# Appendix G

## 2022 Portland District TDG Report

# U.S. Army Corps of Engineers Portland District Quality-Assurance and Quality-Control Evaluation of the 2021-2022 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) 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 2022 indicated the following:

- Data received in real-time from the seven individual monitoring sites ranged from 88.5 percent (at Cascade Island) to > 99.9 percent complete.
- Criteria for real-time data completeness (95 percent) were met at all monitoring stations, except Bonneville forebay (91.9 percent) and Cascade Island (88.5 percent). At Bonneville, the barometric pressure sensor drifted from July 2-15, 2022. The data were later corrected, resulting in final data completeness of 99.8 percent. At Cascade Island, the telemetered sonde was replaced with an internal logging sonde from June 7-22, 2022, in anticipation of high flow. Excluding that period, data completeness was 98.1 percent at the site.
- After approximately three to four weeks of deployment in the river, 64 of 66 TDG sensor field checks were within ±1.0 percent saturation of a secondary standard sensor. Both field checks that failed the guideline were due to ruptured TDG membranes.
- One of 66 barometric pressure field checks was greater than ±1 mmHg of a primary standard, ranging from +15.7 to -0.9 mmHg. The difference of +15.7 mmHg was due to a malfunctioning barometer at Bonneville forebay that drifted for several weeks before it was replaced. The erroneous data was later corrected.
- All 65 water-temperature field checks were within ±0.2 °C of a secondary standard, ranging from -0.04 to + 0.05 °C.
- All 66 TDG sensor laboratory checks that were 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 visited monthly from October 2021 through March 2022. The seven seasonal sites were installed March 29-31, 2022 and were visited every three to four weeks from April 2022 through September 2022.

# 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.

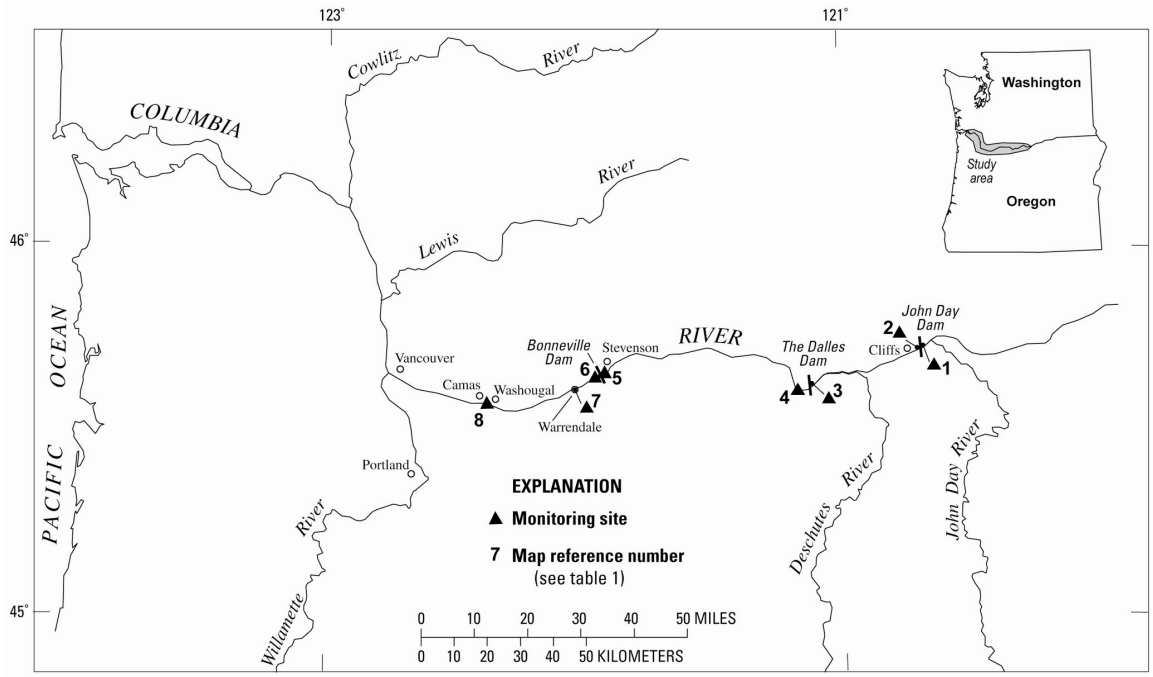


**Figure G-1.** Location of U.S. Army Corp of Engineers dams and total-dissolved-gas monitoring stations, lower Columbia River, Oregon and Washington, water year 2022.

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 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 31, 2022). The USACE database also includes hourly river discharge and spill data at *http://pweb.crohms.org/ftppub/water_quality/tdg/* (accessed October 31, 2022).

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

Seven monitoring stations were operated on the lower Columbia River, from the navigation lock of the John Day Dam (river mile [RM] 215.7) to Dodson, Oregon (RM 140.3) (fig. G-1, table G-1). Data for water year 2022 (October 1, 2021 - September 30, 2022) 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 mid-September 2022, encompassing the usual period for Lower Columbia dam spill operations (April 10 to August 31).

The Warrendale site was moved on May 4, 2022. The dock on which the monitoring site was located was scheduled for major repairs, so the equipment was moved to a second dock on the same property, approximately 300 ft upstream. TDG monitoring will continue at the new dock location because the water depth is greater, and the dock is used less by boaters than the previous location.

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 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 4-5 weeks) at the three year-round stations from September 2021 to March 2022. Cascade Island and the three forebay stations were installed March 29-31, 2022. All seven sites were then visited every three to four weeks until September 2022. Cascade Island was removed September 1, 2022 to minimize the period of non-representative TDG data observed after spill from Bonneville Dam ends. The three forebay sites were removed September 13-14, 2022.

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 adjustment to the water temperature offset was 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 and responsiveness 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 2022.

[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 2022 |
|---|---|---|---|---|---|---|---|
| 1 | JDY | 215.7 | 454314120413701 | Columbia River at John Day navigation lock, Washington (John Day navigation lock) | 45° 43’ 14” | 120° 41’ 37” | 03/29/22–09/13/22 |
| 2 | JHAW | 214.8 | 454249120423500 | Columbia River, right bank, near Cliffs, Washington (John Day tailwater) | 45° 42’ 49” | 120° 42’ 35” | 10/01/21–09/30/22 |
| 3 | TDA | 192.4 | 453712121071200 | Columbia River at The Dalles Dam forebay, Washington (The Dalles forebay) | 45° 37’ 12” | 121° 07’ 12” | 03/30/22-09/13/22 |
| 4 | TDDO | 189.1 | 14105700 | Columbia River at The Dalles, Oregon (The Dalles tailwater) | 45° 36’ 27” | 121° 10’ 20” | 10/01/21–09/30/22 |
| 5 | BON | 146.1 | 453845121562000 | Columbia River at Bonneville Dam forebay, Washington (Bonneville forebay) | 45° 38’ 45” | 121° 56’ 20” | 03/31/22–09/14/22 |
| 6 | CCIW | 145.9 | 453845121564001 | Columbia River at Cascade Island, Washington (Cascade Island) | 45° 38’ 45” | 121° 56’ 40” | 03/31/22–09/01/22 |
| 7 | WRNO | 140.3 | 453630122021400 | Columbia River, left bank, near Dodson, Oregon (Warrendale) | 45° 36’ 30” | 122° 02’ 14” | 10/01/21–09/30/22 |
| 8 | CWMW | 121.7 | 453439122223900 | Columbia River, right bank, at Washougal, Washington (Camas) | 45° 34’ 39” | 122° 22’ 39” | N/A |

# 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 real-time total-dissolved-gas or barometric pressure data, lower Columbia River, Oregon and Washington, water year 2022.

| 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)** | 4,033 | 4 | 99.9 |
| **John Day tailwater (JHAW)** | 8,760 | 28 | 99.6 |
| **The Dalles forebay (TDA)** | 4,013 | 1 | 99.9 |
| **The Dalles tailwater (TDDO)** | 8,760 | 29 | 99.6 |
| **Bonneville forebay (BON)** | 4,005 | 326 | 91.8[1] |
| **Cascade Island (CCIW)** | 3,700 | 425 | 88.5[2] |
| **Warrendale (WRNO)** | 8,760 | 22 | 99.7 |

[1]When excluding the period when erroneous barometric pressure data was later corrected, completeness is 99.8 percent.
[2]When excluding the period when equipment was removed to prevent high flow damage, completeness is 98.1 percent.

Periods for which substantial amounts of TDG 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 or deleted real-time total-dissolved-gas (TDG) or barometric pressure (BP) data, lower Columbia River, Oregon and Washington, water year 2022.

| Date(s) | USACE station identifier | Reason / Note |
|---|---|---|
| 04/29/22 to 04/30/22 | JHAW | Erroneous TDG values – Sonde not deployed to pipe end after pipe flushing |
| 12/19/21, 01/05/22 | TDDO | Missing real-time data transmissions – Inclement weather: Data later recovered |
| 08/24/22 to 08/25/22 | TDDO | Erroneous TDG values - Ruptured membrane |
| 07/2/22 to 7/15/22 | BON | Erroneous BP values – Barometer drift: Data later corrected |
| 06/07/22 to 06/22/22 | CCIW | Missing real-time TDG values – Data later available from logging sonde |
| 07/15/22 to 07/18/22 | CCIW | Erroneous TDG values - Ruptured membrane |
| 01/03/22 | WRNO | Missing real-time data transmissions – Inclement weather: Data later recovered |
| 07/11/22 | WRNO | Erroneous TDG values – Reason unknown |

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 October 30, 2021 and April 29, 2022. After the April flushing, the sonde was not deployed to the end of the pipe and recorded erroneous TDG, water temperature, and depth values until the next day when the sonde was fully re-deployed. No data were deleted during water year 2022 due to stagnation or sediment accumulation at the site.

The drift of the barometric pressure instrument at the Bonneville forebay site occurred in 2 steps. On July 2, 2022, the sensor readings dropped by 3 mmHg, followed by another drop of about 12 mmHg on July 8, 2022. Comparison to the barometric pressure data at both upstream and downstream monitoring stations indicated that the data continued to follow the trend during these periods. The reference barometer field check on July 15, 2022 confirmed a difference of 15-16 mmHg and the barometer was replaced. The data were then corrected from July 2-15, 2022.

The telemetered TDG sonde was removed from CCIW on June 7, 2022 in anticipation of high flow below Bonneville Dam that could overtop the deployment pipe and damage the equipment. An internal logging sonde was deployed until June 22, 2022 and the TDG value was verified by a reference sonde before removal. The TDG and temperature values from the logging sonde were loaded to the database on June 22, 2022. The temperature data were later corrected by -0.08 °C following a lab check of the logging sonde for the range of temperatures during the deployment.

# 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 2022 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 66 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).

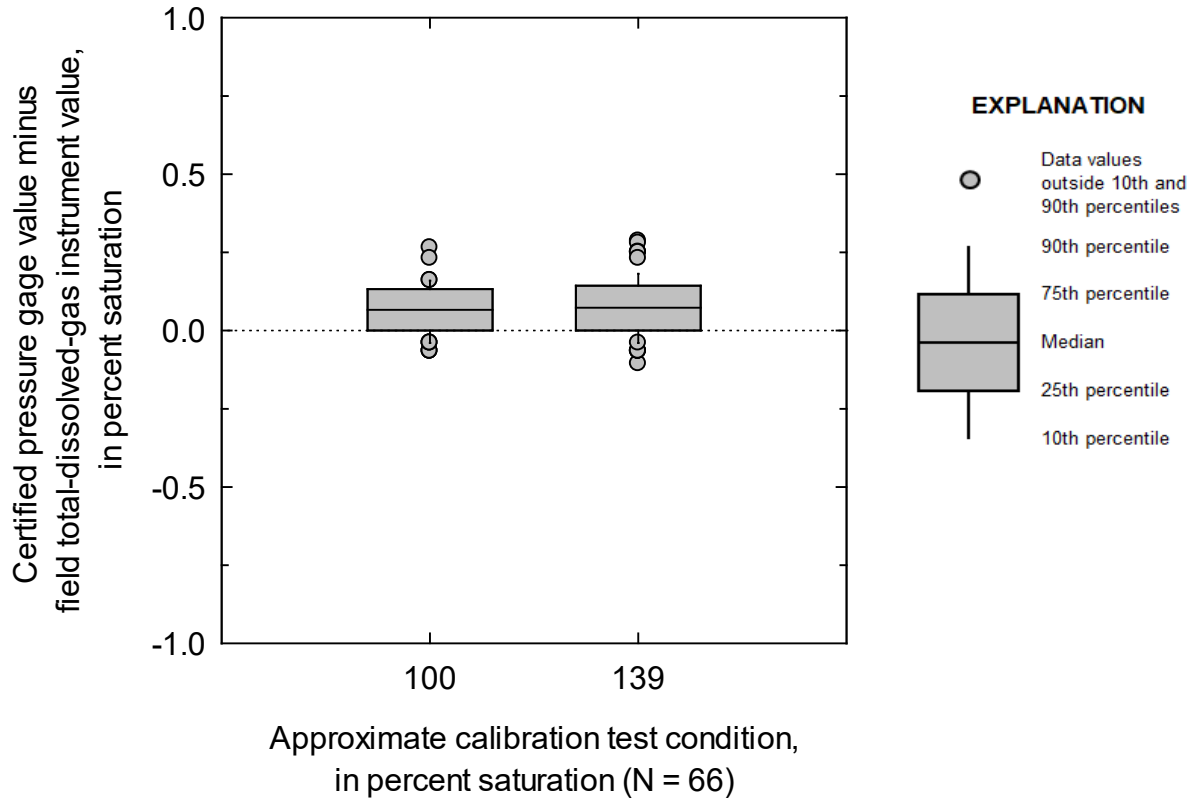


**Figure G-2.** Accuracy of total-dissolved-gas sensors in the laboratory after 3 or more weeks of field deployment at seven monitoring stations in the lower Columbia River, Oregon and Washington, water year 2022 (number of comparison values = 66).

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 June 2022) served 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. One of the 66 field check values was greater than ±1.0 mm Hg of standard values, ranging from -0.9 mmHg to +15.7 mmHg. The difference of +15.7 mmHg was due to the malfunctioning barometer at Bonneville forebay, and 14 days of data were later corrected. This comparison reading is not included in the distribution analysis (figure G-3) because it does not represent the barometer's accuracy during normal function.

The comparisons of the secondary standard temperature sensor and the field temperature sensors are presented in figure G-4. The differences of all 65 field checks were within ±0.20 °C, ranging from -0.04 to +0.05 °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 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 66 TDG field checks were done at the seven monitoring sites. Two of the comparisons were greater than 7 mmHg (approximately ±1.0 percent saturation). Both were due to ruptured TDG membranes, one at The Dalles tailwater and one at Cascade Island. These 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.

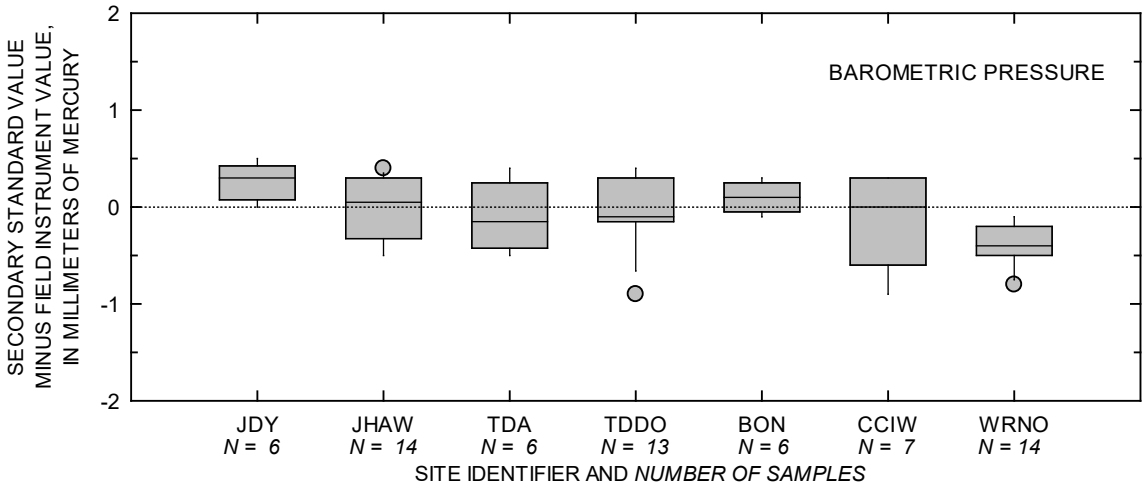


**Figure G-3.** Difference between the secondary standard and the field barometers in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2022. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

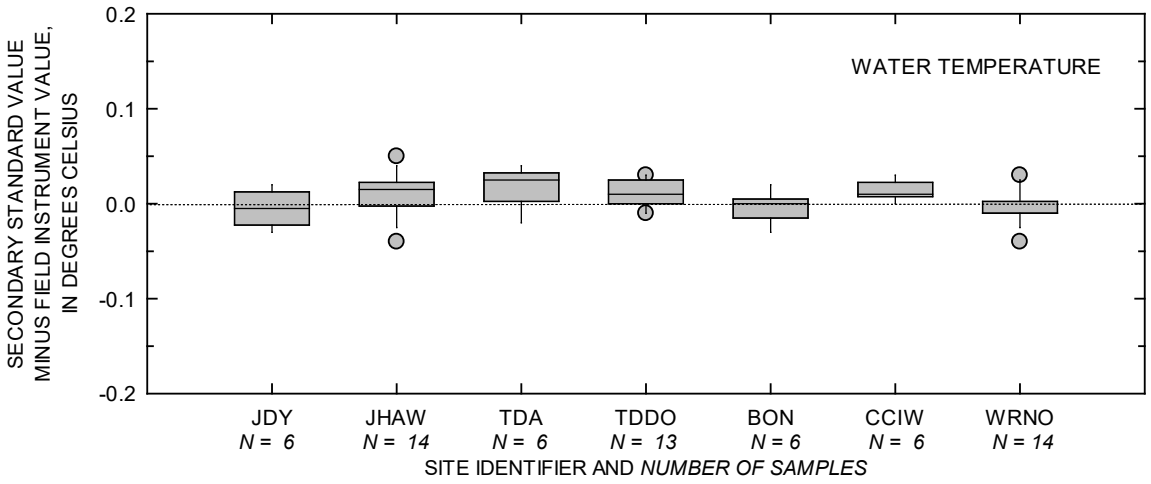


**Figure G-4.** Difference between the secondary standard and the field temperature instruments in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2022. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

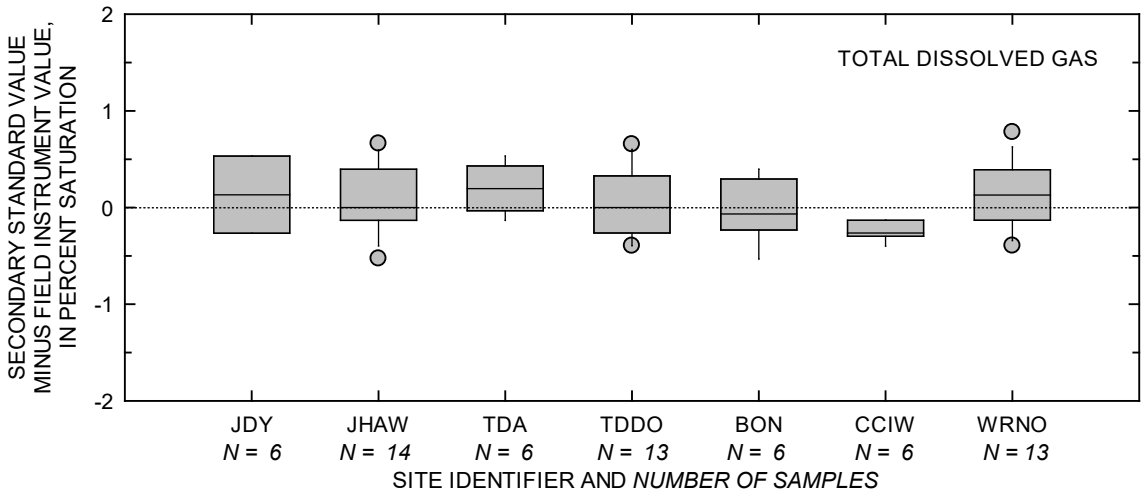


**Figure G-5.** Difference between the secondary standard and the field total-dissolved-gas instruments in the field after 3 or more weeks of deployment at seven stations in the lower Columbia River, Oregon and Washington, water year 2022. See figure G-2 for explanation of boxplots and table G-1 for definitions of station identifiers.

**Table G-4.** Summary of total-dissolved-gas side-by-side reference and field instrument comparisons, water year 2022.

| 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)** | | | | | | | | | | | | | | | |
| 4/19/2022 | 66363 | 65425 | 751.2 | 751 | 0.2 | 0.2 | 8.39 | 8.42 | -0.03 | 0.03 | 803 | 799 | 4 | 4 | 0.53 |
| 5/10/2022 | 66363 | 67480 | 758.0 | 758 | 0.0 | 0.0 | 11.24 | 11.22 | 0.02 | 0.02 | 810 | 810 | 0 | 0 | 0.00 |
| 5/31/2022 | 66363 | 65425 | 756.1 | 756 | 0.1 | 0.1 | 13.16 | 13.16 | 0.00 | 0.00 | 852 | 854 | -2 | 2 | -0.26 |
| 6/23/2022 | 66363 | 67480 | 755.5 | 755 | 0.5 | 0.5 | 14.17 | 14.19 | -0.02 | 0.02 | 912 | 910 | 2 | 2 | 0.26 |
| 7/14/2022 | 66363 | 65425 | 752.4 | 752 | 0.4 | 0.4 | 18.74 | 18.73 | 0.01 | 0.01 | 852 | 854 | -2 | 2 | -0.27 |
| 9/13/2022 | 66363 | 67480 | 748.4 | 748 | 0.4 | 0.4 | 21.55 | 21.56 | -0.01 | 0.01 | 757 | 753 | 4 | 4 | 0.53 |
| **Mean** | | | | | 0.27 | 0.27 | | | 0.00 | 0.01 | | | 1.0 | 2.3 | 0.13 |
| **Median** | | | | | 0.30 | 0.30 | | | 0.00 | 0.01 | | | 1.0 | 2.0 | 0.13 |
| **John Day tailwater (JHAW)** | | | | | | | | | | | | | | | |
| 10/13/2021 | 66363 | 67838 | 758.4 | 758 | 0.4 | 0.4 | 16.79 | 16.83 | -0.04 | 0.04 | 768 | 765 | 3 | 3 | 0.40 |
| 11/19/2021 | 66363 | 65426 | 760.3 | 760 | 0.3 | 0.3 | 11.41 | 11.40 | 0.01 | 0.01 | 840 | 844 | -4 | 4 | -0.53 |
| 12/14/2021 | 66363 | 67838 | 752.9 | 753 | -0.1 | 0.1 | 8.40 | 8.38 | 0.02 | 0.02 | 750 | 747 | 3 | 3 | 0.40 |
| 1/12/2022 | 66363 | 65426 | 763.5 | 764 | -0.5 | 0.5 | 2.82 | 2.77 | 0.05 | 0.05 | 760 | 760 | 0 | 0 | 0.00 |
| 2/1/2022 | 66363 | 67838 | 764.5 | 765 | -0.5 | 0.5 | 3.16 | 3.14 | 0.02 | 0.02 | 792 | 789 | 3 | 3 | 0.39 |
| 3/3/2022 | 66363 | 65426 | 757.8 | 758 | -0.2 | 0.2 | 3.39 | 3.40 | -0.01 | 0.01 | 773 | 774 | -1 | 1 | -0.13 |
| 3/29/2022 | 66363 | 67838 | 756.3 | 756 | 0.3 | 0.3 | 7.40 | 7.39 | 0.01 | 0.01 | 809 | 810 | -1 | 1 | -0.13 |
| 4/19/2022 | 66363 | 67857 | 753.7 | 754 | -0.3 | 0.3 | 8.55 | 8.52 | 0.03 | 0.03 | 864 | 859 | 5 | 5 | 0.66 |
| 5/10/2022 | 66363 | 67838 | 760.3 | 760 | 0.3 | 0.3 | 11.35 | 11.35 | 0.00 | 0.00 | 907 | 907 | 0 | 0 | 0.00 |
| 5/31/2022 | 66363 | 64961 | 757.7 | 758 | -0.3 | 0.3 | 13.27 | 13.27 | 0.00 | 0.00 | 883 | 885 | -2 | 2 | -0.26 |
| 6/23/2022 | 66363 | 67857 | 757.3 | 757 | 0.3 | 0.3 | 14.31 | 14.29 | 0.02 | 0.02 | 922 | 922 | 0 | 0 | 0.00 |
| 7/14/2022 | 66363 | 67838 | 753.6 | 754 | -0.4 | 0.4 | 18.89 | 18.86 | 0.03 | 0.03 | 882 | 882 | 0 | 0 | 0.00 |
| 9/13/2022 | 66363 | 67857 | 752.2 | 752 | 0.2 | 0.2 | 21.54 | 21.55 | -0.01 | 0.01 | 764 | 760 | 4 | 4 | 0.53 |
| 10/3/2022 | 66363 | 67838 | 757.2 | 757 | 0.2 | 0.2 | 19.38 | 19.36 | 0.02 | 0.02 | 767 | 767 | 0 | 0 | 0.00 |
| **Mean** | | | | | -0.02 | 0.31 | | | 0.01 | 0.02 | | | 0.7 | 1.9 | 0.09 |
| **Median** | | | | | 0.05 | 0.30 | | | 0.02 | 0.02 | | | 0.0 | 1.5 | 0.00 |

| Date | Reference sonde number. | Site sonde number | Barometric pressure (mmHg) | | | | Water 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)** | | | | | | | | | | | | | | | |
| 4/20/2022 | 66363 | 66624 | 753.4 | 753 | 0.4 | 0.4 | 8.60 | 8.58 | 0.02 | 0.02 | 846 | 847 | -1 | 1 | -0.13 |
| 5/11/2022 | 66363 | 65427 | 763.2 | 763 | 0.2 | 0.2 | 11.48 | 11.47 | 0.01 | 0.01 | 891 | 888 | 3 | 3 | 0.39 |
| 5/31/2022 | 66363 | 66624 | 759.1 | 759 | 0.1 | 0.1 | 13.18 | 13.20 | -0.02 | 0.02 | 933 | 933 | 0 | 0 | 0.00 |
| 6/23/2022 | 66363 | 65427 | 756.6 | 757 | -0.4 | 0.4 | 14.39 | 14.35 | 0.04 | 0.04 | 892 | 892 | 0 | 0 | 0.00 |
| 7/14/2022 | 66363 | 66624 | 756.5 | 757 | -0.5 | 0.5 | 18.67 | 18.64 | 0.03 | 0.03 | 841 | 838 | 3 | 3 | 0.40 |
| 9/13/2022 | 66363 | 65427 | 750.6 | 751 | -0.4 | 0.4 | 21.34 | 21.31 | 0.03 | 0.03 | 760 | 756 | 4 | 4 | 0.53 |
| **Mean** | | | | | -0.10 | 0.33 | | | 0.02 | 0.03 | | | 1.5 | 1.8 | 0.20 |
| **Median** | | | | | -0.15 | 0.40 | | | 0.03 | 0.03 | | | 1.5 | 2.0 | 0.20 |
| **The Dalles tailwater (TDDO)** | | | | | | | | | | | | | | | |
| 10/13/2021 | 66363 | 64596 | 761.1 | 762 | -0.9 | 0.9 | 16.26 | 16.27 | -0.01 | 0.01 | 765 | 762 | 3 | 3 | 0.39 |
| 11/19/2021 | 66363 | 64598 | 763.3 | 763 | 0.3 | 0.3 | 11.33 | 11.30 | 0.03 | 0.03 | 829 | 824 | 5 | 5 | 0.66 |
| 12/14/2021 | 66363 | 64596 | 754.9 | 755 | -0.1 | 0.1 | 8.53 | 8.53 | 0.00 | 0.00 | 767 | 767 | 0 | 0 | 0.00 |
| 1/12/2022 | 66363 | 64598 | 764.4 | 764 | 0.4 | 0.4 | 2.94 | 2.93 | 0.01 | 0.01 | 755 | 753 | 2 | 2 | 0.26 |
| 2/1/2022 | 66363 | 64596 | 765.9 | 766 | -0.1 | 0.1 | 3.39 | 3.36 | 0.03 | 0.03 | 786 | 782 | 4 | 4 | 0.52 |
| 3/3/2022 | 66363 | 64598 | 760.9 | 761 | -0.1 | 0.1 | 3.91 | 3.91 | 0.00 | 0.00 | 776 | 779 | -3 | 3 | -0.39 |
| 3/30/2022 | 66363 | 64596 | 763.9 | 764 | -0.1 | 0.1 | 7.79 | 7.79 | 0.00 | 0.00 | 801 | 804 | -3 | 3 | -0.39 |
| 4/19/2022 | 66363 | 64598 | 755.1 | 755 | 0.1 | 0.1 | 8.76 | 8.73 | 0.03 | 0.03 | 874 | 874 | 0 | 0 | 0.00 |
| 5/10/2022 | 66363 | 64596 | 762.8 | 763 | -0.2 | 0.2 | 11.54 | 11.54 | 0.00 | 0.00 | 889 | 891 | -2 | 2 | -0.26 |
| 5/31/2022 | 66363 | 64598 | 762.4 | 762 | 0.4 | 0.4 | 13.11 | 13.10 | 0.01 | 0.01 | 913 | 915 | -2 | 2 | -0.26 |
| 6/23/2022 | 66363 | 64596 | 757.9 | 758 | -0.1 | 0.1 | 14.40 | 14.41 | -0.01 | 0.01 | 933 | 934 | -1 | 1 | -0.13 |
| 7/14/2022 | 66363 | 64598 | 754.7 | 755 | -0.3 | 0.3 | 18.92 | 18.90 | 0.02 | 0.02 | 878 | 878 | 0 | 0 | 0.00 |
| 8/25/2022 | - | 64596 | - | - | - | - | - | - | - | - | - | 967 | - | - | - |
| 10/3/2022 | 66363 | 64598 | 761.3 | 761 | 0.3 | 0.3 | 19.36 | 19.35 | 0.01 | 0.01 | 781 | 779 | 2 | 2 | 0.26 |
| **Mean** | | | | | -0.03 | 0.26 | | | 0.01 | 0.01 | | | 0 | 2 | 0.05 |
| **Median** | | | | | -0.10 | 0.20 | | | 0.01 | 0.01 | | | 0.0 | 2.0 | 0.00 |

| 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)** | | | | | | | | | | | | | | | |
| 4/20/2022 | 66363 | 67837 | 753.3 | 753 | 0.3 | 0.3 | 8.72 | 8.72 | 0.00 | 0.00 | 848 | 852 | -4 | 4 | -0.53 |
| 5/11/2022 | 66363 | 66623 | 763.9 | 764 | -0.1 | 0.1 | 11.74 | 11.74 | 0.00 | 0.00 | 871 | 872 | -1 | 1 | -0.13 |
| 6/1/2022 | 66363 | 67837 | 759.0 | 759 | 0.0 | 0.0 | 13.37 | 13.37 | 0.00 | 0.00 | 915 | 916 | -1 | 1 | -0.13 |
| 6/22/2022 | 66363 | 66623 | 762.2 | 762 | 0.2 | 0.2 | 14.29 | 14.30 | -0.01 | 0.01 | 946 | 946 | 0 | 0 | 0.00 |
| 7/15/2022 | 66363 | 67837 | 760.7 | 745 | 15.7 | 15.7 | 19.05 | 19.03 | 0.02 | 0.02 | 849 | 847 | 2 | 2 | 0.26 |
| 9/14/2022 | 66363 | 48242 | 757.1 | 757 | 0.1 | 0.1 | 20.97 | 21.00 | -0.03 | 0.03 | 763 | 760 | 3 | 3 | 0.40 |
| **Mean** | | | | | 2.70 | 2.73 | | | 0.00 | 0.01 | | | -0.2 | 1.8 | -0.02 |
| **Median** | | | | | 0.15 | 0.15 | | | 0.00 | 0.01 | | | -0.5 | 1.5 | -0.07 |
| **Cascade Island (CCIW)** | | | | | | | | | | | | | | | |
| 4/20/2022 | 66363 | 64597 | 754.1 | 755 | -0.9 | 0.9 | 8.77 | 8.74 | 0.03 | 0.03 | 881 | 884 | -3 | 3 | -0.40 |
| 5/11/2022 | 66363 | 67858 | 766.3 | 766 | 0.3 | 0.3 | 11.60 | 11.60 | 0.00 | 0.00 | 923 | 924 | -1 | 1 | -0.13 |
| 6/1/2022 | 66363 | 64597 | 760.2 | 760 | 0.2 | 0.2 | 13.37 | 13.36 | 0.01 | 0.01 | 935 | 937 | -2 | 2 | -0.26 |
| 6/22/2022 | 66363 | 3022A | 763.4 | 764 | -0.6 | 0.6 | - | - | - | - | 945 | 946 | -1 | 1 | -0.13 |
| 7/15/2022 | 66363 | 67858 | 761.3 | 761 | 0.3 | 0.3 | 19.13 | 19.12 | 0.01 | 0.01 | 892 | 894 | -2 | 2 | -0.26 |
| 7/18/2022 | 66363 | 64597 | 765.0 | 765 | 0.0 | 0.0 | 18.95 | 18.94 | 0.01 | 0.01 | 891 | 1380 | - | - | - |
| 9/1/2022 | 66363 | 64961 | 757.8 | 758 | -0.2 | 0.2 | 22.30 | 22.28 | 0.02 | 0.02 | 810 | 812 | -2 | 2 | -0.26 |
| **Mean** | | | | | -0.13 | 0.36 | | | 0.01 | 0.01 | | | -1.8 | 1.8 | -0.24 |
| **Median** | | | | | 0.00 | 0.30 | | | 0.01 | 0.01 | | | -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 |
| **Warrendale (WRNO)** | | | | | | | | | | | | | | | |
| 10/14/2021 | 66363 | 67856 | 768.5 | 769 | -0.5 | 0.5 | 15.62 | 15.60 | 0.02 | 0.02 | 765 | 762 | 3 | 3 | 0.39 |
| 11/9/2021 | 66363 | 67855 | 761.6 | 762 | -0.4 | 0.4 | 12.35 | 12.36 | -0.01 | 0.01 | 775 | 776 | -1 | 1 | -0.13 |
| 12/8/2021 | 66363 | 67856 | 762.3 | 763 | -0.7 | 0.7 | 9.03 | 9.04 | -0.01 | 0.01 | 789 | 787 | 2 | 2 | 0.26 |
| 1/13/2022 | 66363 | 67855 | 767.6 | 768 | -0.4 | 0.4 | 3.09 | 3.09 | 0.00 | 0.00 | 762 | 756 | 6 | 6 | 0.78 |
| 2/1/2022 | 66363 | 67856 | 771.8 | 772 | -0.2 | 0.2 | 3.60 | 3.57 | 0.03 | 0.03 | 782 | 781 | 1 | 1 | 0.13 |
| 3/3/2022 | 66363 | 67855 | 765.8 | 766 | -0.2 | 0.2 | 4.21 | 4.22 | -0.01 | 0.01 | 795 | 792 | 3 | 3 | 0.39 |
| 3/30/2022 | 66363 | 67856 | 768.2 | 769 | -0.8 | 0.8 | 8.33 | 8.37 | -0.04 | 0.04 | 817 | 817 | 0 | 0 | 0.00 |
| 4/20/2022 | 66363 | 67855 | 754.5 | 755 | -0.5 | 0.5 | 8.80 | 8.81 | -0.01 | 0.01 | - | 889 | - | - | - |
| 5/4/2022 | 66363 | 67856 | 762.9 | 763 | -0.1 | 0.1 | 10.77 | 10.78 | -0.01 | 0.01 | 909 | 912 | -3 | 3 | -0.39 |
| 5/31/2022 | 66363 | 67855 | 765.8 | 766 | -0.2 | 0.2 | 13.20 | 13.21 | -0.01 | 0.01 | 901 | 902 | -1 | 1 | -0.13 |
| 6/22/2022 | 66363 | 67856 | 763.9 | 764 | -0.1 | 0.1 | 14.46 | 14.46 | 0.00 | 0.00 | 953 | 955 | -2 | 2 | -0.26 |
| 7/13/2022 | 66363 | 67855 | 761.5 | 762 | -0.5 | 0.5 | 19.22 | 19.23 | -0.01 | 0.01 | 873 | 870 | 3 | 3 | 0.39 |
| 9/14/2022 | 66363 | 67856 | 759.6 | 760 | -0.4 | 0.4 | 20.95 | 20.96 | -0.01 | 0.01 | 774 | 775 | -1 | 1 | -0.13 |
| 10/4/2022 | 66363 | 67855 | 763.5 | 764 | -0.5 | 0.5 | 19.14 | 19.13 | 0.01 | 0.01 | 789 | 786 | 3 | 3 | 0.39 |
| **Mean** | | | | | -0.39 | 0.39 | | | 0.00 | 0.01 | | | 1.0 | 2.2 | 0.13 |
| **Median** | | | | | -0.40 | 0.40 | | | -0.01 | 0.01 | | | 1.0 | 2.0 | 0.13 |

**Table G-5.** Summary of reference and site TDG sensor comparisons measured during lab calibrations, water year 2022.

| 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** | 65425 | 5/5/2022 | P | 751.7 | 1051.7 | 752 | 1052 | -0.04 | -0.04 | N | P |
| **JDY** | 67480 | 5/26/2022 | P | 753.2 | 1053.2 | 752 | 1052 | 0.16 | 0.16 | N | P |
| **JDY** | 65425 | 6/10/2022 | P | 756.5 | 1056.5 | 757 | 1057 | -0.07 | -0.07 | N | P |
| **JDY** | 67480 | 6/28/2022 | P | 760.9 | 1060.9 | 760 | 1059 | 0.12 | 0.25 | N | P |
| **JDY** | 65425 | 9/27/2022 | P | 755.0 | 1055.0 | 755 | 1055 | 0.00 | 0.00 | N | N/A |
| **JDY** | 67480 | 9/27/2022 | P | 755.0 | 1055.0 | 754 | 1054 | 0.13 | 0.13 | N | N/A |
| **JHAW** | 67838 | 10/24/2021 | P | 736.7 | 1036.7 | 735 | 1035 | 0.23 | 0.23 | N | P |
| **JHAW** | 65426 | 12/8/2021 | P | 757.9 | 1057.9 | 757 | 1056 | 0.12 | 0.25 | Y | P |
| **JHAW** | 67838 | 12/22/2021 | P | 748.2 | 1048.2 | 747 | 1047 | 0.16 | 0.16 | N | P |
| **JHAW** | 65426 | 1/28/2022 | P | 768.0 | 1068.0 | 768 | 1068 | 0.00 | 0.00 | N | P |
| **JHAW** | 67838 | 2/18/2022 | P | 769.2 | 1069.2 | 768 | 1067 | 0.16 | 0.29 | Y | P |
| **JHAW** | 67426 | 3/25/2022 | P | 762.5 | 1062.5 | 762 | 1062 | 0.07 | 0.07 | N | P |
| **JHAW** | 67838 | 4/18/2022 | P | 750.9 | 1050.9 | 751 | 1051 | -0.01 | -0.01 | N | P |
| **JHAW** | 67857 | 5/5/2022 | P | 751.6 | 1051.6 | 751 | 1051 | 0.08 | 0.08 | N | P |
| **JHAW** | 67838 | 5/26/2022 | P | 753.2 | 1053.2 | 753 | 1053 | 0.03 | 0.03 | N | P |
| **JHAW** | 64961 | 6/10/2022 | P | 756.7 | 1056.7 | 757 | 1056 | -0.04 | 0.09 | N | P |
| **JHAW** | 67857 | 6/28/2022 | P | 760.9 | 1060.9 | 761 | 1061 | -0.01 | -0.01 | N | P |
| **JHAW** | 67838 | 8/18/2022 | P | 755.1 | 1055.1 | 755 | 1055 | 0.01 | 0.01 | N | P |
| **JHAW** | 67857 | 9/27/2022 | P | 755.1 | 1055.1 | 755 | 1055 | 0.01 | 0.01 | N | P |
| **JHAW** | 67838 | 10/12/2022 | P | 761.9 | 1061.9 | 762 | 1062 | -0.01 | -0.01 | N | P |
| **TDA** | 66624 | 5/5/2022 | P | 751.5 | 1051.5 | 752 | 1051 | -0.07 | 0.07 | N | P |
| **TDA** | 65427 | 5/26/2022 | P | 753.2 | 1053.2 | 752 | 1052 | 0.16 | 0.16 | N | P |
| **TDA** | 66624 | 6/10/2022 | P | 756.5 | 1056.5 | 757 | 1057 | -0.07 | -0.07 | N | P |
| **TDA** | 65427 | 6/28/2022 | P | 760.9 | 1060.9 | 760 | 1060 | 0.12 | 0.12 | N | P |
| **TDA** | 66624 | 9/27/2022 | P | 755.0 | 1055.0 | 755 | 1055 | 0.00 | 0.00 | N | N/A |
| **TDA** | 65427 | 9/27/2022 | P | 755.1 | 1055.1 | 754 | 1054 | 0.15 | 0.15 | 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 | | |
| **TDDO** | 64596 | 10/24/2021 | P | 736.7 | 1036.7 | 736 | 1036 | 0.10 | 0.10 | N | P |
| **TDDO** | 64598 | 12/8/2021 | P | 758.0 | 1058.0 | 758 | 1058 | 0.00 | 0.00 | N | P |
| **TDDO** | 64596 | 12/22/2021 | P | 748.2 | 1048.2 | 747 | 1047 | 0.16 | 0.16 | N | P |
| **TDDO** | 64598 | 1/28/2022 | P | 768.0 | 1068.0 | 767 | 1067 | 0.13 | 0.13 | N | P |
| **TDDO** | 64596 | 2/18/2022 | P | 769.1 | 1069.1 | 768 | 1068 | 0.14 | 0.14 | N | P |
| **TDDO** | 64598 | 3/25/2022 | P | 762.5 | 1062.5 | 762 | 1062 | 0.07 | 0.07 | N | P |
| **TDDO** | 64596 | 4/18/2022 | F | 751.0 | 1051.0 | 750 | 1050 | 0.13 | 0.13 | N | P |
| **TDDO** | 64598 | 5/5/2022 | P | 751.4 | 1051.4 | 751 | 1051 | 0.05 | 0.05 | N | P |
| **TDDO** | 64596 | 5/26/2022 | P | 753.2 | 1053.2 | 752 | 1052 | 0.16 | 0.16 | N | P |
| **TDDO** | 64598 | 6/10/2022 | P | 756.5 | 1056.5 | 756 | 1056 | 0.07 | 0.07 | N | P |
| **TDDO** | 64596 | 6/28/2022 | P | 760.9 | 1060.9 | 760 | 1059 | 0.12 | 0.25 | N | P |
| **TDDO** | 64598 | 8/18/2022 | P | 755.2 | 1055.2 | 754 | 1054 | 0.16 | 0.16 | N | P |
| **TDDO** | 64596 | 9/27/2022 | F | 755.0 | 1055.0 | 754 | 1054 | 0.13 | 0.13 | N | P |
| **TDDO** | 64598 | 10/12/2022 | P | 761.9 | 1061.9 | 761 | 1061 | 0.12 | 0.12 | N | P |
| **BON** | 67837 | 5/5/2022 | P | 751.5 | 1051.5 | 751 | 1052 | 0.07 | -0.07 | N | P |
| **BON** | 66623 | 5/26/2022 | P | 753.5 | 1053.5 | 753 | 1053 | 0.07 | 0.07 | N | P |
| **BON** | 67837 | 6/10/2022 | P | 756.7 | 1056.7 | 756 | 1057 | 0.09 | -0.04 | N | P |
| **BON** | 66623 | - | - | - | - | - | - | - | - | - | - |
| **BON** | 67837 | 9/27/2022 | P | 755.0 | 1055.0 | 754 | 1055 | 0.13 | 0.00 | N | N/A |
| **BON** | 48242 | 9/27/2022 | P | 755.0 | 1055.0 | 753 | 1054 | 0.26 | 0.13 | N | N/A |
| **CCIW** | 64597 | 5/5/2022 | P | 751.5 | 1051.5 | 751 | 1052 | 0.07 | -0.07 | N | P |
| **CCIW** | 67858 | 5/26/2022 | P | 753.2 | 1053.2 | 753 | 1052 | 0.03 | 0.16 | N | P |
| **CCIW** | 64597 | 6/10/2022 | P | 756.7 | 1056.7 | 757 | 1057 | -0.04 | -0.04 | N | P |
| **CCIW** | 3022A | 6/28/2022 | P | 760.7 | 1060.7 | 761 | 1061 | -0.04 | -0.04 | N | P |
| **CCIW** | 67858 | 9/27/2022 | P | 755.0 | 1055.0 | 754 | 1054 | 0.13 | 0.13 | N | N/A |
| **CCIW** | 64597 | 8/18/2022 | F | 755.2 | 1055.2 | 755 | 1055 | 0.03 | 0.03 | N | P |
| **CCIW** | 64961 | 9/27/2022 | F | 755.0 | 1055.0 | 755 | 1054 | 0.00 | 0.13 | 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 | | |
| **WRNO** | 67856 | 10/24/2021 | P | 736.8 | 1036.8 | 736 | 1036 | 0.11 | 0.11 | N | P |
| **WRNO** | 67855 | 12/8/2021 | P | 758.1 | 1058.1 | 758 | 1058 | 0.01 | 0.01 | N | P |
| **WRNO** | 67856 | 12/22/2021 | P | 748.1 | 1048.1 | 747 | 1047 | 0.15 | 0.15 | N | P |
| **WRNO** | 67855 | 1/28/2022 | P | 768.0 | 1068.0 | 768 | 1068 | 0.00 | 0.00 | N | P |
| **WRNO** | 67856 | 2/18/2022 | P | 769.1 | 1069.1 | 768 | 1068 | 0.14 | 0.14 | N | P |
| **WRNO** | 67855 | 3/25/2022 | P | 760.2 | 1060.2 | 760 | 1059 | 0.03 | 0.16 | N | P |
| **WRNO** | 67856 | 4/18/2022 | P | 751.1 | 1051.1 | 750 | 1049 | 0.15 | 0.28 | Y | P |
| **WRNO** | 67855 | 5/4/2022 | P | 759.4 | 1059.4 | 759 | 1059 | 0.05 | 0.05 | N | P |
| **WRNO** | 67856 | 5/26/2022 | P | 753.2 | 1053.2 | 753 | 1054 | 0.03 | -0.11 | N | P |
| **WRNO** | 67855 | 6/10/2022 | P | 756.7 | 1056.7 | 756 | 1056 | 0.09 | 0.09 | N | P |
| **WRNO** | 67856 | 6/28/2022 | P | 760.8 | 1060.8 | 761 | 1061 | -0.03 | -0.03 | N | P |
| **WRNO** | 67855 | 8/18/2022 | P | 755.0 | 1055.0 | 755 | 1055 | 0.00 | 0.00 | N | N/A |
| **WRNO** | 67856 | 9/27/2022 | P | 755.0 | 1055.0 | 755 | 1055 | 0.00 | 0.00 | N | P |
| **WRNO** | 67855 | 10/12/2022 | P | 761.8 | 1061.8 | 761 | 1061 | 0.11 | 0.11 | N | P |