III. List of Tables

might explain the reason that PWD disappeared after February 9. With these issues, it is not possible to draw a valid conclusion whether or not EOR spout replacement mitigated PWD or overpressure at this particular GDF. The vapor to liquid ratio data collected by the ISD system was deemed valid and could be used for comparison.

The Campbell test site was fully equipped with eight factory assembled EOR Nozzles. Prior to EOR nozzle installation, low flow rates (less than 6 gallons per minute) for the 91 grade were observed at all fueling positions. Dispenser integrity leaks were observed at fueling points 3 and 4.

The Gilroy test site was also fully equipped with twelve factory assembled EOR nozzles. Days after initial assessment, leaks developed in the containment system, which were identified by the ISD system. A 10 inch pressure decay test was conducted and multiple leaks were found at the vent riser, the Phase I riser, and the vapor return piping.

Fortunately, all issues found at Campbell and Gilroy sites were corrected prior to the installation of EOR nozzles and the RVP of the gasoline remained high throughout the month of March.

Observations Pertaining to EOR Nozzle Performance

Although the amount of information collected varied by test site (limited information from Granite Bay due to mixture of nozzles) and numerous issues were encountered (San Diego in particular), the following observations can be made pertaining to the performance of the EOR nozzle when compared to the conventional Healy nozzle.

A. UST Pressure Lowered at Two of Four Test Sites

Due to the issues encountered at San Diego test site and the partial installation of EOR nozzles at Granite Bay, UST pressure data collected from only two of the four test sites (Campbell and Gilroy) was deemed valid and acceptable for analysis. As indicated in the table below and the results section of this document, the UST pressure was successfully lowered upon installation of the EOR nozzle at both Campbell and Gilroy test sites. Prior to EOR install, both sites exhibited relatively high UST pressures including PWD. With EOR nozzles installed, the UST pressure averages dropped to vacuum levels.

Table V-1: Change in UST Pressure Observed During EOR Nozzle Evaluation

Test Site	UST Pressure Average (Inches Water Column Gauge)	
	Conventional Healy Nozzle	EOR Nozzle
Granite Bay[9]	N.A.	N.A.
San Diego[10]	2.3	Inconclusive
Campbell	2.6	-4.8
Gilroy	2.5	-3.0

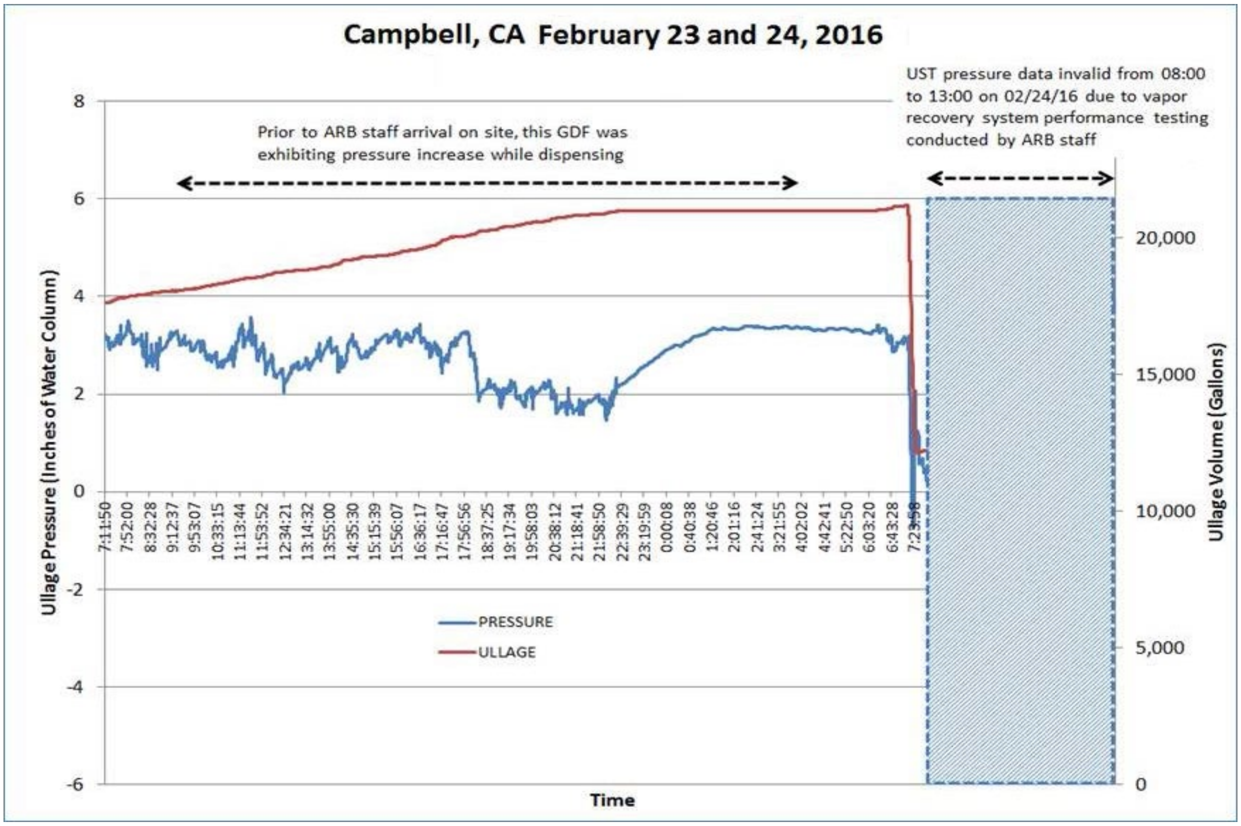
B. PWD Mitigated at Two of Four Test Sites

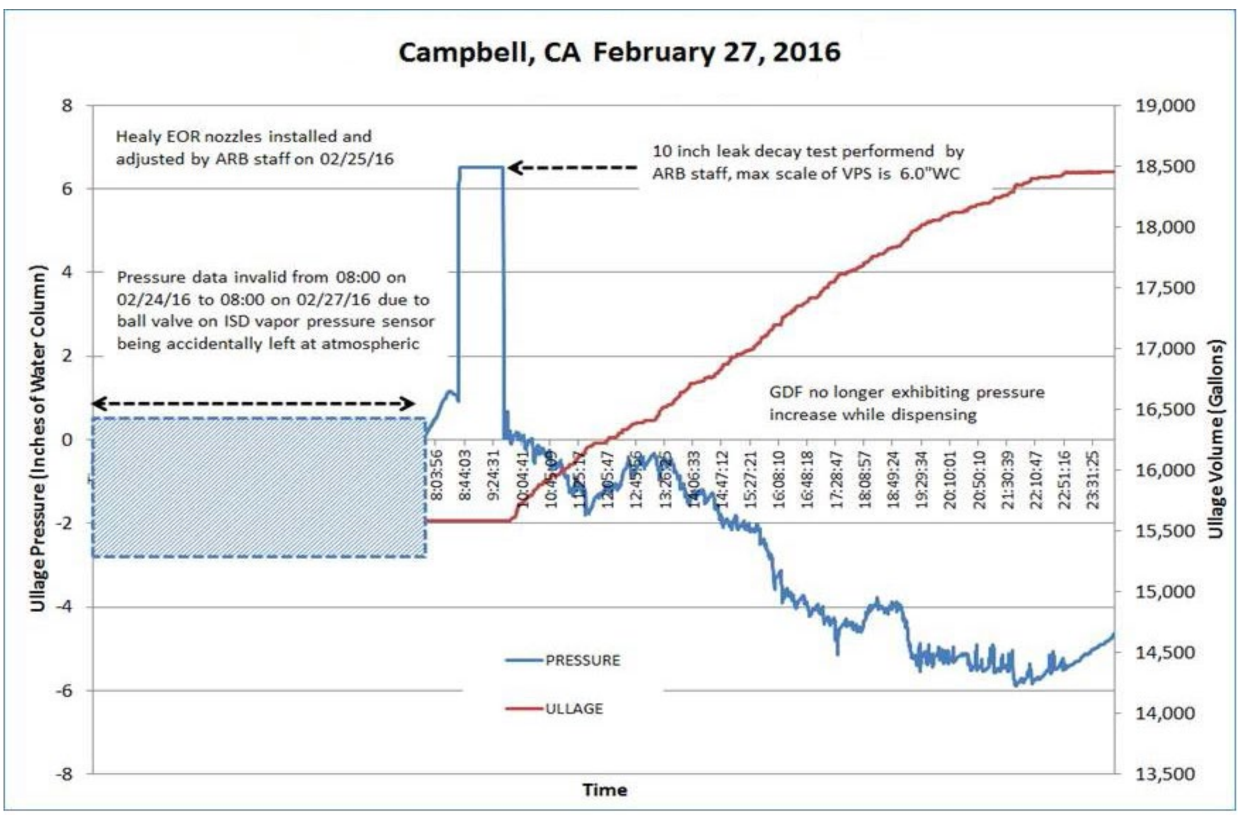
PWD condition was mitigated at two of the four test sites (Campbell and Gilroy) due to the installation of the EOR nozzles. An example of PWD mitigation is depicted in Figures V-1 (provided below) for the Campbell test site. Figures V-1 illustrates the UST pressure and ullage profile hours before and after the EOR nozzle installation. As indicated in Figure V-1, upon installation of the EOR nozzle, the UST pressure values change from positive to negative within hours.

[9] UST pressure data was not collected or analyzed from the Granite Bay test site because the facility was not fully equipped with EOR nozzles, six out of twelve fueling positions were EOR the remaining six were conventional Healy nozzles

[10] UST pressure data collected from the San Diego test site was deemed inconclusive because containment leaks were later found and due to the fact that low RVP winter blend gasoline was introduced at the site in mid-February which was earlier that anticipated by CARB staff

Figure V-1: Campbell Pressure Trace Before & After Installation of EOR Nozzle





C. Vapor to Liquid Ratios Lowered at All Four Test Sites

At all four test sites, the nozzle vapor to liquid ratio site averages were lowered by at least 10% due to the installation of the EOR nozzles. This means that less fresh air is being ingested at the nozzle; therefore less evaporation is expected to occur within the headspace of the USTs. As indicated in the table below, the EOR nozzle lowered the vapor to liquid ratio by an average of 18% based on all four test sites.

Table V-2: Change in Vapor to Liquid Ratios Observed During EOR Nozzle Evaluation

Test Site	Vapor To Liquid Ratio		Percent Change
	Conventional Healy Nozzle	EOR Nozzle	
Granite Bay	0.65	0.56	-13.8
San Diego	0.67	0.60	-10.4
Campbell	0.72	0.50	-30.5
Gilroy	0.63	0.52	-17.5
		Four Site Average	**-18.1**

D. Percentage of Fueling Events w/ Vapor to Liquid Ratio < 0.5 Lowered at All Four Test Sites

The percentage of fueling events with a V/L less than or equal to 0.5 increased at all four test sites due to the installation of the EOR nozzle. This indicated that the EOR nozzle was doing a better job of recognizing vehicles equipped with ORVR and less air ingestion was occurring. As indicated in the table below, the EOR nozzle increased the percentage of fueling events with a V/L less than 0.5 by an average of 19 percentage points.

Table V-3: Change in Distribution of Fueling Events Observed During EOR Nozzle Evaluation

Test Site	Percentage of Fueling Events with Vapor To Liquid Ratio Less Than or Equal to 0.5		Percentage Point Difference
	Conventional Healy Nozzle	EOR Nozzle	
Granite Bay	56%	75%	19
San Diego	40%	58%	18
Campbell	45%	67%	22
Gilroy	50%	65%	15
		Four Site Average	**19**

E. Frequency of ISD Alarms Decreased at Two of Four Test Sites

The number of ISD overpressure alarms after installation of the EOR nozzles was reduced at two of the four test sites. Data collected from the remaining two sites (Granite Bay and San Diego) was deemed inconclusive due to the reasons explained above pertaining to UST pressure. Ideally, 100% of the ISD alarms would be mitigated for all sites upon EOR nozzle installation. This was not observed, but at the Campbell and Gilroy test sites, ISD overpressure alarm frequency was reduced by 58%.

Table V-4: Change in ISD Overpressure Alarm Frequency during EOR Nozzle Evaluation

Test Site	Number of ISD Overpressure Alarms		Percent Reduction
	February 2016 Conventional Healy Nozzle	March 2016 EOR Nozzle	
Granite Bay[11]	N.A.	N.A.	N.A.
San Diego[12]	5	Inconclusive	N.A.
Campbell	4	2	50%
Gilroy	3	1	66%
Two Site Average Reduction in ISD Overpressure Alarms			**58%**

[11] ISD alarm history data was not collected or analyzed from the Granite Bay test site because the facility was not fully equipped with EOR nozzles, six out of twelve fueling positions were EOR the remaining six were conventional Healy nozzles

[12] ISD alarm history data collected from the San Diego test site was deemed inconclusive because containment leaks were later found and due to the fact that low RVP winter blend gasoline was introduced at the site in mid-February which was earlier than anticipated by CARB staff

VI. Conclusions and Recommendations

The objective of this evaluation was to determine the effectiveness of the EOR nozzle feature with regard to improved ORVR vehicle recognition and mitigation of overpressure conditions that commonly occur at GDF's equipped with the Assist Phase II Enhanced Vapor Recovery System during the time of year when winter blend gasoline is sold in California.

In terms of performance relative to the conventional Healy Model 900 nozzle, based on data collected at four test sites, CARB staff has concluded that the EOR nozzle was effective in lowering UST pressure, lowering site average V/L ratio, and lowering the frequency of ISD overpressure alarms. The EOR nozzle also showed improvement with regard to ORVR vehicle mis-identification based on an ORVR vehicle recognition survey was also conducted at two of the four test sites. The following table summarizes the findings specific to EOR nozzles.

Table VI-1: Summary of Findings Pertaining to EOR Nozzle Evaluation

	Test Site			
Parameter:	**Granite Bay**[13]	**San Diego**[14]	**Campbell**[15]	**Gilroy**[16]
Change in UST Pressure?	Not Applicable	Inconclusive	Lowered	Lowered
Change in Site Average V/L[17]?	Lowered	Lowered	Lowered	Lowered
Change in Percentage of V/L <0.5?	Lowered	Increased	Increased	Increase
Change in ORVR Vehicle Recognition Survey?	Improved	Improved	Not Evaluated	Not Evaluated
Change in Frequency of ISD OP Alarm?	Not Applicable	Inconclusive	Lowered	Lowered

[13] Change in UST pressure and frequency of ISD overpressure alarms not evaluated because this test site was partially equipped with EOR nozzles.
[14] Change in UST pressure likely due to change in RVP of winter blend gasoline, see Table IV-7, results of RVP sampling and analysis from San Diego test site
[15] Due to time constraints and availability of CARB staff resources, ORVR vehicle recognition survey was not conducted at this test site
[16] Due to time constraints and availability of CARB staff resources, ORVR vehicle recognition survey was not conducted at this test site
[17] Vapor to Liquid Ratio of all EOR nozzles at each site was intentionally adjusted to 0.95 – 1.00 which is the low end of the allowable range

Because this evaluation occurred at the tail end (February – March) of the 2015/2016 winter blend gasoline distribution time frame, CARB staff recommends that additional field studies be conducted in the future at a larger number of test sites to more completely assess the ability to mitigate overpressure conditions and reduce ISD alarm frequency. These additional studies should cover the entire winter fuel blend time frame which begins in November and ends in March.

VII. Appendices

The following appendices are provided as a supplement to the technical support document:

Appendix I: Vapor to Liquid Ratios, Nozzle Dispensing Rates, and ISD Operability Test Results (Granite Bay Test Site)

Appendix II: Vapor to Liquid Ratios, Nozzle Dispensing Rates, and ISD Operability Vapor Flow Meter Test (San Diego Test Site)

Appendix III: Vapor Recovery System Test Results (Campbell Test Site)

Appendix IV: Vapor Recovery System Test Results (Gilroy Test Site)

Appendix V: Assist ORVR Recognition Protocol

Appendix VI: ORVR Recognition Survey – Raw Data (Granite Bay)

Appendix VII: ISD Data Collected at San Diego Test Site

Appendix VIII: ORVR Recognition Survey – Raw Data (San Diego)

Appendix IX: ISD Data Collected at Campbell Test Site

Appendix X: ISD Data Collected at Gilroy Test Site