Appendix G

2024 Portland District TDG Report

U.S. Army Corps of Engineers Portland District Quality-Assurance and Quality-Control Evaluation of the 2023-2024 Total Dissolved Gas and Water Temperature Data in the Lower Columbia River

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Contents

Significant Findings....3
1.0 Introduction....4
2.0 Data Collection....5
3.0 Data Completeness....8
4.0 Quality-Assurance Data....10

Figures

Figure G-1. Location of U.S. Army Corps of Engineers dams and total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2024. ...4
Figure G-2. Accuracy of total-dissolved-gas sensors in the laboratory after 3 or more weeks of field deployment at seven monitoring stations in the lower Columbia River, Oregon and Washington, water year 2024 (number of comparison values = 76).....10
Figure G-3. Difference between the primary standard and the field barometers in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2024. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.....11
Figure G-4. Difference between the secondary standard and the field temperature instruments in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2024. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers. 12
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 seven stations in the lower Columbia River, Oregon and Washington, water year 2024. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers. 13

Tables

Table G-1. Total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2024.....7

Table G-2. Completeness and quality of real-time total-dissolved-gas or barometric pressure data, lower Columbia River, Oregon and Washington, water year 2024. 8

Table G-3. Periods of missing, deleted, or corrected real-time total-dissolved-gas (TDG) or barometric pressure (BP) data, lower Columbia River, Oregon and Washington, water year 2024.....9

Table G-4. Summary of total-dissolved-gas side-by-side reference and field instrument comparisons, water year 2024.....14

Table G-5. Summary of reference and site TDG sensor comparisons measured during lab calibrations, water year 2024. 18

Significant Findings

An analysis of total-dissolved-gas (TDG) pressure, barometric pressure, and water-temperature data collected at seven fixed monitoring stations on the lower Columbia River in Oregon and Washington in water year 2024 indicated the following:

- Data received in real-time from the seven individual monitoring sites ranged from 92.8 percent (at The Dalles tailwater) to 100 percent complete (at Bonneville forebay and Cascade Island)
- Criteria for real-time data completeness (95 percent) were met at all monitoring stations except The Dalles tailwater (92.8 percent). Stagnant conditions appeared to effect TDG measurements at The Dalles tailwater deployment pipes, and a fouling correction was applied to TDG data from August 3, 2024, to the site visit on August 27, 2024. Excluding that period, data completeness was 99.6 percent at the site.
- After approximately three to eight weeks of deployment in the river, 58 of 73 TDG sensor field checks were within approximately ±0.5 percent saturation of a secondary standard sensor. Three field checks that failed this standard were due to ruptured TDG membranes that resulted in deleted TDG data. All three ruptured membranes were at the John Day tailwater site, with one membrane rupturing after the end of the water year, but before the final field check for the site. Two field checks that failed this standard were likely due to stagnant conditions, subsequent sediment deposition and fouling, and fouling corrections were applied to the associated TDG data. Ten other comparisons were within ±0.7 to 1.3 percent saturation and no data were deleted because of these comparisons.
- Two of the 73 barometric pressure field check values were greater than ±1.0 mmHg of a primary standard, ranging from -1.1 mmHg to +0.5 mmHg. The difference of -1.1 mmHg at two different sites on the same day was likely because of the difference in precision between the digital reference and field barometers.
- All 71 water-temperature field checks were within ±0.2 °C of a secondary standard, ranging from -0.12 to +0.06 °C.
- All 76 TDG sensor laboratory checks performed after field deployment were within ±0.3 percent saturation of a primary standard at ambient air pressure and at ambient air pressure plus 300 mmHg.
- During each scheduled site visit, the TDG sensors were field checked, removed and replaced with recently calibrated sensors, and brought to the lab for calibration checks. The three year-round tailwater sites were generally visited monthly from October 2023 through March 2024 (except for an 8-week period for Warrendale ending in March). The four seasonal sites were installed March 26-29, 2024. All seven sites were then visited every three to four weeks from March 2024 through late-September 2024 (except for a five-week period ending in late-August).

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 mi^2 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.

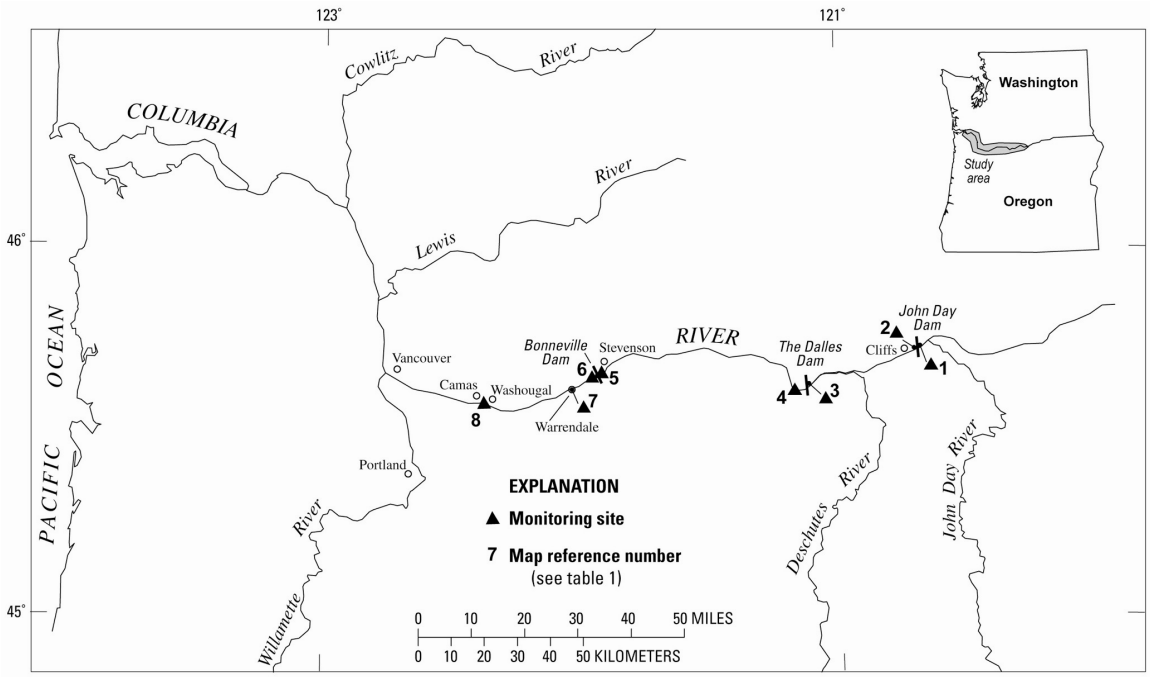

Figure G-1. Location of U.S. Army Corps of Engineers dams and total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2024.

Real-time TDG, barometric pressure, 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 are 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 31, 2024). The USACE database also includes hourly river discharge and spill data at *http://pweb.crohms.org/ftppub/water_quality/tdg/* (accessed October 31, 2024).

This data summary 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 are 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

Seven monitoring stations, from the navigation lock of the John Day Dam (river mile [RM] 215.7) to Dodson, Oregon (RM 140.3) (fig. G-1, sites 1-7; table G-1), were operated on the lower Columbia River. Data for water year 2024 (October 1, 2023 - September 30, 2024) include hourly measurements of TDG pressure, barometric pressure, water temperature, and sensor depth. 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. Four seasonal stations were operated from late-March through late-September 2024, encompassing the usual period for Lower Columbia dam spill operations (April 10 to August 31).

Instrumentation at each monitoring station consists of a Hydrolab or Hydrotech water-quality sonde, a Vaisala or Campbell Scientific (CCIW only) 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 a solar panel. 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 weeks, except for one 8-week interval at WRNO) at the three year-round tailwater stations from September 2023 to March 2024. Cascade Island and the three forebay stations were installed March 26-29, 2024. All seven sites were then visited every three to four weeks until September 2024 except during late August (resulting in a 5-week interval between visits at most sites). Cascade Island measured TDG data from September 1, 2024, to September 25, 2024, (Cascade Island removal) is non-representative of TDG after spill from Bonneville Dam ends. The three forebay sites were removed September 24-25, 2024.

The field check procedure is as follows: The reference Hydrolab MiniSonde, checked and calibrated (if necessary) before the field trip for use as a secondary standard, is deployed alongside the site-deployed instrument and allowed to equilibrate to obtain comparison measurements of TDG and water temperature. The site instrument (which is deployed for 3 or more weeks) is then removed and replaced with another recently laboratory-checked and -calibrated (if necessary) sonde. After the newly deployed instrument equilibrates,

the secondary standard sonde is again used to compare TDG and water temperature values.

Previously, any needed adjustment to the water temperature offset was made within the DCP program. Beginning Water Year 2024, water temperature corrections are no longer applied within the DCP programming. All reference and deployed water temperature sensors are checked in the lab against an NIST-certified thermometer over the range of expected temperatures to verify accuracy within ±0.20 °C. During Water Year 2024, all water temperature sensors were accurate within ±0.20 °C for all measured water temperatures.

The electronic barometer at the monitoring station is checked against portable barometers, NovaLynx 230-M202 and ZM2000N-A10030 (beginning August 2024), calibrated annually to National Institute of Standards and Technology (NIST) standards. If necessary, the barometric pressure offset is adjusted; however, no offsets were adjusted during Water Year 2024.

The sonde removed from the field is then checked in the laboratory. The integrity and responsiveness of the TDG membrane is tested, and the membrane is removed and air-dried. The TDG sensor, without the membrane attached, is tested at a range of pressures spanning the expected range of TDG in the river. If necessary, the TDG sensor is recalibrated after this test. The membrane is then installed on the TDG sensor and retested.

Table G-1. Total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2024.

[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 2024
1	JDY	215.7	454314120413701	Columbia River at John Day navigation lock, Washington (John Day navigation lock)	45° 43’ 14”	120° 41’ 37”	03/26/24–09/24/24
2	JHAW	214.8	454249120423500	Columbia River, right bank, near Cliffs, Washington (John Day tailwater)	45° 42’ 49”	120° 42’ 35”	10/01/23–09/30/24
3	TDA	192.4	453712121071200	Columbia River at The Dalles Dam forebay, Washington (The Dalles forebay)	45° 37’ 12”	121° 07’ 12”	03/27/24-09/24/24
4	TDDO	189.1	14105700	Columbia River at The Dalles, Oregon (The Dalles tailwater)	45° 36’ 27”	121° 10’ 20”	10/01/23–09/30/24
5	BON	146.1	453845121562000	Columbia River at Bonneville Dam forebay, Washington (Bonneville forebay)	45° 38’ 45”	121° 56’ 20”	03/27/24–09/25/24
6	CCIW	145.9	453845121564001	Columbia River at Cascade Island, Washington (Cascade Island)	45° 38’ 45”	121° 56’ 40”	03/29/24–09/25/24
7	WRNO	140.3	453630122021400	Columbia River, left bank, near Dodson, Oregon (Warrendale)	45° 36’ 30”	122° 02’ 14”	10/01/23–09/30/24

3.0 Data Completeness

To assure the accuracy and integrity of the TDG data in the lower Columbia River, hourly values are 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 are 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 are considered meeting quality-assurance standards if they are within ±1 percent saturation of the expected value.

Table G-2. Completeness and quality of real-time total-dissolved-gas or barometric pressure data, lower Columbia River, Oregon and Washington, water year 2024.

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)	4,371	41	99.1
John Day tailwater (JHAW)	8,784	135	98.5
The Dalles forebay (TDA)	4,348	205	95.3
The Dalles tailwater (TDDO)	8,784	630	92.8
Bonneville forebay (BON)	4,370	1	100
Cascade Island (CCIW)	4,324	1	100
Warrendale (WRNO)	8,784	229	97.4

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

Table G-3. Periods of missing, deleted, or corrected real-time total-dissolved-gas (TDG) or barometric pressure (BP) data, lower Columbia River, Oregon and Washington, water year 2024.

Date(s)	USACE station identifier	Reason / Note
05/15/24 to 08/26/24	JDY	Erroneous data (TDG, water temperature, BP, depth values) – Faulty DCP transmissions: data recovered
07/16/24 to 07/18/24	JHAW	Erroneous TDG values – Ruptured membrane
09/11/24	JHAW	Erroneous TDG values – Ruptured membrane
09/21/24 to 09/24/24	JHAW	Erroneous TDG values – Fouled sonde: data corrected
04/28/24 to 05/06/24	TDA	Missing transmissions (TDG, water temperature, BP, depth) – Blocked antenna and solar panel, failed battery: all but 11 data recovered
05/05/24	TDA	Erroneous BP transmission: data recovered
01/18/24 to 01/19/24	TDDO	Missing transmissions (TDG, water temperature, BP, depth) – Weather-related
08/03/24 to 08/27/24	TDDO	Erroneous TDG values – Fouled sonde: data corrected
01/17/24 to 01/19/24	WRNO	Missing transmissions (TDG, water temperature, BP, depth) – Weather related: data recovered
01/20/24 to 01/28/24	WRNO	Erroneous data (TDG, water temperature, depth) – Data later recovered from logging sonde

A faulty DCP at the John Day navigation lock site resulted in intermittent erroneous transmissions between May 15, 2024, to August 26, 2024. Replacement of the DCP on August 26, 2024, resolved the erroneous transmissions, and all data was recovered from the electronic data logs.

TDG data from previous years indicate non-spill factors may affect water circulation at the John Day tailwater deployment pipes and consequently, the 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 July 18, 2024. No data were deleted during water year 2024 due to stagnation or sediment accumulation at the site; however, a fouling correction was applied to John Day tailwater data from September 21, 2024, to the site visit on September 24, 2024. Stagnant conditions appeared to effect TDG measurements at The Dalles tailwater deployment pipes, and a fouling correction was also applied to TDG data from August 3, 2024, to the site visit on September 27, 2024.

A blocked antenna and solar panel, and subsequent failed battery, resulted in intermittent missing transmissions at The Dalles forebay site from April 28, 2024, to May 6, 2024. Replacement of the failed battery resolved the missing transmissions, and all but 11 data were recovered from the electronic data log. Missing transmissions from the Warrendale and The Dalles tailwater sites between January 17 and 18, respectively, to January 19, 2024, were likely weather related and all data were recovered from the electronic data log. Faulty sonde communication at the Warrendale site from January 20, 2024, to January 28, 2024, resulted in intermittent erroneous data, and was resolved at the site visit on January 30, 2024.

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 2024 are presented in this section.

After field deployment for 3 or more weeks, TDG instruments are tested and calibrated (if needed) in the laboratory. First, the sensor is tested, with the gas-permeable membrane in place, for response to supersaturated conditions in soda water. The membrane is then cleaned, removed from the sensor, and allowed to dry for at least 24 hours. Before the membrane is replaced, the TDG sensors are examined independently by comparing the reading of the TDG sensor to barometric pressure (100-percent saturation). A certified digital pressure gage (primary standard) is used to make comparisons at a pressure 300 mmHg greater than barometric pressure (approximately 139-percent saturation). The accuracy of the TDG sensors is 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 76 TDG sensor laboratory checks performed after field deployment were within ±0.3 percent saturation of a primary standard at both test conditions (fig. G-2).

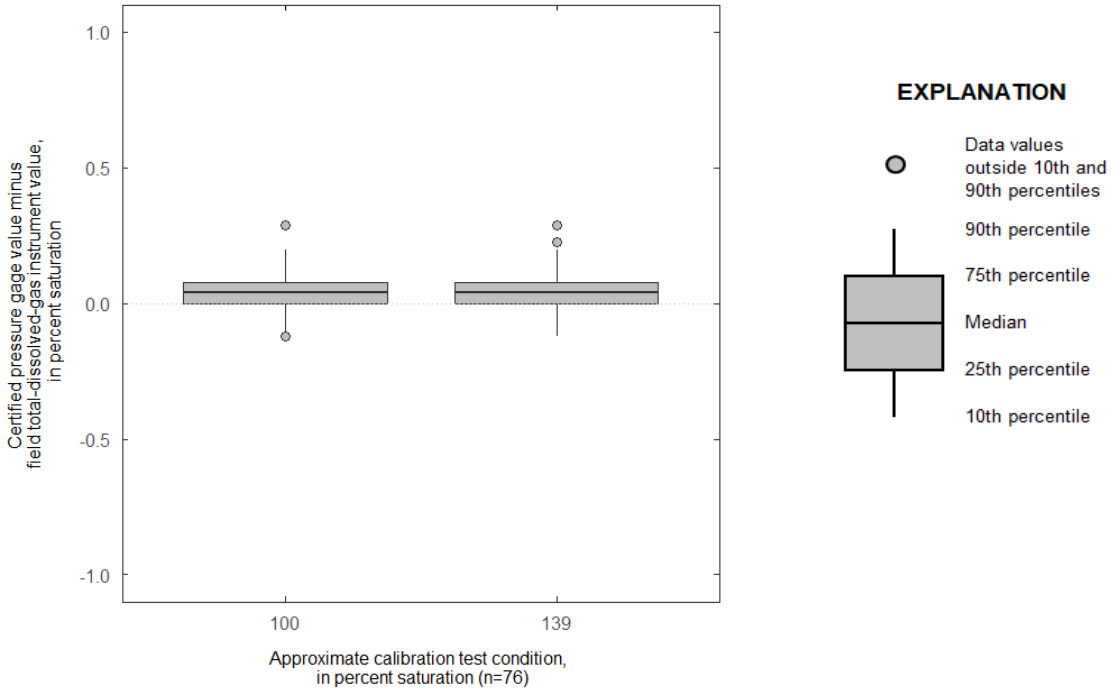

Figure G-2. Accuracy of total-dissolved-gas sensors in the laboratory after 3 or more weeks of field deployment at seven monitoring stations in the lower Columbia River, Oregon and Washington, water year 2024 (number of comparison values = 76).

The differences in barometric pressure, water temperature, and TDG between the reference instruments and the station monitors at the end of their field deployment are measured and recorded as part of every field inspection. These differences, calculated as the standard values minus the field instrument values, are used to compare, and quantify the accuracy and precision

between the two instruments. For water temperature and TDG, the measurements are made with the secondary standard (a lab checked Hydrolab or HydroTech MiniSonde) positioned alongside the monitor deployed in the river. Digital barometers (NIST certified through February 2025 or November 2024) serve as the primary standard for barometric pressure. The distribution of quality-assurance data for each of the three parameters from the seven 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. Two of the 73 field check values were greater than ±1.0 mmHg of primary standard values, ranging from -1.1 mmHg to +0.5 mmHg. The difference of -1.1 mmHg at two different sites on the same day was likely because of the difference in precision between the digital reference and field barometers. The reference barometers measure barometric pressure to a level of precision of 0.1 mmHg, and the field barometers measure barometric pressure to a level of precision of 1 mmHg.

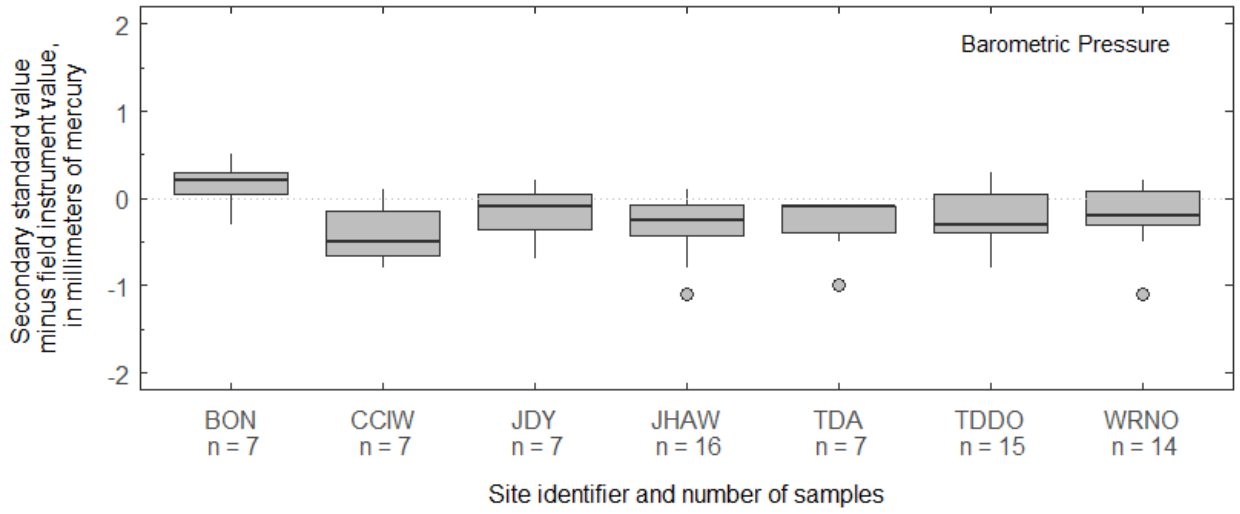

Figure G-3. Difference between the primary standard and the field barometers in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2024. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

The comparisons of the secondary standard temperature sensor and the field temperature sensors are presented in figure G-4. The differences of all 71 field checks were within ±0.20 °C, ranging from -0.12 to +0.06 °C.

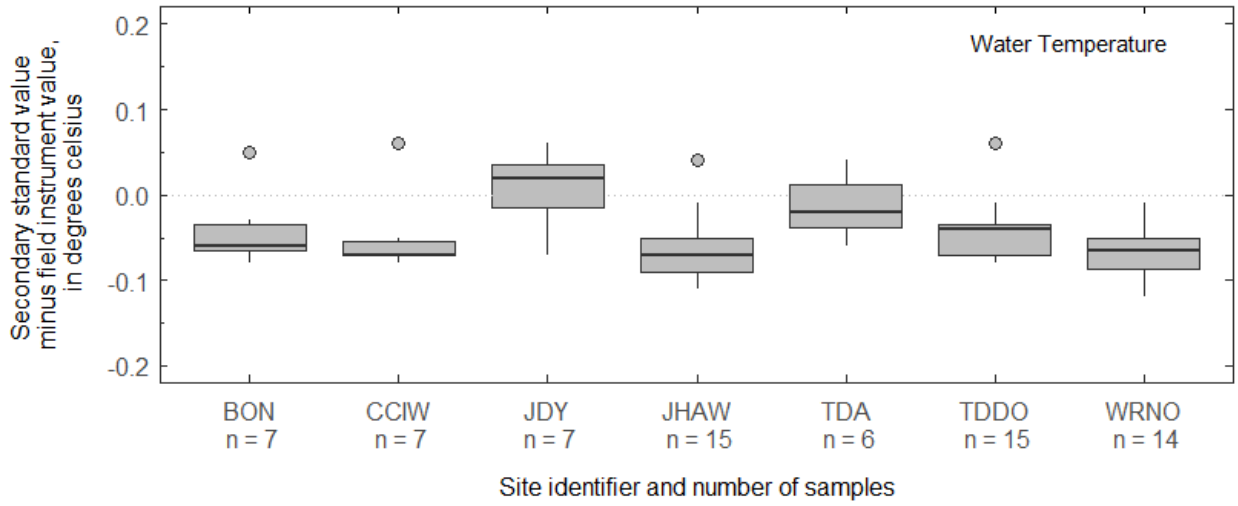

Figure G-4. Difference between the secondary standard and the field temperature instruments in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2024. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

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 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 3-4 mmHg (approximately ±0.5 percent saturation). A total of 73 TDG field checks were done at the seven monitoring sites and 15 checks exceeded this guideline. Nine of these comparisons were within +0.7 to +1.2 percent saturation, likely due to incomplete equilibration of the reference sensor during periods of low to no spill, and no data were deleted or corrected. The final field check at Cascade Island (before seasonal decommissioning) was +1.3 percent saturation due to the rapidly changing TDG after spill had ended, and no data were deleted.

Two checks that exceeded the criteria were likely caused by a decrease in spill which caused sediment deposition on the TDG membrane, and the subsequent decrease in measured TDG. Fouling corrections were applied to the affected data at The Dalles tailwater and John Day tailwater sites. Three checks that exceeded the criteria were because of ruptured TDG membranes that resulted in deleted data at John Day tailwater. (One of the three membranes ruptured after the end of the water year, but before the final field check for the site.) These five comparison readings are not included in distribution analysis (fig. G-5). because these data do not represent the TDG sensor's accuracy during normal function.

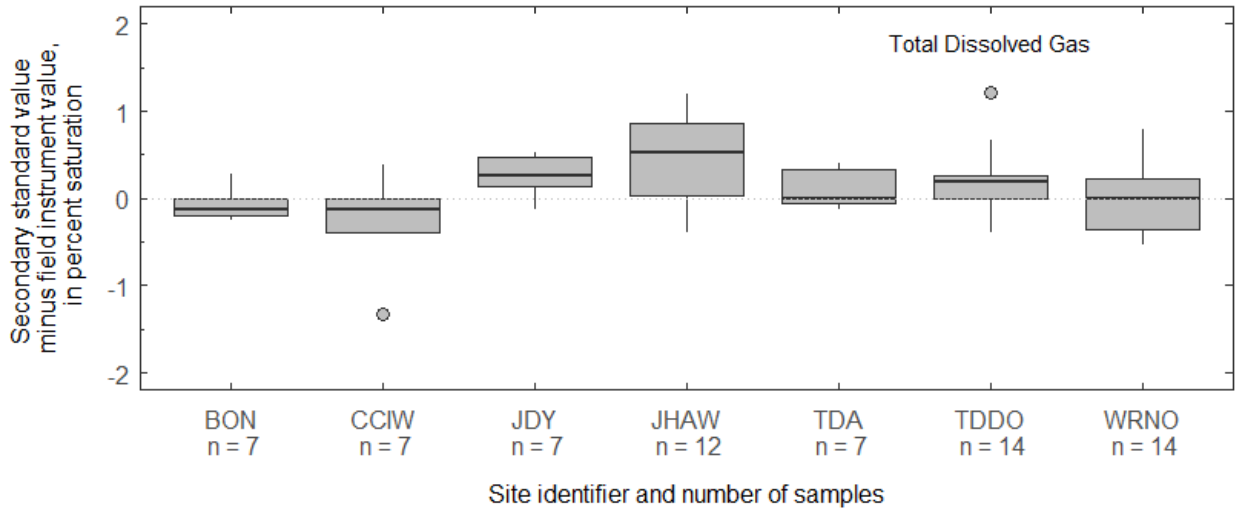

Figure G-5. Difference between the secondary standard and the field total-dissolved-gas instruments in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2024. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

Table G-4. Summary of total-dissolved-gas side-by-side reference and field instrument comparisons, water year 2024.

Date	Reference sonde number.	Site sonde number	Barometric pressure (mmHg)				Water temperature (°C)				Pressure, total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Difference in percent saturation
John Day navigation lock (JDY)															
4/15/2024	65426	66625	758.1	758	0.1	0.1	10.06	10.00	0.06	0.06	797	794	3	3	0.40
5/7/2024	65426	67480	758.0	758	0.0	0.0	11.57	11.55	0.02	0.02	789	788	1	1	0.13
5/28/2024	65426	66625	754.2	754	0.2	0.2	14.33	14.36	-0.03	0.03	819	815	4	4	0.53
6/25/2024	65426	64961	750.9	751	-0.1	0.1	17.69	17.65	0.04	0.04	834	835	-1	1	-0.13
7/18/2024	65426	66625	753.6	754	-0.4	0.4	21.48	21.48	0.00	0.00	815	811	4	4	0.53
8/27/2024	65426	64961	756.3	757	-0.7	0.7	20.95	20.92	0.03	0.03	762	760	2	2	0.26
9/24/2024	65426	66625	747.7	748	-0.3	0.3	19.94	20.01	-0.07	0.07	751	750	1	1	0.13
Mean					-0.17	0.26			0.01	0.04			2.0	2.3	0.26
Median					-0.10	0.20			0.02	0.03			2.0	2.0	0.26
John Day tailwater (JHAW)															
10/10/2023	65425	013123B	744.8	745	-0.2	0.2	18.04	18.09	-0.05	0.05	755	757	-2	2	-0.27
11/7/2023	65425	66626	757.4	758	-0.6	0.6	13.54	13.64	-0.10	0.10	749	746	3	3	0.40
12/8/2023	65425	67857	764.8	765	-0.2	0.2	8.71	8.82	-0.11	0.11	752	746	6	6	0.78
1/3/2024	65426	66625	759.6	760	-0.4	0.4	6.86	6.96	-0.10	0.10	749	747	2	2	0.26
1/30/2024	65426	67857	758.1	758	0.1	0.1	2.55	2.62	-0.07	0.07	748	750	-2	2	-0.26
3/1/2024	65426	66626	745.6	746	-0.4	0.4	5.39	5.49	-0.10	0.10	775	769	6	6	0.80
3/26/2024	65426	67857	757.1	757	0.1	0.1	8.12	8.20	-0.08	0.08	835	826	9	9	1.19
4/15/2024	65426	66626	761.0	761	0.0	0.0	10.15	10.11	0.04	0.04	861	864	-3	3	-0.39
5/7/2024	65426	67857	760.5	761	-0.5	0.5	11.62	11.70	-0.08	0.08	863	862	1	1	0.13
5/28/2024	65426	66626	757.0	757	0.0	0.0	14.34	14.41	-0.07	0.07	853	848	5	5	0.66
6/25/2024	65426	67857	754.9	755	-0.1	0.1	17.33	17.38	-0.05	0.05	877	868	9	9	1.19
7/18/2024	65426	66626	754.7	755	-0.3	0.3	21.53	21.59	-0.06	0.06	754	1100	-346	346	-45.85
8/27/2024	65426	67857	759.2	760	-0.8	0.8	21.02	21.08	-0.06	0.06	831	823	8	8	1.05
9/11/2024	65426	66626	749.6	750	-0.4	0.4	-	-	-	-	831	1060	-229	229	-30.55
9/24/2024	65426	67857	748.8	749	-0.2	0.2	20.01	20.05	-0.04	0.04	761	735	26	26	3.47
10/11/2024	65426	67480	759.9	761	-1.1	1.1	18.40	18.41	-0.01	0.01	761	1068	-307	307	-40.40
Mean					-0.31	0.34			-0.06	0.07			-50.9	60.3	-6.74
Median					-0.25	0.25			-0.07	0.07			2.5	6.0	0.33

Date	Reference sonde number	Site sonde number	Barometric pressure (mmHg)				Water temperature (°C)				Pressure, total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Difference in percent saturation
The Dalles forebay (TDA)															
4/16/2024	65426	65427	764.9	765	-0.1	0.1	10.22	10.18	0.04	0.04	820	818	2	2	0.26
5/8/2024	65425	66362	763.9	764	-0.1	0.1	11.92	11.98	-0.06	0.06	822	823	-1	1	-0.13
5/29/2024	65426	65427	763.9	764	-0.1	0.1	14.44	14.45	-0.01	0.01	836	836	0	0	0.00
6/25/2024	65426	66362	751.5	752	-0.5	0.5	17.33	17.37	-0.04	0.04	843	844	-1	1	-0.13
7/26/2024	65426	65427	758.7	759	-0.3	0.3	-	-	-	-	798	795	3	3	0.40
8/28/2024	65426	66362	762.9	763	-0.1	0.1	20.54	20.57	-0.03	0.03	781	778	3	3	0.39
9/24/2024	65426	65427	752.0	753	-1.0	1.0	19.69	19.67	0.02	0.02	754	754	0	0	0.00
Mean					-0.31	0.31			-0.01	0.03			0.9	1.4	0.11
Median					-0.10	0.10			-0.02	0.04			0.0	1.0	0.00
The Dalles tailwater (TDDO)															
10/10/2023	65425	67858	747.1	747	0.1	0.1	18.27	18.28	-0.01	0.01	770	768	2	2	0.27
11/7/2023	65425	64596	761.6	762	-0.4	0.4	13.75	13.81	-0.06	0.06	758	755	3	3	0.39
12/8/2023	65425	67858	768.1	768	0.1	0.1	8.93	9.01	-0.08	0.08	761	759	2	2	0.26
1/3/2024	65426	64596	761.7	762	-0.3	0.3	6.78	6.85	-0.07	0.07	743	741	2	2	0.26
1/30/2024	65426	67858	759.0	759	0.0	0.0	2.80	2.84	-0.04	0.04	749	748	1	1	0.13
3/1/2024	65426	64598	746.8	747	-0.2	0.2	5.64	5.68	-0.04	0.04	781	772	9	9	1.21
3/26/2024	65426	67858	758.6	759	-0.4	0.4	8.35	8.42	-0.07	0.07	811	811	0	0	0.00
4/15/2024	65426	64596	763.3	764	-0.7	0.7	10.36	10.43	-0.07	0.07	869	868	1	1	0.13
5/8/2024	65426	67858	766.6	767	-0.4	0.4	11.94	11.98	-0.04	0.04	874	877	-3	3	-0.39
5/28/2024	65426	64596	761.3	761	0.3	0.3	14.58	14.52	0.06	0.06	888	883	5	5	0.66
6/25/2024	65426	67858	757.7	758	-0.3	0.3	17.23	17.26	-0.03	0.03	883	884	-1	1	-0.13
7/26/2024	65426	64596	759.2	759	0.2	0.2	21.27	21.34	-0.07	0.07	841	841	0	0	0.00
8/27/2024	65426	67858	762.2	763	-0.8	0.8	21.02	21.06	-0.04	0.04	844	826	18	18	2.36
9/24/2024	65426	64596	755.6	756	-0.4	0.4	19.69	19.75	-0.06	0.06	773	773	0	0	0.00
10/11/2024	65426	67858	761.8	762	-0.2	0.2	18.03	18.06	-0.03	0.03	768	766	2	2	0.26
Mean					-0.23	0.32			-0.04	0.05			3	3	0.36
Median					-0.30	0.30			-0.04	0.06			2.0	2.0	0.26

Date	Reference sonde number	Site sonde number	Barometric pressure (mmHg)				Water temperature (°C)				Pressure, total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Difference in percent saturation
Bonneville forebay (BON)															
4/16/2024	65426	64961	768.1	768	0.1	0.1	10.25	10.20	0.05	0.05	823	824	-1	1	-0.13
5/8/2024	65425	66360	769.5	769	0.5	0.5	11.57	11.64	-0.07	0.07	823	825	-2	2	-0.26
5/30/2024	65426	64598	767.3	767	0.3	0.3	14.44	14.47	-0.03	0.03	858	858	0	0	0.00
6/26/2024	65426	66360	759.2	759	0.2	0.2	17.39	17.45	-0.06	0.06	853	855	-2	2	-0.26
7/25/2024	65426	64598	766.3	766	0.3	0.3	21.03	21.07	-0.04	0.04	794	795	-1	1	-0.13
8/29/2024	65426	66360	762.0	762	0.0	0.0	20.16	20.22	-0.06	0.06	793	793	0	0	0.00
9/25/2024	65425	66360	753.7	754	-0.3	0.3	19.38	19.46	-0.08	0.08	770	768	2	2	0.27
Mean					0.16	0.24			-0.04	0.06			-0.6	1.1	-0.07
Median					0.20	0.30			-0.06	0.06			-1.0	1.0	-0.13
Cascade Island (CCIW)															
4/16/2024	65426	10322B	769.5	770	-0.5	0.5	10.25	10.32	-0.07	0.07	919	922	-3	3	-0.39
5/8/2024	65426	13022A	770.8	771	-0.2	0.2	11.59	11.67	-0.08	0.08	898	899	-1	1	-0.13
5/30/2024	65426	10322B	769.1	769	0.1	0.1	14.44	14.38	0.06	0.06	918	917	1	1	0.13
6/26/2024	65426	13022A	759.2	760	-0.8	0.8	17.42	17.48	-0.06	0.06	881	884	-3	3	-0.40
7/25/2024	65426	10322B	766.9	767	-0.1	0.1	21.01	21.08	-0.07	0.07	867	868	-1	1	-0.13
8/29/2024	65426	13022A	763.5	764	-0.5	0.5	20.19	20.24	-0.05	0.05	857	854	3	3	0.39
9/25/2024	65426	10322B	754.2	755	-0.8	0.8	19.44	19.51	-0.07	0.07	802	812	-10	10	-1.33
Mean					-0.40	0.43			-0.05	0.07			-2.0	3.1	-0.26
Median					-0.50	0.50			-0.07	0.07			-1.0	3.0	-0.13

Date	Reference sonde number	Site sonde number	Barometric pressure (mmHg)				Water temperature (°C)				Pressure, total dissolved gas (mmHg)				
			Reference barometer	Site barometer	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Reference sensor	Site sensor	Differ-ence	Absolute difference	Difference in percent saturation
Warrendale (WRNO)															
10/10/2023	65425	67855	750.6	751	-0.4	0.4	18.07	18.08	-0.01	0.01	771	769	2	2	0.27
11/7/2023	65425	67856	767.0	767	0.0	0.0	13.50	13.60	-0.10	0.10	769	768	1	1	0.13
12/8/2023	65425	67855	772.1	772	0.1	0.1	8.66	8.75	-0.09	0.09	768	768	0	0	0.00
1/3/2024	65426	67856	764.7	765	-0.3	0.3	6.67	6.79	-0.12	0.12	771	771	0	0	0.00
1/30/2024	65426	67855	761.5	762	-0.5	0.5	3.20	3.26	-0.06	0.06	772	766	6	6	0.79
3/29/2024	65426	67856	758.2	758	0.2	0.2	8.38	8.47	-0.09	0.09	831	835	-4	4	-0.53
4/15/2024	65426	67855	768.7	769	-0.3	0.3	10.02	10.09	-0.07	0.07	907	909	-2	2	-0.26
5/14/2024	65426	67856	765.2	765	0.2	0.2	13.46	13.54	-0.08	0.08	916	919	-3	3	-0.39
5/29/2024	65426	67855	770.2	770	0.2	0.2	14.57	14.62	-0.05	0.05	924	924	0	0	0.00
6/25/2024	65426	67856	760.8	761	-0.2	0.2	17.19	17.25	-0.06	0.06	872	873	-1	1	-0.13
7/25/2024	65426	67855	767.8	768	-0.2	0.2	21.13	21.14	-0.01	0.01	885	888	-3	3	-0.39
8/28/2024	65426	67856	766.9	767	-0.1	0.1	20.49	20.54	-0.05	0.05	897	900	-3	3	-0.39
9/24/2024	65426	67855	757.8	758	-0.2	0.2	18.95	18.99	-0.04	0.04	786	783	3	3	0.40
10/11/2024	65426	67856	761.9	763	-1.1	1.1	17.52	17.59	-0.07	0.07	782	780	2	2	0.26
Mean					-0.19	0.29			-0.06	0.06			-0.1	2.1	-0.02
Median					-0.20	0.20			-0.06	0.06			0.0	2.0	0.00

Table G-5. Summary of reference and site TDG sensor comparisons measured during lab calibrations, water year 2024.

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		
JDY	66625	3/18/2024	-	761.1	1061.1	761	1061	0.01	0.01	N	P
JDY	66625	4/24/2024	P	759.0	1059.0	759	1059	0.00	0.00	N	P
JDY	67480	5/20/2024	P	764.9	1064.9	764	1064	0.12	0.12	N	P
JDY	66625	6/21/2024	P	755.1	1055.1	756	1055	-0.12	0.01	N	P
JDY	64961	7/11/2024	P	760.5	1060.5	760	1060	0.07	0.07	N	P
JDY	66625	8/13/2024	P	758.6	1058.6	758	1058	0.08	0.08	N	P
JDY	64961	9/10/2024	P	752.4	1052.4	752	1053	0.05	-0.08	N	P
JDY	66625	10/18/2024	P	764.2	1064.2	764	1064	0.03	0.03	N	P
JHAW	66626	10/3/2023	-	761.6	1061.6	762	1061	-0.05	0.08	N	P
JHAW	13123B	10/31/2023	P	762.5	1062.5	761	1062	0.20	0.07	N	P
JHAW	66626	11/21/2023	P	765.3	1065.3	765	1065	0.04	0.04	Y	P
JHAW	67857	1/2/2024	P	756.3	1056.3	756	1056	0.04	0.04	N	P
JHAW	66626	1/29/2024	P	-	-	-	-	-	-	-	N/A
JHAW	67857	2/14/2024	P	750.7	1050.7	751	1051	-0.04	-0.04	N	P
JHAW	66626	3/18/2024	P	761.0	1061.0	760	1060	0.13	0.13	N	P
JHAW	13123B	4/22/2024	P	758.4	1058.4	758	1059	0.05	-0.08	N	P
JHAW	66626	4/24/2024	P	759.1	1059.1	758	1058	0.14	0.14	N	P
JHAW	67857	5/20/2024	P	764.9	1064.9	765	1065	-0.01	-0.01	N	P
JHAW	66626	6/21/2024	P	755.1	1055.1	755	1055	0.01	0.01	N	P
JHAW	67857	7/11/2024	P	760.5	1060.5	760	1060	0.07	0.07	N	P
JHAW	66626	8/13/2024	F	758.6	1058.6	758	1058	0.08	0.08	N	P
JHAW	67480	9/10/2024	P	752.4	1052.4	752	1052	0.05	0.05	N	P
JHAW	67857	9/10/2024	P	752.4	1052.4	752	1052	0.05	0.05	N	P
JHAW	66626	10/10/2024	F	757.3	1057.3	757	1057	0.04	0.04	N	P
JHAW	67857	10/10/2024	P	757.3	1057.3	757	1057	0.04	0.04	N	P
JHAW	67480	10/18/2024	F	764.0	1064.0	764	1064	0.00	0.00	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		
TDA	65427	3/18/2024	-	761.1	1061.1	761	1061	0.01	0.01	N	P
TDA	65427	4/24/2024	P	759.0	1059.0	759	1059	0.00	0.00	N	P
TDA	66362	5/20/2024	P	764.9	1064.9	765	1065	-0.01	-0.01	N	P
TDA	65427	6/20/2024	P	755.2	1055.2	756	1055	-0.11	0.03	N	P
TDA	66362	7/11/2024	P	760.5	1060.5	761	1061	-0.07	-0.07	N	P
TDA	65427	8/13/2024	P	758.6	1058.6	759	1059	-0.05	-0.05	N	P
TDA	66362	9/10/2024	P	752.4	1052.4	752	1052	0.05	0.05	N	P
TDA	65427	10/18/2024	P	763.9	1063.9	764	1064	-0.01	-0.01	N	P
TDDO	64598	10/31/2023	P	762.5	1062.5	761	1061	0.20	0.20	N	P
TDDO	67858	10/31/2023	P	762.5	1062.5	762	1062	0.07	0.07	N	P
TDDO	64596	11/21/2023	P	765.2	1065.2	763	1063	0.29	0.29	Y	P
TDDO	67858	1/2/2024	P	756.2	1056.2	757	1056	-0.11	0.03	N	P
TDDO	67858	2/14/2024	P	750.7	1050.7	750	1051	0.09	-0.04	N	P
TDDO	64596	3/18/2024	P	761.0	1061.0	760	1061	0.13	0.00	N	P
TDDO	64598	3/18/2024	P	761.2	1061.2	760	1060	0.16	0.16	Y	P
TDDO	64596	4/24/2024	P	759.0	1059.0	759	1059	0.00	0.00	N	P
TDDO	67858	5/20/2024	P	764.8	1064.8	764	1065	0.10	-0.03	N	P
TDDO	64596	6/21/2024	P	755.1	1055.1	756	1056	-0.12	-0.12	N	P
TDDO	67858	7/11/2024	P	760.5	1060.5	760	1060	0.07	0.07	N	P
TDDO	64596	8/13/2024	P	758.6	1058.6	759	1059	-0.05	-0.05	N	P
TDDO	67858	9/10/2024	P	752.4	1052.4	752	1052	0.05	0.05	N	P
TDDO	64596	10/10/2024	P	757.3	1057.3	758	1058	-0.09	-0.09	N	P
TDDO	67858	10/18/2024	P	764.1	1064.1	764	1064	0.01	0.01	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		
BON	64961	3/18/2024	-	761.1	1061.1	761	1062	0.01	-0.12	N	P
BON	64598	3/18/2024	P	761.2	1061.2	760	1060	0.16	0.16	Y	P
BON	64961	4/24/2024	P	758.9	1058.9	759	1059	-0.01	-0.01	N	P
BON	66360	5/20/2024	P	764.9	1064.9	764	1064	0.12	0.12	N	P
BON	64598	6/21/2024	P	755.1	1055.1	755	1055	0.01	0.01	N	P
BON	66360	7/11/2024	P	760.4	1060.4	760	1060	0.05	0.05	N	P
BON	64598	8/13/2024	P	758.5	1058.5	759	1059	-0.07	-0.07	N	P
BON	64598	9/10/2024	P	752.3	1052.3	752	1052	0.04	0.04	N	P
BON	66360	10/18/2024	P	763.9	1063.9	763	1063	0.12	0.12	N	P
CCIW	013022B	3/18/2024	P	761.0	1061.0	761	1061	0.00	0.00	N	P
CCIW	013022B	4/24/2024	P	758.9	1058.9	759	1059	-0.01	-0.01	N	P
CCIW	013022A	5/20/2024	P	764.8	1064.8	764	1065	0.10	-0.03	N	P
CCIW	013022B	6/21/2024	P	755.1	1055.1	755	1054	0.01	0.15	N	P
CCIW	013022A	7/11/2024	P	760.4	1060.4	759	1060	0.18	0.05	N	P
CCIW	013022B	8/13/2024	P	758.6	1058.6	758	1058	0.08	0.08	N	P
CCIW	013022A	9/10/2024	P	752.3	1052.3	751	1052	0.17	0.04	N	P
CCIW	013022B	10/18/2024	P	764.2	1064.2	764	1064	0.03	0.03	N	P
WRNO	67855	10/31/2023	P	762.5	1062.5	762	1061	0.07	0.20	N	P
WRNO	67856	11/21/2023	P	765.2	1065.2	765	1065	0.03	0.03	N	P
WRNO	67855	1/2/2024	P	756.3	1056.3	756	1055	0.04	0.17	N	P
WRNO	67856	1/29/2024	P	-	-	-	-	-	-	-	N/A
WRNO	67855	2/14/2024	P	750.7	1050.7	750	1049	0.09	0.23	N	P
WRNO	67855	3/15/2024	P	-	-	-	-	-	-	-	N/A
WRNO	67855	4/24/2024	P	758.9	1058.9	758	1058	0.12	0.12	N	P
WRNO	67856	5/20/2024	P	764.8	1064.8	765	1065	-0.03	-0.03	N	P
WRNO	67855	6/21/2024	P	755.1	1055.1	755	1054	0.01	0.15	N	P
WRNO	67856	7/11/2024	P	760.4	1060.4	760	1060	0.05	0.05	N	P
WRNO	67855	8/13/2024	P	758.6	1058.6	758	1058	0.08	0.08	N	P
WRNO	67856	9/10/2024	P	752.3	1052.3	752	1052	0.04	0.04	N	P
WRNO	67855	10/10/2024	P	757.2	1057.2	757	1056	0.03	0.16	N	P
WRNO	67856	10/18/2024	P	764.0	1064.0	764	1064	0.00	0.00	N	P