Long-Term Permafrost and Groundwater Monitoring Program for the Tailings Impoundment Facility

2020 Annual Report

Prepared for Teck Alaska, Inc.
Teck PO #1409577-SVC
Kuna Project # 165.030212

February 2021

This Page Intentionally Blank

Table of Contents

Tables

Appendices

Acronyms and Abbreviations

EPA	(US) Environmental Protection Agency
ft amsl	feet above mean sea level
ft bgs	feet below ground surface
kohms	kilo-ohms
Kuna	Kuna Engineering, LLC
QA/QC	Quality Assurance and Quality Control
SEP	Supplemental Environmental Program
TAK	Teck Alaska, Inc.
WMCI	Water Management Consultants, Inc.

1 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 into on November 25, 1997 (US v. Cominco Alaska Incorporated, Civil Action A97-267CV). The Monitoring Program was developed to monitor the 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. The Consent Decree requires the submission of an annual report to provide 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 2020 did not show any significant changes in permafrost depths or groundwater elevations in the area of the Tailings Impoundment Facility. Improved quality checks and maintenance are resulting in improved data acceptance.

2 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 primarily of ore bodies that have been mined (open pits) and associated support facilities. Support facilities include an ore milling and a concentration facility, an employee housing area, a construction camp, an asphalt paved runway, and a power generation facility. The site also includes approximately 300 acres of waste rock piles and a tailings pond (impoundment) behind two earthen dams. The pond is used for storage of tailings and receives drainage from the open pit areas, natural surface run-off, and process waters from the milling operation. Following treatment, water is discharged from the pond during summer months pending upstream water quality considerations. The original Red Dog ore body is no longer being actively mined and is instead receiving waste rock from the mining of the Aqqaluk ore body.

The tailings pond has the potential to affect both permafrost and groundwater in one or more adjacent watersheds/drainages. To document these potential effects, a ground temperature and groundwater level monitoring program began in the mid-1990s as part of the Groundwater Monitoring Supplemental Environmental Project (SEP). Results from this project are documented in the project's report (Water Management Consultants, Inc. 2001) and form the basis for the Long-Term Permafrost and Groundwater Monitoring Plan. Long-term monitoring is intended to demonstrate the continuity of the permafrost and the minimal flow of groundwater beneath and from the impoundment pond. The continuity of subsurface frozen conditions is critical to ensuring that any impacts from dissolved metals in the impoundment do not affect the adjacent watersheds.

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.

3 2020 Data Collection

TAK personnel collect the data from the project thermistors and piezometers. This data is then emailed to Kuna Engineering (Kuna). Appendix B contains a table of the raw data. Kuna is then responsible for the data reduction, presentation, and management.

The Red Dog Mine thermistor and piezometer monitoring locations are illustrated on Figure 3 (northern portion), Figure 4 (central portion), and Figure 5 (southern portion).

Table 1 provides a summary of the quarterly data collection dates for the thermistor strings, and Table 2 provides a summary of the quarterly data collection dates for the piezometers.

Table 1 Summary of the 2020 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	1/10/20	5/3/20	7/24/20	10/19/20
T-95-005	Figure 3	Dam Area	1/10/20	Error	7/14/20	10/19/20
T-96-010	Figure 3	Dam Area	1/10/20	5/3/20	7/14/20	10/19/20
T-97-028	Figure 3	Dam Area	1/10/20	5/3/20	7/24/20	10/19/20
T-97-029	Figure 3	Dam Area	1/10/20	5/3/20	7/24/20	10/19/20
T-97-030	Figure 3	Dam Area	1/10/20	5/3/20	7/24/20	10/19/20
T-14-110	Figure 4	Tailing Impoundment	1/10/20	4/25/20	7/15/20	10/20/20
T-95-004	Figure 4	Dam area	1/10/20	5/3/20	7/25/20	10/31/20
T-05-061	Figure 4	Dam area	1/10/20	5/3/20	7/14/20	10/23/20
T-95-008 #2	Figure 5	Overburden Stockpile	1/10/20	5/3/20	7/24/20	10/19/20
T-96-013	Figure 5	Overburden Stockpile	1/10/20	5/3/20	7/14/20	10/19/20
T-96-021	Figure 5	Overburden Stockpile	1/10/20	5/3/20	7/14/20	10/19/20
T-96-022	Figure 5	Overburden Stockpile	1/10/20	5/3/20	7/14/20	10/19/20
T-96-023	Figure 5	Overburden Stockpile	1/10/20	5/3/20	7/14/20	10/19/20
T-96-012	Figure 5	Bons Creek	1/10/20	5/5/20	7/25/20	10/19/20
T-96-012s	Figure 5	Bons Creek	1/10/20	5/5/20	7/25/20	10/19/20

Table 2 Summary of the 2020 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	1/13/20*	4/26/20	7/18/20	10/19/20
P-96-010	Figure 3	Dam Area	1/17/20*	4/26/20**	7/14/20	10/19/20
P-97-028	Figure 3	Dam Area	1/17/20*	4/26/20	7/14/20	10/19/20
SPP-97-002	Figure 3	Dam Area	1/17/20*	4/26/20**	7/14/20	10/19/20
P-08A	Figure 4	Dam Area	1/17/20*	4/26/20	7/14/20	10/19/20
P-08B	Figure 4	Dam Area	1/17/20*	4/26/20	7/14/20	10/19/20
P-97-020	Figure 4	Dam Area	1/17/20*	4/26/20**	7/14/20	10/19/20
P-96-013	Figure 5	Overburden Stockpile	1/13/20*	4/26/20	7/18/20	10/19/20
P-97-012	Figure 5	Bons Creek	1/13/20*	4/26/20	7/18/20	10/19/20

Notes: Hyphens (-) indicate that data was not collected.
* Indicates that no barometric data was available/listed.
** Indicates inaccurate readings.

4 Data Management and Reporting

As previously described, for 2020, the reading and collection of the data from the thermistors and piezometers was performed by TAK personnel. This data was periodically provided to Kuna to upload to the Red Dog Mine groundwater monitoring database. Microsoft Access™ and Excel™ software are used to generate the tables and graphical plots of the data.

4.1 Thermistor Data Collection

Data collected from the thermistor cables is measured as a resistance value, in kilo-ohms (kohms) using a Dryden Instrumentation T5KMUK Automated Thermistor String Reader. The measured resistance values are subsequently converted to temperatures 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. All measured values are reviewed for errors and omission, and then uploaded to the database.

Some thermistor measurements are not representative of true/valid measurements (i.e., where the measurements are less than zero (0) kohms or greater than 300 kohms). These measurements may also represent issues with the sensors or cable breaks/shorts. These measurements are not uploaded to the database. The out-of-range values are shaded red in the raw data table presented in Appendix B.

4.2 Piezometer Data Collection

As with the thermistor readings, TAK personnel are responsible for providing the measurements from the vibrating wire piezometers and the associated barometric pressure readings from the mine meteorological station. The vibrating wire transducer measurements are then converted by Kuna to groundwater elevations using the individual transducer calibration coefficients, site elevations, and barometric pressure readings. The calibration coefficients for each of the vibrating wire transducers was determined during installation. Following conversion and a quality control review, the 2020 data was uploaded to the database.

4.3 Data Analyses

The ground temperature measurements collected from the sixteen thermistor monitoring locations are graphed using three types of graphs/plots as presented in Appendix C (separate plots for each thermistor string):

- Temperature trumpet plots of data for all years (separate color for each year/quarter);
- Temperature plots of data for the 2020 data according to depth (for each quarter of measurements); and
- Average temperature plots of the 2020 data according to depth.

For each graph, the measurements are presented as auto range and scale limited. The auto range plots represent the validated measurements (i.e., those not eliminated as described previously). 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.

The piezometer (groundwater elevation) data is presented in Appendix D as time series graphs.

5 Summary of Data QA/QC and Data Considerations

Copies of the quarterly report data checklists are provided in Appendix E, with the quarterly data field reporting forms. The checklists are completed by Kuna following the receipt of the quarterly data and sent back to TAK personnel to enable the recollection of data as necessary. 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.

According to the consent decree, a full analysis and interpretation of the data will be provided in the next 5-year monitoring report.

5.1 Thermistor QA/QC

Duplicate measurements were collected from the Dryden Instruments T5KMUK data logger and the Dryden Switchbox Fluke multimeter system. Variations in the thermistor measurements were also compared to previously collected data and trends. The thermistor QA/QC data is presented in Table 3.

Table 3 Summary of 2020 Thermistor QA/QC Data

Quarter	Date	Thermistor	Multi-meter Start Time	Comments
1st Quarter	-	-	-	Not recorded
2nd Quarter	4/26/20	T-96-21	-	
3rd Quarter	7/14/20	T-96-22	1510 hours	Nodes 3, 8, 15 are bad.
4th Quarter	10/19/20	T-95-4	1641 hours	Node 1 is jumpy

5.2 Piezometer QA/QC

Table 4 presents a summary of the QA/QC data for the piezometer readings; duplicate measurements of the P-96-13 piezometer were recorded in the 3rd quarter of 2020.

Table 4 Summary of 2020 Piezometer QA/QC Data

Quarter	Date	Piezometer	Comments
1st Quarter	-	-	Not recorded
2nd Quarter	-	-	Not recorded
3rd Quarter	7/14/20	P-96-13	Value 6582.1
4th Quarter	-	-	Not recorded

5.3 Thermistor System Maintenance

The thermistor measurements from 2020 indicate that several are malfunctioning and require replacement or repair. Shorts or discontinuities may also exist in the cabling/wiring for each thermistor at certain depths. Out-of-range readings may be indicative of these issues.

A program is currently in place to replace the surface connector cables (a common point of failure), as needed.

5.4 Piezometer System Maintenance

Most of the vibrating wire transducers are functioning, with limited erroneous measurements. Negative readings from early 2020 from piezometer P96-013 are potentially attributed to frozen conditions that may have been present in the thermistor. Piezometer SPP-97-002 developed an unknown error resulting in significantly higher groundwater elevation measurements.

6 References

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

This Page Intentionally Blank

Appendix A
Figures

This Page Intentionally Blank

0 20 40 80 Miles

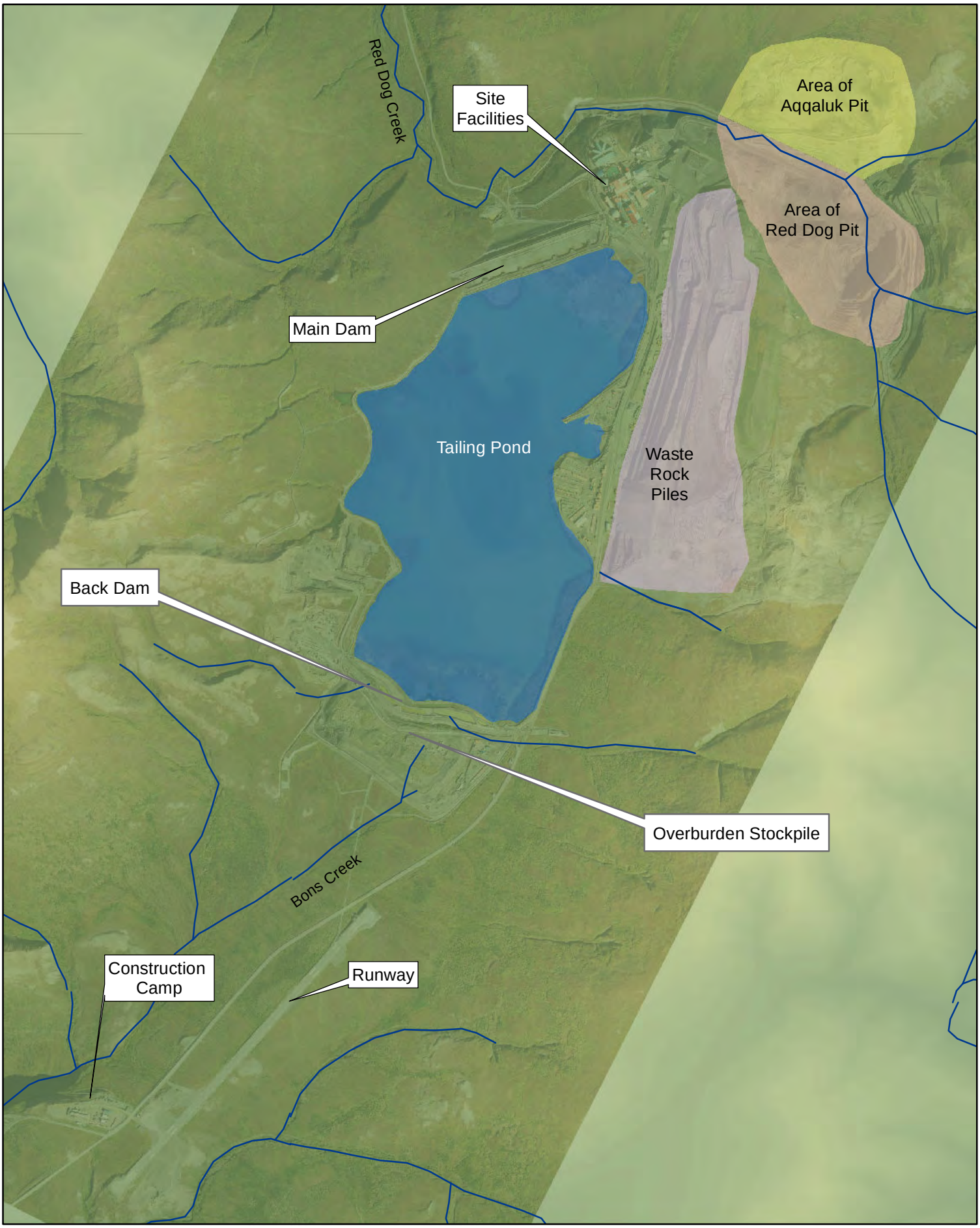
N

KUNA ENGINEERING

DRAWING INFO
Scale: 1:2,500,000
Author: NJB
Job #: 165.030094

Red Dog Mine and Vicinity
Red Dog Mine, Alaska

Figure 1



0 0.25 0.5 1 Miles

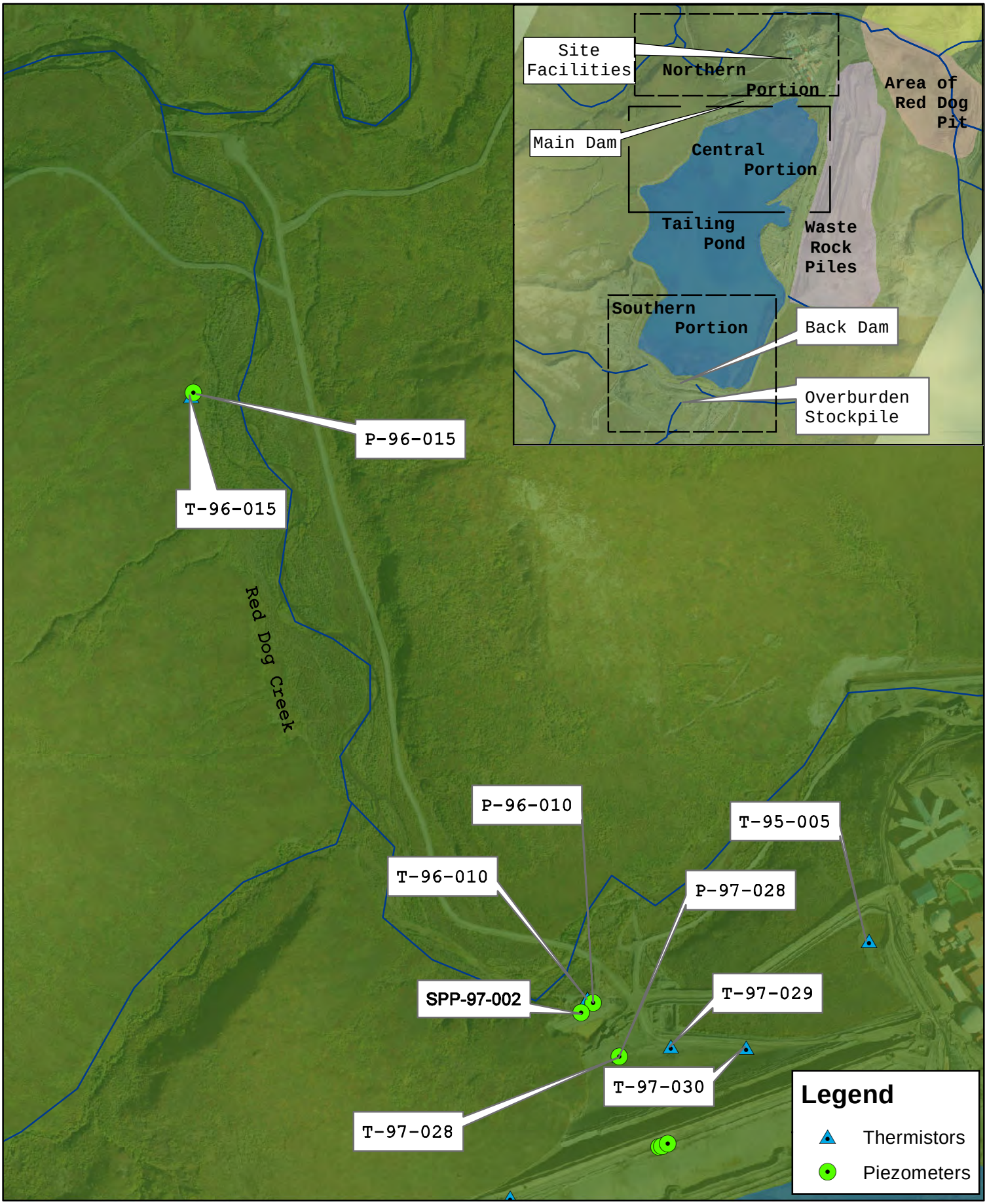
N

KUNA ENGINEERING

DRAWING INFO
Scale: 1:25,000
Author: NJB
Job #: 165.030094

Red Dog Mine Site Layout
Red Dog Mine, Alaska

Figure 2



0 375 750 1,500 Feet

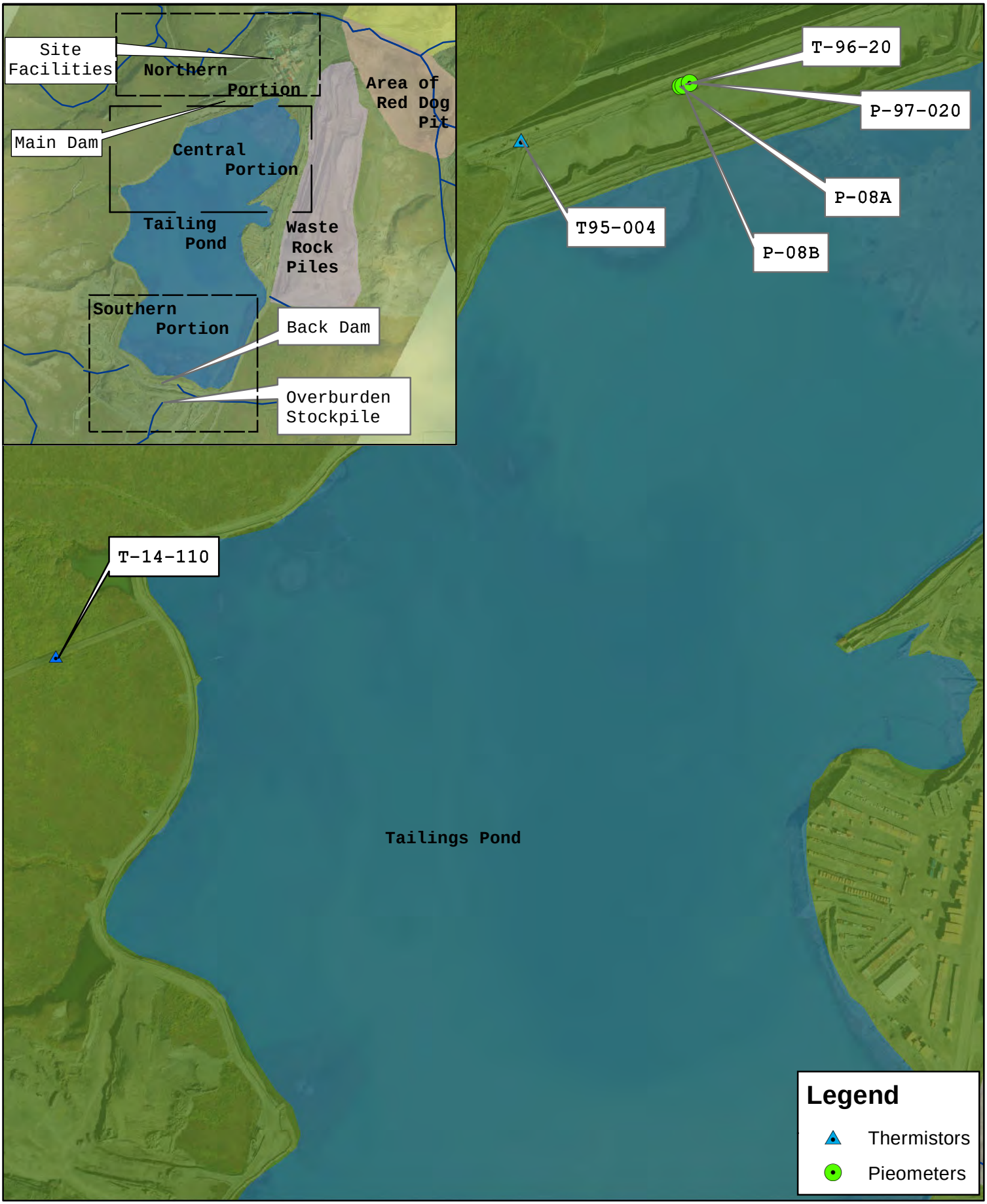
N

KUNA ENGINEERING

DRAWING INFO
Scale: 1:8,000
Author: NJB
Job #: 165.030094

Thermistor & Piezometer Northern Portion Red Dog Mine, Alaska

Figure 3



0 1,875 3,750 7,500 Feet

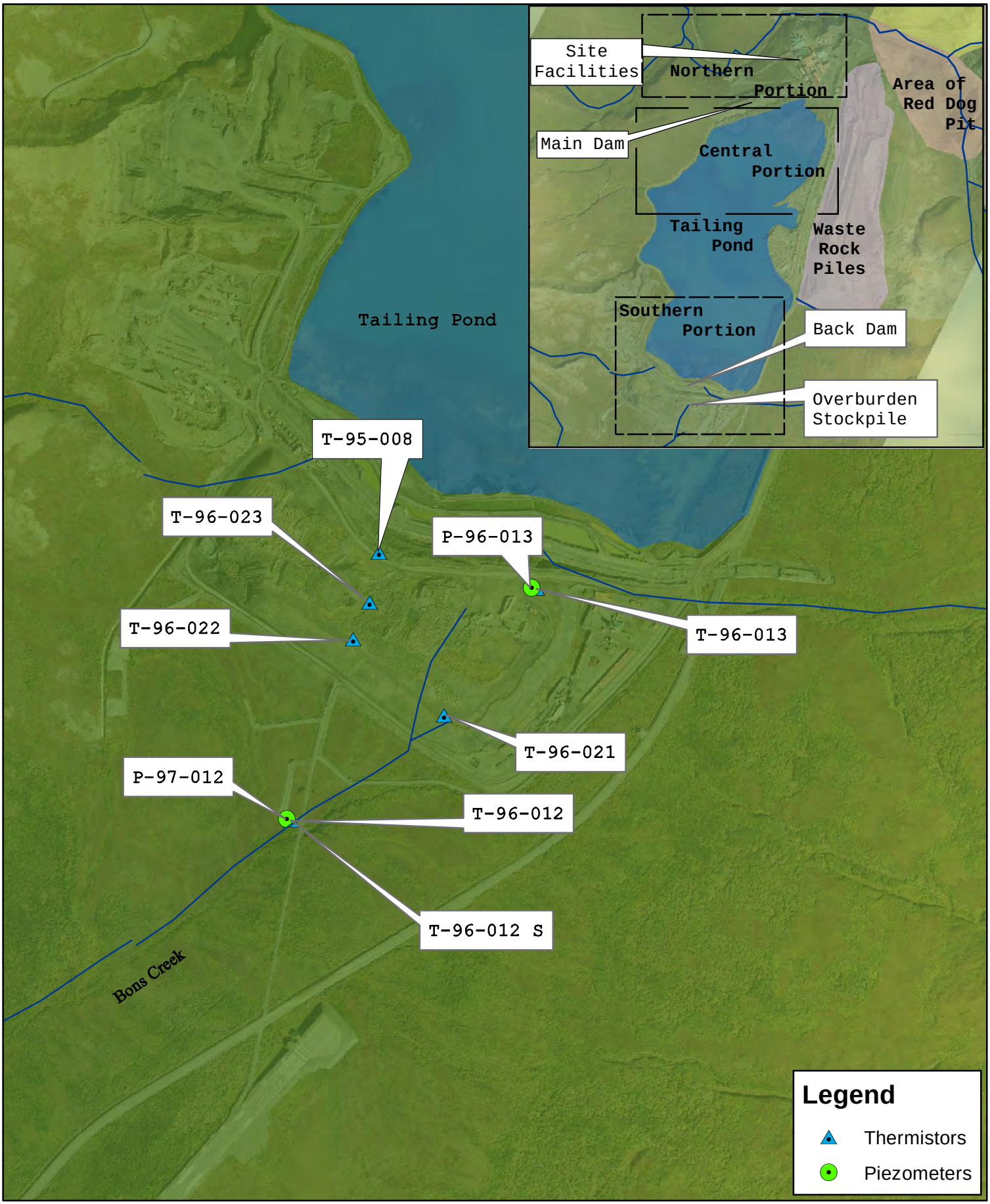
N

KUNA ENGINEERING

DRAWING INFO
Scale: 1:41,037
Author: NJB
Job #: 165.030094

Thermistor & Piezometer
Central Portion
Red Dog Mine, Alaska

Figure 4



0 1,875 3,750 7,500 Feet

N

KUNA ENGINEERING

DRAWING INFO
Scale: 1:10,000
Author: NJB
Job #: 165.030094

Thermistor & Piezometer
Southern Portion
Red Dog Mine, Alaska

Figure 5

This Page Intentionally Blank

Appendix B
Raw Thermistor Data

This Page Intentionally Blank

APPENDIX B - THERMISTOR DATA READINGS 2020

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
T95-8	24	1/10/20 11:16 AM	9999.9	16.658	16.793	20.363	16.951	16.969	16.949	16.938	17.014	17.024	-23.09	-17.31	161.9	17.07	17.016	17.054	17.062	-57.52	9999.9	17.099	17.135	17.085	17.137	17.173
T96-13	24	1/10/20 11:27 AM	9999.9	55.076	55.529	53.932	9999.9	34.385	9999.9	22.975	19.675	17.243	-456	9999.9	9999.9	14.604	14.219	13.953	13.804	13.623	13.517	13.353	9999.9	13.17	-9999	13.099
T96-13s	24	1/10/20 11:29 AM	9999.9	14.673	14.583	16.525	16.739	16.854	17.152	16.966	17.055	17.101	17.194	-35.2	18.758	19.041	18.016	17.185	17.234	-310.9	19.144	16.861	9999.9	16.652	16.561	16.397
T96-21	24	1/10/20 11:43 AM	-42.54	28.795	-15.66	13.72	12.943	13.027	12.829	13.104	13.435	13.833	18.979	9999.9	14.973	15.493	15.764	16.12	16.514	16.618	16.683	16.775	9999.9	16.862	16.894	16.957
T96-22	24	1/10/20 11:49 AM	9999.9	25.915	9999.9	13.958	-62.51	13.694	14.18	-9999	15.479	15.952	16.376	16.687	9999.9	16.804	9999.9	16.922	17.066	9999.9	-521.2	17.12	9999.9	17.16	12.639	16.627
T96-24	24	1/10/20 11:55 AM	9999.9	43.236	47.245	30.425	15.776	13.756	13.123	13.218	13.716	14.214	14.605	15.01	-9999	15.907	16.264	16.543	16.654	9999.9	16.907	16.667	9999.9	16.701	16.697	16.713
T96-23	24	1/10/20 12:02 PM	-9999	-9999	9999.9	9999.9	14.898	15.064	15.243	-25.51	-14.16	-6988	-4145	9999.9	9999.9	16.845	-15.66	-14.88	-2524	-277	16.931	9999.9	9999.9	-14.24	-16.34	-9999
T98-33	10	1/10/20 12:17 PM	9999.9	9999.9	9999.9	-9999	9999.9	-9999	-9590	9999.9	9999.9	-9999														
T98-34	7	1/10/20 12:21 PM	9999.9	20.966	16.227	9999.9	15.819	15.952	16.463																	
T98-35	7	1/10/20 12:24 PM	9999.9	17.304	14.689	14.029	14.127	14.263	15.085																	
T98-35	7	1/10/20 12:29 PM	47.31	17.305	14.69	14.029	14.129	14.267	15.088																	
T96-12s	24	1/10/20 12:38 PM	54.57	55.734	55.148	41.686	30.318	-18.98	17.019	16.289	16.476	16.539	16.597	-4300	-3688	16.663	16.711	16.742	9999.9	16.833	16.836	16.892	16.902	16.941	16.957	16.887
T96-12	24	1/10/20 12:39 PM	18.02	16.664	16.887	16.847	17.097	17.009	17.159	17.009	17.049	16.938	17.109	-31.21	15.433	17.064	16.943	16.886	-34.36	16.677	16.541	16.387	9999.9	16.158	16.007	15.858
T05-67	8	1/10/20 12:48 PM	9999.9	14.935	15.866	15.684	16.297	16.928	-32.8	16.617																
T05-67	8	1/10/20 12:48 PM	9999.9	14.616	16.38	15.689	16.237	16.418	-25.99	16.795																
T05-67	8	1/10/20 12:49 PM	14.512	14.568	15.228	15.721	16.222	16.45	16.535	16.587																
T05-64	7	1/10/20 3:44 PM	-79.35	27.088	29.968	16.782	-46.64	17.192	17.136																	
T05-63	8	1/10/20 3:49 PM	-54.97	19.078	18.015	14.27	37.16	14.646	14.837	15.13																
T95-5	24	1/10/20 3:54 PM	55.626	20.594	20.192	16.533	40.407	16.732	16.784	16.828	16.838	16.856	16.885	16.824	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T97-29	24	1/10/20 4:00 PM	-58.7	19.992	18.837	-36.11	39.458	-123.4	17.903	15.053	15.015	14.935	15.156	-70.39	9999.9	-9999	9999.9	9999.9	9999.9	9999.9	9999.9	-9999	9999.9	9999.9	-9999	9999.9
T97-28	24	1/10/20 4:02 PM	56.422	-18.23	-16.37	14.459	-309.1	14.556	-14.45	-14.39	14.307	-13.79	14.712	-14.29	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T97-30	24	1/10/20 4:03 PM	-56.32	19.826	18.299	13.546	39.79	13.585	-56.19	13.924	14.026	14.116	14.241	14.419	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T96-10	24	1/10/20 4:08 PM	31.525	26.053	36.727	15.918	16.064	15.94	15.956	15.809	15.838	15.775	16.357	15.69	9999.9	9999.9	9999.9	9999.9	9999.9	-9999	-9999	9999.9	9999.9	9999.9	9999.9	9999.9
T05-61	6	1/10/20 4:22 PM	23.265	-17.51	19.764	-13.63	-13.28	-35.68																		
T95-4	24	1/10/20 4:28 PM	-9999	21.504	20.546	-9999	9999.9	-9999	-9999	-9999	9999.9	-9999	-9999	-9999	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T95-4	24	1/10/20 4:29 PM	-920.7	-28.12	-346.8	15.994	-3024	-3064	-2874	-3190	-3584	-7490	-4955	-9999	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T96-15	14	1/12/20 4:00 PM	405.56	22.583	100.98	16.907	16.849	16.723	16.67	16.59	16.54	16.526	16.431	16.355	9999.9	9999.9										
T96-15	14	1/12/20 4:01 PM	-92.83	-28.33	-210.9	16.905	16.849	16.723	16.669	16.59	16.539	16.526	16.429	16.354	9999.9	9999.9										
T96-13	24	5/3/20 8:50 AM	17.75	16.339	14.841	16.513	16.738	16.851	17.163	16.953	17.052	17.097	17.163	17.203	18.805	19.134	18.05	17.181	17.22	17.015	19.08	16.859	16.765	16.655	16.561	16.393
T96-13s	24	5/3/20 8:51 AM	16.33	17.71	17.93	18.07	17.88	17.96	18.28	18.28	18.23	17.94	17.64	17.47	17.18	16.83	16.52	16.25	16.07	15.86	15.62	15.43	15.25	15.05	9999.90	14.79
T96-21	24	5/3/20 8:57 AM	21.09	18.97	17.64	15.82	14.33	13.78	13.05	12.99	13.15	13.52	13.93	14.40	14.92	15.43	15.71	16.09	16.52	16.62	16.68	16.78	16.82	16.86	16.89	16.95
T96-22	24	5/3/20 9:02 AM	18.306	18.485	9999.9	15.752	14.754	14.387	14.493	9999.9	15.319	15.814	16.343	16.654	16.751	16.799	9999.9	16.917	-17.03	16.969	17.052	17.076	17.079	17.155	12.325	17.096
T96-23	24	5/3/20 9:06 AM	-9999	9999.9	16.923	16.73	16.016	15.743	15.787	15.713	15.303	-15.42	16.467	16.738	16.83	16.879	16.19	-15.86	-9999	16.317	17.068	17.131	-15.98	-15.3	16.647	17.248
T96-24	24	5/3/20 9:11 AM	18.15	17.18	17.24	19.48	18.65	16.39	15.03	14.27	14.09	14.26	14.53	14.86	15.34	15.77	16.20	16.54	-9999.00	-9999.00	16.67	16.66	16.63	16.70	16.70	16.71
T95-8	24	5/3/20 9:23 AM	19.76	16.70	16.76	16.94	16.95	16.97	16.95	16.93	17.01	17.02	17.02	17.00	17.00	17.07	17.02	17.05	17.08	17.05	17.07	17.10	17.08	17.08	17.13	17.17
T95-4	24	5/3/20 10:57 AM	-12.76	-20.77	-14.75	-12.76	-15.07	-41.16	-12.31	-11.93	-10.15	-11.13	-9.354	-11.49	-11.38	15.45	-14.29	-13.53	-15.24	-14.53	19.167	-10.72	-9.222	-97.87	-9.56	-10.62
T05-61	6	5/3/20 11:00 AM	15.939	15.323	15.454	15.991	16.551	16.804																		
T96-10	24	5/3/20 11:08 AM	19.39	15.82	32.57	15.83	15.89	15.92	15.94	15.80	15.83	15.77	16.36	15.68	15.57	16.97	20.53	14.99	15.66	16.70	14.71	-13.74	14.80	14.56	26.92	-1148.00
T96-15	14	5/3/20 11:18 AM	17.20	16.90	16.90	16.90	16.80	16.72	16.67	16.59	16.54	16.52	16.42	16.35	16.29	16.24										
T97-30	24	5/3/20 11:27 AM	13.757	13.73	13.709	13.737	13.782	13.747	13.754	13.851	13.928	14.036	14.215	14.42	14.665	14.734	14.878	15.012	15.231	15.177	15.283	15.311	15.352	-1713	-1996	15.326
T97-29	24	5/3/20 11:29 AM	13.284	13.577	13.955	-28.85	14.372	-35.99	17.666	15	14.918	14.81	15.001	-14.57	-14.55	15.873	15.956	15.941	15.774	15.556	15.494	-13.21	14.663	15.175	-14.33	-13.63
T97-28	24	5/3/20 11:30 AM	13.47	-12.67	13.797	14.286	14.512	14.307	14.425	14.452	14.441	-13.84	14.692	-14.25	-21.52	8153.8	15.132	-159.2	-11.99	15.113	15.242	0.0287	15.114	-528.8	15.134	-21.26
T96-12	24	5/5/20 9:56 AM	14.33	15.80	13.68	16.91	18.04	18.28	18.06	17.59	17.10	16.84	16.69	16.62	16.65	16.65	16.69	16.72	9999.90	16.82	16.82	16.81	16.89	16.93	16.95	16.89
T96-12s	24	5/5/20 9:56 AM	18.17	16.65	16.89	16.98	17.08	17.13	17.18	17.23	17.22	17.20	17.24	9999.90	9999.90	17.06	16.94	16.89	16.81	16.68	16.55	16.39	9999.90	16.16	16.02	15.88
T95-5	24	1/10/20 3:54 PM	55.626	20.594	20.192	16.533	40.407	16.732	16.784	16.828	16.838	16.856	16.885	16.824	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T96-12	24	7/25/20 10:07 AM	16.359	16.779	16.88	16.949	17.07	17.117	17.163	16.837	17.123	16.833	17.196	-442.1	9999.9	17.051	16.934	16.93	16.798	16.668	16.534	15.994	7275.9	16.041	15.59	15.55
T96-12s	24	7/25/20 10:04 AM	10.18	10.81	10.12	10.19	10.49	14.00	16.69	16.96	16.95	16.97	16.93	16.84	16.84	16.78	16.80	16.89	-1106.00	16.84	16.60	16.63	16.72	16.92	16.95	16.65
T96-13	24	7/14/20 10:54 AM	12.81	9999.90	15.01	16.49	16.73	16.87	17.17	16.94	17.04	17.09	17.16	17.19	18.85	19.18	18.06	17.20	17.21	17.02	19.10	16.85	16.96	16.64	16.56	16.38
T96-13s	24	7/25/20 2:26 PM	8.7934	8.5947	8.4679	8.6229	9.023	9.5629	9.8901	10.106	10.56	11.088	11.775	12.571	13.331	13.948	14.4	14.651	14.911	15.123	15.275	15.391	15.459	15.486	9999.9	15.59
T95-8	24	7/24/20 5:31 PM	13.337	16.796	16.767	16.921	16.942	16.959	16.944	16.926	17.008	16.997	17.02	16.98	17.002	17.059	17.01	17.047	17.051	17.035	17.059	17.086	17.638	17.074	17.13	17.16

APPENDIX B - THERMISTOR DATA READINGS 2020

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
T96-23	24	7/14/20 11:20 AM	9999.90	9999.90	9.60	12.05	13.95	15.27	15.06	15.44	-11.68	-14.80	16.27	16.77	16.82	16.82	-15.76	-13.17	-13.93	-15.65	16.74	17.12	-15.73	-14.87	-16.16	17.24
T96-22	24	7/14/20 11:38 AM	5.6433	9.7329	9999.9	15.883	15.326	14.985	14.949	9999.9	15.381	15.78	16.297	16.643	16.746	16.792	9999.9	16.907	16.997	16.966	17.044	17.065	17.078	17.14	12.051	17.181
T96-22	24	7/14/20 3:10 PM	4.76	9.21	9999.90	15.88	15.33	14.99	14.95	9999.90	15.38	15.78	16.30	16.64	16.75	16.79	9999.90	16.91	17.00	16.97	17.05	17.07	17.08	17.14	12.06	17.18
T96-24	24	7/14/20 3:35 PM	6.8855	5.7754	5.1959	9.0929	15.382	16.295	15.69	15.129	14.784	14.674	14.782	14.943	15.341	15.742	16.181	16.527	16.643	9999.9	16.661	16.654	16.669	16.688	16.691	16.702
T96-21	24	7/14/20 3:46 PM	4.6735	-7.917	12.871	-14.08	14.719	14.148	13.31	13.24	13.317	13.592	13.999	14.414	14.839	15.331	15.687	16.078	16.507	16.614	16.602	16.686	17.026	16.849	16.881	16.944
T96-15	14	7/14/20 4:28 PM	17.08	16.897	16.885	16.885	16.791	16.71	16.663	16.579	16.532	16.515	16.418	16.342	16.29	16.231										
T96-10	24	7/14/20 4:40 PM	17.03	16.11	33.20	15.78	15.85	15.90	15.93	15.79	15.82	15.76	16.36	15.67	15.58	16.97	20.60	14.99	15.20	16.70	14.71	-13.86	14.86	14.56	27.03	-1143.00
T97-28	24	7/24/20 5:04 PM	13.72	13.78	13.82	13.84	13.98	13.91	13.85	13.89	13.93	14.02	14.20	14.43	14.68	14.73	14.88	15.02	15.19	15.17	15.28	15.31	15.41	-2318.00	-3218.00	15.33
T97-29	24	7/24/20 5:03 PM	13.68	13.574	13.867	-34.98	14.146	-22.24	14.657	-19.94	14.872	14.651	15.008	-32.02	-14.47	15.781	15.864	15.927	15.776	15.524	15.431	-12.5	14.644	-14.45	16.177	-13.4
T97-30	24	7/24/20 5:02 PM	-12.83	-12.76	13.688	13.957	14.268	14.258	14.396	-13.3	14.487	-13.96	14.712	-14.34	-13.42	-9999	15.125	-172.9	-14.13	15.142	15.264	0.0376	15.189	-631.2	-19.25	-19.08
T95-5	24	7/14/20 5:09 PM	16.33	16.04	16.06	16.45	16.58	16.71	16.77	16.80	16.82	16.83	16.86	16.81	16.79	16.78	16.72	16.71	16.63	16.49	16.36	16.19	16.11	15.89	15.74	15.56
T95-4	24	7/25/20 10:43 AM	-13.33	-18.54	14.56	-12.66	-13.12	-37.05	15.68	15.43	-14.03	-15.53	-13.18	-12.13	-14.58	-14.45	-13.66	-12.85	-14.55	-14.66	15.77	15.58	-15.11	-312.80	-14.31	-14.00
T05-61	6	7/14/2020 17:41	14.61	-20.40	14.58	-13.96	-13.20	-37.35																		
T96-12s	24	10/19/2020 10:45	18.903	19.766	19.118	17.839	16.706	16.301	16.376	16.622	16.708	16.806	16.841	16.843	16.861	16.815	16.843	16.85	-9999	16.894	16.879	16.891	-17.02	16.942	16.958	16.904
T96-12s	24	10/19/2020 10:46	18.9	19.762	19.11	17.837	16.705	16.299	16.376	16.622	16.707	16.805	16.839	16.843	16.857	16.812	16.842	16.849	-9999	16.894	16.877	16.887	-16.94	16.942	16.955	16.9
T96-12	24	10/19/2020 10:48	16.279	16.712	16.855	16.831	16.986	16.97	17.033	17.1	17.044	16.982	16.983	-1122	-3695	16.877	16.802	16.656	16.671	16.569	16.333	16.15	-958.3	15.847	15.733	15.726
T96-12	24	10/19/2020 10:48	16.257	16.628	16.794	16.855	16.944	16.882	16.979	17.063	16.881	16.792	16.875	-708.1	-1717	16.817	16.701	16.549	16.593	16.493	16.27	16.115	9999.9	15.654	15.506	15.595
T96-21	24	10/19/2020 11:00	19.413	16.411	13.13	12.713	13.01	13.747	13.628	13.663	13.705	13.896	14.161	14.516	14.951	15.393	15.667	16.048	16.508	16.612	16.651	16.761	16.838	16.848	16.879	16.938
T96-22	24	10/19/2020 11:06	19.195	16.758	-9999	13.704	14.181	14.707	15.098	9999.9	15.656	15.968	16.345	16.636	16.748	16.792	9999.9	16.903	16.997	16.964	17.041	17.061	17.103	17.14	11.823	17.206
T96-22	24	10/19/2020 11:06	19.186	16.755	9999.9	13.704	14.18	14.707	15.097	-9999	15.653	15.966	16.342	16.635	16.748	16.791	9999.9	16.902	16.997	16.964	17.041	17.061	-9999	9999.9	-9999	9999.9
T96-24	24	10/19/2020 11:18	18.219	19.149	19.434	15.918	13.292	13.367	14.074	14.593	14.789	14.884	14.988	15.121	15.473	15.794	16.188	16.528	16.639	5546.9	16.657	16.65	16.656	16.685	16.689	16.698
T96-24	24	10/19/2020 11:18	18.191	19.14	19.428	15.916	13.292	13.366	14.07	14.591	14.788	14.883	14.988	15.121	15.467	15.794	16.188	16.524	16.639	-27.6	16.657	16.648	16.825	16.685	16.688	16.697
T96-13s	24	10/19/2020 11:37	18.495	18.988	19.005	18.991	18.411	17.18	16.227	15.49	14.922	14.403	13.978	13.821	13.698	13.602	13.574	13.574	13.634	13.725	13.799	13.925	-14.06	14.152	-5986	14.392
T96-13s	24	10/19/2020 11:37	18.493	18.987	19.003	18.99	18.411	17.18	16.227	15.49	14.922	14.402	13.978	13.821	13.698	13.602	13.573	13.564	13.635	13.725	13.799	13.925	14.066	14.147	-6143	14.392
T96-13	24	10/19/2020 11:38	14.058	16.6	15.421	16.477	16.73	16.839	17.179	16.94	17.04	17.081	17.149	17.186	18.885	19.257	18.089	17.212	17.1	17.02	19.138	16.846	16.776	16.64	16.555	16.381
T96-23	24	10/19/2020 13:26	9999.9	9999.9	15.902	13.911	14.508	15.453	15.493	15.624	-12.3	-15.05	16.407	16.774	16.828	16.86	15.922	-14.24	-13.96	16.102	16.982	17.117	-15.69	-15.23	-16.36	17.235
T95-8	24	10/19/2020 13:47	15.533	16.733	16.777	16.919	16.942	16.968	16.946	16.933	17.009	17.03	123.82	25.918	17.012	17.057	17.011	17.055	17.048	17.032	-9999	-9999	-17.19	-17.06	17.126	17.176
T95-8	24	10/19/2020 13:47	15.55	16.733	16.777	16.92	16.942	19.591	16.944	16.971	17.013	17.161	-31.18	17.257	16.999	17.059	17.007	17.067	17.048	17.032	17.058	17.083	17.284	17.069	17.126	17.172
T96-15	14	10/19/2020 14:33	16.841	16.922	16.878	16.879	16.787	16.707	16.661	16.577	16.529	16.513	16.415	16.339	16.287	16.228										
T96-10	24	10/19/2020 14:45	14.787	16.161	34.027	15.764	15.818	15.875	15.913	15.773	15.811	15.749	16.357	15.669	15.571	16.981	20.712	14.991	15.197	16.699	14.783	-13.99	-14.82	14.574	27.211	-1109
T96-10	24	10/19/2020 14:45	14.786	16.16	34.027	15.764	15.818	15.875	15.913	15.773	15.811	15.749	16.357	15.668	15.56	16.981	20.712	14.999	15.197	16.694	14.782	-13.97	14.87	14.566	27.211	-1180
T97-28	24	10/19/2020 14:54	13.495	-12.98	13.691	14.026	14.314	14.17	14.327	14.393	14.468	-13.73	14.643	-14.21	-13.14	9999.9	15.115	-185	14.776	15.155	15.238	0.0374	15.141	-624.3	-19.57	-20.86
T97-28	24	10/19/2020 14:54	13.491	-12.99	13.687	14.023	14.312	14.097	14.322	14.15	14.343	-13.68	14.634	-14.2	-13.11	-9999	15.111	-184.8	14.77	15.154	15.239	0.0374	15.197	-620.7	-19.56	-20.84
T97-29	24	10/19/2020 14:56	13.906	13.86	14.012	-96.63	14.215	-60.11	14.723	-20.43	14.78	14.59	14.891	-630	-14.56	15.824	15.83	15.917	15.752	15.378	15.443	-13.3	14.646	15.023	-14.61	-13.56
T97-29	24	10/19/2020 14:57	13.906	13.86	14.012	-27.36	14.21	-28.57	14.724	-18.57	14.783	14.588	14.897	-564.9	-14.56	15.824	15.828	15.978	15.784	15.376	15.434	-13.32	14.644	15.021	-14.61	-13.58
T97-30	24	10/19/2020 14:58	13.892	13.877	13.899	13.899	14.079	14.045	13.975	13.969	13.968	14.027	14.182	14.415	14.683	14.731	14.878	15.008	15.185	15.166	15.273	15.297	15.627	-1997	-856.1	15.32
T97-30	24	10/19/2020 14:59	13.89	13.877	13.899	13.899	14.079	14.045	13.975	13.969	13.968	14.026	14.182	14.415	14.683	14.732	14.878	15.008	15.185	15.166	15.273	15.297	16.1	-2230	-740.2	15.319
T95-5	24	10/19/2020 16:15	13.935	15.247	16.118	16.438	16.566	16.698	16.76	16.793	16.818	16.82	16.845	16.802	16.8	16.735	16.686	-286.4	16.623	16.48	16.359	16.186	16.12	15.886	15.737	15.558
T05-61	6	10/23/2020 10:54	15.567	18.645	16.314	15.73	16.242	16.425																		
T95-4	24	10/31/2020 15:33	-13.31	-15.42	-12.62	-12.39	-11.06	-33.71	-11.25	-12.56	-11	-10.92	-11.55	-11.47	-9999	9999.9	-9999	-9999	-9999	9999.9	-9999	9999.9	9999.9	9999.9	9999.9	-9999
T95-4	24	10/31/2020 15:56	-13.27	-13.11	-12.49	-12.08	-10.78	-33.64	-11.17	-12.53	-10.92	-13	-11.49	-11.48	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9	9999.9
T14-110*	24	10/20/2020 0:00	33.818	32.576	32.234	31.892	31.766	31.892	31.766	31.892	32	32	32.108	32.234	32.234	32.342	32.45	32.576	32.792	33.134	33.26	33.476	33.818	34.052	34.394	34.736
T14-110*	24	7/14/2020 0:00	31.892	32.792	32.342	31.892	31.766	31.892	31.892	31.892	31.892	32	32	32.234	32.234	32.342	32.45	32.576	32.792	33.026	33.26	33.476	33.818	34.052	34.394	34.61
T14-110*	24	4/25/2020 15:46	31.892	33.26	32.342	31.892	31.766	31.892	31.766	31.892	32	32	32.108	32.234	32.108	32.342	32.45	32.576	32.918	33.026	33.26	33.476	33.818	34.052	34.268	34.61
T14-110*	24	1/10/2020 23:59	33.24	33.71	32	31.89	31.77	31.77	31.77	31.77	32	32	32	32.23	32.23	32.34	32.45	32.58	32.79	33.03	33.26	33.48	33.82	34.05	34.27	34.61

Notes:

Num of Therms = total number of thermistor sensors at each site (string)

Date/Time = mm/dd/yy hh:mm

Measurements are shown in kohms. *T14-110 measurements are in Celsius

Red highlighted data represent measurements that are outside of database criteria and omitted from the database.

Appendix C
Thermistor Plots

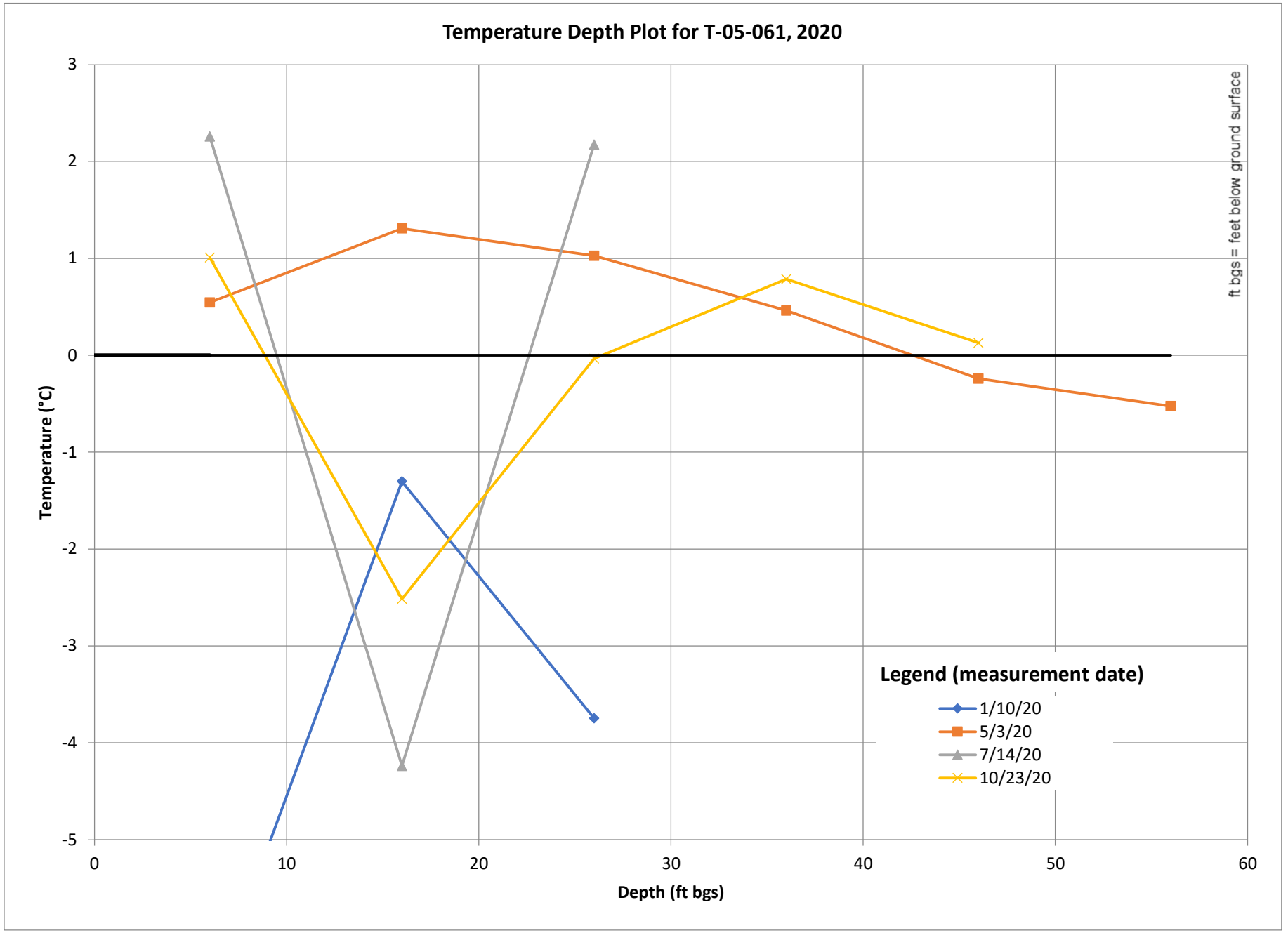
3 plots per thermistor:

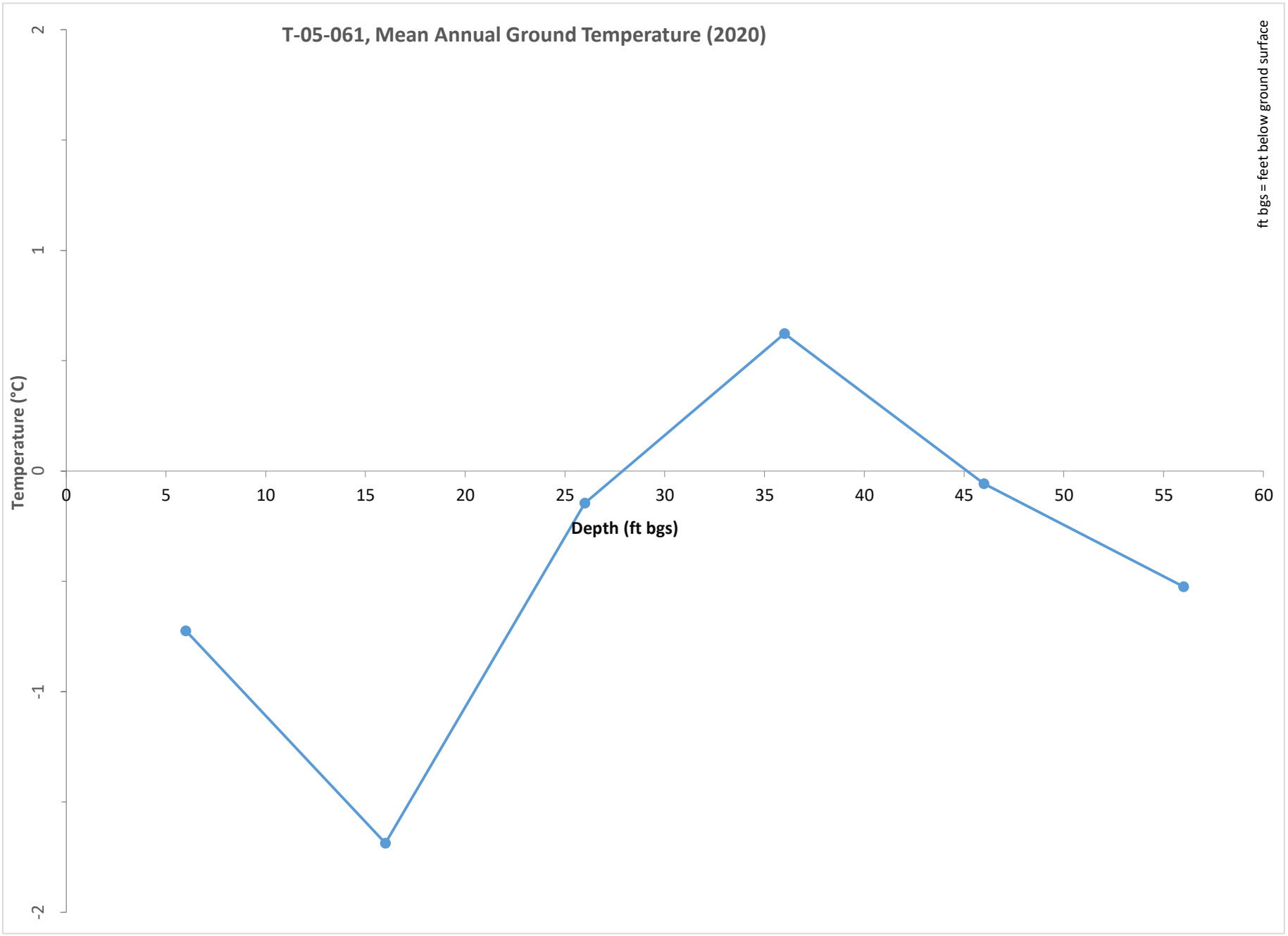
- 2020 quarterly temperatures vs. depth
- 2020 average temperature vs. depth
- Cumulative temperature vs. depth (by quarter)

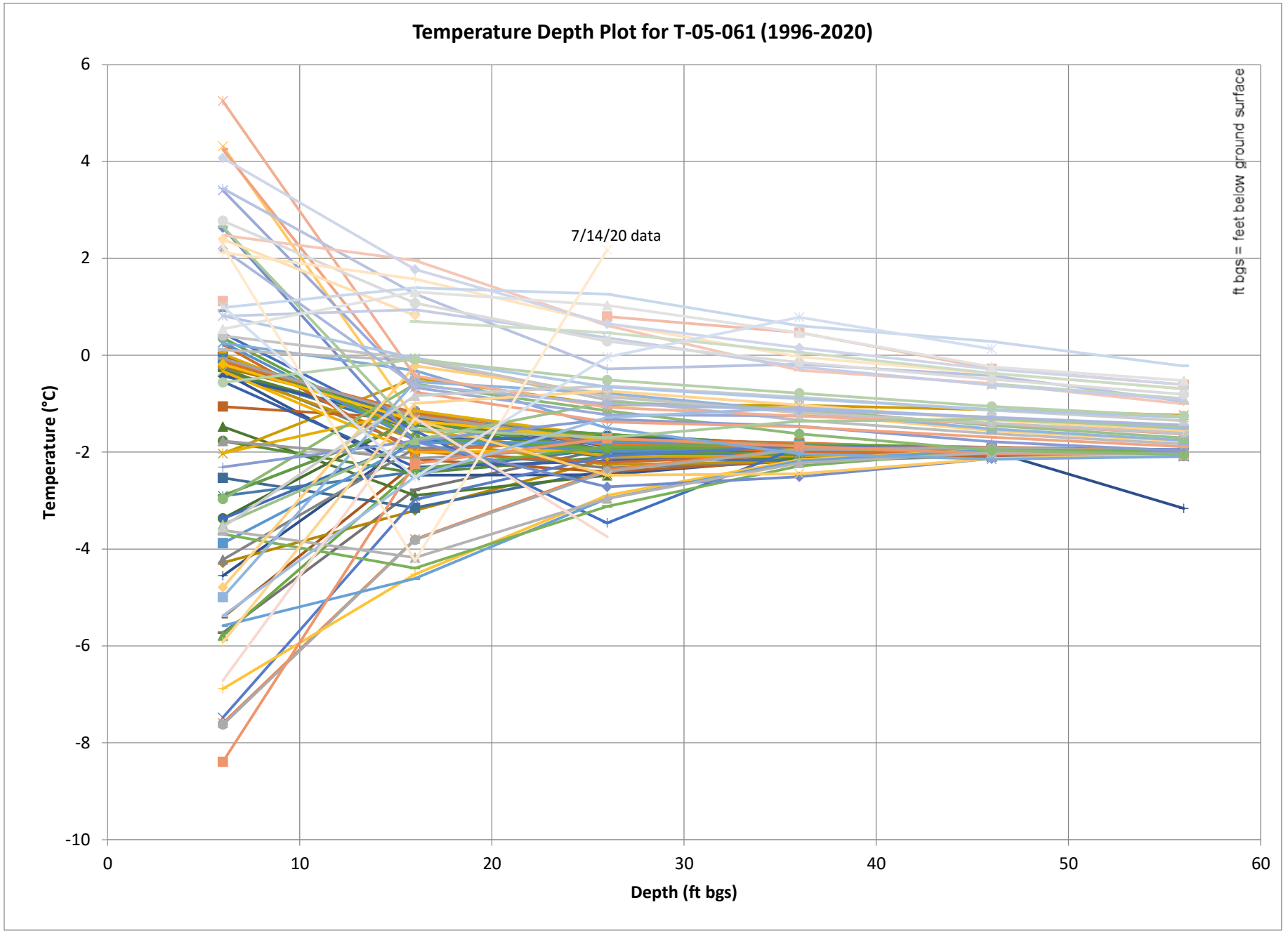
This Page Intentionally Blank

Thermistor T-05-61

This Page Intentionally Blank


Temperature Depth Plot for T-05-061, 2020
Temperature (°C)
3
2
1
0
-1
-2
-3
-4
-5
0
10
20
30
40
50
60
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/14/20
10/23/20

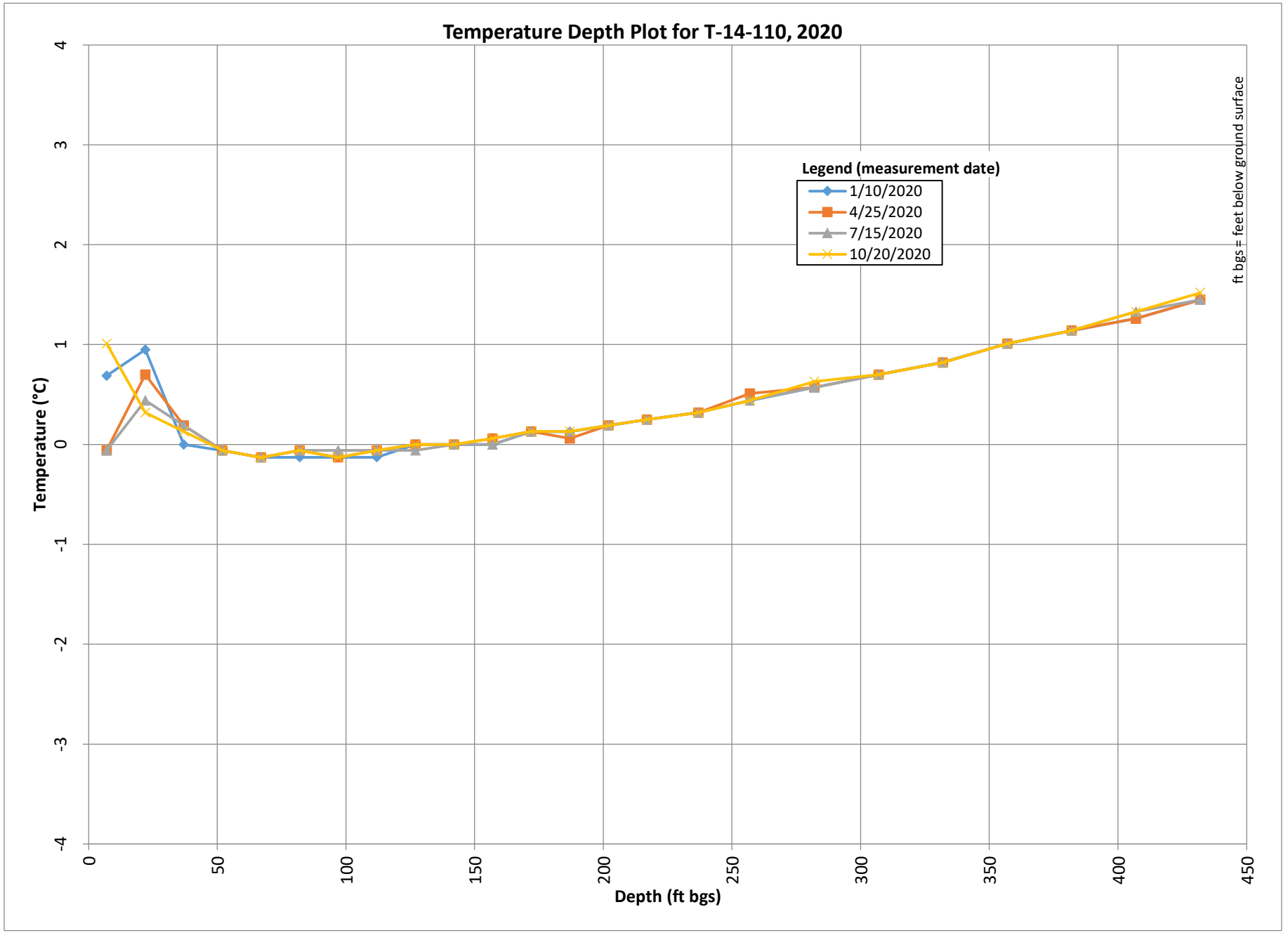

T-05-061, Mean Annual Ground Temperature (2020)
Temperature (°C)
2
1
0
-1
-2
0
5
10
15
20
25
30
35
40
45
50
55
60
Depth (ft bgs)
ft bgs = feet below ground surface

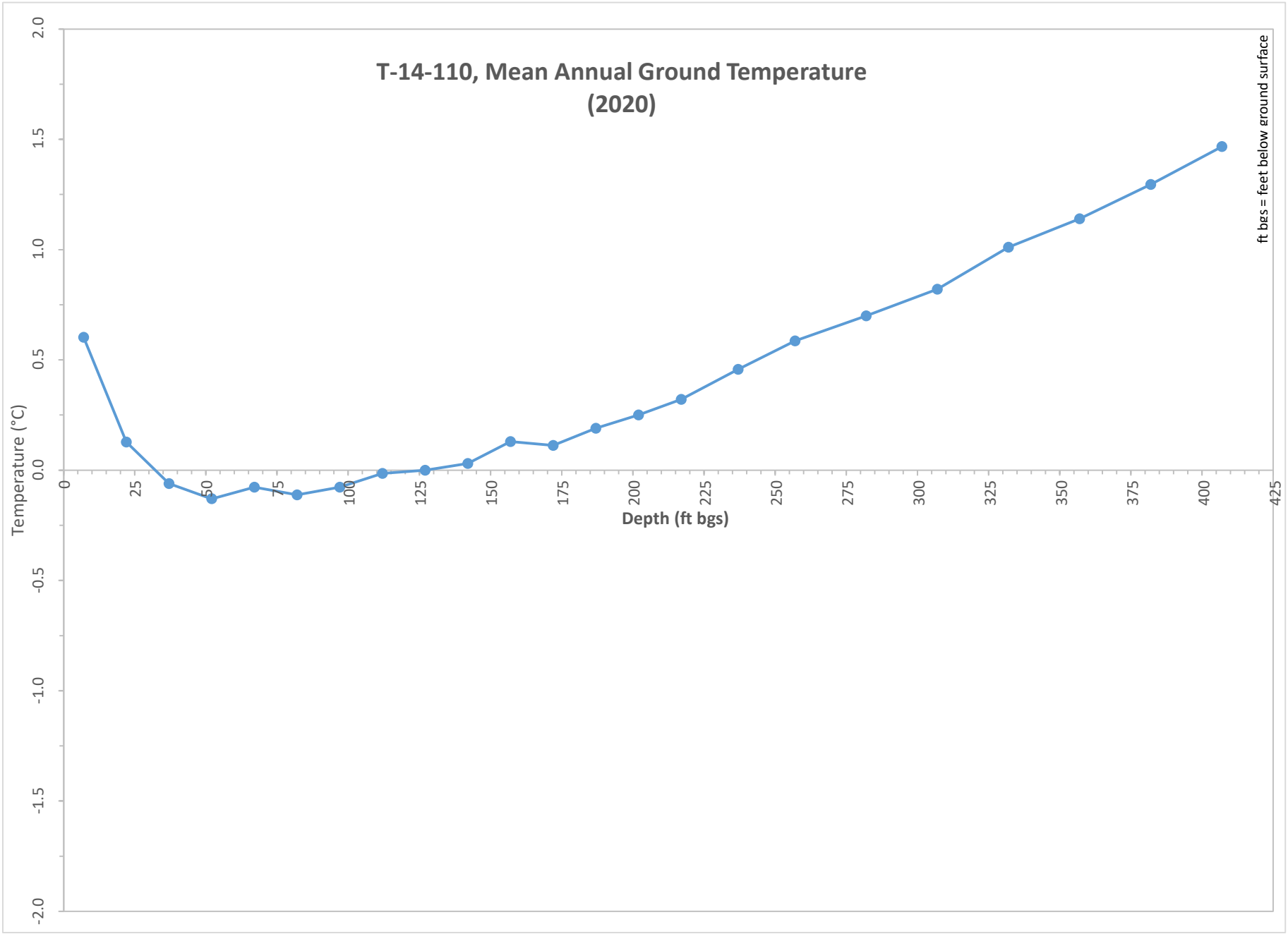

Temperature Depth Plot for T-05-061 (1996-2020)
7/14/20 data
ft bgs = feet below ground surface
Temperature (°C)
Depth (ft bgs)
6
4
2
0
-2
-4
-6
-8
-10
0
10
20
30
40
50
60

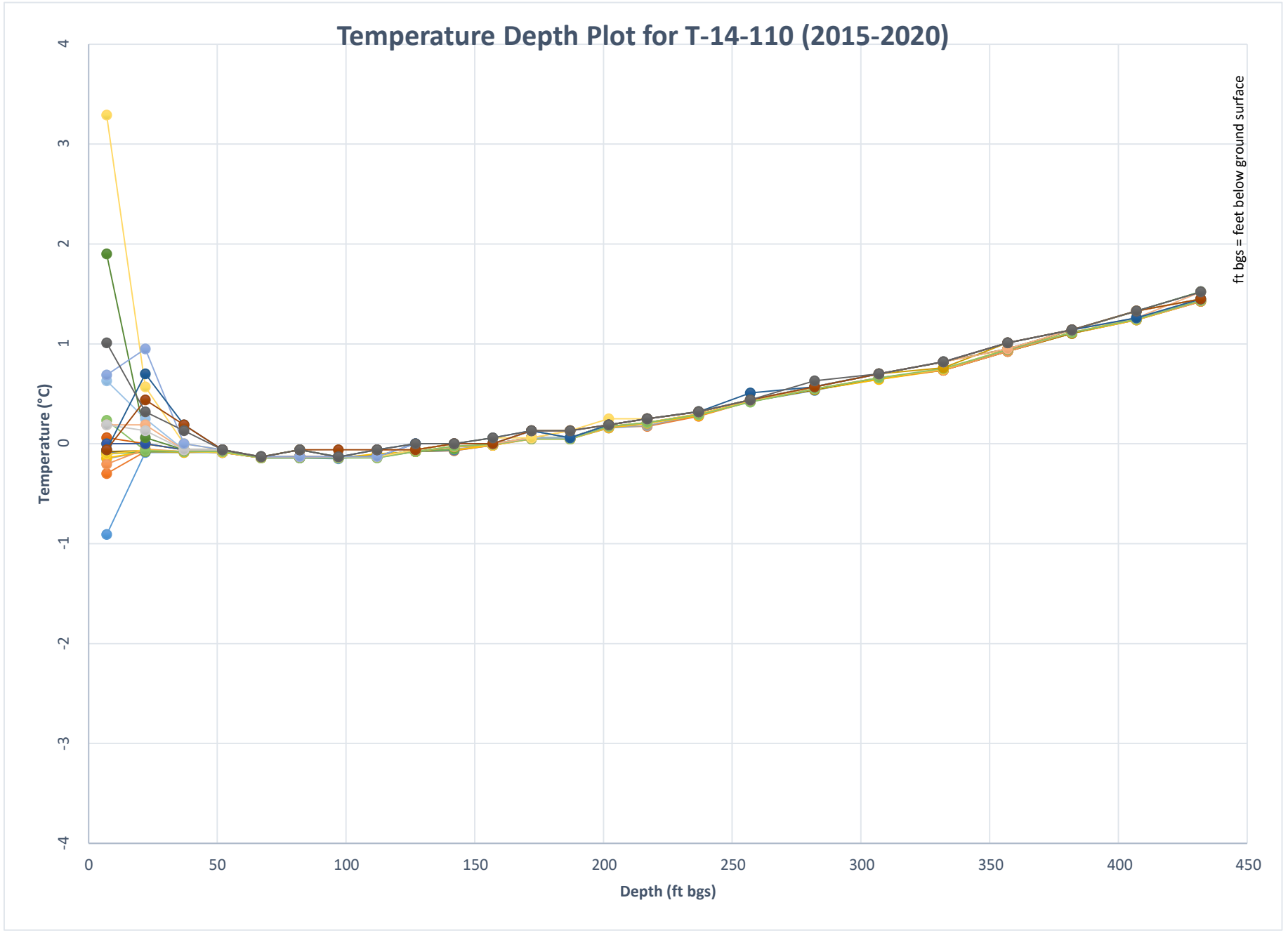
This Page Intentionally Blank

Thermistor T-14-110

This Page Intentionally Blank


Temperature Depth Plot for T-14-110, 2020
Legend (measurement date)
1/10/2020
4/25/2020
7/15/2020
10/20/2020
Temperature (°C)
4
3
2
1
0
-1
-2
-3
-4
0
50
100
150
200
250
300
350
400
450
Depth (ft bgs)
ft bgs = feet below ground surface

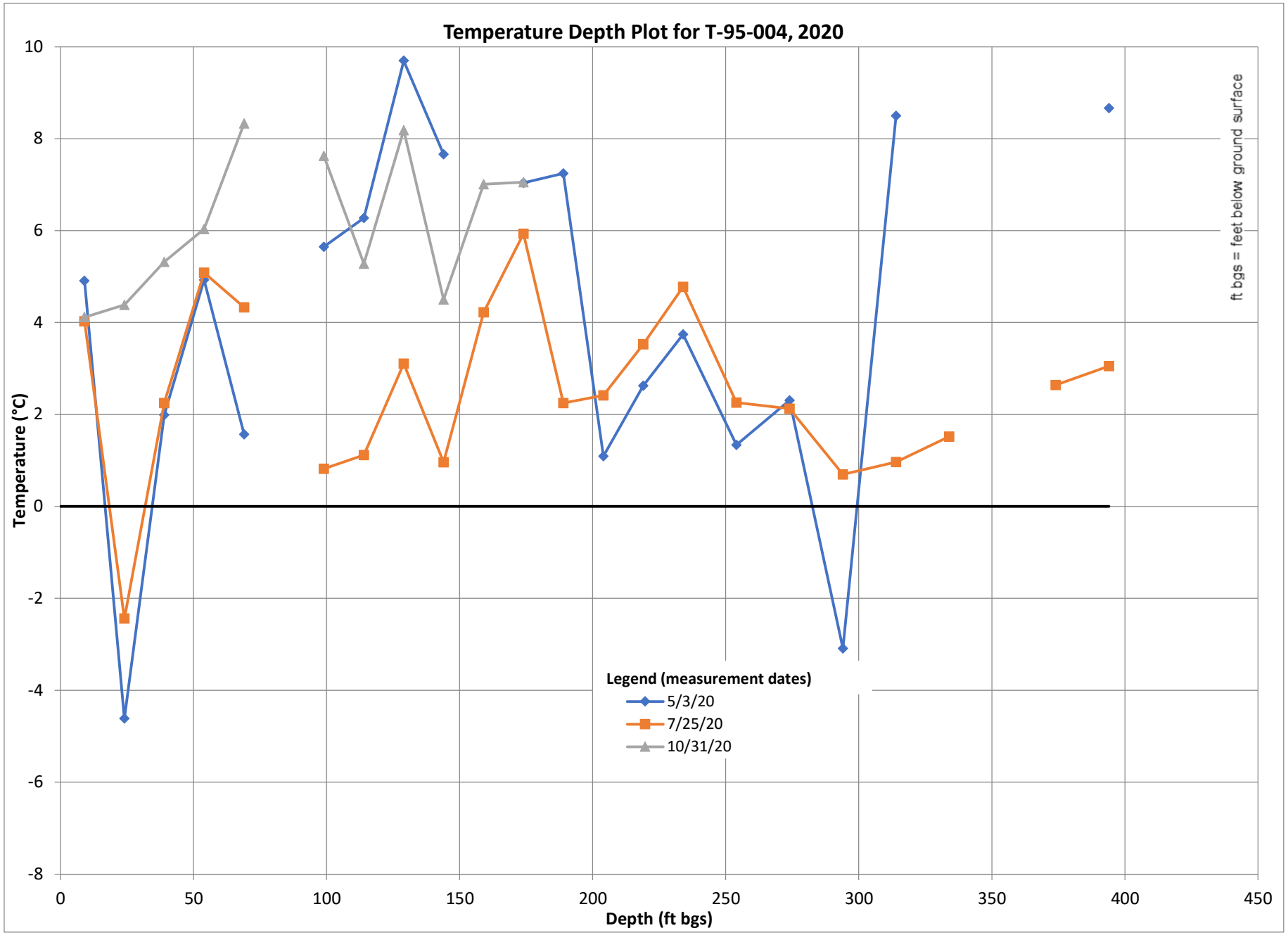

T-14-110, Mean Annual Ground Temperature
(2020)
Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
Depth (ft bgs)
ft bgs = feet below ground surface

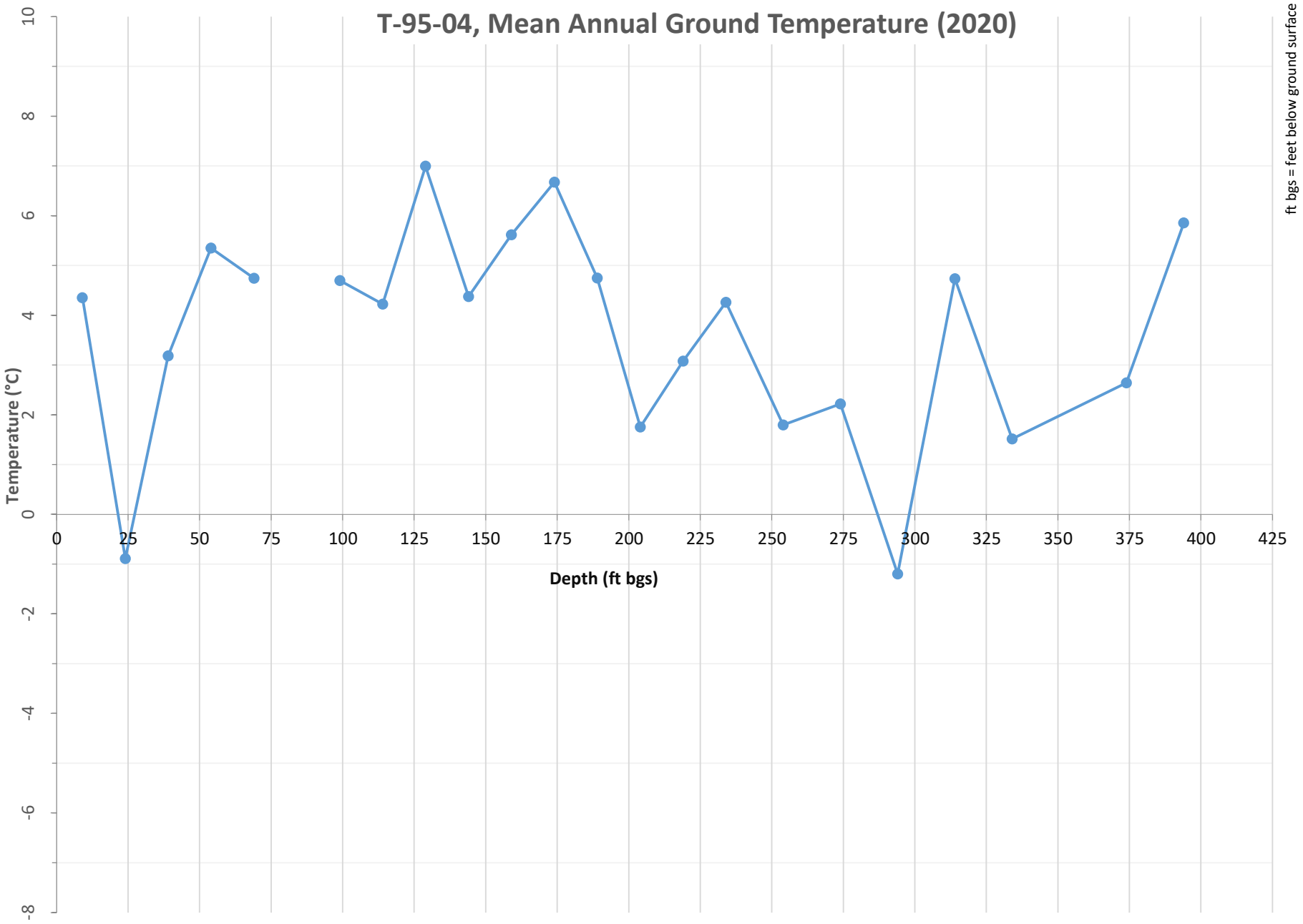

Temperature Depth Plot for T-14-110 (2015-2020)
Temperature (°C)
4
3
2
1
0
-1
-2
-3
-4
0
50
100
150
200
250
300
350
400
450
Depth (ft bgs)
ft bgs = feet below ground surface

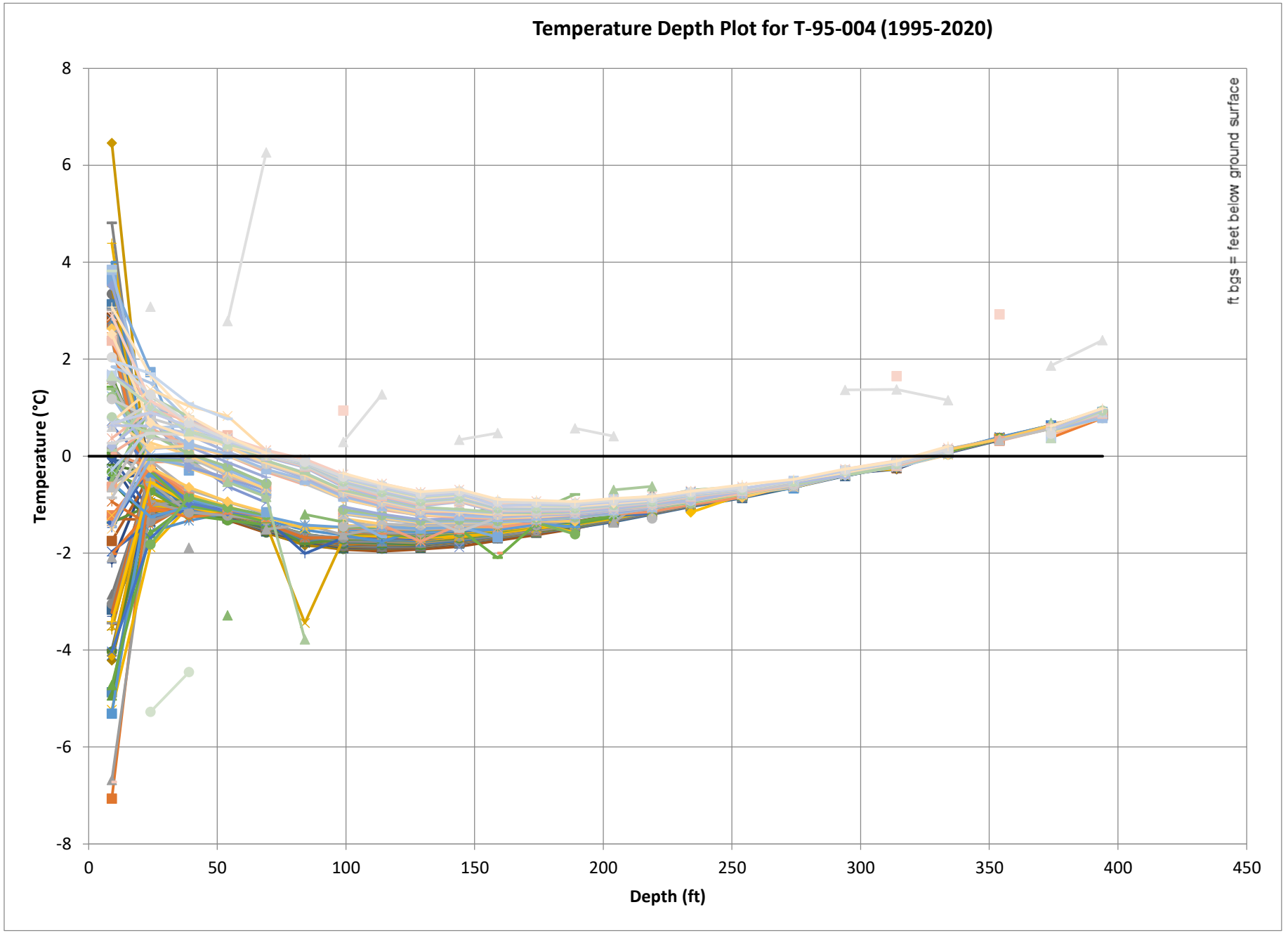
This Page Intentionally Blank

Thermistor T-95-04

This Page Intentionally Blank


Temperature Depth Plot for T-95-004, 2020
Temperature (°C)
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement dates)
5/3/20
7/25/20
10/31/20
10
8
6
4
2
0
-2
-4
-6
-8
0
50
100
150
200
250
300
350
400
450

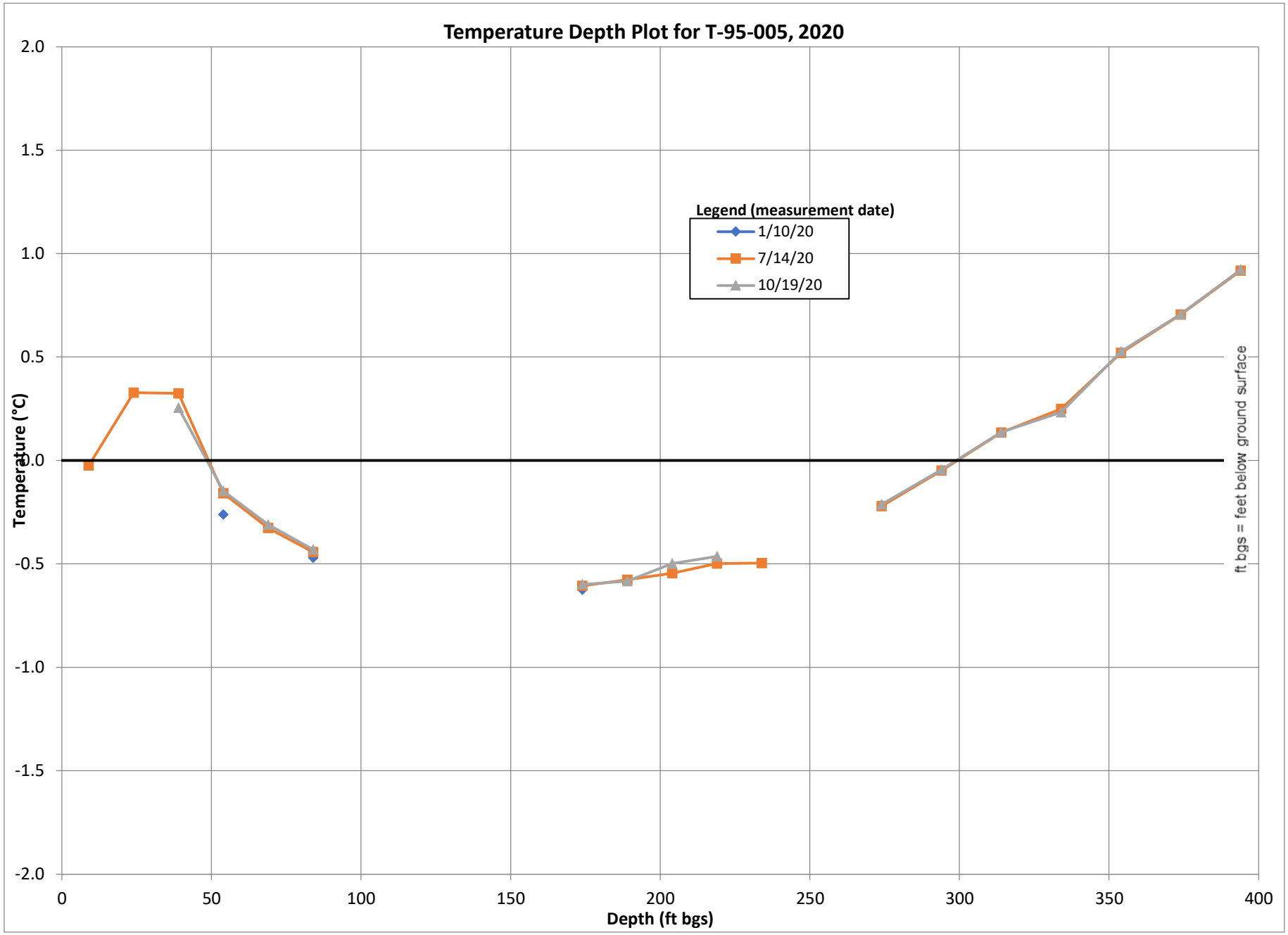

T-95-04, Mean Annual Ground Temperature (2020)
Temperature (°C)
10
8
6
4
2
0
-2
-4
-6
-8
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
Depth (ft bgs)
ft bgs = feet below ground surface

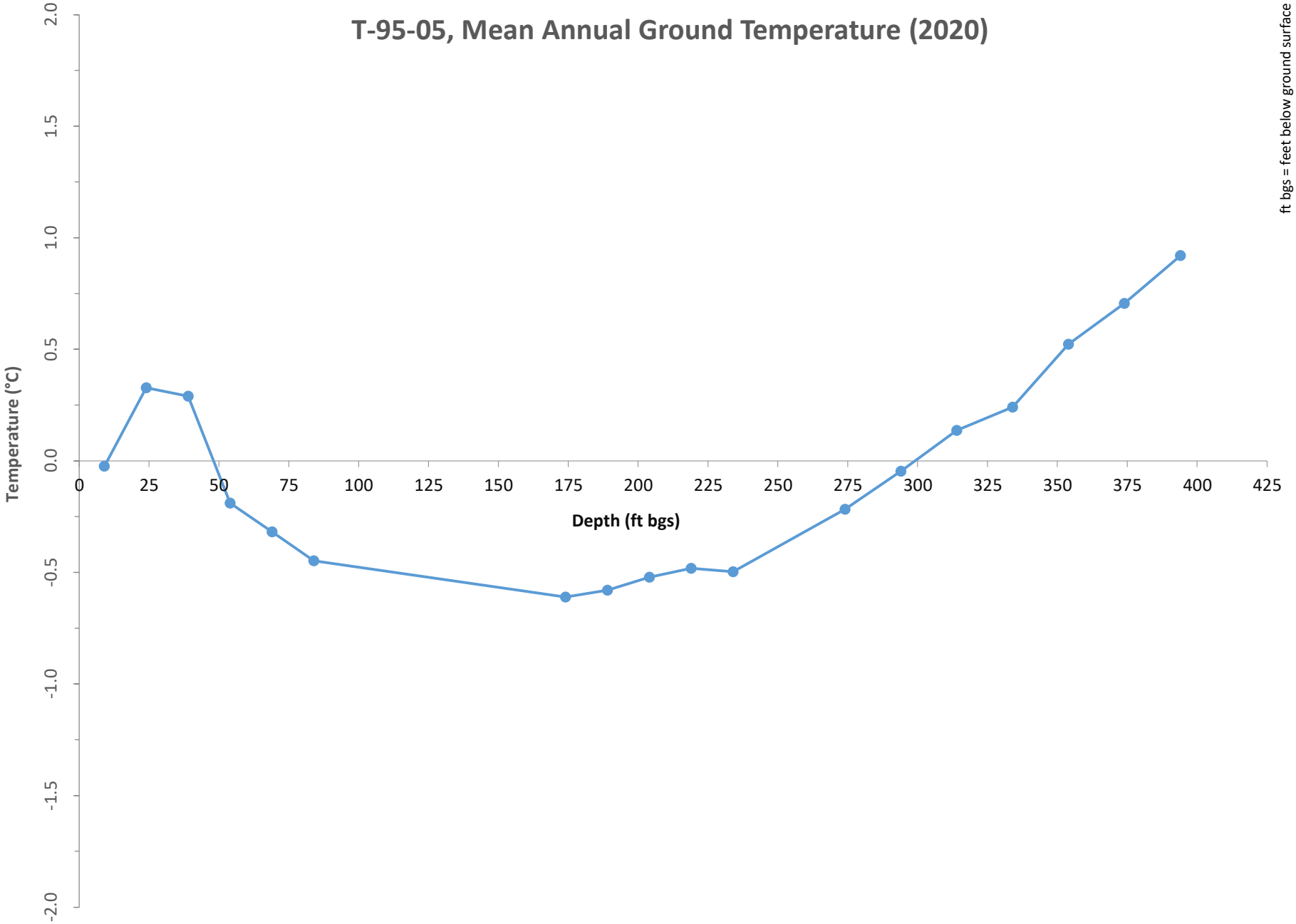

Temperature Depth Plot for T-95-004 (1995-2020)
Temperature (°C)
8
6
4
2
0
-2
-4
-6
-8
0
50
100
150
200
250
300
350
400
450
Depth (ft)
ft bgs = feet below ground surface

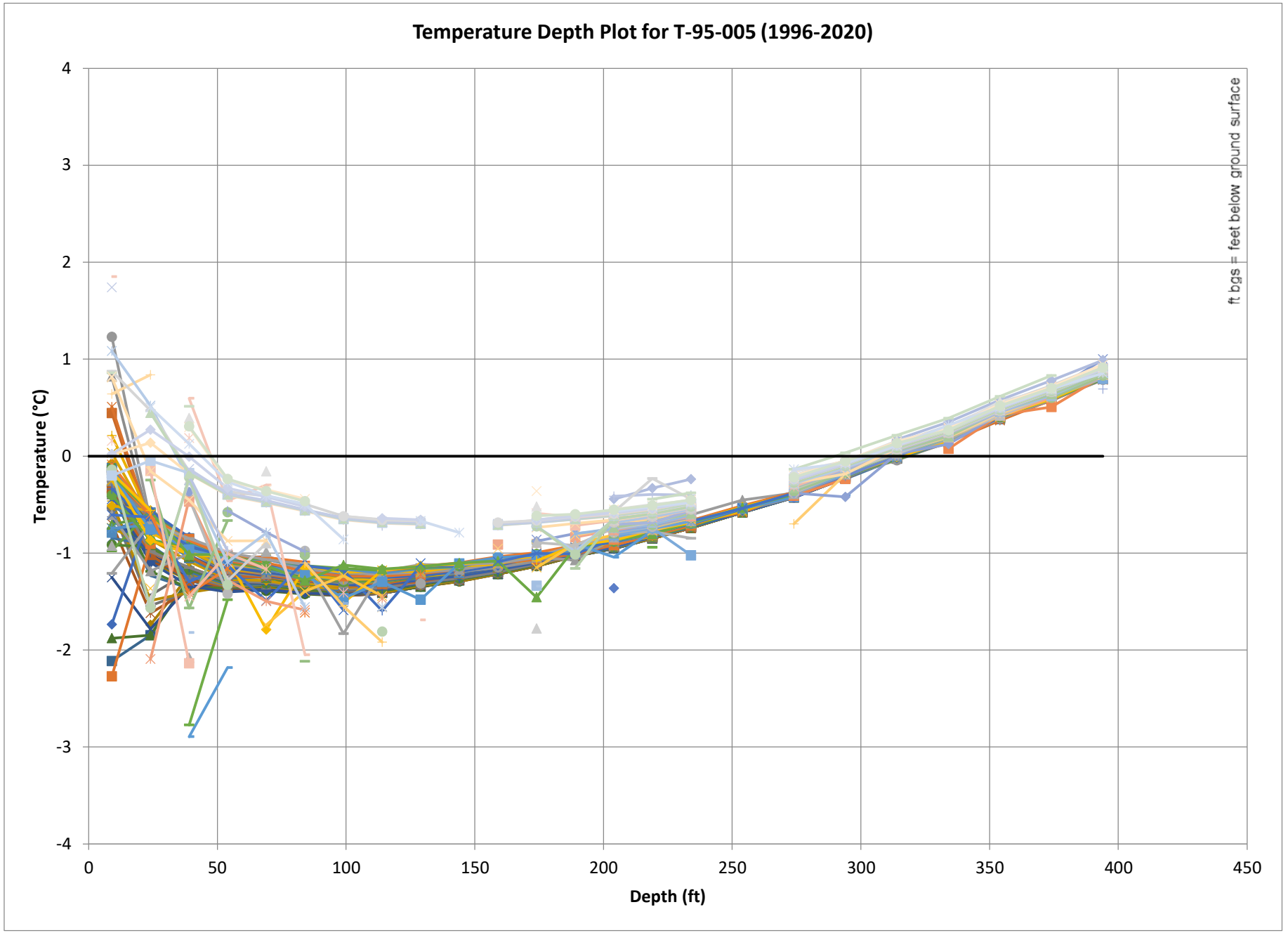
This Page Intentionally Blank

Thermistor T-95-05

This Page Intentionally Blank


Temperature Depth Plot for T-95-005, 2020
Legend (measurement date)
1/10/20
7/14/20
10/19/20
Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
50
100
150
200
250
300
350
400
Depth (ft bgs)
ft bgs = feet below ground surface

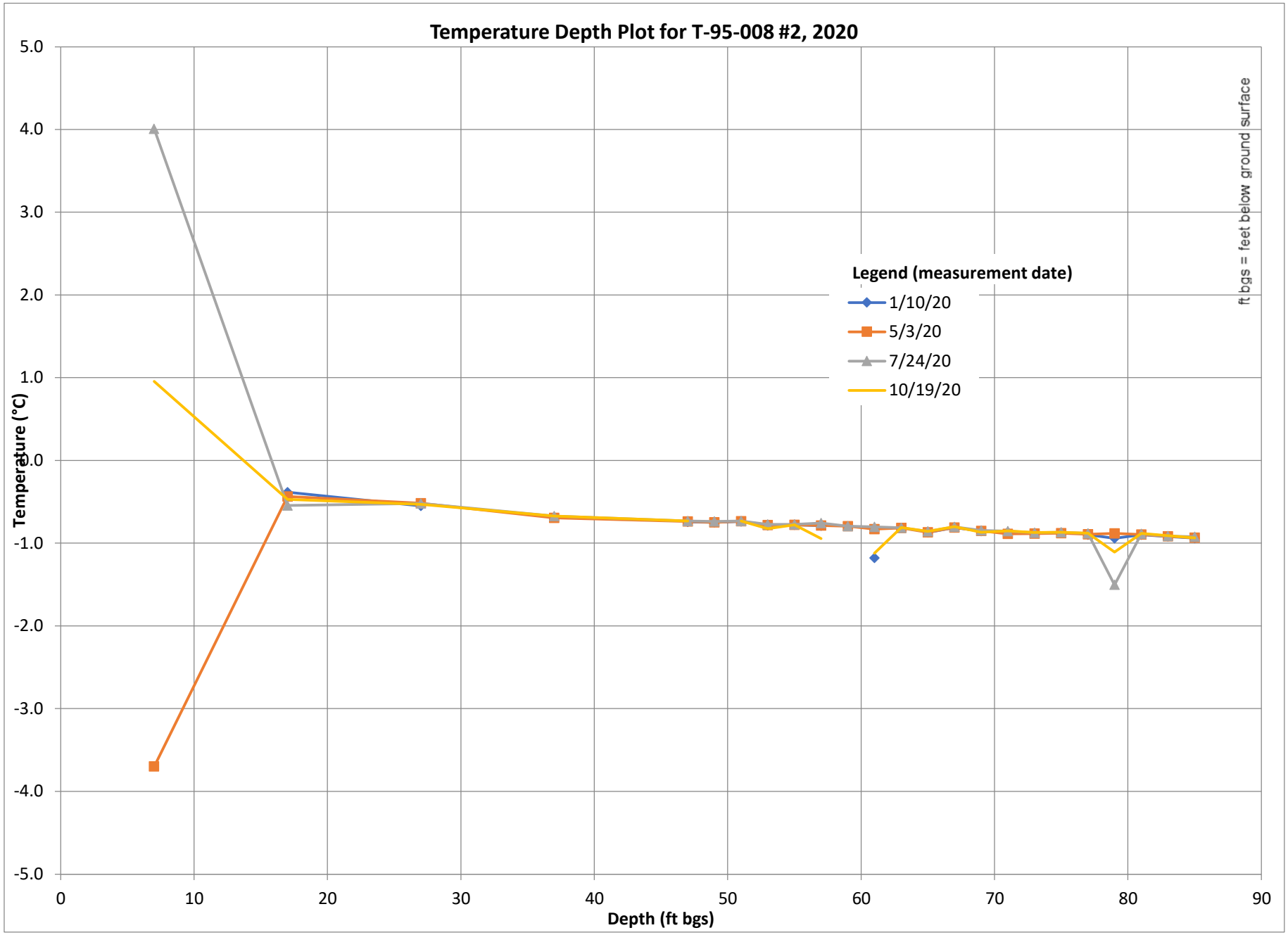

T-95-05, Mean Annual Ground Temperature (2020)
Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
Depth (ft bgs)
ft bgs = feet below ground surface

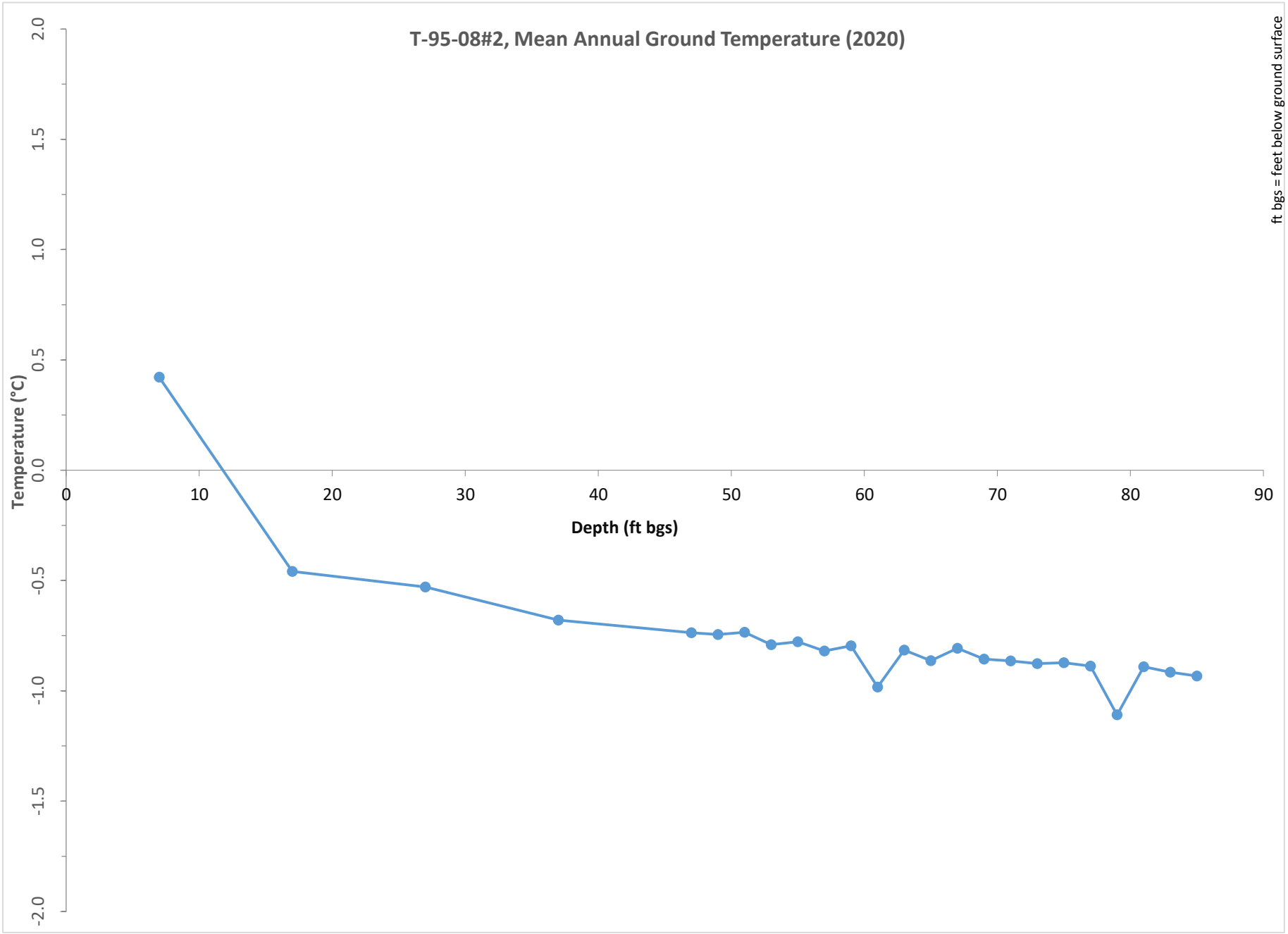

Temperature Depth Plot for T-95-005 (1996-2020)
Temperature (°C)
4
3
2
1
0
-1
-2
-3
-4
0
50
100
150
200
250
300
350
400
450
Depth (ft)
ft bgs = feet below ground surface

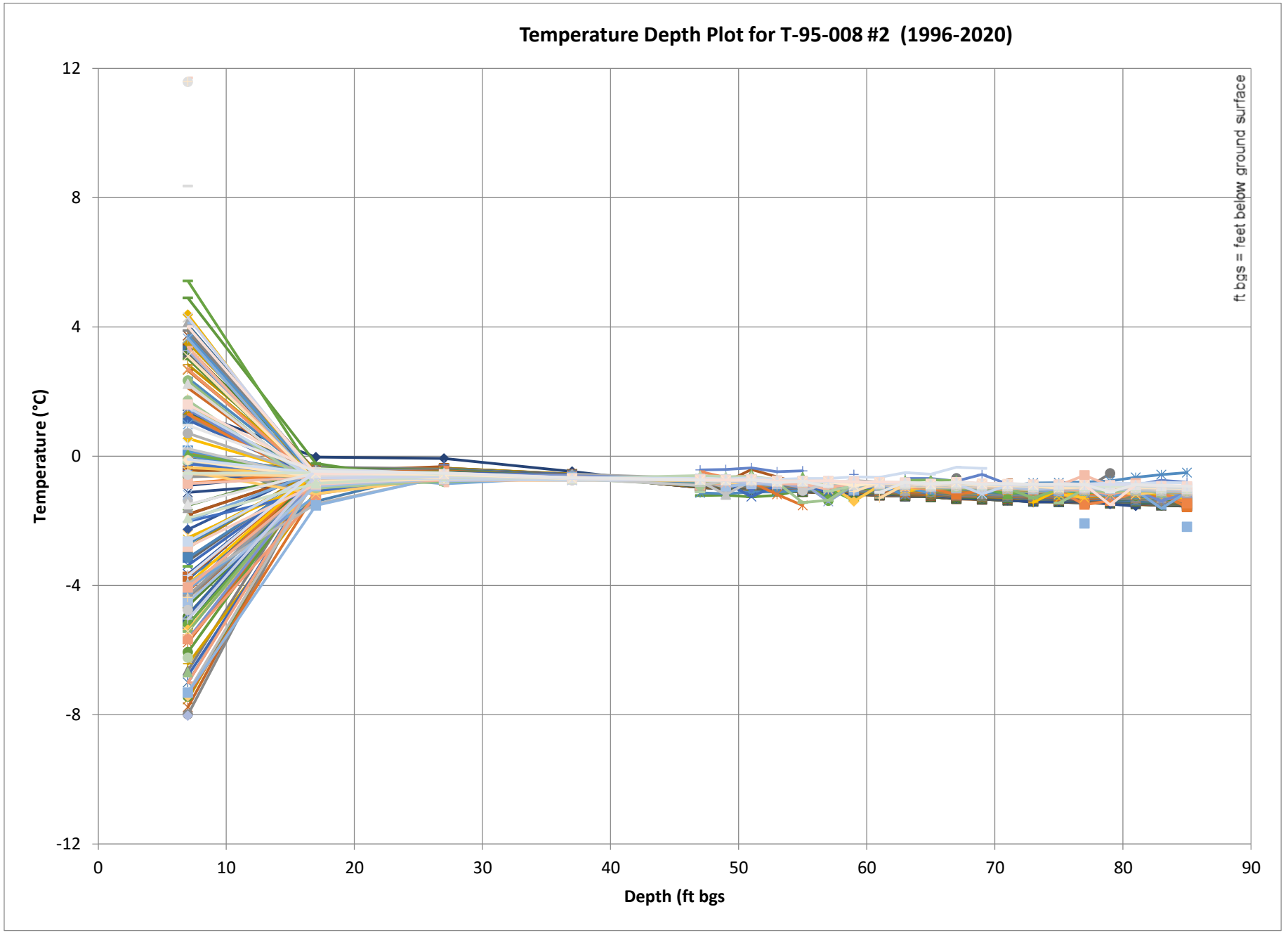
This Page Intentionally Blank

Thermistor T-95-08#2

This Page Intentionally Blank


Temperature Depth Plot for T-95-008 #2, 2020
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
Depth (ft bgs)
Legend (measurement date)
1/10/20
5/3/20
7/24/20
10/19/20
ft bgs = feet below ground surface

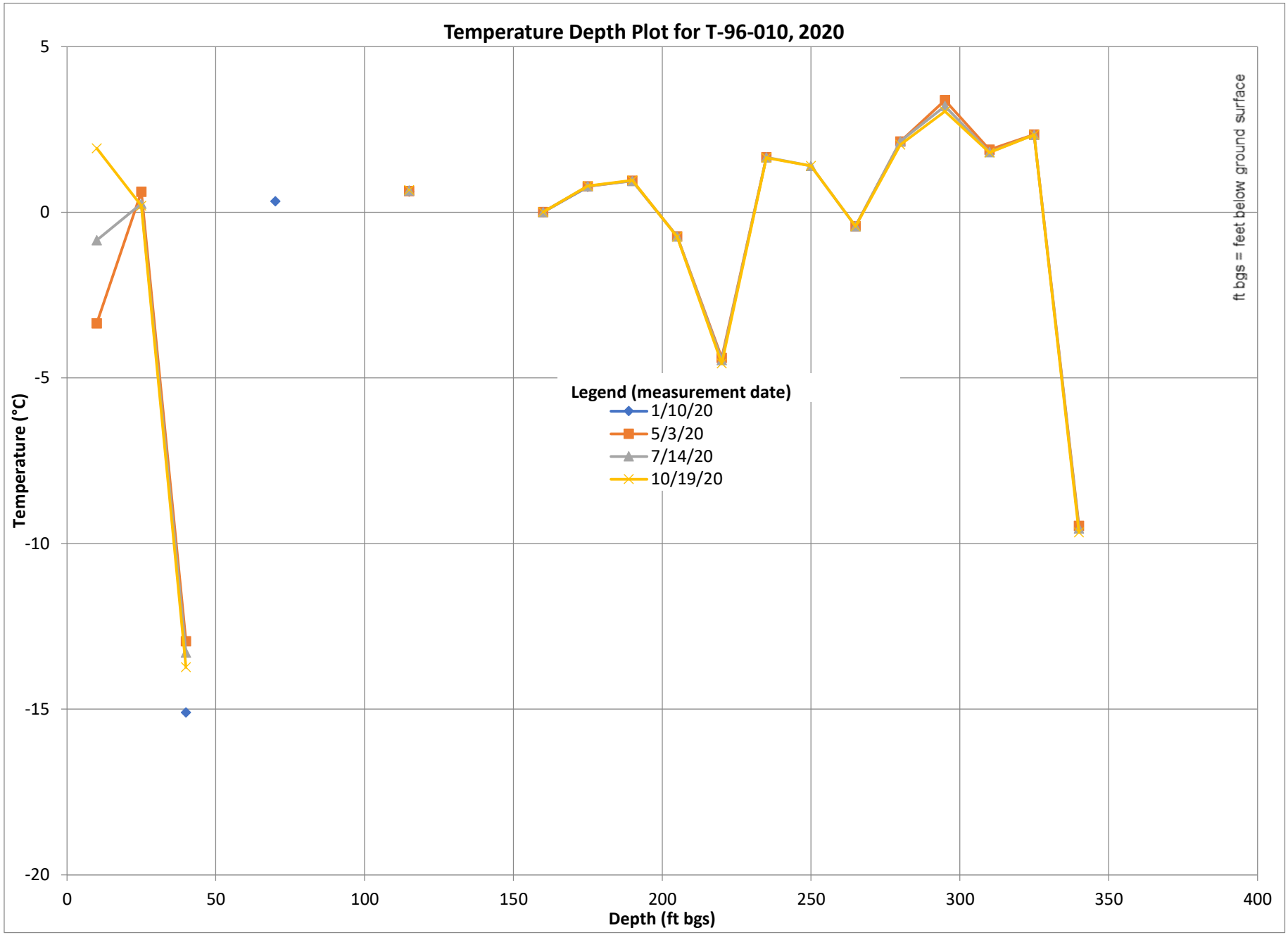

T-95-08#2, Mean Annual Ground Temperature (2020)
Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
Depth (ft bgs)
ft bgs = feet below ground surface

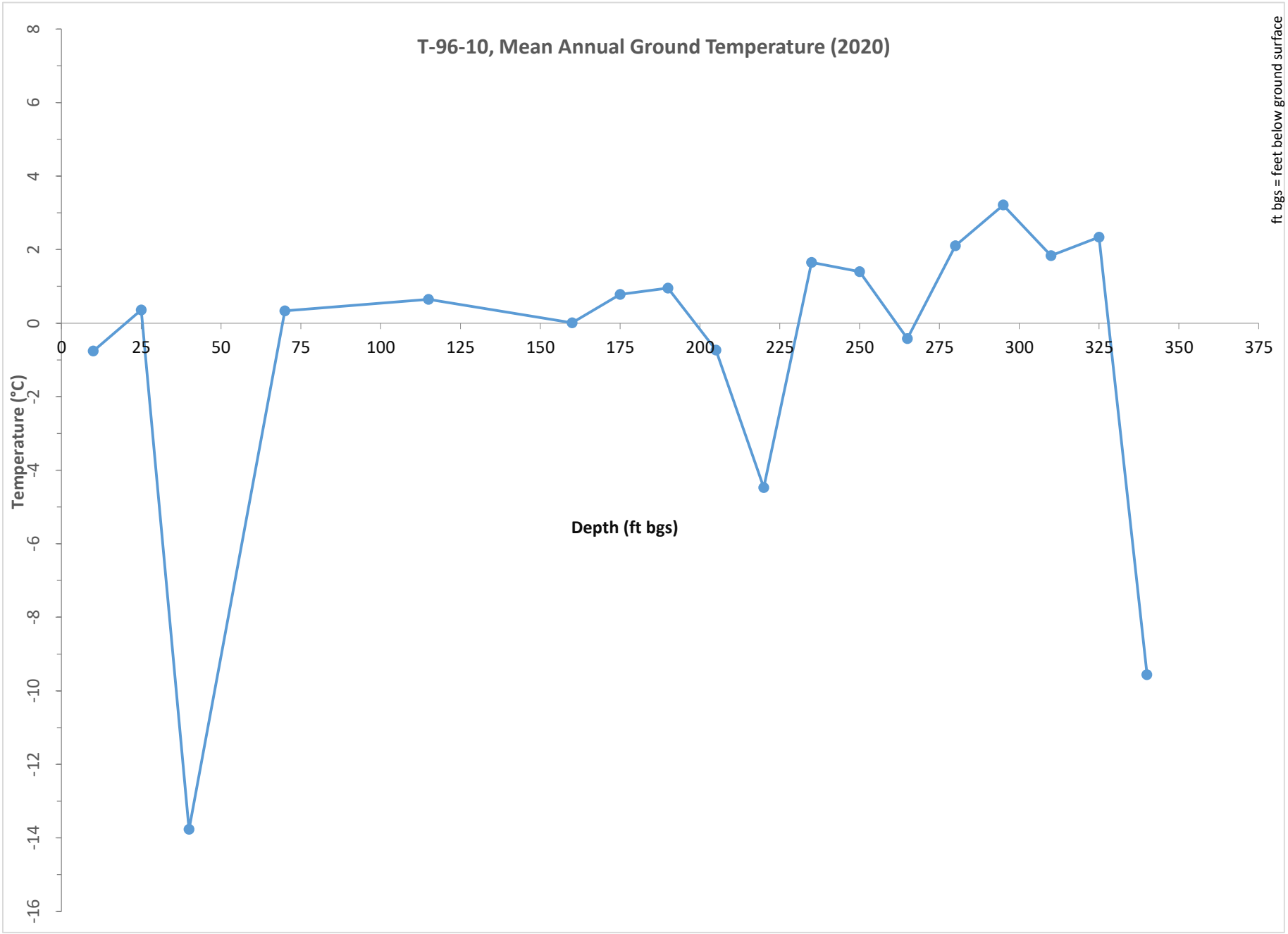

Temperature Depth Plot for T-95-008 #2 (1996-2020)
12
8
4
0
-4
-8
-12
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
Depth (ft bgs
ft bgs = feet below ground surface

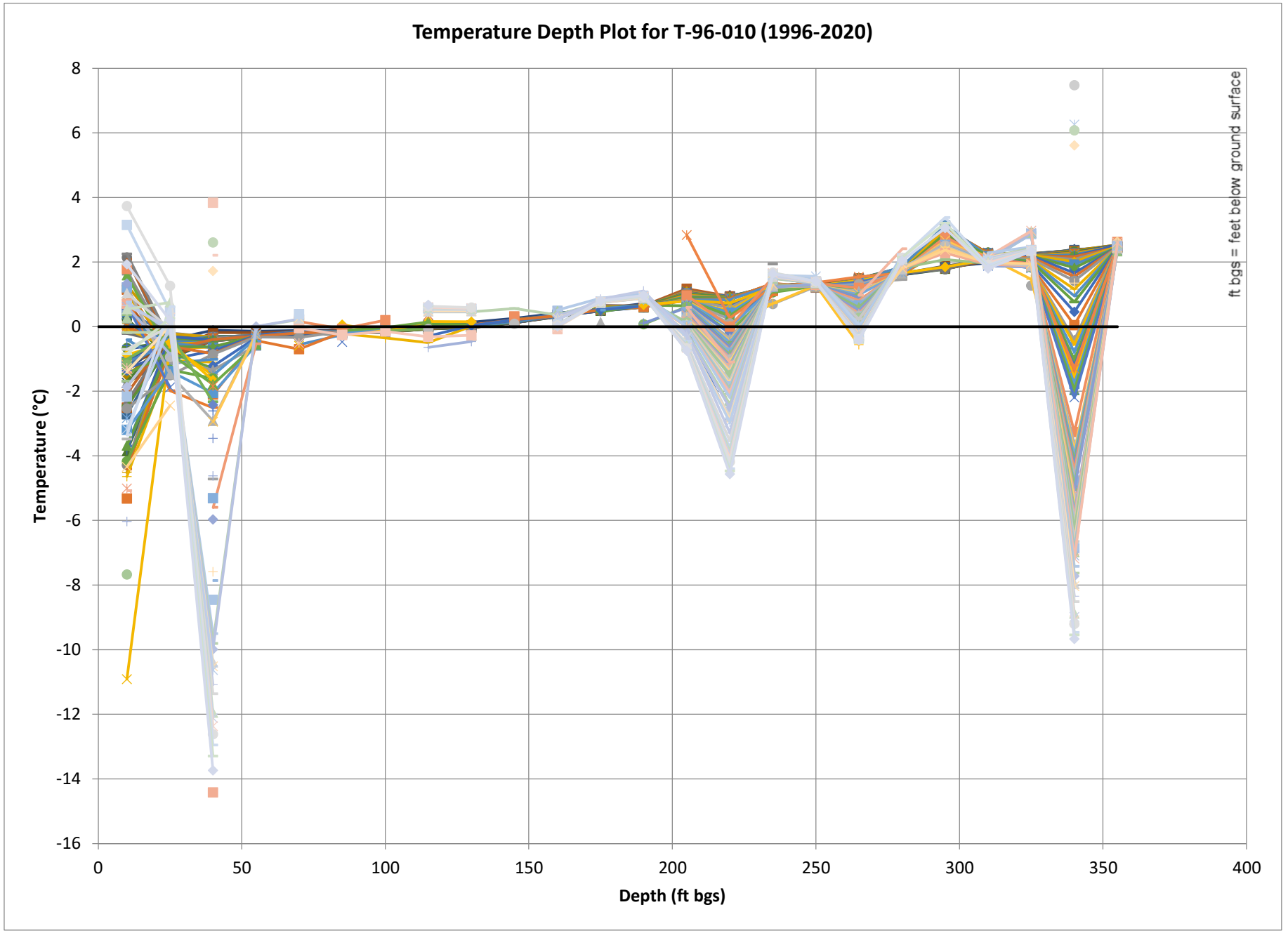
This Page Intentionally Blank

Thermistor T-96-10

This Page Intentionally Blank


Temperature Depth Plot for T-96-010, 2020
5
0
-5
-10
-15
-20
Temperature (°C)
0
50
100
150
200
250
300
350
400
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/14/20
10/19/20

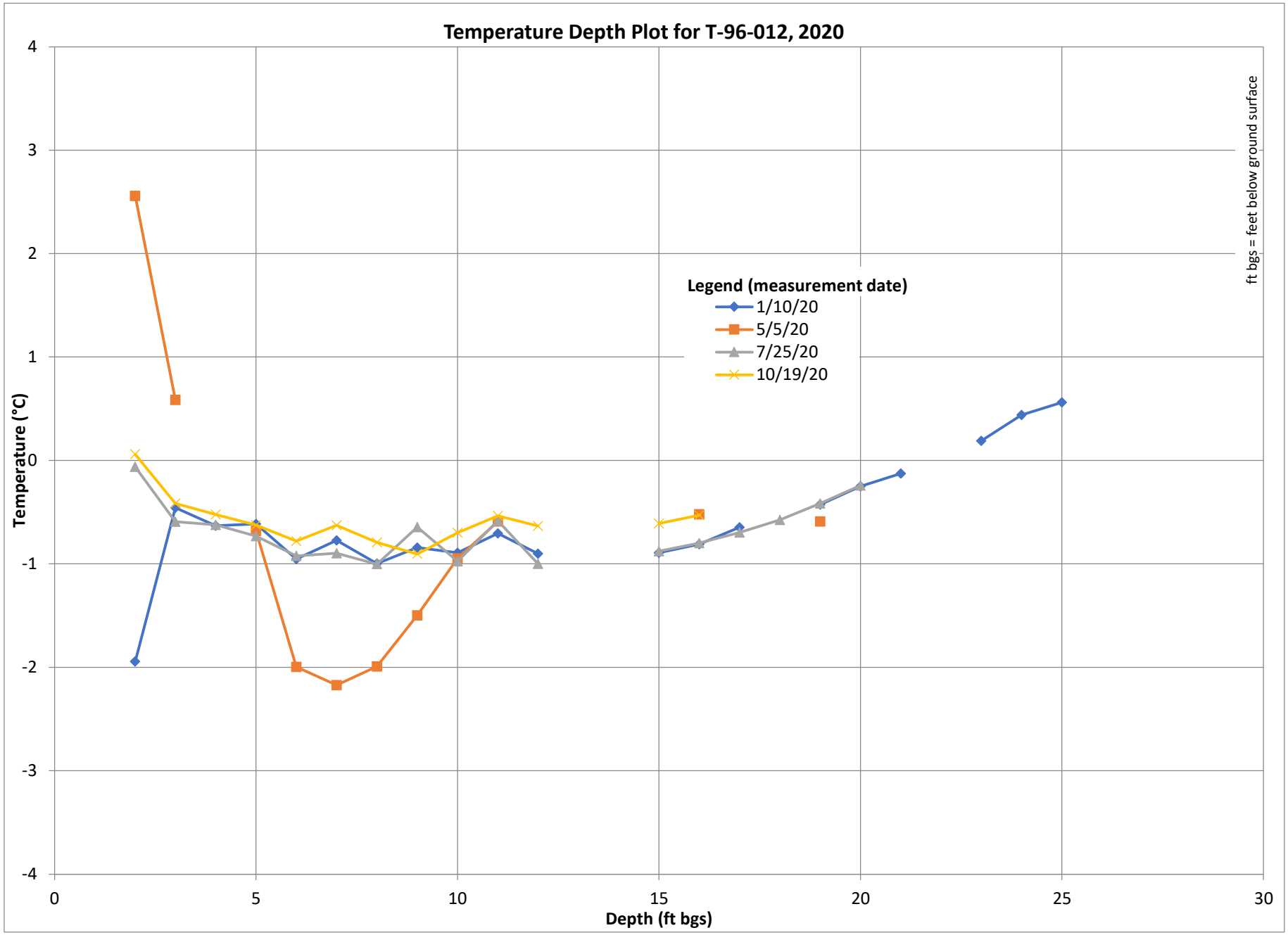

T-96-10, Mean Annual Ground Temperature (2020)
Temperature (°C)
Depth (ft bgs)
ft bgs = feet below ground surface
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375

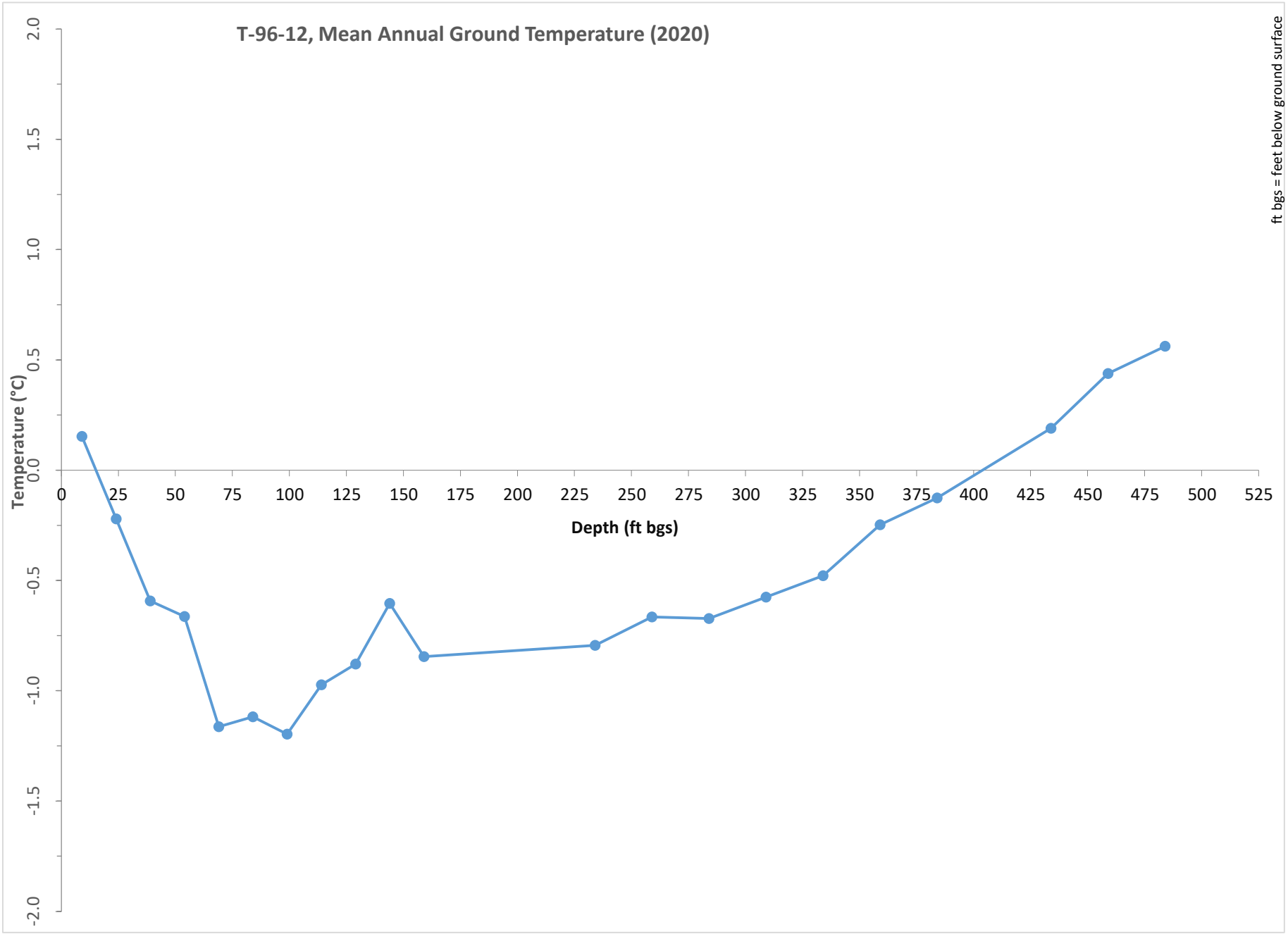

Temperature Depth Plot for T-96-010 (1996-2020)
Temperature (°C)
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
50
100
150
200
250
300
350
400
Depth (ft bgs)
ft bgs = feet below ground surface

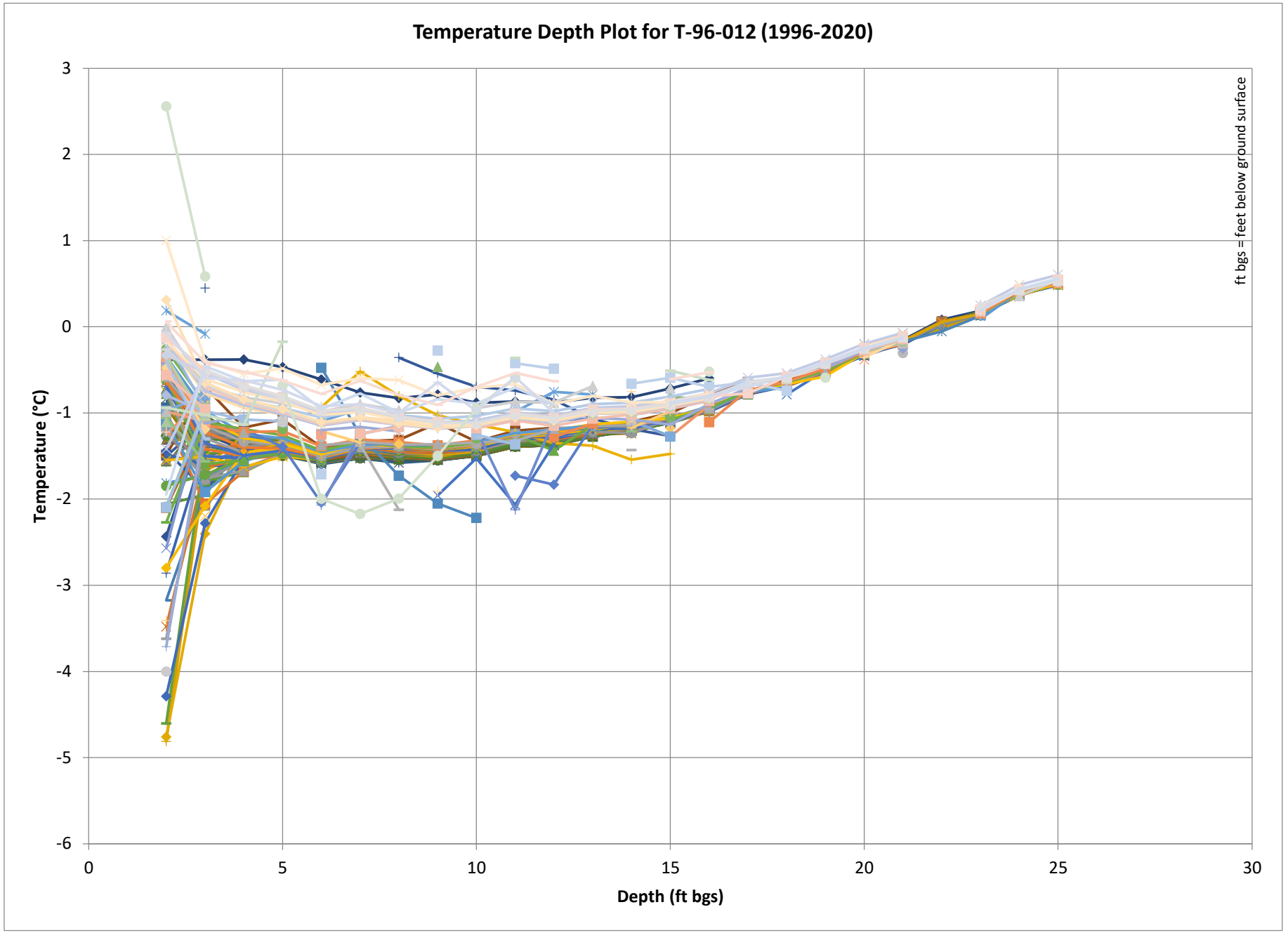
This Page Intentionally Blank

Thermistor T-96-12

This Page Intentionally Blank


Temperature Depth Plot for T-96-012, 2020
Temperature (°C)
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/5/20
7/25/20
10/19/20
4
3
2
1
0
-1
-2
-3
-4
0
5
10
15
20
25
30

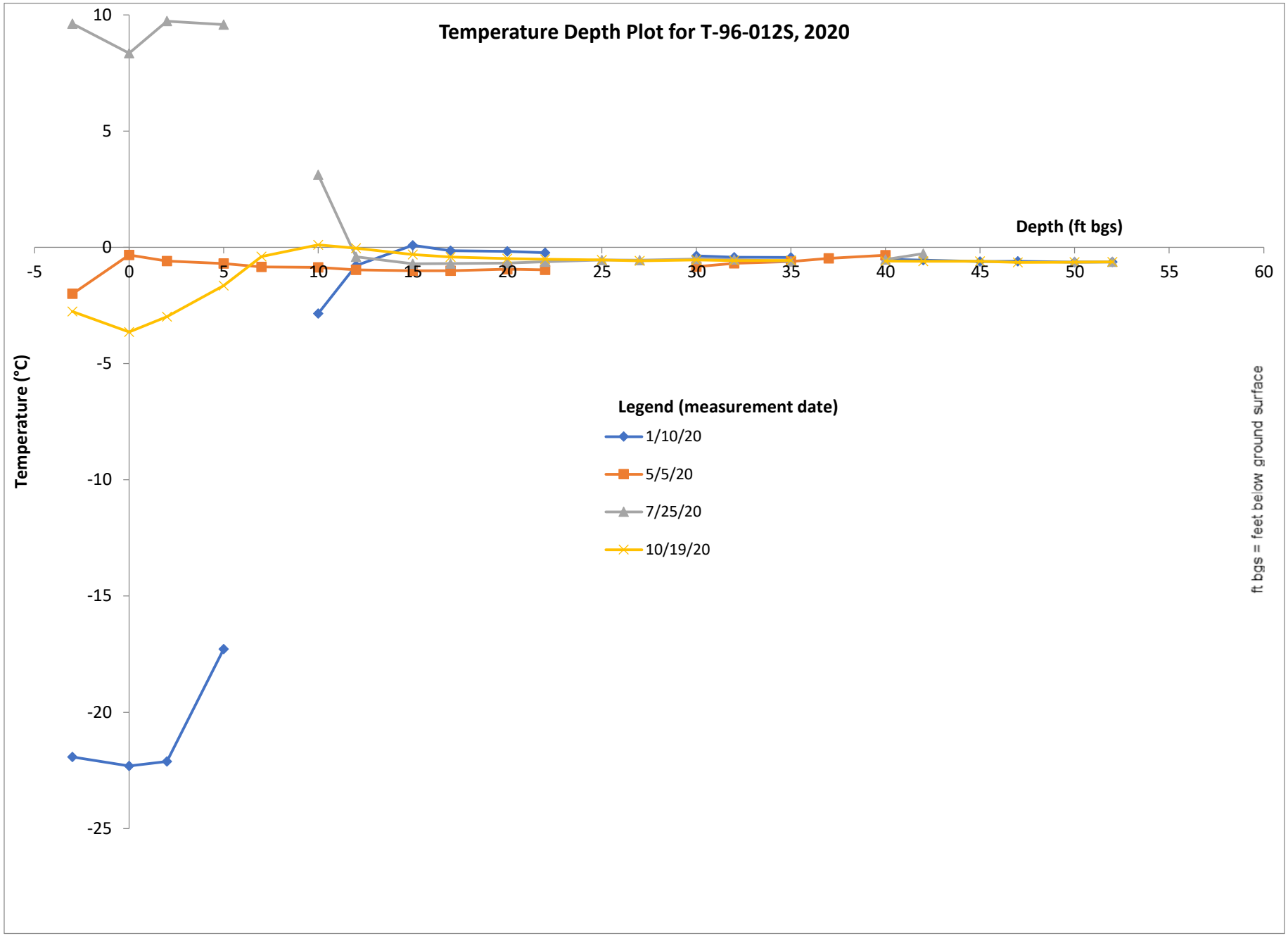

T-96-12, Mean Annual Ground Temperature (2020)
Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
500
525
Depth (ft bgs)
ft bgs = feet below ground surface

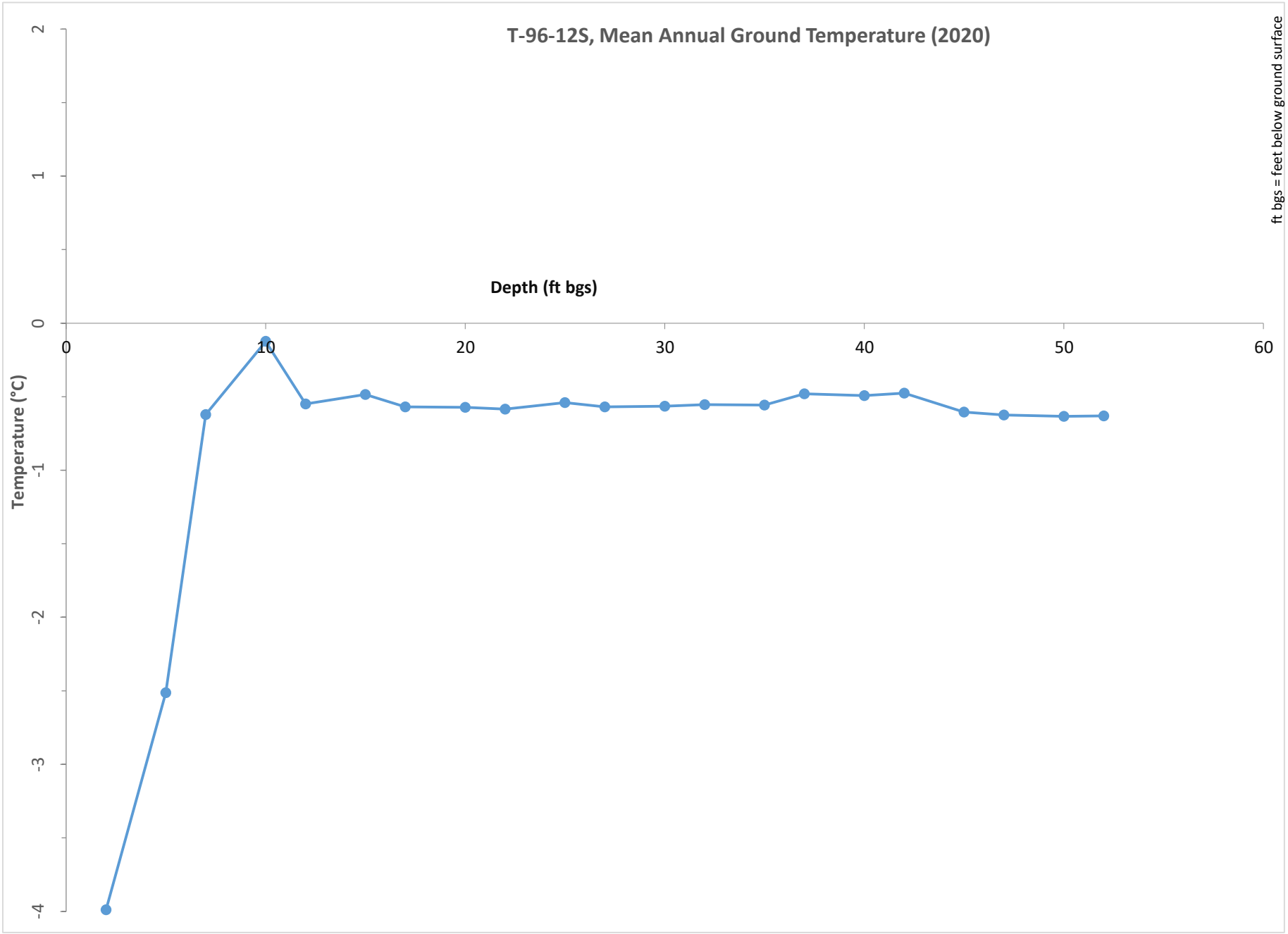

Temperature Depth Plot for T-96-012 (1996-2020)
Temperature (°C)
3
2
1
0
-1
-2
-3
-4
-5
-6
0
5
10
15
20
25
30
Depth (ft bgs)
ft bgs = feet below ground surface

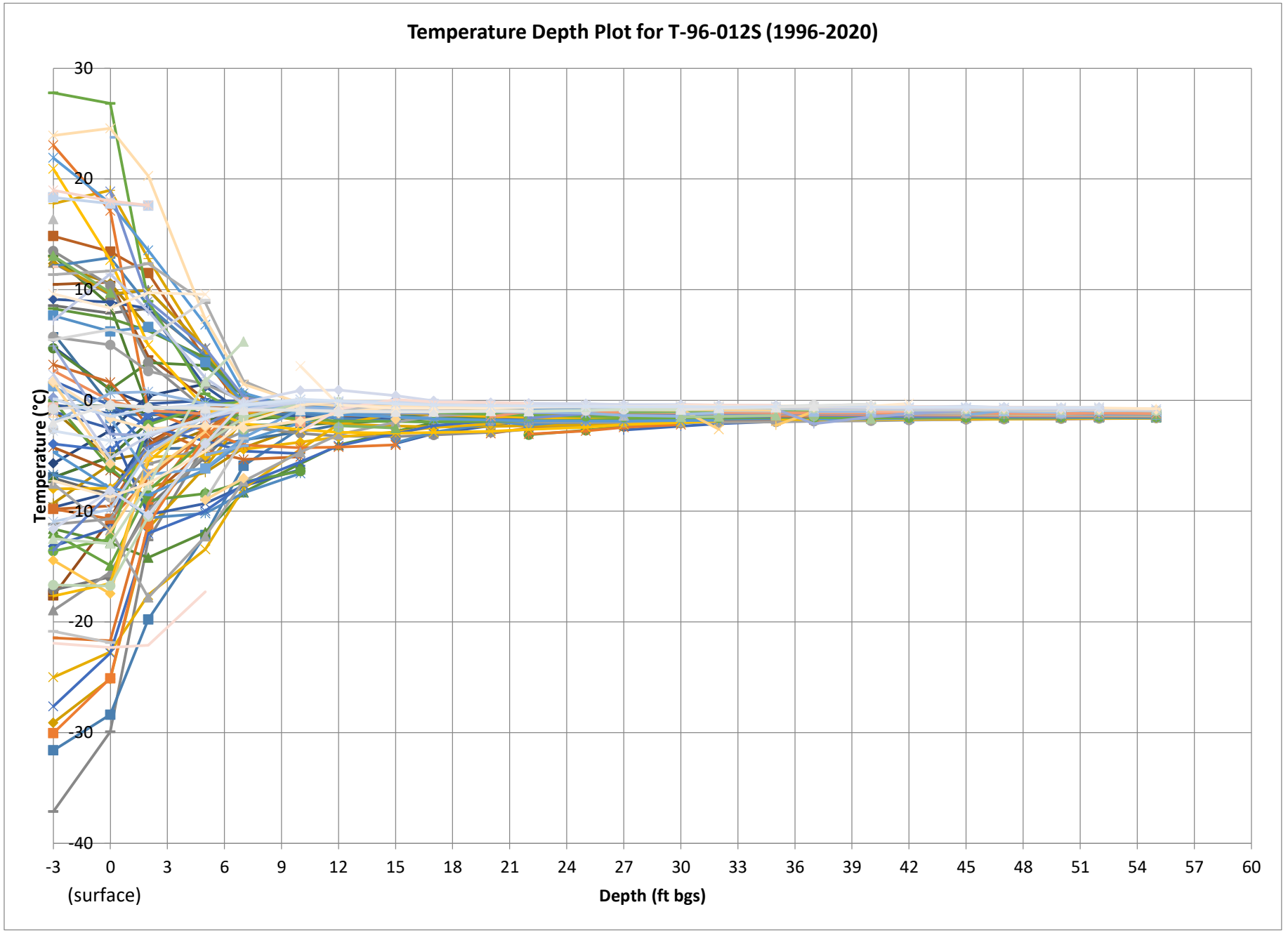
This Page Intentionally Blank

Thermistor T-96-12S

This Page Intentionally Blank


Temperature Depth Plot for T-96-012S, 2020
Depth (ft bgs)
Temperature (°C)
10
5
0
-5
-10
-15
-20
-25
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
Legend (measurement date)
1/10/20
5/5/20
7/25/20
10/19/20
ft bgs = feet below ground surface

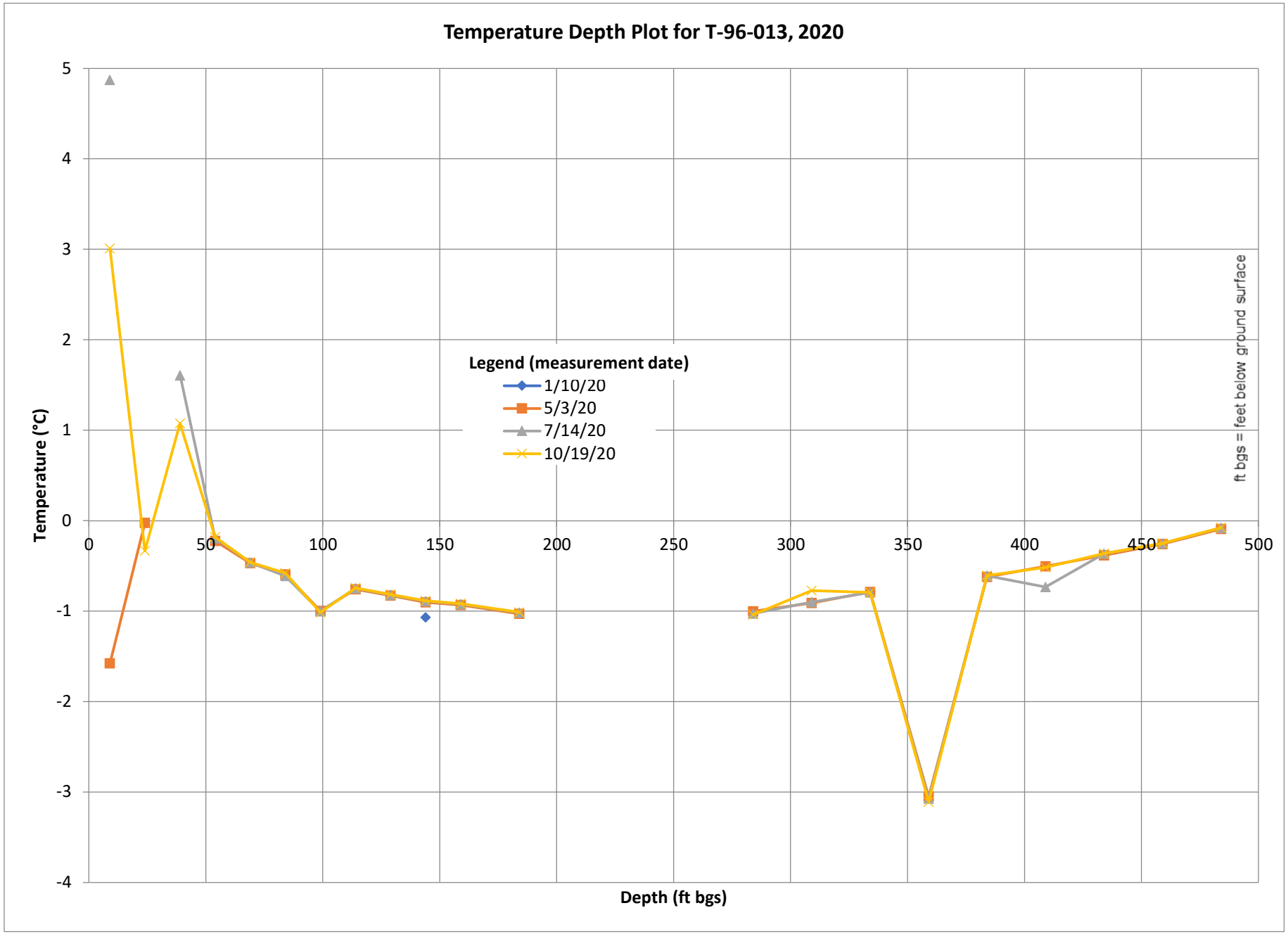

T-96-12S, Mean Annual Ground Temperature (2020)
Depth (ft bgs)
Temperature (°C)
ft bgs = feet below ground surface
2
1
0
-1
-2
-3
-4
0
10
20
30
40
50
60

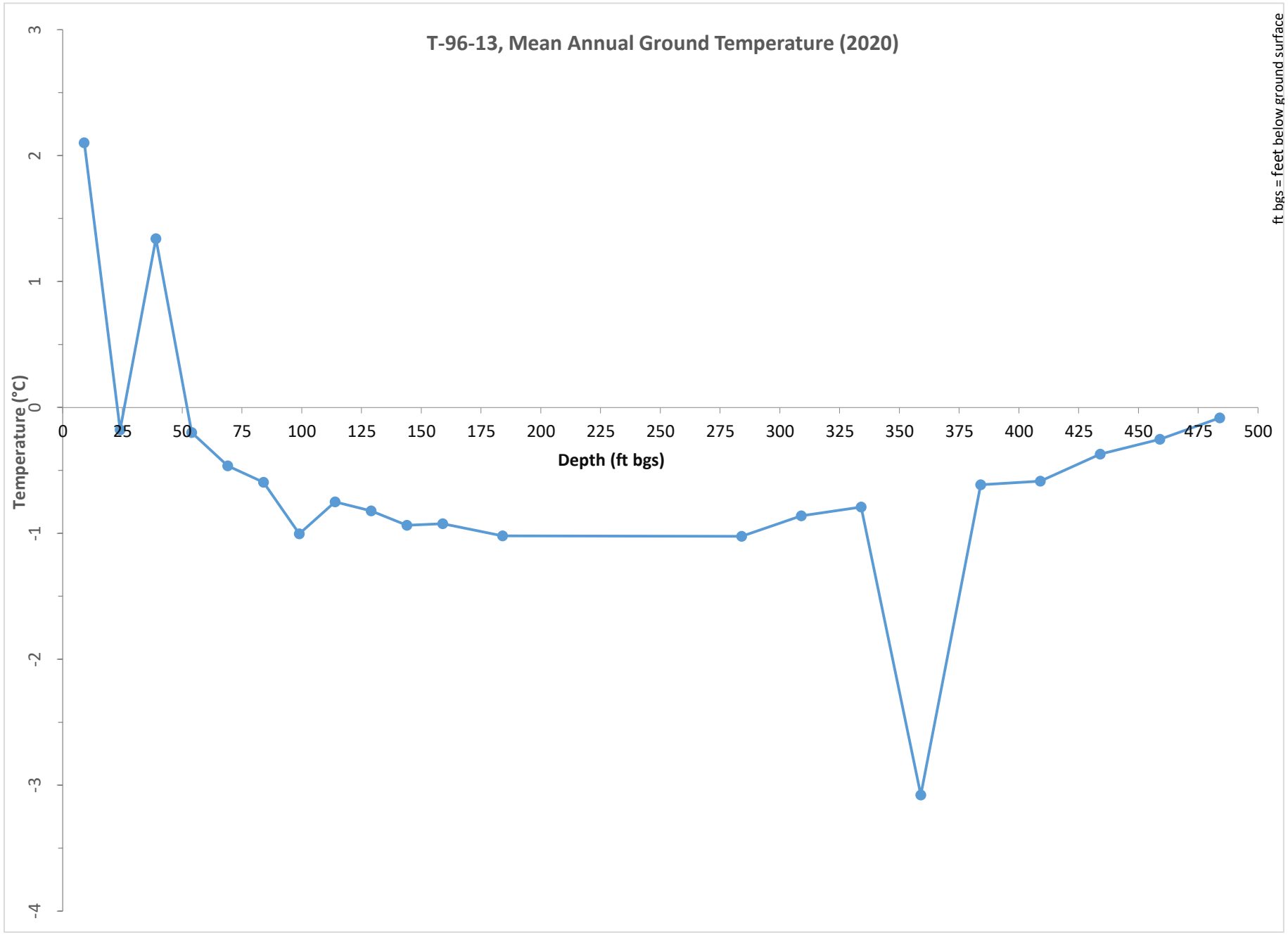

Temperature Depth Plot for T-96-012S (1996-2020)
Temperature (°C)
30
20
10
0
-10
-20
-30
-40
-3
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
(surface)
Depth (ft bgs)

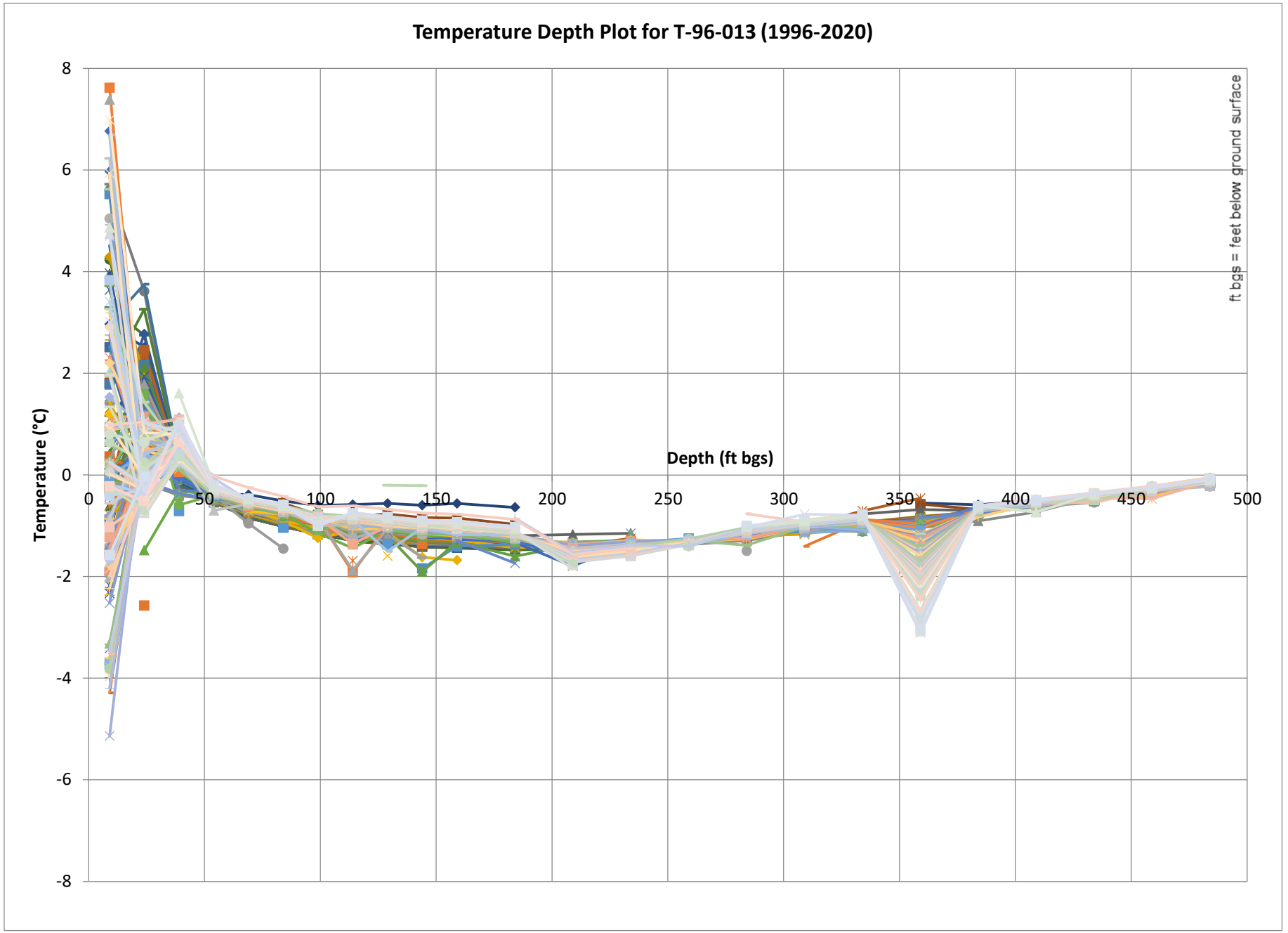
This Page Intentionally Blank

Thermistor T-96-13

This Page Intentionally Blank


Temperature Depth Plot for T-96-013, 2020
Temperature (°C)
5
4
3
2
1
0
-1
-2
-3
-4
0
50
100
150
200
250
300
350
400
450
500
Depth (ft bgs)
Legend (measurement date)
1/10/20
5/3/20
7/14/20
10/19/20
ft bgs = feet below ground surface

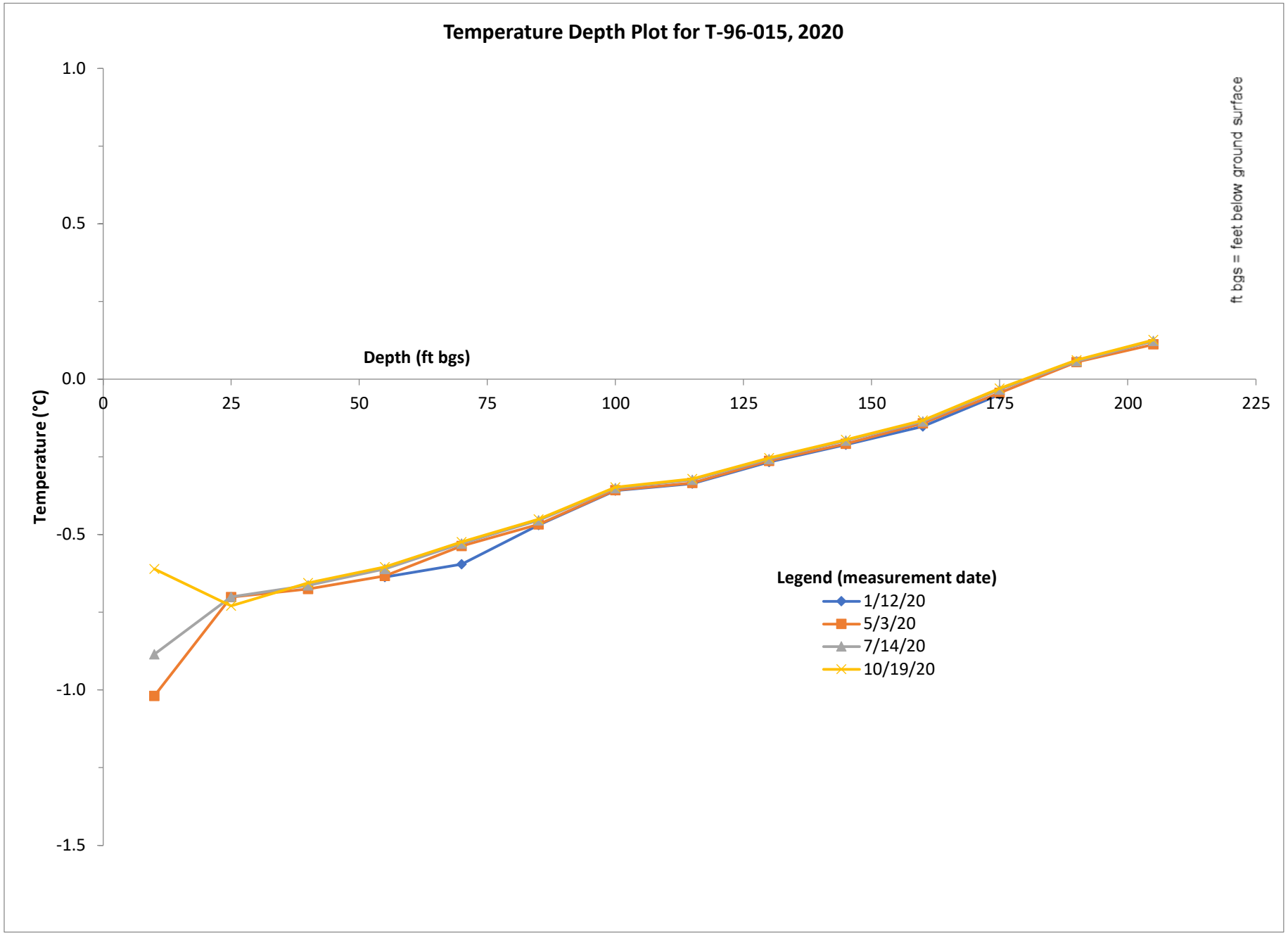

T-96-13, Mean Annual Ground Temperature (2020)
Temperature (°C)
3
2
1
0
-1
-2
-3
-4
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
500
Depth (ft bgs)
ft bgs = feet below ground surface

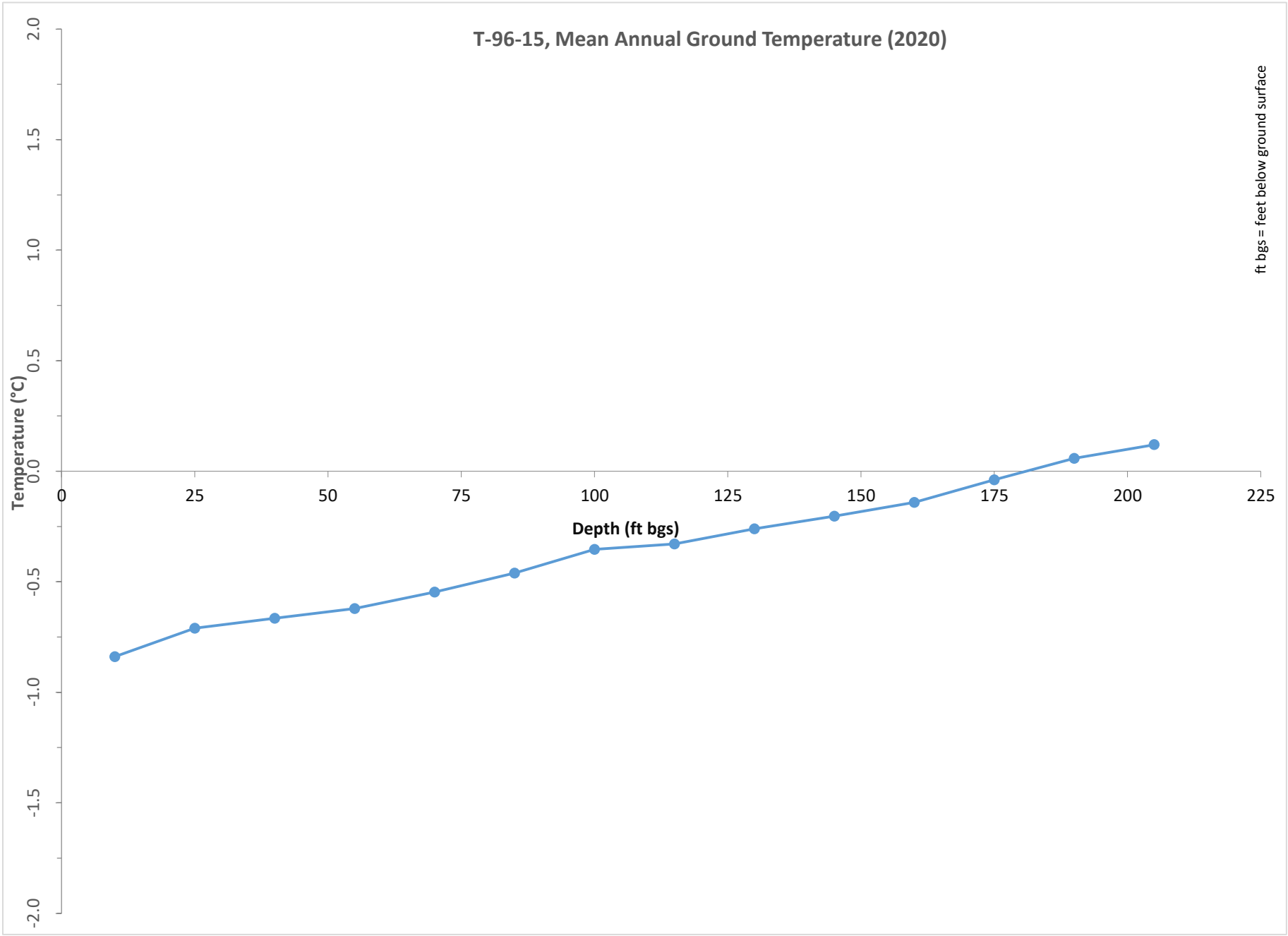

Temperature Depth Plot for T-96-013 (1996-2020)
Temperature (°C)
8
6
4
2
0
-2
-4
-6
-8
Depth (ft bgs)
0
50
100
150
200
250
300
350
400
450
500
ft bgs = feet below ground surface

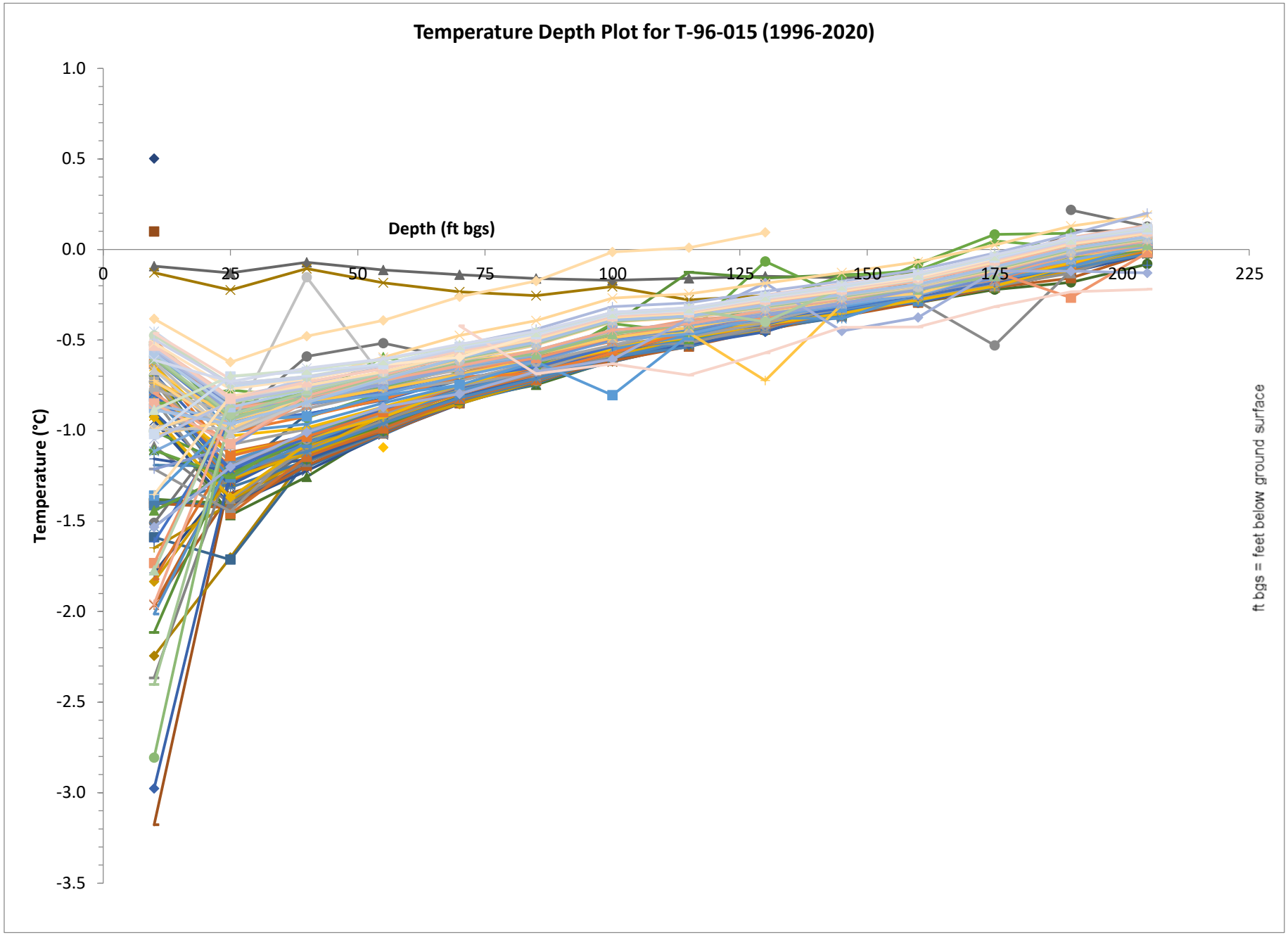
This Page Intentionally Blank

Thermistor T-96-15

This Page Intentionally Blank


Temperature Depth Plot for T-96-015, 2020
1.0
0.5
0.0
-0.5
-1.0
-1.5
Temperature (°C)
0
25
50
75
100
125
150
175
200
225
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement date)
1/12/20
5/3/20
7/14/20
10/19/20

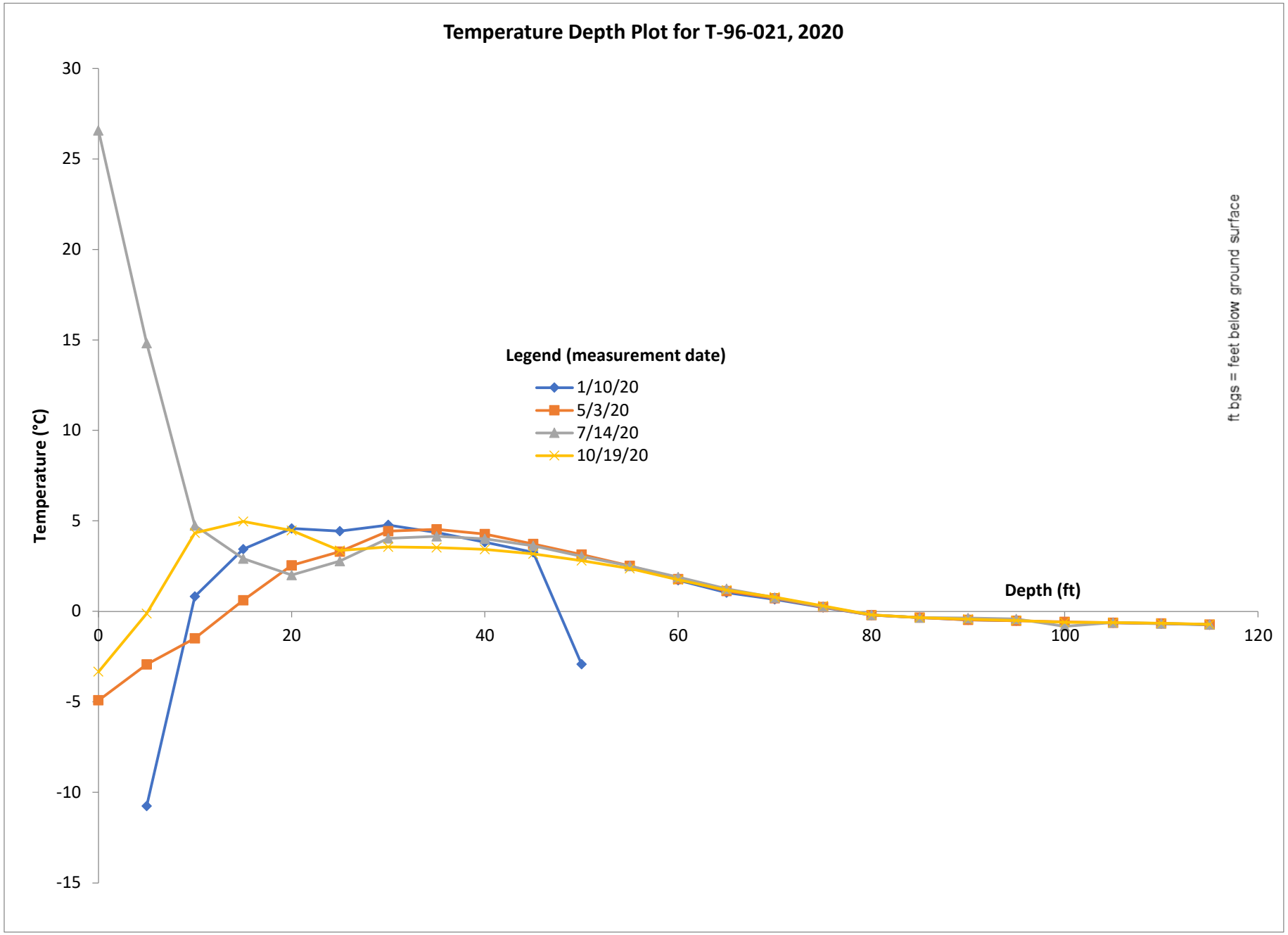

T-96-15, Mean Annual Ground Temperature (2020)
Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
25
50
75
100
125
150
175
200
225
Depth (ft bgs)
ft bgs = feet below ground surface

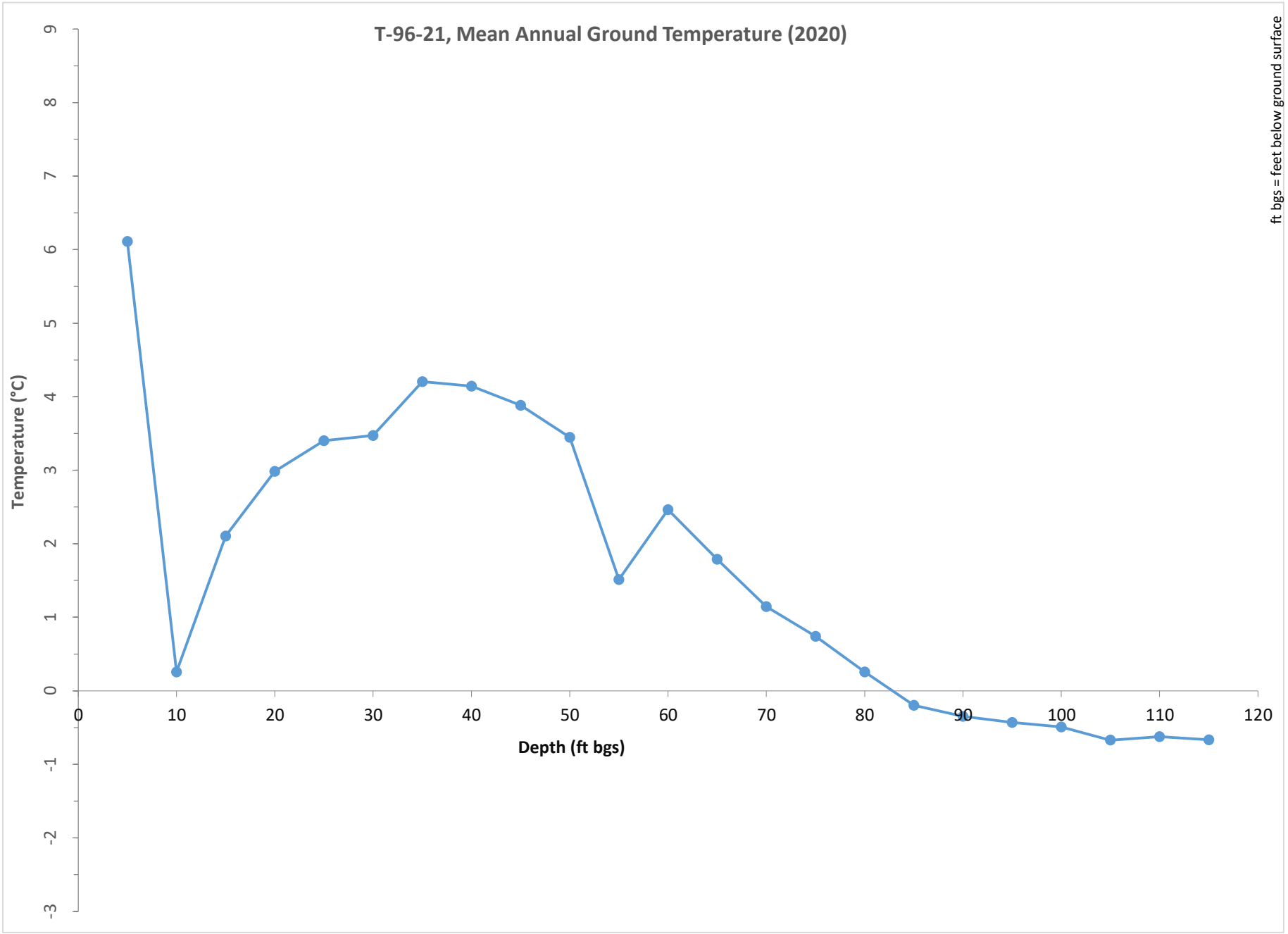

Temperature Depth Plot for T-96-015 (1996-2020)
Depth (ft bgs)
Temperature (°C)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
0
25
50
75
100
125
150
175
200
225
ft bgs = feet below ground surface

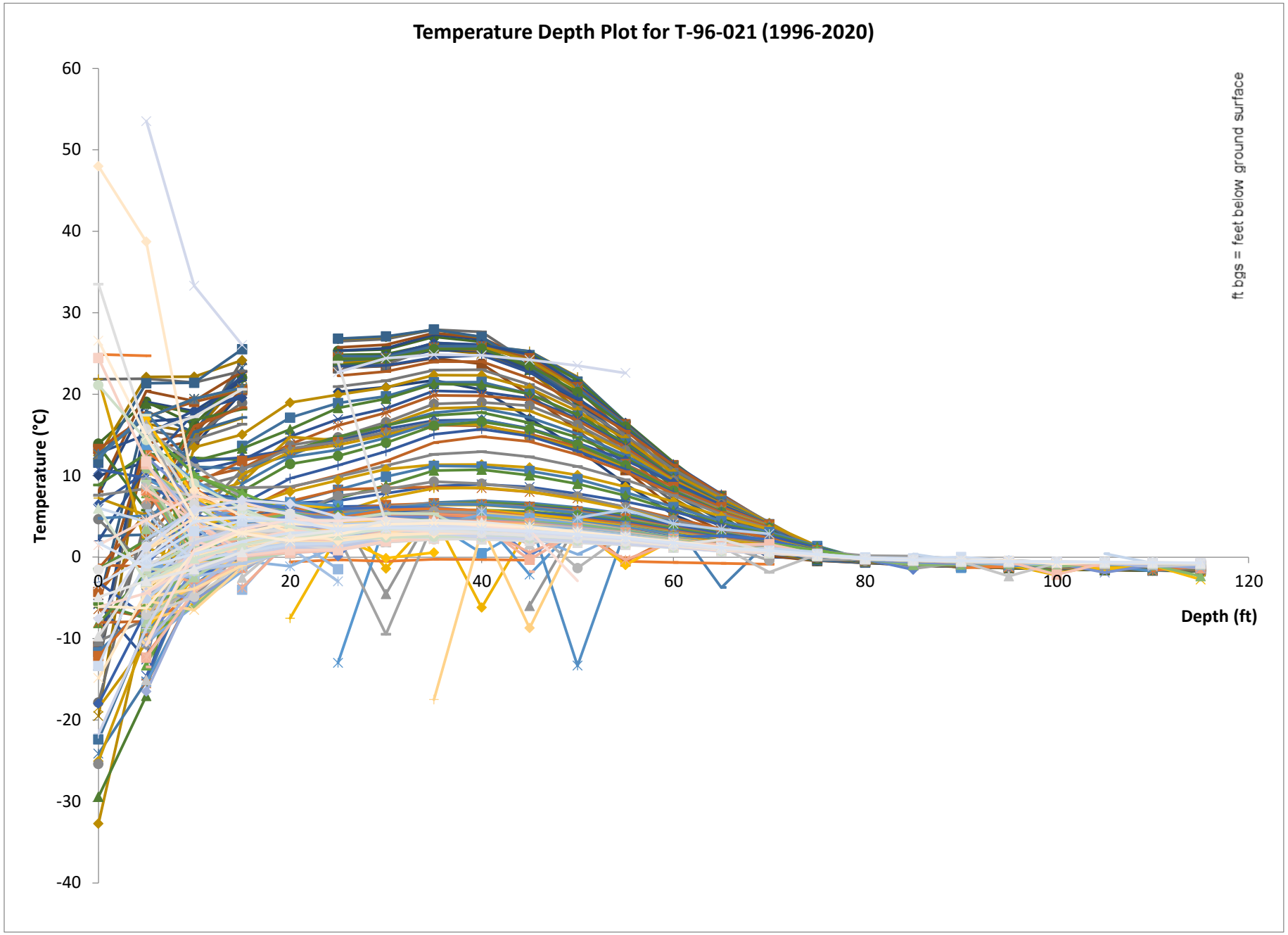
This Page Intentionally Blank

Thermistor T-96-21

This Page Intentionally Blank


Temperature Depth Plot for T-96-021, 2020
Temperature (°C)
30
25
20
15
10
5
0
-5
-10
-15
0
20
40
60
80
100
120
Depth (ft)
Legend (measurement date)
1/10/20
5/3/20
7/14/20
10/19/20
ft bgs = feet below ground surface

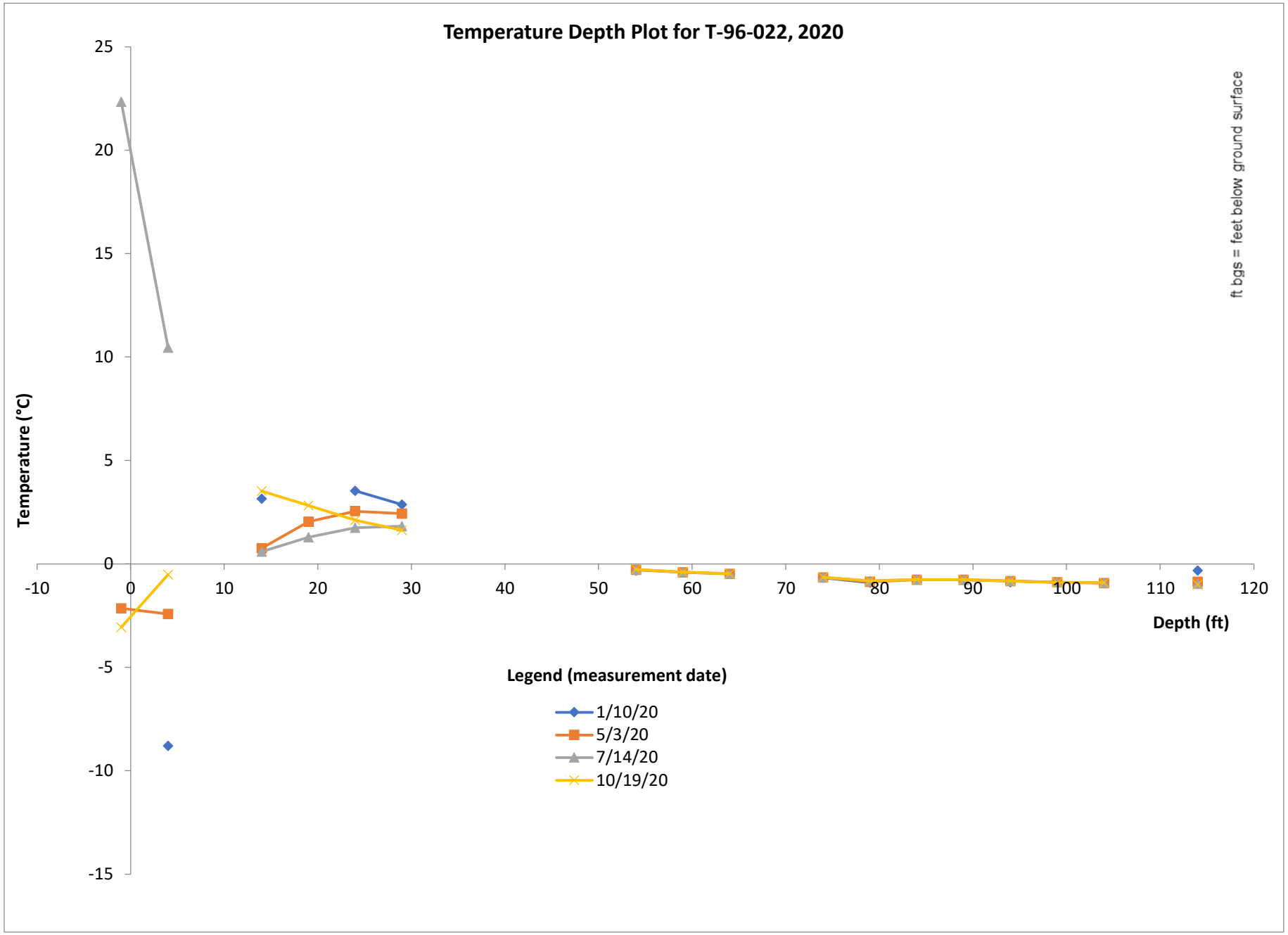

T-96-21, Mean Annual Ground Temperature (2020)
Temperature (°C)
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
0
10
20
30
40
50
60
70
80
90
100
110
120
Depth (ft bgs)
ft bgs = feet below ground surface

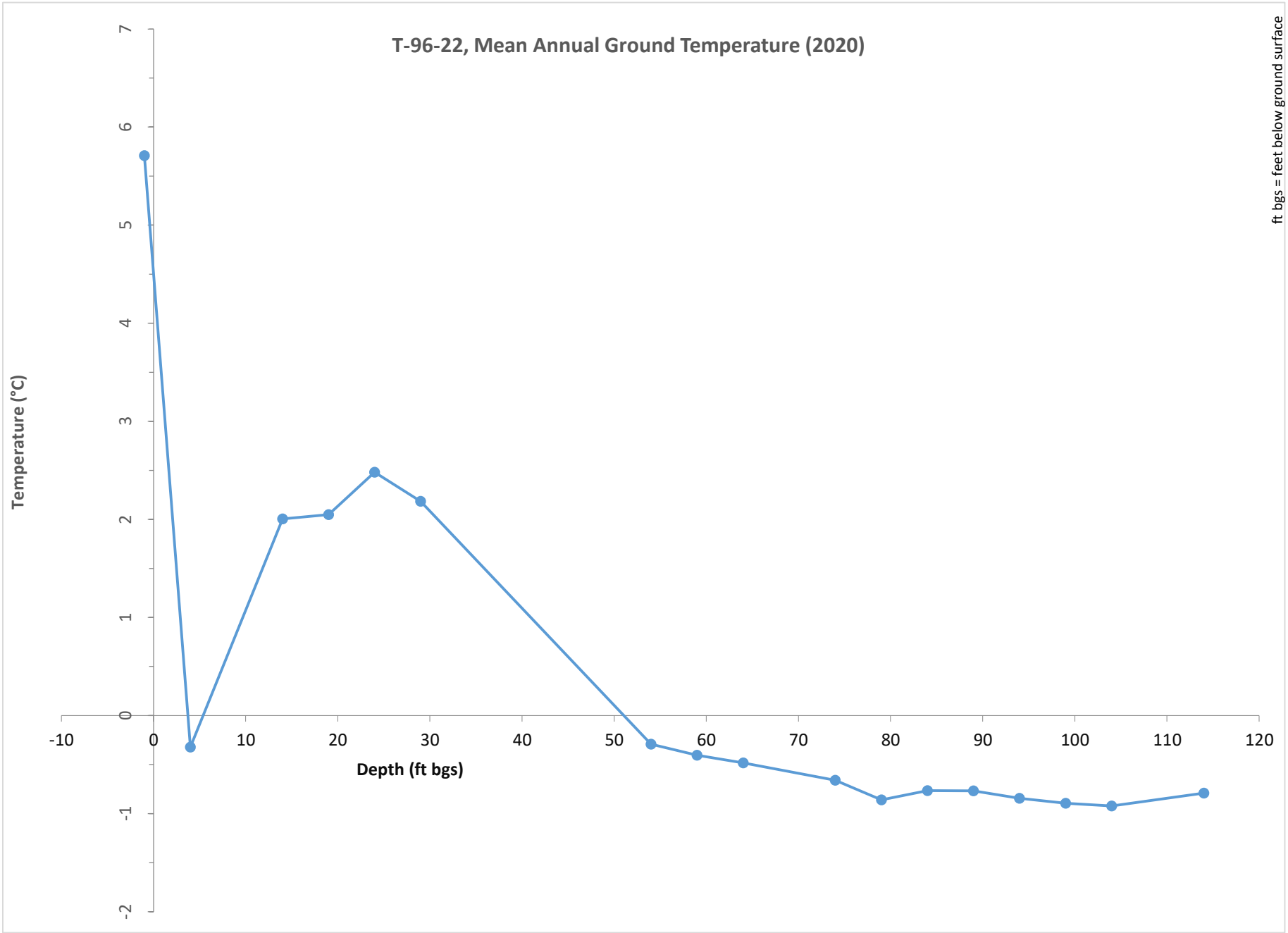

Temperature Depth Plot for T-96-021 (1996-2020)
Temperature (°C)
60
50
40
30
20
10
0
-10
-20
-30
-40
0
20
40
60
80
100
120
Depth (ft)
ft bgs = feet below ground surface

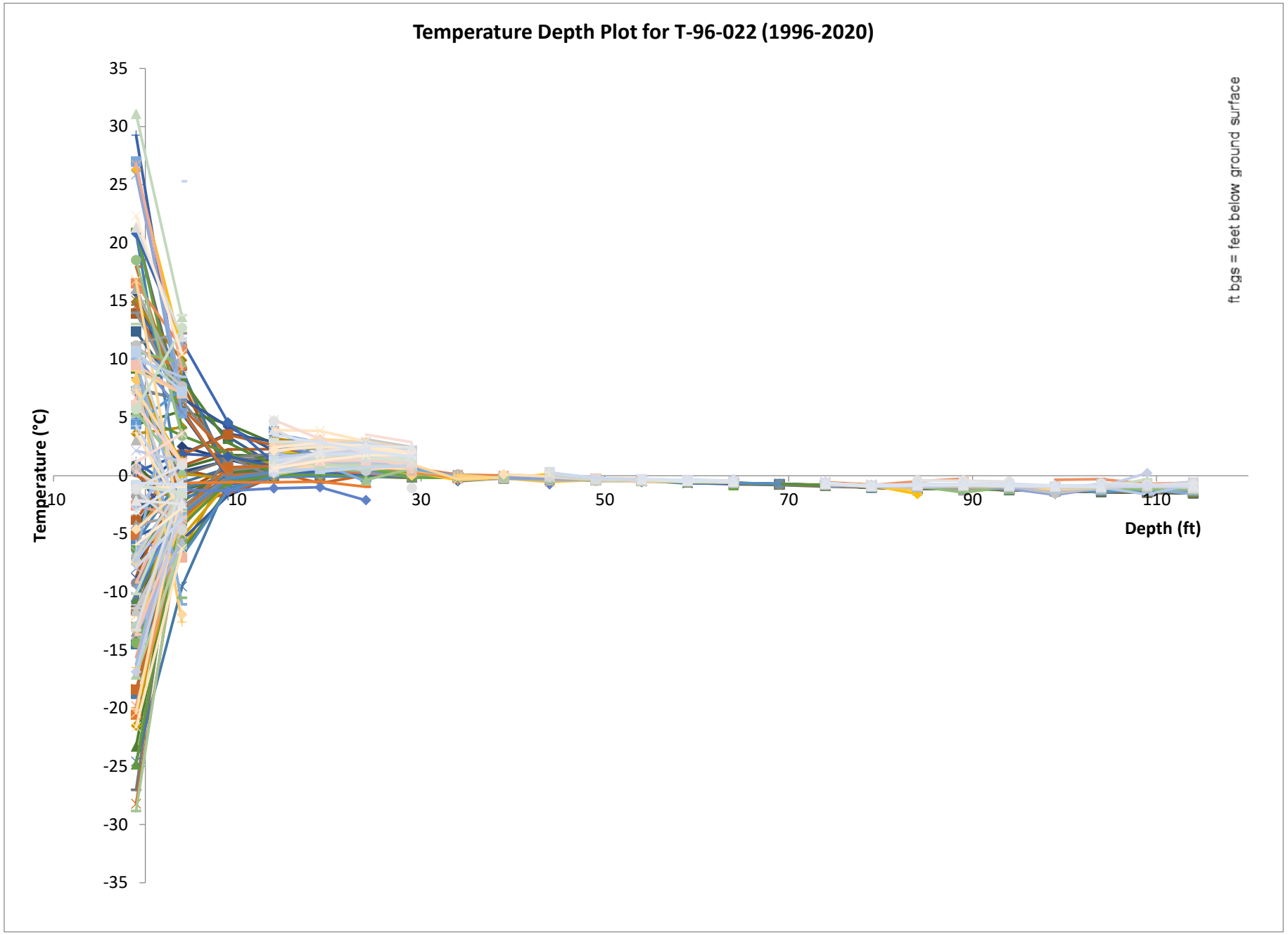
This Page Intentionally Blank

Thermistor T-96-22

This Page Intentionally Blank


Temperature Depth Plot for T-96-022, 2020
Temperature (°C)
25
20
15
10
5
0
-5
-10
-15
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
Depth (ft)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/14/20
10/19/20

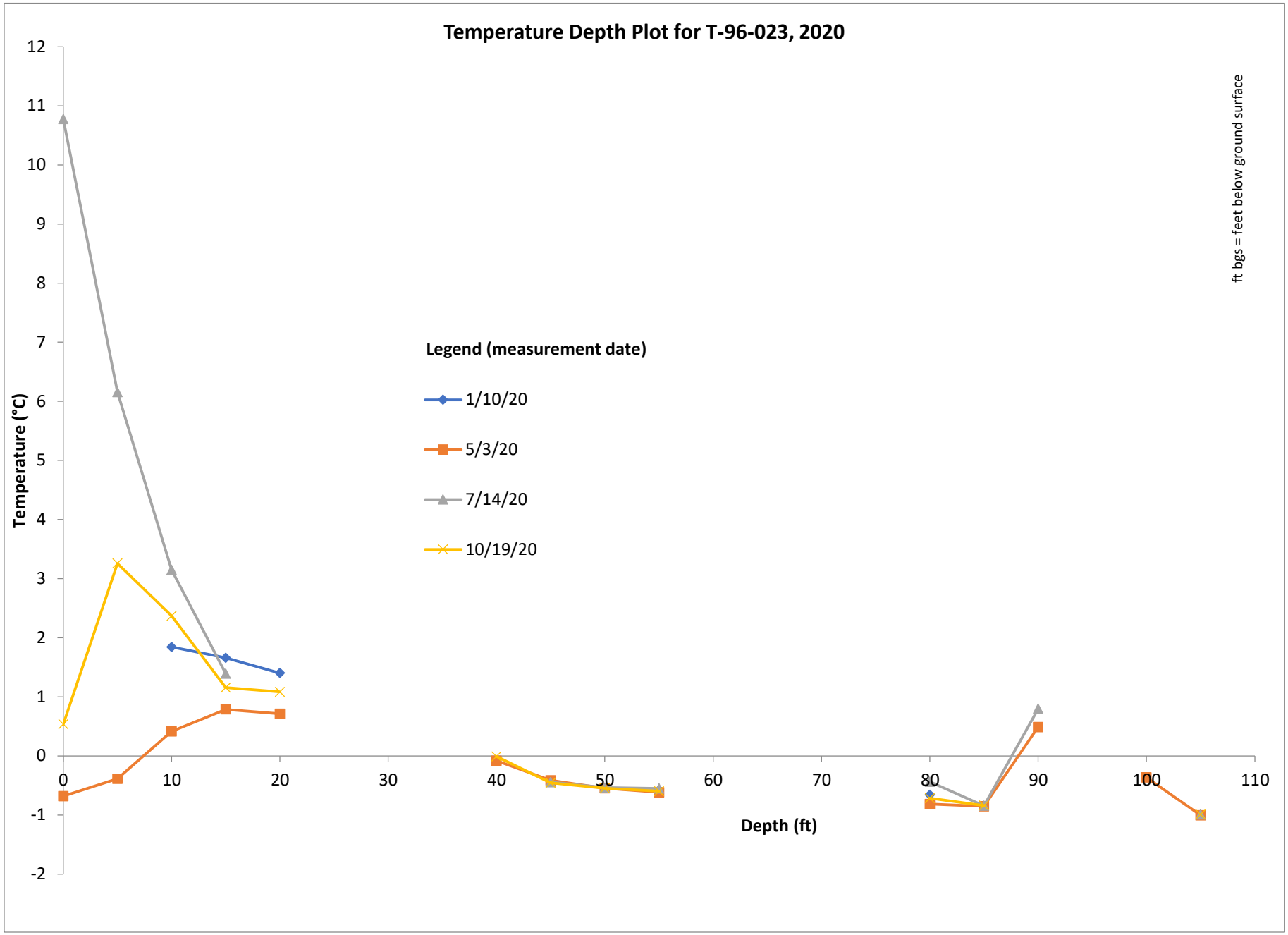

T-96-22, Mean Annual Ground Temperature (2020)
Temperature (°C)
7
6
5
4
3
2
1
0
-1
-2
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
Depth (ft bgs)
ft bgs = feet below ground surface

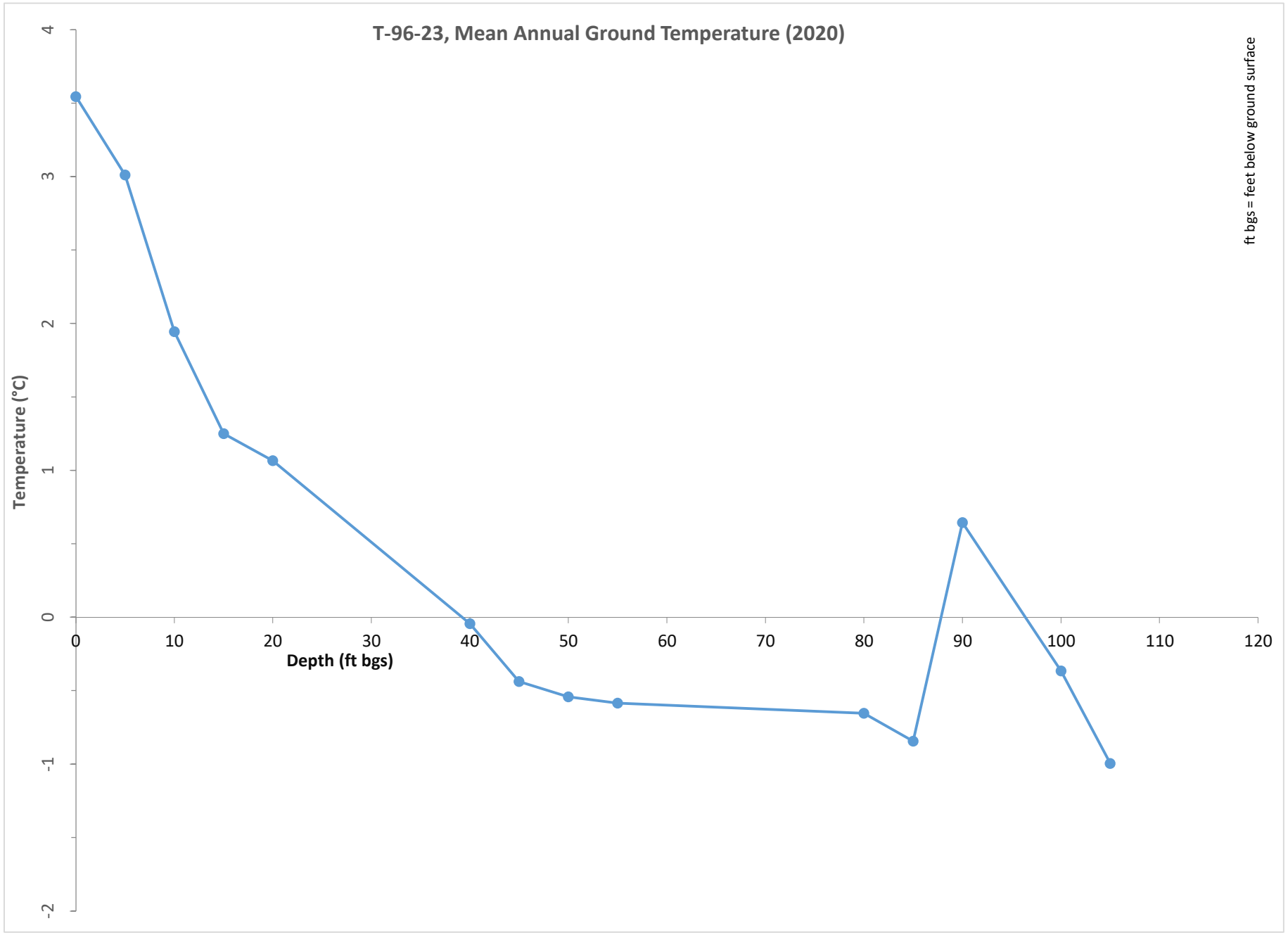

Temperature Depth Plot for T-96-022 (1996-2020)
Temperature (°C)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
10
10
30
50
70
90
110
Depth (ft)
ft bgs = feet below ground surface

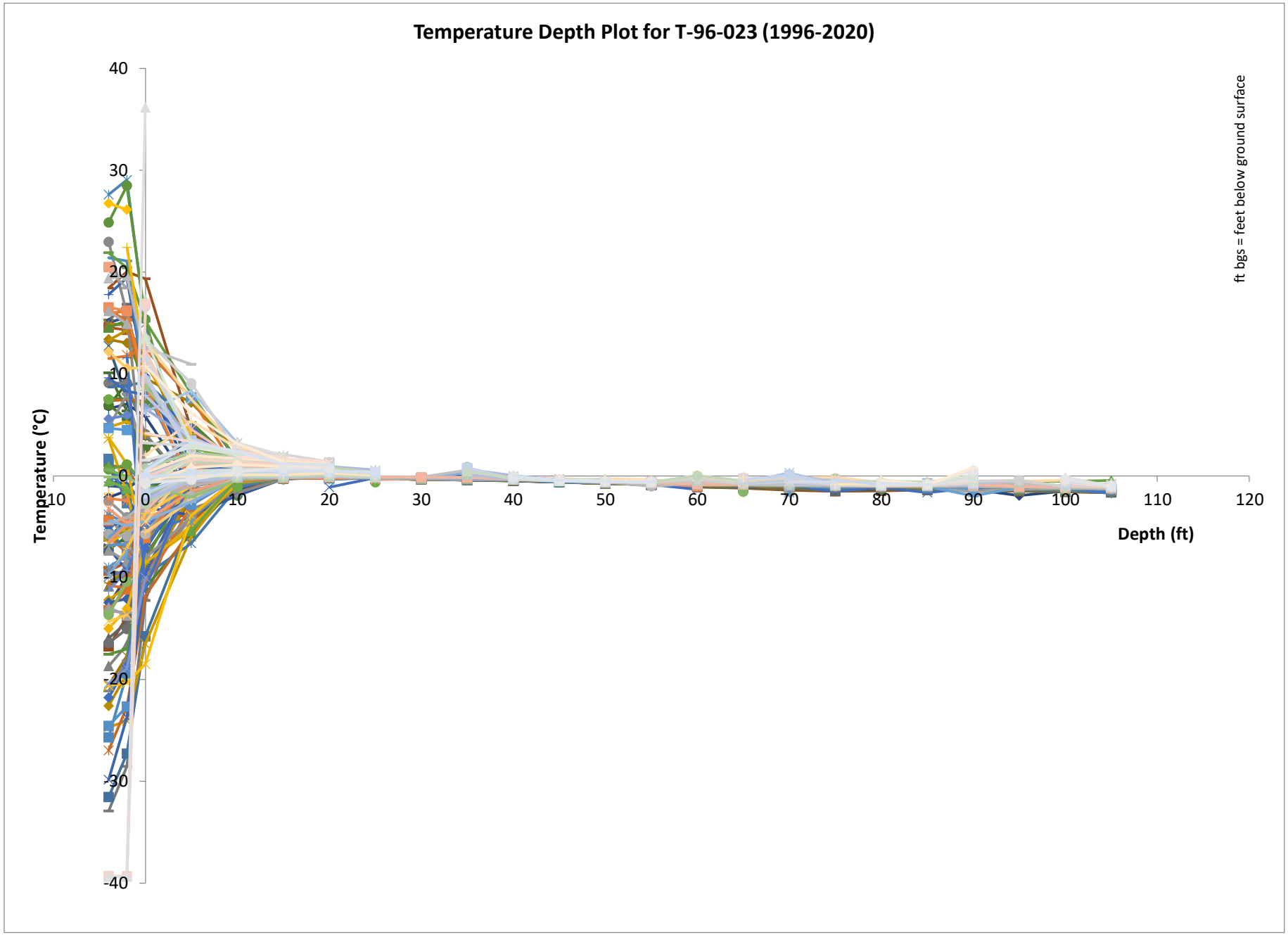
This Page Intentionally Blank

Thermistor T-96-23

This Page Intentionally Blank


Temperature Depth Plot for T-96-023, 2020
Temperature (°C)
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
0
10
20
30
40
50
60
70
80
90
100
110
Depth (ft)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/14/20
10/19/20

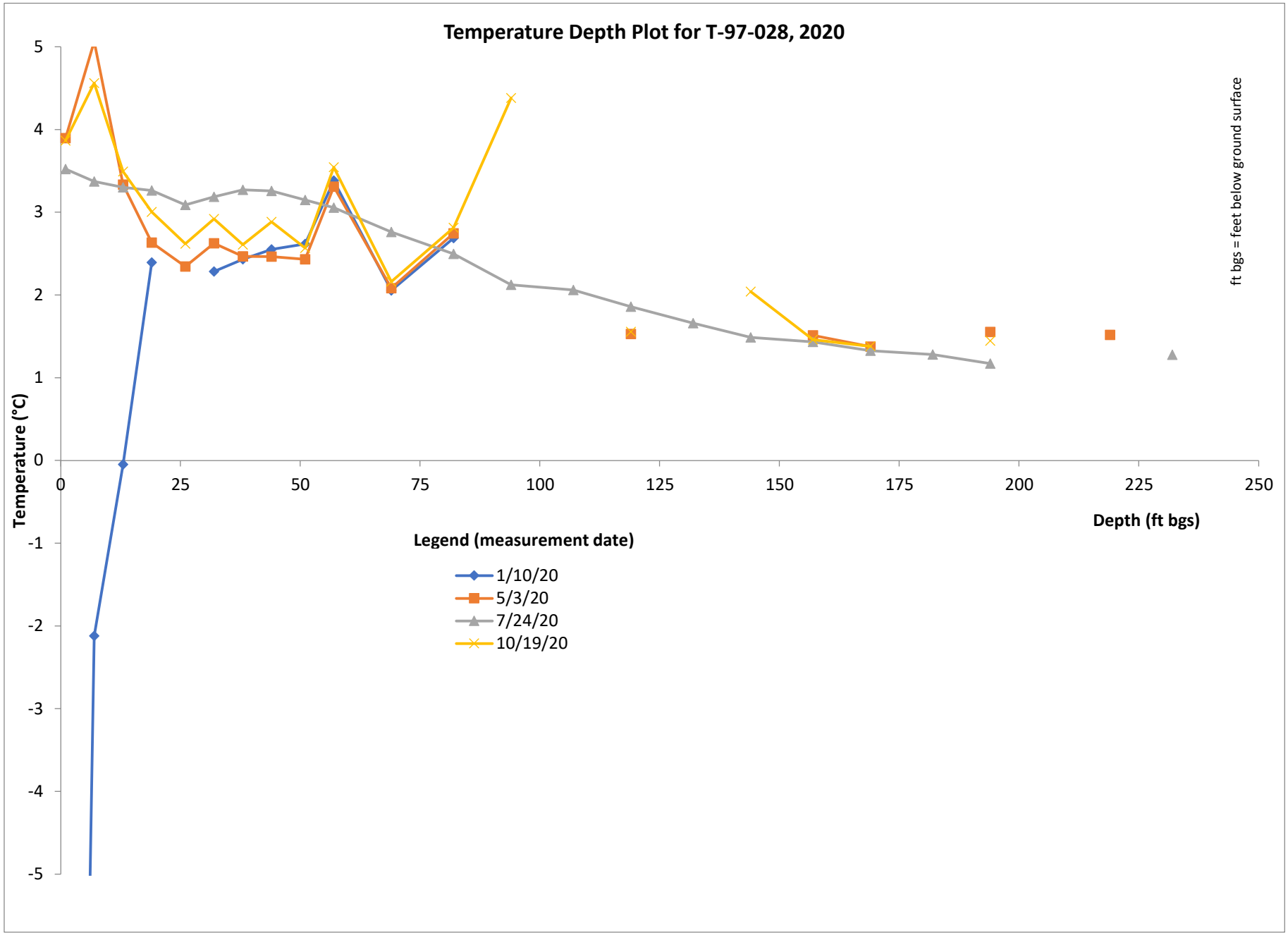

T-96-23, Mean Annual Ground Temperature (2020)
Temperature (°C)
4
3
2
1
0
-1
-2
0
10
20
30
40
50
60
70
80
90
100
110
120
Depth (ft bgs)
ft bgs = feet below ground surface

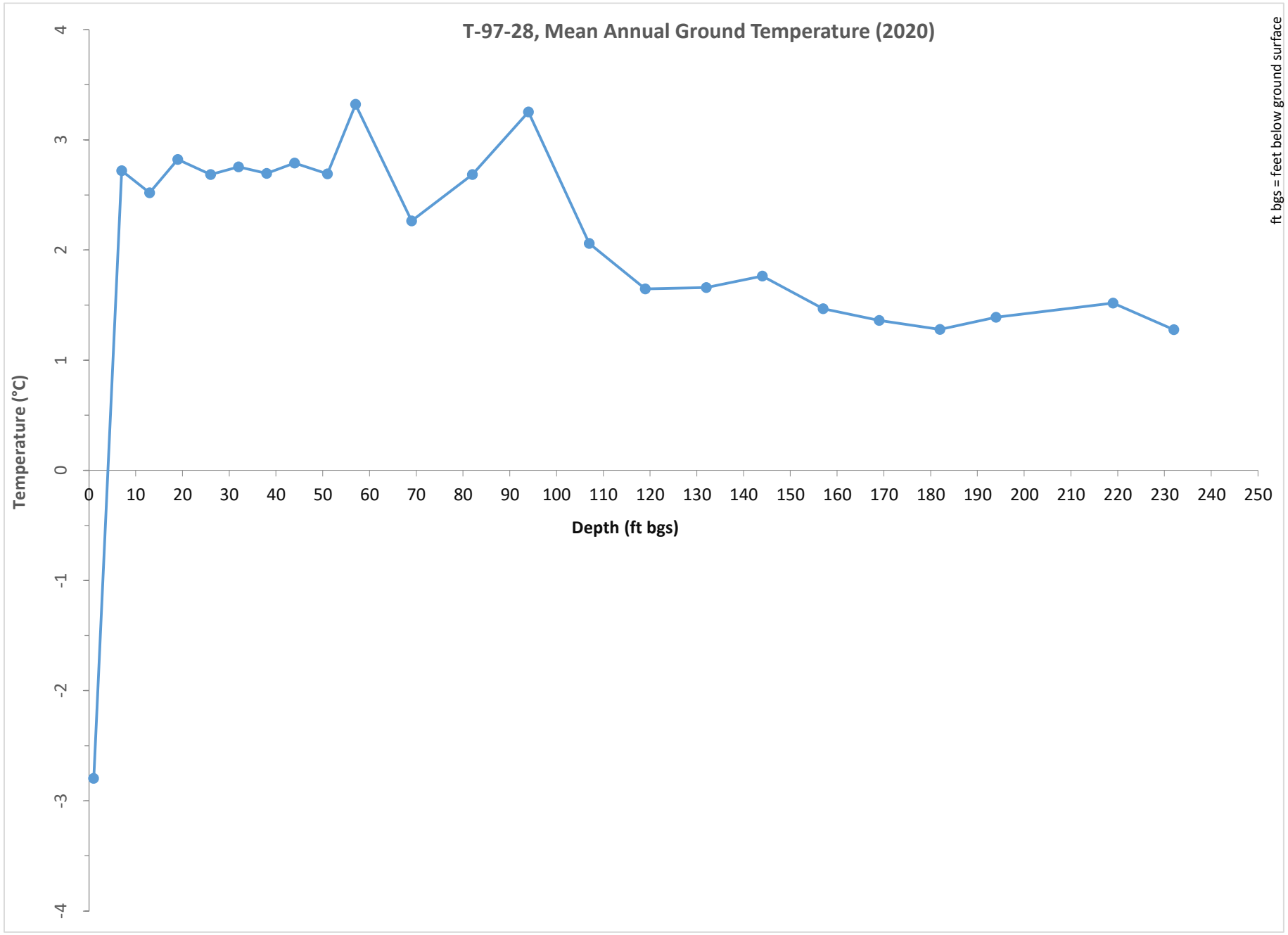

Temperature Depth Plot for T-96-023 (1996-2020)
Temperature (°C)
Depth (ft)
ft bgs = feet below ground surface
40
30
20
10
0
-10
-20
-30
-40
-10
0
10
20
30
40
50
60
70
80
90
100
110
120

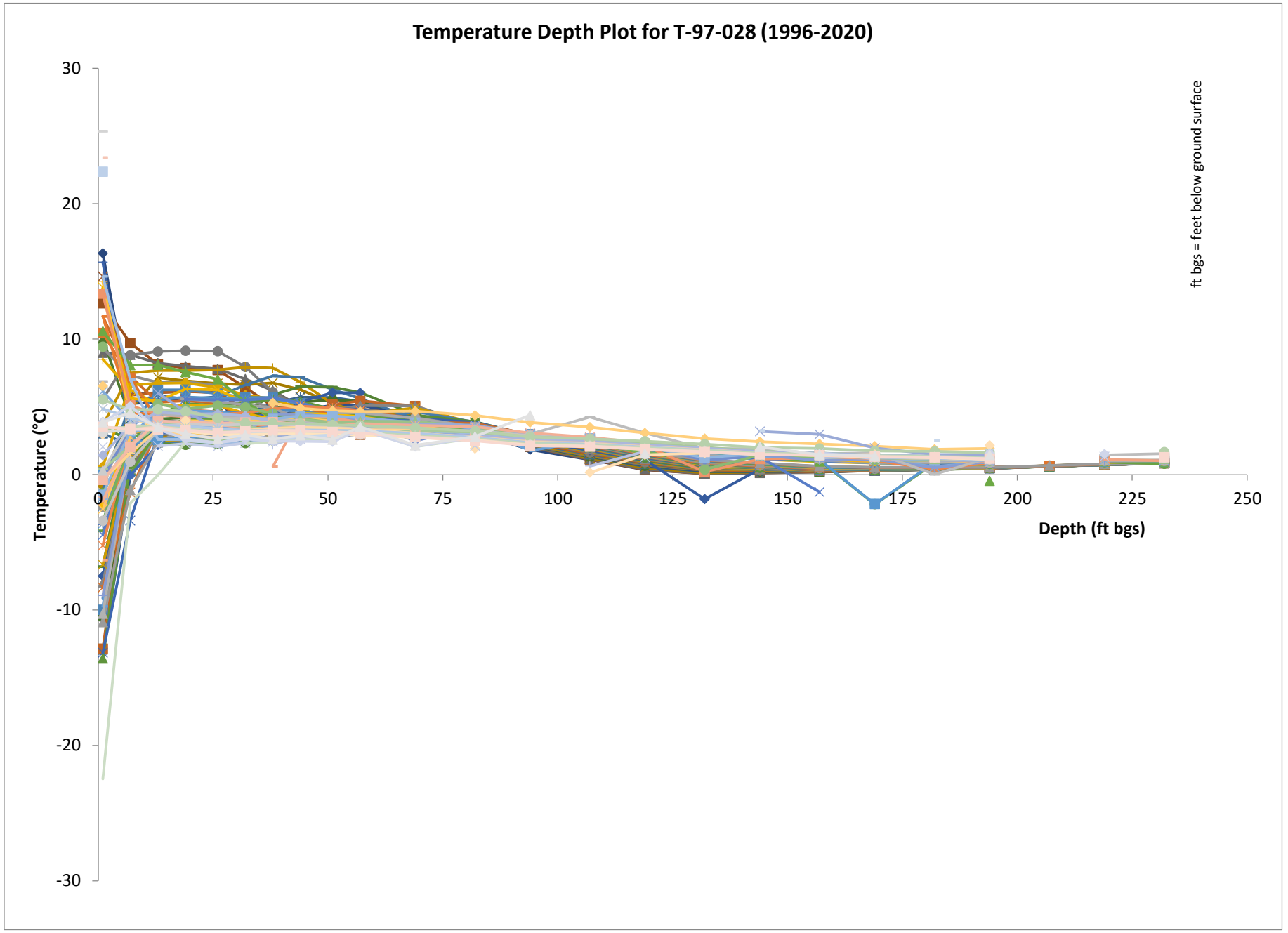
This Page Intentionally Blank

Thermistor T-97-28

This Page Intentionally Blank


Temperature Depth Plot for T-97-028, 2020
Temperature (°C)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
25
50
75
100
125
150
175
200
225
250
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/24/20
10/19/20

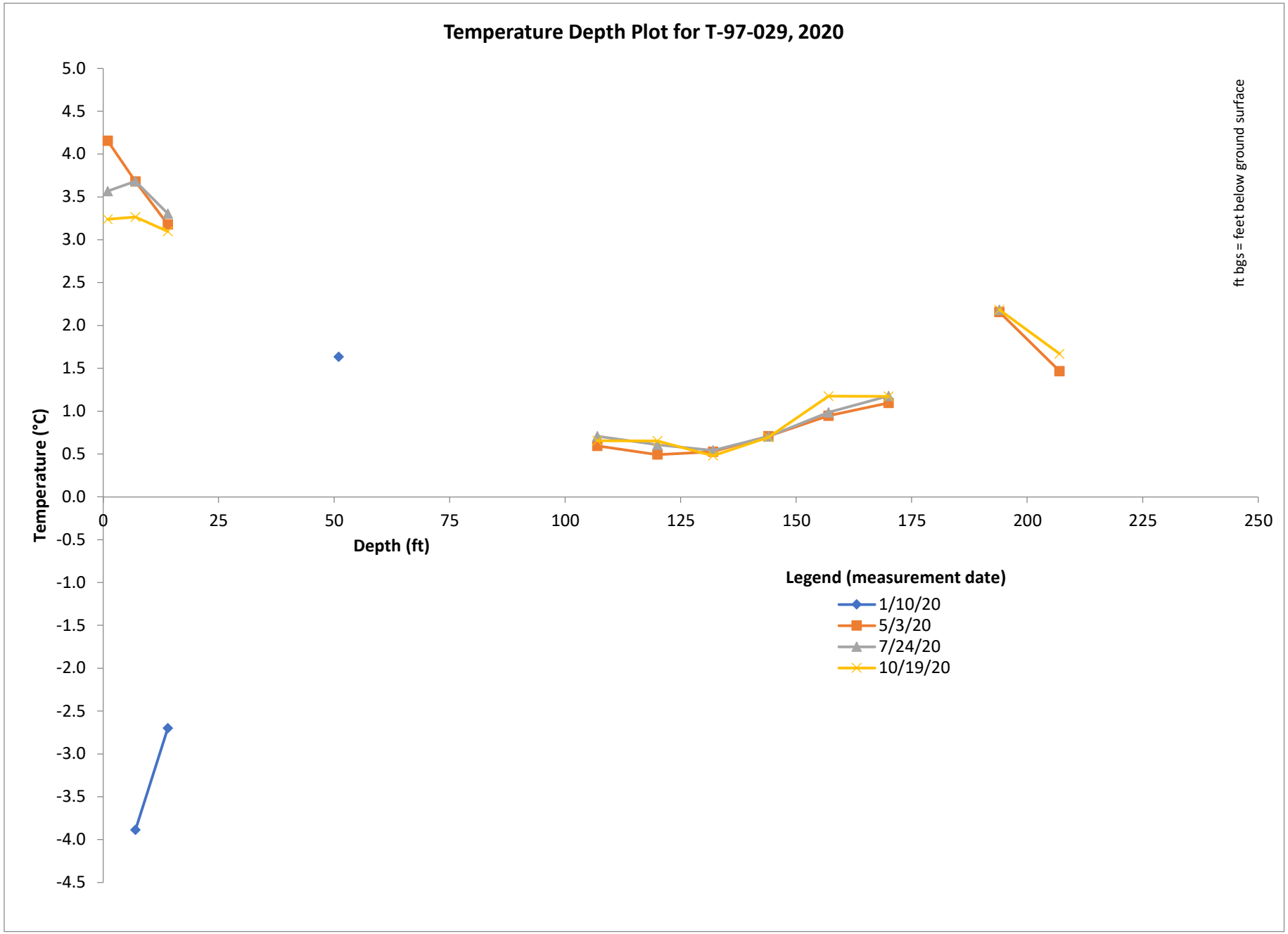

T-97-28, Mean Annual Ground Temperature (2020)
Temperature (°C)
4
3
2
1
0
-1
-2
-3
-4
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Depth (ft bgs)
ft bgs = feet below ground surface

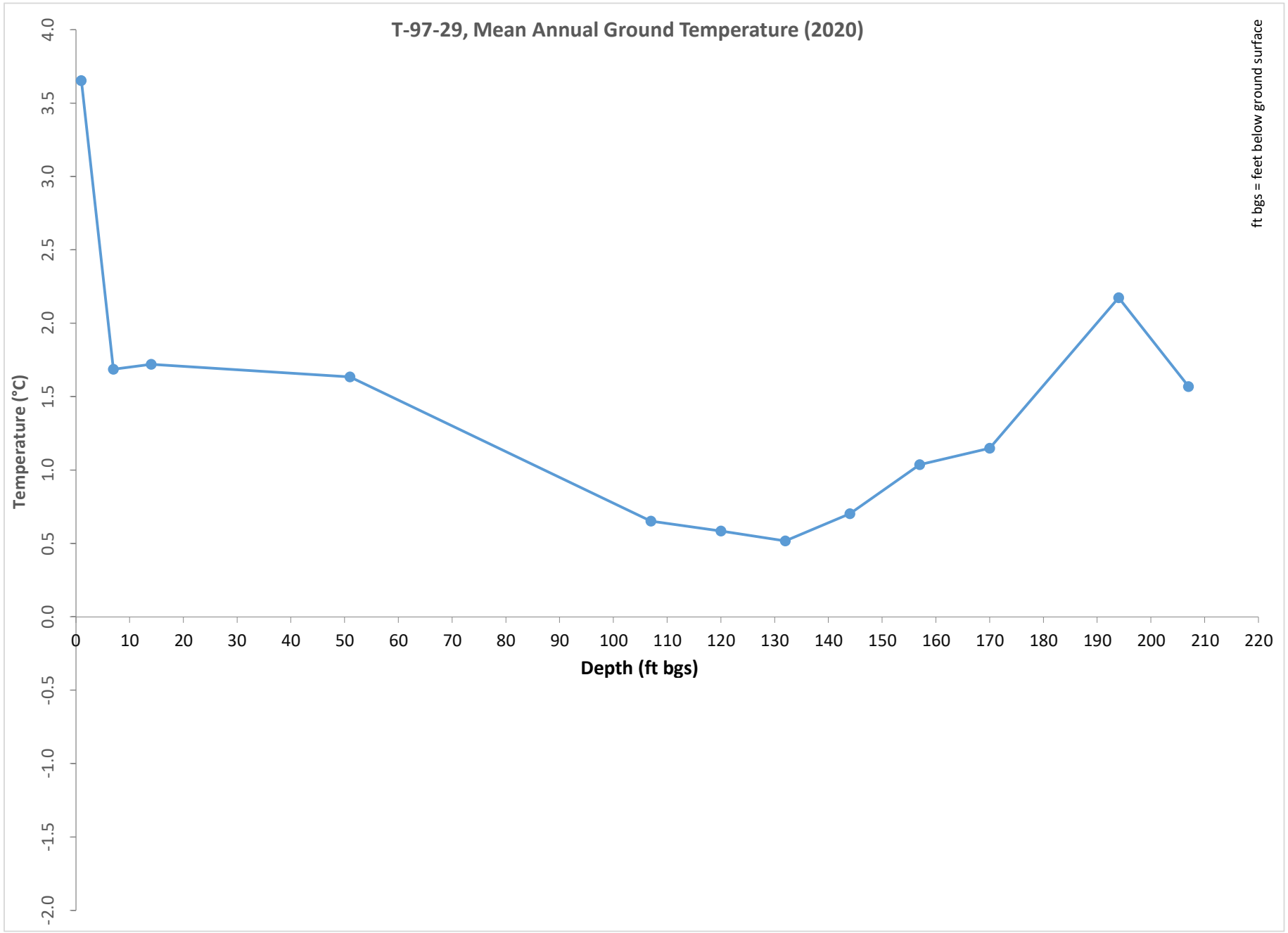

Temperature Depth Plot for T-97-028 (1996-2020)
Temperature (°C)
30
20
10
0
-10
-20
-30
0
25
50
75
100
125
150
175
200
225
250
Depth (ft bgs)
ft bgs = feet below ground surface

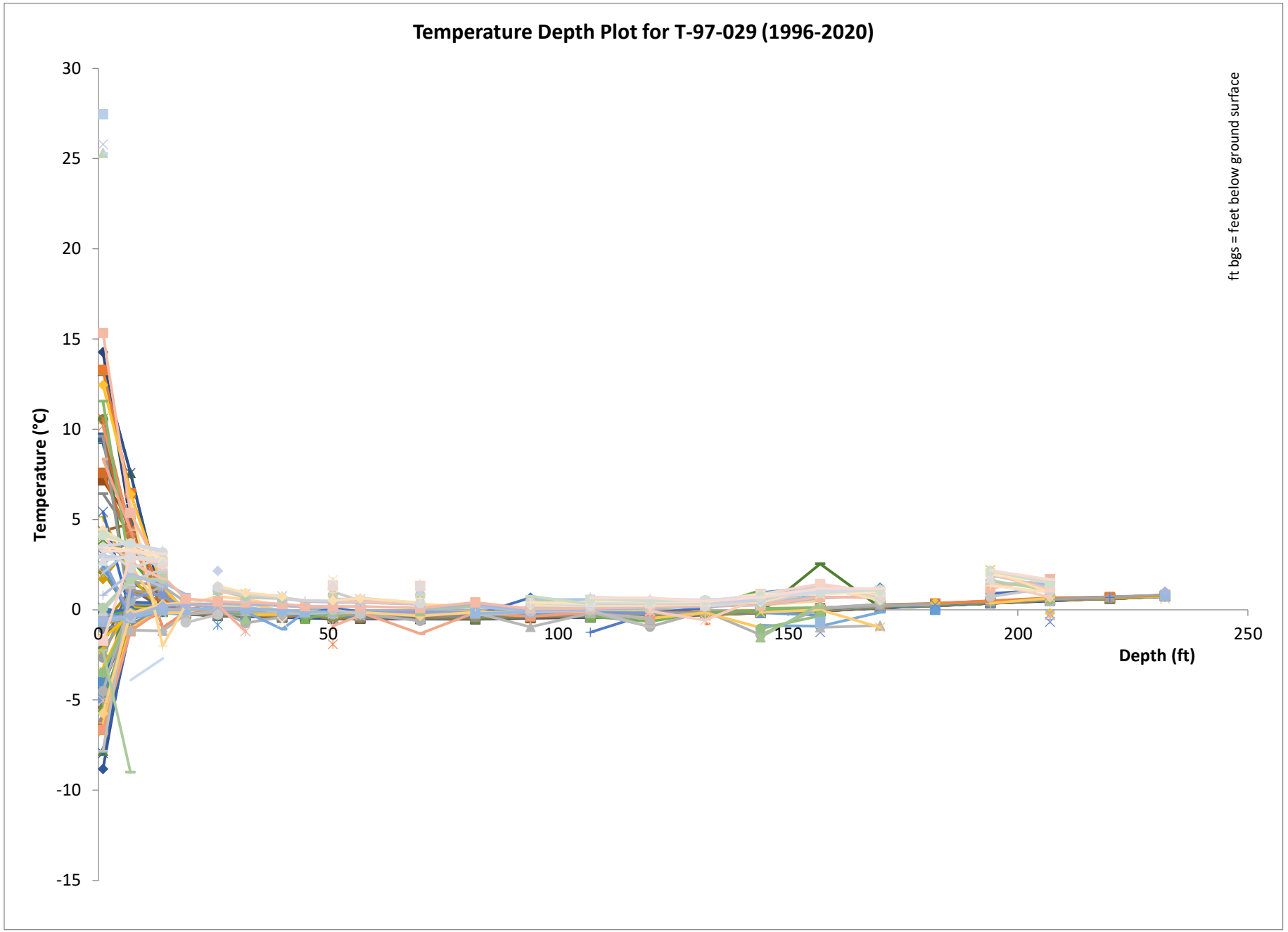
This Page Intentionally Blank

Thermistor T-97-29

This Page Intentionally Blank


Temperature Depth Plot for T-97-029, 2020
Temperature (°C)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
0
25
50
75
100
125
150
175
200
225
250
Depth (ft)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/24/20
10/19/20

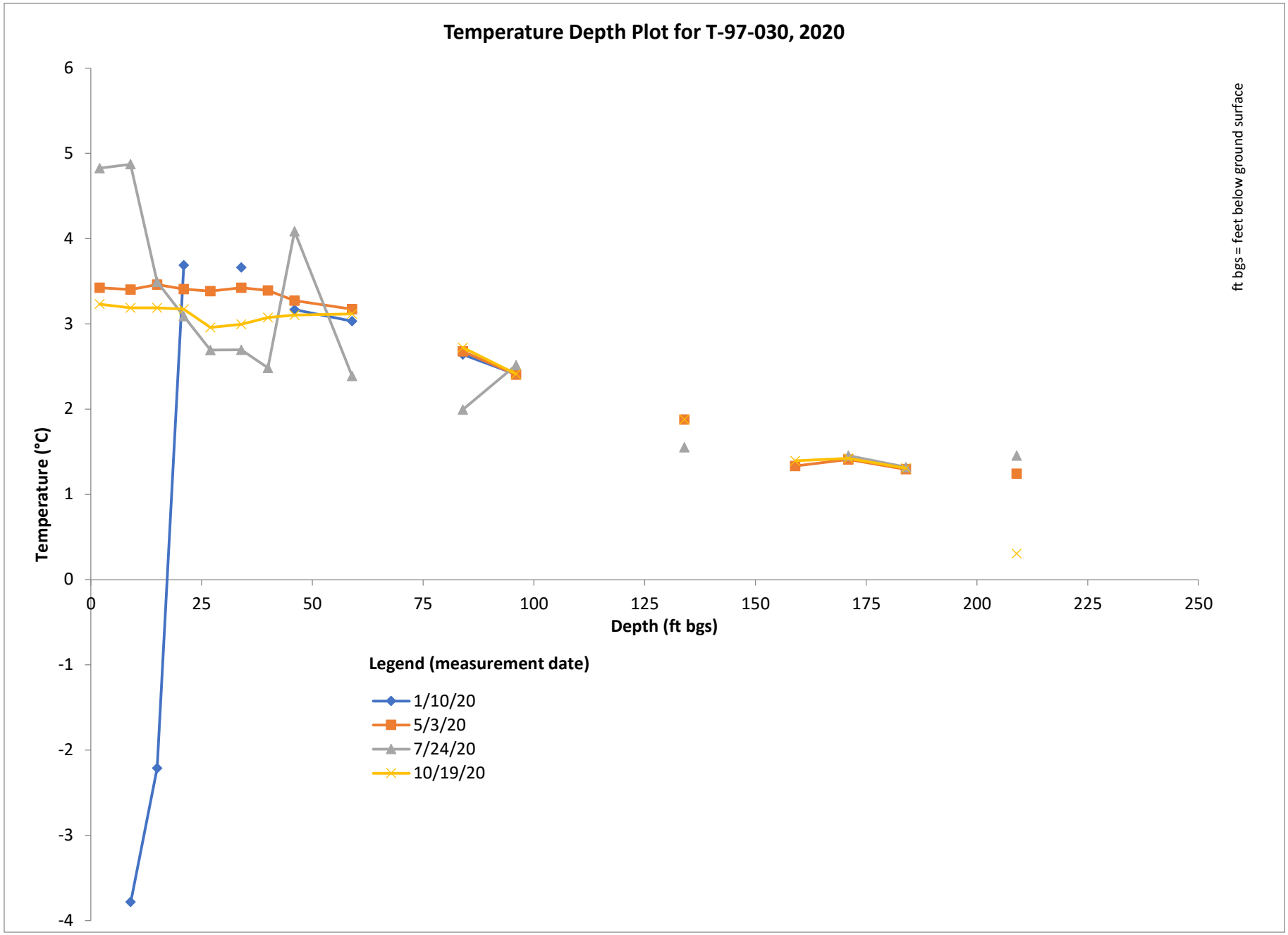

T-97-29, Mean Annual Ground Temperature (2020)
Temperature (°C)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Depth (ft bgs)
ft bgs = feet below ground surface

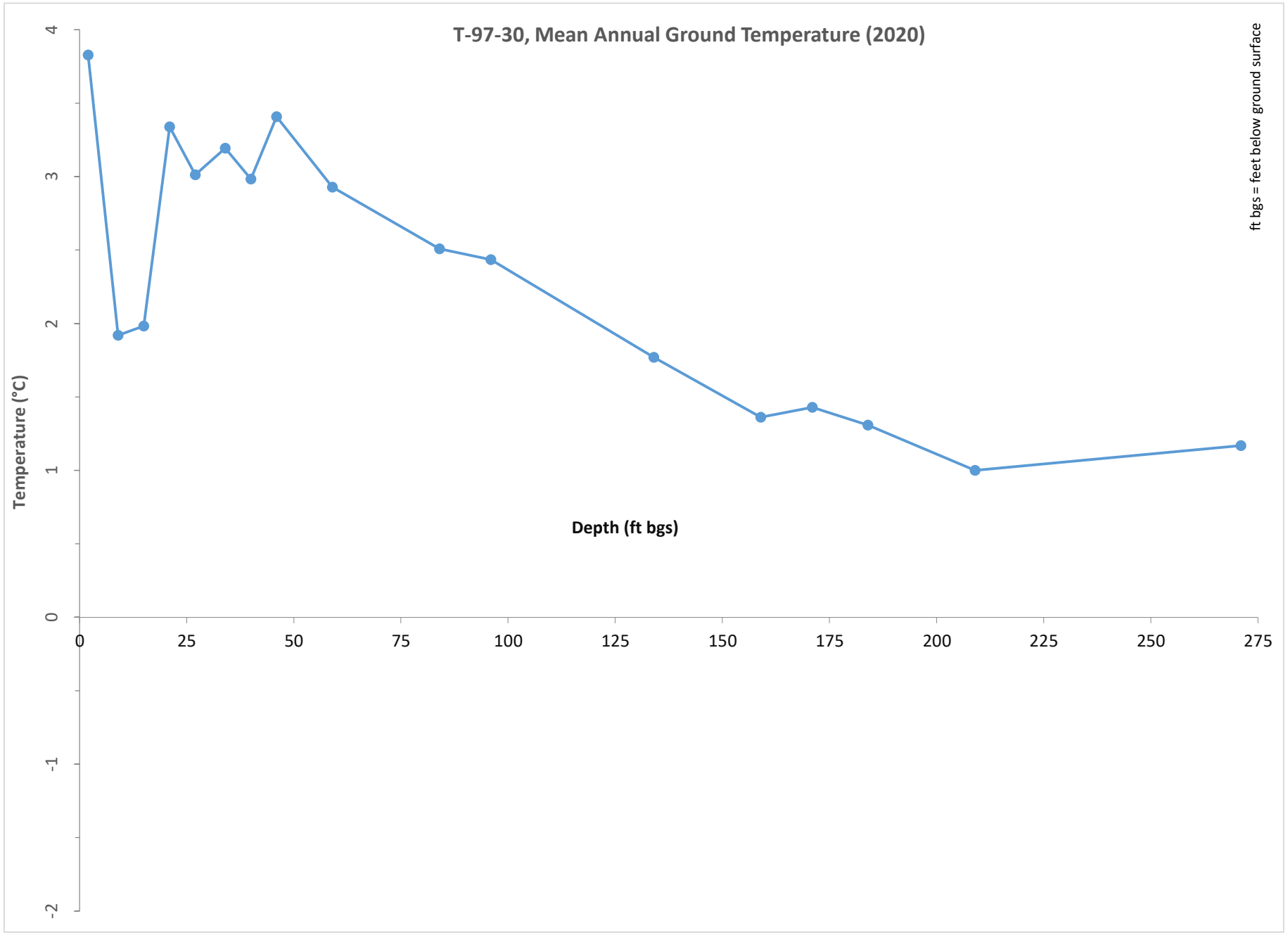

Temperature Depth Plot for T-97-029 (1996-2020)
Temperature (°C)
30
25
20
15
10
5
0
-5
-10
-15
0
50
100
150
200
250
Depth (ft)
ft bgs = feet below ground surface

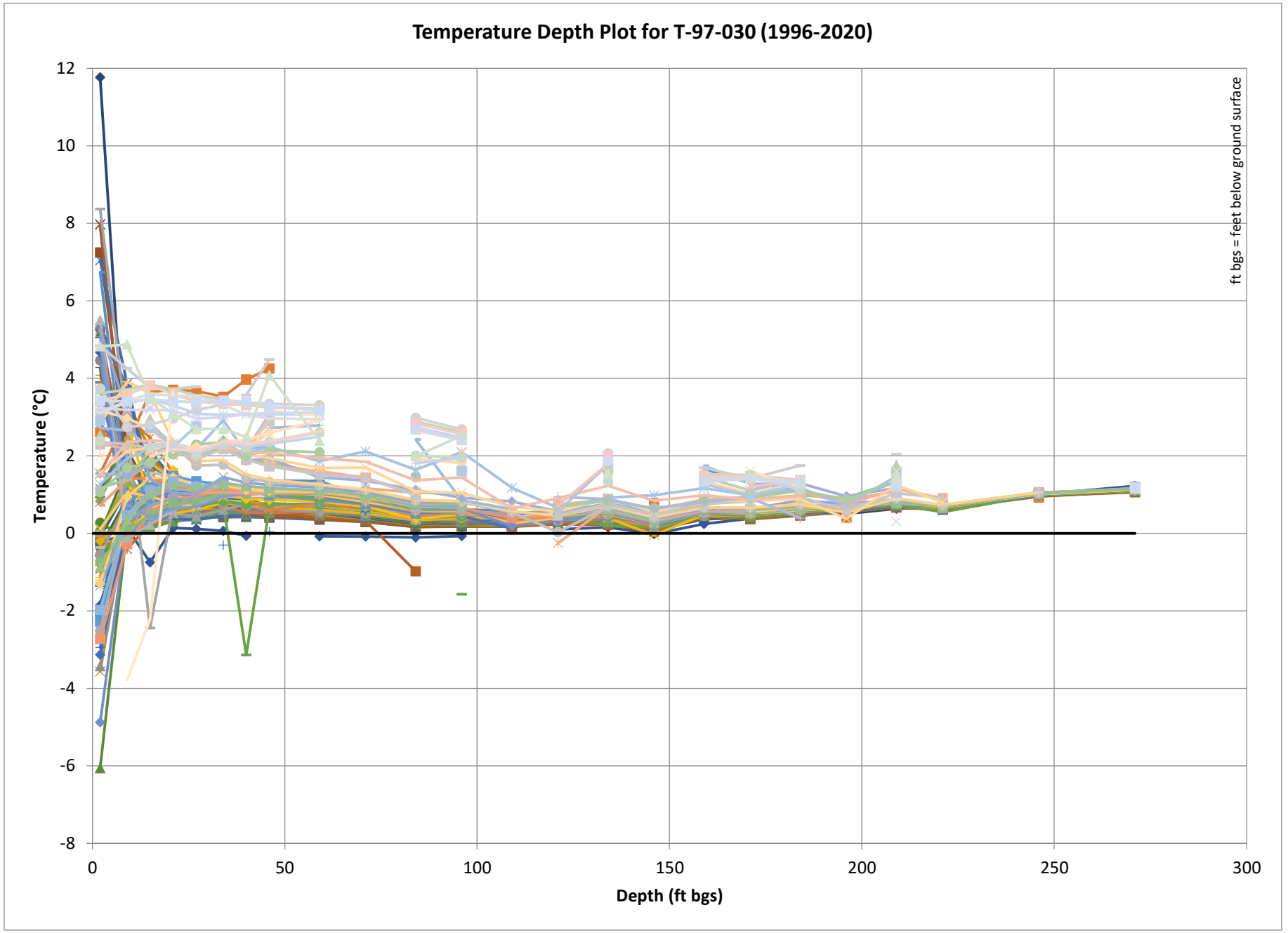
This Page Intentionally Blank

Thermistor T-97-30

This Page Intentionally Blank


Temperature Depth Plot for T-97-030, 2020
Temperature (°C)
Depth (ft bgs)
ft bgs = feet below ground surface
Legend (measurement date)
1/10/20
5/3/20
7/24/20
10/19/20


T-97-30, Mean Annual Ground Temperature (2020)
Temperature (°C)
Depth (ft bgs)
ft bgs = feet below ground surface
4
3
2
1
0
-1
-2
0
25
50
75
100
125
150
175
200
225
250
275


Temperature Depth Plot for T-97-030 (1996-2020)
Temperature (°C)
12
10
8
6
4
2
0
-2
-4
-6
-8
0
50
100
150
200
250
300
Depth (ft bgs)
ft bgs = feet below ground surface

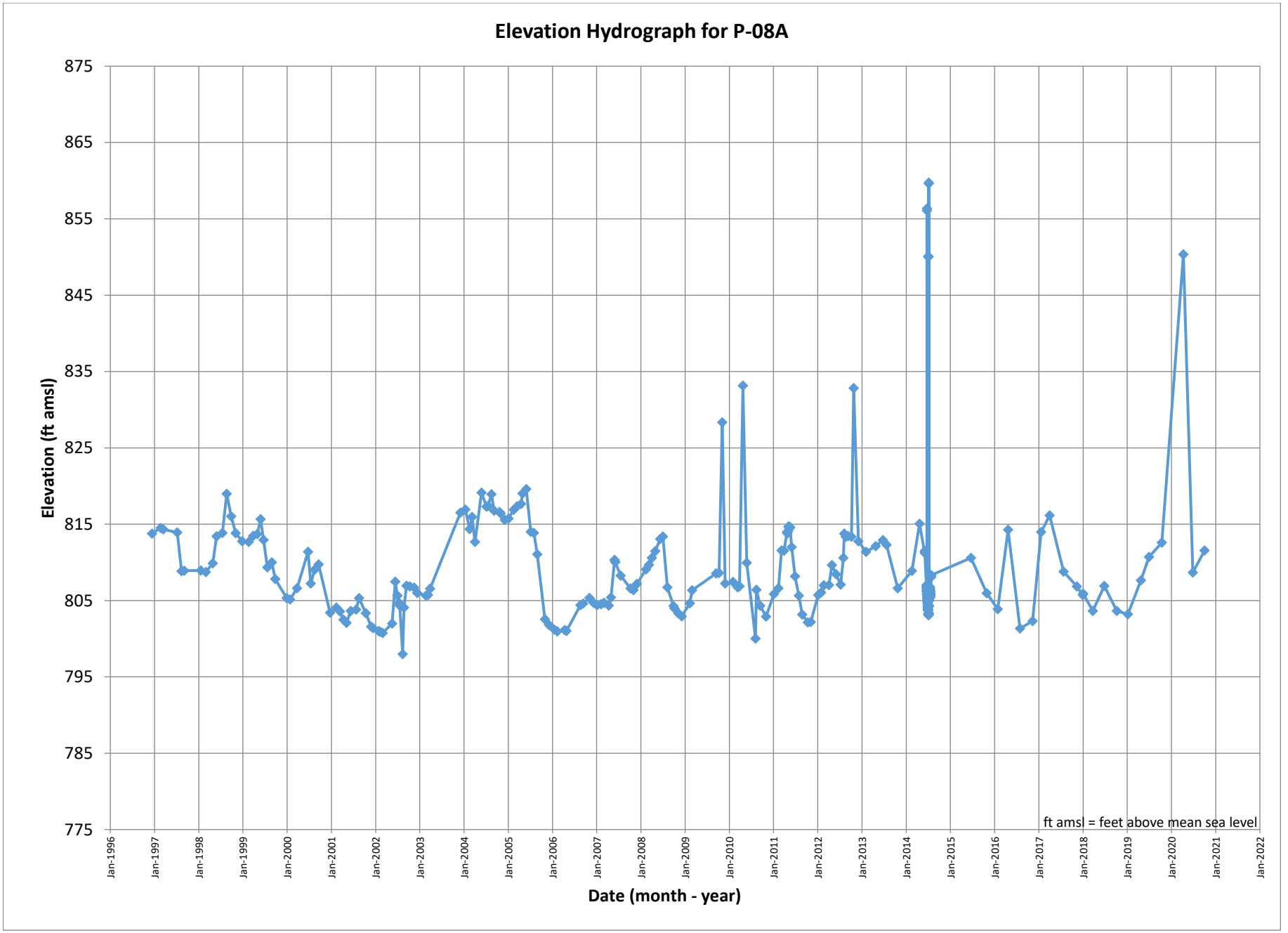
This Page Intentionally Blank

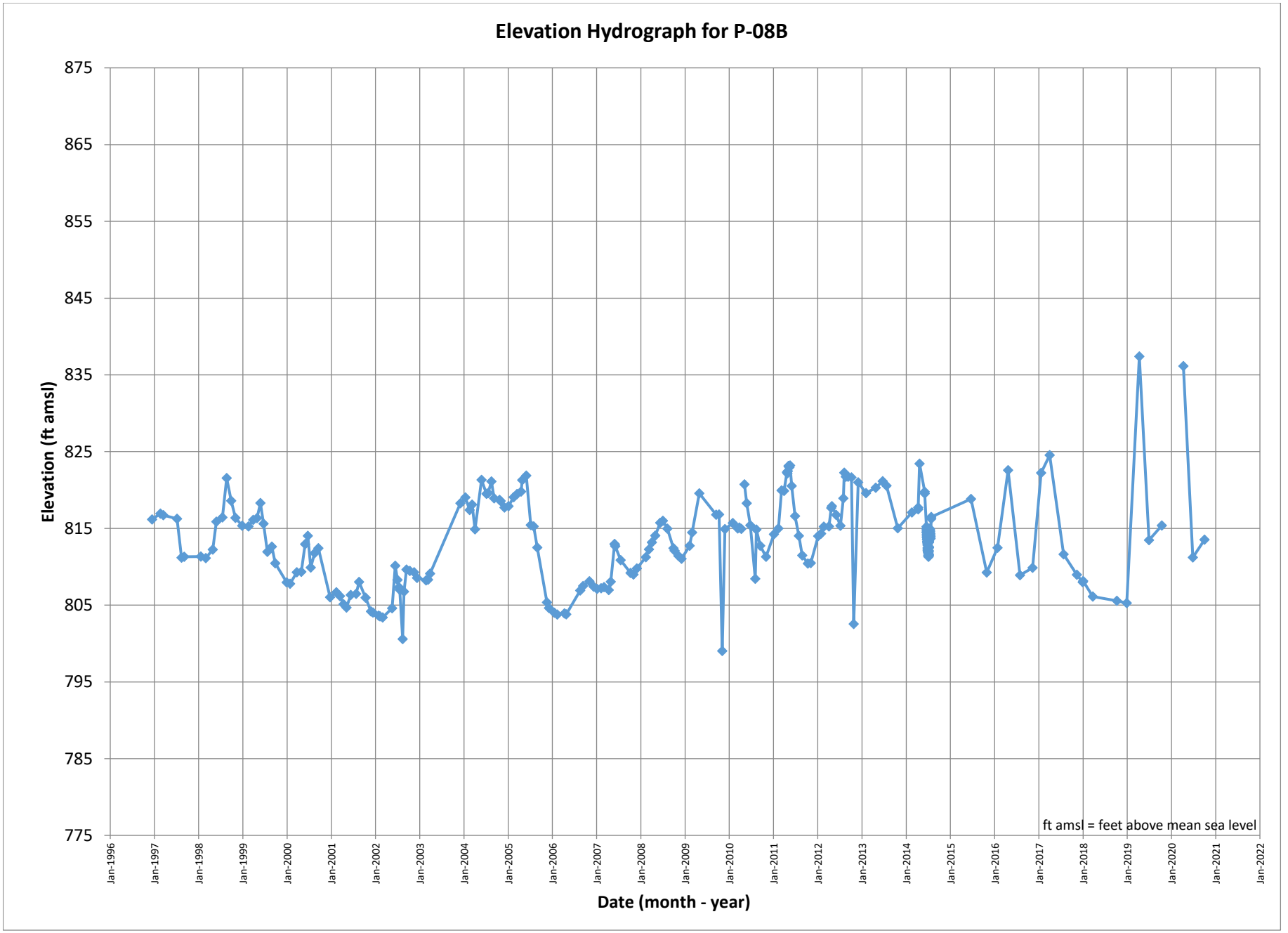
Appendix D
Piezometer Plots

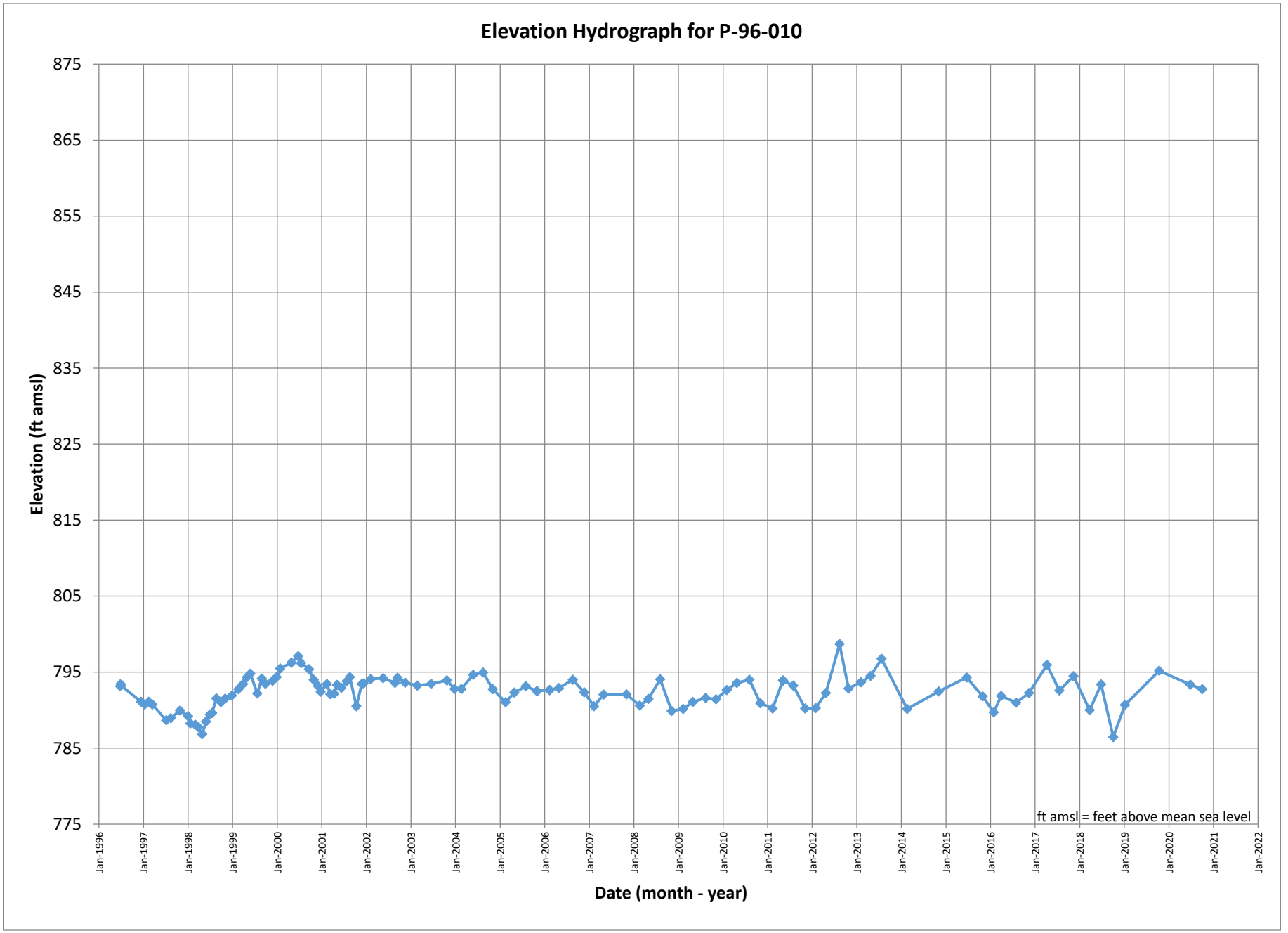
This Page Intentionally Blank

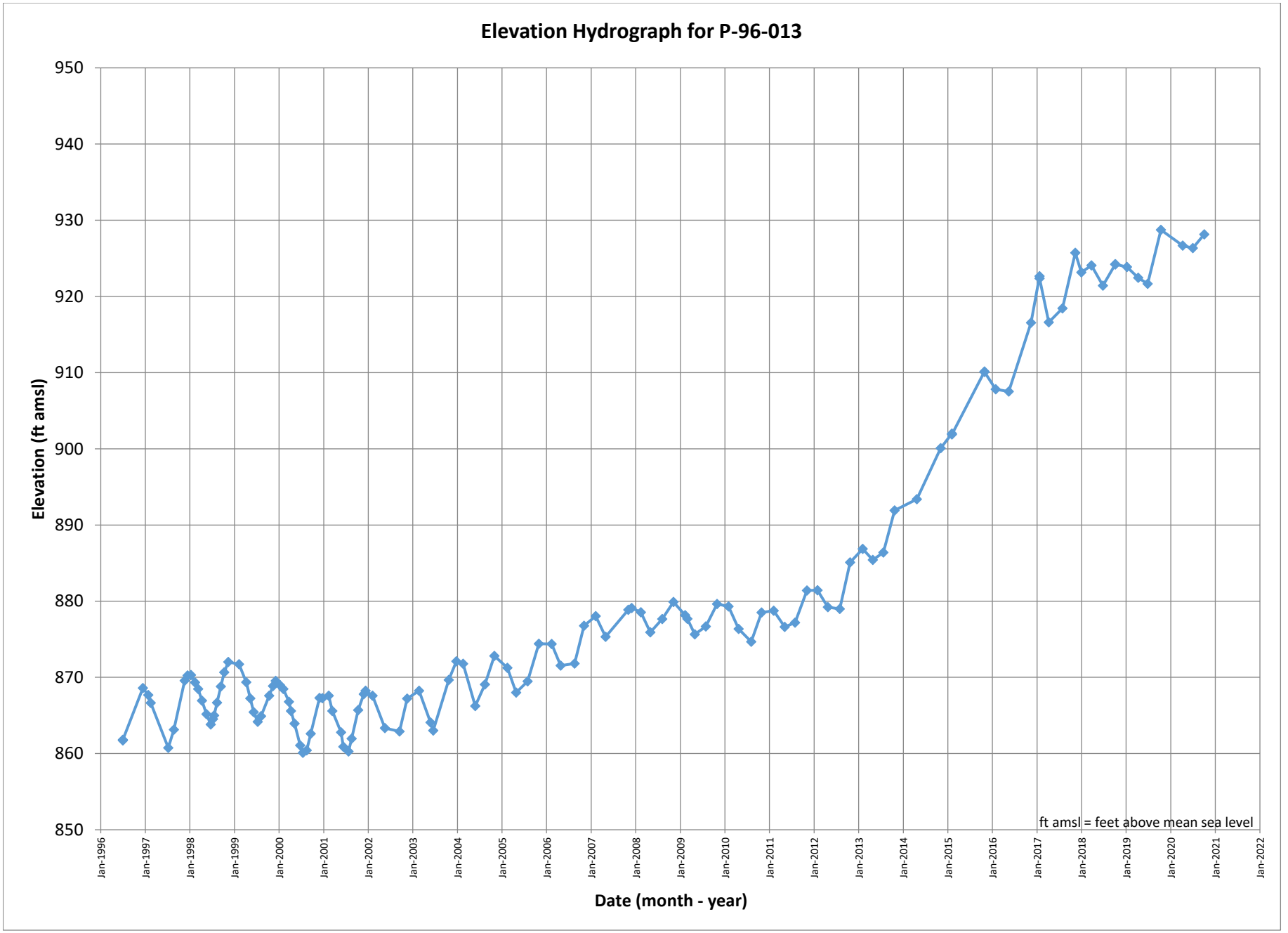
Piezometer Water Elevations (ft amsl)

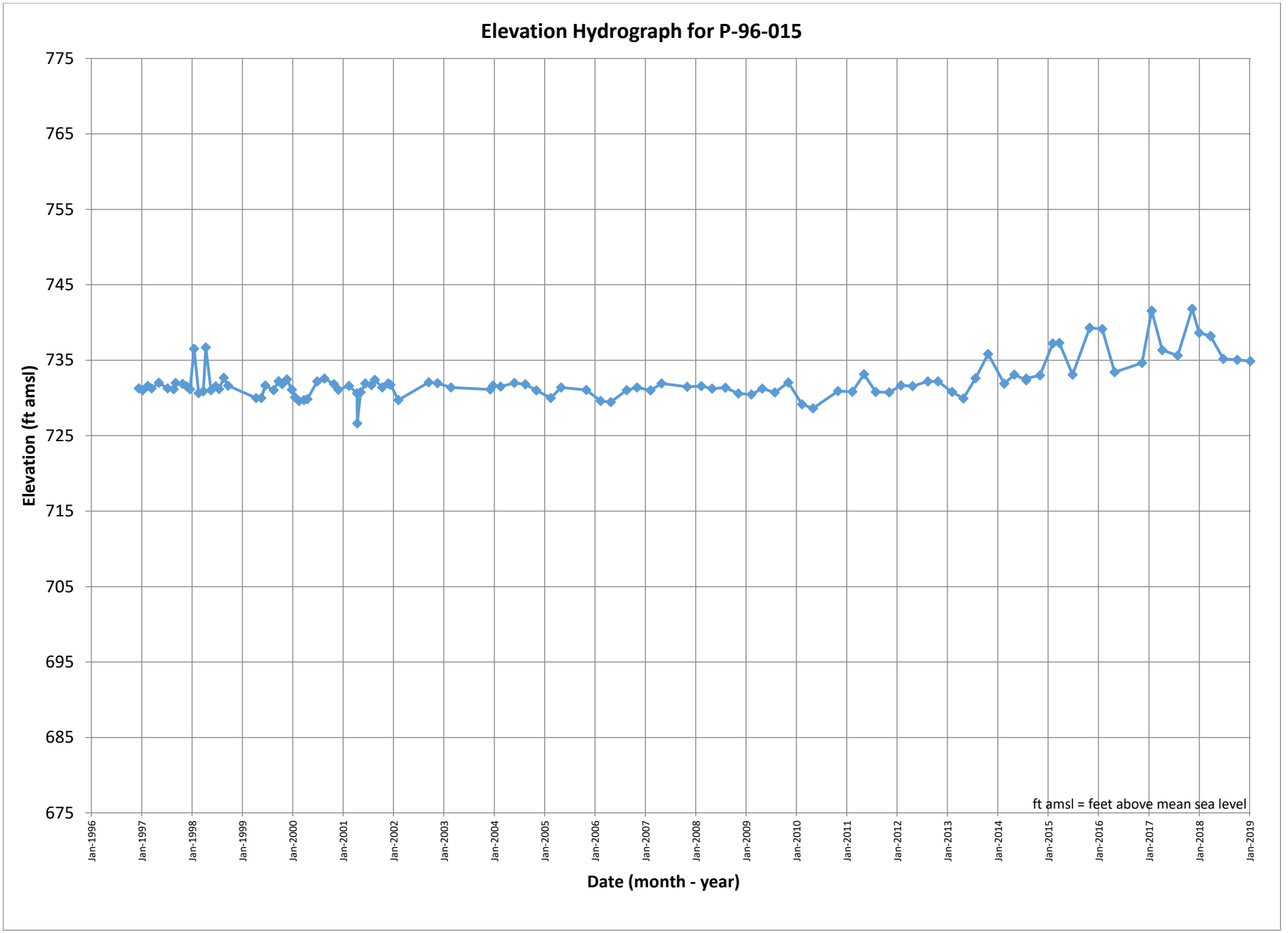
This Page Intentionally Blank

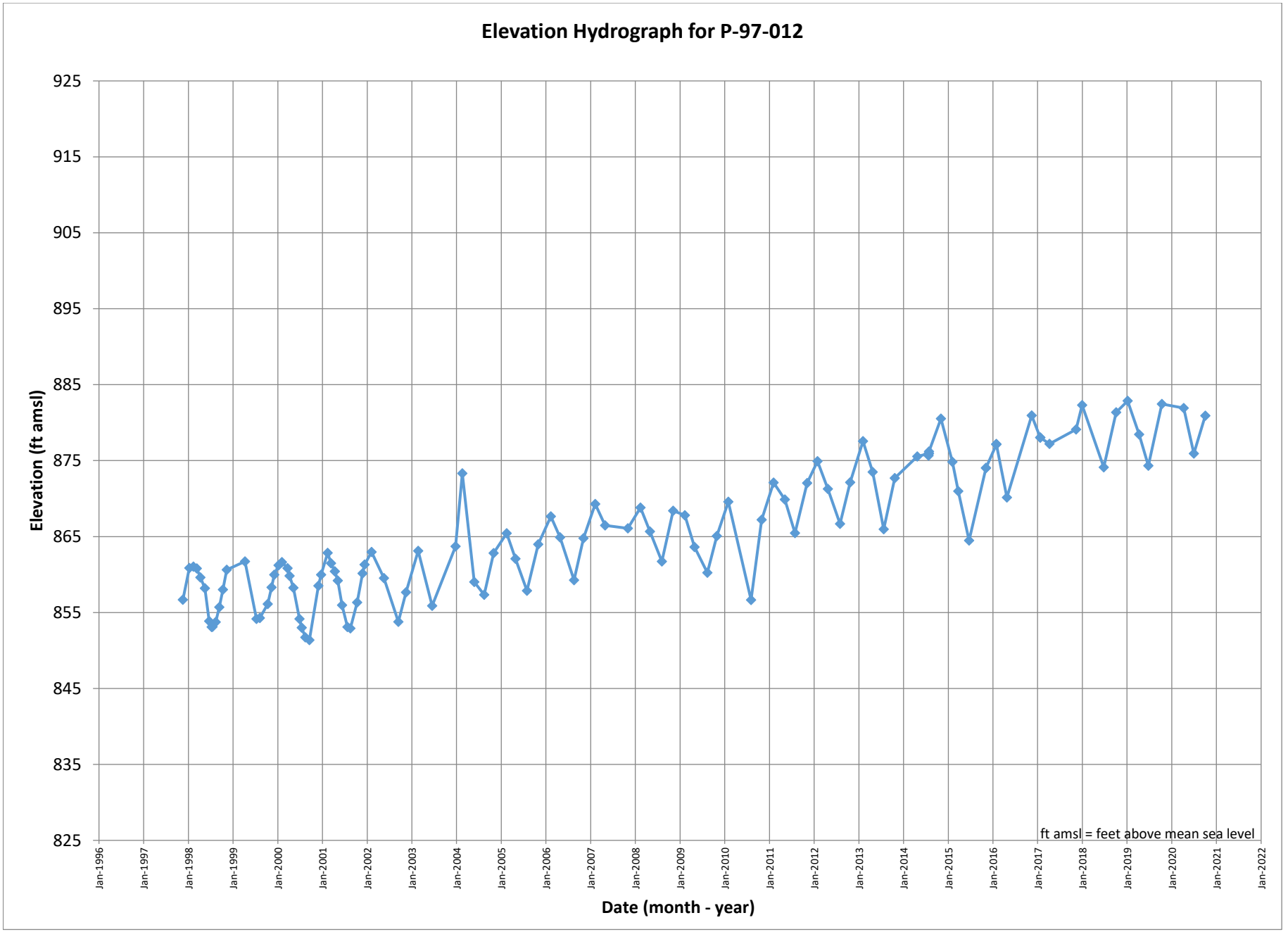

Elevation Hydrograph for P-08A
875
865
855
845
835
825
815
805
795
785
775
Elevation (ft amsl)
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft amsl = feet above mean sea level

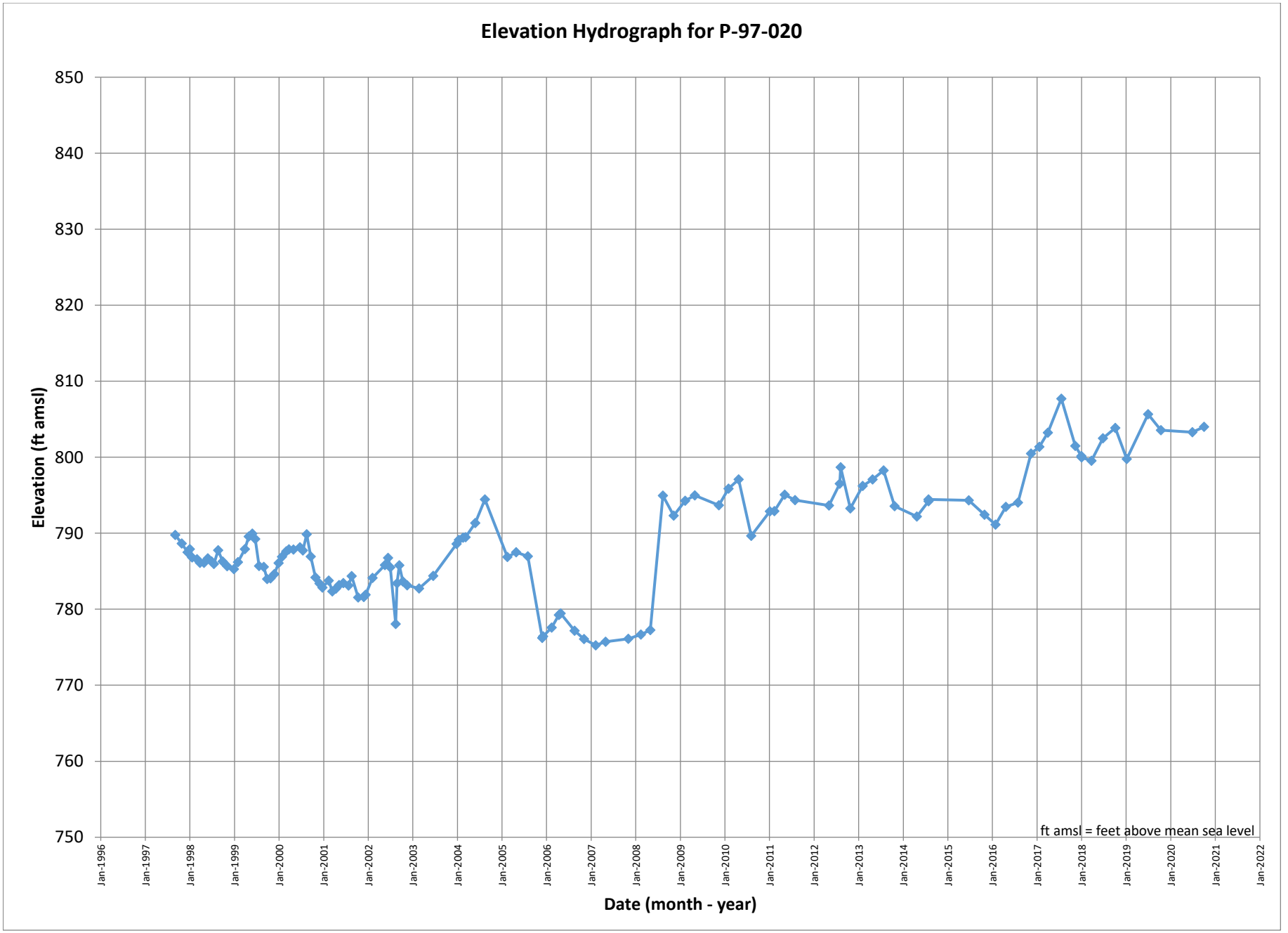

Elevation Hydrograph for P-08B
875
865
855
845
835
825
815
805
795
785
775
Elevation (ft amsl)
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft amsl = feet above mean sea level

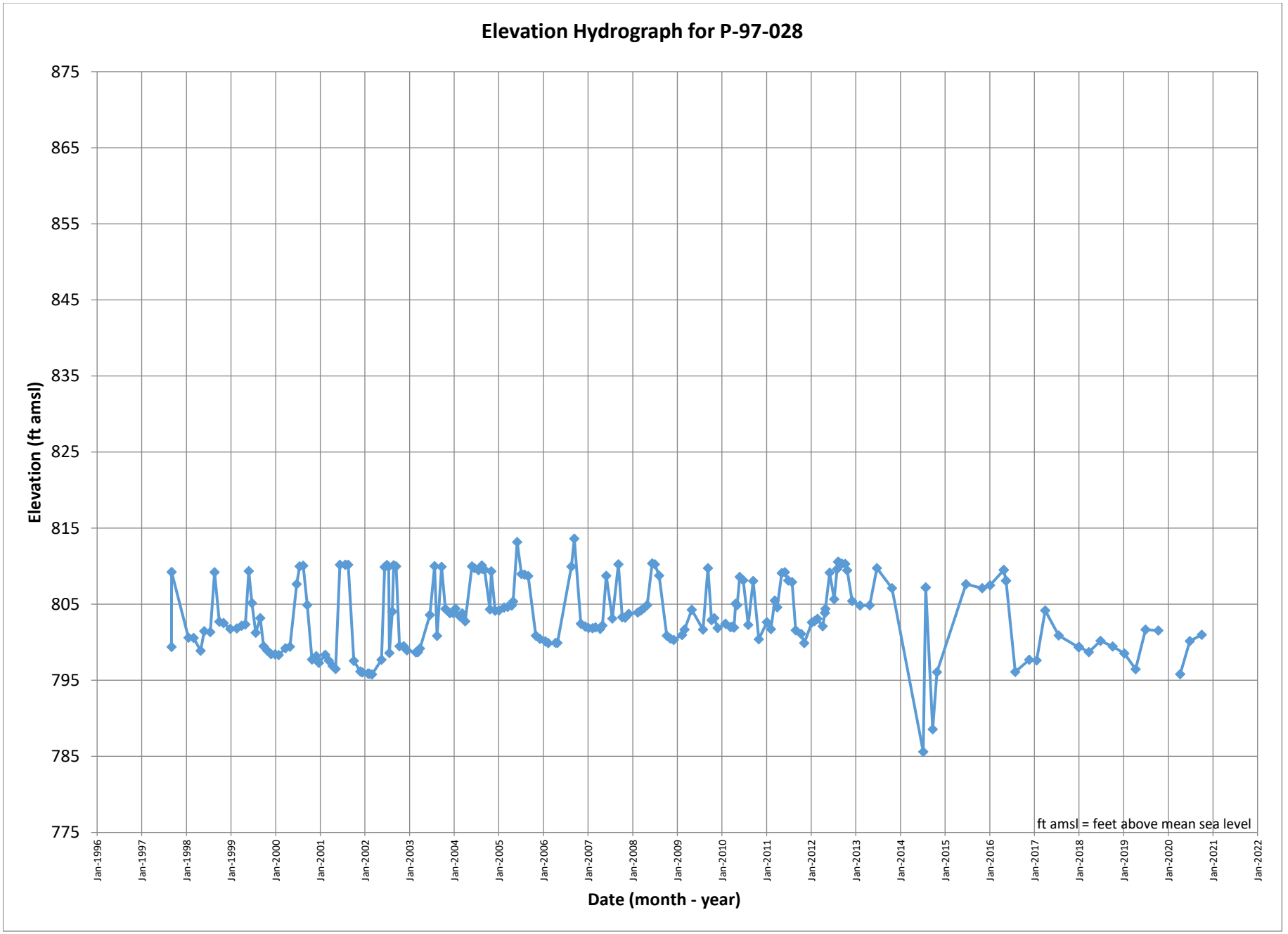

Elevation Hydrograph for P-96-010
Elevation (ft amsl)
875
865
855
845
835
825
815
805
795
785
775
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft amsl = feet above mean sea level

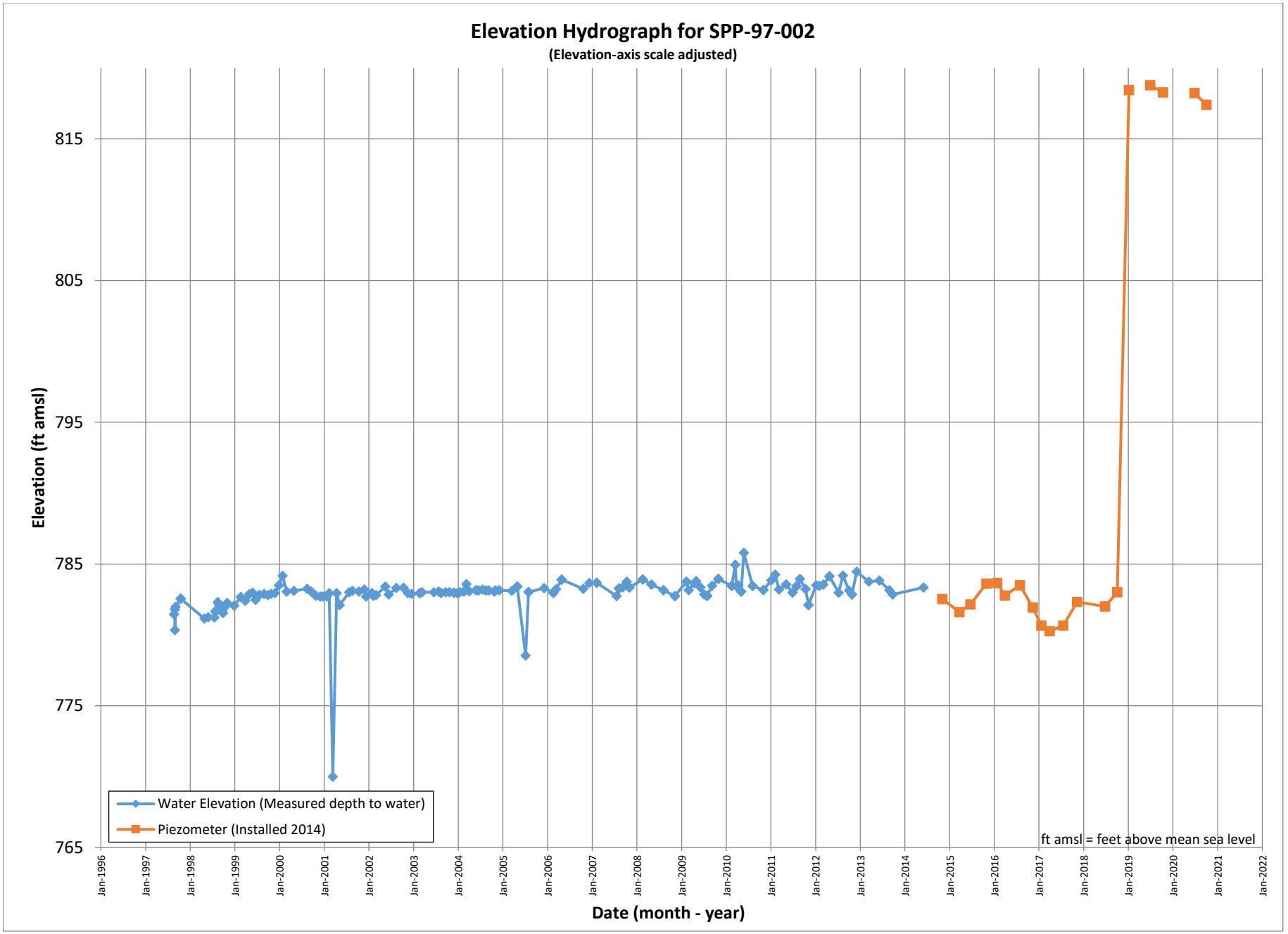

Elevation Hydrograph for P-96-013
Elevation (ft amsl)
950
940
930
920
910
900
890
880
870
860
850
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft amsl = feet above mean sea level


Elevation Hydrograph for P-96-015
775
765
755
745
735
725
715
705
695
685
675
Elevation (ft amsl)
ft amsl = feet above mean sea level
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Date (month - year)


Elevation Hydrograph for P-97-012
925
915
905
895
885
875
865
855
845
835
825
Elevation (ft amsl)
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft amsl = feet above mean sea level


Elevation Hydrograph for P-97-020
Elevation (ft amsl)
850
840
830
820
810
800
790
780
770
760
750
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft amsl = feet above mean sea level

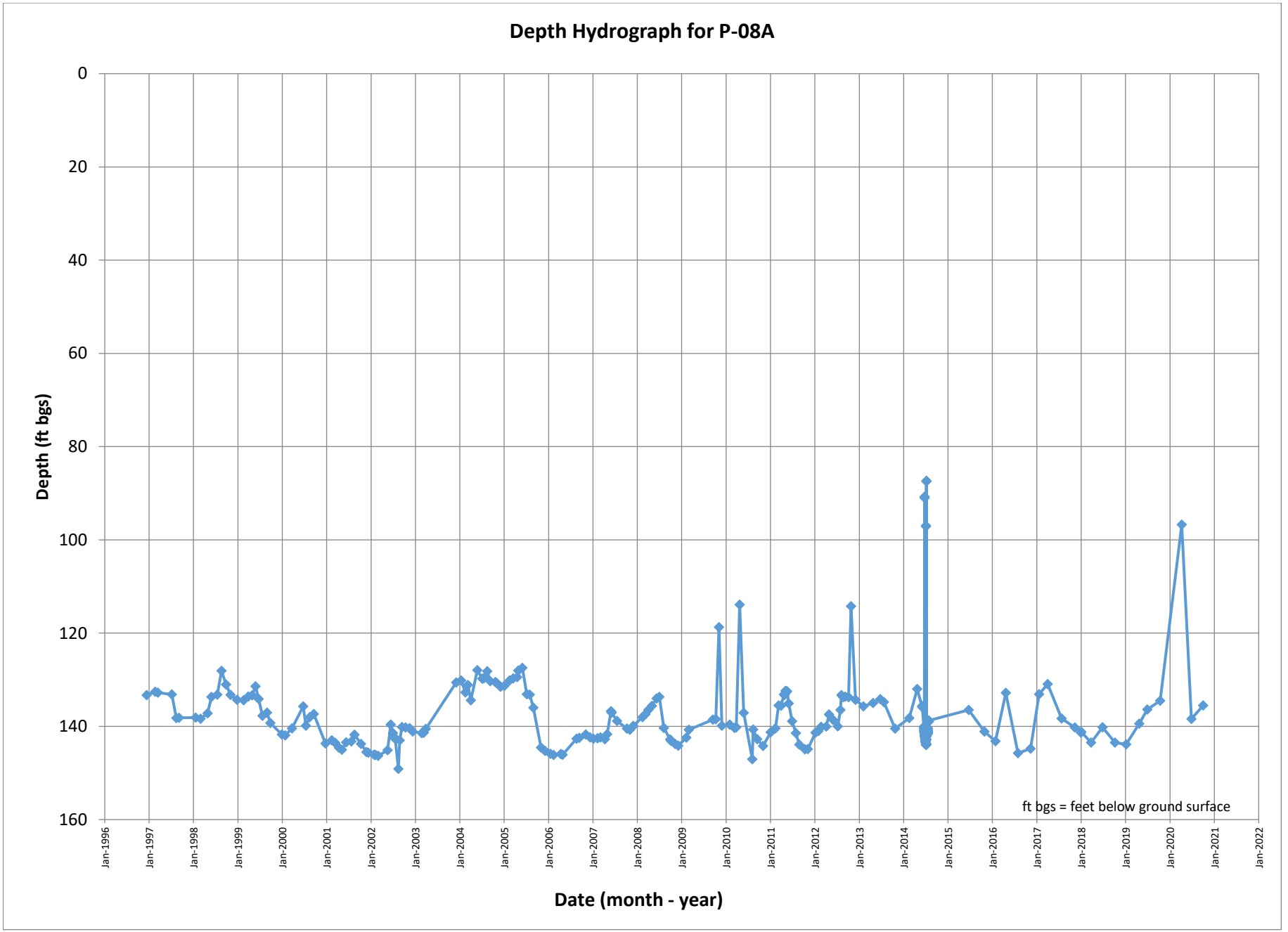

Elevation Hydrograph for P-97-028
Elevation (ft amsl)
875
865
855
845
835
825
815
805
795
785
775
ft amsl = feet above mean sea level
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)

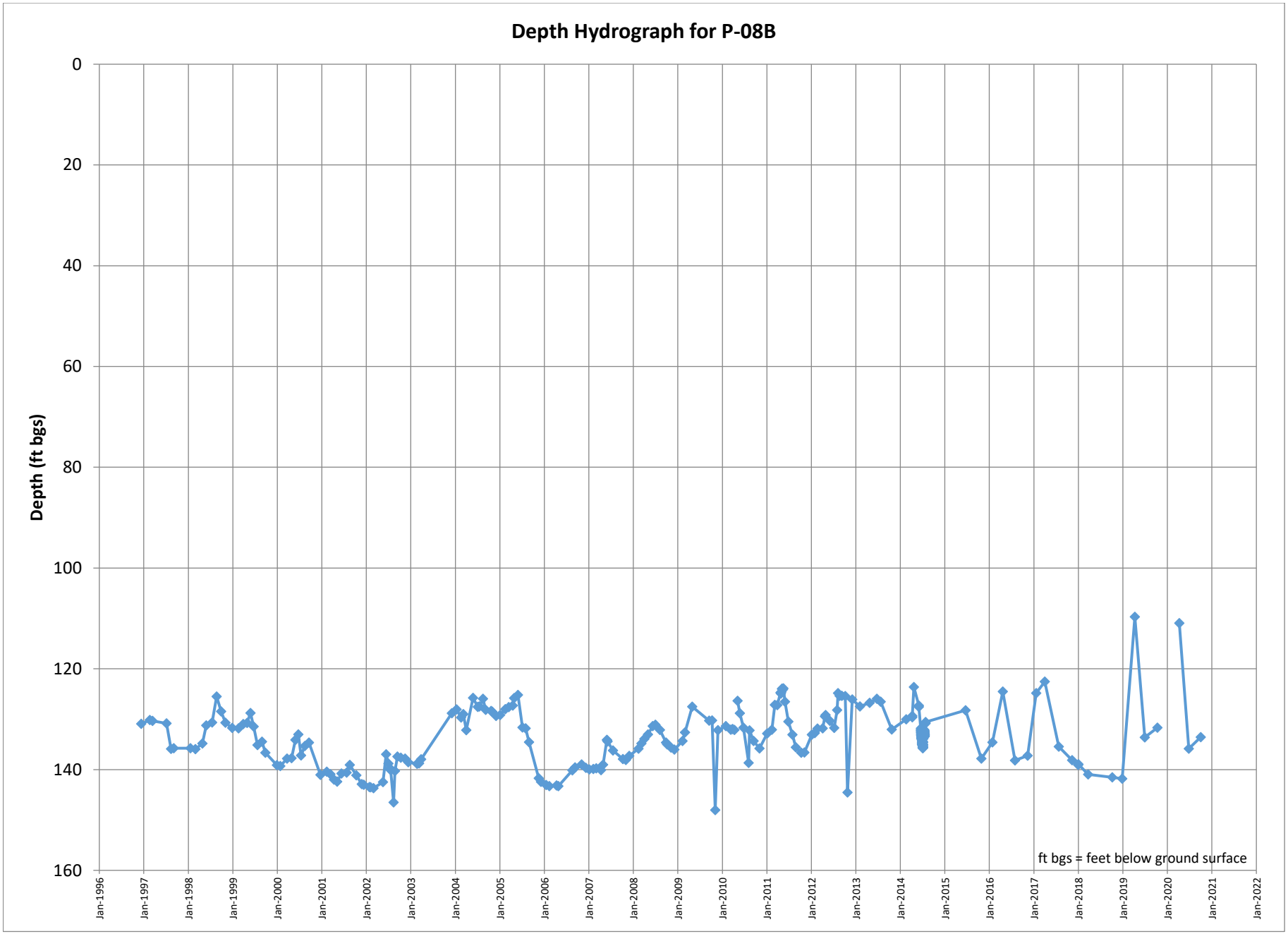

Elevation Hydrograph for SPP-97-002
(Elevation-axis scale adjusted)
Elevation (ft amsl)
815
805
795
785
775
765
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
Water Elevation (Measured depth to water)
Piezometer (Installed 2014)
ft amsl = feet above mean sea level

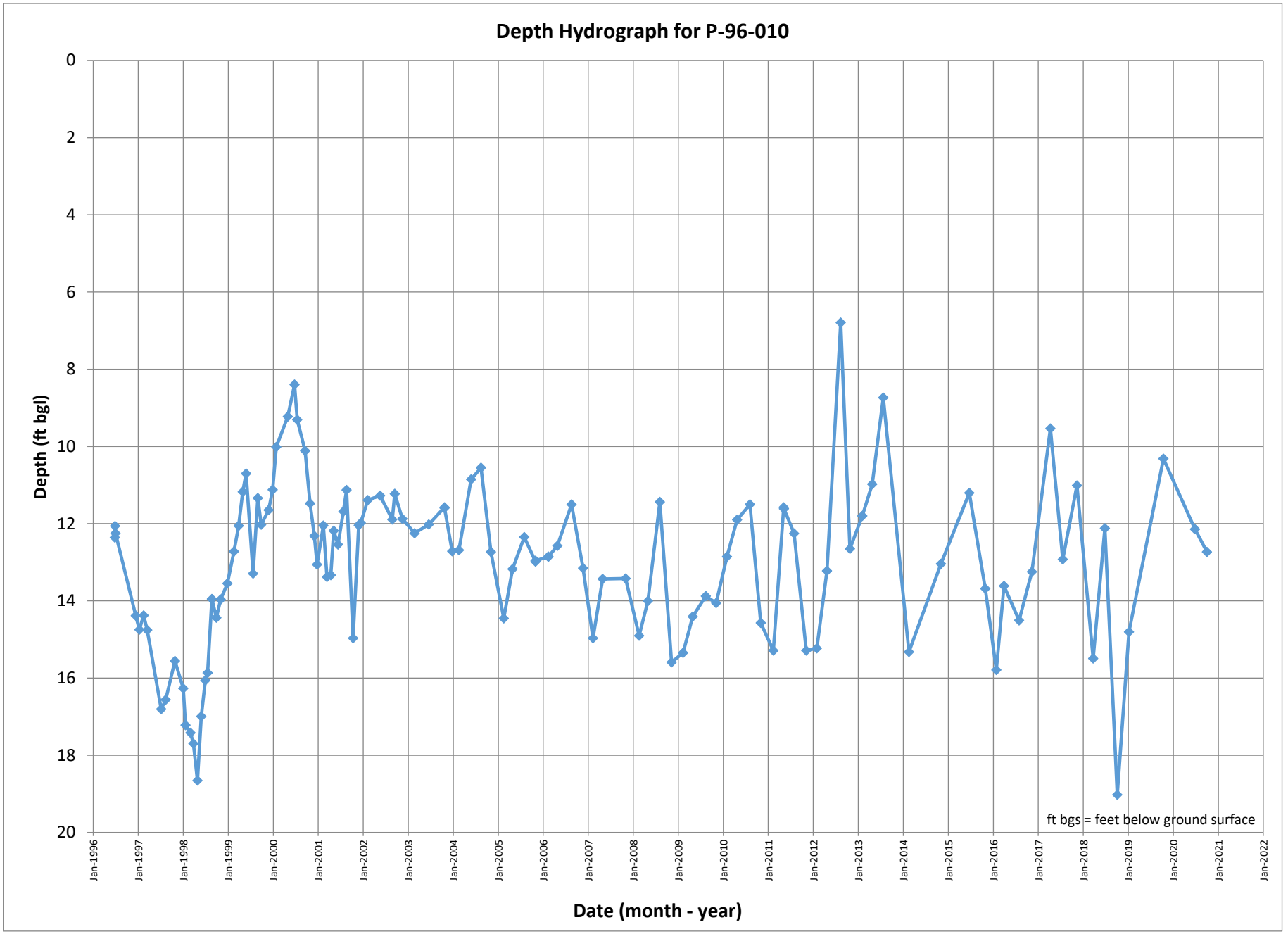
This Page Intentionally Blank

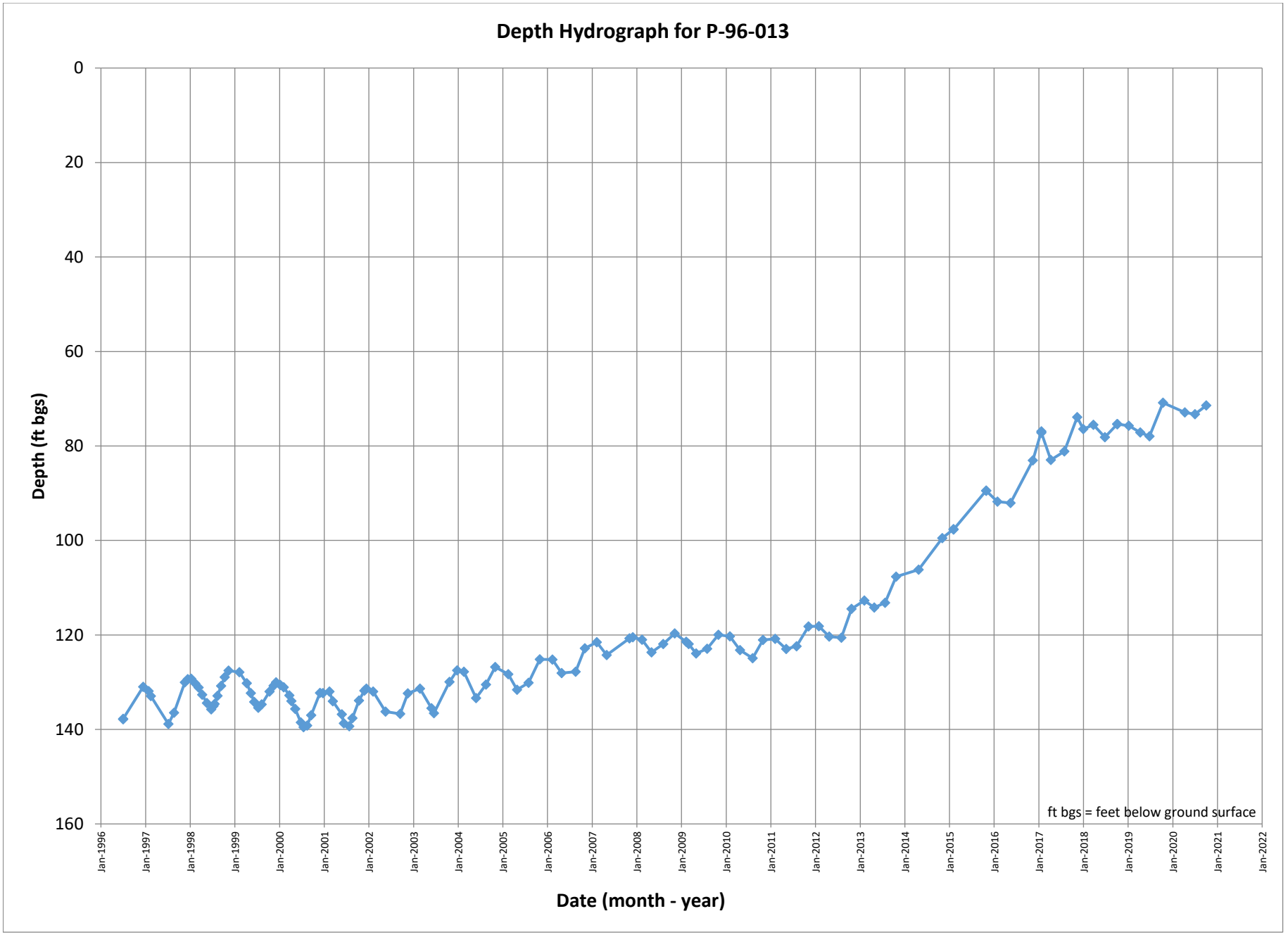
Piezometer Water Depths (ft bgs)

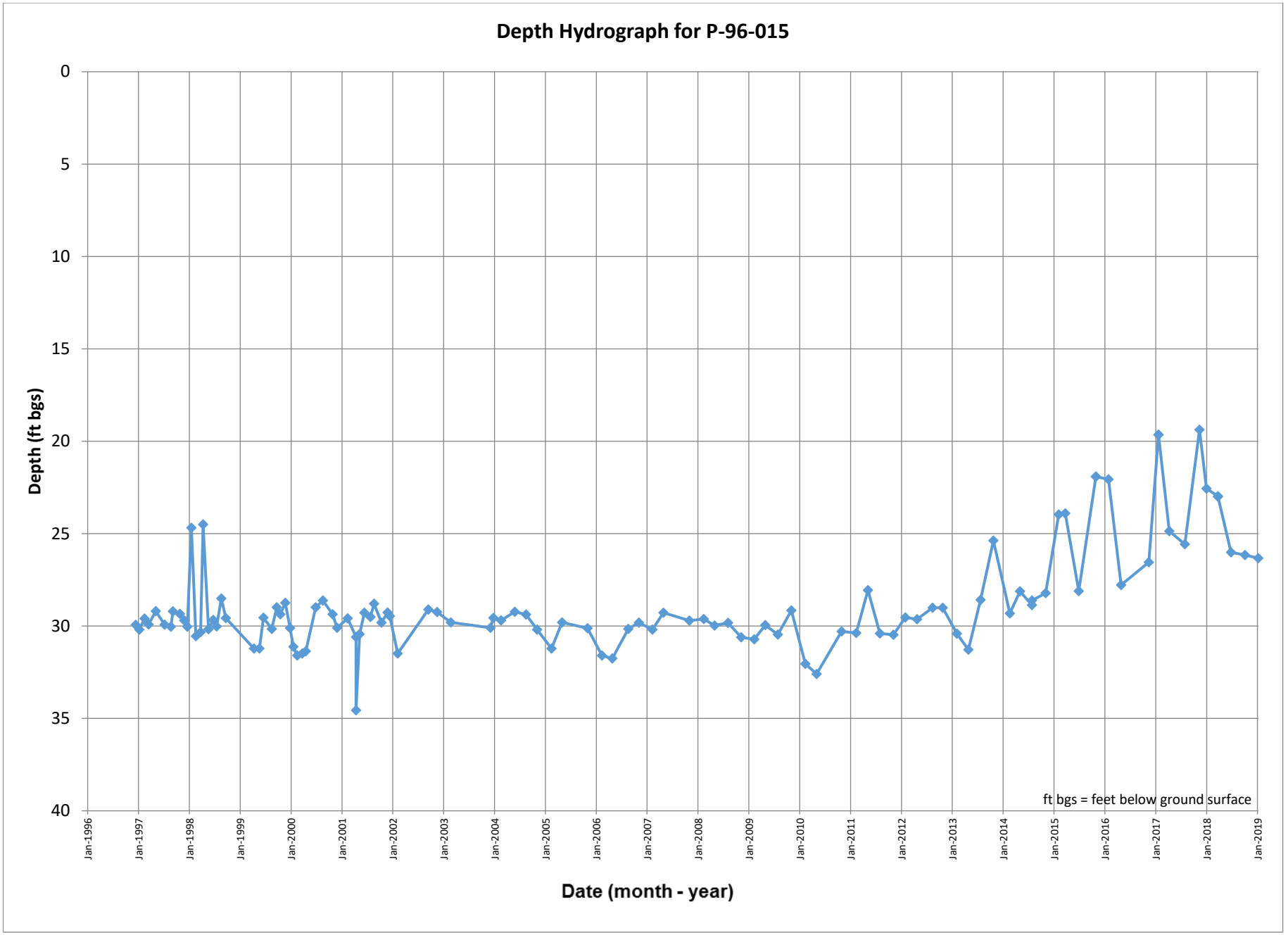
This Page Intentionally Blank

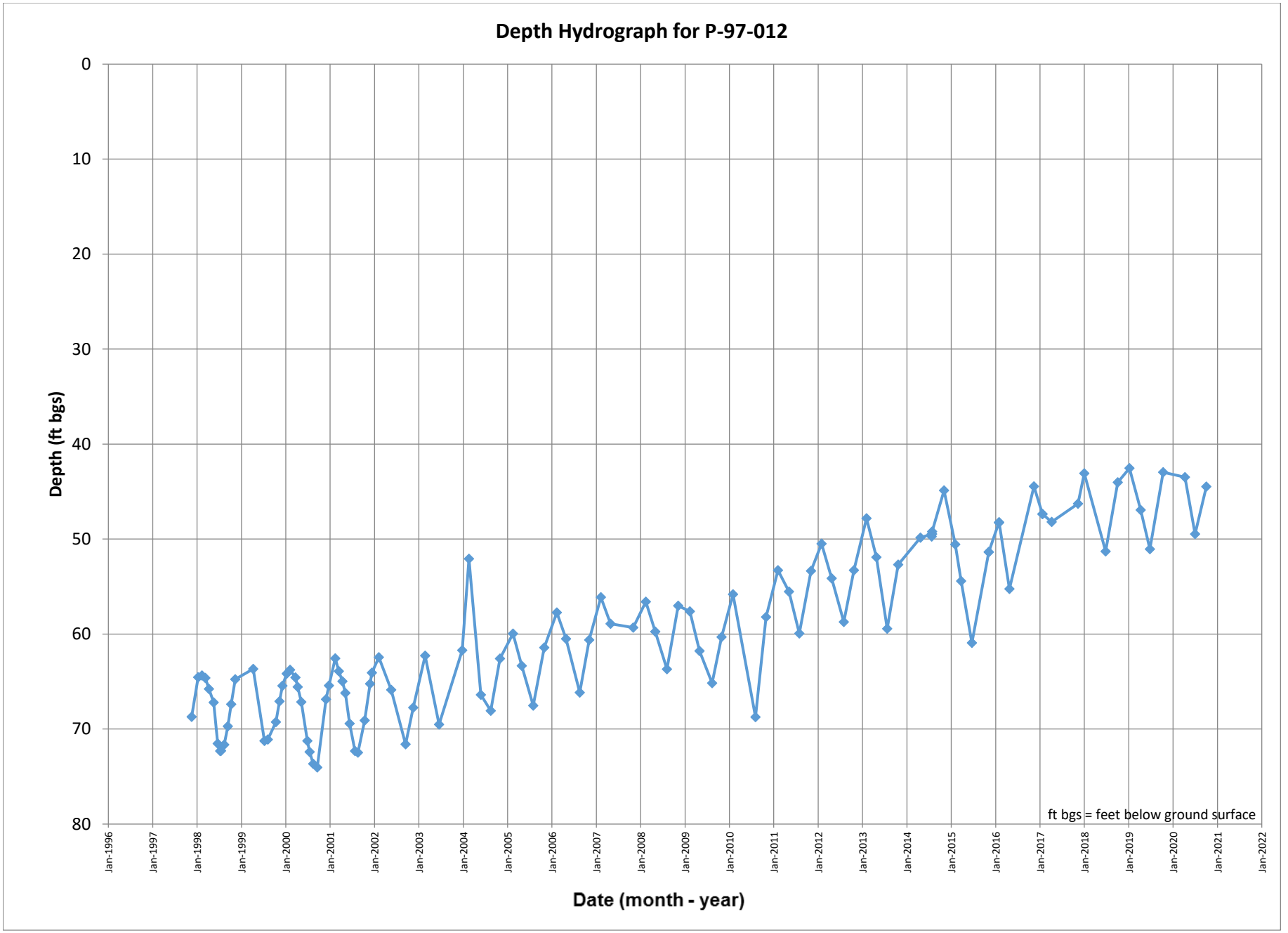

Depth Hydrograph for P-08A
Depth (ft bgs)
0
20
40
60
80
100
120
140
160
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft bgs = feet below ground surface

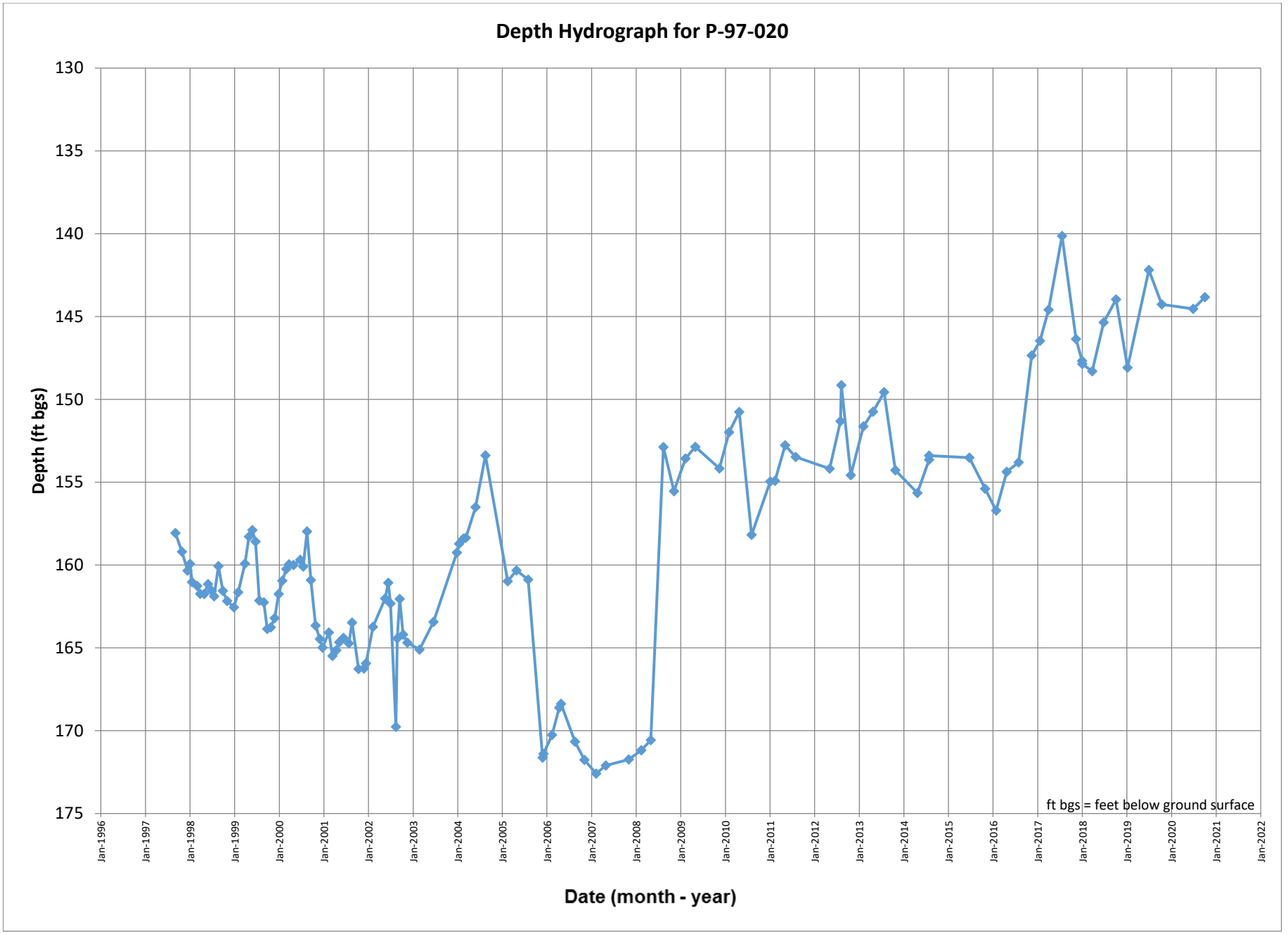

Depth Hydrograph for P-08B
Depth (ft bgs)
0
20
40
60
80
100
120
140
160
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
ft bgs = feet below ground surface

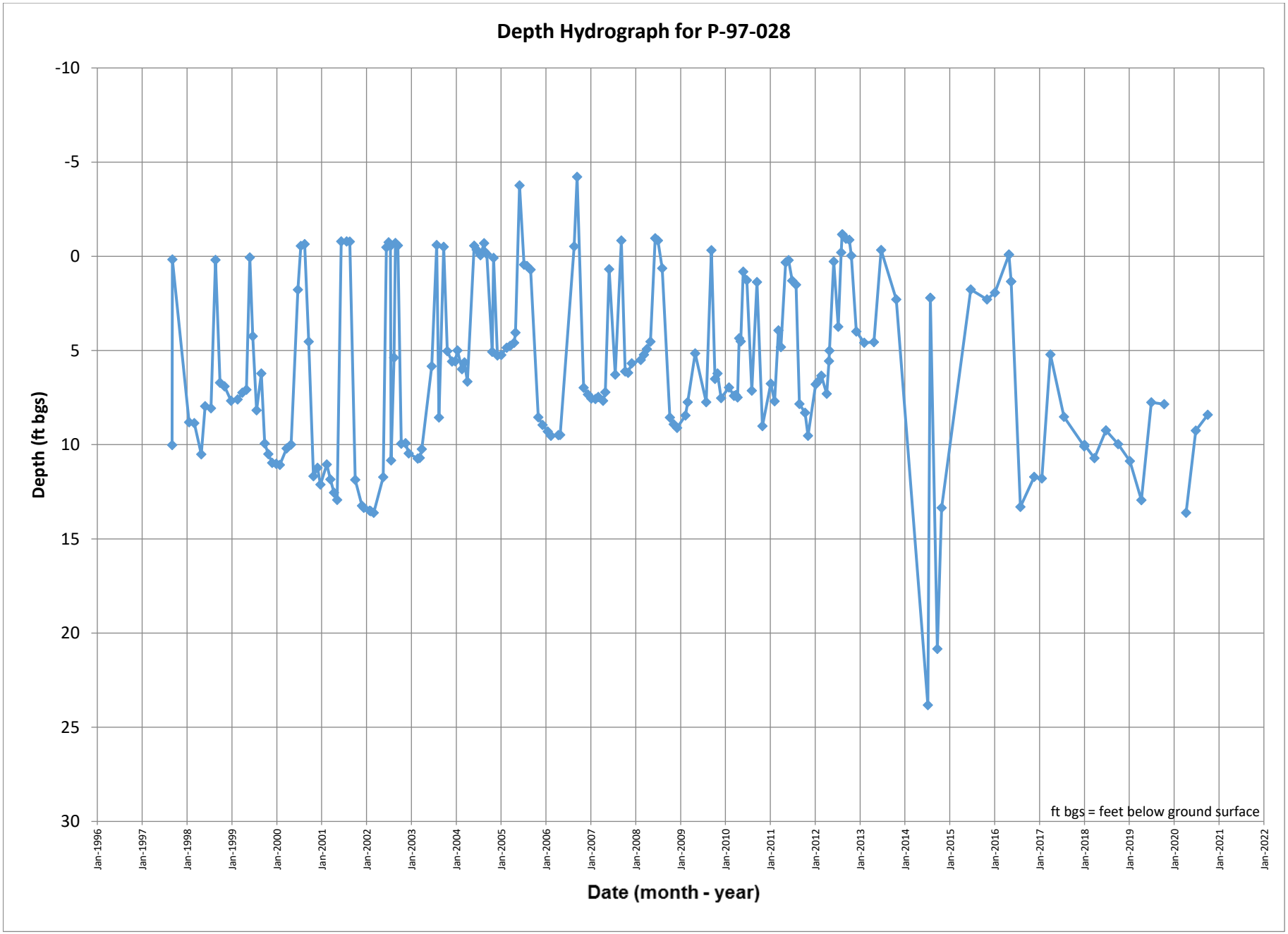

Depth Hydrograph for P-96-010
Depth (ft bgl)
0
2
4
6
8
10
12
14
16
18
20
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft bgs = feet below ground surface

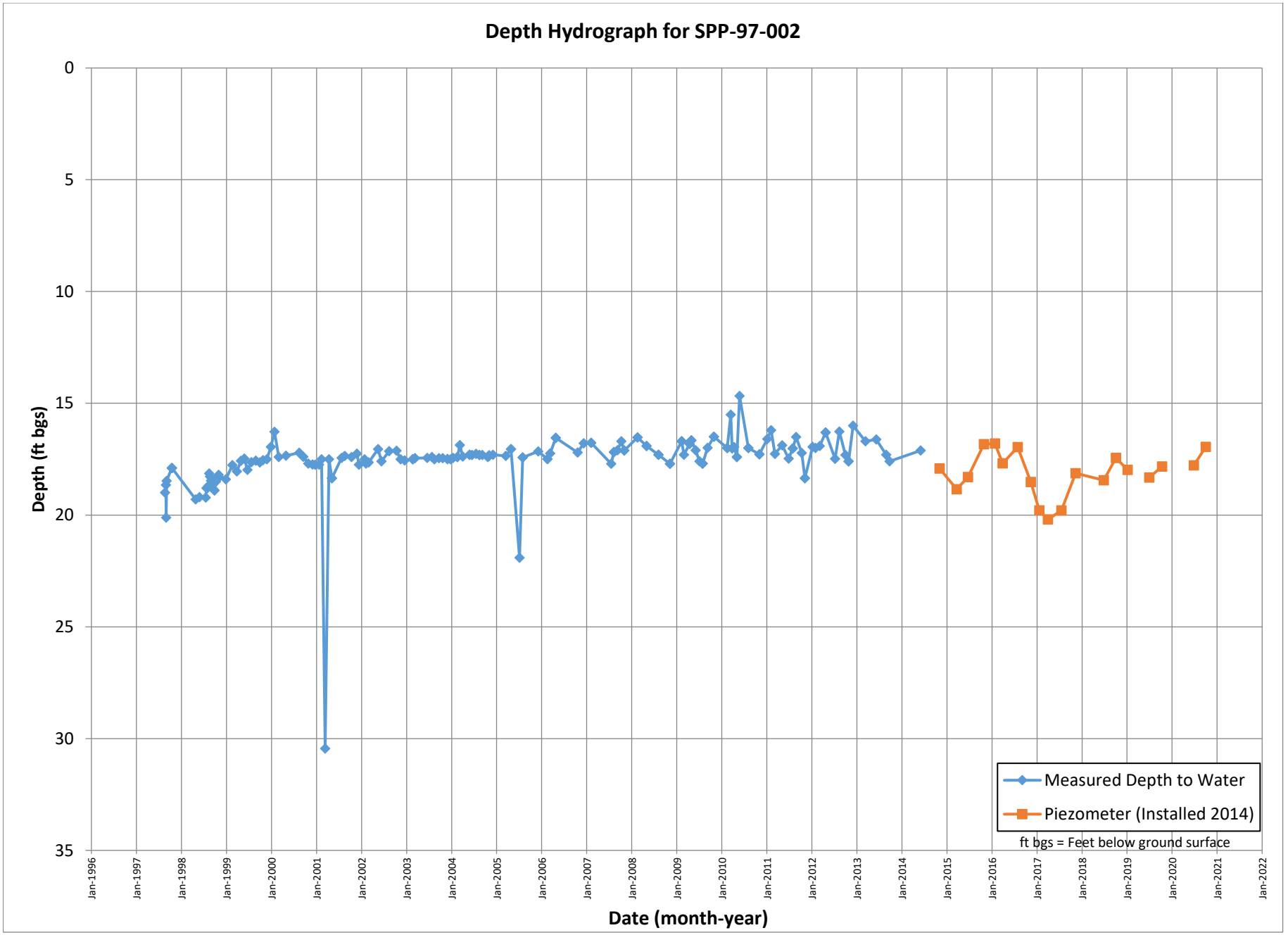

Depth Hydrograph for P-96-013
Depth (ft bgs)
0
20
40
60
80
100
120
140
160
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft bgs = feet below ground surface


Depth Hydrograph for P-96-015
Depth (ft bgs)
0
5
10
15
20
25
30
35
40
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Date (month - year)
ft bgs = feet below ground surface


Depth Hydrograph for P-97-012
Depth (ft bgs)
0
10
20
30
40
50
60
70
80
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft bgs = feet below ground surface


Depth Hydrograph for P-97-020
Depth (ft bgs)
130
135
140
145
150
155
160
165
170
175
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft bgs = feet below ground surface


Depth Hydrograph for P-97-028
-10
-5
0
5
10
15
20
25
30
Depth (ft bgs)
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month - year)
ft bgs = feet below ground surface


Depth Hydrograph for SPP-97-002
Depth (ft bgs)
0
5
10
15
20
25
30
35
Jan-1996
Jan-1997
Jan-1998
Jan-1999
Jan-2000
Jan-2001
Jan-2002
Jan-2003
Jan-2004
Jan-2005
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
Date (month-year)
Measured Depth to Water
Piezometer (Installed 2014)
ft bgs = Feet below ground surface

This Page Intentionally Blank

Appendix E
QA/QC Data and Field Forms

This Page Intentionally Blank

1st Quarter 2020

This Page Intentionally Blank

KUNA QUARTERLY REPORT DATA CHECKLIST **Quarter** Q1 2020 **Date** 04/07/2020

For Teck/RedDog Longterm Groundwater and Permafrost monitoring

☐ **YES / NO** Quarterly data received from Teck. Date received: 01/16/2020

☐ **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:

_____

☐ **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: The barometric pressure was listed as mBar which is not consistent with prior readings in the past.

_____

_____

_____

_____

_____

QUARTER Q1 2020 **DATE** 04/07/2020

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 (manually add "#2")	**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**	Had only errors

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**	Yes, but the readings were in mBar vs. PSI in the past.

Quarterly Thermistor QA / QC

Location: T96-13 Date: 11/10/19

Technician: TSP/FDP Start Time: 1025 Stop Time: 1030

Node	Ohms	Comments	Node	Temperature
Test	16.35		Test	
1	49.9		1	
2	55.2		2	
3	55.7		3	
4	54.1		4	
5	46.1		5	
6	34.5		6	
7	27.4		7	
8	23.0		8	
9	19.7		9	
10	17.2		10	
11	16.1		11	
12	15.5		12	
13	15.0		13	
14	14.6		14	
15	14.2		15	
16	13.9		16	
17	13.7		17	
18	13.6		18	
19	13.4		19	
20	13.3		20	
21	13.2		21	
22	13.1		22	
23	OL	No reading	23	
24	13.0		24	
Test	16.33		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

Date 1/10/20

Quarterly Thermistor Piezometer Readings

Technician: TSP / TDP Thermrdr: 19976 Geokon Row: General Weather: 0°C, clear

Col. Row #Ports	Well	Location	Collection Method Instrument	Nodes	Piezo PSI Therm Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24		1/10/20	0°F, clear
25	*P96-13	Overburden	Geokon Piezometer			1/13/20	22 ~~0°F, clear~~ TDP 16°F, snow
29	*T96-13	Overburden	Yellow box Thermistor	24	3	1/10/20	0°F, clear QA/QC performed
30	T96-13S	Overburden	Yellow box Thermistor	24	3	1/10/20	0°F, clear
31	*T96-21	Overburden	Yellow box Thermistor	24	3	1/10/20	-5°F, clear
32	*T96-22	Overburden	Yellow box Thermistor	24	3	1/10/20	-5°F, clear
33	*T96-23	Overburden	Yellow box Thermistor	24	3	1/10/20	-5°F, clear
34	T96-24	Overburden	Yellow box Thermistor	24	3	1/10/20	-5°F, clear
24	*P97-12	Blast Road	Geokon Piezometer			1/13/20	3°F, ~~clear~~ TDP 16°F, snow
27	*T96-12	Blast Road	Yellow box Thermistor	24	3	1/10/20	0°F, clear
28	*T96-12S	Blast Road	Yellow box Thermistor	24	3	1/10/20	0°F, clear
12	T98-33	Cold Storage	Yellow box Thermistor	10	3	1/10/20	-3°F, clear,
13	T98-34	Cold Storage	Yellow box Thermistor	11	3	1/10/20	-3°F, clear, Read 7 of 11 nodes
14	T98-35	Cold Storage	Yellow box Thermistor	11	3	1/10/20	-3°F, clear, Read 7 of 11 nodes. Took this reading twice due to damaged connection. Same reading
133	T05-67	By "3 Way"	Yellow box Thermistor	8	0	1/10/20	+3°F, clear,
~~4~~	~~WingWall~~	~~Power House~~	~~Nautiz Geokon logger~~				
~~1~~	~~P05-63~~	~~Zn Thickener~~	~~Nautiz Geokon logger~~				
129	T05-63	Zn Thickener	Yellow box Thermistor	8	3	1/10/20	3°F, clear
130	T05-64	By CSB	Yellow box Thermistor	7	3	1/10/20	3°F, clear, R
132	T05-66	South of CSB	Yellow box Thermistor	8		1/10/20	Connection is severed. Look like the wind blew a cover or case of some sort and cut the line.
70	*T95-05	By sandfilter	Yellow box Thermistor	24	3	1/10/20	3°F, clear
127	*T05-61	TDAM (end)	Yellow box Thermistor	6	3	1/10/20	3°F, clear slippery surface walking to connection
69	*T95-04	TDAM (end)	Yellow box Thermistor	24	3	1/10/20	Lots of ice in connection.
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24			
75	*T97-28	Buttress	Yellow box Thermistor	24	3	1/10/20	A
76	*T97-29	Buttress	Yellow box Thermistor	24	3	1/10/20	B
77	*T97-30	Buttress	Yellow box Thermistor	24	3	1/10/20	C
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	3	1/10/20	3°F, clear
65	TDAM T7	Seepage Dam	Yellow box Thermistor				Could not locate. Might be buried due to new seepage BLDG
23	*P96-15	Lower RDC	Geokon Piezometer			1/13/20	22 16°F, snow
44	*T96-15	Lower RDC	Yellow box Thermistor	14	3	1/12/20	5°F, overcast

*SEP Thermister. 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.

2nd Quarter 2020

This Page Intentionally Blank

KUNA QUARTERLY REPORT DATA CHECKLIST **Quarter** Q2 2020 **Date** 05/06/2020

For Teck/RedDog Longterm Groundwater and Permafrost monitoring

☐ **YES / NO** Quarterly data received from Teck. Date received: 05/03/2020

☐ **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:

Data was not received for T-96-005

☐ **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 Q2 2020 **DATE** 05/06/2020

Thermistor	Data Received? Y / N	Comments
T-96-015	**Y**	
T-05-061	**Y**	
T-95-005	**N**	Not accessible
T-96-010	**Y**	
T-97-028	**Y**	
T-97-029	**Y**	
T-97-030	**Y**	
T-14-110	**Y**	
T-95-008 #2 (manually add "#2")	**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**	

Quarterly Thermistor QA / QC

Location: T96-21 Date: 4/24/202

Technician: JWH/TDP Start Time: 1015 Stop Time: 1018

Node	Ohms	Comments	Node	Temperature
Test	~~16.33~~ 16.32		Test	
1	21.32		1	
2	19.40		2	
3	17.99		3	
4	15.74		4	
5	14.16		5	
6	13.67		6	
7	13.00		7	
8	12.97		8	
9	13.14		9	
10	13.52		10	
11	13.94		11	
12	14.42		12	
13	14.94		13	
14	15.45		14	
15	15.73		15	
16	16.11		16	
17	16.53		17	
18	16.63		18	
19	16.69		19	
20	16.79		20	
21	16.84		21	
22	16.88		22	
23	16.91		23	
24	16.97		24	
Test	16.32		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

Date

5/3/20 & 5/5/20

Quarterly Thermistor Piezometer Readings

GK-392

~~GK-4103~~ TDP

5/5/20: clear 40°F, E wind @ 16mph 30.05 in Hg, 44% relative humidity

Technician(s): TDP + JWA

Geokon ID #: —

Thermrdr ID #: 199176

General Weather: ~~5/3/20~~ clear 25°F, N wind @ 5mph 29.05 in Hg, 56% relative humidity 5/3/20

Col. # Row	Well	Location	Collection Method Instrument	Nodes	Piezo PSI or Therm Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24		5/3/20	
25	*P96-13	Overburden	Geokon Piezometer			4/26/20	
29	*T96-13	Overburden	Yellow box Thermistor	24		5/3/20	
30	T96-13S	Overburden	Yellow box Thermistor	24	Error 3	5/3/20	
31	*T96-21	Overburden	Yellow box Thermistor	24	Error 3	5/3/20	QAQC conducted (4/26/20)
32	*T96-22	Overburden	Yellow box Thermistor	24	Error 3	5/3/20	
33	*T96-23	Overburden	Yellow box Thermistor	24	Error 3	5/3/20	
34	T96-24	Overburden	Yellow box Thermistor	24		5/3/20	
24	*P97-12	Blast Road	Geokon Piezometer			4/26/20	
27	*T96-12	Blast Road	Yellow box Thermistor	24	Error 3	5/5/20 ~~5/3/20~~ TDP	Resampled @ 5/5/20
28	*T96-12S	Blast Road	Yellow box Thermistor	24	Error 3	5/5/20 ~~5/3/20~~ TDP	Resampled @ 5/5/20
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24		4/25/20	Downloaded from server
70	*T95-05	By sandfilter	Yellow box Thermistor	24		—	No access, work being done around ~~around~~ pizzo TDP
127	*T05-61	TDAM (end)	Yellow box Thermistor	6		5/3/20	
69	*T95-04	TDAM (end)	Yellow box Thermistor	24	Error 3	5/3/20	
75	*T97-28	Buttress	Yellow box Thermistor	24	Error 3	5/3/20	
76	*T97-29	Buttress	Yellow box Thermistor	24	Error 3	5/3/20	
77	*T97-30	Buttress	Yellow box Thermistor	24	Error 3	5/3/20	
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	Error 3	5/3/20	
23	*P96-15	Lower RDC	Geokon Piezometer			~~4/25/20~~ 4/26/20	
44	*T96-15	Lower RDC	Yellow box Thermistor	14		5/7/20	

Remember to print QAQC form for Thermistor Qualtrax ID # 783

*SEP Thermister. 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.

3rd Quarter 2020

This Page Intentionally Blank

KUNA QUARTERLY REPORT DATA CHECKLIST **Quarter** Q3 2020 **Date** 08/03/2020

For Teck/RedDog Longterm Groundwater and Permafrost monitoring

☐ **YES / NO** Quarterly data received from Teck. Date received: 07/31/2020

☐ **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:

_____

☐ **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 Q3 2020 **DATE** 08/03/2020

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 (manually add "#2")	**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**	

Date 7/14/20

Kelson Phillips

Quarterly Thermistor Piezometer Readings

Technician(s): Adam Mercuieff Geokon ID #: 392 Thermrdr ID #: 2 19977 General Weather: Clear, Sunny, no precip., East wind 11mph

Col. # Row	Well	Location	Collection Method Instrument	Nodes	Piezo PSI or Therm Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24	3	7/14/20	~~Value 658~~ Abn 2nd reading Rd 24 Err 3 7/24
25	*P96-13	Overburden	Geokon Piezometer		0	7/14/20	Value 6582.9/QaQc Value 6582.1
29	*T96-13	Overburden	Yellow box Thermistor	24	3	7/14/20	2nd Reading 24 rd Err 3 7/24/20
30	T96-13S	Overburden	Yellow box Thermistor	24	3	7/14/20	Re Read 7/25/2020
31	*T96-21	Overburden	Yellow box Thermistor	24	3	7/14/20	
32	*T96-22	Overburden	Yellow box Thermistor	24	3	7/14/20	QaQc Performed
33	*T96-23	Overburden	Yellow box Thermistor	24	3	7/14/20	walked to; cracked
34	T96-24	Overburden	Yellow box Thermistor	24	3	7/14/20	walked to; no cap
24	*P97-12	Blast Road	Geokon Piezometer		0	7/14/20	Value=6230.5/QaQc Value=6238.0
27	*T96-12	Blast Road	Yellow box Thermistor	24	3	7/14/20	Drove 2nd Reading Err 3 7/24/20
28	*T96-12S	Blast Road	Yellow box Thermistor	24	3	7/14/20	Drove 2nd Reading Rd 24 Err 3 7/24/20
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24		7/14/20	
70	*T95-05	By sandfilter	Yellow box Thermistor	24	0	7/14/20	In RO area behind hut
127	*T05-61	TDAM (end)	Yellow box Thermistor	6	3	7/14/20	walk
69	*T95-04	TDAM (end)	Yellow box Thermistor	24	3	7/14/20	Walk 2nd reading Rd 24 Err 3 7/25/2020 7/24/20
75	*T97-28	Buttress	Yellow box Thermistor	24	3	7/14/20	Walk
76	*T97-29	Buttress	Yellow box Thermistor	24	3	7/14/20	walked
77	*T97-30	Buttress	Yellow box Thermistor	24	3	7/14/20	walked to 2nd Reading 24 rd err 3 7/24/20
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	3	7/14/20	Drove to
23	*P96-15	Lower RDC	Geokon Piezometer		0	7/14/20	Value=7533.1/QaQc=7533.1
44	*T96-15	Lower RDC	Yellow box Thermistor	14	0	7/14/20	Walked to

Remember to print QAQC form for Thermistor Qualtrax ID # 783

*SEP Thermister. 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: T-96-22 Date: 7/14/20

Technician: APM/KMP Start Time: 1510 Stop Time: 1520

Node	Ohms	Comments	Node	Temperature
Test	16.31	N/A	Test	N/A
1	14.78	↓	1	79.0
2	9.22	↓	2	52.9
3	0	Error	3	-131.1
4	15.89	N/A	4	33.0
5	15.35	↓	5	34.2
6	15.00	↓	6	35.0
7	14.99	↓	7	35.1
8	0	Error	8	-131.1
9	15.39	N/A	9	34.1
10	15.82	↓	10	33.2
11	16.31	↓	11	32.1 ~~34.3~~ APM
12	16.68	↓	12	31.3 ~~31.7~~ APM
13	16.77	↓	13	31.1 ~~31.0~~ APM
14	16.83	↓	14	30 ~~-131.2~~ APM
15	0	Error	15	~~-131.2~~ ~~30.8~~ APM
16	16.92	N/A	16	~~30.8~~ ~~30.6~~ APM
17	17.07	↓	17	~~30.6~~ ~~30.7~~ APM
18	17.99	↓	18	~~30.9~~ ~~30.3~~ APM
19	17.06	↓	19	30.9 ~~30.5~~ APM
20	17.08	↓	20	~~30.5~~ ~~30.4~~ APM
21	17.09	↓	21	~~30.4~~ ~~30.3~~ APM
22	17.15	↓	22	~~30.3~~ ~~42.8~~ APM
23	17.11	↓	23	42.9 APM
24	17.25	↓	24	~~30.2~~ APM
Test	16.31	↓	Test	N/A

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: T96-12 Digital Morris 57060 multimeter Date: 7/25/20

Technician: KWP/DJS Start Time: 1547 Stop Time: 1550

Node Test	Ohms	Comments
	16.31	
1	16.37	
2	16.79	
3	16.90	
4	16.99	
5	17.08	
6	17.13	
7	17.18	
8	17.22	
9	17.21	
10	17.2	
11	17.24	
12	OL	
13	OL	
14	17.08	
15	16.95	
16	16.89	
17	16.81	
18	16.68	
19	16.55	
20	16.39	
21	OL	
22	16.16	
23	16.02	
24	15.88	
Test	16.31	

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

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

This Page Intentionally Blank

4th Quarter 2020

This Page Intentionally Blank

KUNA QUARTERLY REPORT DATA CHECKLIST **Quarter** Q4 2020 **Date** 11/02/2020

For Teck/RedDog Longterm Groundwater and Permafrost monitoring

☐ **YES / NO** Quarterly data received from Teck. Date received: 10/23/2020

☐ **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:

_____

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

Barometer reading is incorrect. Seems to have been a copy of P-97-08.
Will be a reading between 3500-5000.

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

Additional Comments:

_____

_____

_____

_____

QUARTER Q4 2020 **DATE** 11/02/2020

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 (manually add "#2")	**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	N	Barometer reading is incorrect. Seems to have been a copy of P-97-08. Will be a reading between 3500-5000.

Quarterly Thermistor QA / QC

Location: T95-04 Date: 10/31/2020

Technician: JWM Start Time: 1558 Stop Time: 1602

Node	Ohms	Comments	Node	Temperature
Test	16.36		Test	
1	19.04		1	
2	21.6	Jumpy	2	
3	17.9		3	
4	15.1		4	
5	15.5		5	
6	OL		6	
7	16.1		7	
8	16.1		8	
9	15.8		9	
10	16.2		10	
11	16.2		11	
12	16.1		12	
13	OL		13	
14	OL		14	
15	OL		15	
16	OL		16	
17	OL		17	
18	OL		18	
19	OL		19	
20	OL		20	
21	OL		21	
22	OL		22	
23	OL		23	
24	OL		24	
Test	16.35		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

Date

Quarterly Thermistor Piezometer Readings

Technician(s): James Mills Geokon ID #: 392 Thermrdr ID #: 2 19977 General Weather: Overcast, flurries, 10 mph

Col. # Row	Well	Location	Collection Method Instrument	Nodes	Piezo PSI or Therm Error	Date	Comments
26	*T95-08	Overburden	Yellow box Thermistor	24	3	10/19/2020	
25	*P96-13	Overburden	Geokon Piezometer		210		~~1332~~ 1335 Charge nitro
29	*T96-13	Overburden	Yellow box Thermistor	24	0		Switched around Read this one
30	T96-13S	Overburden	Yellow box Thermistor	24	3		
31	*T96-21	Overburden	Yellow box Thermistor	24	~~3~~ OK		✓
32	*T96-22	Overburden	Yellow box Thermistor	24	3		
33	*T96-23	Overburden	Yellow box Thermistor	24	3		Read Once
34	T96-24	Overburden	Yellow box Thermistor	24	3		
24	*P97-12	Blast Road	Geokon Piezometer				@ ~~1317~~ 1342 No PSI Gum
27	*T96-12	Blast Road	Yellow box Thermistor	24	3		Read twice Previous error 3
28	*T96-12S	Blast Road	Yellow box Thermistor	24	3		Read twice Previous error
1	*T14-110	W. Tails Pond	Beaded Stream Datalogger	24			
70	*T95-05	By sandfilter	Yellow box Thermistor	24	3		
127	*T05-61	TDAM (end)	Yellow box Thermistor	6			Did not collect. Active tailing discharge at the Therm site. Not Safe.
69	*T95-04	TDAM (end)	Yellow box Thermistor	24	3		QAQC Read twice, second time was after a brushing.
75	*T97-28	Buttress	Yellow box Thermistor	24	3		
76	*T97-29	Buttress	Yellow box Thermistor	24	3		
77	*T97-30	Buttress	Yellow box Thermistor	24	3		
71	*T96-10	Seepage Dam	Yellow box Thermistor	24	3		
23	*P96-15	Lower RDC	Geokon Piezometer		0 psi		psi broken Charge nitro
44	*T96-15	Lower RDC	Yellow box Thermistor	14	OK		✓

P96-10 Seepage Dam Read Psi

Remember to print QAQC form for Thermistor Qualtrax ID # 783

*SEP Thermister. 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: T-95-04 Date: 10/19/2020

Technician: JWM Start Time: 1641 Stop Time: 1645

Node Test	Ohms	Comments
~~Test~~	16.3	
1	75.6	Jumpy
2	36.1	
3	15.7	
4	49.7	
5	47.6	
6	16.6	
7	Null	
8	Null	
9	Null	
10	Null	
11	Null	
12	Null	
13	Null	
14	Null	
15	Null	
16	Null	
17	Null	
18	Null	
19	Null	
20	Null	
21	Null	
22	Null	
23	Null	
24	Null	
Test	16.3	

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

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