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Technical Support Document

Evaluation to Identify Potential ISD Report Options for Characterizing UST Ullage Pressure Data

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EXECUTIVE SUMMARY

CARB staff analysis found that in-station diagnostic (ISD) system overpressure alarms are not effective at detecting repairable vapor recovery equipment malfunctions at gasoline dispensing facilities (GDFs) and, therefore, do not accomplish the purpose of ISD alarms envisioned when CARB adopted the Enhanced Vapor Recovery (EVR) regulations [CARB, 2020f]. Further, CARB staff evaluations indicate pressure driven emissions (PDE) do not significantly impact regional and statewide efforts to attain air quality standards for ozone [CARB, 2020d]. Even so, there is an ongoing need to identify GDFs that might have elevated PDE for long periods using cost-effective methods. This Technical Support Document provides an evaluation designed to identify potential ISD system report options that can be used to identify which GDFs might have elevated PDE, and that can be implemented by software changes on existing ISD equipment.

CARB staff evaluated GDF underground storage tank (UST) headspace (ullage) 30-hour (short-term conditions), 2-week, and monthly pressure data periods (long-term conditions). The findings indicate the majority of GDFs throughout California have ISD systems that do not store enough pressure data to adequately characterize long-term conditions at a given GDF. More than 90 percent of California GDFs have ISD systems that save only 30 hours of pressure data. However, the findings indicate that 30 hours of pressure data cannot characterize long-term conditions due to the variability in the daily pressures at a given GDF. This finding is not a surprise because several processes can cause short-term pressure increases that are not associated with equipment malfunctions, including but not limited to:

- The delivery of fuel can cause a short-term pressure excursion that may be related to differences in fuel properties between the delivered fuel and the fuel already in the UST. Pressure excursions also can result from faulty Phase I components on the delivery vehicle or a failure of the operator to follow standard operating procedures.
- Variations in traffic patterns and GDF operating hours throughout the week.
- Customer behavior during refueling operations.

Simple enhancements to the currently certified ISD software would improve the ability to identify GDFs that might have prolonged periods of elevated UST ullage pressure and associated pressure driven emissions. Staff recommends the following amendments to CARB's certification procedure CP-201[1] requirements for ullage pressure vapor containment monitoring and reporting:

[1] CP-201: Vapor Recovery Certification Procedure CP – 201: Certification Procedure for Vapor Recovery Systems at Gasoline Dispensing Facilities [CARB, 2019a].

- Require GDF vapor recovery ISD systems to store and make available for download, at a minimum, the 14 most recent days of UST ullage pressure and UST ullage volume data.
- Require GDF vapor recovery ISD systems to calculate the percentage of UST ullage pressure data in different pressure ranges as defined below and generate a monthly ullage pressure data report available for download in the following format:

UST ullage pressure ≤ 0.00 inches H2O[2]	__%
0.00 inches H2O < UST ullage pressure	__%
0.00 inches H2O < UST ullage pressure ≤ 0.30 inches H2O	__%
0.30 inches H2O < UST ullage pressure ≤ 1.30 inches H2O	__%
1.30 inches H2O < UST ullage pressure ≤ 2.50 inches H2O	__%
UST ullage pressure > 2.50 inches H2O	__%

- Require the ISD system to maintain an electronic archive of the monthly ullage pressure data report for a period of at least 12 months.

Given the variability observed in daily pressure data, these amendments would provide several benefits to GDF operators, service contractors, CARB, and Air Districts:

- Easily accessible monthly pressure reports with long-term data would help service contractors conduct more effective trouble shooting to identify equipment problems (e.g., vapor leaks and inoperable vapor processors) and their causes. The additional data and reports could reduce the need for multiple site visits and time-consuming pressure data analysis. Reducing time needed for site visits and data analysis would reduce costs for GDF operators.
- Storage of two weeks of pressure data would reduce the number of site visits, and therefore costs, for future studies. Currently, to obtain adequate pressure data to characterize long-term conditions at GDFs with ISD systems that store only 30 hours of pressure data, Air Districts and CARB staff must either conduct daily site visits for several weeks to download 30 hours of pressure data per visit, or install a computer with proprietary software to store longer periods of data and conduct site visits approximately every 14 days.

There are currently two CARB-certified ISD systems, and one already saves two weeks of pressure data. CARB staff seeks to adopt uniform standards for all certified systems,

[2] Inches water column gauge is expressed as “inches H2O” in CARB’s vapor recovery certification and test procedures, many of which were first published decades ago, and as ”WCG in more recent technical documents, because in certain cases it is important to distinguish between gauge pressure and absolute pressure. Absolute pressure is the sum of gauge pressure and barometric pressure.

when possible, and the benefits of additional pressure data would identify only those GDFs where additional mitigation measures may be necessary to protect public health.

In addition, both ISD systems currently provide reports with weekly and monthly pressure summaries to compare to the two overpressure alarm criteria currently required by CP-201. The monthly percentage calculations used to generate the current ISD summaries are similar to the pressure percentage calculations needed to generate the above ISD report proposed by CARB staff. This demonstrates the feasibility of ISD systems to generate and store the proposed pressure report.

Both ISD system manufacturers have informed CARB staff that the manufacturers can modify the ISD software to provide two weeks of pressure data and the proposed pressure report using the certified ISD systems already installed at the GDFs.

I. BACKGROUND

CARB certification procedure CP-201 [CARB, 2019a] requires GDFs that dispense more than 600,000 gallons per year to be equipped with an ISD system. CARB first approved ISD requirements in March 2000 as part of the Enhanced Vapor Recovery (EVR) regulations for GDFs equipped with USTs. ISD requirements were fully implemented throughout the state by 2010. The ISD system is comprised of various hardware components, sensors, and software. The ISD system continuously monitors the collection and containment of gasoline vapors within the UST and issues warning and failure alarms when the thresholds specified in Section 9 of CP-201 are exceeded. The intention of the alarms envisioned when the Board adopted the EVR regulations was to provide an early indicator of vapor recovery equipment malfunctions that need repair so that GDF operators can maintain higher in-use effectiveness of vapor recovery systems.

Among the parameters monitored by ISD is the pressure within the headspace or ullage of the UST. CARB certification procedures do not have requirements for the amount of pressure data that must be stored by ISD. There are currently two CARB-certified ISD systems. The INCON ISD system saves pressure data every minute for a 2-week period while the Veeder-Root ISD system saves pressure data every 20 seconds for a 30-hour period. The Veeder-Root ISD system is installed at more than 90 percent of GDFs throughout California. To obtain 2 weeks of pressure data at these GDFs, Air Districts and CARB staff must either conduct daily site visits to download 30 hours of pressure data per visit or install and maintain a computer with proprietary software that is connected to the ISD console.

Although CARB certification procedures do not have requirements for the amount of saved pressure data, the certification procedures do require that, if the pressure within the UST ullage exceeds a certain threshold, ISD triggers an overpressure warning alarm that notifies the GDF operator of a potential vapor recovery system problem that may require maintenance. CARB certification procedure CP-201 requires ISD to have two overpressure alarm criteria:

1. Malfunction Criteria – Gross Failure
   The GDF vapor recovery ISD system shall assess, on a weekly basis, when the UST ullage pressure exceeds 1.5 inches water column gauge ("WCG) for at least 5% of the time, shall activate a warning alarm, and shall record the event.
2. Malfunction Criteria – Degradation
   The GDF vapor recovery ISD system shall assess, on a monthly basis, when the UST ullage pressure exceeds 0.50"WCG for at least 25% of the time, shall activate a warning alarm, and shall record the event.

When an ISD OP alarm is triggered, the GDF operator will typically call/schedule a contractor for troubleshooting and repair service. When responding to the ISD OP alarm, the contractor conducts recommended testing and troubleshooting per the ISD Installation, Operation, and Maintenance Manuals contained within CARB Executive Order VR-202 [CARB, 2019b] or VR-204 [CARB, 2018]. If the GDF operator ignores an ISD warning alarm and the OP condition persists, an ISD failure alarm is triggered, leading to a shutdown of GDF dispensing operations. ISD systems also have warning and failure alarms for vapor collection and leaks and these alarms are effective at detecting vapor recovery equipment problems. In this staff report, only ISD OP criteria will be evaluated.

Over the past eleven years, CARB staff has studied the increase in ISD OP alarms at GDFs equipped with Phase II EVR systems. ISD OP alarms are caused by gasoline evaporation rates that generate vapor volumes that cannot be contained within the UST vapor space and exceed the capacity of the vapor processor used to manage UST pressure. The majority of ISD OP alarms are triggered by the ISD system during the winter fuel period (November through February). During winter, gasoline is not required to comply with a Reid Vapor Pressure specification (RVP 7) that CARB enforces during the summer fuel season [CARB, 2017c and 2017d]. CARB staff have concluded that higher fuel volatility (not vapor recovery equipment malfunctions) is the primary driver for the increase in ISD OP alarms observed during winter months [CARB, 2017c and 2017d].

CARB staff analysis found that the ISD OP alarms are not effective at detecting vapor recovery equipment malfunctions and therefore do not accomplish the purpose of ISD alarms envisioned when CARB adopted the EVR regulations [CARB, 2020f]. Further, even though the pressure driven emissions can vary substantially from one GDF to the next, pressure driven emissions do not significantly impact regional and statewide efforts to attain air quality standards for ozone [CARB, 2020b and 2020d].

There are other uses for UST ullage pressure data, including but not limited to the following:

- Pressure data can be used to identify sites that exhibit prolonged pressure excursions leading to increased pressure driven emissions.
- Pressure data can be used to evaluate trends in GDF pressure driven emissions. For example, the magnitude of PDE is expected to decrease with implementation of recently adopted regulations to improve the compatibility between GDF nozzle spout and bellows dimensions and newer motor vehicle fill pipes, increases in the population of vehicles equipped with on board refueling vapor recovery (ORVR) systems, and reductions in gasoline consumption [CARB, 2018b]. CARB staff plans to conduct future statewide ISD surveys (Blitzes) to assess whether the magnitude of PDE decreases as predicted.
- Pressure data can be used as one of several parameters to conduct certification renewal evaluations of Phase II Enhanced Vapor Recovery systems. Renewal evaluations are conducted once every four years and if system deficiencies are found, they must be resolved to the satisfaction of the CARB Executive Officer.
- Pressure data could be used to evaluate site-specific pressure driven emission factors needed to support GDF permitting requirements.

However, to accomplish these uses, ISD systems need to store enough pressure data to adequately characterize longer-term conditions at a given GDF.

The objective of this evaluation is to identify potential ISD pressure report alternatives that can be used to identify GDFs that are likely to have significantly elevated pressure driven emissions.

II. METHODOLOGY AND RESULTS

A. Data Collection

Between 2013 and 2018, CARB staff conducted two types of monitoring that resulted in the collection of extensive UST ullage pressure data sets:

- Periodic, short-term “Mega Blitz” (Blitz) monitoring at numerous GDFs with vacuum assist and balance Phase II EVR vapor recovery systems (“assist GDFs” and “balance GDFs”, respectively); and
- Long-term monitoring at a smaller number of assist and balance GDFs.

<u>Short-term “Mega Blitzes” (Blitz)</u>: ISD system monitoring data, including UST ullage pressure data, were downloaded during the first two weeks of October 2013, December 2013, February 2014, December 2015, and December 2018. About 95 percent of GDFs monitored by the Blitz events had Veeder-Root ISD systems that save 30 hours of pressure data. A recent survey of Air Districts similarly found that approximately 93 percent of GDFs statewide have Veeder-Root ISD systems [CARB, 2020e]. For the remaining Blitz GDFs with INCON ISD systems, CARB staff downloaded two weeks of pressure data.

Each Blitz monitoring event included 77 to 108 balance GDFs and 168 to 272 assist GDFs. For the Blitz monitoring events, CARB selected GDFs with a variety of operating characteristics within defined geographic regions that collectively account for approximately 95 percent of the GDFs in California. CARB staff designed the site selection approach to produce monitoring data that can provide a relatively instantaneous "snapshot" of pressure conditions at the GDFs that, collectively, are representative of regional and statewide GDF operating conditions. CARB staff conducted Blitz monitoring in October 2013 to characterize conditions before high-RVP (wintertime) gasoline is sold. CARB staff conducted Blitz monitoring in December 2013 and February 2014 because prior monitoring indicated overpressure conditions are more prevalent when stored gasoline volatility reaches a maximum in December before declining through the remainder of the winter season [CARB, 2017b]. CARB staff conducted additional Blitz monitoring in December 2015 and December 2018 to evaluate long-term trends for the month that typically experiences the highest frequency of overpressure conditions.

Long-term Study (LTS): CARB staff downloaded nearly continuous ISD system monitoring data between 2016 and 2018 from a smaller sample of balance equipped GDFs. The pressure data from this compilation can be used to evaluate short-term (24 hour/daily) and long-term pressure characteristics at each study site. In addition, CARB staff installed equipment at the LTS sites that enabled the collection of data to support calculation of site-specific emission factors. Separate CARB staff technical documents provide descriptions of the monitoring efforts and emission factor calculation methods [CARB, 2020a-c and g]. CARB staff also evaluated a smaller sample of assist equipped GDFs during an earlier phase of this study, but the data for those GDFs was not needed for this evaluation.

B. Evaluation Methods and Results

CARB staff used both qualitative and quantitative methods to assess options for ISD pressure reports for assist and balance GDFs. CARB staff used different methods for balance GDFs compared to assist GDFs because of the differences in the processes that affect their UST ullage pressure and pressure driven emissions:

Factor	Assist	Balance
Nozzle emission factor at pressure	not applicable	✓
Nozzle emission factor at vacuum	not applicable	✓
Fugitive/vent line emissions	✓	✓

Factor	Assist	Balance
PWD [(a)]	✓	not applicable
RIFE [(b)]	not applicable	✓
VDAPP [(c)]	not applicable	✓
Throughput	✓	✓
Distribution of different nozzle makes and models	✓	✓

(a) PWD: Pressure increase while dispensing

(b) RIFE: Reverse idle flow emissions, the volume of gasoline vapor that is vented from idle (no fuel dispensing) nozzles when the nozzle is left out of the dispenser with the vapor check valve held open.

(c) VDAPP: Percent volume dispensed at positive pressure

Detailed descriptions of the above parameters affecting pressure driven emissions are provided in other Technical Support Documents.[3]

All tables and figures mentioned in the following sections are located after the References (Section IV).

1. Balance GDFs

a. Comparison of Short- and Long-Term VDAPPs

CARB staff used the available short-term Blitz and Long-Term Study pressure data to calculate the percent of volume dispensed at positive pressure (VDAPP) for each balance GDF. VDAPP is one of two key parameters needed to estimate site-specific pressure driven emission factors (PDEF). CARB staff's Technical Support Document VR-OP-B2 [CARB, 2020a] provides a detailed description of the data sets and methods used to calculate VDAPP values for balance GDFs monitored during the Blitz events and the Long-Term Study.

The second key parameter is the volume of gasoline vapor that is vented from idle (no fuel dispensing) nozzles when the nozzle is left out of the dispenser with the vapor check valve held open, typically referred to as "reverse idle flow emissions" or RIFE. The Blitz ISD system monitoring data enable the calculation of VDAPP but not RIFE. As described in Technical Support Document VR-OP-B2 [CARB, 2020a], the ISD console does not store enough vapor flow meter totalizer data to produce a representative RIFE value. Therefore, RIFE was not included in this evaluation.

Of the 27 LTS GDFs with balance Phase II EVR systems, 16 were included in one or more of the Blitz monitoring events. Several of the LTS sites were monitored in multiple years. For the GDFs monitored during the Blitz events, CARB staff could calculate

[3] Citations: CARB, 2017a, 2017b, 2017c, 2020a, 2020b, 2020c, and 2020g. Section IV References provides the full citations.

short-term (30-hour) VDAPP values. For comparison to the Blitz VDAPPs, CARB staff calculated short-term (24hour, "daily") VDAPP values for the LTS GDFs during the first two weeks of December 2016 and 2017, February 2017 and 2018, and October 2016, 2017, and 2018. CARB staff also calculated site-specific two-week averages of the LTS daily VDAPPs ("long-term VDAPPs"). Table 1 provides the two-week LTS site-specific average VDAPPs and 30-hour Blitz VDAPPs. Spreadsheets of LTS daily VDAPPs are too large to include in this document; a Microsoft Excel file with the spreadsheets is available upon request.

Figure 1 provides regression graphs that compare the December, February, and October Blitz VDAPPs to the long-term LTS VDAPPs for December 2017, February 2018, and October 2018, respectively. As shown in Table 1, none of the Blitz monitoring events included 11 of the LTS sites: sites 4, 12, 13, 14, 18, 19, 21, 22, 24, 25, and 27. Consequently, there are not enough LTS sites with both Blitz and LTS data to regress Blitz VDAPPs against two-week average LTS VDAPPs calculated for December 2016, February 2017, and October 2016 and 2017. Table 2 summarizes the regression results.

Figures 2, 3, and 4 provide plots that compare the short-term Blitz and short- and long-term LTS VDAPPs by GDF, for December, February, and October, respectively.

The comparisons illustrated in Figures 1 through 4 show several patterns relevant for this evaluation:

- Short-term Blitz VDAPPs may be generally predictive of long-term LTS VDAPPs, as evidenced by the statistically significant correlations ($p \leq 0.05$, two-tailed) for four of the five regressions shown in Figure 1.
- Short-term (30-hour) Blitz VDAPPs typically fall within the range of the LTS daily VDAPPs at a given GDF, even though Blitz monitoring occurred in different years from the LTS (Figures 2–4). However, LTS daily VDAPPs at a given GDF can have an extensive range within a two-week period, and even GDFs with generally low VDAPPs can have the occasional elevated daily VDAPP.
- Some Blitz VDAPPs are more than twice the long-term (two-week average) LTS VDAPPs for a given GDF, and others are less than half the long-term LTS VDAPPs. This finding is not surprising given the range in daily LTS VDAPPs observed at each site. However, it indicates we cannot rely on a single 30-hour VDAPP calculation to characterize long-term conditions at a site. In contrast, two-week average VDAPPs vary little from year to year at a given site.

These findings indicate that two-week average VDAPPs are more representative of long-term pressure conditions at a given balance GDF than any single short-term (30-hour) VDAPP value. Short-term Blitz VDAPPs are generally predictive of long-term LTS VDAPPs at a given balance GDF relative to other GDFs, but any single short-term VDAPP could substantially under- or over-estimate long-term VDAPPs.

This finding is not a surprise because several processes can cause short-term pressure increases that are not associated with equipment malfunctions, including but not limited to:

- The delivery of fuel can cause a short-term pressure excursion that may be related to differences in fuel properties between the delivered fuel and the fuel already in the UST. Pressure excursions also can result from faulty Phase I components on the delivery vehicle or a failure of the operator to follow standard operating procedures.
- Variations in traffic patterns and GDF operating hours throughout the week.
- Customer behavior during refueling operations.

b. Comparison of Pressure Profiles and Percentiles to Site-Specific Emission Factors

To further assess options for ISD pressure reports for balance GDFs, CARB staff compared site-specific, pressure driven emission factors for Long-Term Study sites to the following using X-Y (regression) graphs:

- Percentage of UST ullage pressure data during the (a) first week of December, (b) first two weeks of December, and (c) entire month of December, in the following pressure ranges ("pressure profiles"):
    A. UST ullage pressure ≤ 0.00"WCG
    B. 0.00"WCG < UST ullage pressure
    C. 0.00"WCG < UST ullage pressure ≤ 0.30"WCG
    D. 0.30 inches H2O < UST ullage pressure ≤ 1.30"WCG
    E. 1.30 inches H2O < UST ullage pressure ≤ 2.50"WCG
    F. UST ullage pressure > 2.50"WCG

    Pressure ranges A and B are useful because they provide the percentage of pressure data that is negative and positive, which allows quick determination of whether UST ullage has experienced long-term positive pressure. Pressure ranges C through F are subsets of range B. Pressure range C can be used to identify balance GDFs that may be exhibiting high VDAPP [CARB, 2017c]. Pressure ranges D and E can identify GDFs that may have significant fugitive emissions and range F can be used to evaluate whether there may be significant emissions from the vent line pressure relief valve. Fugitive and vent line emissions are possible with both balance and assist vapor recovery systems; however, significant fugitive and vent line emissions during fuel dispensing operations have been observed mainly at assist sites exhibiting 'pressure increase while dispensing' (PWD) (see Section II.B.2) [CARB, 2017b].

- December “DGRD 75%" pressure values downloaded in ISD reports, which ISD systems calculate and store for comparison to CP-201’s “degradation” overpressure alarm criterion (see Section I).
- December monthly percentiles of pressure data downloaded and compiled by CARB staff.

The purpose of the regressions is to identify which type of pressure calculation best predicts GDF-specific monthly pressure driven emissions factors, and therefore would be a useful tool to include in the ISD software to identify GDFs that may have elevated pressure driven emissions. All comparisons are based on December data because UST ullage pressures, associated overpressure alarms, VDAPP values, and pressure driven emissions tend to peak in December [CARB, 2020a and 2020g]. In other words, if a GDF were to ever have prolonged elevated UST ullage pressure, elevated pressure would likely occur in December. Separate CARB staff technical documents provide descriptions of the data sets and methods used to calculate December pressure driven emission factors for each of the Long-Term Study sites [CARB, 2020a and 2020b].

Currently, there are two Phase II EVR nozzle models certified and available for use at balance GDFs in California, one manufactured by Vapor Systems Technologies, Inc. (VST) and the second by Emco Wheaton Retail (EMCO). These balance nozzles may be combined with a variety of hose, vapor processor, and ISD system options to form a complete Phase II system. Only approximately 8 percent of annual California gasoline throughput is dispensed through EMCO nozzles [CARB, 2020g]. To evaluate whether nozzle model might affect the evaluation, CARB staff evaluated separate regressions for (a) all balance GDF study sites and (b) balance GDF study sites that had only or mostly VST nozzles installed. Not enough GDFs had EMCO nozzles installed to enable EMCO-specific regressions. Of the 26 study sites, 21 GDFs had the VST nozzle, 2 GDFs had a mix of VST and EMCO nozzles, and 3 GDFs had primarily the EMCO nozzle installed.

The Long-Term Study spanned multiple years, but not every GDF was monitored in each year. More GDFs were monitored in December 2017 than 2016, and the GDFs monitored in December 2017 had a broader range of VDAPP values that better represent statewide conditions [CARB, 2020a]. Consequently, this evaluation includes pressure data and PDEF estimates for December 2017 for all GDFs except those that were monitored only in 2016. Table 3 describes the monitoring periods assessed for each GDF. Spreadsheets of the raw pressure data downloaded from the GDF ISD systems, and the calculated pressure profiles, percentile pressures, and pressure driven emission estimates that are regressed in Figures 5 through 10, are too large to include in this attachment. Microsoft Excel files with the spreadsheets are available upon request.

Table 4 provides a summary of the regression results presented in Figures 5 through 10. The figures and regression results indicate several traits relevant for this evaluation:

- Pressure profiles:
  - The three types of pressure profiles – based on one week, two weeks, and entire month of pressure data – each have at least three pressure ranges that are significantly correlated ($p<0.05$, two-tailed) with PDEFs. This indicates each type of profile has at least some capability to predict long-term (monthly) pressure driven emissions.
  - Two weeks of pressure data are better than just one week for predicting monthly PDEFs, but not as good as a full month. More ranges of the monthly pressure profiles are significantly correlated with PDEFs, and the correlations are stronger, than the pressure profiles based on one and two weeks of pressure data, as evidenced by the higher R values and lower p values (Table 4) for the correlations with monthly pressure profiles.
  - The monthly pressure percentage for the **0.0"WCG < UST pressure ≤ 0.3"WCG** range had the strongest correlation with PDEF for all three pressure profile types (one week, two weeks, and full month), which indicates this pressure range may be particularly useful for identifying a GDF that may have elevated VDAPP, which leads to excess pressure driven emissions.
  - Regressions that excluded GDFs with EMCO nozzles have stronger correlations between the pressure profiles and PDEFs (Table 4.C). In addition, as shown on Figure 7, the 3 GDFs with EMCO nozzles plot higher on the regression charts (have relatively higher PDEFs) than GDFs with VST nozzles and GDFs with a mix of VST and EMCO, and therefore should have a regression separate from GDFs with VST nozzles. However, there are not enough study sites with EMCO nozzles to develop a regression.
- ISD report “DGRD 75%” and pressure percentiles:
  - ISD monthly report DGRD 75% values are significantly correlated to PDEFs even though they have only one decimal place.
  - The monthly 75th percentiles and ISD report's DGRD 75% values have an even stronger correlation with monthly PDEFs than the pressure profiles based on one and two weeks of pressure data, and less strong then monthly pressure profiles.

These results indicate improving the ISD pressure reports to include the percentages of UST ullage pressure data in different pressure ranges could be a cost effective way to better characterize long-term pressure conditions at a given GDF (compared to requiring all GDFs to install new equipment to enable the ISD systems to generate site-specific emission factors). More detailed pressure reports would provide the type of information CARB needs to evaluate future trends and to assess whether the magnitude of overpressure conditions decrease as predicted for implementation of recently adopted regulations.

Even so, there is substantial variability in site-specific conditions between sites. For example, the regression between the monthly pressure percentages for the **0.0"WCG < UST pressure** range (Table 4.B, VST & mixed VST/EMCO only) and PDEFs has the strongest correlation ($R=0.9086$, $p<0.001$, two-tailed). Study sites with pressure percentages less than 15 percent have PDEFs with very little variability, a range of about 0.1 lbs/kgal (0.3 to 0.4 lbs/kgal, Figure 7.B). However, study sites with pressure percentages in the range of 19 to 22 percent have PDEFs with double that range (0.37 to 0.57 lbs/kgal).

Consequently, CARB staff recommends that improved ISD pressure reports should be used only as a screening tool to identify GDFs that may warrant further investigation. Further investigation may include vapor recovery equipment troubleshooting and repair to establish baseline operating conditions and the installation of continuous monitoring equipment to more accurately measure site specific pressure driven emissions over a longer time frame.

CARB staff further evaluated the 75^{th} percentile pressure values, which had the strongest correlation with PDEF, to determine the effect of reducing the number of decimal places. The regressions illustrated in Figure 9 are based on percentile values that were not rounded. However, the regressions illustrated in Figure 8 are based on ISD Report “DGRD 75%" pressure values that the ISD system truncates to one decimal place. As illustrated in Figure 10 and Table 4, the correlations between the 75^{th} percentile pressure values and PDEFs are all statistically significant regardless of the number of decimal places. There is virtually no difference in correlation significance of the unrounded 75^{th} percentiles and 75^{th} percentiles rounded to two or three decimal places. The correlation between the 75^{th} percentiles rounded to one decimal place and PDEFs (Figure 10.D) is statistically significant but relatively lower. Further, Figure 10.D indicates that although the 75^{th} percentile pressure is generally a good predictor of PDEFs, the confidence in the prediction is poor for 75^{th} percentile pressures greater than zero, given the broad range of PDEFs (0.45 to 0.75 lbs/kgal) that plot at 0.1”WCG on the graph. The same type of variability is observed in the graphs for 75^{th} percentiles with more decimal places, but the variability is less. As a result, CARB recommends that if the ISD systems continue to provide “DGRD 75%" or add more percentile pressure calculations, those calculations should be provided with at least two decimal places.

2. Assist GDFs

As noted earlier, the majority of GDFs included in the December 2018 Blitz were equipped with Veeder-Root ISD systems that store only 30 hours of pressure data. Fifteen of the assist GDFs had INCON ISD systems that store two weeks of pressure data; all these GDFs are in the greater San Diego region. CARB staff evaluated pressure data collected from these 15 sites to determine whether 30-hour pressure data stored by ISD systems at assist GDFs is useful for predicting longer-term pressure conditions. Staff compared the prevalence of GDFs exhibiting ‘pressure increase while dispensing’ (PWD) based on 30 hours of pressure data to the prevalence of PWD based on 2 weeks of pressure data. PWD is a key parameter for estimating the magnitude of pressure driven emissions. CARB staff’s Technical Support Document VR-OP-G3 [CARB, 2020g] provides a detailed description of the data sets and methods used to calculate %PWD values for assist GDFs monitored during the Blitz.

Table 5 provides the percentage of pressure records above 1.30 inches water column (“WCG) for each site for (a) the entire 2 weeks and (b) the final 30 hours of the 2-week monitoring period. For a GDF to be designated as PWD, at least 20 percent of the 30-hour or 2-week ullage pressure data must exceed 1.30 “WCG, the alarm criterion used by the ISD manufacturers to set a weekly OP alarm.

The regression graph provided in Figure 11 indicates that the percentage of pressure records above 1.30“WCG based on 30 hours of data may be generally predictive of the percentage based on 2 weeks of pressure data, as evidenced by the statistically significant correlation ($p \leq 0.001$, two-tailed).

Even so, Figure 11 also illustrates the substantial variability in site-specific conditions between sites. For example:

- Study sites with 30-hour pressure percentages in the 40 to 50 percent range have 2-week pressure percentages that span 12 to 40 percent.
- Study sites with 30-hour pressure percentages in the 80 to 90 percent range have 2-week pressure percentages that span 15 to 64 percent.

This indicates 30 hours of pressure data might provide only a preliminary indication of which GDFs might have elevated pressure profiles.

In addition, the 30-hour pressure data are not good predictors of long-term PWD designation. As illustrated in Table 5, 8 of the 15 GDFs (~53%) are designated as PWD based on 30 hours of pressure data, but only 3 GDFs (20%) are designated as PWD based on 2 weeks of pressure data. This indicates 30 hours of pressure data will not provide the same PWD results as two weeks of pressure data. In other words, 30 hours of pressure data are not a good predictor of long-term conditions and could lead to pressure driven emission estimates that are biased high or low by an unknown amount.

Figure 12 provides graphs of ullage volume (headspace) and ullage pressure for each of the 15 assist GDFs that further illustrate this finding. UST pressure can vary substantially throughout the day, and from day to day. This observation is consistent with findings from past CARB studies [CARB, 2017a and 2017c]. These studies found that even though gasoline sold during the winter fuel period without RVP limits is the primary cause of overpressure conditions, a variety of other GDF characteristics can determine whether or not a GDF exhibits PWD. Such GDF characteristics include, but are not limited to, the following:

- Variation in the composition of the vehicle fleet the uses each GDF as it pertains to vehicle design parameters that affect the amount of air ingestion to the UST (e.g., percentage of vehicles with ORVR and fill pipe design features that allow excess air ingestion);
- GDF operating hours (e.g., whether or not a GDF closes at night, and duration of closure);
- Temporal variation in fueling activity on an hourly and daily basis throughout the week due to commuter patterns;
- Gasoline throughput; and
- UST ullage volume.

In addition, infrequent events can cause short-term pressure increases at specific GDFs or regionally, such as:

- A fuel delivery involving defective Phase I cargo tank components or a failure to follow best practices during the delivery;
- Reduced fuel dispensing due to the occurrence of holidays or closure for repairs; and
- Substantial changes in UST temperature (e.g., due to weather changes or temperature of delivered fuel).

Because of the UST ullage pressure variability caused by these GDF characteristics and processes, PWD designations based on only 30 hours of pressure data can change depending on the 30-hour period selected. As a result, CARB staff recommends that PWD designations be based on at least two weeks of pressure data.

III. CONCLUSIONS AND RECOMMENDATIONS

CARB staff analyses indicate pressure driven emissions from GDFs do not significantly impact regional and statewide efforts to attain air quality standards for ozone. Even so, there is still an ongoing need to identify GDFs that might have elevated pressure driven emissions. The findings indicate the majority of GDFs throughout California have ISD systems that do not store enough pressure data to adequately characterize long-term conditions at a given GDF.

Simple enhancements to the currently certified ISD software would improve the ability to identify GDFs that might have prolonged periods of elevated UST ullage pressure and associated pressure driven emissions. Staff recommends the following amendments to CARB's certification procedure requirements for ullage pressure vapor containment monitoring and reporting:

- Require GDF vapor recovery ISD systems to store and make available for download, at a minimum, the 14 most recent days of UST ullage pressure and UST ullage volume data.
- Require GDF vapor recovery ISD systems to calculate the percentage of UST ullage pressure data in different pressure ranges as defined below and generate a monthly ullage pressure data report available for download in the following format:

UST ullage pressure ≤ 0.00 inches H_2O	__%
0.00 inches H_2O < UST ullage pressure	__%
0.00 inches H_2O < UST ullage pressure ≤ 0.30 inches H_2O	__%
0.30 inches H_2O < UST ullage pressure ≤ 1.30 inches H_2O	__%
1.30 inches H_2O < UST ullage pressure ≤ 2.50 inches H_2O	__%
UST ullage pressure > 2.50 inches H_2O	__%

- Require the ISD system to maintain an electronic archive of the monthly ullage pressure data report for a period of at least 12 months.

Given the variability observed in daily pressure data, these amendments would provide several benefits to GDF operators, service contractors, CARB, and Air Districts:

- Easily accessible monthly pressure reports with long-term data would help service contractors conduct more effective trouble shooting to identify equipment problems (e.g. vapor leaks and inoperable vapor processors) and their causes. The additional data and reports could reduce the need for multiple site visits and time-consuming pressure data analysis. Reducing time needed for site visits and data analysis would reduce costs for GDF operators.
- Storage of two weeks of pressure data would reduce the number of site visits, and therefore costs, for future studies. Currently, to obtain adequate pressure data to characterize long-term conditions at GDFs with ISD systems that store only 30 hours of pressure data, Air Districts and CARB staff must either conduct daily site visits for several weeks to download 30 hours of pressure data per visit, or install a computer with proprietary software to store longer periods of data and conduct site visits approximately every 14 days.

There are currently two CARB-certified ISD systems, and one already saves two weeks of pressure data. CARB staff seeks to adopt uniform standards for all certified systems, when possible, and the benefits of additional pressure data would identify only those GDFs where additional mitigation measures may be necessary to protect public health.

In addition, both ISD systems currently provide reports with weekly and monthly pressure summaries to compare to the two overpressure alarm criteria currently required by CP-201. The monthly percentage calculations used to generate the current ISD summaries are similar to the pressure percentage calculations needed to generate the above ISD report proposed by CARB staff. This demonstrates the feasibility of ISD systems to generate and store the proposed pressure report.

Both ISD system manufacturers have informed CARB staff that the ISD software to provide two weeks of pressure data and the proposed pressure report using the certified ISD systems already installed at the GDFs.

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V. TABLES

Table 1. Summary of Blitz and Long-Term Study VDAPPs

LTS Site Code	30-Hour Blitz VDAPPs^					Two-Week Average of LTS Daily VDAPPs for First Two Weeks of Each Month						
	Dec. 2013	**Dec. 2015**	**Dec. 2018**	**Feb. 2014**	**Oct. 2013**	**Dec. 2016**	**Dec. 2017**	**Feb. 2017**	**Feb. 2018**	**Oct. 2016**	**Oct. 2017**	**Oct 2018**
1	15.16%				0%		4.46%		1.86%			0.70%
2	9.46%				1.76%		8.79%		5.56%			0.97%
3	26.41%	31.05%	12.45%	15.31%	7.42%		12.80%		12.75%			3.59%
4						4.12%		4.99%		0.72%		
5	12.18%	8.74%	6.63%	4.60%	1.59%		6.30%		5.62%			2.68%
6	6.51%	11.11%	5.97%		3.23%		8.85%		7.26%			3.83%
7	20.00%	15.35%			5.27%		20.26%		11.94%			
8	7.61%	13.43%	16.50%		2.10%		8.70%		7.73%			3.35%
9	5.67%	9.79%	5.79%	5.34%	1.67%		10.91%		10.93%			
10	10.39%	12.85%	4.57%		1.67%		11.35%	9.15%			1.39%	
11	2.75%	14.60%	10.75%	3.59%	1.39%		8.75%		8.44%			
12						3.11%	2.31%	1.33%	2.63%	0.82%		1.37%
13						1.79%	3.15%	0.80%	1.23%	0.16%		0.16%
14						5.51%		3.48%			1.28%	
15	8.24%	13.54%	5.84%	1.73%	1.13%		10.03%		5.24%			0.45%
16		10.24%					7.37%		4.41%			2.65%
17	5.57%	10.88%	6.06%	4.68%	1.03%		8.17%		5.86%			2.74%
18						3.04%	2.34%	1.06%	0.86%	0.30%	0.57%	0.18%
19						2.45%		2.00%			0.02%	
20	1.01%			0.72%	0.03%	3.44%	1.32%	0.88%	1.09%	0.13%	0.18%	
21								0.72%				
22						2.40%	2.53%	1.33%	1.54%		0.44%	0.15%
23	12.96%	4.62%	7.09%	4.07%	1.09%		6.96%		2.74%			3.40%
24						4.58%					1.44%	
25						2.27%		2.13%				
26	22.58%	27.81%	17.53%	23.26%	2.90%		18.95%		11.36%			3.89%
27										2.76%		

Table 2. Summary of regression results for comparisons of 30-hour Blitz VDAPPs to site-specific two-week averages of Long-Term Study daily VDAPPs for balance GDFs

Comparison	n^	R^2	R	p (two-tailed)	Significant Correlation ?
Blitz Dec 2013 vs. LTS Dec 2017	15	0.4962	0.7044	0.005	Yes
Blitz Dec 2015 vs. LTS Dec 2017	13	0.5019	0.7084	0.01	Yes
Blitz Dec 2018 vs. LTS Dec 2017	11	0.3061	0.5533	0.1	No
Blitz Feb 2014 vs. LTS Feb 2018	8	0.6812	0.8253	0.02	Yes
Blitz Oct 2013 vs. LTS Oct 2018	10	0.3789	0.6155	0.005	Yes

^ n = # of LTS sites with both Blitz and LTS data

Table 3. Summary of UST ullage pressure data availability for the comparison of Long-Term Study balance GDFs' pressure profiles and percentiles to their site-specific emission factors

Site Code	Available UST Ullage Pressure Data Period		Nozzle Model*	Sites Included in Each Type of Pressure Calculations				
				Pressure Profile			December ISD Report "DGRD 75%" Value	December Pressure Percentiles
	Start Date	End Date		First week of December	First 2 weeks of December	December		
1	12/3/2017	12/31/2017	A	X	X	X	X	X
2	12/1/2017	12/31/2017	A	X	X	X	X	X
3	12/3/2017	12/31/2017	A	X	X	X	X	X
4	12/7/2016	12/31/2016	A	X	X	X	X	X
5	12/3/2017	12/31/2017	A	X	X	X	X	X
6	12/1/2017	12/31/2017	A	X	X	X	X	X
7	12/18/2017	12/31/2017	A	n/a^	n/a	X	X	X
8	12/3/2017	12/31/2017	A	X	X	X	X	X
9	12/1/2017	12/31/2017	A	X	X	X	X	X
10	12/1/2017	12/31/2017	A	X	X	X	X	X
11	12/1/2017	12/31/2017	A	X	X	X	X	X
12	12/1/2016	12/31/2016	A	X	X	X	X	X
13	12/1/2016	12/31/2016	A	X	X	X	X	X
14	12/1/2016	12/31/2016	B	X	X	X	X	X
15	12/3/2017	12/31/2017	B	X	X	X	X	X
16	12/3/2017	12/31/2017	A	X	X	X	X	X
17	12/3/2017	12/31/2017	Mix	X	X	X	X	X
18	12/4/2016	12/31/2016	A	X	X	X	X	X
19	12/4/2016	12/31/2016	A	X	X	X	X	X
20	12/1/2017	12/31/2017	A	X	X	X	X	X
21	12/11/2017	12/31/2017	Mix	n/a	X	X	X	X
22	12/1/2016	12/24/2016	A	X	X	X	X	X
23	12/3/2017	12/31/2017	B	X	X	X	X	X
24	12/1/2016	12/31/2016	A	X	X	X	X	X
25	12/1/2016	12/31/2016	A	X	X	X	X	X
26	12/3/2017	12/31/2017	A	X	X	X	X	X

* Model A: VST nozzle. Model B: EMCO nozzle. Mix: Mix of VST and EMCO nozzles.

^ n/a: not available

Table 4. Summary of regression results for comparisons of December PDEFs for Long-Term Study balance GDFs to pressures profiles and percentages

For each type of regression analysis that has more than one regression, the regression with the strongest correlation (lowest p value and highest R-value) is highlighted with bold text.

Pressure Range or Percentile Compared to December PDEFs	**n^**	**R^2**	**R**	**p** (two-tailed)	**Significant Correlation ?**
A. Regressions with UST ullage pressure profiles for the first week of December (Figure 5)					
UST pressure ≤ 0.0"WCG	24	0.4479	0.6693	<0.001	Yes
0.0"WCG < UST pressure	24	0.4479	0.6693	<0.001	Yes
0.0"WCG < UST pressure ≤ 0.3"WCG	**24**	**0.4508**	**0.6714**	**<0.001**	**Yes**
0.3"WCG < UST pressure ≤ 1.3"WCG	24	0.0510	0.2258	>0.2	No
1.3"WCG < UST pressure ≤ 2.5"WCG	24	0.0233	0.1526	>0.2	No
> 2.5 "WCG	24	0.0066	0.0812	>0.2	No
B. Regressions with UST ullage pressure profiles for the first 2 weeks of December (Figure 6)					
UST pressure ≤ 0.0"WCG	25	0.5454	0.7385	<0.001	Yes
0.0"WCG < UST pressure	25	0.5454	0.7385	<0.001	Yes
0.0"WCG < UST pressure ≤ 0.3"WCG	**25**	**0.6116**	**0.7820**	**<0.001**	**Yes**
0.3"WCG < UST pressure ≤ 1.3"WCG	25	0.0751	0.2740	<0.2	No
1.3"WCG < UST pressure ≤ 2.5"WCG	25	0.0262	0.1619	>0.2	No
> 2.5 "WCG	25	0.0005	0.0224	>0.2	No
C. Regressions with UST ullage pressure profiles for December (Figure 7)					
UST pressure ≤ 0.0"WCG	26	0.5810	0.7622	<0.001	Yes
*Model A & mixed A/B only**	23	0.8256	0.9086	<0.001	Yes
0.0"WCG < UST pressure	26	0.5810	0.7622	<0.001	Yes
Model A & mixed A/B only	**23**	**0.8256**	**0.9086**	**<0.001**	**Yes**
0.0"WCG < UST pressure ≤ 0.3"WCG	**26**	**0.6295**	**0.7934**	**<0.001**	**Yes**
Model A & mixed A/B only	**23**	**0.7589**	**0.8711**	**<0.001**	**Yes**
0.3"WCG < UST pressure ≤ 1.3"WCG	26	0.1630	0.4037	<0.05	Yes
Model A & mixed A/B only	23	0.4052	0.6366	<0.001	Yes
1.3"WCG < UST pressure ≤ 2.5"WCG	26	0.0326	0.1806	<0.5	No
Model A & mixed A/B only	23	0.1203	0.3468	<0.1	No
> 2.5 "WCG	26	0.0094	0.0970	>0.5	No
Model A & mixed A/B only	23	0.0008	0.0283	>0.05	No

Pressure Range or Percentile Compared to December PDEFs	n^	R^2	R	p (two-tailed)	Significant Correlation ?
D. Regressions with December ISD Report "DGRD 75%" values (Figure 8)					
ISD Report "DGRD 75%"	26	0.5501	0.7417	<0.001	Yes
Model A & mixed A/B only	23	0.6783	0.8236	<0.001	Yes
E. Regressions with UST ullage pressure profiles for December (Figure 9)					
95th percentile pressure	26	0.1600	0.4000	<0.05	Yes
Model A & mixed A/B only	23	0.3372	0.5807	<0.005	Yes
75th percentile pressure	**26**	**0.6216**	**0.7884**	**<0.001**	**Yes**
Model A & mixed A/B only	**23**	**0.7940**	**0.8911**	**<0.001**	**Yes**
5th percentile pressure	26	0.5616	0.7494	<0.001	Yes
Model A & mixed A/B only	23	0.4534	0.6733	<0.001	Yes
10th percentile pressure	26	0.4879	0.6985	<0.001	Yes
Model A & mixed A/B only	23	0.3897	0.6243	<0.002	Yes
25th percentile pressure	26	0.5008	0.7077	<0.001	Yes
Model A & mixed A/B only	23	0.4406	0.6638	<0.001	Yes
50th percentile pressure	26	0.5761	0.7590	<0.001	Yes
Model A & mixed A/B only	23	0.5848	0.7647	<0.001	Yes
Average	26	0.7135	0.8447	<0.001	Yes
Model A & mixed A/B only	23	0.7118	0.8437	<0.001	Yes
90th percentile pressure	26	0.1963	0.4431	<0.05	Yes
Model A & mixed A/B only	23	0.3563	0.5969	<0.005	Yes
99th percentile pressure	26	0.0890	0.2983	<0.2	No
Model A & mixed A/B only	23	0.2091	0.4573	<0.05	Yes
F. Regressions with December monthly pressure 75th percentiles rounded to include 1, 2, or 3 decimal places (Figure 10)					
No rounding	26	0.6216	0.7884	<0.001	Yes
3 decimal places	26	0.6217	0.7885	<0.001	Yes
2 decimal places	26	0.6192	0.7869	<0.001	Yes
1 decimal place	26	0.5829	0.7635	<0.001	Yes

^ n = # of LTS sites included in the regression.

* Model A: VST nozzle. Model B: EMCO nozzle. Mix: Mix of VST and EMCO nozzles.

Table 5. Summary of pressure data evaluated for assist GDFs with ISD systems that store two weeks of pressure data

Site Code	30 Hours of Pressure Data		2 Weeks of Pressure Data		% Data >1.30"WCG [a]		PWD? [b]	
	Start Date	End Date	Start Date	End Date	30 hours	2 Weeks	30 Hours	2 Weeks
1	12/12/2018 6:16	12/13/2018 12:16	11/29/2018 12:17	12/13/2018 12:16	37.4%	33.2%	Yes	Yes
2	12/11/2018 7:57	12/12/2018 13:57	11/28/2018 13:58	12/12/2018 13:57	90.6%	64.3%	Yes	Yes
3	12/10/2018 3:17	12/11/2018 9:17	11/27/2018 9:18	12/11/2018 9:17	42.4%	12.3%	**Yes**	**No**
4	12/10/2018 3:37	12/11/2018 9:37	11/27/2018 9:38	12/11/2018 9:37	0.0%	0.0%	No	No
5	12/11/2018 5:53	12/12/2018 11:53	11/28/2018 11:54	12/12/2018 11:53	0.1%	18.1%	No	No
6	12/10/2018 8:30	12/11/2018 14:30	11/27/2018 14:31	12/11/2018 14:30	81.2%	14.6%	**Yes**	**No**
7	12/11/2018 11:36	12/12/2018 17:36	11/28/2018 17:37	12/12/2018 17:36	0.0%	0.5%	No	No
8	12/10/2018 4:21	12/11/2018 10:21	11/27/2018 10:22	12/11/2018 10:21	0.0%	0.0%	No	No
9	12/12/2018 3:45	12/13/2018 9:45	11/29/2018 9:46	12/13/2018 9:45	24.1%	17.6%	**Yes**	**No**
10	12/10/2018 5:26	12/11/2018 11:26	11/27/2018 11:27	12/11/2018 11:26	21.9%	9.4%	**Yes**	**No**
11	12/12/2018 9:55	12/13/2018 15:55	11/29/2018 15:56	12/13/2018 15:55	0.2%	0.1%	No	No
12	12/9/2018 2:19	12/10/2018 8:19	11/26/2018 8:20	12/10/2018 8:19	0.0%	0.0%	No	No
13	12/11/2018 3:39	12/12/2018 9:39	11/28/2018 9:40	12/12/2018 9:39	0.0%	0.0%	No	No
14	12/11/2018 1:45	12/12/2018 7:45	11/28/2018 7:46	12/12/2018 7:45	26.4%	2.9%	**Yes**	**No**
15	12/10/2018 2:55	12/11/2018 8:55	11/27/2018 8:56	12/11/2018 8:55	48.8%	39.6%	Yes	Yes
						PWD %	**53.3%**	**20.0%**

(a) Percentage of pressure records above 1.30 inches water column gauge ("WCG).

(b) For a GDF to be designated as PWD, at least 20 percent of the 30-hour or 2---week ullage pressure data must exceed 1.30"WCG. Bold text indicates GDFs that have different PWD designations based on 30 hours of pressure data compared to 2 weeks of pressure data.

VI. FIGURES

Figure 1. Regression graphs that compare December, February, and October 30-hour Blitz VDAPPs to the site-specific, two-week averages of Long-Term Study daily VDAPPs

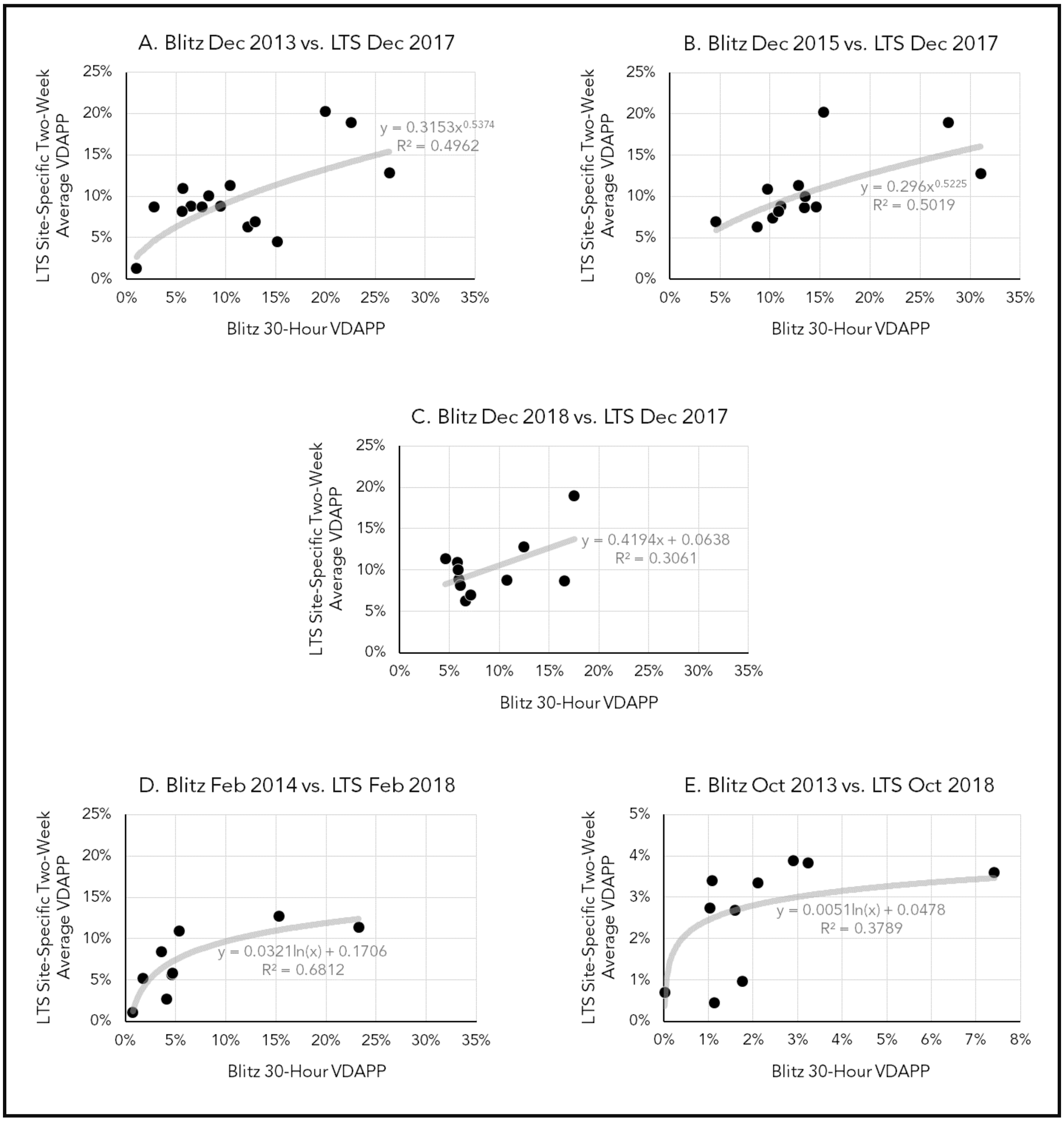


Figure 2. Long-Term Study daily VDAPPs during the first 2 weeks of December 2016 and December 2017 compared to December 2013, December 2015, and December 2018 30-hour Blitz VDAPPs

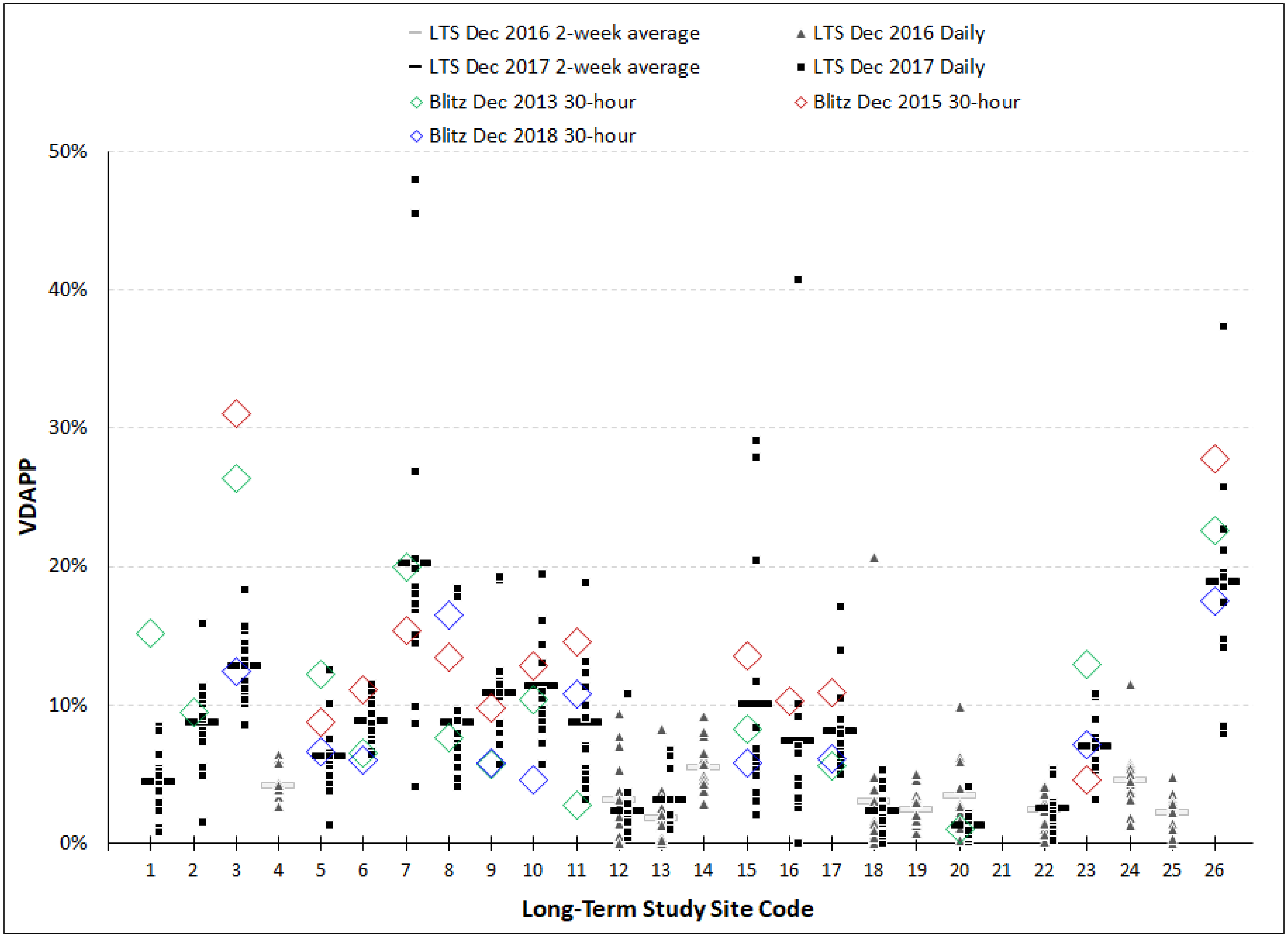


Figure 3. Long-Term Study daily VDAPPs during the first 2 weeks of February 2017 and February 2018 compared to February 2014 30-hour Blitz VDAPPs

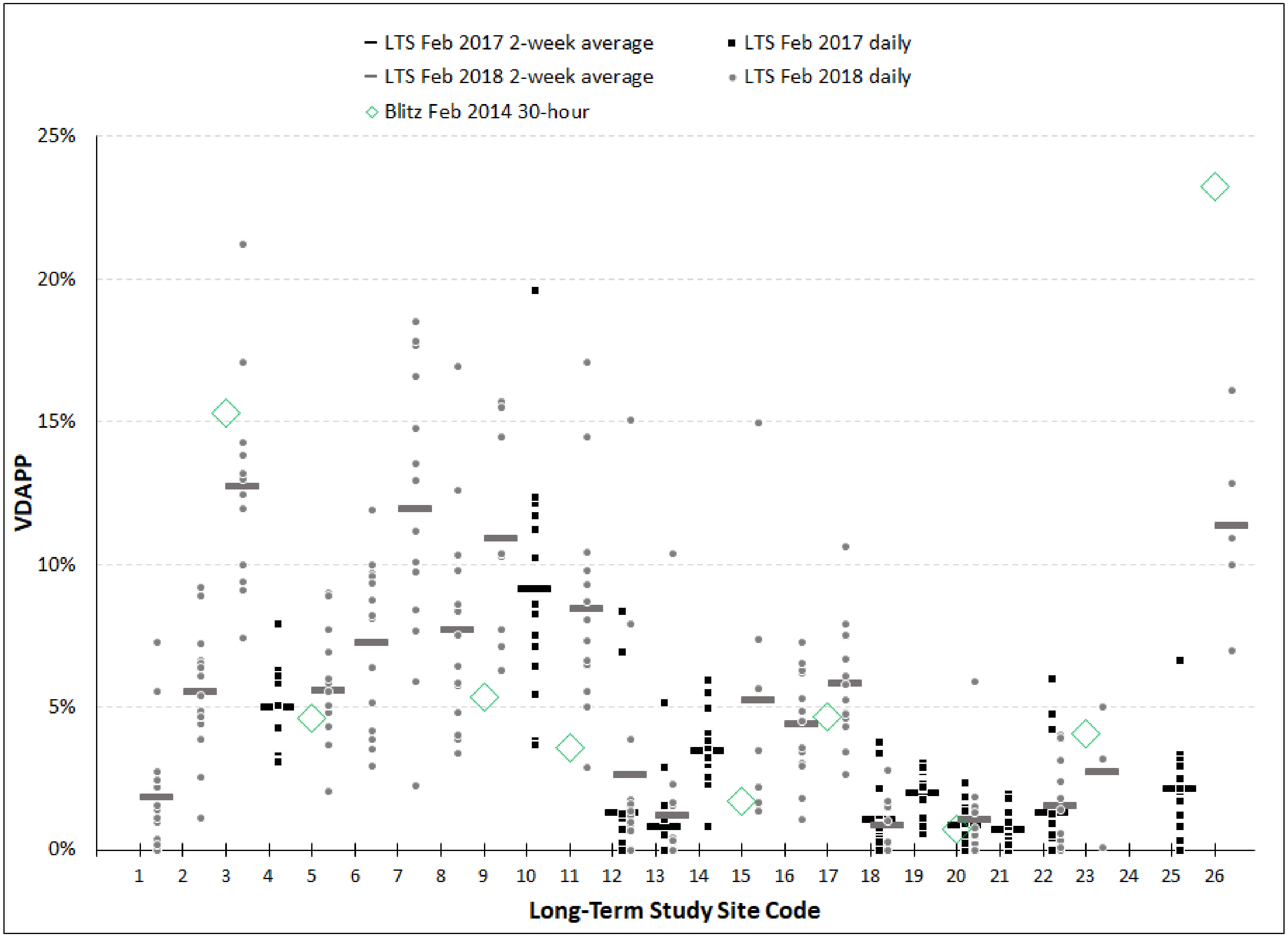
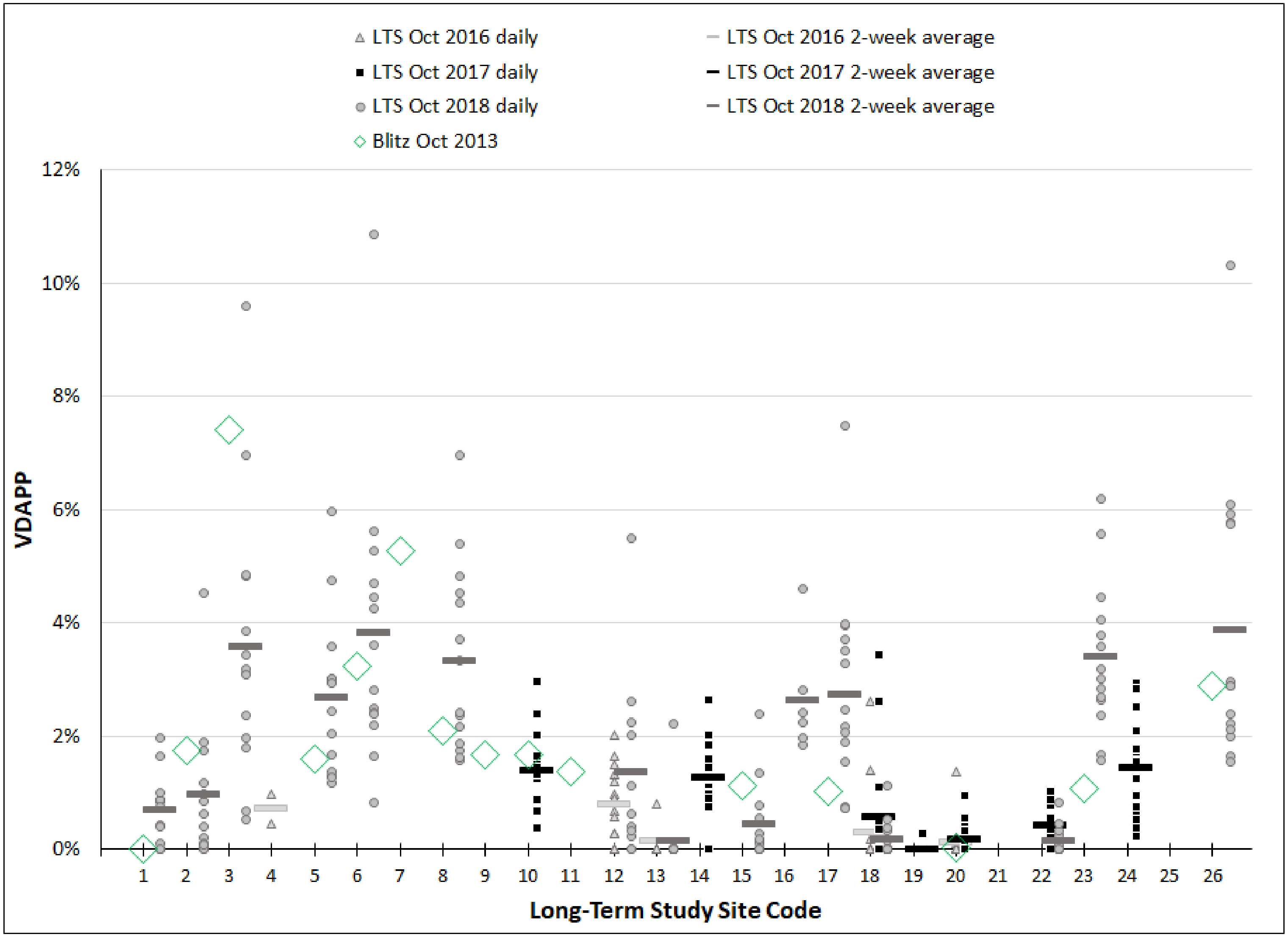


Figure 4. Long-Term Study daily VDAPPs during the first 2 weeks of October 2016, 2017, and 2018 compared to October 2013 30-hour Blitz VDAPPs



LEGEND FOR FIGURES 5 THROUGH 10

There are two different models of Phase II EVR nozzles certified for use at balance GDFs. Figures 5 through 10 use different symbols to indicate the type of nozzle installed at each GDF when Long-Term Study monitoring occurred:

- Light grey circles for the 21 GDFs with the VST nozzle
- Dark grey circles for the 3 GDFs with the EMCO nozzle
- White circles for the 2 GDFs with a mix of VST and EMCO

Figure 5. UST ullage pressure profiles for the first week of December compared to December monthly PDEFs for Long-Term Study balance GDFs

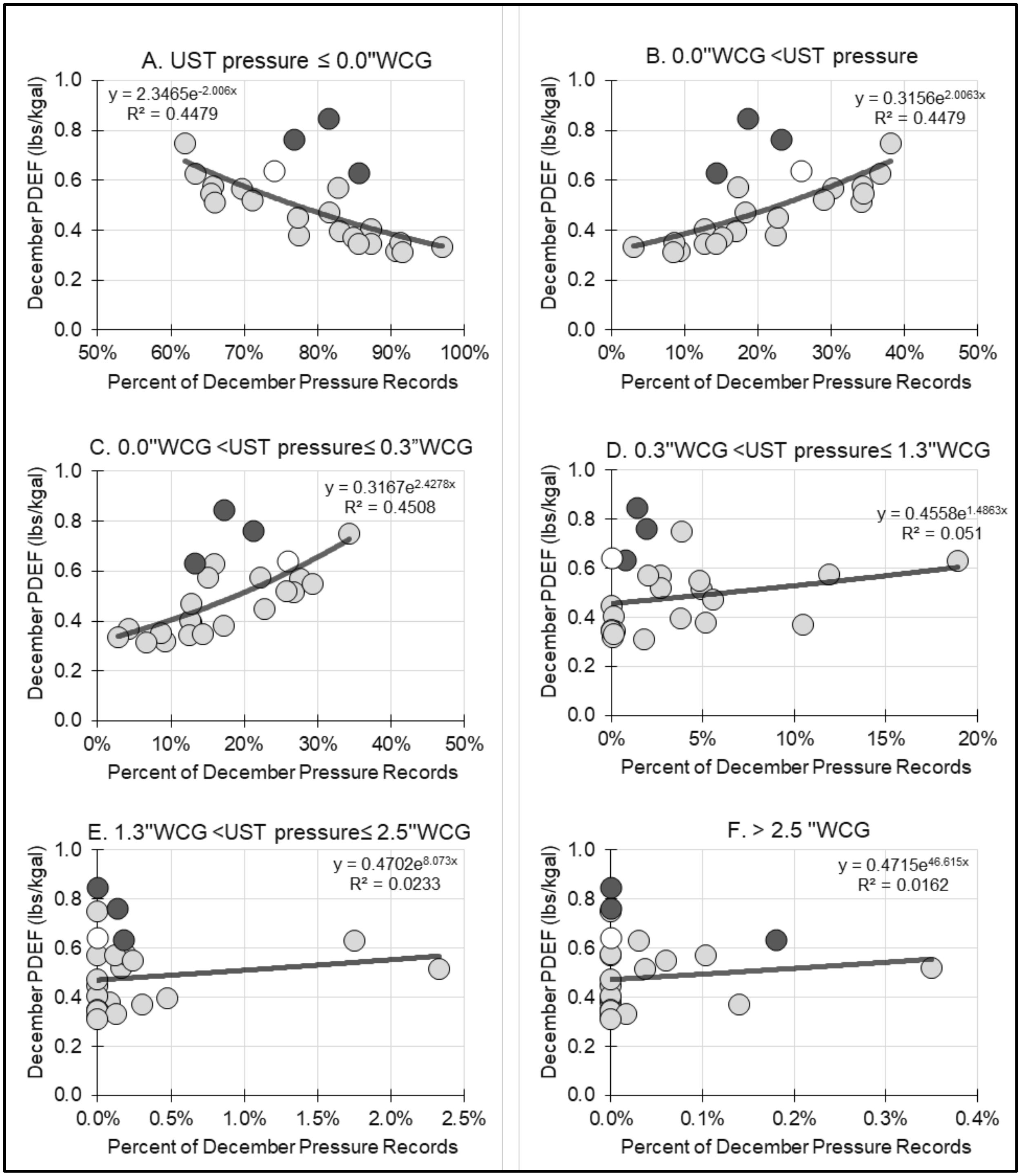


Figure 6. UST ullage pressure profiles for the first two week of December compared to December monthly PDEFs for Long-Term Study balance GDFs

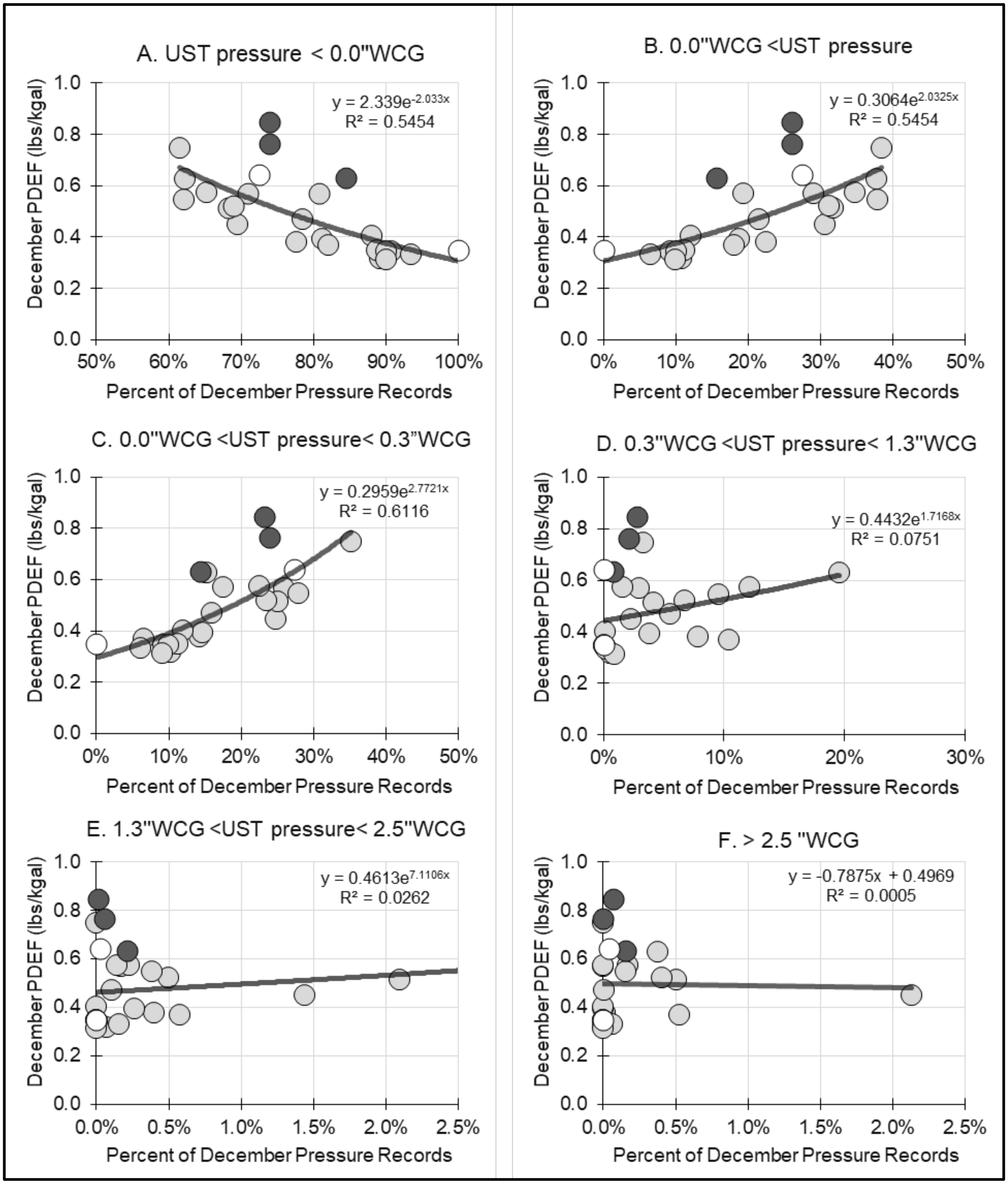


Figure 7. December monthly UST ullage pressure profiles compared to December monthly PDEFs for Long-Term Study balance GDFs

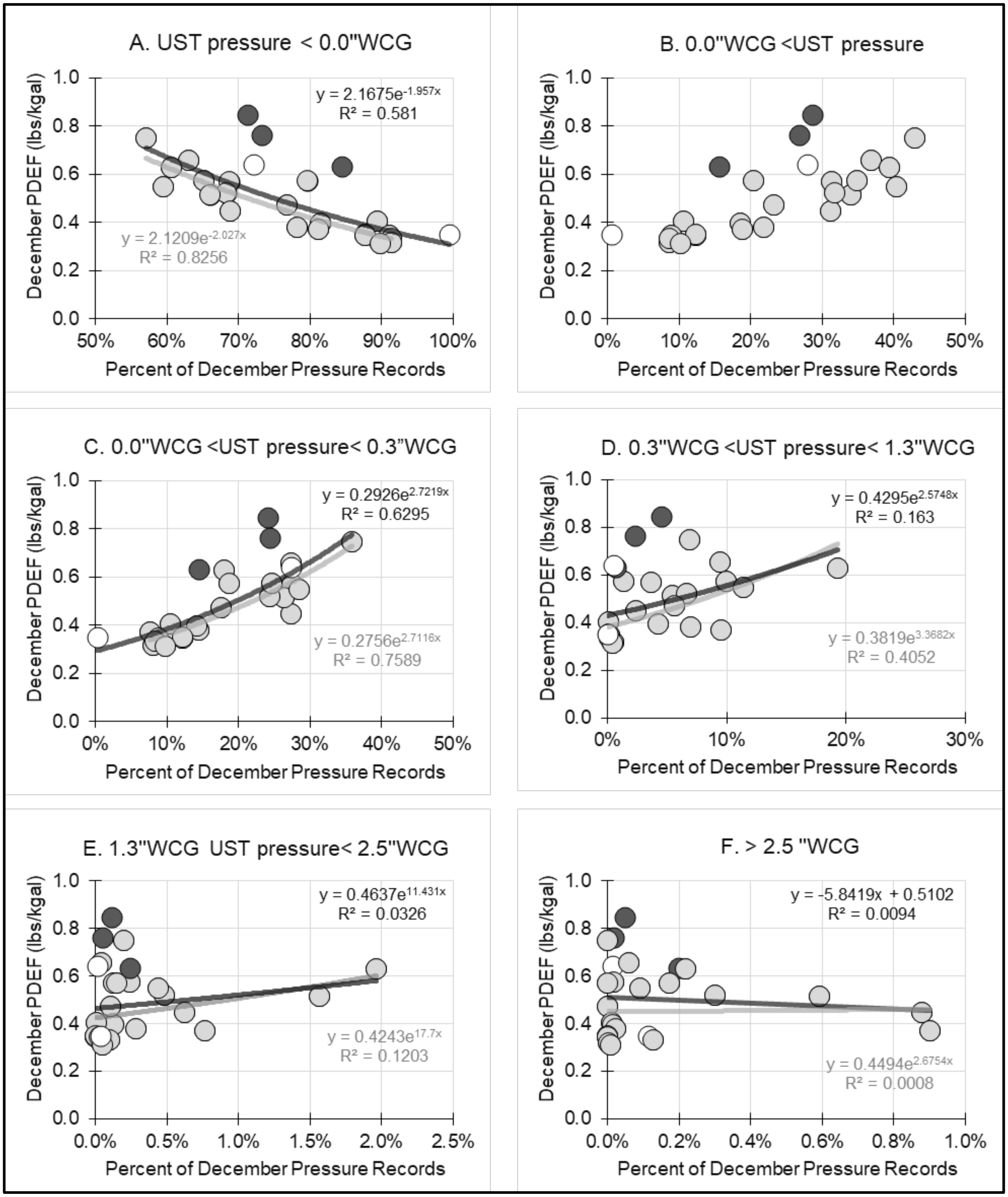


Figure 8. December ISD Report “DGRD 75%” values compared to December monthly PDEFs for Long-Term Study balance GDFs

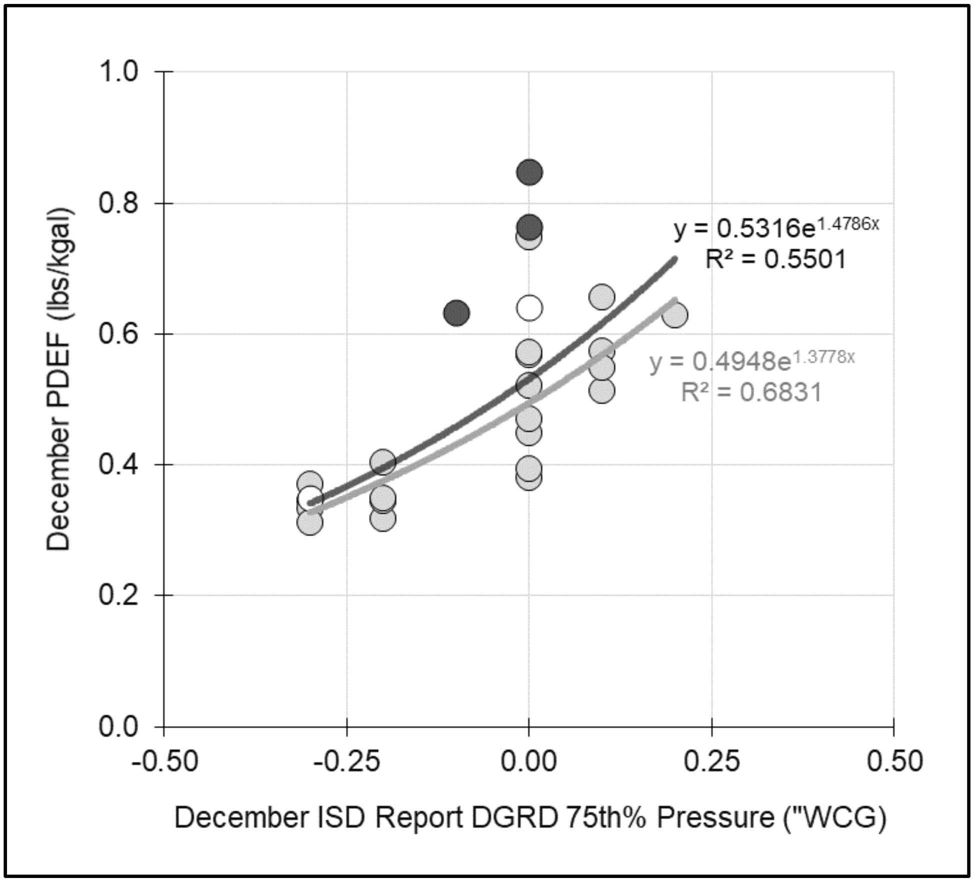


Figure 9. December monthly pressure percentiles compared to December monthly PDEFs for Long-Term Study balance GDFs

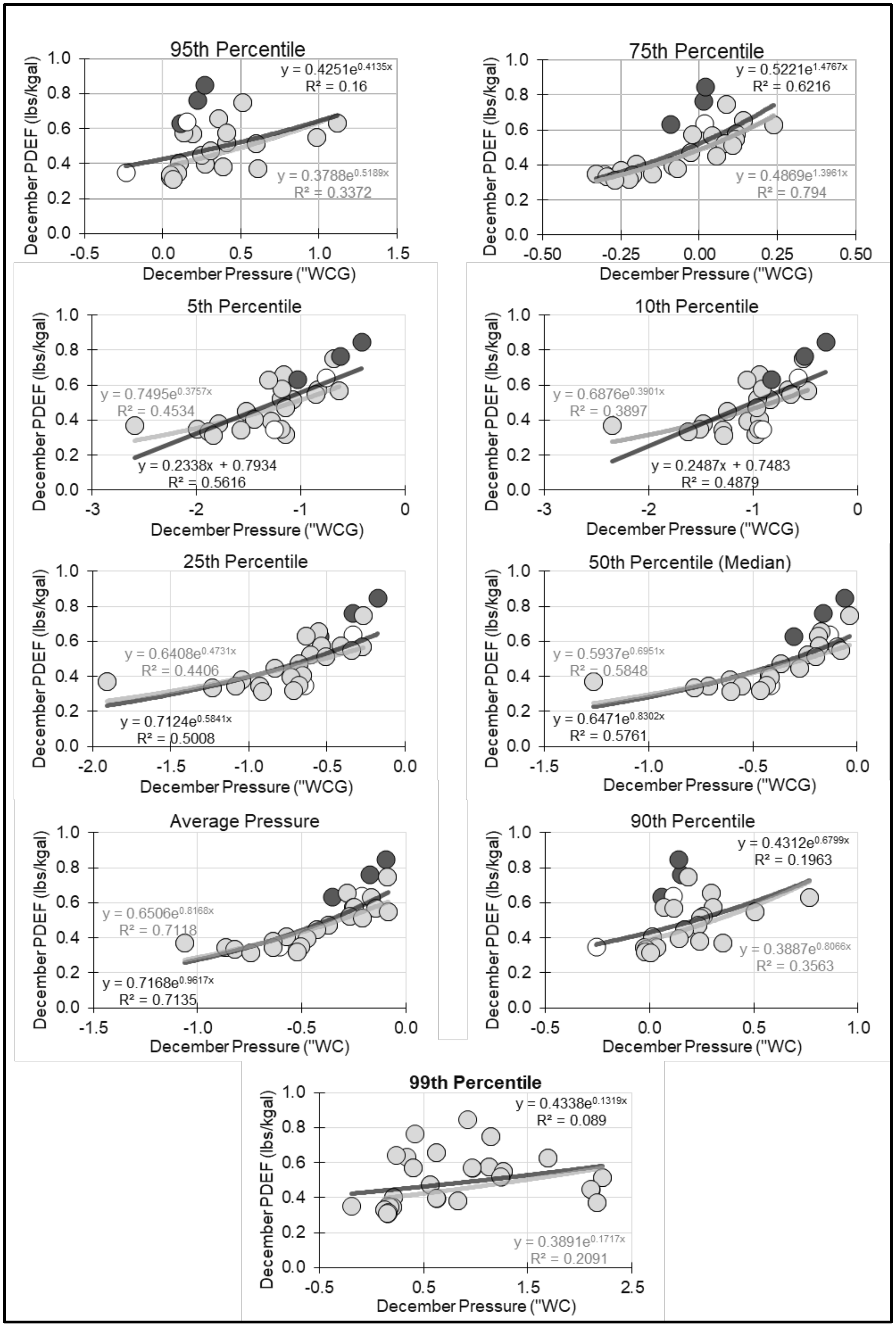


Figure 10. December monthly pressure 75th percentiles rounded to include 1, 2, or 3 decimal places compared to December PDEFs for LTS balance GDFs

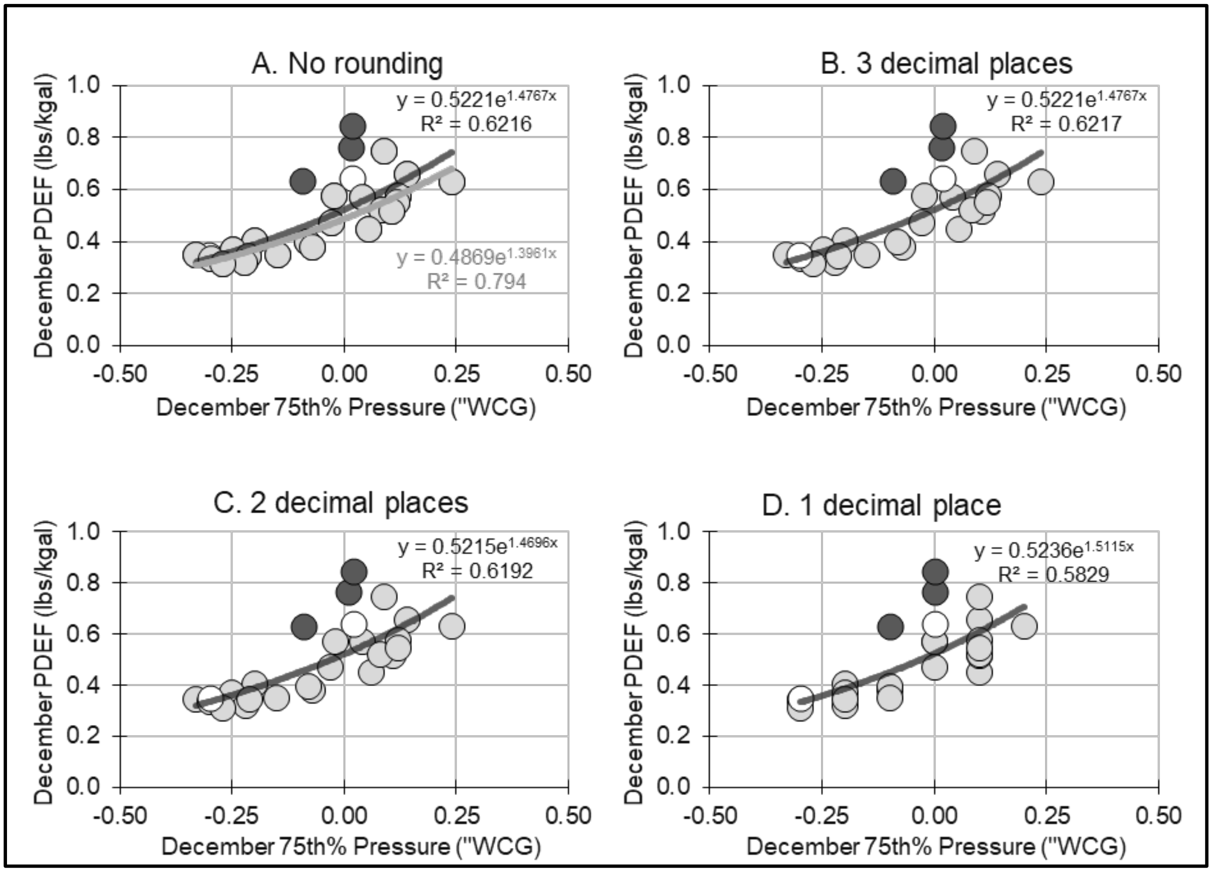
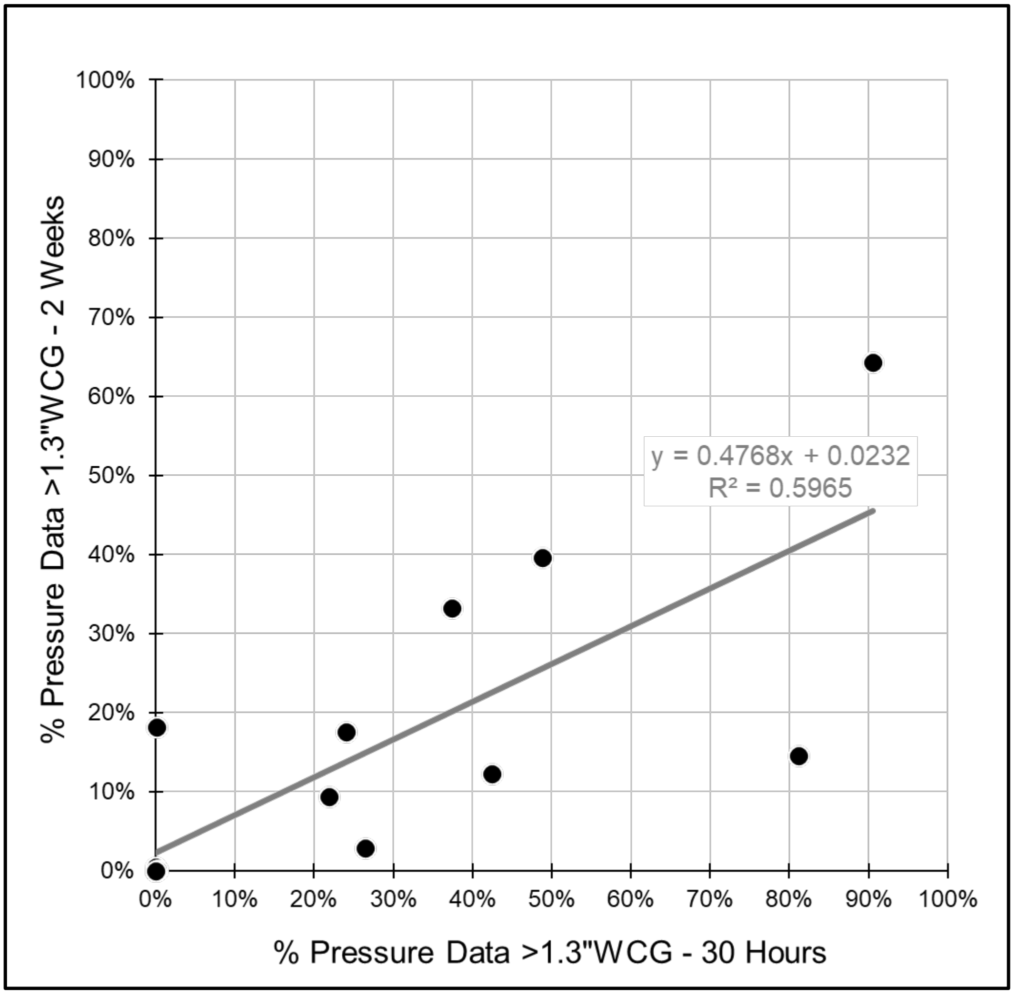


Figure 11. Regression graph that compares the percentage of pressure records above 1.30 inches water column gauge ("WCG) for 30 hours to the percentage for 2 weeks for 15 assist GDFs



LEGEND FOR FIGURE 12

Figure 12 provides graphs of ullage pressure and ullage volume for each of the 15 assist GDFs evaluated in Section II.B.2. The x- and y-axes have the same scale for every graph:

- x-axis: November 26, 2018 12:00 a.m. through December 14, 2018 12:00 a.m.
- y-axis (primary): Ullage (headspace), 0 to 40,000 gallons
- y-axis (secondary): Pressure, -10 to 10 inches water column gauge ("WCG)

In each graph the grey line plots ullage, the black line plots ullage pressure, and the blue line indicates the threshold for 'pressure increase while dispensing' (PWD) designations, 1.30"WCG. For a GDF to be designated as PWD, at least 20 percent of the ullage pressure data must exceed 1.30"WCG for a given period (e.g., two weeks).

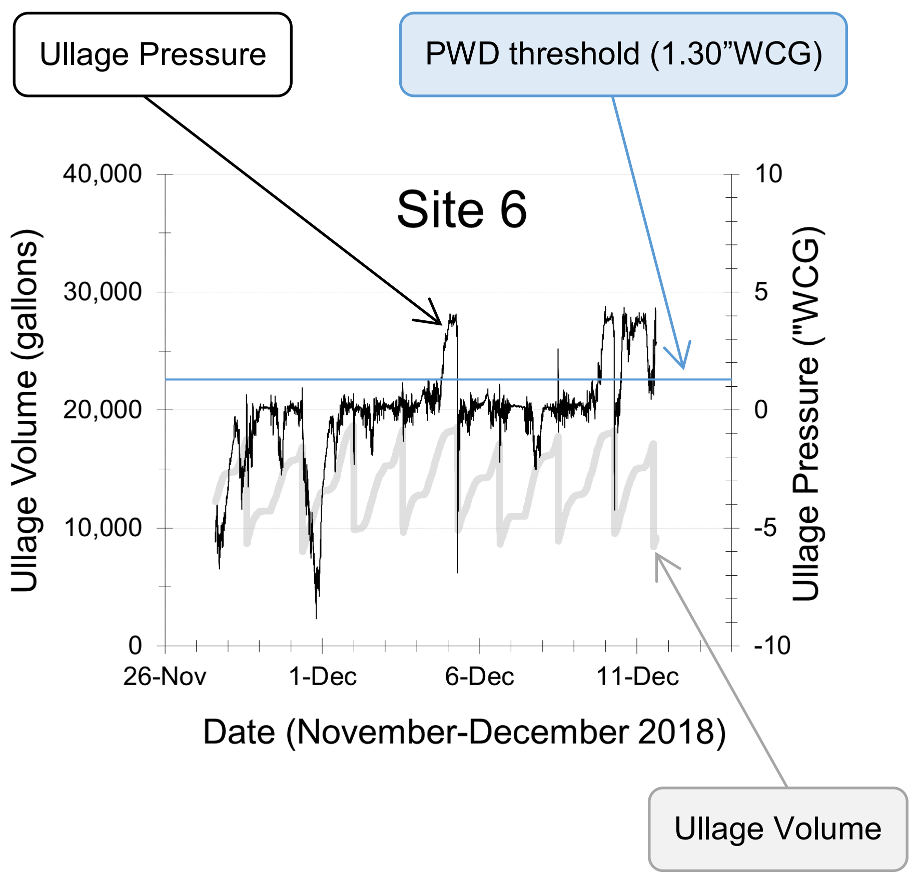


Figure 12. Graphs of UST ullage volume and ullage pressure 15 assist GDFs