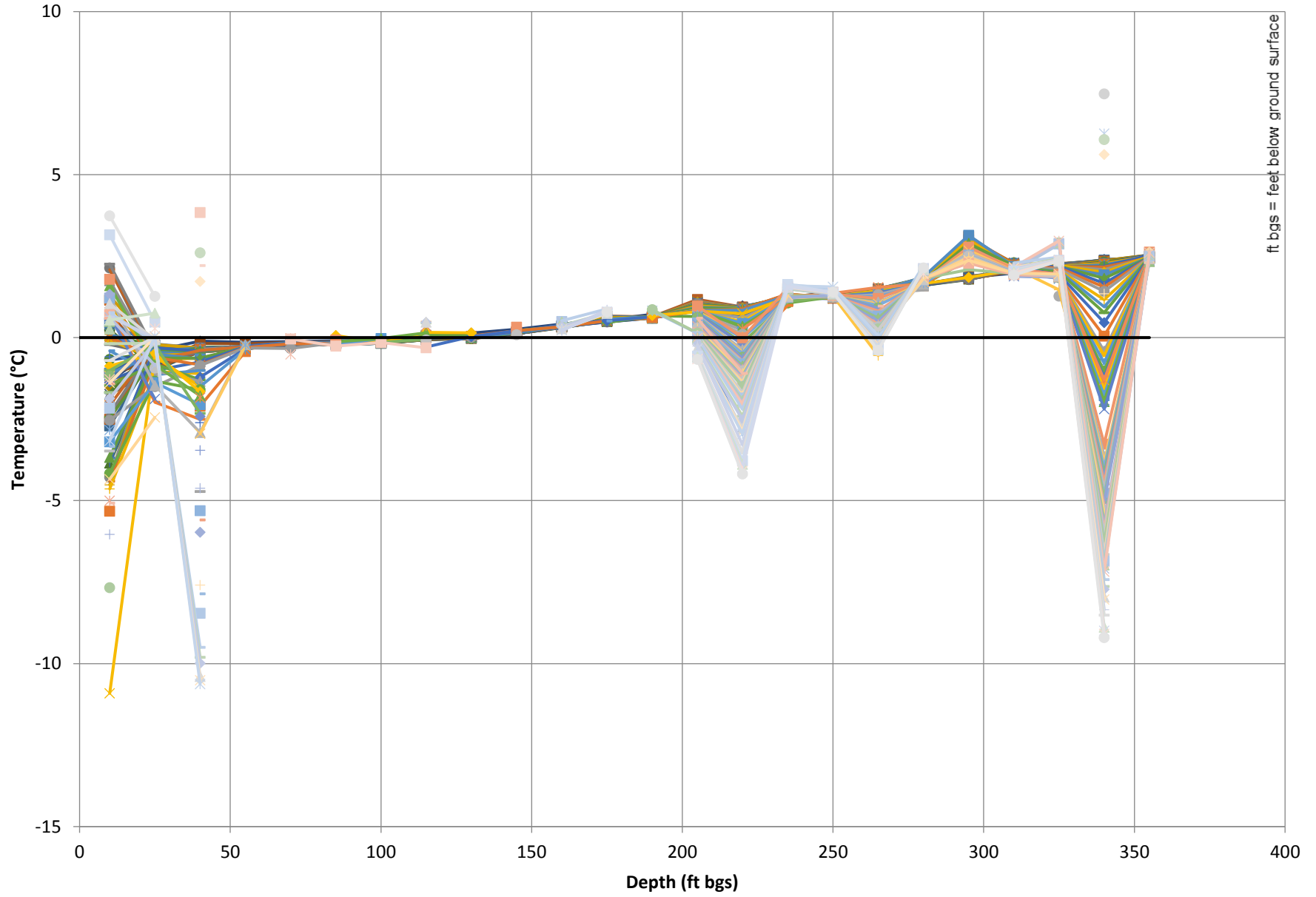




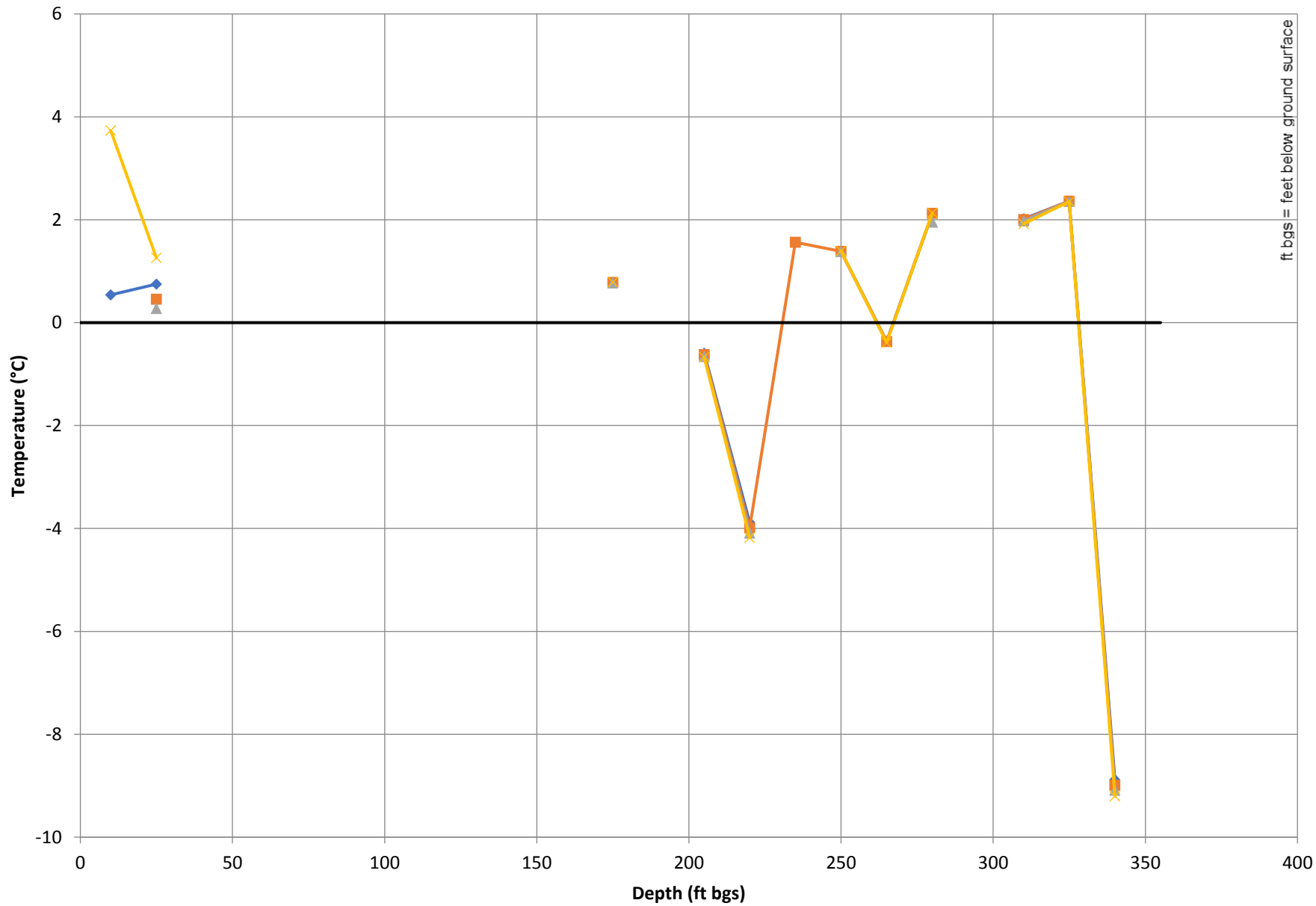
T-95-08#2, Mean Annual Ground Temperature (2019)

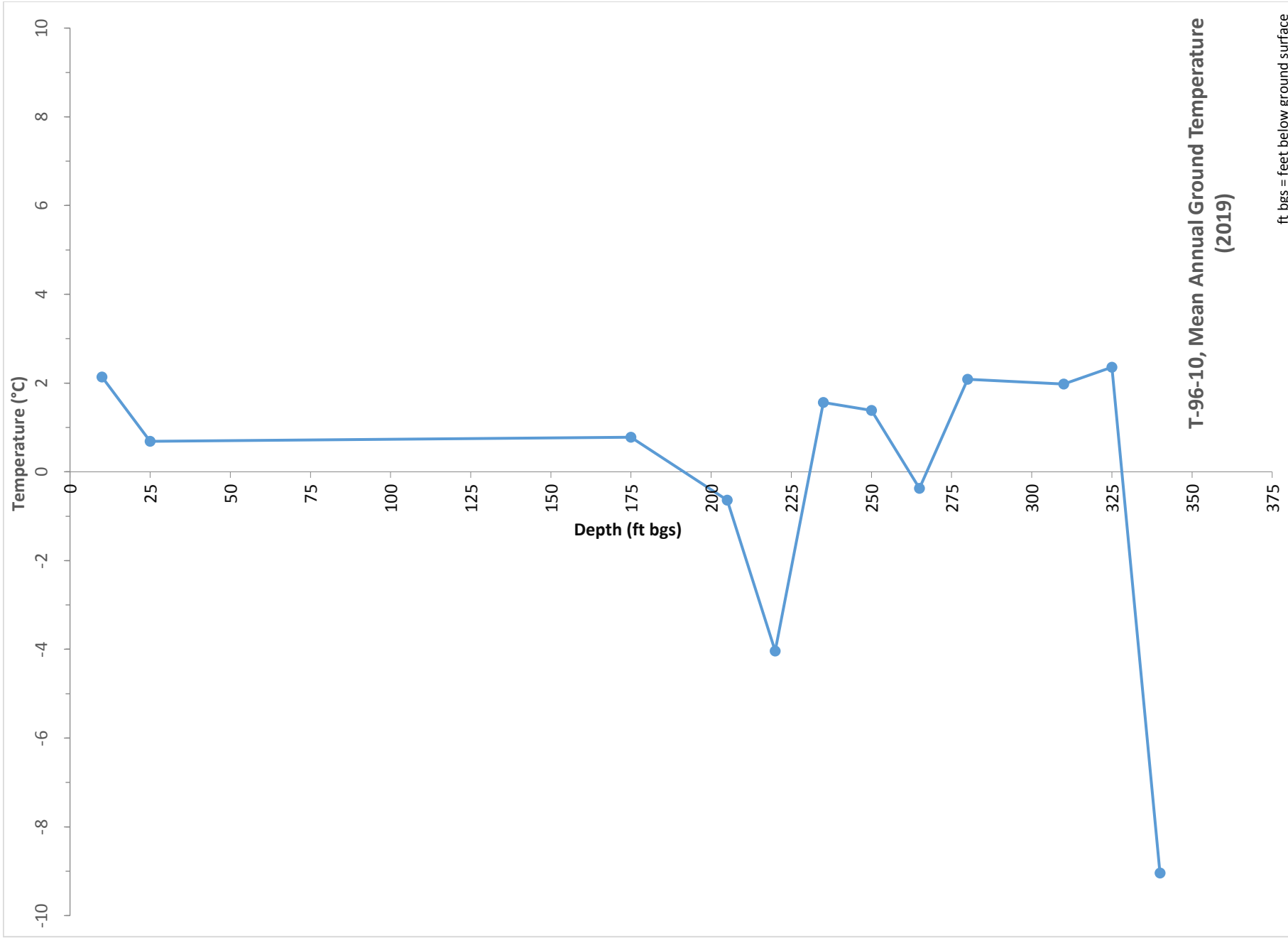
ft. bgs = feet below ground surface

Temperature Depth Plot for T-96-010

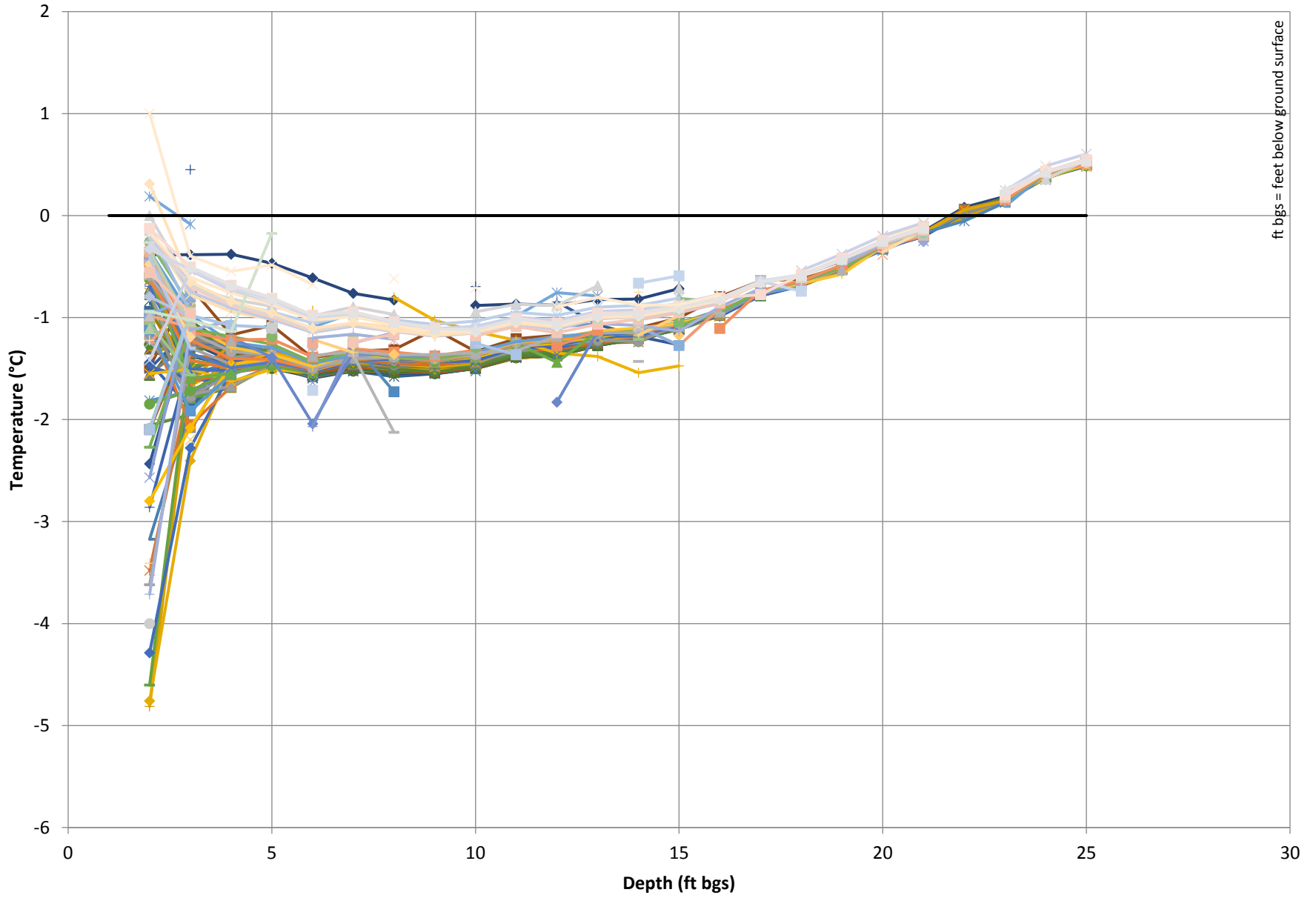


Temperature Depth Plot for T-96-010, 2019

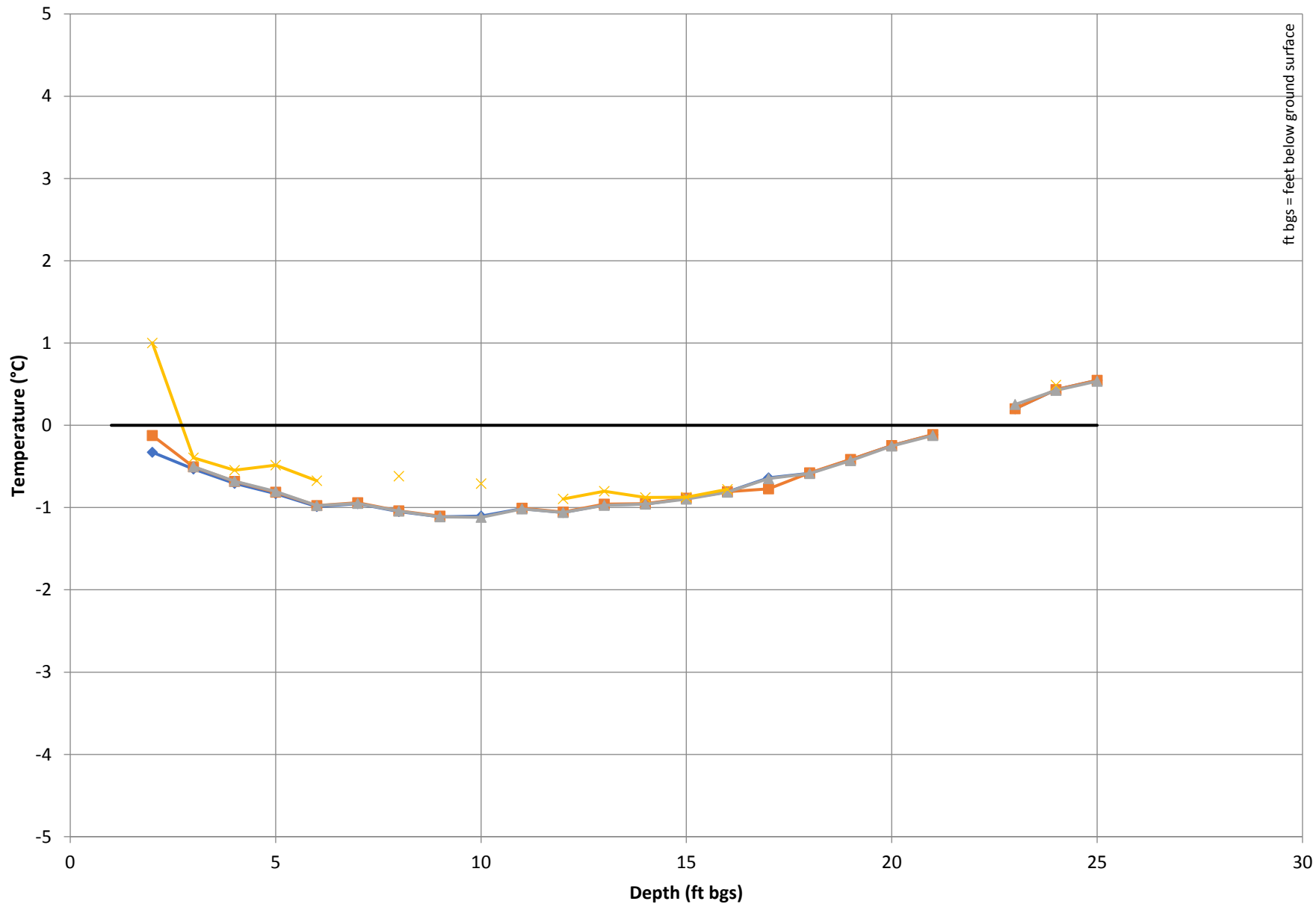


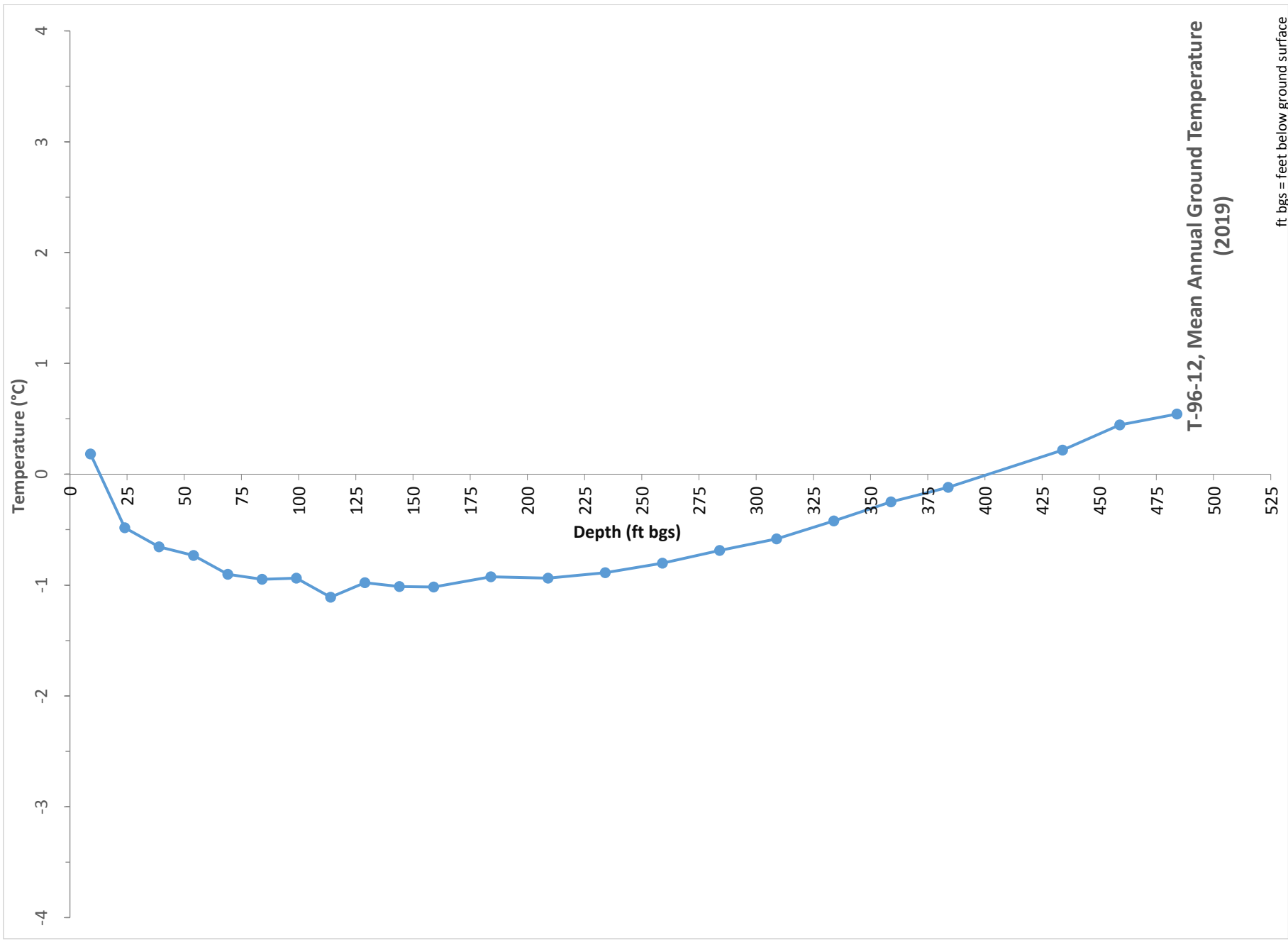


Temperature Depth Plot for T-96-012

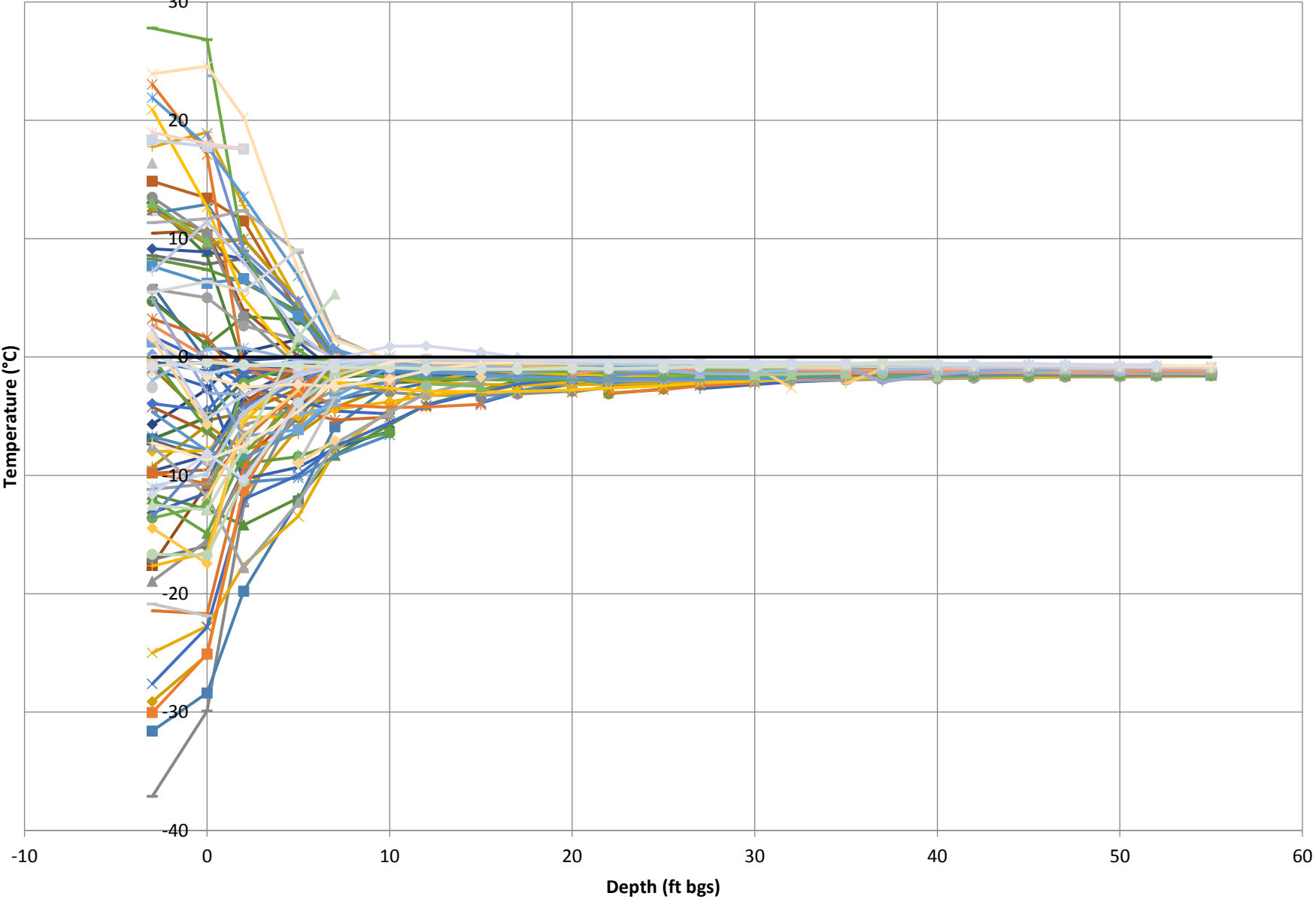


Temperature Depth Plot for T-96-012, 2019

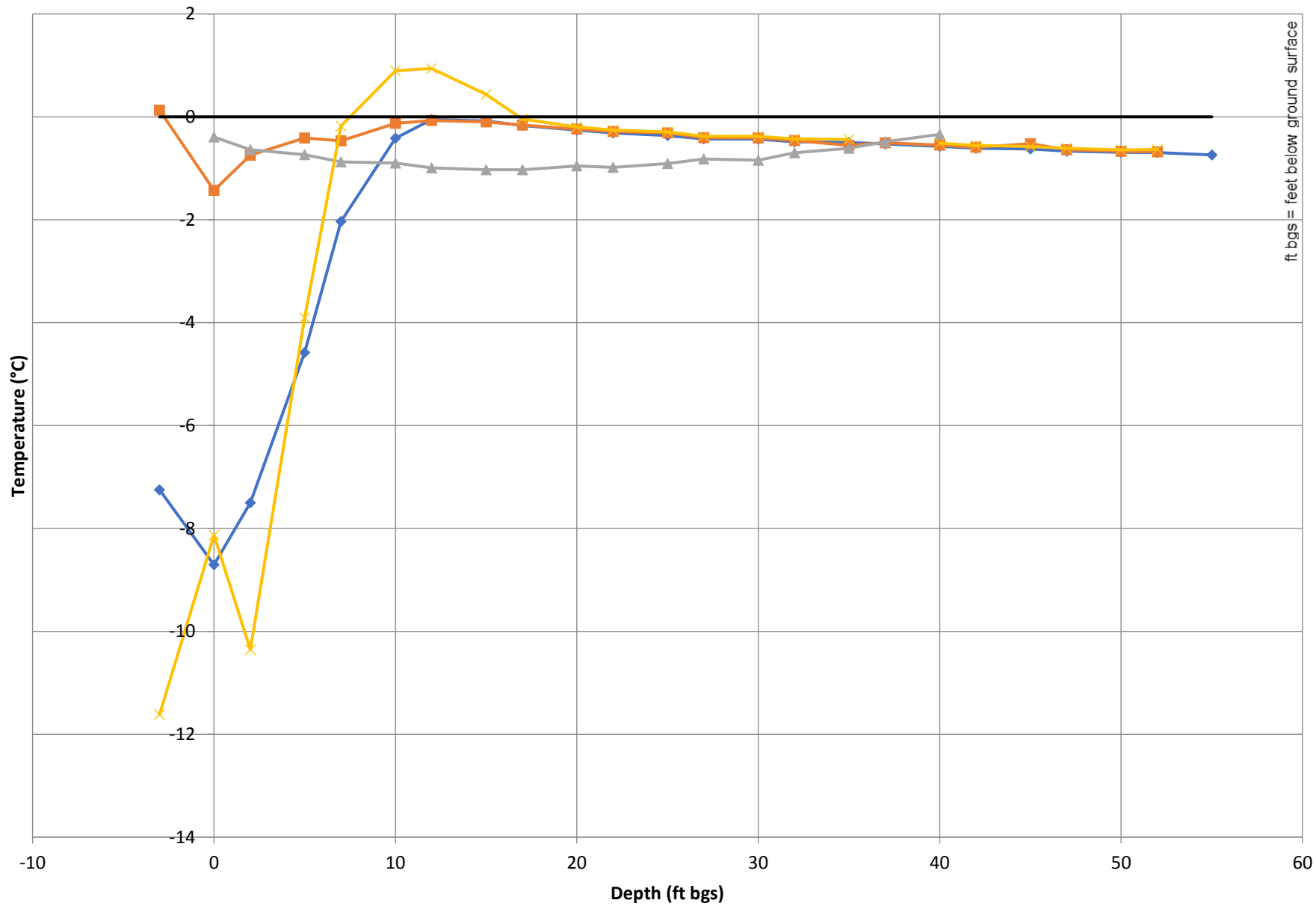


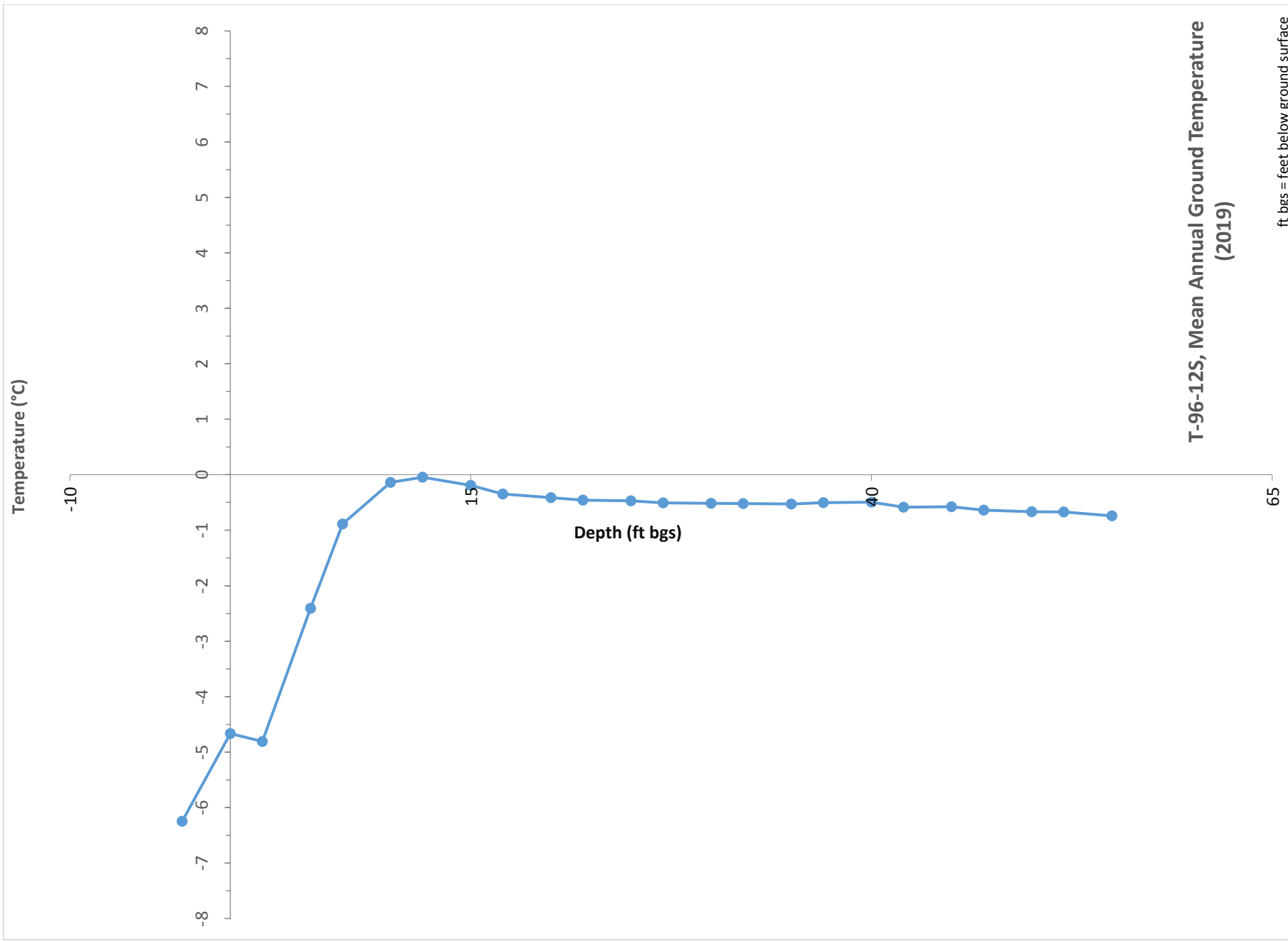


Temperature Depth Plot for T-96-012S



Temperature Depth Plot for T-96-012S, 2019

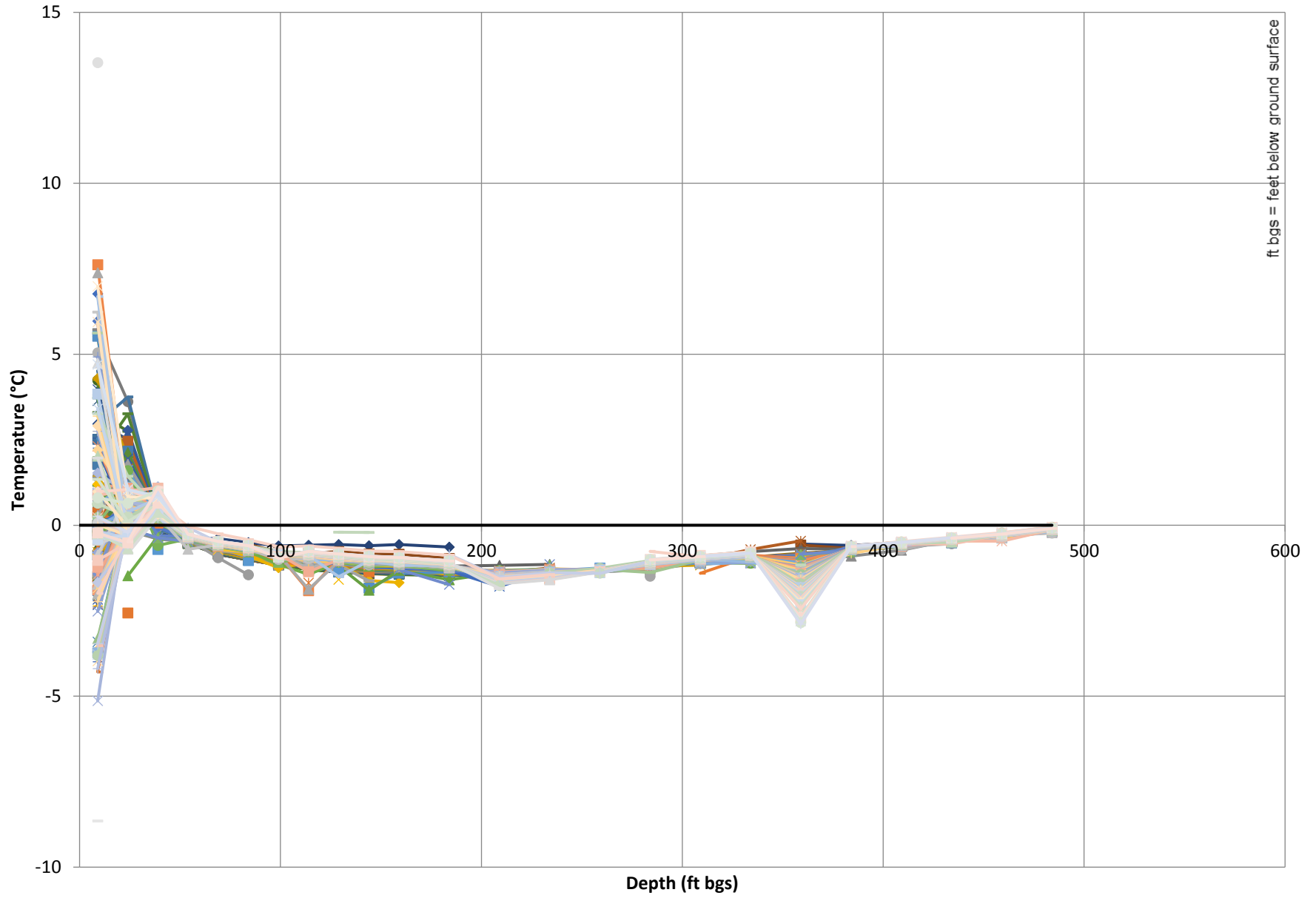




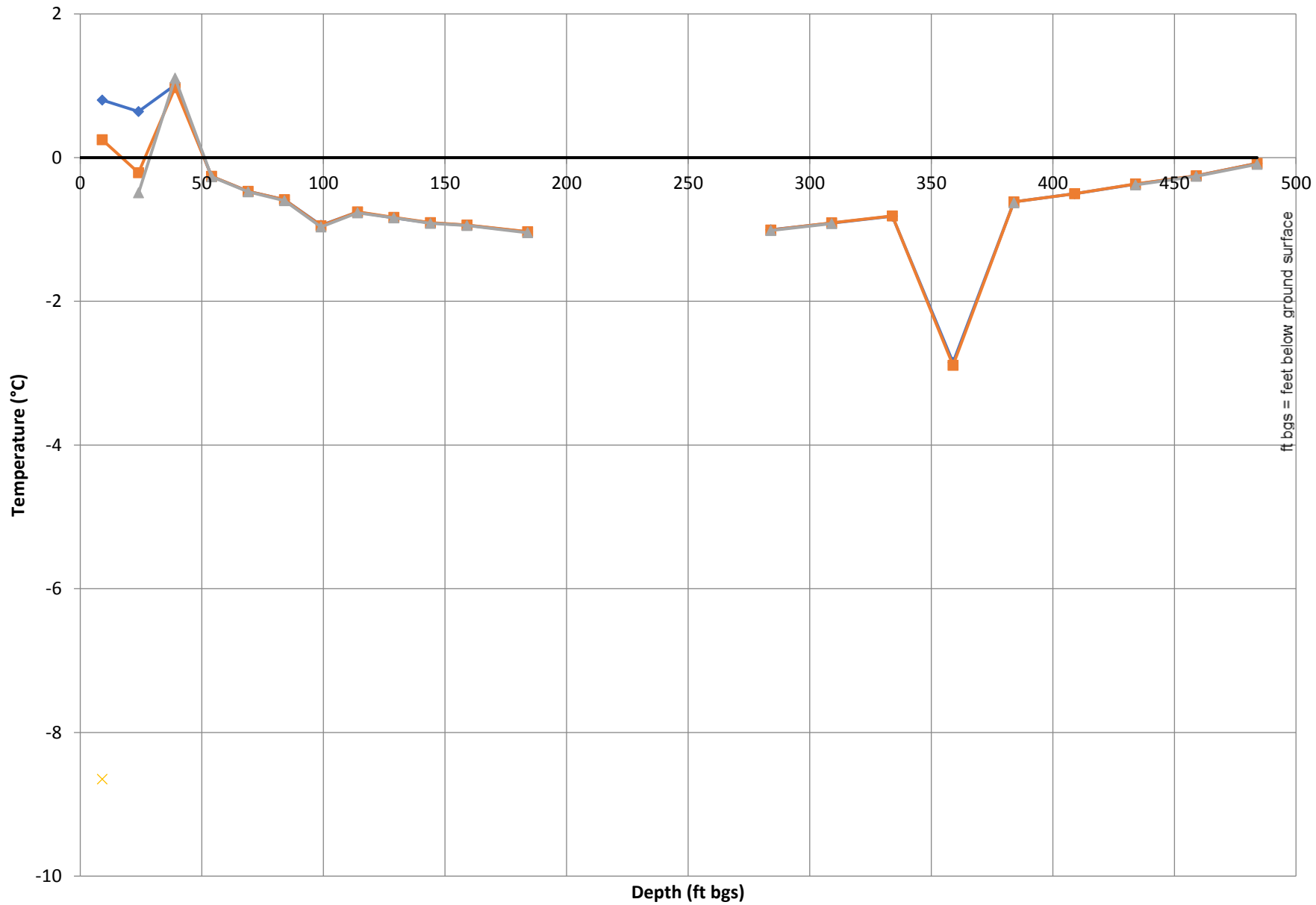
T-96-12S, Mean Annual Ground Temperature (2019)

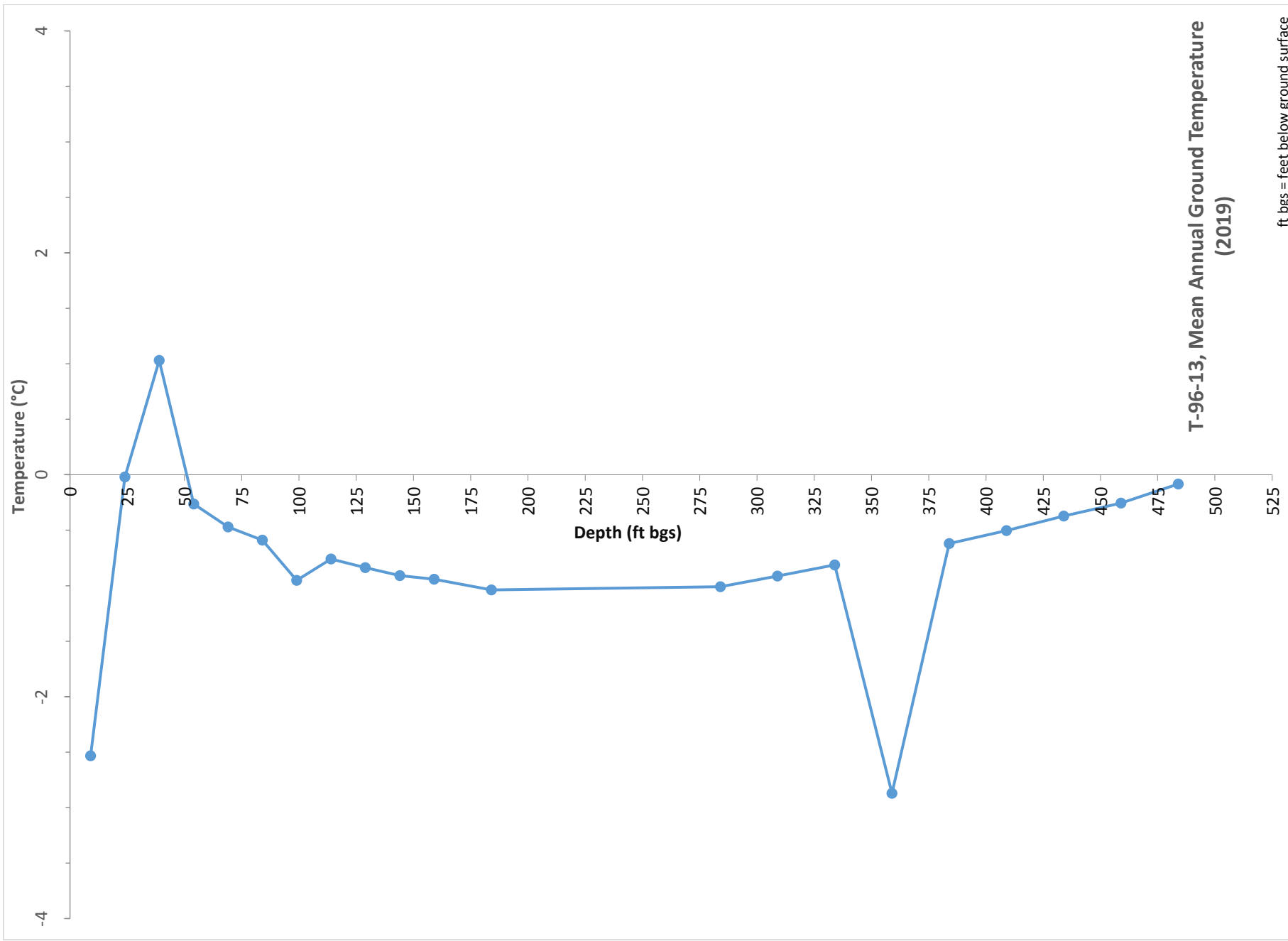
ft. bgs = feet below ground surface

Temperature Depth Plot for T-96-013

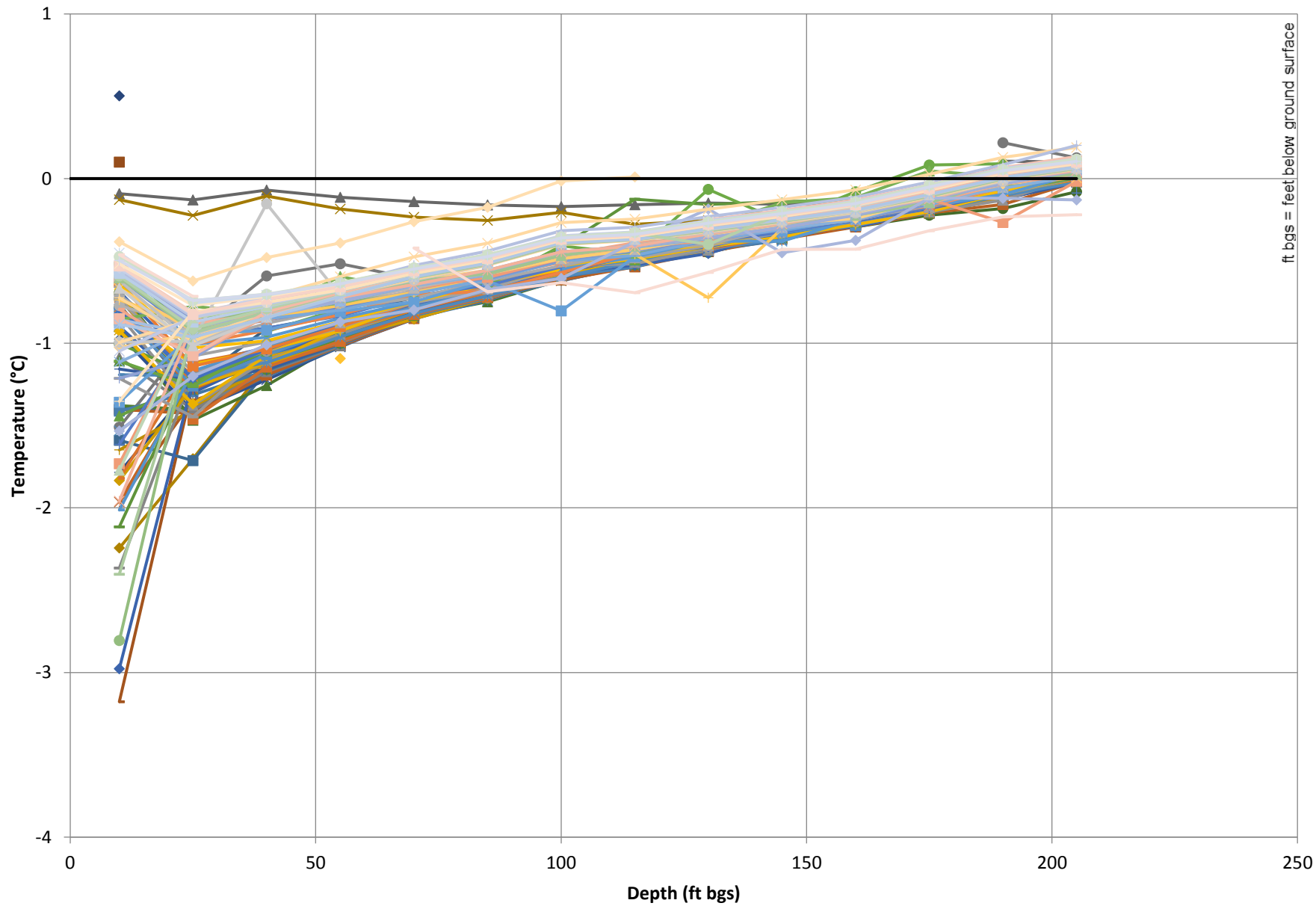


Temperature Depth Plot for T-96-013, 2019

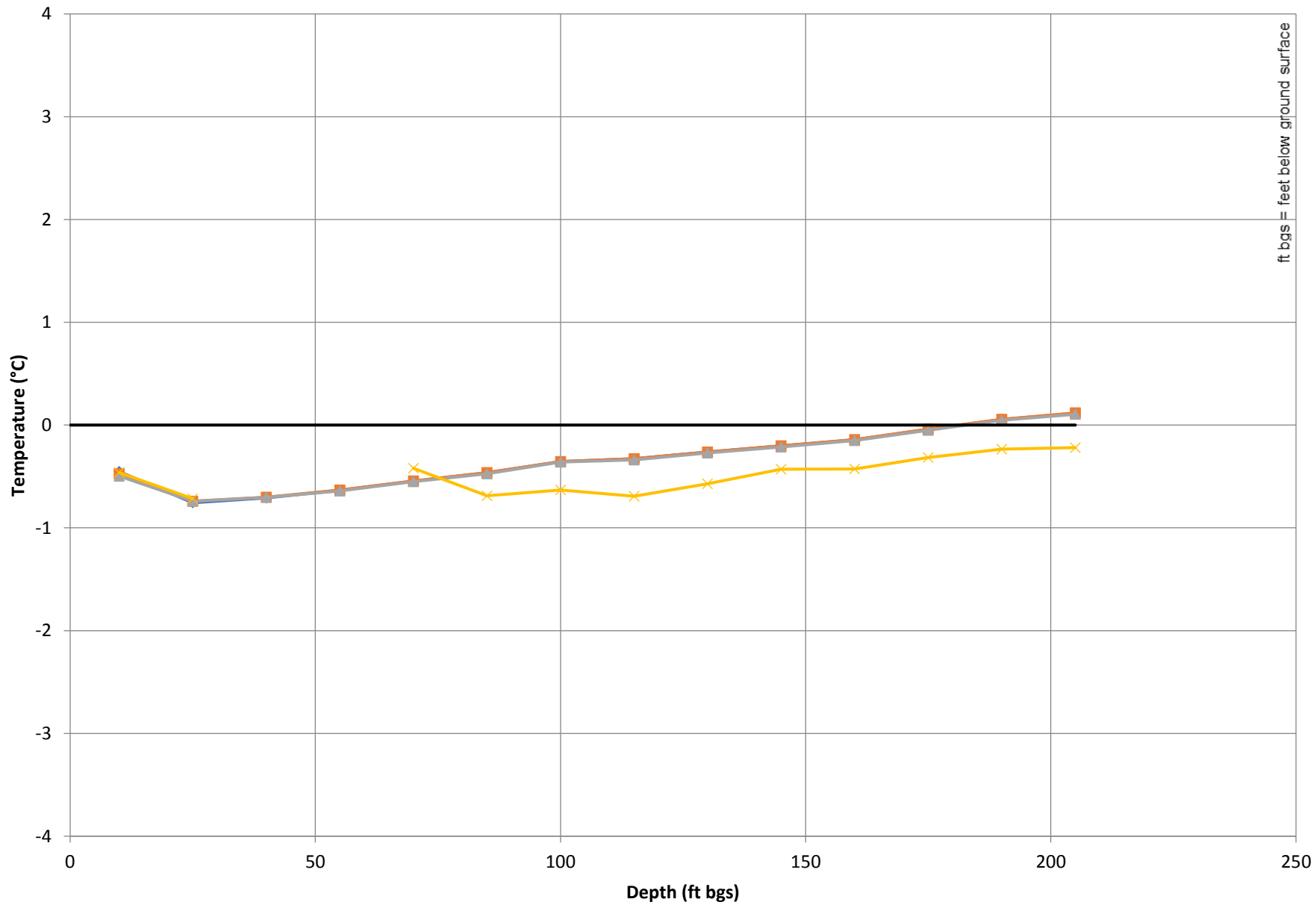


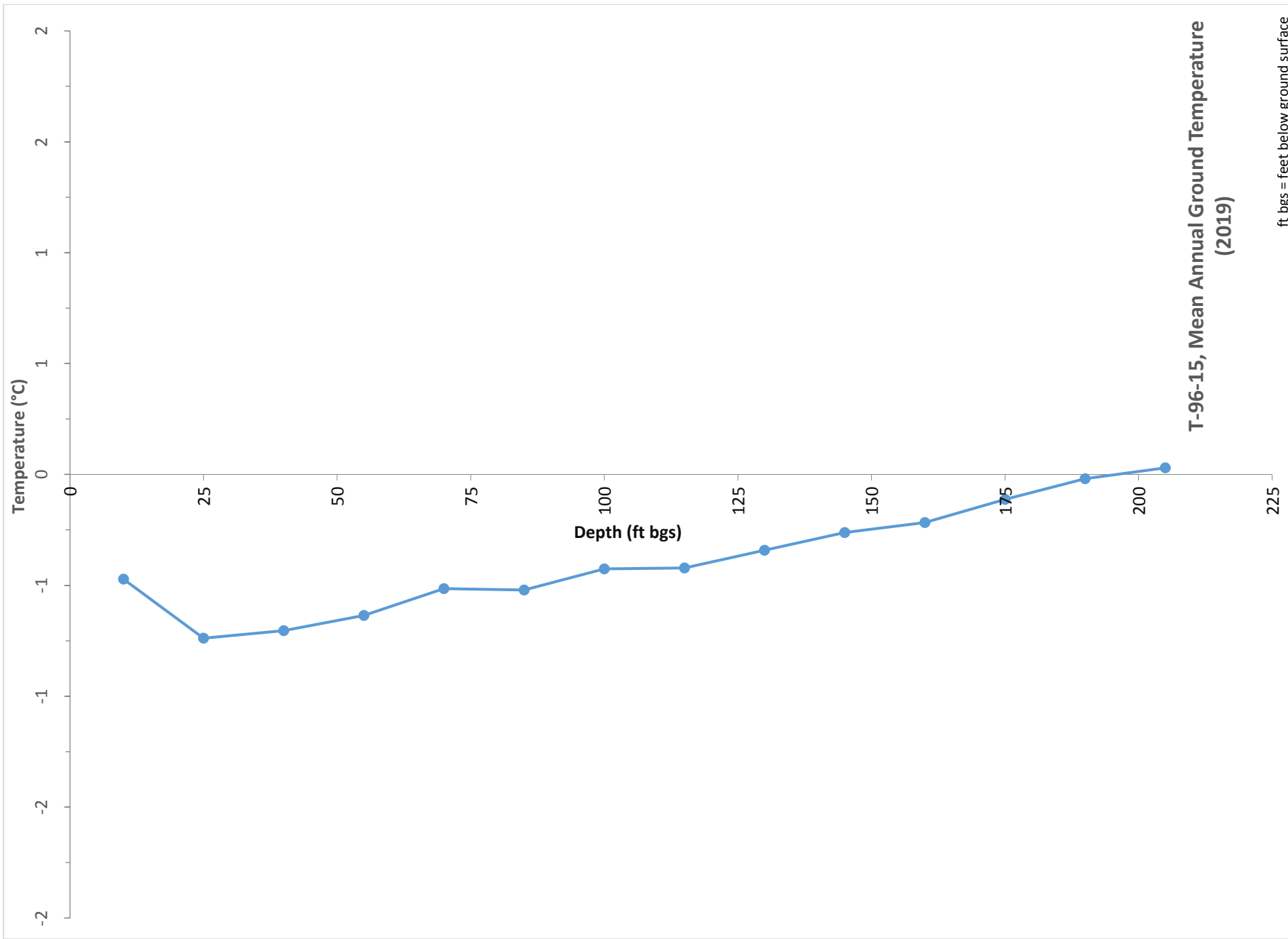


Temperature Depth Plot for T-96-015



Temperature Depth Plot for T-96-015, 2019

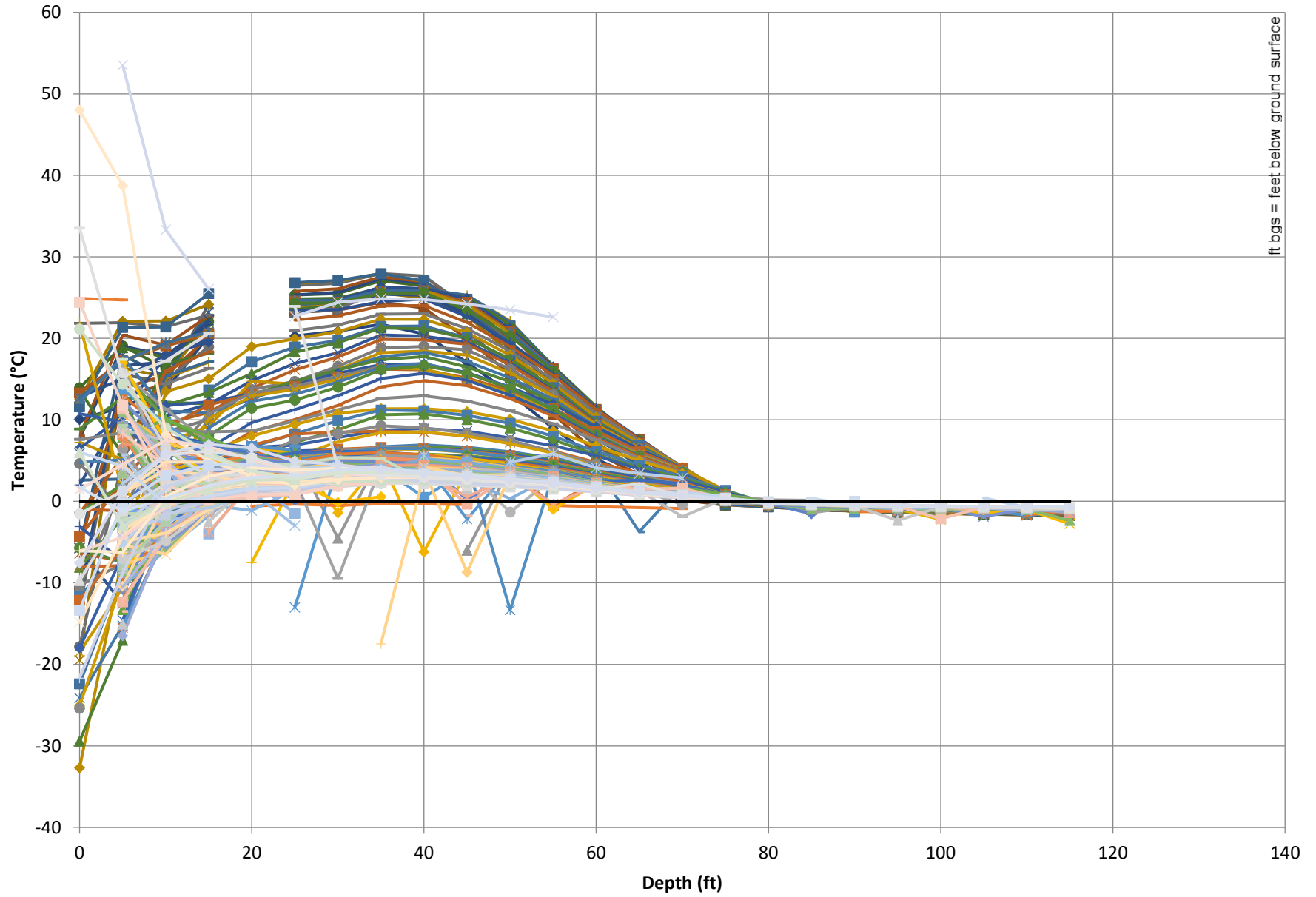




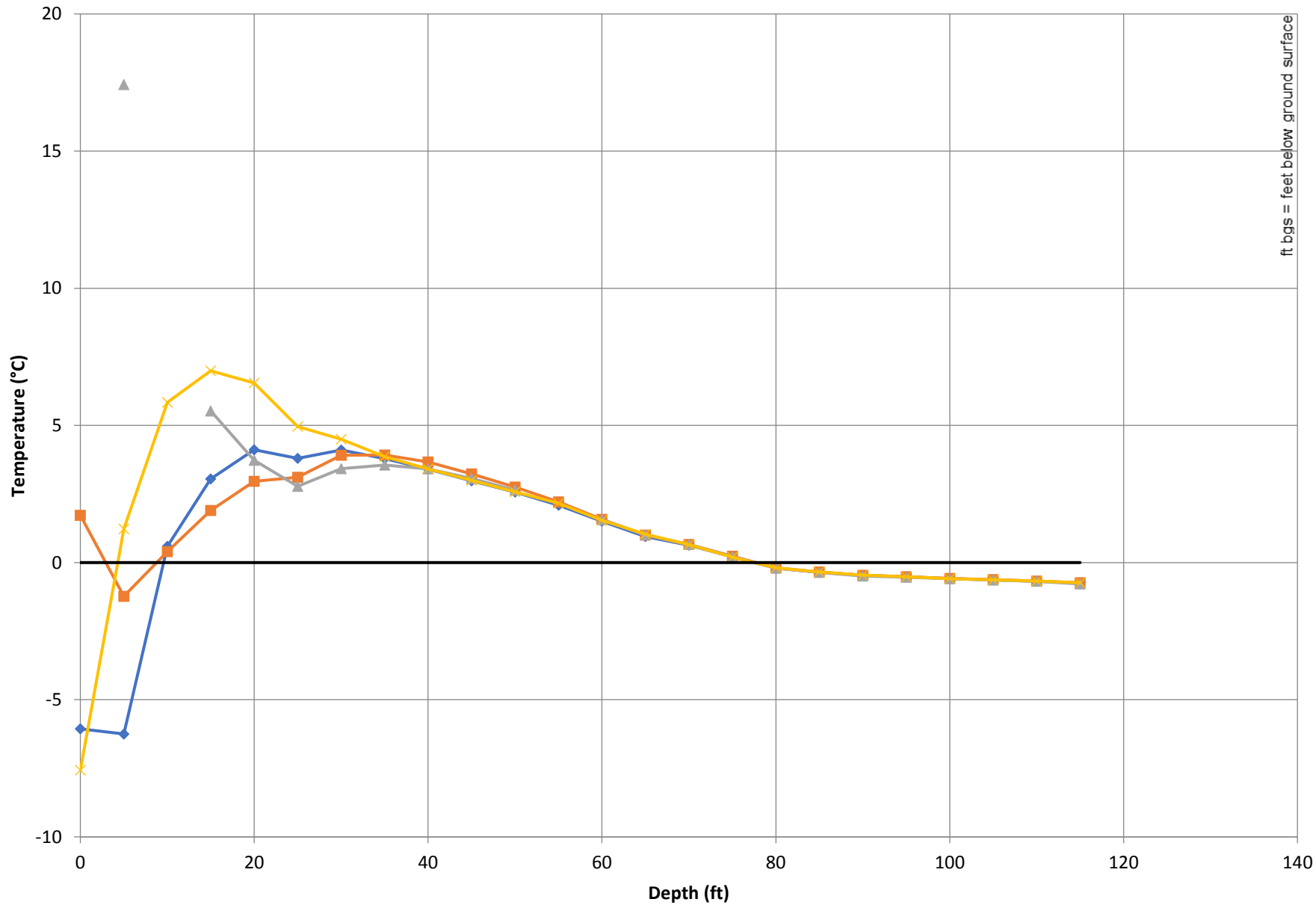
T-96-15, Mean Annual Ground Temperature (2019)

ft. bgs = feet below ground surface

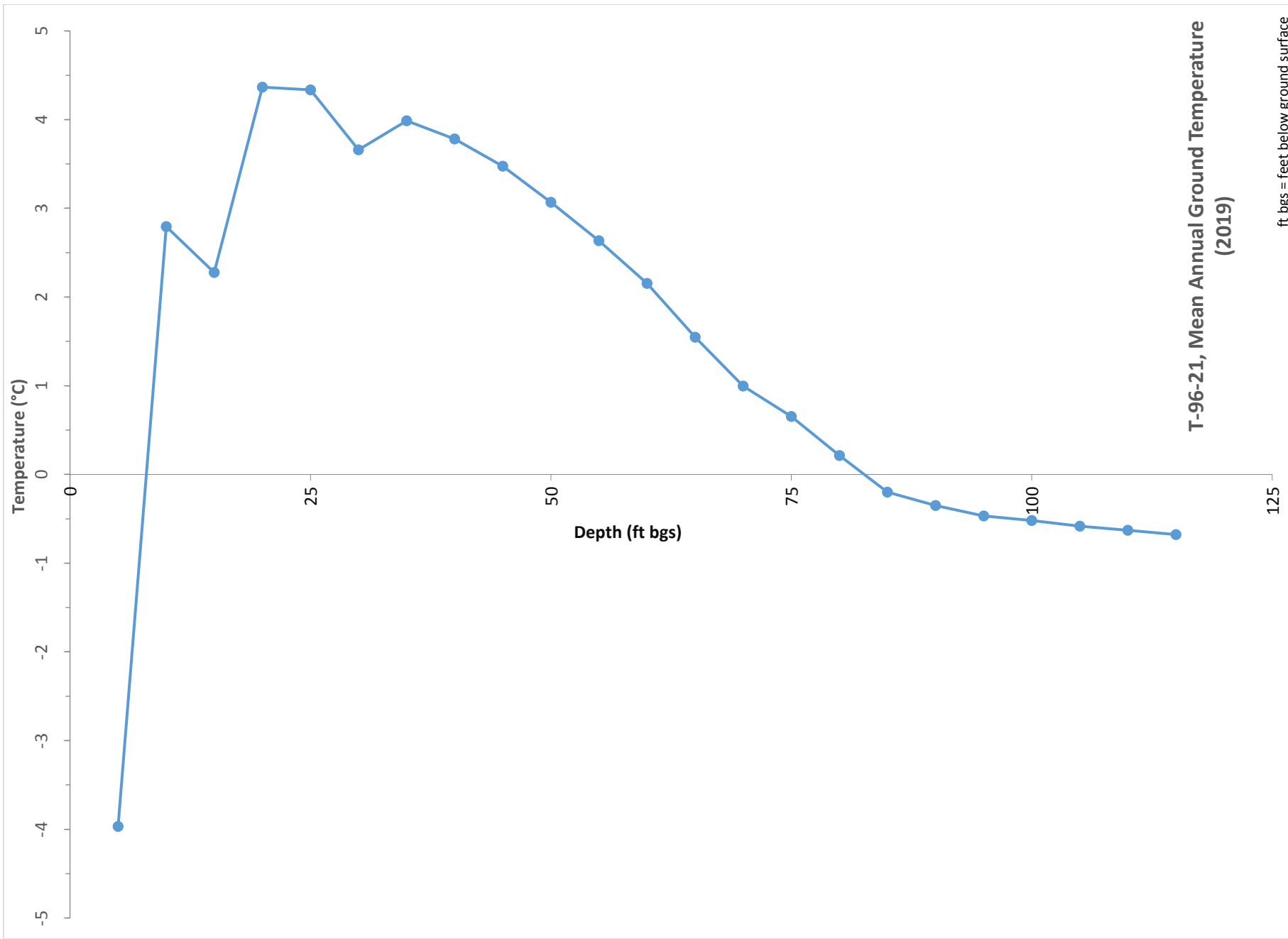
Temperature Depth Plot for T-96-021



Temperature Depth Plot for T-96-021, 2019



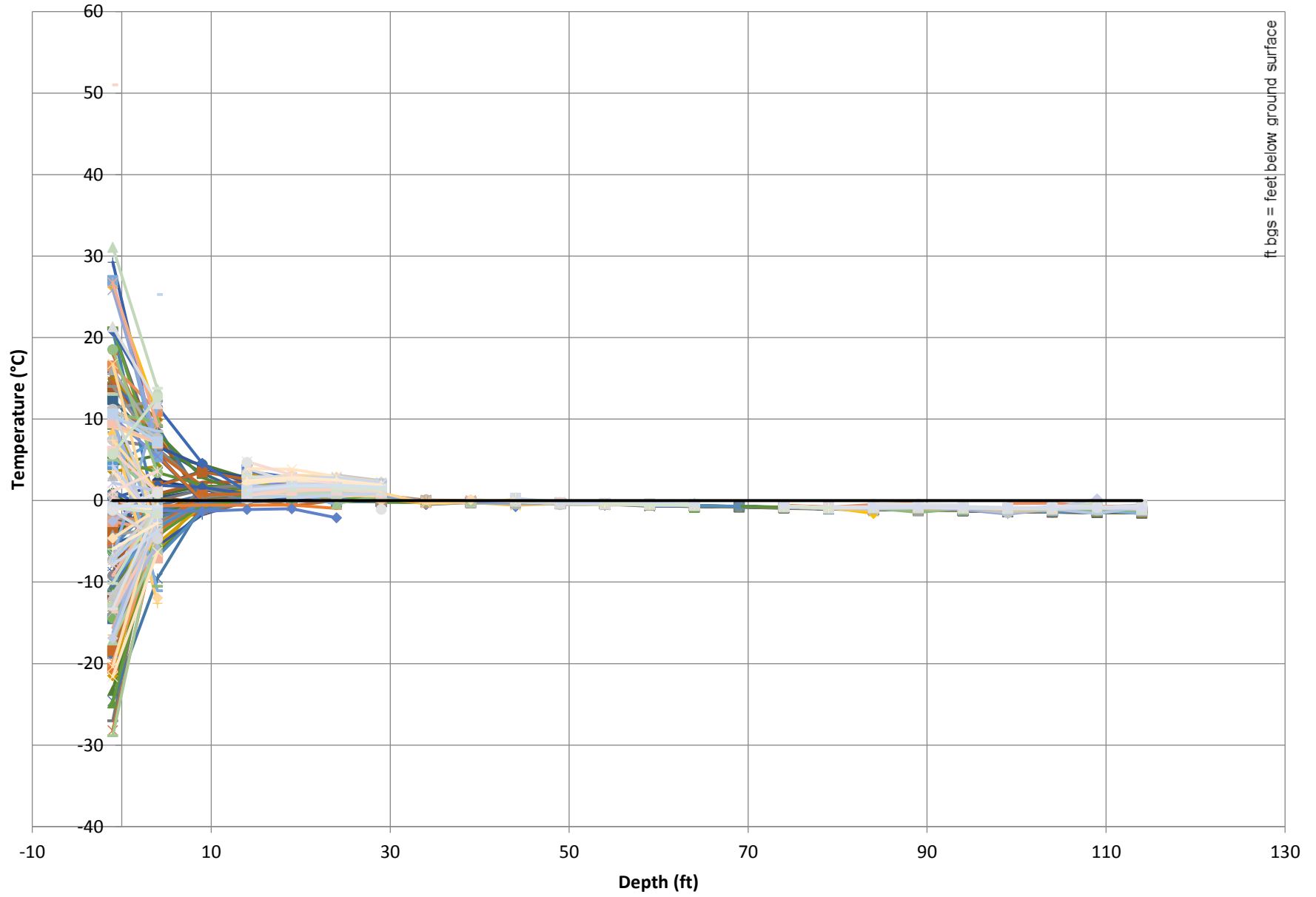
ft bgs = feet below ground surface



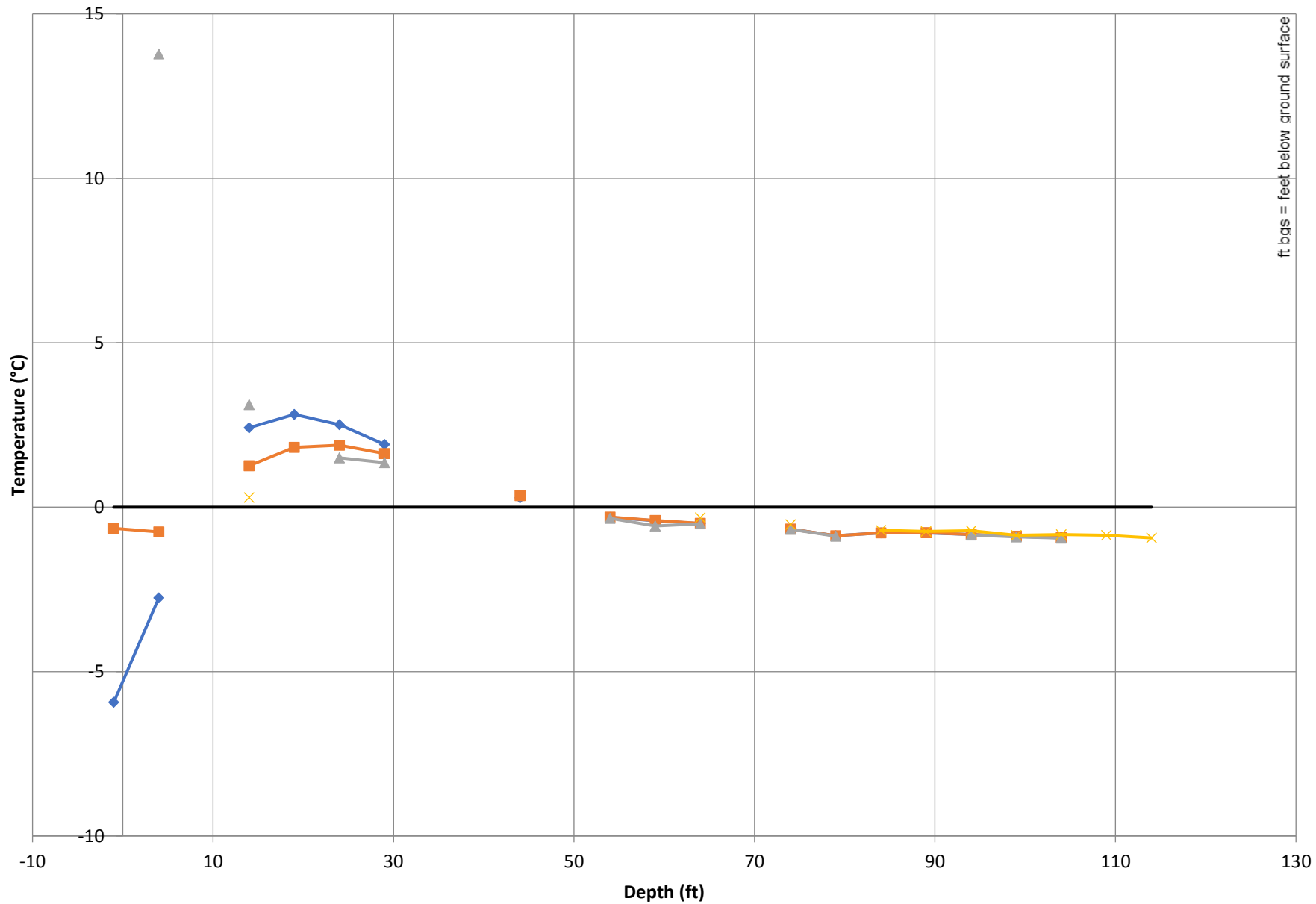
T-96-21, Mean Annual Ground Temperature (2019)

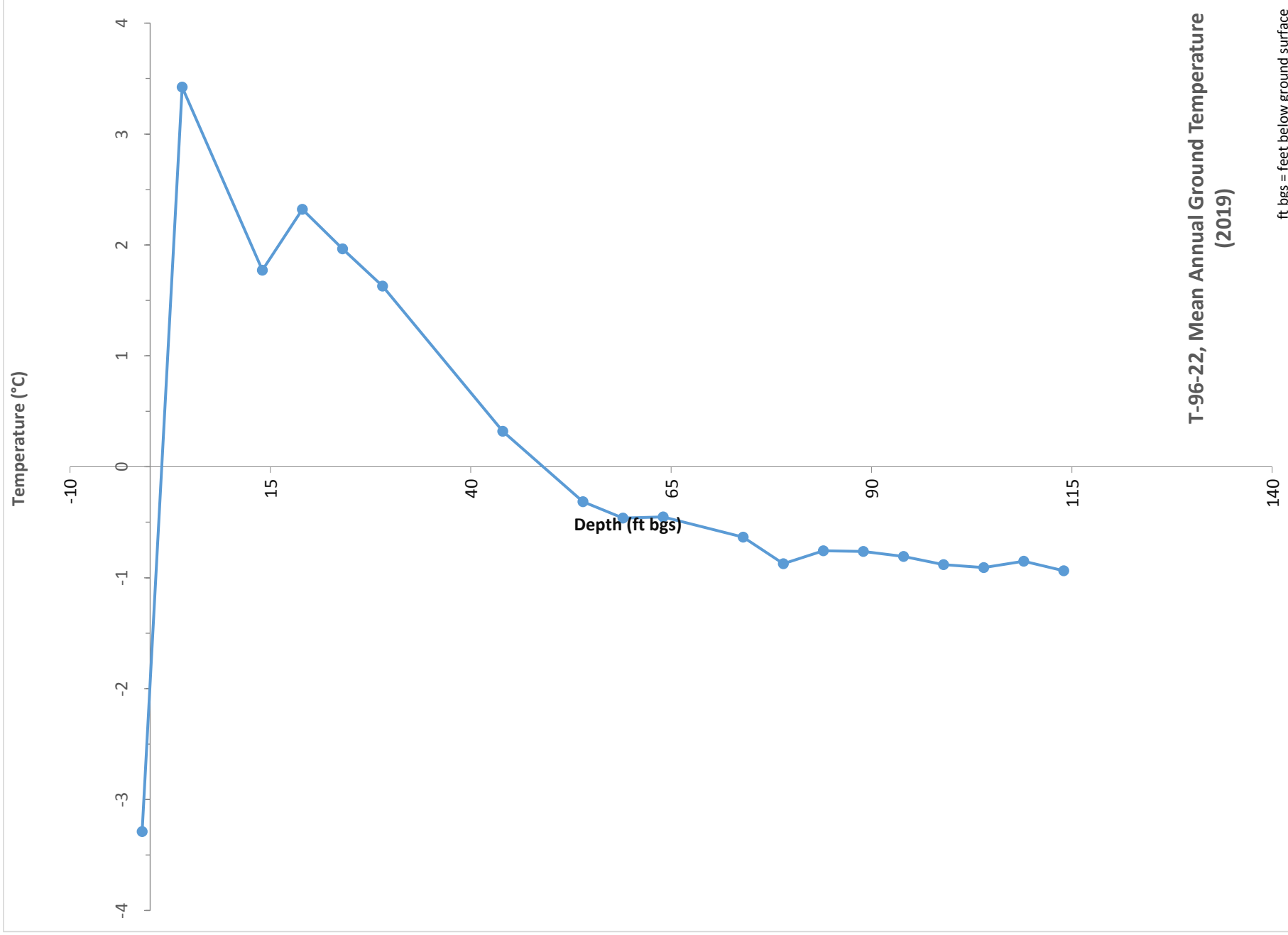
ft. bgs = feet below ground surface

Temperature Depth Plot for T-96-022



Temperature Depth Plot for T-96-022, 2019

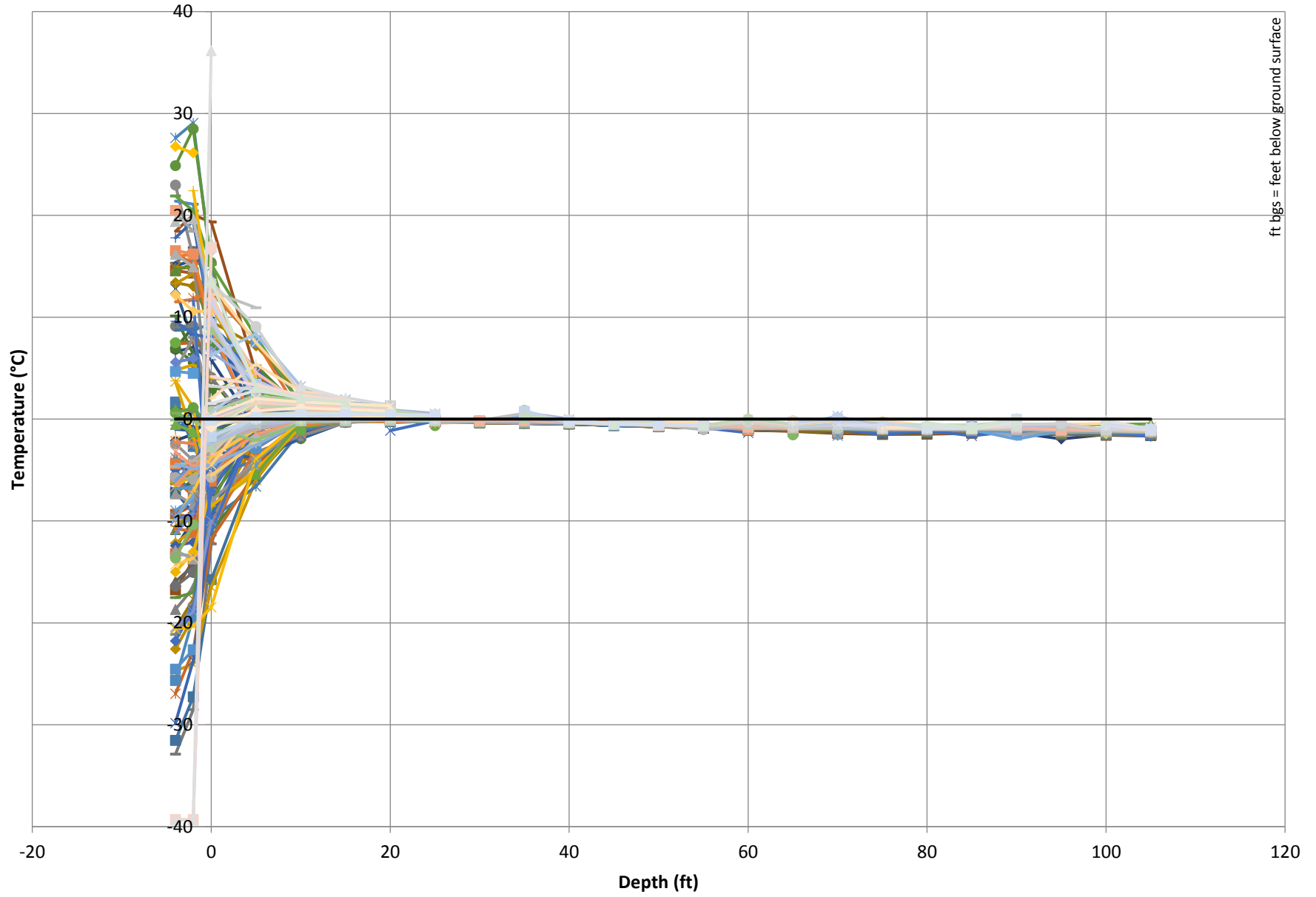




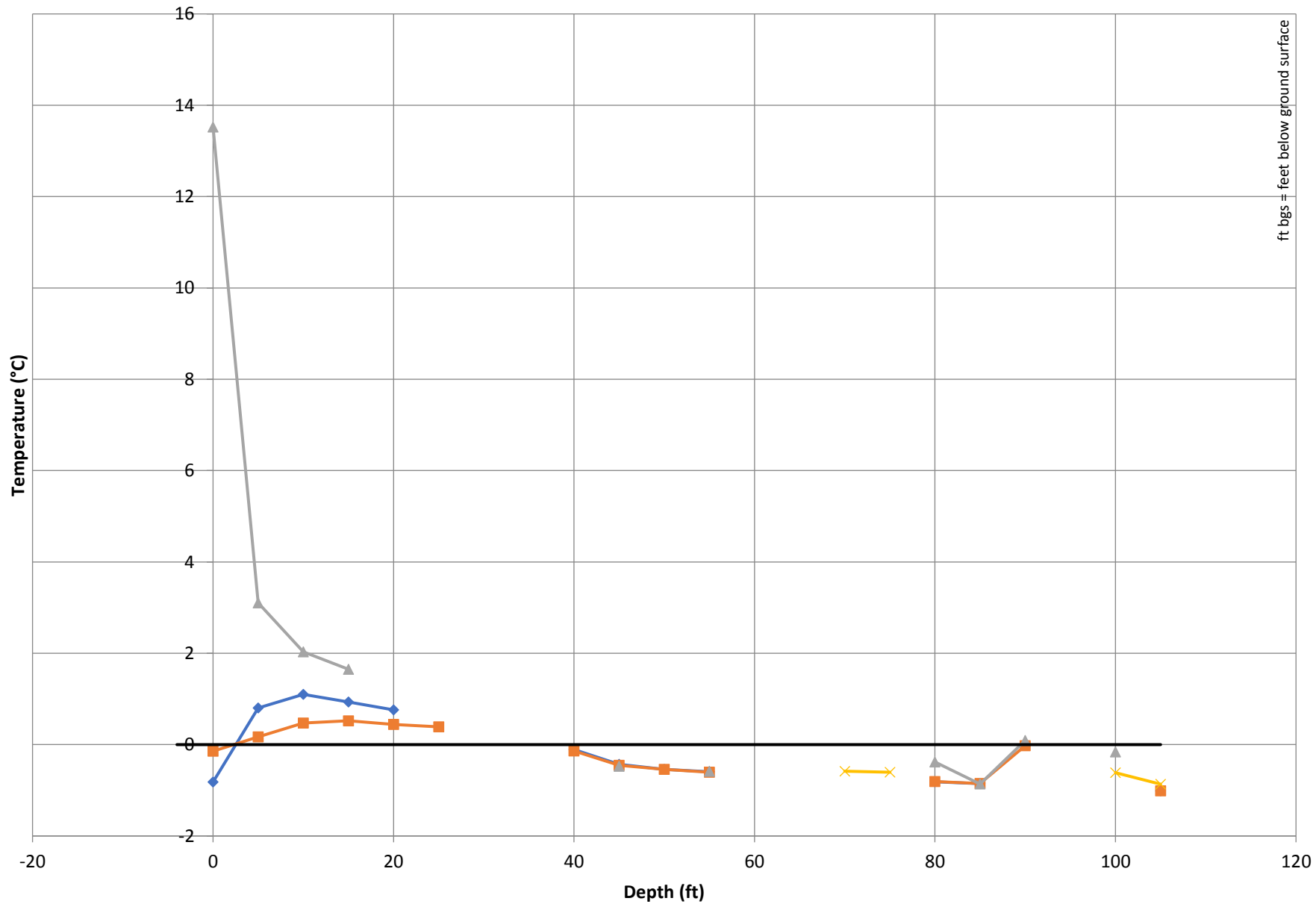
T-96-22, Mean Annual Ground Temperature (2019)

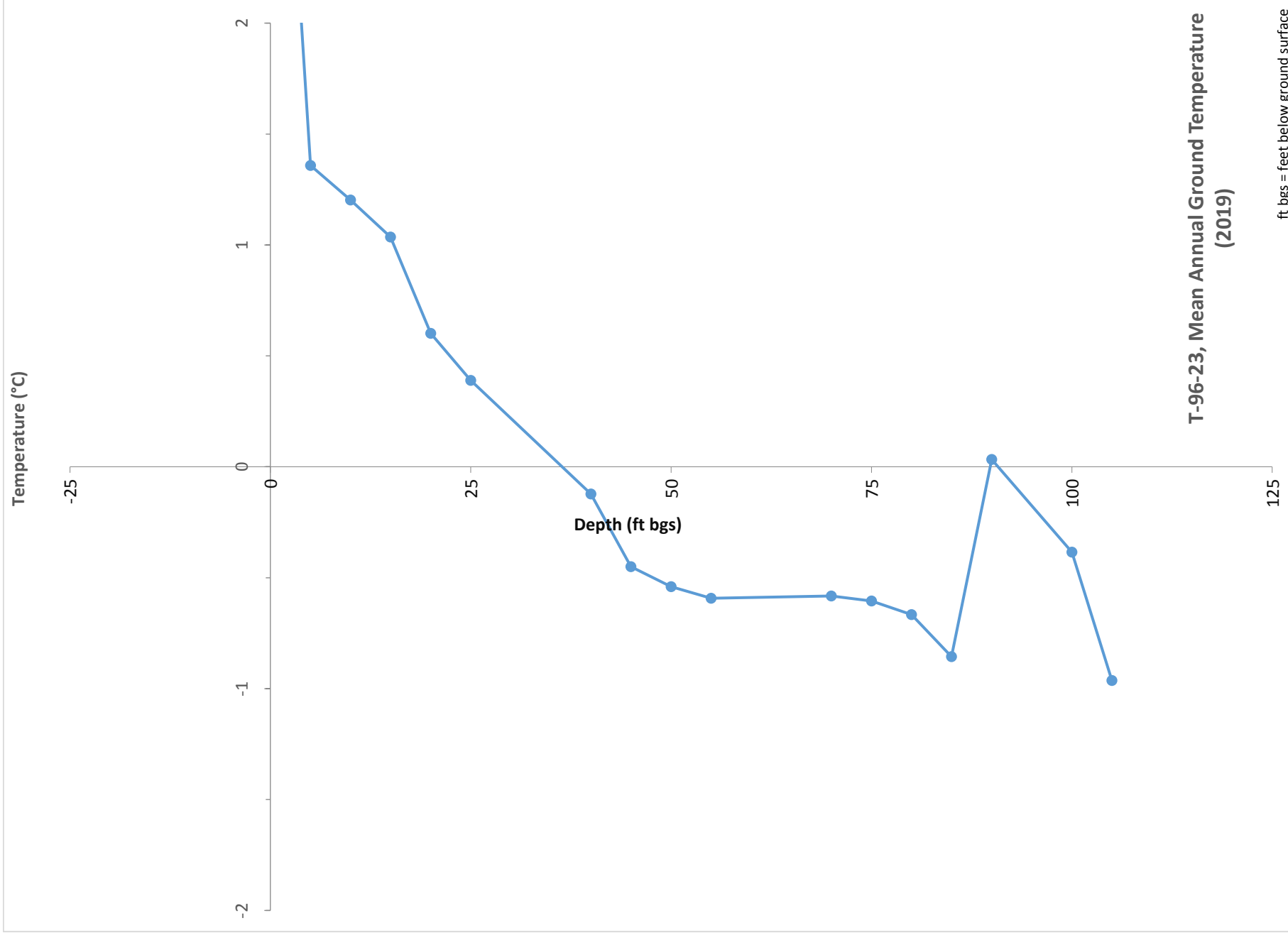
ft. bgs = feet below ground surface

Temperature Depth Plot for T-96-023



Temperature Depth Plot for T-96-023, 2019

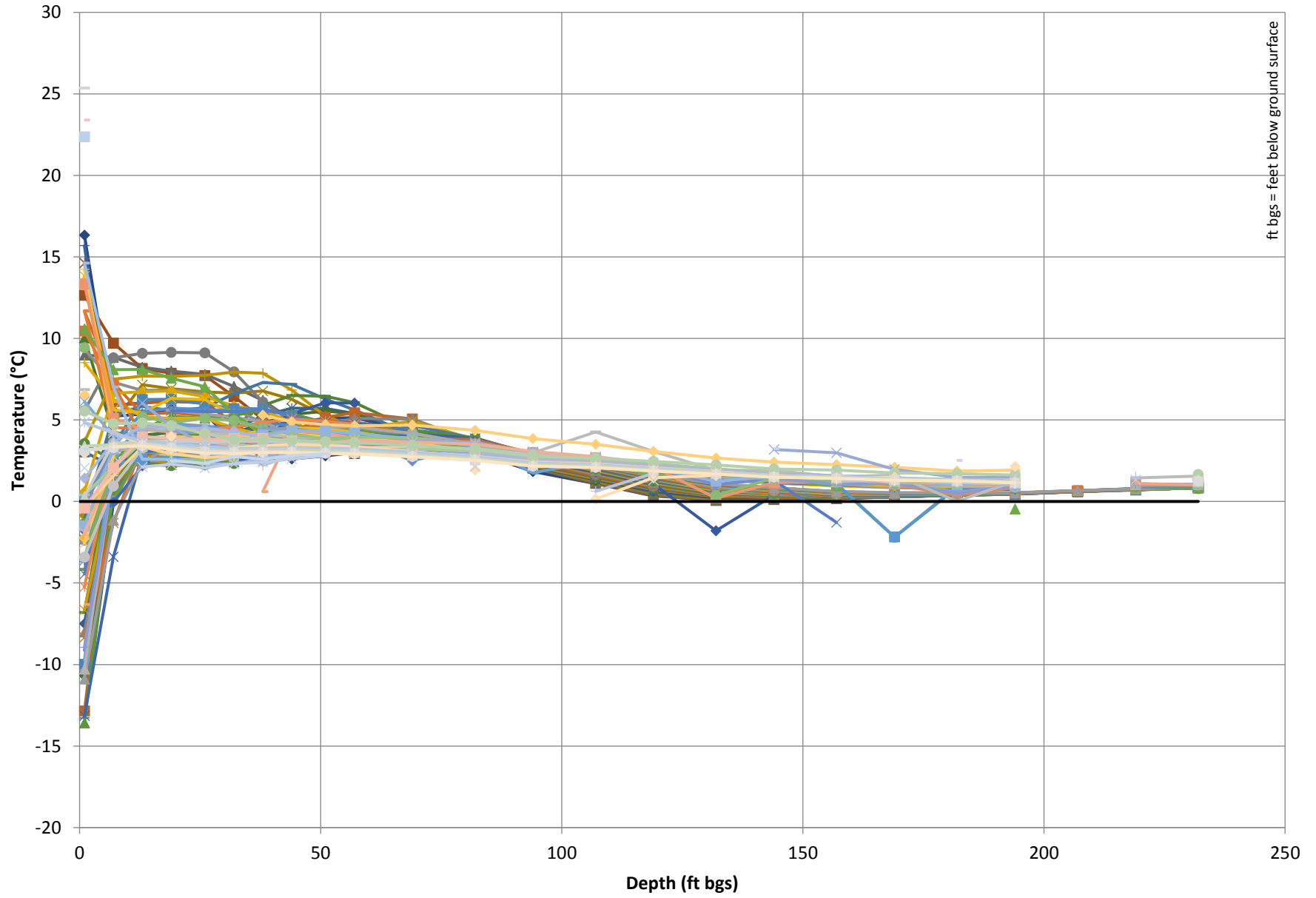




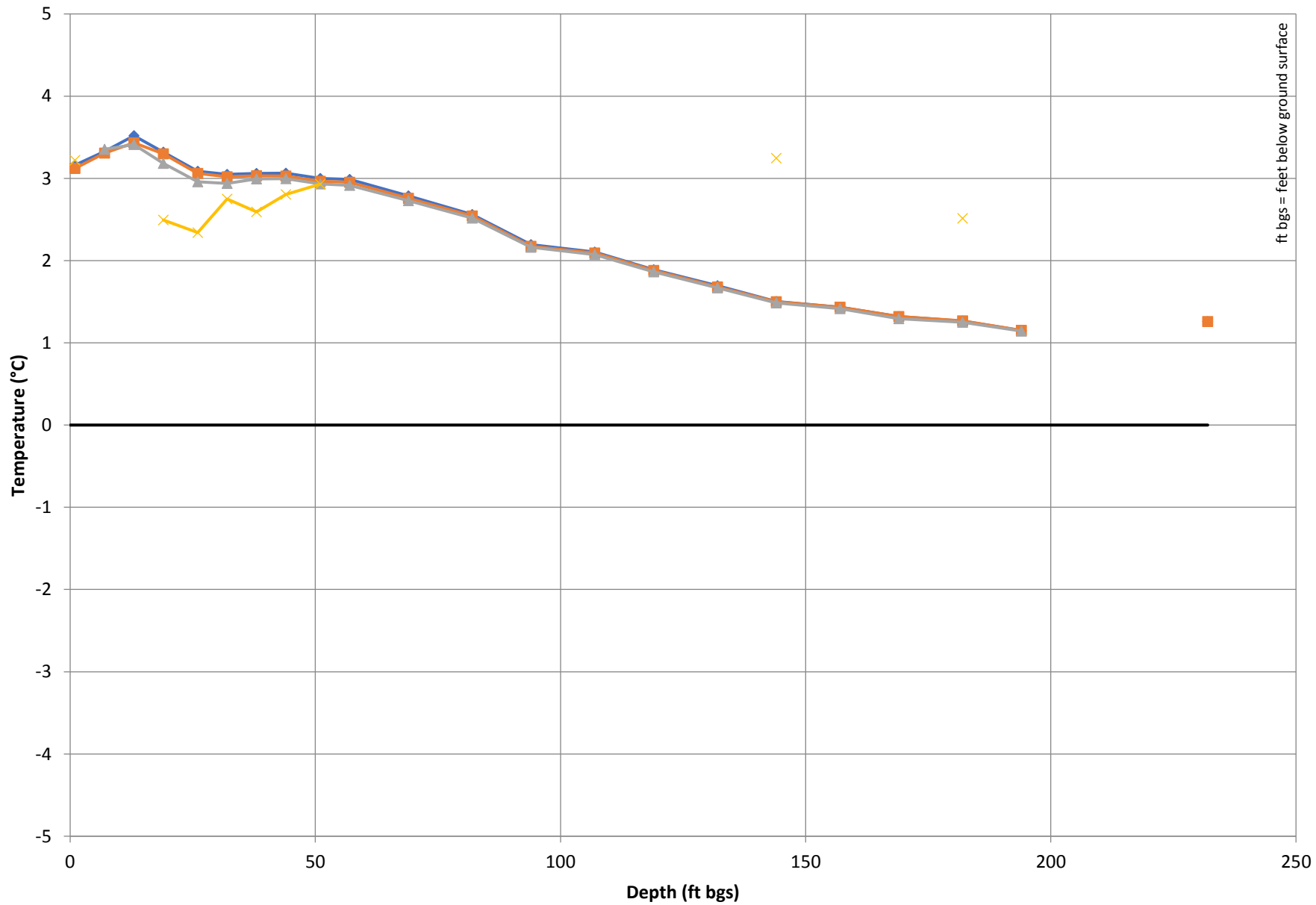
T-96-23, Mean Annual Ground Temperature (2019)

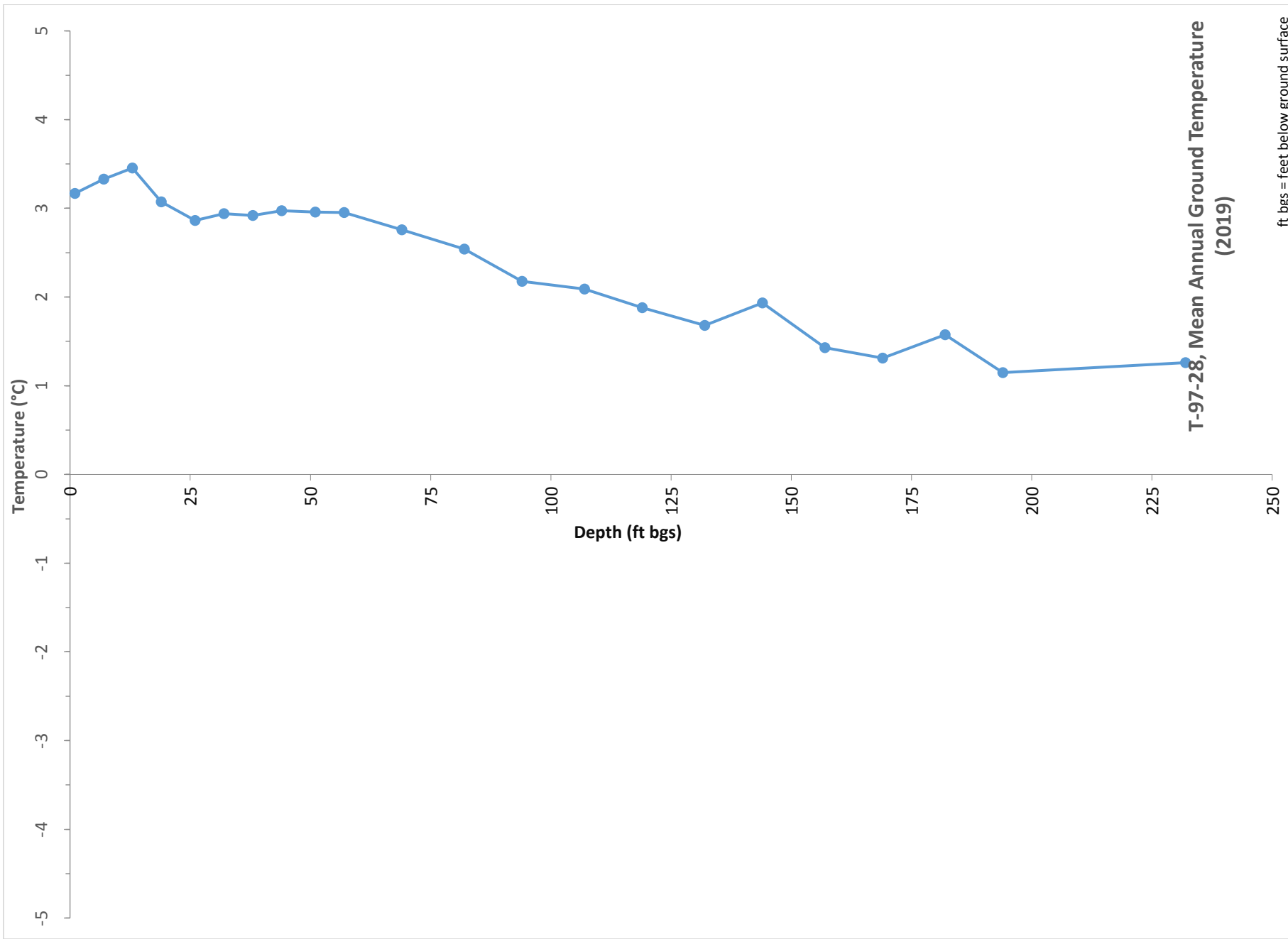
ft. bgs = feet below ground surface

Temperature Depth Plot for T-97-028



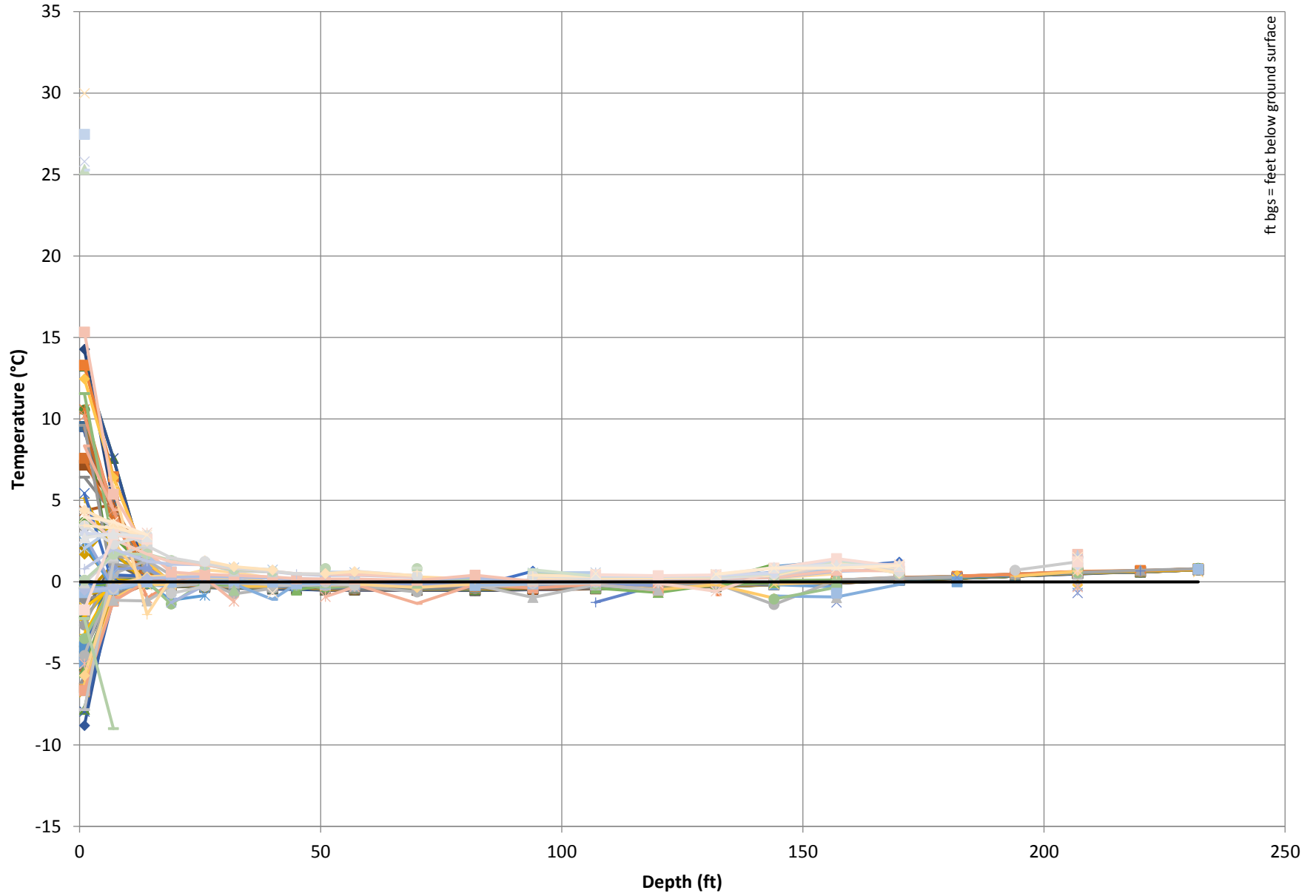
Temperature Depth Plot for T-97-028, 2019



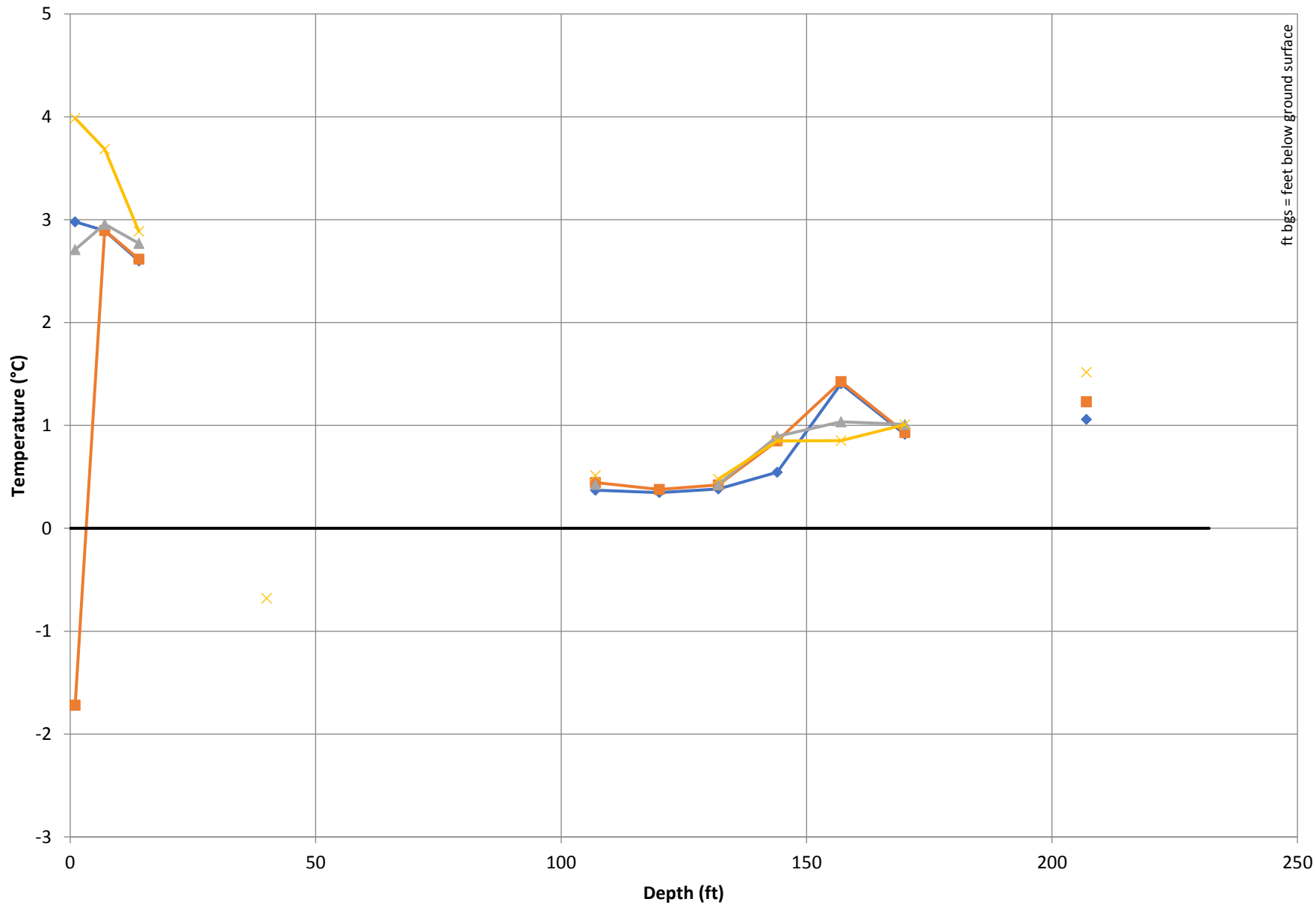


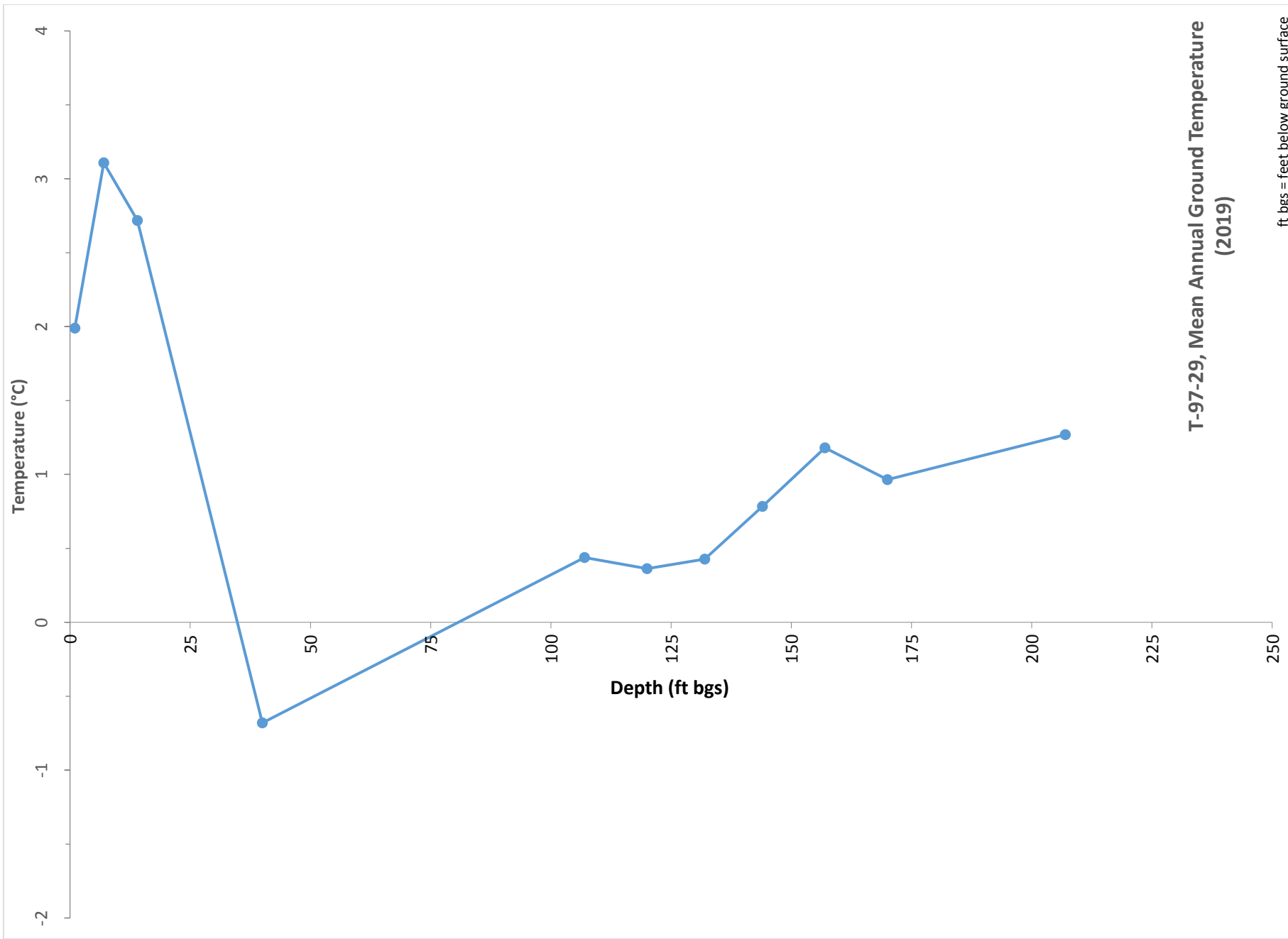
ft. bgs = feet below ground surface

Temperature Depth Plot for T-97-029



Temperature Depth Plot for T-97-029, 2019

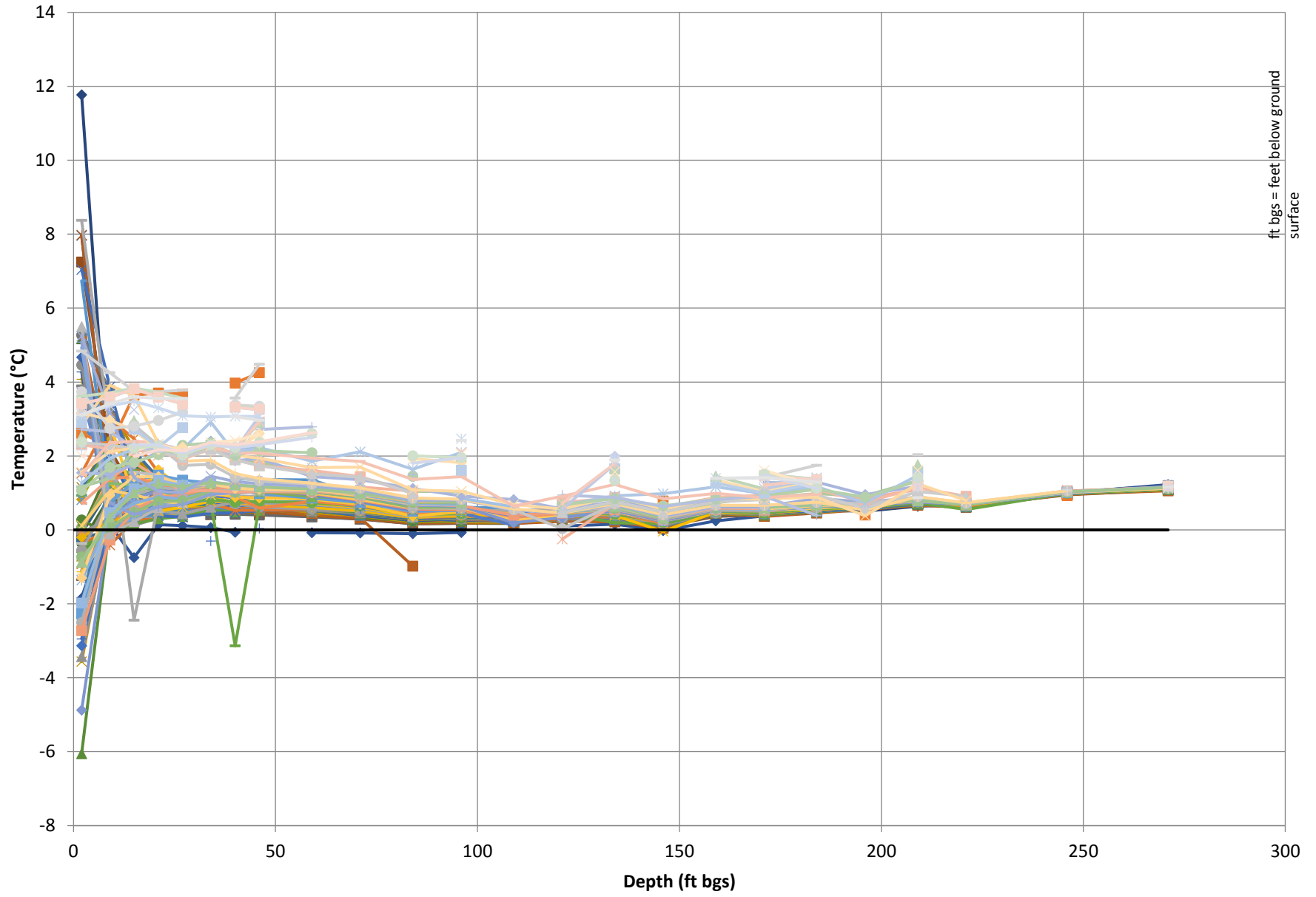




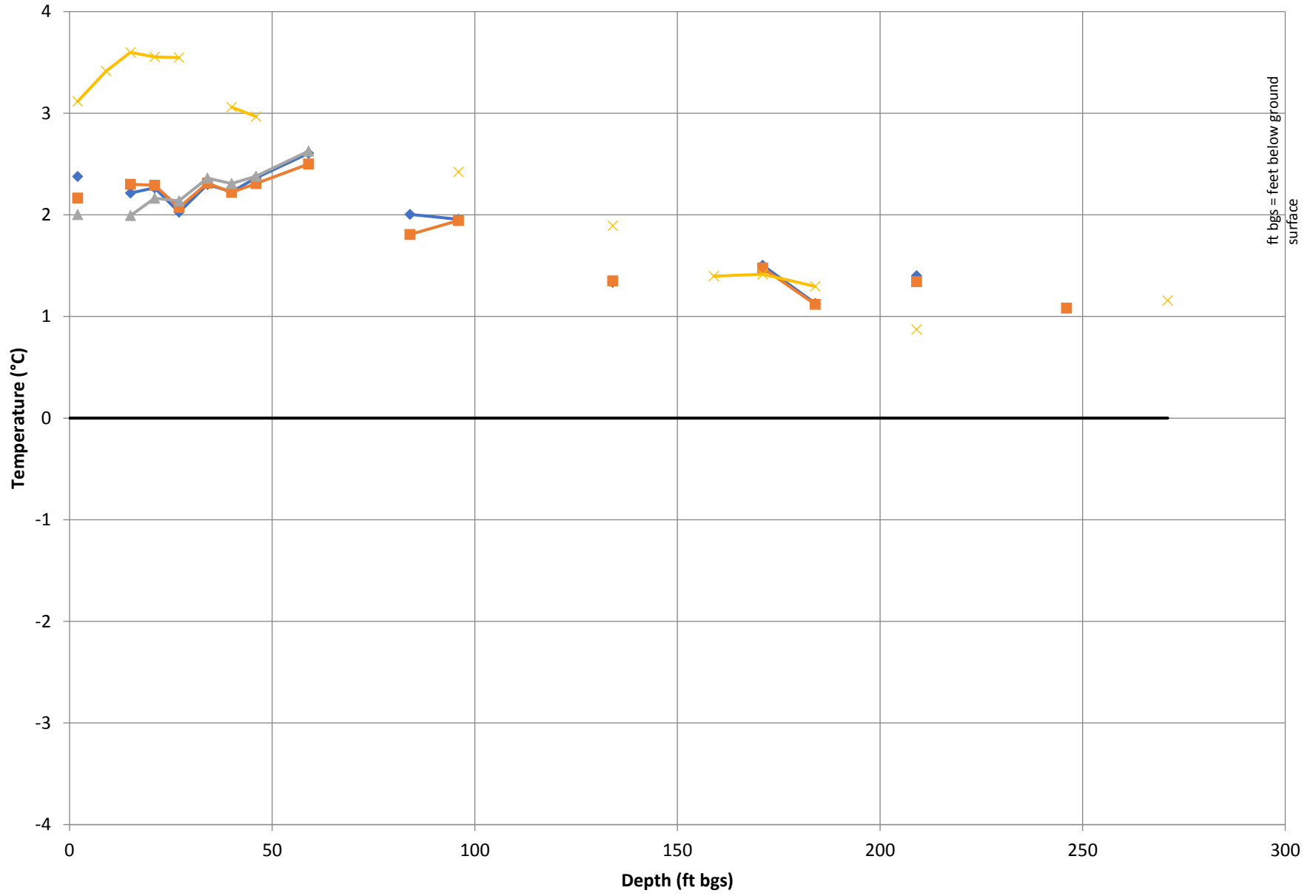
T-97-29, Mean Annual Ground Temperature (2019)

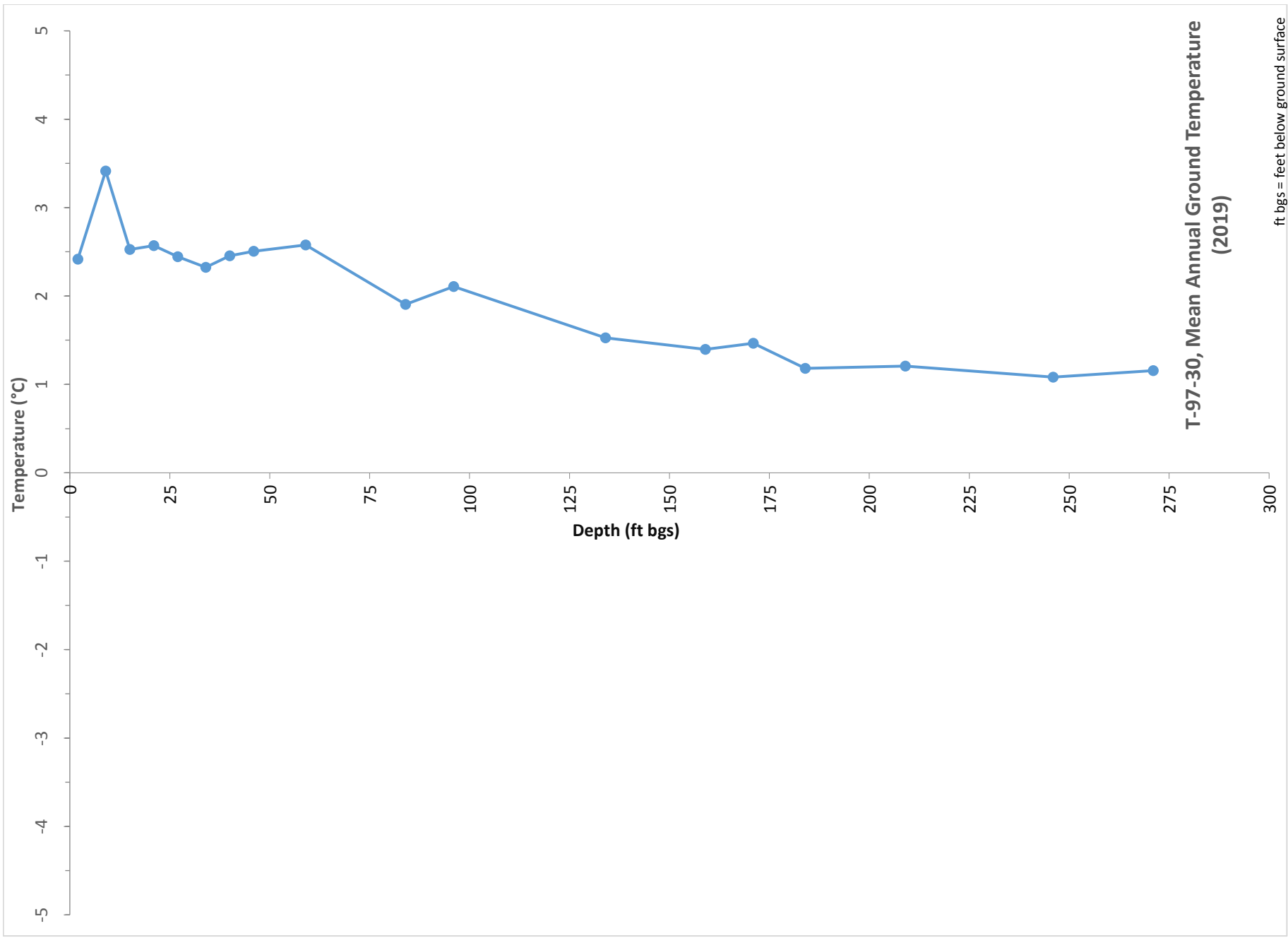
ft. bgs = feet below ground surface

Temperature Depth Plot for T-97-030



Temperature Depth Plot for T-97-030, 2019



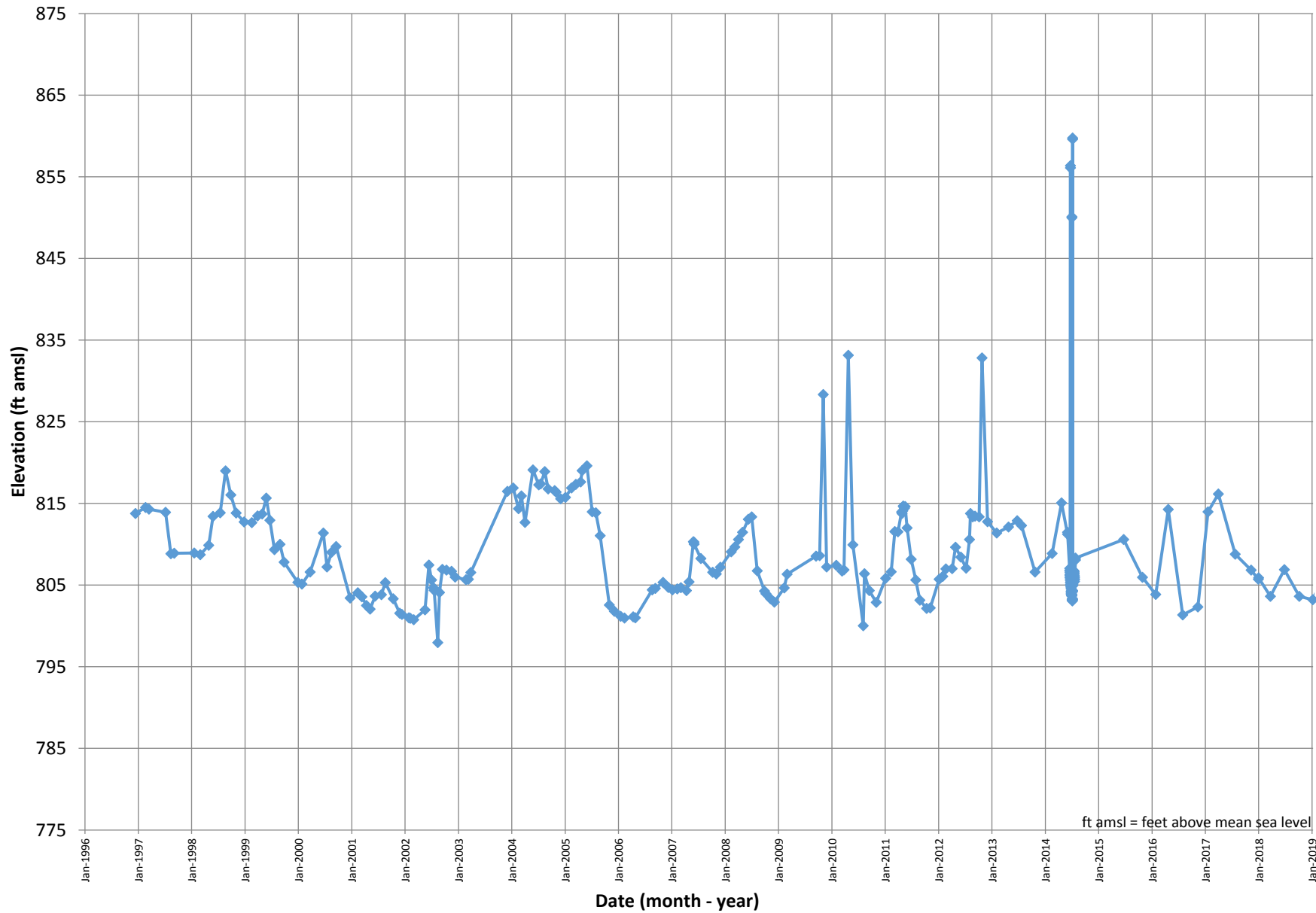


T-97-30, Mean Annual Ground Temperature (2019)

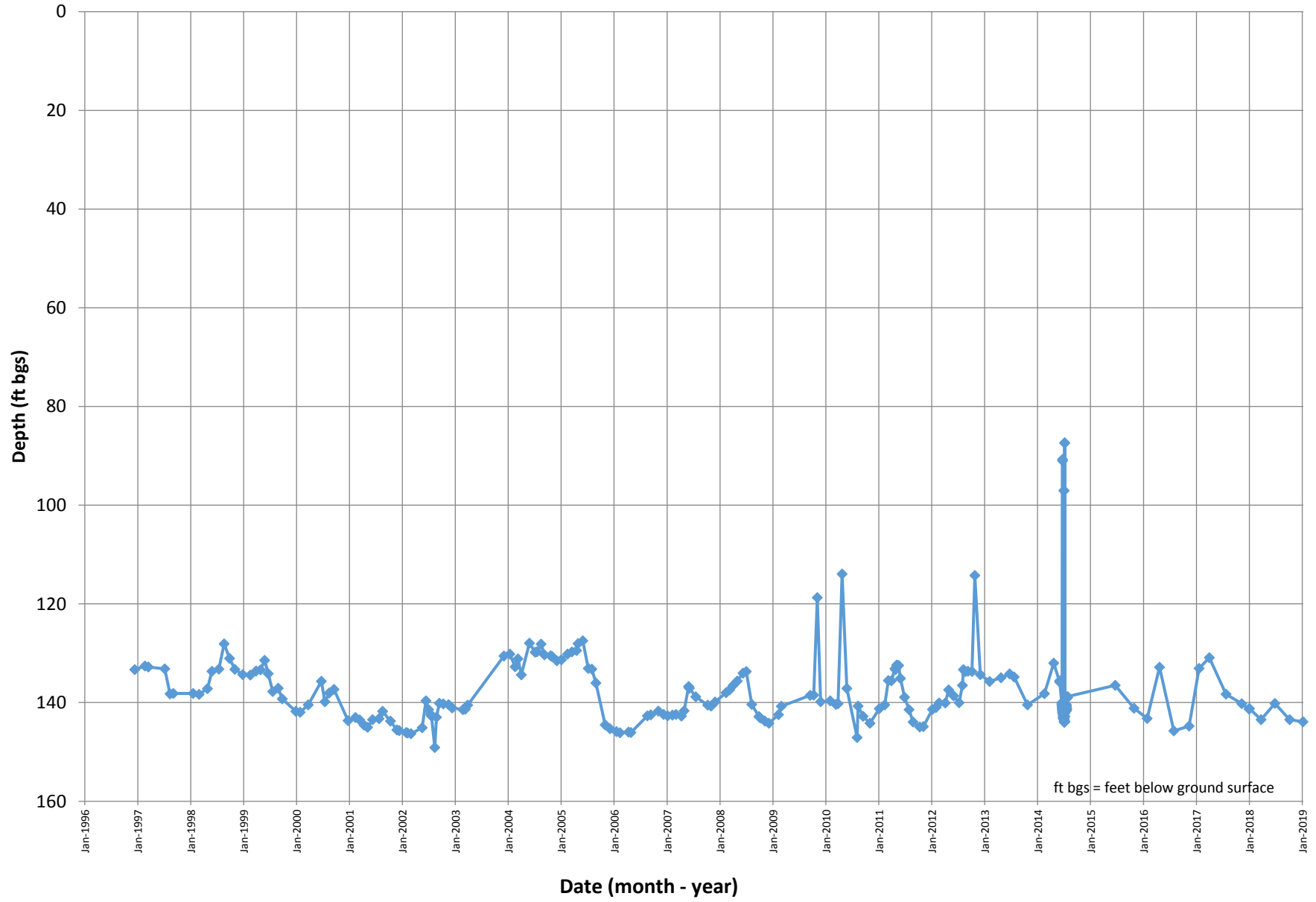
ft bgs = feet below ground surface

Appendix C Piezometer Plots

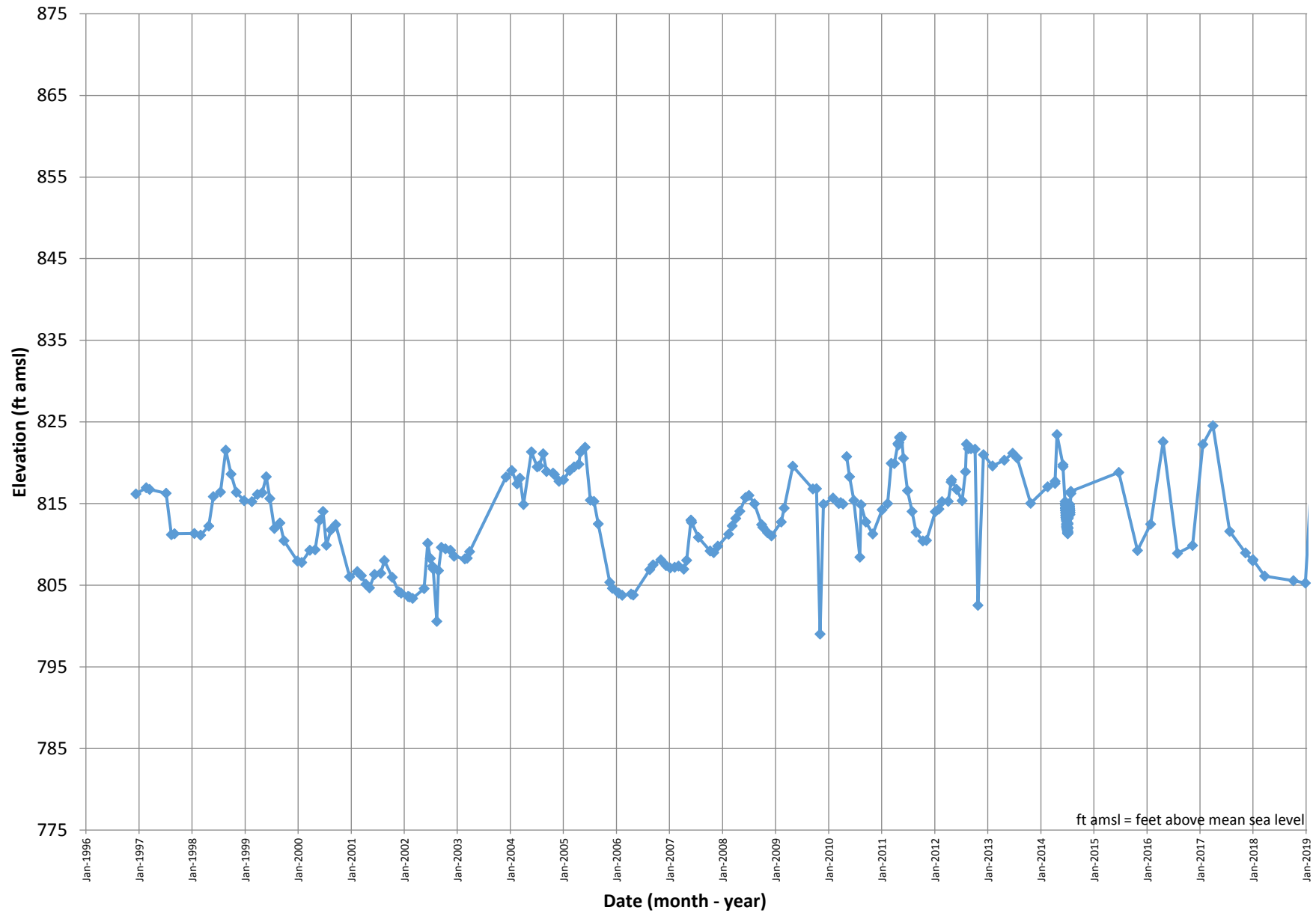
Elevation Hydrograph for P-08A



Depth Hydrograph for P-08A

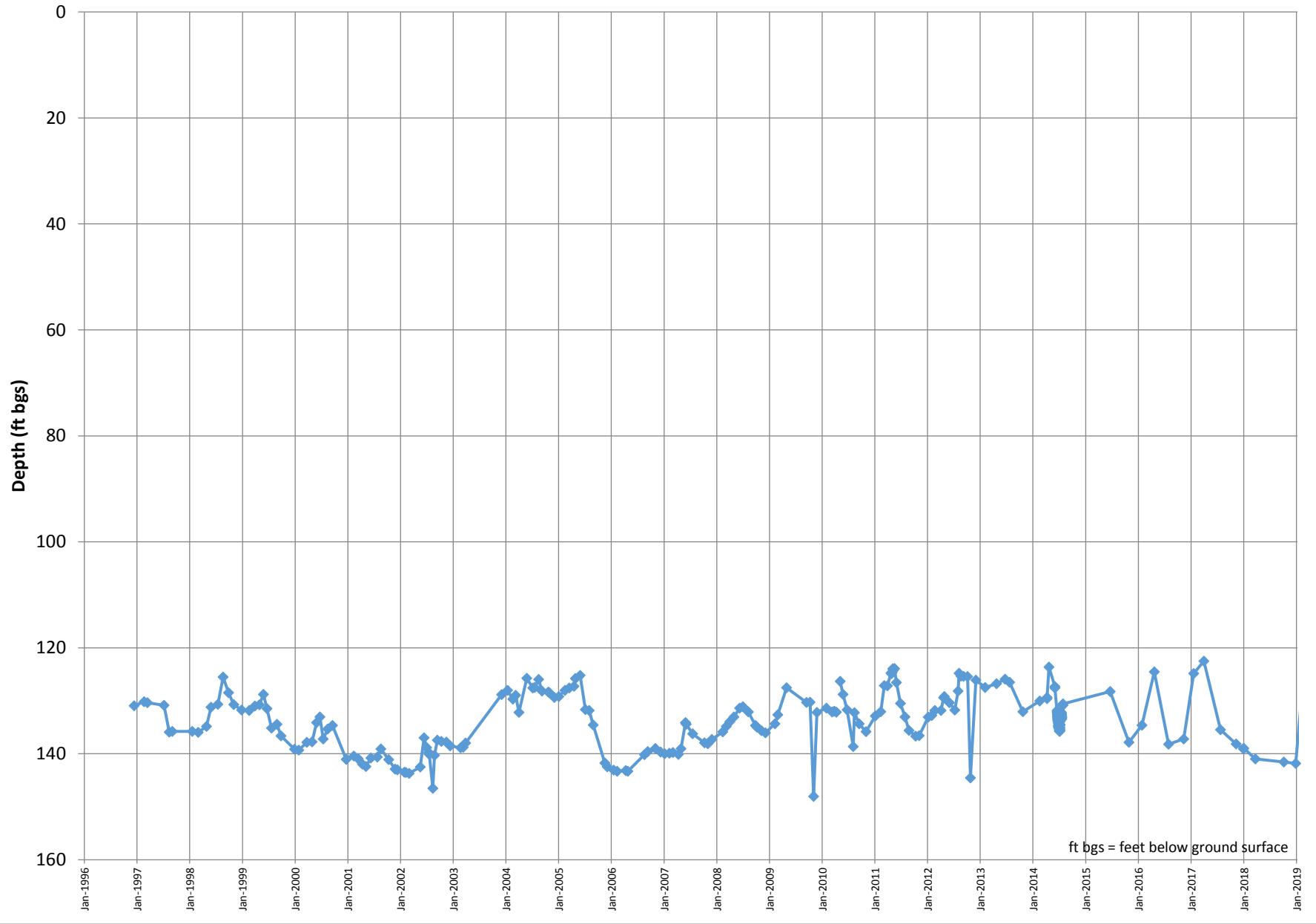


Elevation Hydrograph for P-08B

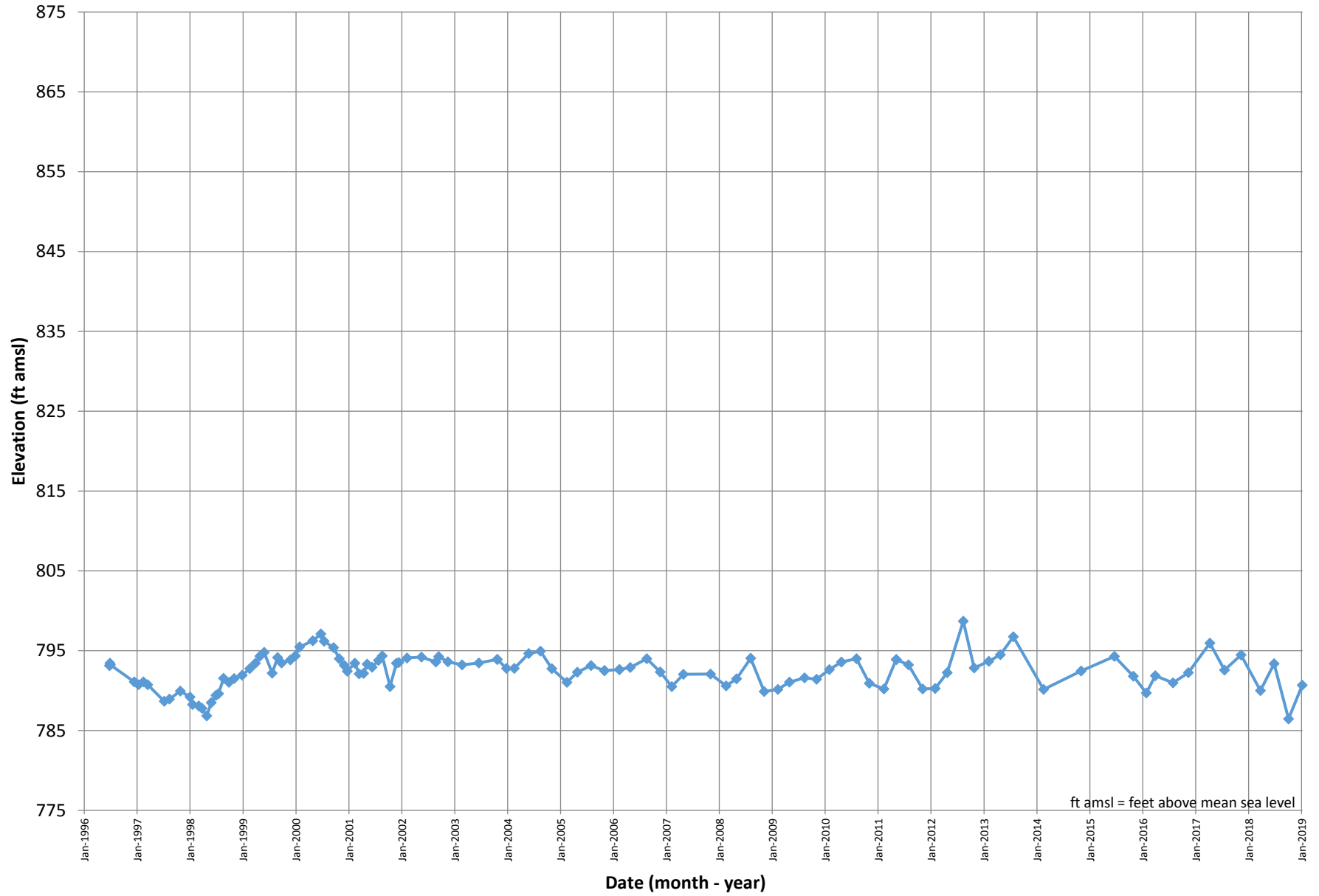


ft amsl = feet above mean sea level

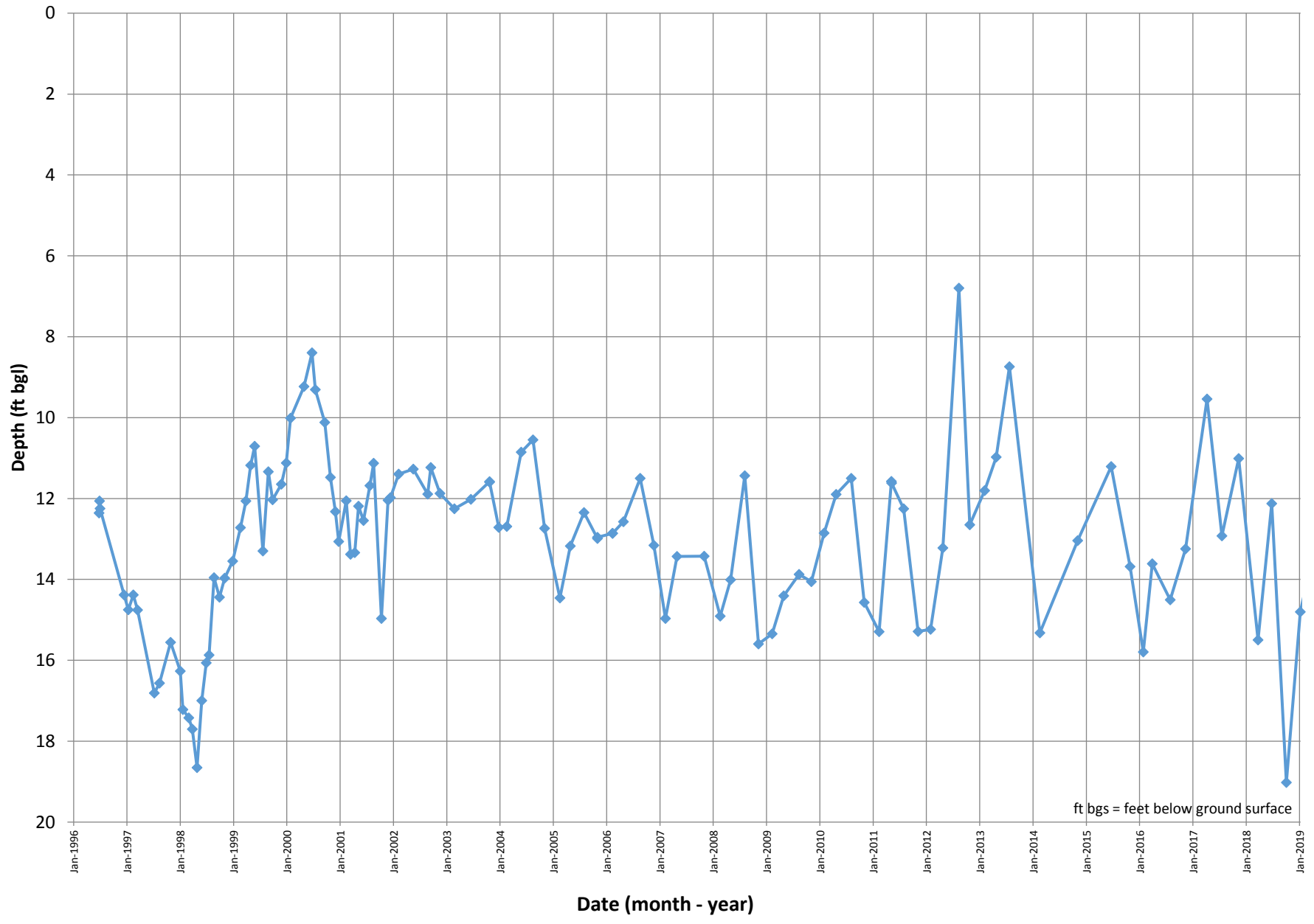
Depth Hydrograph for P-08B



Elevation Hydrograph for P-96-010

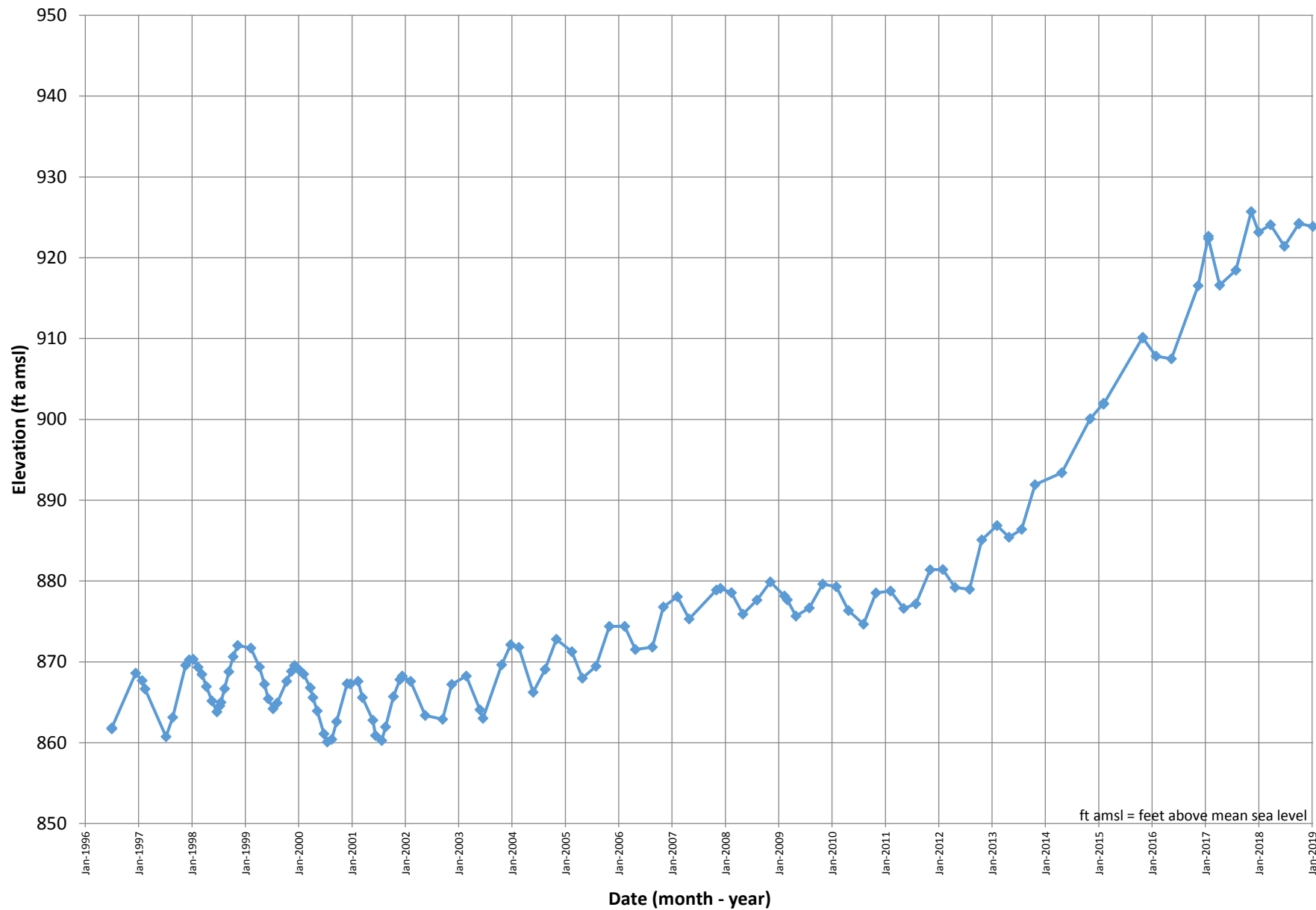


Depth Hydrograph for P-96-010

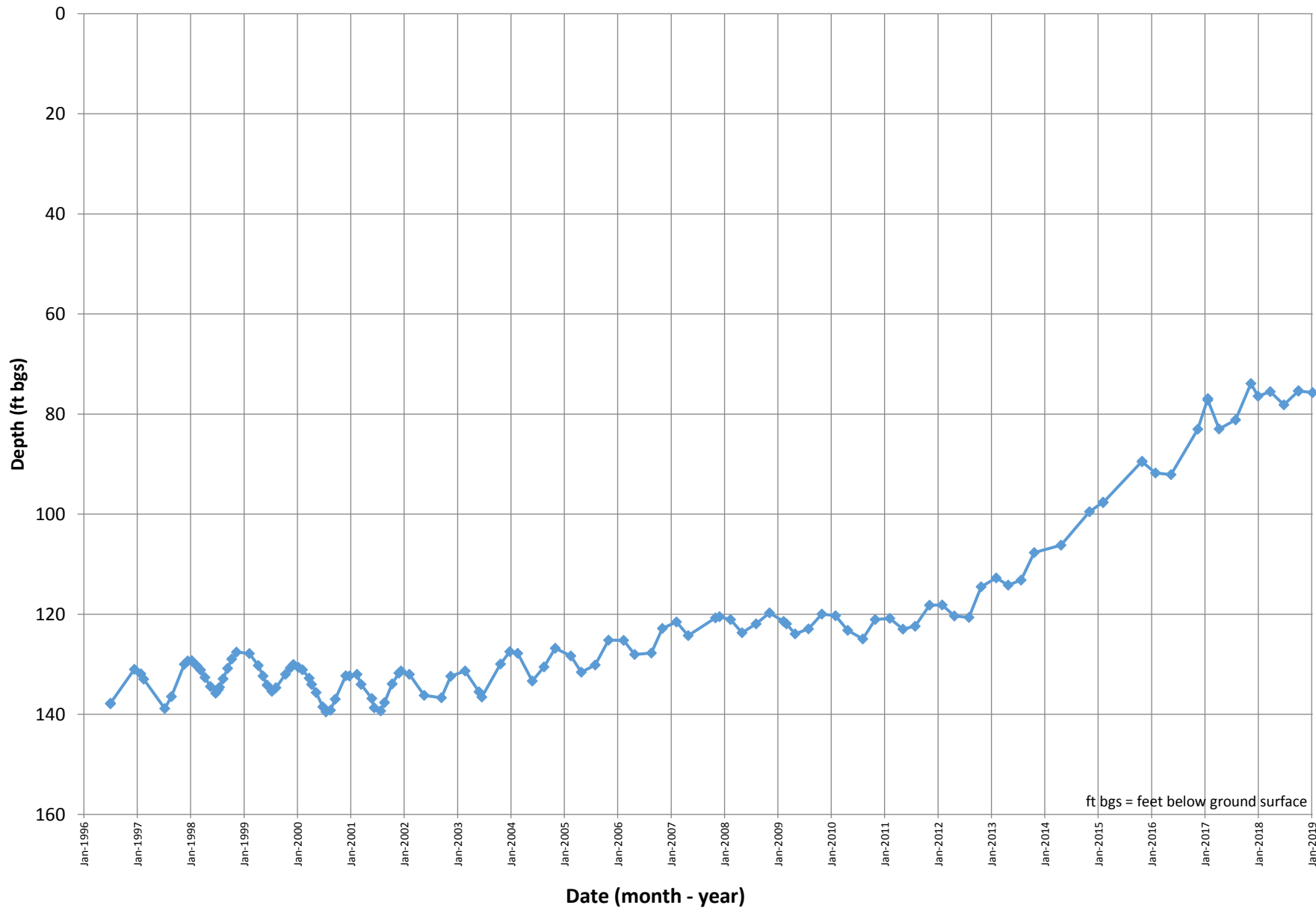


ft bgs = feet below ground surface

Elevation Hydrograph for P-96-013

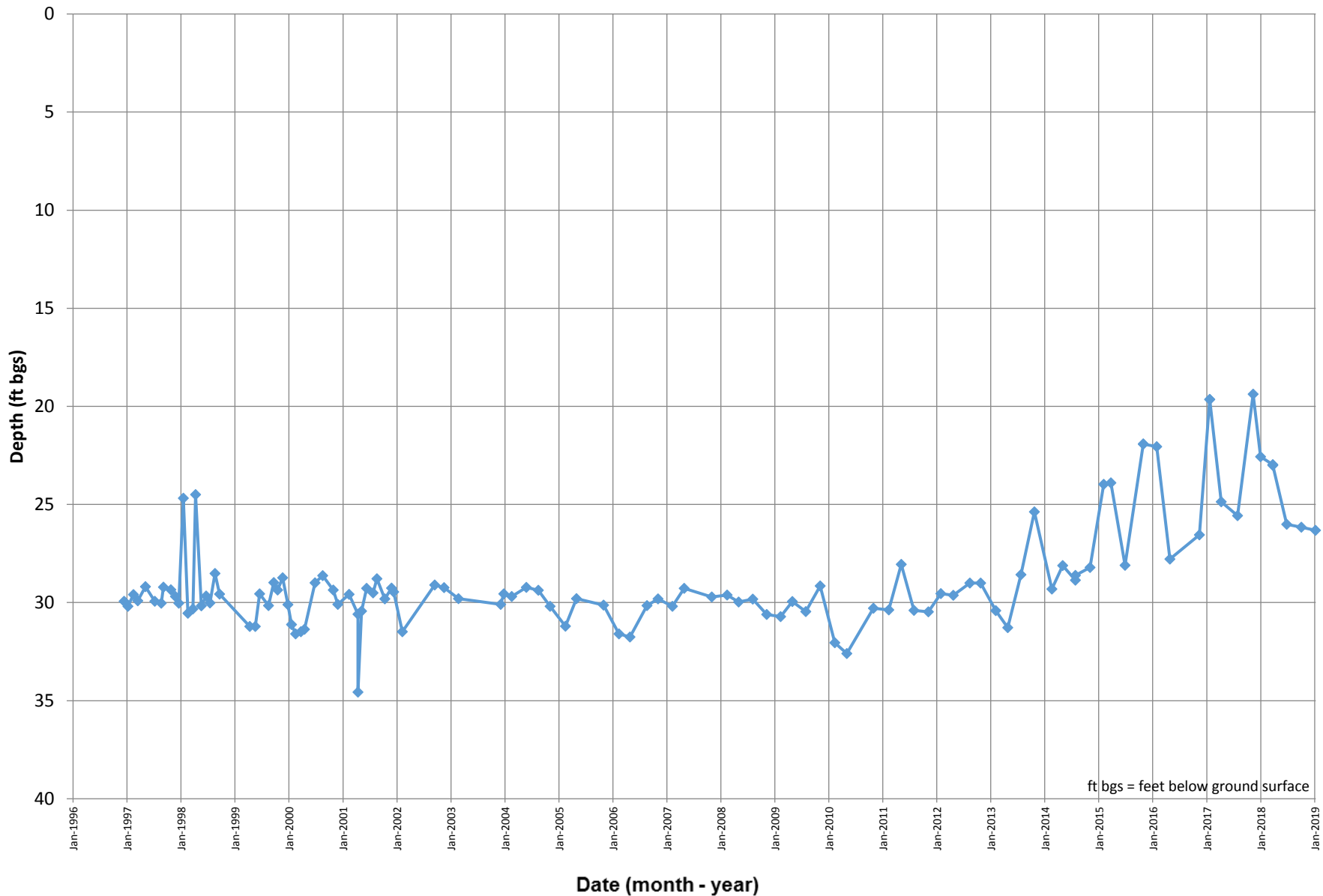


Depth Hydrograph for P-96-013

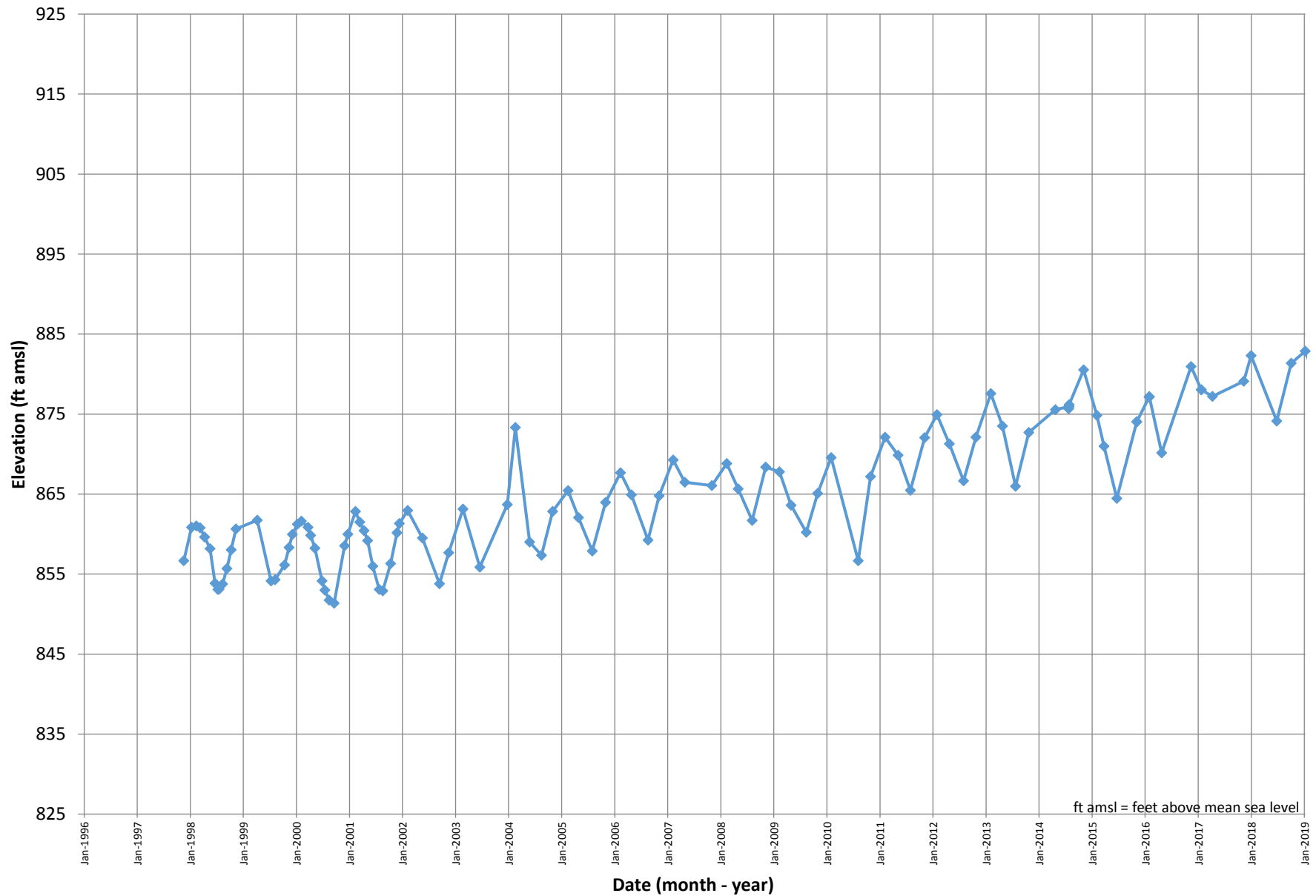


ft bgs = feet below ground surface

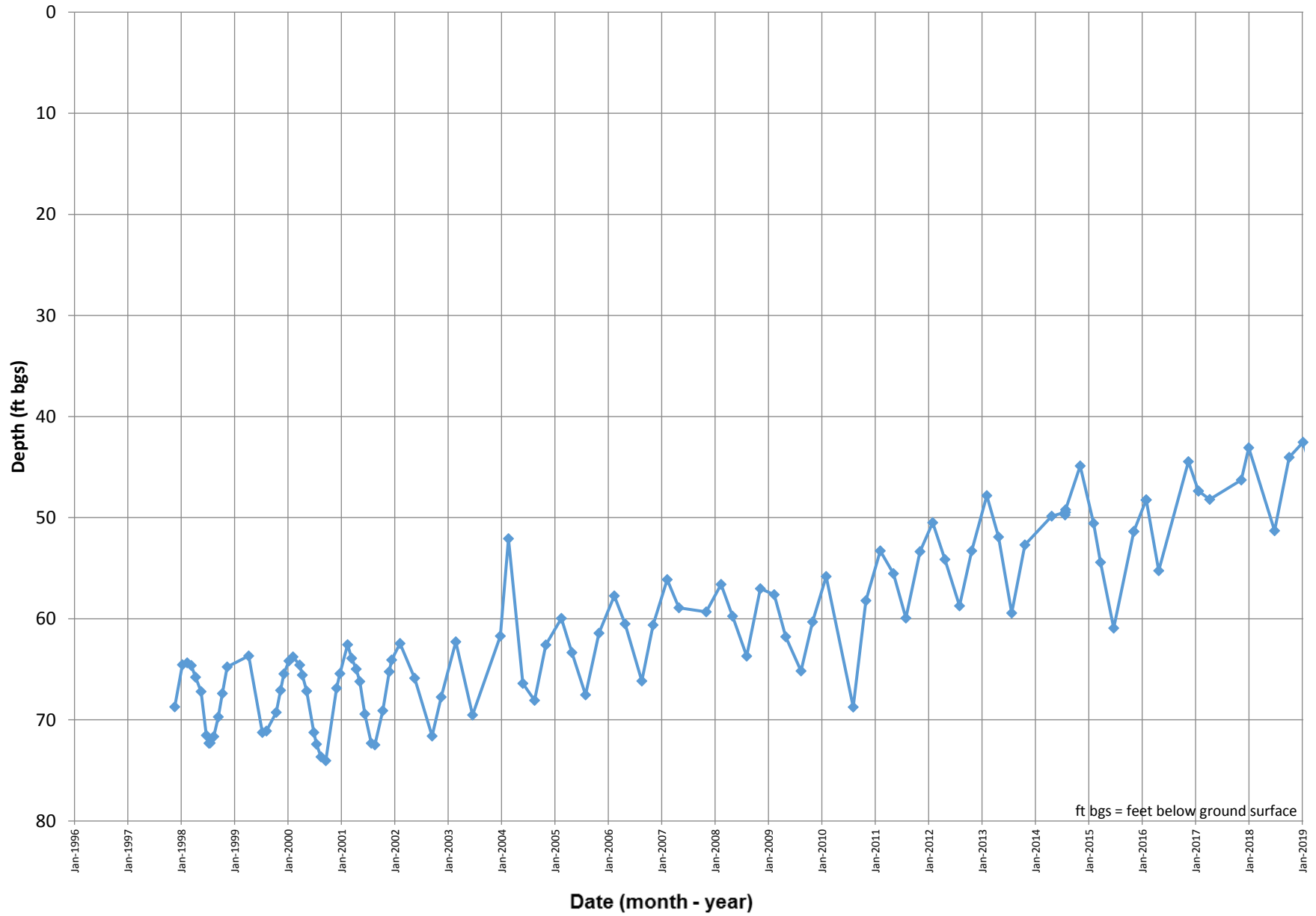
Depth Hydrograph for P-96-015



Elevation Hydrograph for P-97-012

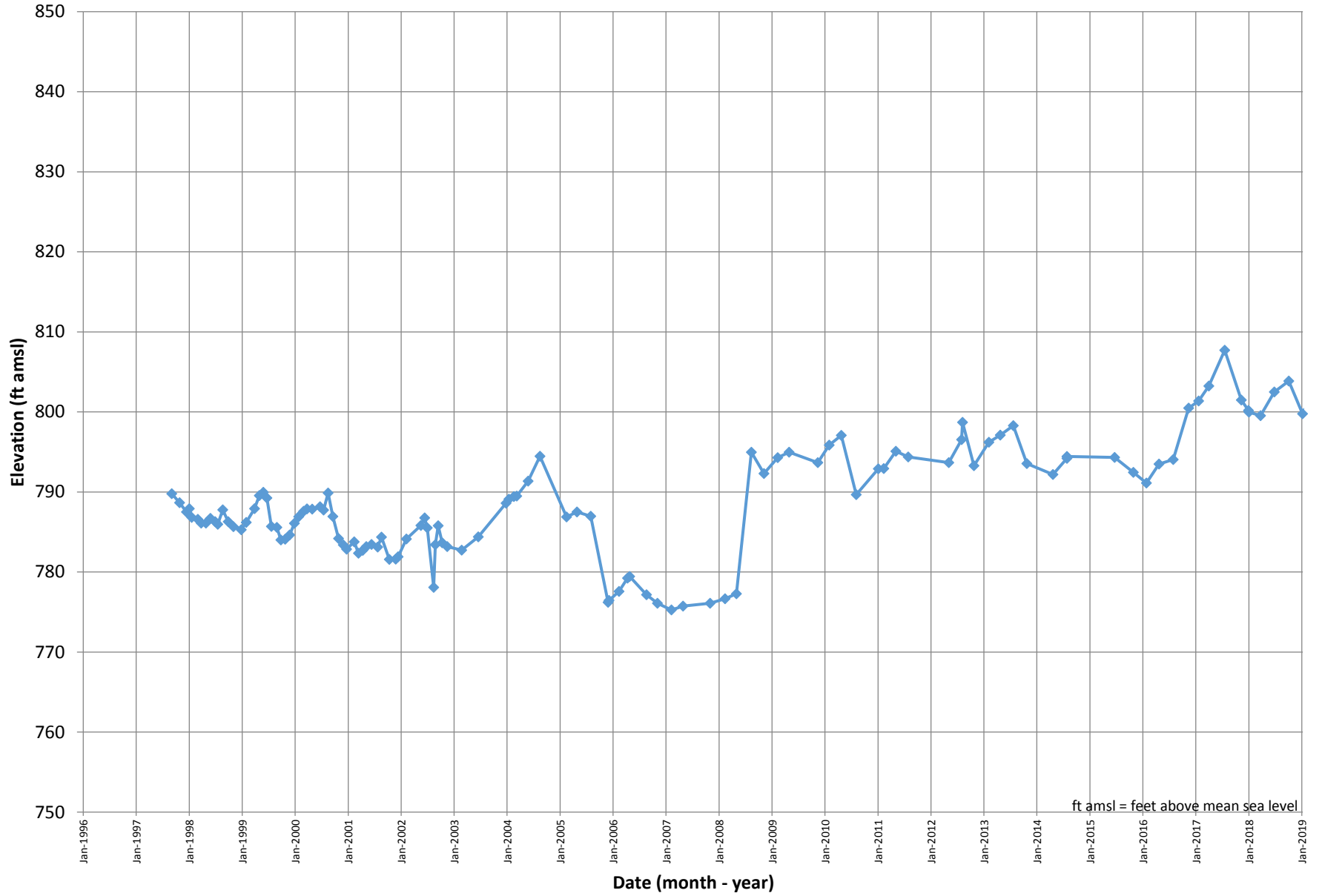


Depth Hydrograph for P-97-012

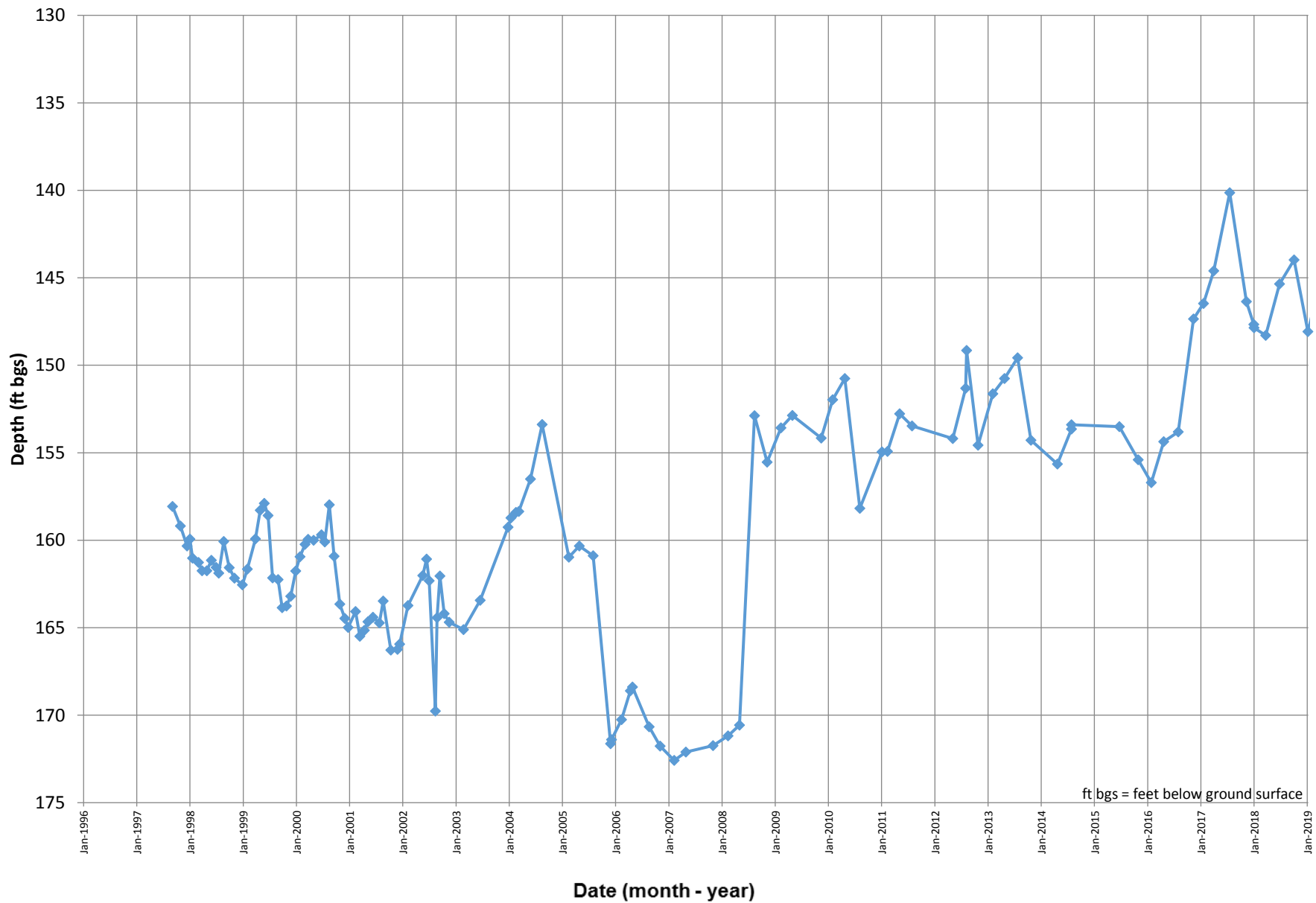


ft bgs = feet below ground surface

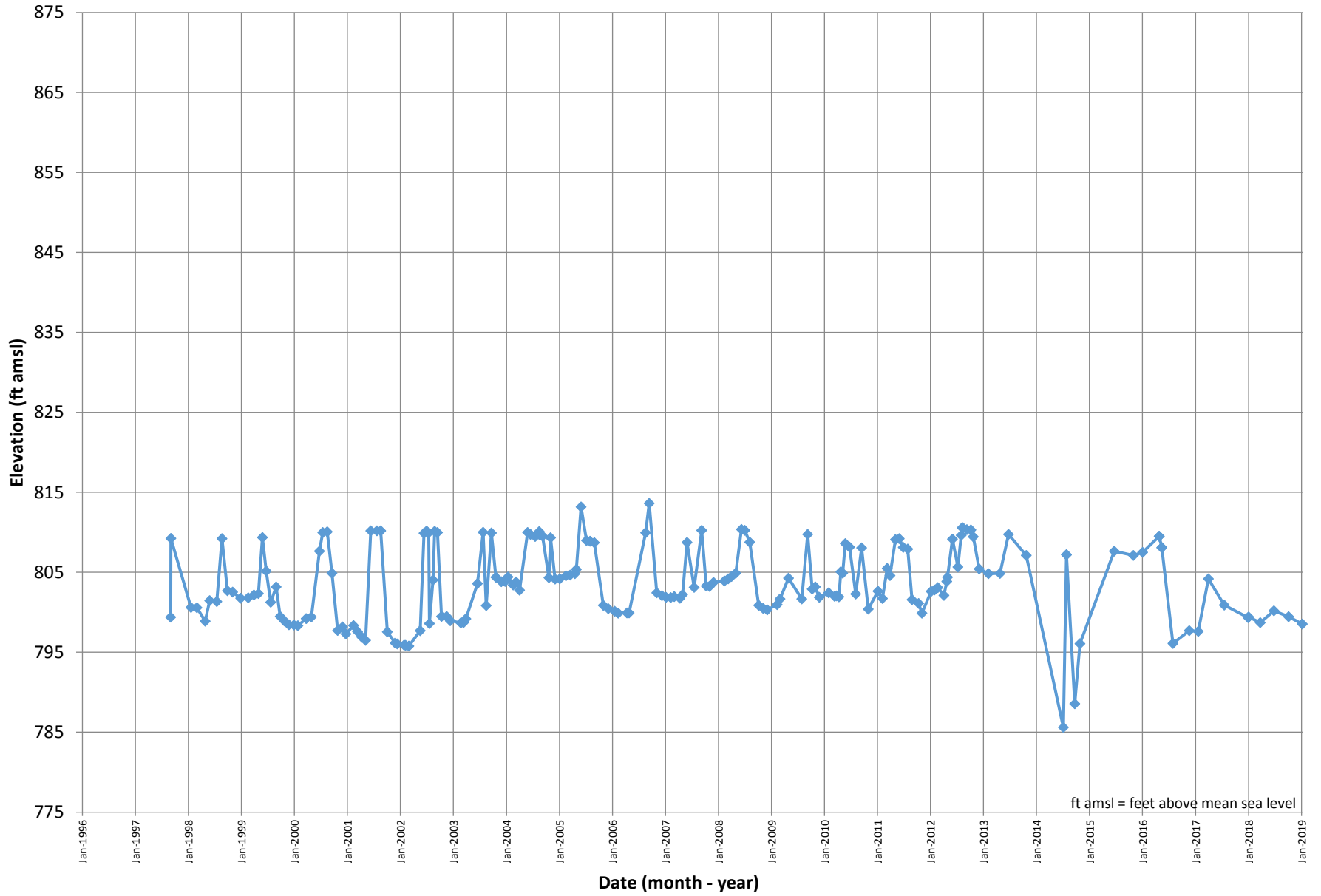
Elevation Hydrograph for P-97-020



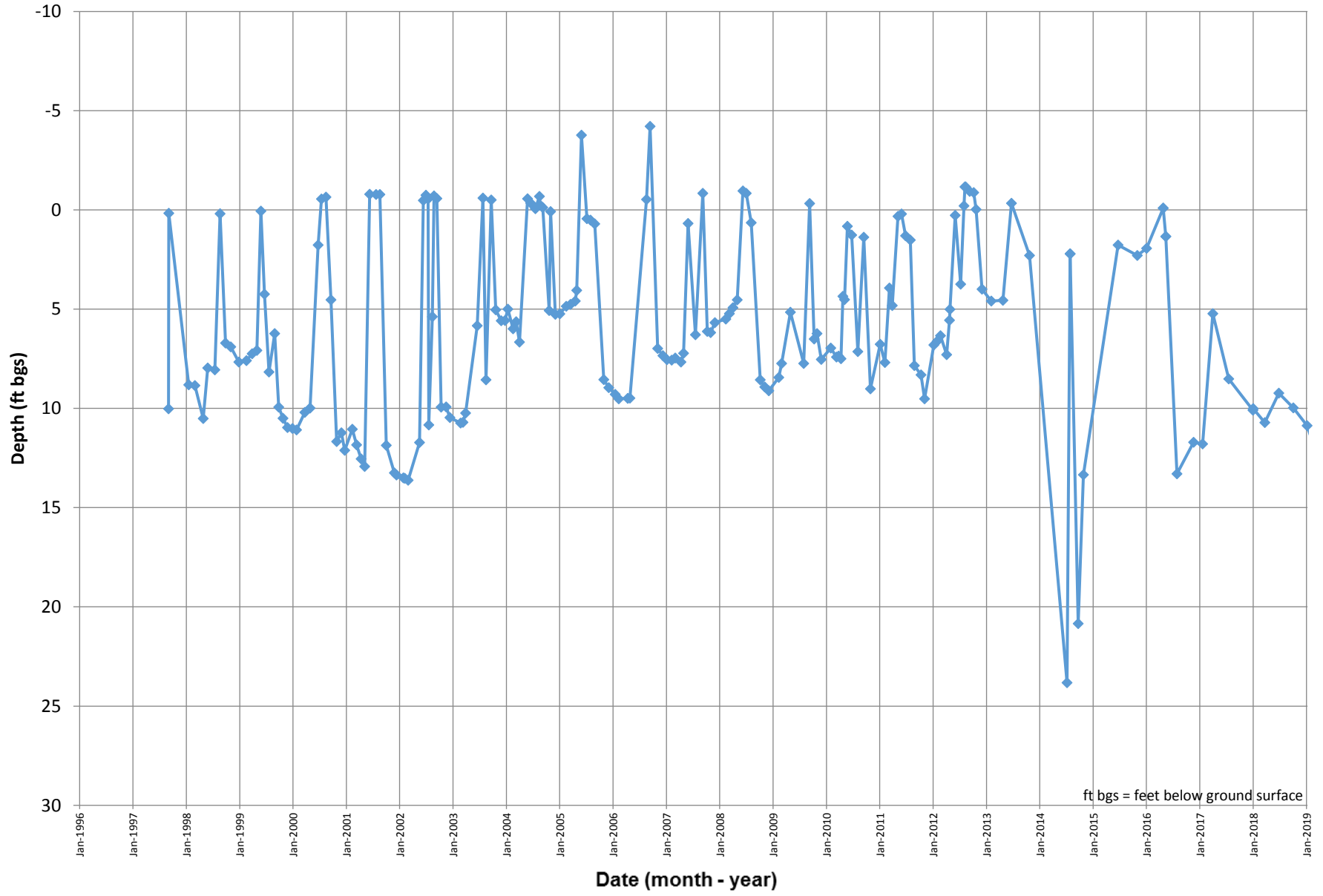
Depth Hydrograph for P-97-020



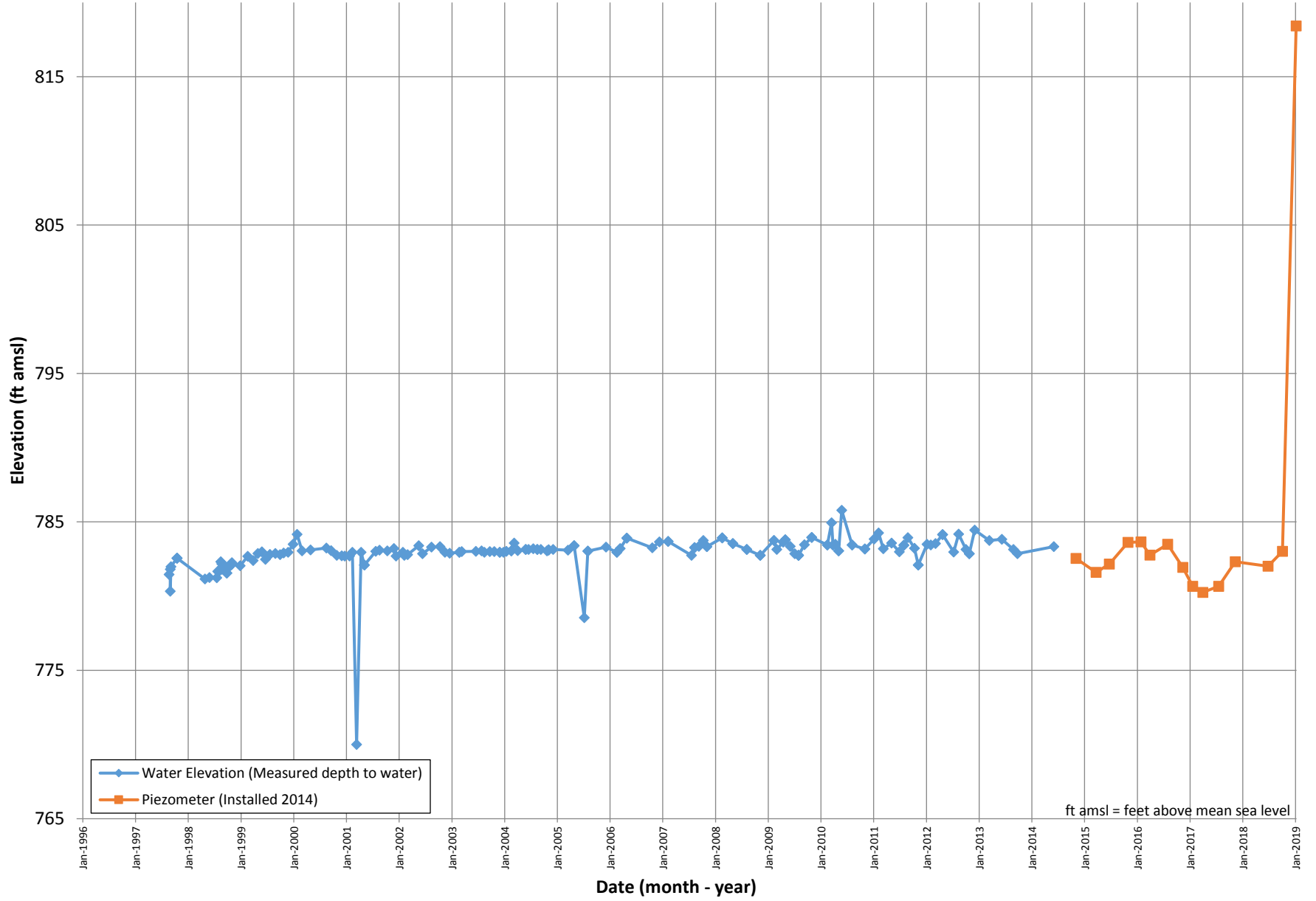
Elevation Hydrograph for P-97-028



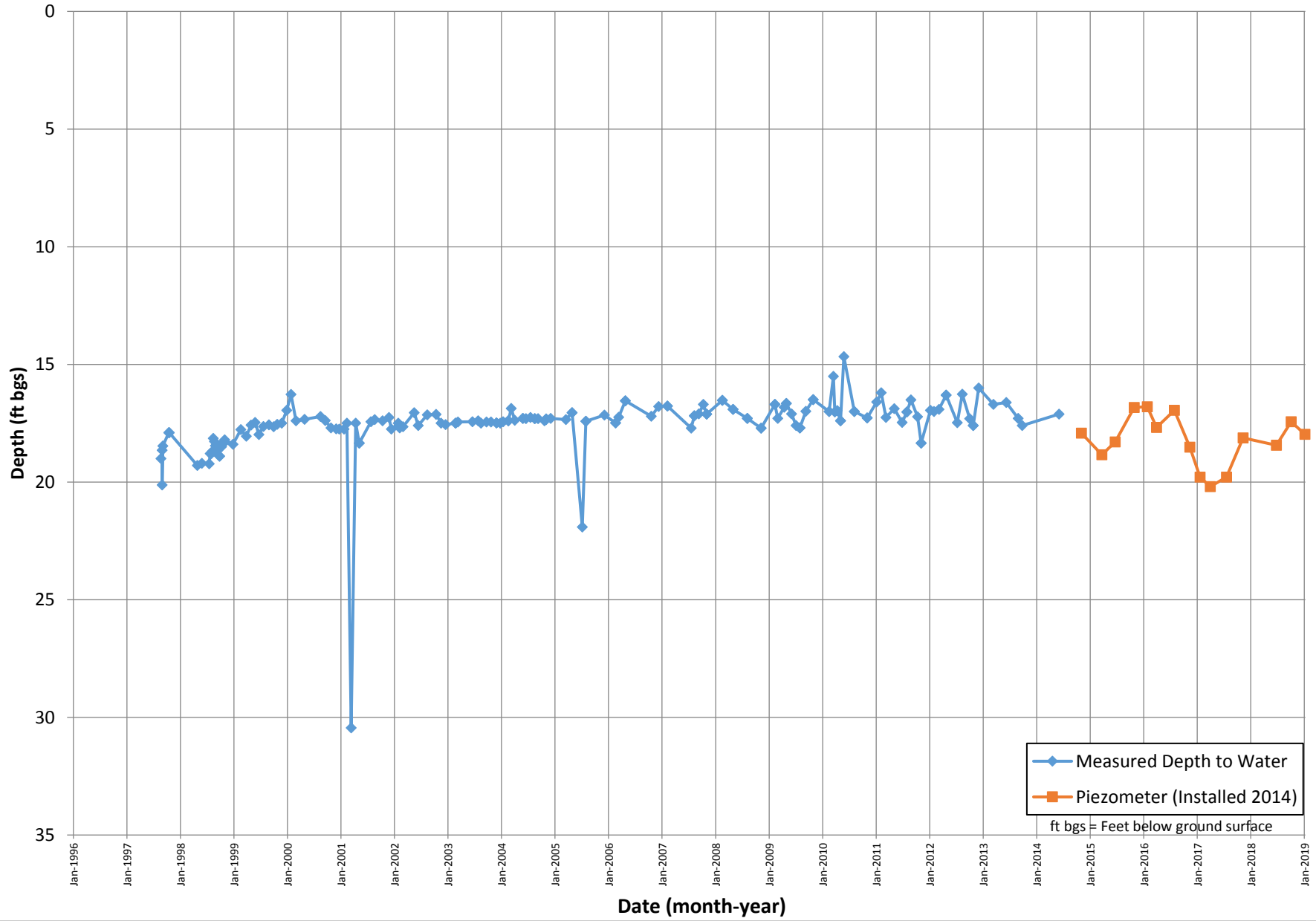
Depth Hydrograph for P-97-028



Elevation Hydrograph for SPP-97-002 (Elevation-axis scale adjusted)



Depth Hydrograph for SPP-97-002



Appendix D
Quality Control / Quality Assurance

Date 1-23-19

Quarterly Thermistor Piezometer Readings

M. Doudy

Technician: Wade S Tristen P

Thermidr: 19977

Geokon Row:

General Weather:

Col. Row #Ports	Well	Location	Collection Method Instrument	Nodes	Piezo PSI Therm. Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24	0	1-23-19	
25	*P96-13	Overburden	Geokon Piezometer		22.585	1-23-19	
29	*T96-13	Overburden	Yellow box Thermistor	24	0	1-23-19	
30	T96-13S	Overburden	Yellow box Thermistor	24	3	1-23-19	
31	*T96-21	Overburden	Yellow box Thermistor	24	3	1-23-19	
32	*T96-22	Overburden	Yellow box Thermistor	24	3	1-23-19	
33	*T96-23	Overburden	Yellow box Thermistor	24	3	1-23-19	
34	T96-24	Overburden	Yellow box Thermistor	24	3	1-23-19	
24	*P97-12	Blast Road	Geokon Piezometer			1-23-19	QAQC
27	*T96-12	Blast Road	Yellow box Thermistor	24	3	1-23-19	
28	*T96-12S	Blast Road	Yellow box Thermistor	24	3	1-23-19	
12	T98-33	Cold Storage	Yellow box Thermistor	10	3	1-23-19	
13	T98-34	Cold Storage	Yellow box Thermistor	11	3	1-23-19	
14	T98-35	Cold Storage	Yellow box Thermistor	11	3	1-23-19	
133	T05-67	By "3 Way"	Yellow box Thermistor	8	0	1-23-19	
4	WingWall	Power House	Nautiz Geokon logger				WiFi
1	P05-63	Zn Thickener	Nautiz Geokon logger				WiFi
129	T05-63	Zn Thickener	Yellow box Thermistor	8	0	1-23-19	
130	T05-64	By CSB	Yellow box Thermistor	7	3	1-23-19	
132	T05-66	South of CSB	Yellow box Thermistor	8	3	1-23-19	
70	*T95-05	By sandfilter	Yellow box Thermistor	24	0	1-23-19	
127	*T05-61	TDAM (end)	Yellow box Thermistor	6	0	1-23-19	
69	*T95-04	TDAM (end)	Yellow box Thermistor	24	3	1-23-19	
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24			Get Data by logging in
75	*T97-28	Buttress	Yellow box Thermistor	24	3	1-23-19	
76	*T97-29	Buttress	Yellow box Thermistor	24	3	1-23-19	
77	*T97-30	Buttress	Yellow box Thermistor	24	3	1-23-19	
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	3	1-23-19	
65	TDAM T7	Seepage Dam	Yellow box Thermistor		3	1-23-19	
23	*P96-15	Lower RDC	Geokon Piezometer		0	1-23-19	
44	*T96-15	Lower RDC	Yellow box Thermistor	14	0	1-23-19	

*SEP Thermistor. QC: CR850 Multimeter readings to be taken within 5 min. of each other, Quarterly.

*SEP Piezometer. QC: Duplicate Reading with Geokon to be taken within 5 min. of each other, Quarterly.

Quarterly Thermistor QA / QC

Location: T9612

Date: 1-23-19

Technician: XMS

Start Time: 10:35

Stop Time: 11:00

Node Test	Ohms	Comments	Node Test	Temperature	Read these locations on noted month.	
					Month	Location
1	16.33		1			
2	16.47		2		Feb-17	T 95-04
3	16.76		3		May-17	T 96-21
4	16.99		4		Aug-17	T96-22
5	17.07		5		Nov-17	T 96-23
6	17.16		6		Feb-18	T 96-12
7	17.20		7		May-18	T 95-15
8	17.24		8		Aug-18	T 96-05
9	17.28		9		Nov-18	T 96-10
10	17.21		10		Feb-19	T 97-28
11	17.25		11		May-19	T 97-29
12	17.28		12		Aug-19	T 97-30
13	17.20		13		Nov-19	T 95-8
14	17.10		14		Feb-20	T 96-13
15	17.11		15		May-20	T 96-21
16	16.98		16		Aug-20	T 96-22
17	16.97		17			
18	16.84		18			
19	16.71		19			
20	16.57		20			
21	16.41		21			
22	OL		22			
23	6.18		23			
24	6.04		24			
Test	15.91		Test			
	16.34					

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T96-12S

Date: 1-23-18

Technician: AMS

Start Time: 10:50

Stop Time: 10:54

Node Test	Ohms	Comments
1	16.55	
2	23.69	
3	25.85	
4	24.30	
5	20.82	
6	18.20	
7	16.80	
8	16.43	
9	16.46	
10	16.54	
11	16.64	
12	16.69	
13	16.72	
14	16.76	
15	16.76	
16	16.80	
17	16.83	
18	16.90	
19	16.92	
20	16.94	
21	7.0	
22	7.01	
23	6.04	
24	OL	
Test	16.33	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T96-135

Date: 1-23-19

Technician: VMS

Start Time: _____

Stop Time: _____

Node Test	Ohms	Comments
1	16.34	
2	22.49	
3	23.32	
4	23.88	
5	24.58	
6	23.41	
7	20.91	
8	19.11	
9	17.78	
10	16.85	
11	16.21	
12	15.70	
13	15.37	
14	15.10	
15	14.83	
16	14.63	
17	14.50	
18	14.42	
19	14.35	
20	14.27	
21	14.23	
22	14.21	
23	14.18	
24	14.20	
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T-96-21

Date: 1-23-19

Technician: NMS Start Time: _____ Stop Time: _____

Node Test	Ohms	Comments
1	16.34	
2	22.43	
3	22.63	
4	15.89	
5	14.02	
6	13.28	
7	13.48	
8	13.79	
9	13.51	
10	13.75	
11	14.07	
12	14.37	
13	14.75	
14	15.17	
15	15.61	
16	15.83	
17	16.16	
18	16.55	
19	16.66	
20	16.72	
21	16.81	
22	16.86	
23	16.90	
24	16.93	
Test	17.00	
	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
Record test readings before and after other readings.
CR850 & multimeter readings are to be taken within 5 minutes of each other.

	T96-21	T96-23	T96-22	T96-10
Test	16.34	16.34	16.34	16.33
1	22.25	OL	22.52	15.89
2	22.41	OL	18.94	15.78
3	22.43	17.08	OL	30.94
4	20.96	15.79	14.52	16.08
5	15.72	15.51	14.22	16.03
6	14.30	15.67	14.45	16.01
7	13.85	15.8	14.92	16.02
8	13.95	16.03	OL	15.88
9	14.33	16.10	15.83	15.89
0	14.69	16.03	16.18	15.82
1	14.99	16.53	16.49	16.36
2	15.27	16.80	16.73	15.74
3	15.68	16.86	16.81	15.61
4	15.99	16.95	16.86	16.93
5	16.33	16.64	OL	20.04
6	16.59	16.74	16.95	15.16
7	16.69	16.90	17.1	15.24
8	OL	16.88	17.03	16.95
9	16.71	17.15	17.09	15.01
0	16.70	17.17	17.11	15.43
1	16.68	17.16	17.13	14.80
2	16.73	16.91	17.20	14.94
3	16.74	17.22	13.46	26.39
		17.3	16.15	3.24
4	16.75	16.24	16.34	16.24

Quarterly Thermistor QA / QC

Location: 28 + 29 + 30

Date: 1-3-19

Technician: JMS TSP

Start Time: _____ Stop Time: _____

28 29 30

Node Test	Ohms	Comments
1	14.0	14.56
2	13.85	14.58
3	13.70	14.69
4	13.86	14.71
5	14.01	14.91
6	14.04	14.75
7	14.04	14.70
8	14.06	14.70
9	14.13	14.71
10	14.21	14.82
11	14.44	15.20
12	14.66	15.14
13	14.74	23.84
14	14.89	OL
15	14.89	15.50
16	15.03	16.972
17	15.21	15.23
18	15.21	15.34
19	15.32	15.5
20	15.35	28.5
21	15.46	15.39
22	15.46	1.41
23	15.31	15.49
24	15.39	30.05
Test	16.34	16.34

14.66
14.74

Jump

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T 96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T-9504

Date: 1-23-19

Technician: VMS BP

Start Time: _____

Stop Time: _____

Node Test	Ohms	Comments
1	16.34	
2	13.10	
3	14.65	
4	14.54	
5	14.93	
6	12.09	
7	19.80	
8	16.34	
9	16.14	
10	16.48	
11	16.51	
12	16.55	
13	16.63	
14	16.76	
15	16.58	
16	16.27	
17	16.76	
18	16.39	
19	15.9	
20	15.97	
21	15.78	
22	15.75	
23	0.63	
24	15.31	
Test	15.17	
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T-9835

Date: 1-23-19

Technician: JMS

Start Time: _____

Stop Time: _____

Node Test	Ohms	Comments
1	16.34	
2	24.29	
3	16.41	
4	14.68	
5	14.44	
6	14.82	
7	14.99	
8	15.33	
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T 96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T98.33

Date: 1-23-19

Technician: AMS TSP

Start Time: _____ Stop Time: _____

Node Test	Ohms	Comments
1	16.34	
2	16.34	250
3	16.34	16.45
4	16.34	14.6
5	13.89	
6	10.7	19.20 Jump
7	13.99	
8	14.41	
9	14.78	
10	15.04	
11	15.27	
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
Record test readings before and after other readings.
CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T98-34

Date: 1/23/19

Technician: BP/NMS Start Time: _____ Stop Time: _____

Node Test	Ohms	Comments
	16.34	
1	57.5	Jumpy
2	20.87	
3	16.69	
4	OL	
5	15.85	
6	16.08	
7	16.58	
8	OL ^{1st} 8.49	Jumpy
9	8 ^{2nd} 10.36	Jumpy
10	12.95	
11	14.4	
12	11.9	
13	5.0	Jumpy
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
Record test readings before and after other readings.
CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T-05606

Date: 1-23-18

Technician: Chris TSP

Start Time: _____

Stop Time: _____

Node Test	Ohms	Comments
1	16.33	
2	19.12	
3	16.40	
4	16.68	
5	16.98	
6	17.11	
7	17.24	
8	17.24	
9	17.31	
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
Record test readings before and after other readings.
CR850 & multimeter readings are to be taken within 5 minutes of each other.

Quarterly Thermistor QA / QC

Location: T-05-64

Date: 1/23/19

Technician: [Signature]

Start Time: _____ Stop Time: _____

Node Test	Ohms	Comments
1	16.34	
2	16.49	
3		Unstable
4	16.91	
5	17.01	
6	17.08	
7	17.12	
8	17.14	
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Test	16.34	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T 96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
Record test readings before and after other readings.
CR850 & multimeter readings are to be taken within 5 minutes of each other.

WHP QUARTERLY REPORT DATA CHECKLIST

Quarter Q1 2019

Date 02/04/2019

For Teck/Red Dog Long-Term Groundwater and Permafrost monitoring

- YES / NO** Quarterly data received from Teck. Date received: 01/29/2019

- YES / NO** Data received for 16 Thermistors

- YES / NO** Data received for 9 Piezometers

- YES / NO** QA/QC Forms received for both Thermistors and Piezos

- YES / NO** Is data complete for all Thermistors? If "No" make note of data gaps:
Errors occurred at some nodes on 8 thermistors

- YES / NO** Is data complete for all Piezometers? If "No" make note of data gaps:

- YES / NO** Field Notes for the Quarter. Are data gaps/irregularities addressed?

Additional Comments: _____

QUARTER Q1 2019 DATE 02/04/2019

Thermistor	Data Received? Y / N	Comments
T-96-015	Y	
T-05-061	Y	
T-95-005	Y	
T-96-010	Y	Errors at 4 of 24 nodes
T-97-028	Y	Errors at 2 of 24 nodes
T-97-029	Y	Errors at 5 of 24 nodes
T-97-030	Y	Errors at 8 of 24 nodes
T-14-110	Y	
T-95-008 #2 <small>(manually add "#2")</small>	Y	
T-96-013	Y	
T-96-021	Y	
T-96-022	Y	Errors at 3 of 24 nodes
T-96-023	Y	Errors at 8 of 24 nodes
T-96-012	Y	Errors at 1 of 24 nodes
T-96-012s	Y	
T-95-004	Y	Errors at 10 of 24 nodes

Piezometer	Data Received? Y / N	Comments
P-96-015	Y	
P-08A	Y	
P-08B	Y	
P-96-010	Y	
P-97-020	Y	
P-97-028	Y	
SPP-97-002	Y	
P-96-013	Y	
P-97-012	Y	
Barometer	Y	

Date 4-27-19

Quarterly Thermistor Piezometer Readings

Technician(s) DJSheldon / JWMills

Thermrdr: 19977

Geokon Row: 304

Weather: 20°F overcast Light winds

Barometric Pressure: 29.33"

Col. Row #Ports	Well	Location	Collection Method Instrument	Nodes	Piezo PSI Therm. Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24			
25	*P96-13	Overburden	Geokon Piezometer				225 psi
29	*T96-13	Overburden	Yellow box Thermistor	24	✓		
30	T96-13S	Overburden	Yellow box Thermistor	24			Read w/switch box
31	*T96-21	Overburden	Yellow box Thermistor	24	✓		
32	*T96-22	Overburden	Yellow box Thermistor	24			Node 3 + 8 are bad
33	*T96-23	Overburden	Yellow box Thermistor	24			Node 1 + 2 bad, Read w/switch box
34	T96-24	Overburden	Yellow box Thermistor	24			One bad Node
24	*P97-12	Blast Road	Geokon Piezometer		✓		
27	*T96-12	Blast Road	Yellow box Thermistor	24	✓		
28	*T96-12S	Blast Road	Yellow box Thermistor	24	✓		
12	T98-33	Cold Storage	Yellow box Thermistor	10			buried
13	T98-34	Cold Storage	Yellow box Thermistor	11			Node 4 is bad
14	T98-35	Cold Storage	Yellow box Thermistor	11			buried
133	T05-67	By "3 Way"	Yellow box Thermistor	8	✓		✓
4	WingWall	Power House	Nautiz Geokon logger				
1	P05-63	Zn Thickener	Nautiz Geokon logger				
129	T05-63	Zn Thickener	Yellow box Thermistor	8			No good Readings
130	T05-64	By CSB	Yellow box Thermistor	7			Damaged, cable ripped from well
132	T05-66	South of CSB	Yellow box Thermistor	8	✓		
70	*T95-05	By sandfilter	Yellow box Thermistor	24			buried
127	*T05-61	TDAM (end)	Yellow box Thermistor	6	✓		
69	*T95-04	TDAM (end)	Yellow box Thermistor	24			buried in Frozen Slurry
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24			
75	*T97-28	Buttress	Yellow box Thermistor	24			Last Node bad
76	*T97-29	Buttress	Yellow box Thermistor	24			QAQC
77	*T97-30	Buttress	Yellow box Thermistor	24			buried Read 5/1/19
71	*T96-10	Seepage Dam	Yellow box Thermistor	24			Node 24 is bad, historically, P96-10 is 50 psi
65	TDAM T7	Seepage Dam	Yellow box Thermistor				Node 2, 3, 4 bad, reread good
23	*P96-15	Lower RDC	Geokon Piezometer				QAQC on Row 4, 0 psi
44	*T96-15	Lower RDC	Yellow box Thermistor	14	✓		

Quarterly Thermistor QA / QC

Location: T97-30

Date: 5-1-19

Technician: JWM Start Time: 1031 Stop Time: 1034

Node	Ohms	Comments	Node	Temperature	Read these locations on noted month.	
Test			Test		Month	Location
1	16.33		1		Feb-17	T 95-04
2	14.67		2		May-17	T 96-21
3	NA	unstable / jumpy	3		Aug-17	T96-22
4	14.64		4		Nov-17	T 96-23
5	14.66		5		Feb-18	T 96-12
6	14.87		6		May-18	T 95-15
7	14.74		7		Aug-18	T 96-05
8	14.7		8		Nov-18	T 96-10
9	14.72		9		Feb-19	T 97-28
10	14.79		10		May-19	T 97-29
11	Jumpy/NA	Jumpy	11		Aug-19	T 97-30
12	15.23		12		Nov-19	T 95-8
13	15.18		13		Feb-20	T 96-13
14	NA	Jumpy	14		May-20	T 96-21
15	NA	OL	15		Aug-20	T 96-22
16	15.49		16			
17	1.17m		17			
18		Jumpy	18			
19		Jumpy	19			
20	15.51		20			
21	29.6		21			
22	15.41	15.41	22			
23	NA	Jumpy	23			
24	15.67	Jumpy JWM	24			
Test	NA	Jumpy	Test			
Test	16.33					

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Teck

Quarterly Thermistor QA / QC

Location: T-96-23

Date: 4-27-19

Technician: DJS/JWm Start Time: 1643

Stop Time: 1646

Node	Ohms	Comments	Node	Temperature	Read these locations on noted month.	
Test			Test		Month	Location
	16.34					
1		OL	1			
2		OL	2		Feb-17	T 95-04
3	16.5		3		May-17	T 96-21
4	16.31		4		Aug-17	T96-22
5	16.0		5		Nov-17	T 96-23
6	16.0		6		Feb-18	T 96-12
7	16.06		7		May-18	T 95-15
8	16.26		8		Aug-18	T 96-05
9	16.35		9		Nov-18	T 96-10
10		Jumpy	10		Feb-19	T 97-28
11	16.56		11		May-19	T 97-29
12	16.81		12		Aug-19	T 97-30
13	16.86		13		Nov-19	T 95-8
14	16.94		14		Feb-20	T 96-13
15		Jumpy	15		May-20	T 96-21
16	16.86		16		Aug-20	T 96-22
17		Jumpy	17			
18		Jumpy	18			
19	17.14		19			
20	17.17		20			
21		Jumpy	21			
22		Jumpy	22			
23	17.18		23			
24	17.29		24			
Test	16.34		Test			

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Teck

Quarterly Thermistor QA / QC

Location: T-96-13

Date: 4-27-19

Technician: DJS/Jum Start Time: 1625

Stop Time: 1628

Node	Ohms	Comments
Test	16.34	
1	15.32	
2	17.87	
3	17.75	
4	17.59	
5	17.45	
6	17.15	
7	17.17	
8	16.93	
9	16.74	
10	16.45	
11	16.15	
12	15.96	
13	15.84	
14	15.66	
15	15.48	
16	15.38	
17	15.32	
18	15.25	
19	15.17	
20	15.1	
21	15.06	
22	14.98	
23	N/A	Stumpy
24	14.91	
Test	16.34	

Node	Temperature
Test	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Teck

Quarterly Thermistor QA / QC

Location: T97-29

Date: 4-27-19

Technician: DJS/JWM Start Time: 1437

Stop Time: 1443

Node	Ohms	Comments	Node	Temperature	Read these locations on noted month.	
Test	16.33		Test		Month	Location
1	14.17		1		Feb-17	T 95-04
2	14.2		2		May-17	T 96-21
3	14.4		3		Aug-17	T96-22
4	14.54		4		Nov-17	T 96-23
5	14.7		5		Feb-18	T 96-12
6	14.88		6		May-18	T 95-15
7	15.03		7		Aug-18	T 96-05
8	15.21		8		Nov-18	T 96-10
9	15.3		9		Feb-19	T 97-28
10	15.39		10		May-19	T 97-29
11	15.58		11		Aug-19	T 97-30
12	15.79	Slowly rising	12		Nov-19	T 95-8
13	15.89	Slowly rising	13		Feb-20	T 96-13
14	16.05		14		May-20	T 96-21
15	16.09		15		Aug-20	T 96-22
16	16.06		16			
17	16.04		17			
18	15.92		18			
19	15.98		19			
20	15.84		20			
21	200K	bad Node	21			
22	15.55		22			
23	0.607m	bad ?	23			
24	15.53		24			
Test	15.33		Test			

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.



For Teck/Red Dog Long term Groundwater and Permafrost monitoring

- YES / NO** Quarterly data received from Teck. Date received: 05/06/2019

- YES / NO** Data received for 16 Thermistors

- YES / NO** Data received for 9 Piezometers

- YES / NO** QA/QC Forms received for both Thermistors and Piezometers

- YES / NO** Is data complete for all Thermistors? If "No" make note of data gaps:

See page 2

- YES / NO** Is data complete for all Piezometers? If "No" make note of data gaps:

P-08A data is not included

- YES / NO** Field Notes for the Quarter. Are data gaps/irregularities addressed?

Additional Comments: _____

QUARTER Q2 2019 DATE 05/08/2019

Thermistor	Data Received? Y / N	Comments
T-96-015	N	Only 7/14 readings given
T-05-061	Y	
T-95-005	N	Buried
T-96-010	N	Only 7/24 readings given
T-97-028	N	Only 7/24 readings given
T-97-029	N	Only 7/24 readings given
T-97-030	Y	
T-14-110	Y	
T-95-008 #2 <small>(manually add "#2")</small>	N	Do data given
T-96-013	N	Only 7/24 readings given
T-96-021	N	Only 7/24 readings given
T-96-022	N	Only 7/24 readings given
T-96-023	N	Only 7/24 readings given
T-96-012	N	Only 7/24 readings given
T-96-012s	N	Only 7/24 readings given
T-95-004	N	Buried

Piezometer	Data Received? Y / N	Comments
P-96-015	Y	
P-08A	N	No data
P-08B	Y	
P-96-010	Y	
P-97-020	Y	
P-97-028	Y	
SPP-97-002	Y	
P-96-013	Y	
P-97-012	Y	
Barometer	N	Value is not consistent with historical values

Date: 7-16-19

Quarterly Thermistor Piezometer Readings

Technician(s):		Thermidr:		General Weather & Barometric Pressure:			
James Mills / Dennis J Shelton		Geokon Serial# Geokon Row# Switch box 4 16320		Overcast, Wind SE @ 5 mph			
Col. Row #Ports	Well	Location	Collection Method Instrument	Nodes	Check if complete	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24	✓		
25	*P96-13	Overburden	Geokon Piezometer		✓	7-17-19	QAQC on Row 5
29	*T96-13	Overburden	Yellow box Thermistor	24	✓		Error 3
30	T96-13S	Overburden	Yellow box Thermistor	24	✓		Error 3
31	*T96-21	Overburden	Yellow box Thermistor	24	✓		Error 3
32	*T96-22	Overburden	Yellow box Thermistor	24	✓		Error 3
33	*T96-23	Overburden	Yellow box Thermistor	24	✓		Error 3
34	T96-24	Overburden	Yellow box Thermistor	24	✓		
24	*P97-12	Blast Road	Geokon Piezometer		✓	7-17-19	
27	*T96-12	Blast Road	Yellow box Thermistor	24	✓		Error 3
28	*T96-12S	Blast Road	Yellow box Thermistor	24	✓		Use second reading. Error 3
12	T98-33	Cold Storage	Yellow box Thermistor	10	✓		
13	T98-34	Cold Storage	Yellow box Thermistor	11	✓		
14	T98-35	Cold Storage	Yellow box Thermistor	11	✓		
133	T05-67	By "3 Way"	Yellow box Thermistor	8	✓		
129	T05-63	Zn Thickener	Yellow box Thermistor	8	✓		
130	T05-64	By CSB	Yellow box Thermistor	7			Cable broken off @ connector
132	T05-66	South of CSB	Yellow box Thermistor	8	✓		
70	*T95-05	By sandfilter	Yellow box Thermistor	24	✓		
127	*T05-61	TDAM (end)	Yellow box Thermistor	6	✓		Error 3
69	*T95-04	TDAM (end)	Yellow box Thermistor	24			buried in slurry
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24	✓		
75	*T97-28	Buttress	Yellow box Thermistor	24	✓		Error 3 reread
76	*T97-29	Buttress	Yellow box Thermistor	24	✓		Error 3
77	*T97-30	Buttress	Yellow box Thermistor	24	✓		QAQC
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	✓		
65	TDAM T7	Seepage Dam	Yellow box Thermistor		-		Removed
23	*P96-15	Lower RDC	Geokon Piezometer		✓	7-17-19	
44	*T96-15	Lower RDC	Yellow box Thermistor	14	✓	7-17-19	

Quarterly Thermistor QA / QC

Location: T 97-30

Date: 7-16-19

Technician: DJS/JWM Start Time: 1723

Stop Time: 1727

Node	Ohms	Comments
Test	16.33	
1	14.83	
2	14.96	Slowly Climbing
3	14.93	
4	14.76	
5	14.87	
6	14.7	
7	14.65	
8	14.69	
9	14.75	Slowly Climbing
10	14.82	slowly climbing
11	15.22	slowly climbing
12	15.1	slowly climbing
13	29.96	
14	OL	
15	15.48	
16	400k	unstable
17	15.24	slowly climbing
18	15.35	slowly climbing
19	15.49	
20	31.7	NO "K"
21	15.37	
22	1.38m	climbing
23	15.61	slowly climbing
24	30.5	dropping
Test	16.33	

Node	Temperature
Test	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

Teck

For Teck/Red Dog Long term Groundwater and Permafrost monitoring

- YES / NO** Quarterly data received from Teck. Date received: 07/29/2019
- YES / NO** Data received for 16 Thermistors
- YES / NO** Data received for 9 Piezometers
- YES / NO** QA/QC Forms received for both Thermistors and Piezometers
- YES / NO** Is data complete for all Thermistors? If "No" make note of data gaps:
Missing T-95-004. Mentioned in the e-mail.
- YES / NO** Is data complete for all Piezometers? If "No" make note of data gaps:
Missing P-96-010. Given as N/A without explanation.
- YES / NO** Field Notes for the Quarter. Are data gaps/irregularities addressed?

Additional Comments: _____

QUARTER Q3 2019 DATE 07/29/2019

Thermistor	Data Received? Y / N	Comments
T-96-015	Y	
T-05-061	Y	
T-95-005	Y	
T-96-010	Y	
T-97-028	Y	
T-97-029	Y	
T-97-030	Y	
T-14-110	Y	
T-95-008 #2 <small>(manually add "#2")</small>	Y	
T-96-013	Y	
T-96-021	Y	
T-96-022	Y	
T-96-023	Y	
T-96-012	Y	
T-96-012s	Y	
T-95-004	N	Buried in Slurry but e-mail said reading was taken.

Piezometer	Data Received? Y / N	Comments
P-96-015	Y	
P-08A	Y	
P-08B	Y	
P-96-010	N	Reading is N/A
P-97-020	Y	
P-97-028	Y	
SPP-97-002	Y	
P-96-013	Y	
P-97-012	Y	
Barometer	Y	

Date 10/16/19

Quarterly Thermistor Piezometer Readings

Technician: TSP/APM

Thermrdr: 19977

Geokon Row:

General Weather: Clear Skies, 27°F

Col. Row #Ports	Well	Location	Collection Method Instrument	Nodes	Piezo PSI Therm. Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24	3	10/16/19	Brushed off connection; was dirty
25	*P96-13	Overburden	Geokon Piezometer	24		10/16/19	27"
29	*T96-13	Overburden	Yellow box Thermistor	24	3	10/16/19	10.8ix
30	T96-13S	Overburden	Yellow box Thermistor	24	3	10/16/19	50.0ix
31	*T96-21	Overburden	Yellow box Thermistor	24	3	10/16/19	
32	*T96-22	Overburden	Yellow box Thermistor	24	3	10/16/19	Had to walk in 6" of snow
33	*T96-23	Overburden	Yellow box Thermistor	24	3	10/16/19	↓
34	T96-24	Overburden	Yellow box Thermistor	24	3	10/16/19	Had to walk in 6" snow. Raised flag for visibility
24	*P97-12	Blast Road	Geokon Piezometer			10/16/19	
27	*T96-12	Blast Road	Yellow box Thermistor	24	3	10/16/19	Buried in snow; brushed off snow; ice
28	*T96-12S	Blast Road	Yellow box Thermistor	24	3	10/16/19	
12	T98-33	Cold Storage	Yellow box Thermistor	10	3	10/16/19	
13	T98-34	Cold Storage	Yellow box Thermistor	11	3	10/16/19	Stopped reading after 7 nodes
14	T98-35	Cold Storage	Yellow box Thermistor	11	0	10/16/19	Stopped reading after 7 nodes
133	T05-67	By "3 Way"	Yellow box Thermistor	8	0	10/16/19	
4	WingWall	Power House	Nautiz-Geokon-logger				
4	P05-63	Zn Thickener	Nautiz-Geokon-logger				
129	T05-63	Zn Thickener	Yellow box Thermistor	8	0	10/16/19	
130	T05-64	By CSB	Yellow box Thermistor	7	N/A	10/16/19	Connector spliced off APM fipped off
132	T05-66	South of CSB	Yellow box Thermistor	8	0	10/16/19	
70	*T95-05	By sandfilter	Yellow box Thermistor	24	0	10/16/19	
127	*T05-61	TDAM (end)	Yellow box Thermistor	6	0	10/16/19	Dirty; brushed off; put down on busy ship
69	*T95-04	TDAM (end)	Yellow box Thermistor	24	3	10/16/19	Dirty; brushed off. Wire exposed. Stood up the stand
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24			Mark when downloaded
75	*T97-28	Buttress	Yellow box Thermistor	24	3	10/16/19	"A" Therm's relocated; using data to determine
76	*T97-29	Buttress	Yellow box Thermistor	24	3	10/16/19	"B"
77	*T97-30	Buttress	Yellow box Thermistor	24	3	10/16/19	"C"
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	3	10/16/19	
65	TDAM T7	Seepage Dam	Yellow box Thermistor			10/16/19	Not in service; Buried
23	*P96-15	Lower RDC	Geokon Piezometer			10/16/19	12.2m
44	*T96-15	Lower RDC	Yellow box Thermistor	14	3	10/16/19	

Quarterly Thermistor QA / QC

Location: T 95-8

Date: 10/23/19

Technician: TOP/TSP

Start Time: 7:53

Stop Time: 8:55

Node Test	Ohms	Comments
	16.32	
1	15.26	
2	16.72	
3	16.88	
4	16.95	
5	16.97	
6	16.99	
7	16.97	
8	16.95	
9	17.04	
10	17.05	
11	17.05	
12	17.01	
13	17.03	
14	17.09	
15	17.06	
16	17.07	
17	17.08	
18	17.07	
19	17.09	
20	17.12	
21	17.11	
22	17.10	
23	17.16	
24	17.19	
Test	16.33	

Node Test	Temperature
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
Test	

Read these locations on noted month.

Month	Location
Feb-17	T 95-04
May-17	T 96-21
Aug-17	T96-22
Nov-17	T 96-23
Feb-18	T 96-12
May-18	T 95-15
Aug-18	T 96-05
Nov-18	T 96-10
Feb-19	T 97-28
May-19	T 97-29
Aug-19	T 97-30
Nov-19	T 95-8
Feb-20	T 96-13
May-20	T 96-21
Aug-20	T 96-22

Teck

Make a comment if reading jumps around and takes a long time to stabilize.
 QA / QC readings to be done on 5% of SEP required thermistors - see above schedule.
 Record test readings before and after other readings.
 CR850 & multimeter readings are to be taken within 5 minutes of each other.

For Teck/Red Dog Long term Groundwater and Permafrost monitoring

- YES / NO** Quarterly data received from Teck. Date received: 10/23/2019

- YES / NO** Data received for 16 Thermistors

- YES / NO** Data received for 9 Piezometers

- YES / NO** QA/QC Forms received for both Thermistors and Piezometers

- YES / NO** Is data complete for all Thermistors? If "No" make note of data gaps:

- YES / NO** Is data complete for all Piezometers? If "No" make note of data gaps:

- YES / NO** Field Notes for the Quarter. Are data gaps/irregularities addressed?

Additional Comments: _____

QUARTER Q4 2019 DATE 10/24/2019

Thermistor	Data Received? Y / N	Comments
T-96-015	Y	
T-05-061	Y	
T-95-005	Y	
T-96-010	Y	
T-97-028	Y	
T-97-029	Y	
T-97-030	Y	
T-14-110	Y	
T-95-008 #2 <small>(manually add "#2")</small>	Y	
T-96-013	Y	
T-96-021	Y	
T-96-022	Y	
T-96-023	Y	
T-96-012	Y	
T-96-012s	Y	
T-95-004	Y	

Piezometer	Data Received? Y / N	Comments
P-96-015	Y	
P-08A	Y	
P-08B	Y	
P-96-010	Y	
P-97-020	Y	
P-97-028	Y	
SPP-97-002	Y	
P-96-013	Y	
P-97-012	Y	
Barometer	Y	