

Appendix G

2020 Portland District TDG Report

U.S. Army Corps of Engineers Portland District Quality-Assurance and Quality-Control Evaluation of the 2019-2020 Total Dissolved Gas and Water Temperature Data in the Lower Columbia River

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Significant Findings

An analysis of total-dissolved-gas (TDG) and water-temperature data collected at eight fixed monitoring stations on the lower Columbia River in Oregon and Washington in water year 2020 indicated the following:

- Data received in real-time from the eight individual monitoring sites ranged from 94.6 percent (at Cascade Island (CCIW)) to 100 percent complete.
- Criteria for data completeness (95 percent) were met at all monitoring stations, except for CCIW. Equipment was removed at CCIW from May 20 to 26 and June 1 to 4 in anticipation of high flows at the site, accounting for 95 percent of the annual real-time data loss. TDG and water temperature data were later available for this period from internal-logging sensors that were deployed.
- After three to six weeks of deployment in the river, 87 of 93 TDG sensor field checks were within ± 1.0 percent saturation of a secondary standard sensor. Five of the field checks that failed the ± 1.0 percent saturation guideline were due to ruptured membranes on the TDG sensors. The other instance (+1.4 percent saturation) was due to slow equilibration of the reference sensor at CCIW prior to spill beginning and did not appear to be a true indication of an inaccurate field sensor.
- Four of 91 barometric pressure field checks were greater than ± 1 mmHg of a primary standard, ranging from -2.0 to +1.5 mmHg. The offsets within the dataloggers were adjusted accordingly, and no data were deleted or corrected due to sensor drift.
- All 93 water-temperature field checks were within ± 0.2 °C of a secondary standard, ranging from -0.08 to + 0.04 °C.
- All 90 TDG sensor laboratory checks that were performed after field deployment were within ± 0.5 percent saturation of a primary standard at ambient air pressure and at ambient air pressure plus 300 mmHg.
- The year-round TDG sensors were field-checked, removed from the monitoring stations, and lab-calibrated monthly from October 2019 through March 2020. The seasonal sensors were installed the week prior to any COVID-19 restrictions and all field and lab work was completed on a three-week schedule from mid-March until August. Hazardous air-quality conditions due to regional wildfires delayed the September removal of the seasonal sensors by one week and delayed the September field checks of the year-round sensors until October 2020.

1.0 Introduction

The U.S. Army Corps of Engineers (USACE) operates several dams in the lower Columbia River Basin in Oregon and Washington (fig. G-1), which encompasses 259,000 mi² of the Pacific Northwest. These dams are multipurpose structures that fulfill regional needs for flood control, navigation, irrigation, recreation, hydropower production, fish and wildlife habitat, water-quality maintenance, and municipal and industrial water supply. When water is released through the spillways of these dams (instead of being routed through the turbines to generate electricity), ambient air is

entrained in the water. This results in an increase in the concentration of dissolved gases (referred to here as “total dissolved gas,” or “TDG”) in the water downstream of the spillways. The USACE regulates streamflow and spill from its dams on the lower Columbia River to minimize the production of excess TDG downstream of the dams, with the additional goal of providing for fish passage through the spillways.

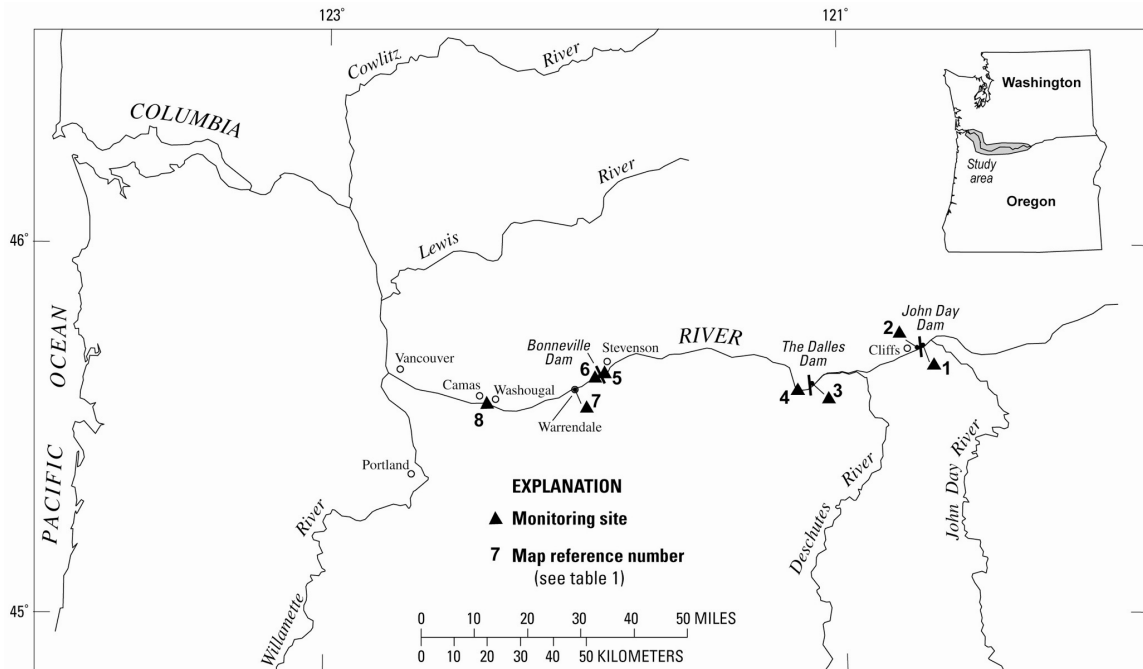


Figure G-1. Location of U.S. Army Corp of Engineers dams and total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2020.

Real-time TDG and water-temperature data are vital to the USACE for dam operation and for monitoring compliance with environmental regulations. The data are used by water managers to maintain water-quality conditions that facilitate fish passage and ensure their survival in the lower Columbia River. The U.S. Geological Survey (USGS), in cooperation with the Portland District of the USACE, has collected TDG and related data in the lower Columbia River each year since 1996. The hourly values were stored in both the USGS database and in a USACE database and are available online within approximately one hour of the time of collection. The current and historical TDG and water-temperature data in the USGS database can be accessed at https://waterdata.usgs.gov/or/nwis/current/?type=usacetdg&group_key=basin_cd (accessed October 27, 2020). The USACE database also includes hourly river discharge and spill data at http://pweb.crohms.org/ftppub/water_quality/tdg/ (accessed October 27, 2020).

This report presents the TDG, barometric pressure, and water temperature quality-assurance and quality-control data that demonstrate the USACE Portland District compliance with the 2019 TDG monitoring plan. To assure the accuracy and integrity of the data needed for managing and modeling TDG in the lower Columbia River, hourly values were reviewed relative to concurrent field measurements, laboratory sensor

calibrations, and inter-site comparisons. All deleted or missing data are explained in detail.

2.0 Data Collection

Eight monitoring stations were operated on the lower Columbia River, from the navigation lock of the John Day Dam (river mile [RM] 215.7) to Camas, Washington (RM 121.7) (fig. G-1, table G-1). Data for water year 2020 (October 1, 2019–September 30, 2020) include hourly measurements of TDG pressure, barometric pressure, water temperature, and sensor depth. Five of the stations (John Day navigation lock, The Dalles forebay, Bonneville forebay, Cascade Island, and Camas) were operated from mid-March through late-September 2020, encompassing the usual period for dam spill operations (April 1 to August 31). The John Day tailwater, The Dalles tailwater, and Warrendale stations are operated year-round. Warrendale is used to provide backup data for Cascade Island during the spill season and assists in monitoring TDG levels in relation to chum redds below Bonneville Dam during the winter. Camas remains part of the monitoring program although TDG data from the station is no longer part of the USACE spill management program.

Instrumentation at each monitoring station consists of a Hydrolab water-quality sonde, a Vaisala electronic barometer, and a Sutron SatLink2 or SatLink3 data-collection platform (DCP). The instruments at each station are powered by a 12-volt battery that is charged by either a solar panel or a 120-volt alternating-current line. Measurements are collected, logged, and transmitted every hour. The DCP transmits the four most recent hours of logged data to the Geostationary Operational Environmental Satellite system (GOES). The data are transferred and automatically decoded to the USACE and USGS databases.

Station visits were completed monthly (every 4-5 weeks) at the three year-round stations from September 2019 to March 2020. Seasonal stations were installed March 10-12, 2020, prior to any COVID-19 travel restrictions. All stations were then visited every three weeks from March through August 2020. Cascade Island was removed September 2, 2020 to minimize the period of non-representative TDG data observed after spill from Bonneville Dam ends. The removal of the remainder of the seasonal sites was delayed by one week in September due to hazardous air-quality conditions from area wildfires. The September field checks of the seasonal sites were also delayed until October 2020.

The field check procedure was as follows: A reference Hydrolab (which was calibrated before the field trip for use as a secondary standard) was deployed alongside the field-deployed instrument and allowed to equilibrate in order to obtain comparison measurements of TDG and water temperature. The field instrument (which had been deployed for 3 or more weeks) was then removed and replaced with another Hydrolab that had been recently calibrated in the laboratory. After the newly deployed instrument equilibrated, the secondary standard was again used to compare TDG and water temperature values. Any needed adjustments to the water temperature offset were then made within the DCP program. The electronic barometer at the monitoring station was checked against a portable barometer (NovaLynx 230-M202) that is calibrated annually to National Institute of Standards and Technology (NIST) standards. If necessary, the barometric pressure offset was also adjusted.

The Hydrolab that was removed from the field was later checked in the laboratory. The integrity of the TDG membrane was tested, and the membrane was removed and air-dried. The TDG sensor (without the membrane attached) was tested (and recalibrated, if necessary) at a range of pressures spanning the expected range of TDG in the river. The membrane was then installed on the TDG sensor and retested.

Table G-1. Total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2020.

[Map reference number refers to figure G-1; River mile is distance from the mouth of the Columbia River.]

Map reference number	USACE station identifier	River mile	USGS station number	USGS station name (and abbreviated station name)	Latitude (NAD27)	Longitude (NAD27)	Period of record in water year 2020
1	JDY	215.7	454314120413701	Columbia River at John Day navigation lock, Washington (John Day navigation lock)	45° 43' 14"	120° 41' 37"	03/11/20–09/23/20
2	JHAW	214.8	454249120423500	Columbia River, right bank, near Cliffs, Washington (John Day tailwater)	45° 42' 49"	120° 42' 35"	10/01/19–09/30/20
3	TDA	192.4	453712121071200	Columbia River at The Dalles Dam forebay, Washington (The Dalles forebay)	45° 37' 12"	121° 07' 12"	03/12/20–09/23/20
4	TDDO	189.1	14105700	Columbia River at The Dalles, Oregon (The Dalles tailwater)	45° 36' 27"	121° 10' 20"	10/01/19–09/30/20
5	BON	146.1	453845121562000	Columbia River at Bonneville Dam forebay, Washington (Bonneville forebay)	45° 38' 45"	121° 56' 20"	03/12/20–09/24/20
6	CCIW	145.9	453845121564001	Columbia River at Cascade Island, Washington (Cascade Island)	45° 38' 45"	121° 56' 40"	03/12/20–09/02/20
7	WRNO	140.3	453630122021400	Columbia River, left bank, near Dodson, Oregon (Warrendale)	45° 36' 30"	122° 02' 14"	10/01/19–09/30/20
8	CWMW	121.7	453439122223900	Columbia River, right bank, at Washougal, Washington (Camas)	45° 34' 39"	122° 22' 39"	03/10/20–09/24/20

3.0 Data Completeness

To assure the accuracy and integrity of the TDG data in the lower Columbia River, hourly values were reviewed relative to concurrent field measurements, laboratory instrument calibrations, and daily inter-site comparisons. A summary of the completeness of the TDG percent saturation data is shown in table G-2. Data were based on the total number of hourly TDG and barometric pressure data values that could have been collected during the monitoring season. TDG saturation values were considered to meet quality-assurance standards if they were within ± 1 percent saturation of the expected value.

Table G-2. Completeness and quality of total-dissolved-gas data, lower Columbia River, Oregon and Washington, water year 2020.

Abbreviated station name (USACE station identifier)	Planned monitoring (hours)	Number of missing or deleted hourly values	Percent of real-time TDG data passing quality assurance criteria
John Day navigation lock (JDY)	4,708	1	99.9+
John Day tailwater (JHAW)	8,784	74	99.2
The Dalles forebay (TDA)	4,684	0	100
The Dalles tailwater (TDDO)	8,784	49	99.4
Bonneville forebay (BON)	4,699	2	99.9+
Cascade Island (CCIW)	4,174	224	94.6 ¹
Warrendale (WRNO)	8,784	224	97.4
Camas (CWMW)	4,751	0	100

¹When excluding the period when equipment was removed to prevent potential damage during predicted high flow, completeness is 99.7 percent.

Periods for which substantial amounts of TDG data were missing from the database are listed in table G-3. Deletions associated with the slow equilibration of newly deployed sensors during site visits are not included in the table.

Table G-3. Periods of missing or deleted real-time total-dissolved-gas (TDG) data, lower Columbia River, Oregon and Washington, water year 2020.

Date	USACE station identifier	Reason / Note
12/02/19 to 12/04/19	TDDO	Erroneous values - ruptured membrane
04/03/20	CCIW	Erroneous values – newly deployed sensor very slow to equilibrate
05/20/20 to 05/26/20	CCIW	Equipment removed - data filled from auxiliary sensors
06/01/20 to 06/04/20	CCIW	Equipment removed - data filled from auxiliary sensors
07/17/20 to 07/20/20	JHAW	Erroneous values - ruptured membrane
08/12/20 to 08/18/20	WRNO	Erroneous values - ruptured membrane
08/24/20	TDDO	Erroneous values - ruptured membrane
09/08/20 to 09/09/20	WRNO	Erroneous values – sonde resting on riverbed

In late May and early June, streamflow below Bonneville Dam was forecast to reach the stage at which the monitoring equipment at CCIW has been damaged in the past. To prevent the chance of damage, the telemetered TDG sondes were removed and internal-logging sondes were installed. Real-time TDG and temperature data were interrupted during these periods, but all data were later recovered and loaded into the databases.

TDG data from previous years indicate non-spill factors may affect water circulation at the John Day tailwater deployment pipes and consequently, TDG measurements. To reduce stagnant conditions or a buildup of sediment in the deployment pipes during the spill season, both the reference and site sonde pipes were flushed with compressed air on April 2, 2020. The scheduled September pipe flushing was delayed until October due to the hazardous air quality in the region. No data were deleted during water year 2020 due to stagnation or sediment accumulation at the site.

4.0 Quality-Assurance Data

The collection of accurate data for TDG, barometric pressure, and water temperature involves several quality-assurance procedures, including side-by-side instrument comparisons in the field, sensor calibrations in the laboratory, daily checks of the data, and data review and archiving. The results of the quality-assurance procedures for water year 2020 are presented in this section.

After field deployment for 3 or more weeks, the TDG instruments were tested and calibrated in the laboratory. First, the sensor was tested, with the gas-permeable membrane in place, for response to supersaturated conditions in soda water. The membrane was then cleaned, removed from the sensor, and allowed to dry for at least 24 hours. Before replacing the membrane, the TDG sensors were examined independently by comparing the reading of the TDG sensor to barometric pressure (100-percent saturation). Using a certified digital pressure gage (primary

standard), comparisons also were made at pressures of 300 mmHg greater than barometric pressure (approximately 139-percent saturation). The accuracy of the TDG sensors was calculated as the difference between the primary standard and the TDG sensor reading (expected minus actual) for the two test conditions divided by the barometric pressure and multiplied by 100 to obtain a percent difference. All 90 TDG sensor laboratory checks performed after field deployment were within ± 0.5 percent saturation of a primary standard at ambient air pressure (fig. G-2).

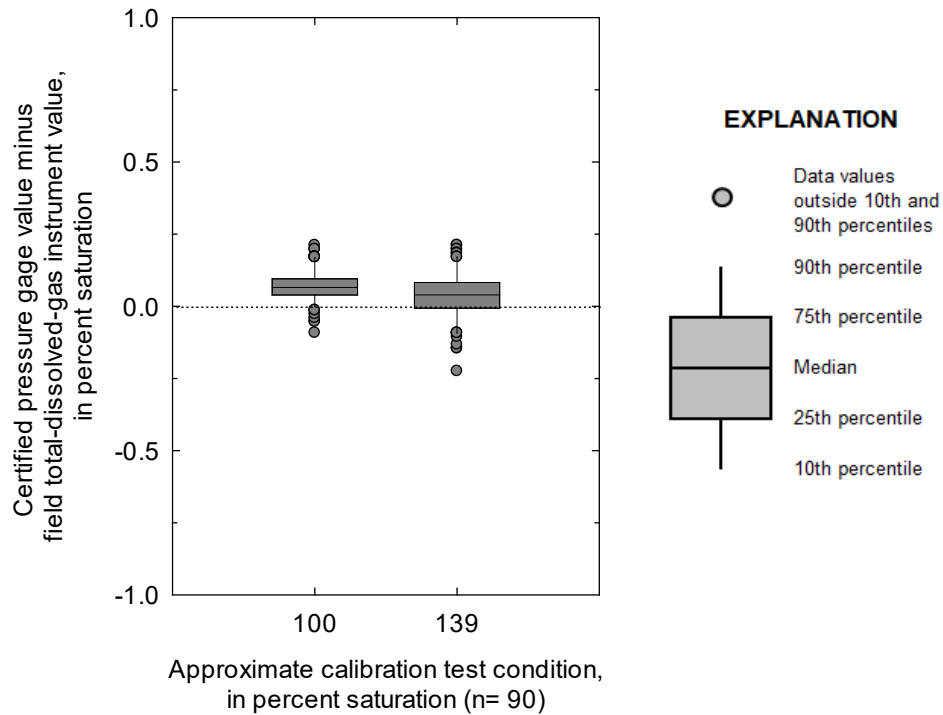


Figure G-2. Accuracy of total-dissolved-gas sensors in the laboratory after 3 or more weeks of field deployment at eight monitoring stations in the lower Columbia River, Oregon and Washington, water year 2020 (number of comparison values = 90).

The differences in barometric pressure, water temperature, and TDG between the reference instruments and the station monitors at the end of their field deployment were measured and recorded as part of every field inspection. These differences, calculated as the standard values minus the field instrument values, were used to compare and quantify the accuracy and precision between the two instruments. For water temperature and TDG, the measurements were made with the secondary standard (a recently calibrated Hydrolab) positioned alongside the monitor deployed in the river. A digital barometer (NIST certified through January 2021) served as the primary standard for barometric pressure. The distribution of quality-assurance data for each of the three parameters from the eight stations is shown in figures G-3, G-4, and G-5. The data used to generate the boxplots in figures G-2–5 are shown in tables G-4 and G-5.

Comparisons of the digital reference barometer and the field barometers are shown in figure G-3. Four of the 91 field check values were greater than ± 1 mm Hg of standard values, ranging from -2.0 mmHg to +1.5 mmHg. Analysis of the quality assurance comparisons did not indicate any needed data corrections or deletions.

The comparisons of the secondary standard temperature sensor and the field temperature sensors are presented in figure G-4. The differences of all 93 field checks were within ± 0.20 °C, ranging from -0.08 to +0.04 °C.

Differences between the secondary standard TDG sensor and the field TDG sensors were computed following equilibration of the secondary standard instrument to site conditions before removing the field instrument. The side-by-side equilibrium was generally considered complete after a minimum of 20 minutes (and a maximum of 2 hours) when the TDG values for the sensors were within 3 mmHg (less than ± 0.5 percent saturation). A total of 93 TDG field checks were made at the 8 monitoring sites. Six of the comparisons were greater than 7 mmHg (± 1.0 percent saturation). Five of these results were due to ruptured TDG membranes: one at John Day tailwater, two at The Dalles tailwater, and two at Warrendale. Comparison readings for the five TDG membrane failures are not included in quality assurance analysis because these data do not represent TDG sensor accuracy (fig. G-5). The remaining field check outside the range of ± 1.0 percent saturation occurred at Cascade Island in early April. This appears to be the result of slow equilibration of the reference sensor. Hydrologic conditions within the spill channel below Bonneville Dam are known to produce large TDG variations and slow equilibration times during non-spill periods. No other data were corrected or deleted prior to any of the comparisons.

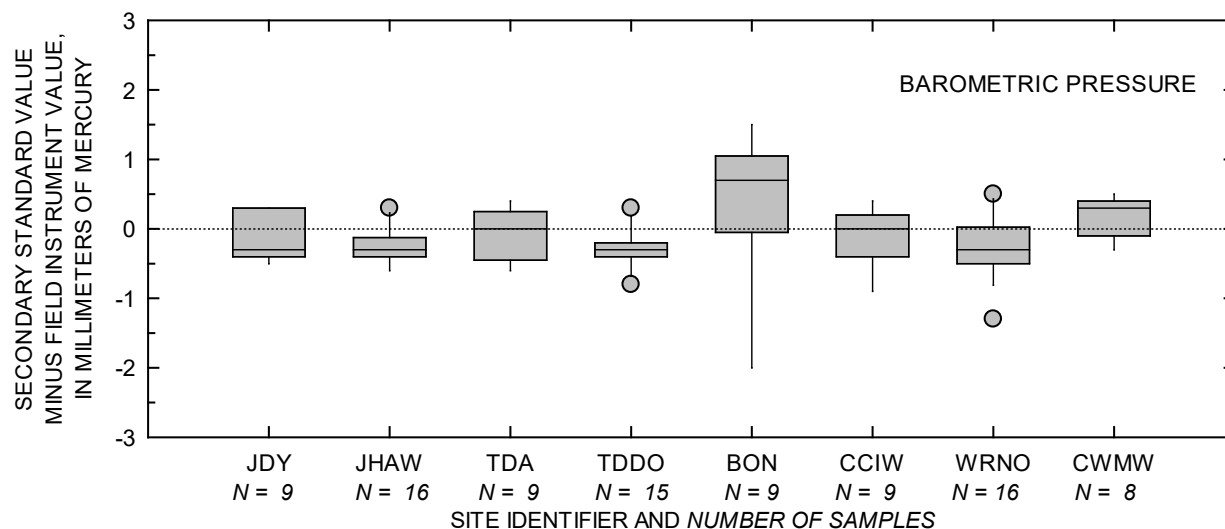


Figure G-3. Difference between the secondary standard and the field barometers in the field after 3 or more weeks of deployment at eight stations in the lower Columbia River, Oregon and Washington, water year 2020. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

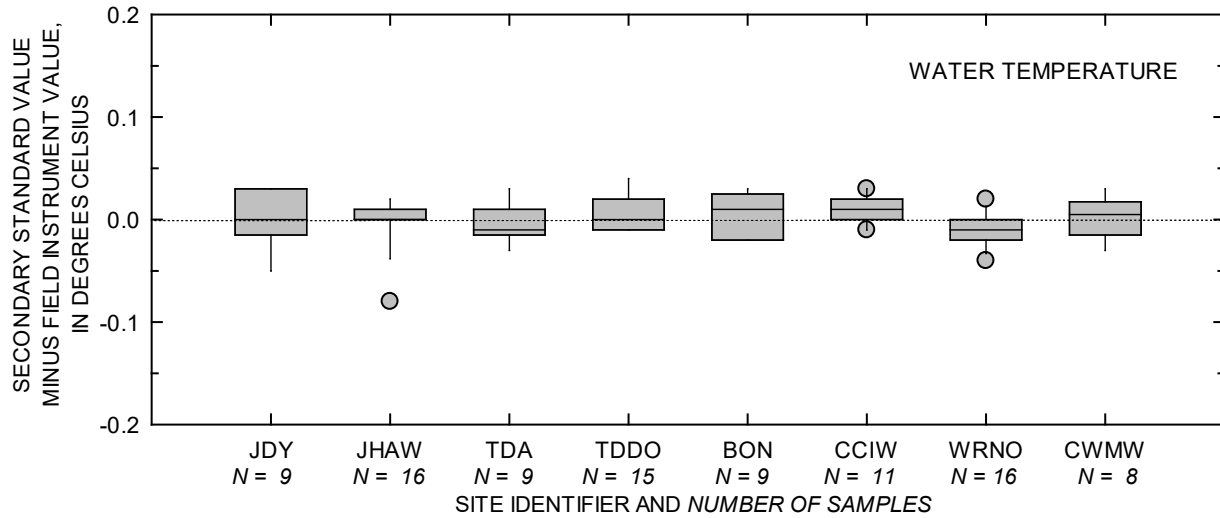


Figure G-4. Difference between the secondary standard and the field temperature instruments in the field after 3 or more weeks of deployment at eight stations in the lower Columbia River, Oregon and Washington, water year 2020. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

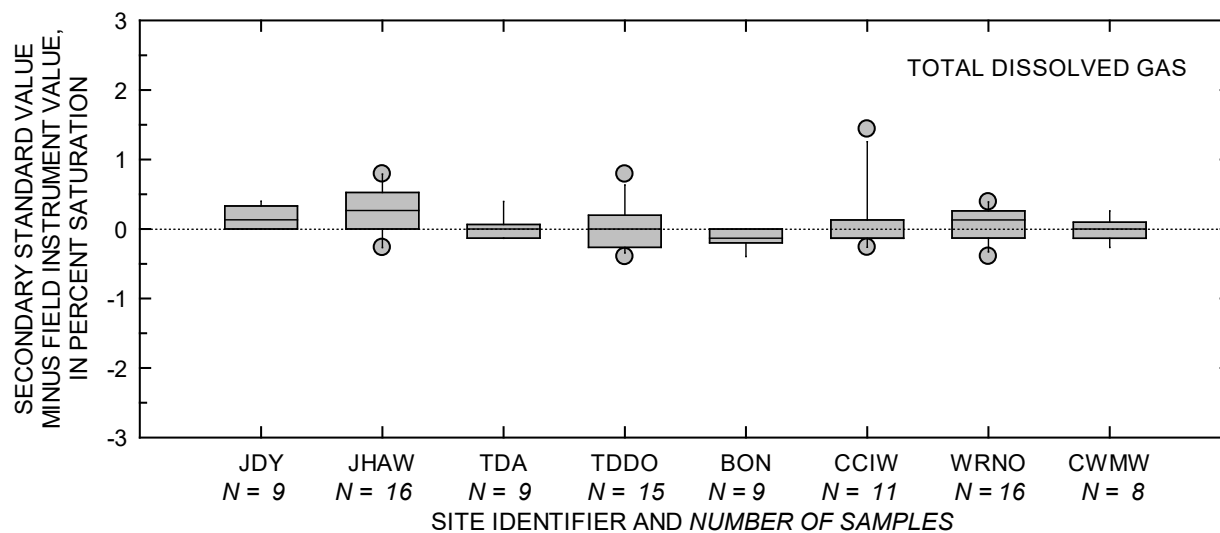


Figure G-5. Difference between the secondary standard and the field total-dissolved-gas instruments in the field after 3 or more weeks of deployment at eight stations in the lower Columbia River, Oregon and Washington, water year 2020. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

Table G-4. Summary of total-dissolved-gas side-by-side reference and field instrument comparisons, water year 2020.

Date	Reference sonde number.	Site sonde number	Barometric Pressure (mmHg)				Temperature (°C)				Pressure total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Difference, in percent saturation
John Day navigation lock (JDY)															
3/31/2020	66361	65426	754.6	755	-0.4	0.40	6.99	6.96	0.03	0.03	783	780	3	3	0.40
4/20/2020	66361	65425	755.2	755	0.2	0.20	10.52	10.49	0.03	0.03	829	829	0	0	0.00
5/11/2020	66361	65426	747.6	748	-0.4	0.40	12.87	12.87	0.00	0.00	885	883	2	2	0.27
6/2/2020	66361	65425	755.7	756	-0.3	0.30	14.18	14.17	0.01	0.01	832	832	0	0	0.00
6/22/2020	66361	65426	754.5	755	-0.5	0.50	15.95	15.97	-0.02	0.02	855	855	0	0	0.00
7/13/2020	66361	65425	753.3	753	0.3	0.30	18.24	18.24	0.00	0.00	824	824	0	0	0.00
8/3/2020	66361	65426	754.6	755	-0.4	0.40	21.54	21.51	0.03	0.03	808	807	1	1	0.13
8/24/2020	66361	65425	749.3	749	0.3	0.30	21.33	21.38	-0.05	0.05	789	787	2	2	0.27
9/23/2020	66361	65426	751.3	751	0.3	0.30	19.04	19.05	-0.01	0.01	743	740	3	3	0.40
Mean					-0.10	0.34			0.00	0.02			1.2	1.2	0.16
Median					-0.30	0.30			0.00	0.02			1.0	1.0	0.13
John Day tailwater (JHAW)															
10/7/2019	66361	67838	757.8	758	-0.2	0.20	17.19	17.27	-0.08	0.08	753	751	2	2	0.26
11/4/2019	66361	67837	762.9	763	-0.1	0.10	11.75	11.74	0.01	0.01	753	747	6	6	0.79
12/6/2019	66361	67838	758.4	759	-0.6	0.60	7.19	7.19	0.00	0.00	733	730	3	3	0.40
1/7/2020	66361	67837	754.8	755	-0.2	0.20	6.02	6.02	0.00	0.00	751	751	0	0	0.00
2/4/2020	66361	67838	768.6	769	-0.4	0.40	4.44	4.44	0.00	0.00	765	763	2	2	0.26
3/11/2020	66361	67837	759.2	759	0.2	0.20	5.97	5.96	0.01	0.01	785	782	3	3	0.40
3/31/2020	66361	67838	756.7	757	-0.3	0.30	7.18	7.18	0.00	0.00	786	780	6	6	0.79
4/20/2020	66361	67837	756.6	757	-0.4	0.40	10.72	10.72	0.00	0.00	887	888	-1	1	-0.13
5/11/2020	66361	67838	750.7	751	-0.3	0.30	12.91	12.90	0.01	0.01	903	901	2	2	0.27
6/2/2020	66361	67837	759.4	760	-0.6	0.60	14.17	14.17	0.00	0.00	955	951	4	4	0.53
6/22/2020	66361	67838	756.0	756	0.0	0.00	16.15	16.14	0.01	0.01	900	899	1	1	0.13
7/13/2020	66361	67837	756.8	757	-0.2	0.20	18.38	18.36	0.02	0.02	858	860	-2	2	-0.26
7/20/2020	66361	67838	755.5	756	-0.5	0.50	19.71	19.69	0.02	0.02	884	1087	-203	203	-26.87
8/3/2020	66361	67837	758.3	758	0.3	0.30	21.54	21.52	0.02	0.02	883	878	5	5	0.66
8/24/2020	66361	64961	752.6	753	-0.4	0.40	21.37	21.38	-0.01	0.01	848	850	-2	2	-0.27
10/5/2020	66361	67838	761.7	762	-0.3	0.30	18.40	18.42	-0.02	0.02	760	757	3	3	0.39
Mean					-0.25	0.31			0.00	0.01			-10.7	15.3	-1.42
Median					-0.30	0.30			0.00	0.01			2.0	2.5	0.27

Date	Reference sonde number.	Site sonde number	Barometric Pressure (mmHg)				Temperature (°C)				Pressure total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Difference, in percent saturation
The Dalles forebay (TDA)															
4/1/2020	66361	66624	758.4	759	-0.6	0.60	7.31	7.30	0.01	0.01	784	781	3	3	0.40
4/20/2020	66361	66625	758.1	758	0.1	0.10	10.72	10.73	-0.01	0.01	841	841	0	0	0.00
5/11/2020	66361	66624	748.4	749	-0.6	0.60	13.17	13.16	0.01	0.01	901	902	-1	1	-0.13
6/3/2020	66361	66625	759.3	759	0.3	0.30	14.20	14.21	-0.01	0.01	890	891	-1	1	-0.13
6/22/2020	66361	66624	757.9	758	-0.1	0.10	16.11	16.10	0.01	0.01	871	872	-1	1	-0.13
7/13/2020	66361	66625	757.7	758	-0.3	0.30	18.15	18.16	-0.01	0.01	826	826	0	0	0.00
8/4/2020	66361	66624	758.0	758	0.0	0.00	21.52	21.54	-0.02	0.02	822	822	0	0	0.00
8/24/2020	66361	66625	751.4	751	0.4	0.40	21.53	21.50	0.03	0.03	805	805	0	0	0.00
9/23/2020	66361	66624	752.2	752	0.2	0.20	19.21	19.24	-0.03	0.03	751	750	1	1	0.13
Mean					-0.07	0.29			0.00	0.02			0.1	0.8	0.01
Median					0.00	0.30			-0.01	0.01			0.0	1.0	0.00
The Dalles tailwater (TDDO)															
10/7/2019	66361	67481	757.6	758	-0.4	0.40	17.25	17.21	0.04	0.04	772	769	3	3	0.40
11/4/2019	66361	64596	762.8	763	-0.2	0.20	11.67	11.67	0.00	0.00	762	761	1	1	0.13
12/4/2019	66361	67480	758.6	759	-0.4	0.40	7.79	7.76	0.03	0.03	748	966	-218	218	-28.74
1/7/2020	66361	67481	754.4	755	-0.6	0.60	6.17	6.17	0.00	0.00	755	755	0	0	0.00
2/4/2020	66361	67480	769.0	769	0.0	0.00	4.39	4.37	0.02	0.02	767	767	0	0	0.00
3/12/2020	66361	67481	767.7	768	-0.3	0.30	6.19	6.20	-0.01	0.01	784	785	-1	1	-0.13
4/1/2020	66361	64596	760.2	761	-0.8	0.80	7.35	7.35	0.00	0.00	788	790	-2	2	-0.26
4/20/2020	66361	67481	757.7	758	-0.3	0.30	11.09	11.09	0.00	0.00	882	885	-3	3	-0.40
5/11/2020	66361	64596	749.8	750	-0.2	0.20	13.17	13.18	-0.01	0.01	924	923	1	1	0.13
6/3/2020	66361	67481	760.6	761	-0.4	0.40	14.28	14.24	0.04	0.04	946	944	2	2	0.26
6/22/2020	66361	64596	761.1	761	0.1	0.10	16.09	16.09	0.00	0.00	888	890	-2	2	-0.26
7/13/2020	66361	67481	760.3	760	0.3	0.30	18.20	18.21	-0.01	0.01	868	870	-2	2	-0.26
8/3/2020	66361	64596	758.7	759	-0.3	0.30	21.70	21.70	0.00	0.00	882	876	6	6	0.79
8/24/2020	66361	67481	755.6	756	-0.4	0.40	21.42	21.42	0.00	0.00	841	976	-135	135	-17.87
10/5/2020	66361	64596	762.7	763	-0.3	0.30	18.45	18.46	-0.01	0.01	772	774	-2	2	-0.26
Mean					-0.28	0.33			0.01	0.01			-23	25	-3.10
Median					-0.30	0.30			0.00	0.01			-1.0	2.0	-0.13

Date	Reference sonde number.	Site sonde number	Barometric Pressure (mmHg)				Temperature (°C)				Pressure total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Difference, in percent saturation
Bonneville forebay (BON)															
4/3/2020	66361	66360	762.4	762	0.4	0.40	7.50	7.50	0.00	0.00	789	792	-3	3	-0.39
4/21/2020	66361	-	766.8	766	0.8	0.80	10.99	10.98	0.01	0.01	845	846	-1	1	-0.13
5/12/2020	66361	66623	752.5	751	1.5	1.50	13.30	13.29	0.01	0.01	894	895	-1	1	-0.13
6/2/2020	66361	66360	760.2	759	1.2	1.20	14.54	14.56	-0.02	0.02	905	907	-2	2	-0.26
6/23/2020	66361	66623	758.3	758	0.3	0.30	16.60	16.57	0.03	0.03	887	888	-1	1	-0.13
7/14/2020	66361	66363	761.9	761	0.9	0.90	18.27	18.25	0.02	0.02	856	856	0	0	0.00
8/6/2020	66361	66623	759.0	761	-2.0	2.00	21.46	21.43	0.03	0.03	812	812	0	0	0.00
8/25/2020	66361	66363	757.7	757	0.7	0.70	20.92	20.94	-0.02	0.02	802	802	0	0	0.00
9/24/2020	66361	66623	759.6	760	-0.4	0.40	19.01	19.03	-0.02	0.02	763	764	-1	1	-0.13
Mean					0.38	0.91			0.00	0.02			-1.0	1.0	-0.13
Median					0.70	0.80			0.01	0.02			-1.0	1.0	-0.13
Cascade Island (CCIW)															
4/3/2020	66361	67858	764.4	765	-0.6	0.60	7.52	7.53	-0.01	0.01	851	840	11	11	1.44
4/21/2020	66361	64597	768.2	768	0.2	0.20	10.94	10.91	0.03	0.03	889	891	-2	2	-0.26
5/12/2020	66361	67858	753.2	753	0.2	0.20	13.37	13.38	-0.01	0.01	889	890	-1	1	-0.13
5/20/2020	62008	64597	-	763	-	-	12.91	12.89	0.02	0.02	938	939	-1	1	-0.13
5/26/2020	62008	62522	762.9	763	-0.1	0.10	13.21	13.19	0.02	0.02	936	937	-1	1	-0.13
6/1/2020	62008	64597	-	764	-	-	14.13	14.10	0.03	0.03	931	931	0	0	0.00
6/4/2020	62008	49627	761.8	762	-0.2	0.20	14.52	14.52	0.00	0.00	941	937	4	4	0.53
6/23/2020	66361	67858	760.1	761	-0.9	0.90	16.62	16.61	0.01	0.01	908	909	-1	1	-0.13
7/14/2020	66361	64597	763.0	763	0.0	0.00	18.26	18.25	0.01	0.01	893	895	-2	2	-0.26
8/6/2020	66361	67858	759.1	759	0.1	0.10	21.51	21.49	0.02	0.02	886	885	1	1	0.13
9/2/2020	66361	64597	761.4	761	0.4	0.40	20.78	20.77	0.01	0.01	790	791	-1	1	-0.13
Mean					-0.10	0.30			0.01	0.02			0.6	2.3	0.08
Median					0.00	0.20			0.01	0.01			-1.0	1.0	-0.13

Date	Reference sonde number.	Site sonde number	Barometric Pressure (mmHg)				Temperature (°C)				Pressure total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Reference sensor	Site sensor	Difference	Absolute difference	Difference, in percent saturation
Warrendale (WRNO)															
10/7/2019	66361	67855	761.5	762	-0.5	0.50	16.98	16.98	0.00	0.00	775	774	1	1	0.13
11/5/2019	66361	67856	766.4	766	0.4	0.40	11.16	11.18	-0.02	0.02	772	771	1	1	0.13
12/4/2019	66361	67855	758.7	759	-0.3	0.30	7.77	7.79	-0.02	0.02	755	754	1	1	0.13
1/7/2020	66361	67856	761.8	762	-0.2	0.20	6.29	6.29	0.00	0.00	768	766	2	2	0.26
2/4/2020	66361	67855	774.6	775	-0.4	0.40	4.31	4.32	-0.01	0.01	774	771	3	3	0.39
3/10/2020	66361	67856	768.7	769	-0.3	0.30	5.81	5.85	-0.04	0.04	792	789	3	3	0.39
4/1/2020	66361	67855	763.4	764	-0.6	0.60	7.45	7.45	0.00	0.00	816	819	-3	3	-0.39
4/6/2020	66361	67856	760.5	760	0.5	0.50	8.06	8.07	-0.01	0.01	827	868	-41	41	-5.39
4/21/2020	66361	64961	769.4	770	-0.6	0.60	10.88	10.88	0.00	0.00	910	911	-1	1	-0.13
5/12/2020	66361	67856	754.5	755	-0.5	0.50	13.39	13.42	-0.03	0.03	894	894	0	0	0.00
6/3/2020	66361	67855	763.7	765	-1.3	1.30	14.55	14.56	-0.01	0.01	938	940	-2	2	-0.26
6/22/2020	66361	67856	765.5	766	-0.5	0.50	16.27	16.29	-0.02	0.02	882	881	1	1	0.13
7/13/2020	66361	67855	763.7	764	-0.3	0.30	18.17	18.17	0.00	0.00	875	873	2	2	0.26
8/4/2020	66361	67856	761.8	762	-0.2	0.20	21.46	21.45	0.01	0.01	885	886	-1	1	-0.13
8/18/2020	66361	67855	764.2	764	0.2	0.20	21.61	21.59	0.02	0.02	868	923	-55	55	-7.20
10/5/2020	66361	67856	765.1	765	0.1	0.10	18.54	18.55	-0.01	0.01	783	781	2	2	0.26
Mean					-0.28	0.43			-0.01	0.01			-5.4	7.4	-0.71
Median					-0.30	0.40			-0.01	0.01			1.0	2.0	0.13
Camas (CWMW)															
4/2/2020	66361	64598	766.8	767	-0.2	0.20	7.62	7.65	-0.03	0.03	813	811	2	2	0.26
4/22/2020	66361	67857	765.2	765	0.2	0.20	10.97	10.94	0.03	0.03	876	876	0	0	0.00
6/5/2020	66361	64598	754.4	754	0.4	0.40	14.91	14.90	0.01	0.01	902	903	-1	1	-0.13
6/23/2020	66361	67857	758.2	758	0.2	0.20	17.24	17.22	0.02	0.02	888	889	-1	1	-0.13
7/14/2020	66361	64598	763.4	763	0.4	0.40	19.02	19.01	0.01	0.01	864	864	0	0	0.00
8/4/2020	66361	67857	760.7	761	-0.3	0.30	22.01	22.01	0.00	0.00	863	865	-2	2	-0.26
8/25/2020	66361	64598	760.5	760	0.5	0.50	20.94	20.94	0.00	0.00	821	821	0	0	0.00
9/24/2020	66361	67857	762.4	762	0.4	0.40	18.90	18.92	-0.02	0.02	767	766	1	1	0.13
Mean					0.20	0.33			0.00	0.02			-0.1	0.9	-0.02
Median					0.30	0.35			0.00	0.01			0.0	1.0	0.00

Table G-5. Summary of reference and site TDG sensor comparisons measured during lab calibrations, water year 2020.

USACE Station identifier	Site sonde number	Date checked	Soda test (Pass/Fail/N/A)	Reference Barometric pressure (mmHg)		Site sensor Total pressure (mmHg)		Difference between reference pressure and site sensor total pressure (percent saturation)		Calibrated (Y/N)	Pressure test (Pass/Fail/N/A)
				+0	+300	+0	+300	+0	+300		
				CWMW	64598	4/8/2020	P	763.3	1063.3		
CWMW	67857	4/26/2020	P	758.9	1058.9	759	1060	-0.01	-0.14	N	P
CWMW	64598	6/7/2020	P	758.2	1058.2	758	1058	0.03	0.03	N	P
CWMW	67857	6/29/2020	P	758.6	1058.6	759	1059	-0.05	-0.05	N	P
CWMW	64598	7/19/2020	P	758.3	1058.3	758	1058	0.04	0.04	N	P
CWMW	67857	8/15/2020	P	755.6	1055.6	755	1055	0.08	0.08	N	P
CWMW	64598	8/28/2020	P	758.3	1058.3	758	1059	0.04	-0.09	N	N/A
CWMW	67857	9/24/2020	P	765.3	1065.3	765	1065	0.04	0.04	N	N/A
WRNO	67855	11/1/2019	P	761.0	1061.0	760	1060	0.13	0.13	N	P
WRNO	67856	11/29/2019	P	752.8	1052.8	752	1053	0.11	-0.03	N	P
WRNO	67855	1/2/2020	P	761.3	1061.3	760	1060	0.17	0.17	N	P
WRNO	67856	1/31/2020	P	762.0	1062.0	761	1062	0.13	0.00	N	P
WRNO	67855	2/14/2020	P	763.1	1063.1	762	1062	0.14	0.14	N	P
WRNO	67856	3/28/2020	P	758.6	1058.6	758	1059	0.08	-0.05	N	P
WRNO	67855	4/8/2020	P	763.3	1063.3	763	1062	0.04	0.17	N	P
WRNO	67856	4/8/2020	F	763.2	1063.2	763	1063	0.03	0.03	N	P
WRNO	64961	4/26/2020	P	759.0	1059.0	759	1060	0.00	-0.13	N	P
WRNO	67856	5/21/2020	P	758.5	1058.5	758	1058	0.07	0.07	N	P
WRNO	67855	6/7/2020	P	758.1	1058.1	757	1057	0.15	0.15	N	P
WRNO	67856	6/29/2020	P	758.6	1058.6	758	1058	0.08	0.08	N	P
WRNO	67855	7/19/2020	P	758.3	1058.3	757	1057	0.17	0.17	N	P
WRNO	67856	8/15/2020	P	755.6	1055.6	755	1055	0.08	0.08	N	P
WRNO	67855	8/28/2020	F	758.3	1058.3	757	1058	0.17	0.04	N	P
WRNO	67856	10/5/2020	P	765.3	1065.3	765	1065	0.04	0.04	N	P
CCIW	67858	4/8/2020	P	763.3	1063.3	762	1062	0.17	0.17	N	P
CCIW	64597	4/26/2020	P	759.1	1059.1	759	1059	0.01	0.01	N	P
CCIW	67858	5/21/2020	P	758.5	1058.5	757	1057	0.20	0.20	N	P
CCIW	64597	6/7/2020	P	758.1	1058.1	758	1058	0.01	0.01	N	P
CCIW	67858	6/29/2020	P	758.5	1058.5	757	1058	0.20	0.07	N	P
CCIW	62008	6/29/2020	P	758.7	1058.7	759	1059	-0.04	-0.04	N	N/A
CCIW	64597	7/19/2020	P	758.3	1058.3	758	1058	0.04	0.04	N	P

USACE Station identifier	Site sonde number	Date checked	Soda test (Pass/Fail/N/A)	Reference Barometric pressure (mmHg)		Site sensor Total pressure (mmHg)		Difference between reference pressure and site sensor total pressure (percent saturation)		Calibrated (Y/N)	Pressure test (Pass/Fail/N/A)
				+0	+300	+0	+300	+0	+300		
CCIW	67858	8/15/2020	P	755.6	1055.6	754	1054	0.21	0.21	N	P
CCIW	64597	9/2/2020	P	765.3	1065.3	765	1065	0.04	0.04	N	N/A
BON	66360	4/8/2020	P	763.3	1063.3	764	1064	-0.09	-0.09	N	P
BON	66623	5/21/2020	P	758.5	1058.5	758	1057	0.07	0.20	N	P
BON	66623	6/29/2020	P	758.6	1058.6	758	1058	0.08	0.08	N	P
BON	66363	7/19/2020	P	758.3	1058.3	758	1058	0.04	0.04	N	P
BON	66623	8/15/2020	P	755.6	1055.6	755	1054	0.08	0.21	N	P
BON	66363	8/28/2020	P	758.3	1058.3	758	1058	0.04	0.04	N	N/A
BON	66623	10/16/2020	P	765.4	1065.4	765	1064	0.05	0.18	N	N/A
TDDO	67481	11/29/2019	P	752.8	1052.8	752	1052	0.11	0.11	N	P
TDDO	64596	2/14/2020	P	763.1	1063.1	763	1063	0.01	0.01	N	P
TDDO	67480	1/2/2020	F	761.3	1061.3	761	1061	0.04	0.04	N	P
TDDO	67481	1/31/2020	P	762.0	1062.0	761	1061	0.13	0.13	N	P
TDDO	67481	3/28/2020	P	758.6	1058.6	758	1058	0.08	0.08	N	P
TDDO	64596	4/8/2020	P	763.3	1063.3	763	1064	0.04	-0.09	N	P
TDDO	67481	4/26/2020	P	759.2	1059.2	758	1059	0.16	0.03	N	P
TDDO	64596	5/21/2020	P	758.6	1058.6	758	1059	0.08	-0.05	N	P
TDDO	67481	6/7/2020	P	758.0	1058.0	757	1057	0.13	0.13	N	P
TDDO	64596	6/29/2020	P	758.6	1058.6	759	1059	-0.05	-0.05	N	P
TDDO	67481	7/19/2020	P	758.3	1058.3	757	1058	0.17	0.04	N	P
TDDO	64596	8/15/2020	P	755.6	1055.6	755	1055	0.08	0.08	N	P
TDDO	67481	8/28/2020	F	758.3	1058.3	757	1058	0.17	0.04	N	P
TDDO	64596	10/16/2020	P	765.5	1065.5	765	1065	0.07	0.07	N	P
TDDO	67480	10/11/2019	P	760.8	1060.8	761	1061	-0.03	-0.03	N	P
TDDO	67481	10/11/2019	P	760.8	1060.8	760	1060	0.11	0.11	N	P
TDA	66624	4/8/2020	P	763.3	1063.3	763	1063	0.04	0.04	N	P
TDA	66625	4/26/2020	P	759.2	1059.2	759	1059	0.03	0.03	N	P
TDA	66624	5/21/2020	P	758.5	1058.5	758	1058	0.07	0.07	N	P
TDA	66625	6/14/2019	P	758.0	1058.0	758	1058	0.00	0.00	N	P
TDA	66624	6/29/2020	P	758.6	1058.6	758	1058	0.08	0.08	N	P
TDA	66625	7/19/2020	P	758.4	1058.4	758	1058	0.05	0.05	N	P
TDA	66624	8/15/2020	P	755.5	1055.5	755	1055	0.07	0.07	N	P
TDA	66625	8/28/2020	P	758.3	1058.3	758	1059	0.04	-0.09	N	N/A

USACE Station identifier	Site sonde number	Date checked	Soda test (Pass/Fail/N/A)	Reference Barometric pressure (mmHg)		Site sensor Total pressure (mmHg)		Difference between reference pressure and site sensor total pressure (percent saturation)		Calibrated (Y/N)	Pressure test (Pass/Fail/N/A)
				+0	+300	+0	+300	+0	+300		
				TDA	66624	10/16/2020	P	765.5	1065.5		
JHAW	67838	11/1/2019	P	760.7	1060.7	760	1060	0.09	0.09	N	P
JHAW	67837	11/29/2019	P	752.9	1052.9	753	1054	-0.01	-0.15	N	P
JHAW	67838	1/2/2020	P	761.3	1061.3	761	1061	0.04	0.04	N	P
JHAW	67837	1/31/2020	P	762.0	1062.0	761	1061	0.13	0.13	N	P
JHAW	67838	2/14/2020	P	763.2	1063.2	763	1062	0.03	0.16	N	P
JHAW	67837	3/28/2020	P	758.6	1058.6	758	1059	0.08	-0.05	N	P
JHAW	67838	4/8/2020	P	763.2	1063.2	763	1063	0.03	0.03	N	P
JHAW	67837	4/26/2020	P	758.8	1058.8	758	1059	0.11	-0.03	N	P
JHAW	67838	5/21/2020	P	758.7	1058.7	758	1059	0.09	-0.04	N	P
JHAW	67837	6/7/2020	P	758.0	1058.0	757	1058	0.13	0.00	N	P
JHAW	67838	6/29/2020	P	758.6	1058.6	758	1058	0.08	0.08	N	P
JHAW	67837	7/19/2020	P	758.4	1058.4	758	1058	0.05	0.05	N	P
JHAW	67838	8/15/2020	F	755.4	1055.4	755	1054	0.05	0.19	N	P
JHAW	67837	8/15/2020	P	755.5	1055.5	755	1055	0.07	0.07	N	P
JHAW	64961	8/28/2020	P	758.3	1058.3	758	1059	0.04	-0.09	N	P
JHAW	67838	10/16/2020	P	765.5	1065.5	765	1065	0.07	0.07	N	P
JDY	65426	4/8/2020	P	763.2	1063.2	763	1062	0.03	0.16	N	P
JDY	65425	4/26/2020	P	759.2	1059.2	759	1060	0.03	-0.11	N	P
JDY	65426	5/21/2020	P	758.5	1058.5	758	1058	0.07	0.07	N	P
JDY	65425	6/7/2020	P	758	1058.0	758	1058	0.00	0.00	N	P
JDY	65426	6/29/2020	P	758.7	1058.7	758	1058	0.09	0.09	N	P
JDY	65425	7/19/2020	P	758.4	1058.4	758	1059	0.05	-0.08	N	P
JDY	65426	8/15/2020	P	755.5	1055.5	755	1055	0.07	0.07	N	P
JDY	65425	8/28/2020	P	758.3	1058.3	758	1060	0.04	-0.22	N	N/A
JDY	65426	10/16/2020	P	765.5	1065.5	765	1065	0.07	0.07	N	N/A