CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Las Gallinas Valley Sanitary District Natural Gas Fueling Infrastructure Installation Project

Prepared for: California Energy Commission

Prepared by: Las Gallinas Valley Sanitary District

Gavin Newsom, Governor

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California Energy Commission

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-14-608 to provide funding for projects that establish or expand infrastructure necessary to store, distribute and dispense compressed natural gas for use in natural gas vehicles. In response to PON-14-608, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards August 12, 2015 and the agreement was executed as ARV-15-038 on January 14, 2016.

ABSTRACT

This final project report documents the planning, fueling station equipment, specifications, and initial throughput from the installation of a new compressed natural gas fueling system at the Las Gallinas Valley Sanitary District made possible through the California Energy Commission grant ARV-15-038. This report also provides analysis of the six months operational data collected at the station.

The project results show that the installation of the compressed natural gas stations provides a critical support to the Las Gallinas Valley Sanitary District's efforts in phasing out diesel operated trucks and providing a steady supply of compressed natural gas as back-up to the Renewable Natural Gas system at the Waste Water Treatment Plant. The project also supports the Las Gallinas Valley Sanitary District's compressed natural gas fleet.

Keywords: California Energy Commission, Las Gallinas Valley Sanitary District, Compressed Natural Gas, Renewable Natural Gas, Waste Water Treatment Plant

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EXECUTIVE SUMMARY

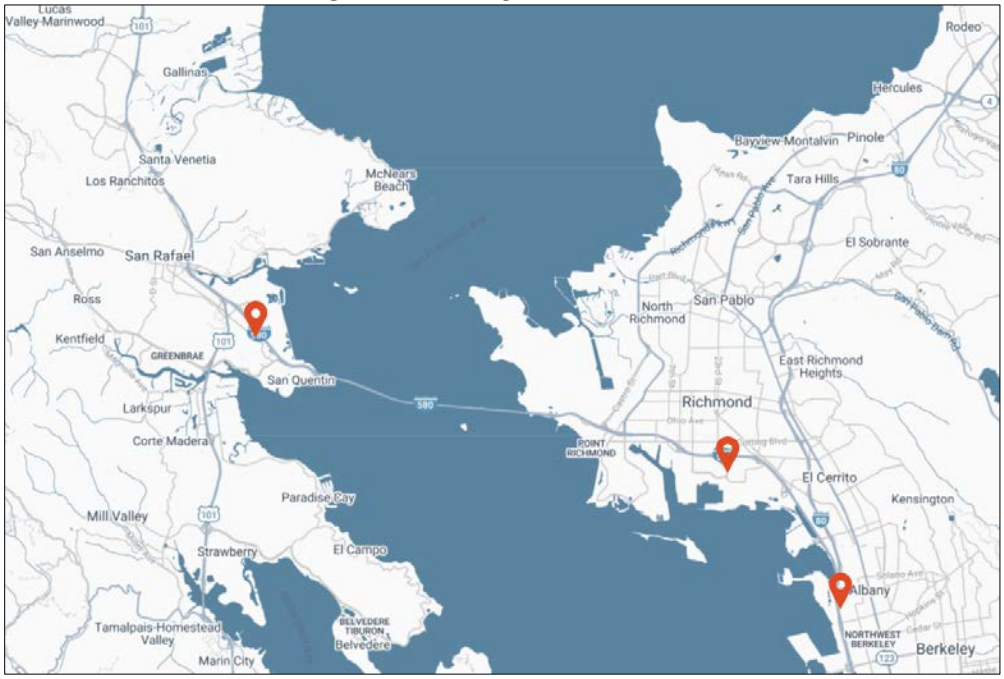
This final report prepared for the California Energy Commission meets all reporting requirements of the Agreement ARV-15-038 with the Las Gallinas Valley Sanitary District. This project installed and operated one fast-fill compressed natural gas station to provide back-up to the Waste Water Treatment Plant time-fill Renewable Natural Gas station. This project will also provide compressed natural gas to compressed natural gas trucks through the PG&E supply lines.

CHAPTER 1: Project Introduction

Background

The Las Gallinas Valley Sanitary District (the District) was awarded a CEC grant (ARV-15-038) in 2015 to build and operate a natural gas fueling infrastructure at the District's wastewater treatment plant located north of San Rafael, in a semi-rural area next to San Pablo Bay. The closest compressed natural gas (CNG) station is at the Pacific Gas and Electric San Rafael Service Center more than ten miles to the south. Figure 1 shows location of the project and the closest CNG stations which are within 20 miles from the District.

Figure 1: Project Location



Source: CNG Now. Last accessed April 2, 2018

Project Description

The District was the applicant but collaborated with other team members to complete this project. The team includes the owner and operator of the CNG fueling station, the Design Engineer which was Cornerstone Environmental Group, a Tetra Tech Company (Cornerstone). Cornerstone assisted with design, procurement, and engineering during construction of the CNG fast-fill station. Cornerstone developed specifications for the project, created and managed the bid proposal, and provided technical expertise in CNG and CNG facilities. Western Water of Santa Rosa, California won the bid for the procurement and installation of the CNG infrastructure. The District coordinated with PG&E prior to construction to ensure permitting and design requirements were met.

The cost for construction and installation for this CNG station was $495,550, which is about $155,820 less than the original total budget amount for the project. The Energy Commission grant of $250,000 covered part of the total cost. The match funds contributed by partners and

supporters was more than the minimum of 25 percent of the total allowable cost (approximately $83,300). Table 1 shows the actual expenses compared to the budget.

Table 1: Actual Expenses vs Budget

Task	CTP Grant	Match Share	Actual	Budget
Administration	-	$35,985.43	$35,985.43	$108,662.00
Finalize Design, Plans, and Specifications	-	$5,592.50	$5,592.50	$88,710.00
Equipment Procurement and Delivery	$250,000.00	$69,000.00	$319,000.00	$319,000.00
Construction	-	$135,000.00	$135,000.00	$135,000.00
Operation	-	$0.00	$0.00	$0.00
Data Collection and Analysis	-	$0.00	$0.00	$0.00
TOTAL	**$250,000.00**	**$245,550.93**	**$495,550.93**	**$651,372.00**

Source: Las Gallinas Valley Sanitary District

The natural gas fueling infrastructure project is part of a larger, innovative project that will play an important role in the future of wastewater bioenergy systems in California. The larger project is a new approach for wastewater treatment facilities that will provide a cost-effective and efficient technologically advanced strategy for maximizing on-site bioenergy resources. Figure 2 shows the banner at the site acknowledging Energy Commission funding for this project.

Figure 2: Funding Acknowledgement

Photo Credit: Las Gallinas Valley Sanitary District

CHAPTER 2: Installation and Deployment

The project team began construction at the Smith Ranch Road in February 2016. Grading was done on the site in preparation for paving and foundation installation prior to the receipt of CNG fueling equipment. Piping from the PG&E meter to the fueling station was installed along with secondary-electrical power from the existing source at the Smith Ranch Pump Station. After significant delays in receipt of equipment, the CNG equipment was received and installed on-site in March 2017. Figure 3 shows the aerial view of the new CNG facility.

Figure 3: Aerial View of the new CNG Facility

Photo Credit: Las Gallinas Valley Sanitary District

CNG Fueling Infrastructure

The 15-foot by 7-foot, skid-mounted CNG facility includes a single tower NGD-25 ST Xebec natural gas dryer; a Coltri GL-24-AST000 four-stage reciprocating compressor capable of providing a delivery pressure of 4,000 pounds per square inch gauge at a flow rate of 24 standard cubic feet per minute. Figures 4 and 5 show different views of the CNG infrastructure. The compressor provides filling of the cascade storage tanks. A Greenline GL-

B065 fast-fill control panel with cascade actuator controls filling from the fast-fill cascade tanks. The cascade tanks provide a 120 Gasoline Gallon Equivalent (GGE) Cascade storage capacity with four 30 GGE capacity high pressure cylinders.

Figure 4: CNG Infrastructure Looking South

Photo Credit: Las Gallinas Valley Sanitary District

Figure 5: CNG Infrastructure Looking North

Photo Credit: Las Gallinas Valley Sanitary District

A standalone GreenLine standard high hose CNG dispenser was installed at the station, with no metering capabilities since currently only the District has access to and utilizes the equipment. Should this change in the future, a metered fill post will be installed. To quantify

the volume of CNG used during filling, a flow meter was installed in the supply pipeline to the CNG station. The flow meter shown in Figure 6 provides the amount of CNG fuel, provided in GGE. The Emerson Micro Motion CNG flow meter provides the volume based on an instantaneous reading of mass of the gas traveling through the meter. The new station can store 120 GGE of CNG at 4,000 psig working pressure, and this provides 40 GGE of useable CNG at fast-fill rate. The system fuels a half-filled tank flusher truck within approximately 20 minutes.

Figure 6: Micro Motion Flow Meter

Photo Credit: Las Gallinas Valley Sanitary District

Final Inspection and Testing

The CNG fast-fill station was connected to the PG&E supply in March 2017, and on June 28, 2017, GreenLine, the equipment distributor, inspected the CNG fueling infrastructure and signed off on start-up of the fast-fill CNG station. The test report for the compressor is included in Appendix A.

CHAPTER 3: Usage and Data Collection

Data collection started in August 2017. Prior to the construction of the fast-fill station with this project, the District wastewater treatment plant had a fleet of three diesel-powered Class 6 trucks that are used for operations. The District has now replaced one of the trucks with a CNG-fueled truck. Figure 7 shows a CNG truck fueling at the facility.

Figure 7: CNG Truck Fueling at the Facility

Photo Credit: Las Gallinas Valley Sanitary District

Each of the existing trucks has a 50-gallon fuel tank and are each driven approximately 10,000 miles a year. The trucks are in operation about 1,700 hours a year, during which time they are typically not accumulating mileage, but operating in-place while they perform maintenance work on sewer facilities; therefore, the mileage does not adequately reflect their overall fuel usage. The new CNG trucks will be purchased one at a time by the District, as the District becomes familiar with the CNG station and the use of CNG trucks.

The District has been using the fast-fill station consistently for the last six months, August through March 2018 (the CNG truck was not used in September because of maintenance issues despite the CNG fueling station being available for use). While the station was not operational prior to that time, the CNG truck was available for use and the District was fueling at a CNG station inconveniently located further away. Over a six-month period, there were several inoperative days, which included downtime that resulted in reprogramming of the priority panel to increase efficiency in the discharging of the fueling tanks. However, the District does not track the days that the CNG fueling station was inoperable. In March 2018, the CNG truck underwent maintenance and modifications to the truck accessories. The truck operators have mentioned that they are pleased with the CNG truck's capacity and fuel train

operating capabilities. Table 2 Summarizes data collected from August 2017 to February 2018 from the CNG fueling station project.

Table 2: Monthly Data Collection

Month	Total Runtime Per Month for CNG Truck (Hours)	Number of Days Vehicle Driven	Approximate gallons of CNG per diesel gallon equivalent (DGE) for the month
August 2017	184	23	266
September 2017	0	0	0
October 2017	176	22	139
November 2017	160	20	170
December 2017	160	20	160
January 2018	184	23	194
February 2018	160	20	136

Source: Las Gallinas Valley Sanitary District

Emissions Reductions Calculations

During the six months of data collection, it is estimated that the CNG truck operated for roughly 1,030 hours and used approximately 1,200 GGE of CNG. Based on this information, it is estimated that the CNG truck will operate for 2,050 hours per year and use a total of approximately 2,400 GGE of CNG. This equates to 1.2 GGE per hour (gal/hr) or 1.05 DGE per hour, based on the conversion of 114,000 British thermal units (BTUs) per gallon of gasoline and 128,400 BTUs per gallon of diesel.

Since the District did not track mileage or fuel consumption for the previous diesel truck, it was assumed for emissions offset purposes that the diesel truck operated approximately the same amount of time, 2,050 hours per year, as estimated for the CNG truck. However, since the miles per gallon (mpg) or gallons per hour (gal/hr) are unknown for the diesel truck, the estimate of 1.2 gal/hr was used (based on 2,500 gallons of diesel consumed per year). The estimate is based on the previously estimated consumption of 2,500 diesel gallons per year over 2,050 hours.

Emissions factors for the fuel utilized was derived from Subpart C of the Environmental Protection Agency Mandatory Reporting Greenhouse Gas Rule for diesel and CNG. The emissions factors for the diesel and CNG engines were derived from the California Air Resource Board Executive Orders U-R-001-0228 and A-021-0646-2.

The District's fleet goal is to eventually convert the two remaining diesel trucks to CNG, and potentially purchase a CNG vehicle for general District use. One CNG truck was used to evaluate the annual GHG reductions presented in Table 3. The CNG truck with 300 horsepower (hp) replaced a 255 hp diesel truck.

Table 3: Greenhouse Gas Reductions

Month	DGEs per hour assumed for emissions from CNG Truck (gal/hr)	Particulate Matter (PM) psig displaced by one CNG truck ($PM_{2.5}$ & PM_{10}) (lbs/month)	Oxides of Nitrogen (NOx) displaced by one CNG vehicle (lbs/month)	Carbon Dioxide (CO_2) displaced by CNG vehicles[1]
August 2017	1.04	14	246	1,596
September 2017	-	-	-	-
October 2017	1.04	14	235	834
November 2017	1.04	12	214	1,020
December 2017	1.04	12	214	960
January 2018	1.04	14	246	1,164
February 2018	1.04	12	214	816

Source: Las Gallinas Valley Sanitary District

Because of the difference in engine sizes, the emissions factors for carbon dioxide (CO_2), particulate matter (PM) less than or equal to 10 micrometers in diameter (PM10), non-methane hydrocarbons (NMHC), and nitrogen dioxide (NOx) are presented in Table 4 as lb/hr to normalize the difference in hp output from each engine. The emissions factors provided by the Environmental Protection Agency and CARB executive orders are provided in grams per breaking horse power-hours, and then were normalized to lbs/hr to eliminate the difference in horsepower between the two trucks.

Table 4: Emission Factors

Engine Type	CO_2 (kg/MMBTU)	CH_4 (kg/MMBTU)	N_2O (kg/MMBTU)	CO (lb/hr)	PM_{10} (lb/hr)	NMHC (lb/hr)	NO_x (lb/hr)
Caterpillar C7 Diesel Engine	73.96	3.00E-03	6.00E-04	1.47	0.084	2.77	1.35
Cummins ISL G 300 HP (CNG Engine)	53.02	1.00E-03	1.00E-04	10.25	0.007	0.093	0.013

Source: Las Gallinas Valley Sanitary District

Based on these emissions factors, diesel has a carbon intensity of 21 lbs CO_2/DGE, or approximately 44,700 lbs of CO_2 per year total. Following conversion from diesel to CNG, CNG has a CO_2 emission factor of 15 lbs CO_2/DGE, or approximately 31,960 lbs of CO_2 per year. The conversion of one truck from diesel to CNG results in an approximately 30 percent reduction in CO_2 emissions.

This project represents an estimated annual displacement of approximately 2,500 DGE of diesel fuel, approximately 160 pounds of particulate matter, approximately 2,740 pounds of NO_x, and 12,780 pounds of CO_2.

[1] The Co_2 measured at 21 lbs/DGE for diesel and 15 lbs/DGE for CNG, and the CO_2 emission factors provided in kg/MMBTU were converted based on 128,400 BTU/DGE.

CHAPTER 4: Observations and Challenges

The project is a success and the visibility of a public agency utilizing CNG in the Las Gallinas community provides a positive example of government in action towards a cleaner California. However, the District CNG station is not accessible to the public for several reasons. The small space at the Smith Ranch Road Pump Station makes public accessibility limited and increasing the flow of traffic on the adjacent side street would not be favorable to nearby residents. In addition, while the Smith Ranch Road Pump Station is located within a fence, security of the existing pump station and CNG station is a major consideration.

The PG&E piping connection created a delay in project start-up because the District requested that the Contractor demobilize while the PG&E service upgrade request went through and the waste water treatment plant work was completed. Piping design was refined to accommodate the PG&E space requirements for the new meter.

Civil improvement work such as site grading, retaining wall installation, and concrete pads for equipment foundations also contributed to the delays in completing the project. The District required installation of a retaining wall instead of grading existing ground.

There were significant delays in the fueling station equipment purchase and delivery which ultimately delayed the construction phase by about seven months. Upon delivery and installation, equipment was operational for a day (training) but the site soon realized there was a leak and that the tanks were not providing enough pressure at the dispenser to fill the vehicle. It was also difficult to get the equipment manufacturer, Greenline, on-site to repair and complete the Installation.

CHAPTER 5: Conclusions

This project achieved the District's goals to install a new CNG fueling station to fuel its new CNG truck.

The Energy Commission grant provided the much-needed incentive to support District's efforts to phase out diesel operated trucks and provide a steady supply of CNG as back-up to the Renewable Natural Gas system.

This project is evidence that despite the small scale of the facility, an economical and efficient CNG vehicle program can be achieved for a wastewater treatment facility. The District has several green projects supported by the community, including water reclamation ponds and solar energy production, all within the facility's property. Replacing diesel operated trucks with the cleaner burning CNG not only benefits the District financially in the long run, but allows the District to decrease its air pollution emissions.

The District has every intention of continued operation and utilization of the CNG station for vehicle fueling beyond the terms of the Energy Commission's funding agreement. The District is planning to replace the remainder of its diesel-fueled trucks with CNG-fueled vehicles, which is a significant financial investment.

GLOSSARY

ALTERNATIVE AND RENEWABLE FUELS AND VEHICLE TECHNOLOGY PROGRAM (ARFVTP) – Also known as the Clean Transportation Program, was created by Assembly Bill 118 (Nunez, Chapter 750, Statutes of 2007), the program with an annual budget of about $100 million supports projects that develop and improve alternative and renewable low-carbon fuels, improve alternative and renewable fuels for existing and developing engine technologies, expand transit and transportation infrastructures, and establishing workforce training programs, conduct public education and promotion, and create technology centers, among other tasks.

CALIFORNIA AIR RESOURCES BOARD (CARB or ARB) - The "clean air agency" in the government of California, whose main goals include attaining and maintaining healthy air quality; protecting the public from exposure to toxic air contaminants; and providing innovative approaches for complying with air pollution rules and regulations.

COMPRESSED NATURAL GAS (CNG) - Natural gas that has been compressed under high pressure, typically between 2,000 and 3,600 pounds per square inch, held in a container. The gas expands when released for use as a fuel.

CARBON DIOXIDE (CO2) - A colorless, odorless, non-poisonous gas that is a normal part of the air. Carbon dioxide is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent).

DIESEL GALLON-EQUIVALENT (DGE) - is the amount of alternative fuel it takes to equal the energy content of one liquid gallon of diesel gasoline.

GASOLINE GALLON EQUIVALENT (GGE) - is the amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline. GGE allows consumers to compare the energy content of competing fuels against a commonly known fuel—gasoline. GGE also compares gasoline to fuels sold as a gas (natural gas, propane, and hydrogen) and electricity.[2]

GREENHOUSE GASES (GHG) – Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

HORSEPOWER (HP) - A unit for measuring the rate of doing work. One horsepower equals about three-fourths of a kilowatt (745.7 watts).

LAS GALLINAS VALLEY SANITARY DISTRICT (The District) - Las Gallinas Valley Sanitary District (LGVSD) is located in the Las Gallinas Valley between central San Rafael and Novato.

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[2] Gasoline Gallon Equivalent Definition (https://www.definitions.net/).

In 1955, our original wastewater treatment plant was constructed to address health problems associated with failing septic tanks in Santa Venetia.[3]

NOx -- Oxides of nitrogen that are a chief component of air pollution that can be produced by the burning of fossil fuels. Also called nitrogen oxides.

PG&E - The acronym for Pacific Gas and Electric Company an electric and natural gas utility serving the central and northern California region.

POUNDS PER SQUARE INCH GUAGE (PSIG) - The pressure relative to atmosphere.[4]

[3] Las Gallinas Valley Sanitary District Homepage (http://www.lgvsd.org/about-us/).

[4] Pounds per Square Inch Definition (https://www.energy.gov/eere/bioenergy/full-text-glossary).

APPENDIX A: COMPRESSOR TEST REPORT

CUSTOMER NUMBER: # 11700622

COMPRESSOR TEST REPORT

CUSTOMER: Las Galinas Sanitary **DATE:** 06-28-17

MODEL: GL-24 **S/N:** GLFSC0001170 **PUMP RPM:** 1100

UNIT RECEIVED CLEAN: ☐ **GRADE OF AESTHETIC APPEARANCE:** 1 2 3 4 5 6 7 8 **9** 10

DRIVE TYPE: ELECTRIC ☐ GAS ☐ DIESEL ☐ MAKE: COLTRI MODEL: GL-24 CNG

S/N: SC0011633 HP 15 RPM 1100 SHEAVE N/A BELT YES

HZ 18.3 FULL LOAD AMPS 48 FLA SERVICE FACTOR VOLTS 230 VAC PHASE 3

LUBRICATION: [X] TYPE SNYN OIL CAPACITY 6 Quarts QTS. LEVEL DECAL [X]

OIL PRESSURE 12 PSI OIL TEMPERATURE 108 °F **ROTATION:** [X] ROTATION DECAL [X]

[X] [X] [X]

PRESSURE SWITCH SET@ 4,400 PSI **OVER PRESSURE SET @** 4,400 PSI

LEAK TESTED @ 5,000 PSI **CRANK CASE BLOW BY:** .078 LPM

FLOW RATE: 3,600 PSI (50% RATED PSI) 24 CFM 4,000 PSI (FULL RATED PSI) 20 CFM

VOLTAGE: SHOP ☐ GENERATOR ☐ NO LOAD RUN 230VAC START 49 A/Strt

AMPS: **RUN** **(1)** 46.3 **(2)** 45.5 **(3)** 47.1 **@** 4000 **PSI** (FULL RATED PSI)

RUN (1) 40.8 (2) 40.2 (3) 41 @ 2000 PSI (50% RATED PSI)

START (1) 47 (2) 47.8 (3) 49 (PEAK-INRUSH)

(50% RATED PSI) STAGE PRESSURE (FULL RATED PSI)		AMBIENT TEMP.	(FULL RATED PSI) TEMPERATURE °F (FULL RATED PSI)	
@ PSI	@ 5 PSI	°F	SUCTION	DISCHARGE
PSI	52 PSI	1ST STAGE	210 °F	229 °F
PSI	280 PSI	2ND STAGE	165 °F	194 °F
PSI	976 PSI	3RD STAGE	182 °F	209 °F
PSI	3200 PSI	4TH STAGE	145 °F	176 °F
PSI	PSI	5TH STAGE	°F	°F
CABINET TEMP.	F°	FINAL		°F

AUTO DRAINS: [X] 1 2 **3**

TRAP DISCHARGE: CLEAR [X] SLIGHTLY OILY ☐ VERY OILY ☐ MAYONNAISE ☐

TIMED FILL TEST: 4 HOURS AFTER WARM-UP **FINAL HOUR METER:** 371

TIME: 1 : 25 MIN:SEC (0 3,000 PSI FILL TEST) **TEST BOTTLE SIZE:** 126 SCF

CALCULATED FLOW RATE: 22 SCFM ÷ .60 SEC = 10.4 GPH

AIR TEST: TEST KIT TYPE N/A S/N N/A

4 GAS ANALYZER: O_2 N/A CO N/A CO_2 N/A MOISTURE N/A

DECALS APPLIED: S/N PLATE [X] SAFETY/WARNING [X] GLF CUST☐MER ☐

CRITICAL INFORMATION FILLED OUT BY TECHNIIAN Rev 3.4, 6/28/2017

CUSTOMER NUMBER: # 11700622

COMMENTS ON MACHINE AND/OR REASONS FOR TEST FAILURE:

AREA FOR DIAGRAMS

MACHINE WILL NEED TO BE SET BACK INTO FAST FILL MODE BY PRESSING THE START BUTTON ON THE HMI SCREEN. THIS PROCESS WILL ONLY NEED TO OCCUR WHEN THE MACHINE IS IN A FAULT AND THE OPERATOR CLEARS THE FAULT. THE START BUTTON FOR THE FAST FILL IS LOCATED ON THE BOTTOM LEFT CORNER OF THE MAIN PAGE.

SECOND ISSUE WAS THE GAS TEMP ERROR - THIS IS WAS ADRESSED BY RE-CALIBRATING THE SETPOINTS TO ACCOMODATE A WIDER TEMPERATURE VARIANCE (220- NOW SET TO 260).

MACHINE HAS A TANK OVERPRESSURE SAFEGUARD IN THE PROGRAM THAT MONITORS THE STORAGE PRESSURE. DUE TO TEMPERATURES WE HAVE ADJUSTED THIS SETPOINT TO 4800PSIG. THE TANKS HAVE MANUAL OVERPRESSURE RELIEFS SET @ 5000PSIG.

GREENLINE MADE ADJUSTEMENTS TO THE PRIORITY PANEL ADDING A CHECK VALVE FOR THE DOME LOAD REGULATOR. THIS FIX ACCOMODATED THE NON FULL FILL ISSUE COMPLAINT.

GREENLINE ADDED THE ROOF CANOPY FOR SHADE - LEAK CHECKED THE SYSTEM AND PERFORMED NUMERIOUS TRUCK FILLS TO SHAKE THE SYSTEM DOWN.

MACHINE TESTED BY JUSTIN BEERER **PASS** [X] **FAIL** [ ]

CRITICAL INFORMATION IS IN **RED** **MUST BE FILLED OUT** **BY TECHNICIAN**

APPENDIX B: LAS GALLINAS DIESEL ENGINE CALCULATIONS

Emissions Summary | Diesel Engine | Las Gallinas

Emission Unit	Description	Maximum Engine Horsepower (hp)	Calculated Emissions									
			Criteria Pollutants						HAP		GHG Emissions	
			CO (lb/hr) (tpy)	Nox (lb/hr) (tpy)	PM_{10} (lb/hr) (tpy)	$PM_{2.5}$ (lb/hr) (tpy)	VOC (lb/hr) (tpy)	SO_2 (lb/hr) (tpy)	Total (lb/hr) (tpy)	Maximum Single (lb/hr) (tpy)	CO_2 (lb/hr) (tpy)	CO_{2e} (lb/hr) (tpy)
1	Engine	255.0	1.467	1.349	0.084	0.084	2.767	0.003	5.77E-04	1.86E-04	25.638	25.729
			1.502	1.790	0.086	0.086	2.832	0.003	5.90E-04	1.90E-04	26.241	26.333

Note: Fuel type utilized for this engine is diesel number 2.

Equipment Information	Value
Type	IC Engine
Manufacturer	Caterpillar
Model	C7
Power Output Rating (1)	224 ekW
Mechanical Output Rating (2)	255 hp
Engine Displacement	439.3 in.^3
RPM (1)	2,200 rpm
Volumetric Efficiency (3)	0.9
Fuel Utilized	Diesel

Fuel Information	Value
Diesel Heating Value [LHV] (4)	128,748 Btu/gal
Consumption [per hour] (5)	1.2 gal/hr
Heat Input	.16 MMBtu/hr

Operating Schedule	Value
Hours Per Year (6)	2,047 hr/yr

Exhaust Information	
Temperature (1)	900 deg F
Exhaust flow (1)	2,113 cfm

[1] Manufacturer's specifications. Temperature and exhaust flow typical for this type of engine.

[2] Derived from rated power output derived from California Air Resource Board (CARB) Executive Order (EO) U-R-001-0228 Engine Model Summary Template BHP @ RPM.

[3] Typical for naturally aspirated 2 and 4 cycle diesel engines.

[4] Derived from rated power output based on lower heating value for Number 2 diesel fuel of 18,390 Btu/lb and diesel density of 7.001 lb/gal.

[5] Derived from California Air Resource Board (CARB) EO U-R-001-0228 Engine Model Summary Template Fuel Rate at peak horsepower in lbs/hr converted to gal/hr.

(Diesel gal/hr = 71 / 7.001)

[6] Operations 8 hours a day, Monday through Friday, 7:00 AM to 3:00 PM.

Criteria Pollutants	Value - Emissions
CO (1)	1.47 lb/hr
NOx (1)	1.35 lb/hr
PM10 (1)	0.08 lb/hr
HC (1)	2.77 lb/hr
SO2 (2)	1.70E-02 lb/MMBtu

Criteria Pollutants	Value
CO	1.4673 lb/hr 1.5018 tons/yr
NOx	1.3492 lb/hr 1.3809 tons/yr
PM10	0.0838 lb/hr 0.0858 tons/yr
PM2.5	0.0838 lb/hr 0.0858 tons/yr
VOC	2.7669 lb/hr 2.8319 tons/yr
SO2	0.003 lb/hr 0.0027 tons/yr

[1] CO, NOx, and HC (VOC) Per California Air Resources Board (CARB), Executive Order (EO) U-R-001-0228. NOx value listed as N/A in EO.

[2] SO2 based on Santa Barbara County Air Pollution Control District , Gaseous Fuel SOx Emission Factor, <http://www.sbcapod.org/eng/tech/sulfur01.htm>, 15 November 2013.

GHG Emissions for LPG Engine Combustion

Volume of fuel combusted per year Based on facility data	2,500	gallons/yr
Default high heat value of the fuel	1.287E-01	mmBtu/gallon
CO_2 Emissions		
Fuel-specific default CO_2 emission factor (EF) From Table C-1 of subpart C of Mandatory Reporting of GHG Rule	73.96	Kg CO_2/mmBtu
CO_2 Emissions	24	metric Tons
	26	short tons
Global warming potential for CO_2 (GWP)	1.0	
Convert emissions to CO_2e	23.806	metric tons CO_2e
	26.241	short tons
CH_4 Emissions		
Fuel-specific default CH_4 emission factor (EF) From Table C-2 of subpart C of Mandatory Reporting of GHG Rule	3.00E-03	Kg CH_4/mmBtu
CH_4 Emissions	0.0010	metric Tons
	0.0011	short tons
Global warming potential for CH_4 (GWP)	25	
Convert emissions to CO_2e	0.024	metric tons CO_2e
	0.027	short tons
N_2O Emissions		
Fuel-specific default N_2O emission factor (EF) From Table C-2 of subpart C of Mandatory Reporting of GHG Rule	6.00E-04	Kg N_2O/mmBtu
N_2O Emissions	0.0002	metric Tons
	0.0002	short tons
Global warming potential for N_2O (GWP)	310	
Convert emissions to CO_2e	0.060	metric tons CO_2e
	0.066	short tons
GHG Emissions	**23.890**	metric Tons of CO_2e
	26.333	short tons of CO2e

Heat Input = .16 MMBtu/hr
Mechanical Output = 255 hp

LFG Compound	HAP	VOC	CAS	Emission Factor[1] Fuel Input (lb/MMBtu)	Emissions (lb/hr)	Emissions (tpy)
Benzene	x	x	71-43-2	9.33E-04	1.47E-04	1.50E-04
Toluene (methylbenzene)	x	x	108-88-3	4.09E-04	6.43E-05	6.58E-05
Xylenes (m, o, p)	x	x	1330-20-7	2.85E-04	4.48E-05	4.59E-05
Propylene	--	--	7647-01-0	2.58E-03	4.06E-04	4.15E-04
Formaldehyde	x	x	50-00-0	1.18E-03	1.86E-04	1.90E-04
Acetaldehyde	x	x	75-07-0	7.67E-04	1.21E-04	1.23E-04
Acrolein	x	x	107-02-8	9.25E-05	1.45E-05	1.49E-05
Naphthalene	--	--	2-02-004-01	8.48E-05	1.33E-05	1.36E-05
Total PAH	--	x	--	1.68E-04	2.64E-05	2.70E-05
Total HAP	--	--	--	3.67E-03	5.77E-04	5.90E-04
Maximum Single HAP	--	--	--	1.18E-03	1.86E-04	1.90E-04

[1] AP42 5th Ed., "Compilation of Air Pollutant Emissions Factors, Vol. 1: Gasoline and Diesel Industrial Engines, " Tables 3.4-2, Oct. 1996

Pollutant	Certification Standards[1]			
			Emission Rate	Emission Rate
	(g/Kw-hr)	bhp	(lb/hr)	(g/bhp-hr)
CO	3.5	255	1.467	2.610
PM10	0.2	255	0.084	0.149
NMHC	6.6	255	2.767	4.922
NO_X[2]	1.8	255	1.349	2.400

[1] CO, PM10, and NMHC Per California Air Resources Board (CARB), Executive Order (EO) U-R-001-0228

[2]NOx value not included in EO U-R-001-0228. Value derived from Carl Moyer Program Guidelines Part II of VI, Table 1-3, Nox emissions for Model Year 2004 - 2006.

CO = Carbon Monoxide

Nox = Nitrogen Dioxide

PM10 = Particulate matter less than or equal to 10 micrometers in diameter

NMHC = Non methane hydrocarbons

KW/hr= kilowatts per hour

MW= molecular weight

lb/hr = pounds per hour

deg F to Rankine	459.676
universal gas constant	0.7302 atm-ft3/lb-mol-R
million	1.00E+06
# lb per g	2.20E-03
# minutes per hour	60
# lbs per ton	2000
# lbs per kg	2.205
ppm	1.00E-06
MW SO_2 (lb/lb-mol)	64.066
kW to hp	1.341
lb/MMbtu to Btu/hr-hr	7000
engine efficiency	0.9
4 cycle air intake flow constant	3456
deg F to R	460.00
standard temp, R	540.00
liter to cubic inches	61.02
GWP	
CO2 to CO2	1.00
10^3 gal to gal	0.001
g/bhp-hr to gkW-hr	1.34

APPENDIX C: LAS GALLINAS CNG ENGINE CALCULATIONS

Emission Unit	Description	Maximum Engine Horsepower (hp)	Calculated Emissions									
			Criteria Pollutants						HAP		GHG Emissions	
			CO (lb/hr) (tpy)	NO_x (lb/hr) (tpy)	PM_{10} (lb/hr) (tpy)	$PM_{2.5}$ (lb/hr) (tpy)	VOC (lb/hr) (tpy)	SO_2 (lb/hr) (tpy)	Total (lb/hr) (tpy)	Maximum Single (lb/hr) (tpy)	CO_2 (lb/hr) (tpy)	CO_{2e} (lb/hr) (tpy)
1	Engine	300.0	10.251	0.013	0.007	0.007	0.093	0.002	9.03E-03	7.08E-03	13.884	13.898
			10.662	0.014	0.007	0.007	0.096	0.002	9.39E-03	7.37E-03	14.439	14.454

Equipment Information	Value
Type	IC Engine
Manufacturer	Cummins
Model	ISL G 300 HP
Power Output Rating (1)	224 ekW
Mechanical Output Rating (2)	300 hp
Engine Displacement	543.1 in.^3
RPM (1)	2,100 rpm
Volumetric Efficiency (3)	0.9
Fuel Utilized	CNG

Fuel Information	Value
Diesel Heating Value [LHV] (3)	128,748 Btu/gal
Consumption (4,5)	1.04 gal/hr
Heat Input	.13 MMBtu/hr

Operating Schedule	Value
Hours Per Year (5)	2,080 hr/yr

Exhaust Information	
Temperature (1)	900 deg F
Exhaust flow (1)	2,493 cfm

[1] Manufacturer's specifications. Temperature and exhasut flow typical for this type of engine.

[2] Typical for naturally aspirated 2 and 4 cycle diesel engines.

[3] Derived from rated power output based on lower heating value for diesel of 128,748 BTU/gal.

[4] Derived from total usage as reported by site divided by available working hours in August 2017 through February 2018. No fuel was utilized in September 2017, per site.

[5] Operations 8 hours a day, Monday through Friday, 7:00 AM through 3:00 PM.

Criteria Pollutants	Value - Emissions
CO (1)	10.25 lb/hr
NOx (1)	0.01 lb/hr
PM10 (1)	0.01 lb/hr
HC (1)	0.09 lb/hr
SO2 (2)	1.70E-02 lb/MMBtu

Criteria Pollutants	Value
CO	10.2515 lb/hr 10.6615 tons/yr
NOx	0.0132 lb/hr 0.0138 tons/yr
PM10	0.0066 lb/hr 0.0069 tons/yr
PM2.5	0.0066 lb/hr 0.0069 tons/yr
VOC	0.0926 lb/hr 0.0963 tons/yr
SO2	0.002 lb/hr 0.0024 tons/yr

[1] CO, NOx, and HC (VOC) Per California Air Resources Board (CARB), Executive Order (EO) A-021-0646-2.

[2] SO2 based on Santa Barbara County Air Pollution Control District , Gaseous Fuel SOx Emission Factor, <http://www.sbcapcd.org/eng/tech/sulfur01.htm>, 15 November 2013.

3 VOC emissions not provided in EO A-021-0646-2.

GHG Emissions for LPG Engine Combustion

Volume of fuel combusted per year Based on facility data	2,167	gallons/yr
Default high heat value of the fuel	1.140E-01	mmBtu/gallon
CO_2 Emissions		
Fuel-specific default CO_2 emission factor (EF) From Table C-1 of subpart C of Mandatory Reporting of GHG Rule	53.02	Kg CO_2/mmBtu
CO_2 Emissions	13	metric Tons
	14	short tons
Global warming potential for CO_2 (GWP)	1.0	
Convert emissions to CO_2e	13.099	metric tons CO_2e
	14.439	short tons
CH_4 Emissions		
Fuel-specific default CH_4 emission factor (EF) From Table C-2 of subpart C of Mandatory Reporting of GHG Rule	1.00E-03	Kg CH_4/mmBtu
CH_4 Emissions	0.0002	metric Tons
	0.0003	short tons
Global warming potential for CH_4 (GWP)	25	
Convert emissions to CO_2e	0.006	metric tons CO_2e
	0.007	short tons
N_2O Emissions		
Fuel-specific default N_2O emission factor (EF) From Table C-2 of subpart C of Mandatory Reporting of GHG Rule	1.00E-04	Kg N_2O/mmBtu
N_2O Emissions	0.0000	metric Tons
	0.0000	short tons
Global warming potential for N_2O (GWP)	310	
Convert emissions to CO_2e	0.008	metric tons CO_2e
	0.008	short tons
GHG Emissions	**13.113**	metric Tons of CO_2e
	14.454	short tons of CO2e

Heat Input = .13 MMBtu/hr
Mechanical Output = 300 hp

LFG Compound	HAP	VOC	CAS	Emission Factor[1] Fuel Input (lb/MMBtu)	Emissions (lb/hr)	Emissions (tpy)
Benzene	x	x	71-43-2	4.40E-04	5.90E-05	6.14E-05
Toluene (methylbenzene)	x	x	108-88-3	4.08E-04	5.47E-05	5.69E-05
Xylenes (m, o, p)	x	x	1330-20-7	1.84E-04	2.47E-05	2.57E-05
Formaldehyde	x	x	50-00-0	5.28E-02	7.08E-03	7.37E-03
Acetaldehyde	x	x	75-07-0	8.36E-03	1.12E-03	1.17E-03
Acrolein	x	x	107-02-8	5.14E-03	6.90E-04	7.17E-04
Naphthalene	--	--	2-02-004-01	7.44E-05	9.98E-06	1.04E-05
Total PAH	--	x	--	2.69E-05	3.61E-06	3.75E-06
Total HAP	--	--	--	**6.73E-02**	9.03E-03	9.39E-03
Maximum Single HAP	--	--	--	**5.28E-02**	7.08E-03	7.37E-03

[1] AP42 5th Ed., "Compilation of Air Pollutant Emissions Factors, Vol. 1: Natural Gas-fired Reciprocating Engines, " Tables 3.2-2, Oct. 1996.

Pollutant	Certification Standards[1]			
			Emission Rate	Emission Rate
	(g/bhp-hr)	bhp	(lb/hr)	(g/Kw-hr)
CO	15.5	300	10.251	11.558
PM10	0.01	300	0.007	0.007
NMHC	0.14	300	0.093	0.104
NO_X	0.02	300	0.013	0.015

[1] CO, PM10, NMHC, and NOx Per California Air Resources Board (CARB), Executive Order (EO) A-021-0646-2

CO = Carbon Monoxide

Nox = Nitrogen Dioxide

PM10 = Particulate matter less than or equal to 10 micrometers in diameter

NMHC = Non methane hydrocarbons

KW/hr= kilowatts per hour

MW= molecular weight

lb/hr = pounds per hour

deg F to Rankine	459.676
universal gas constant	0.7302 atm-ft3/lb-mol-R
million	1.00E+06
# lb per g	2.20E-03
# minutes per hour	60
# lbs per ton	2000
# lbs per kg	2.205
ppm	1.00E-06
MW SO_2 (lb/lb-mol)	64.066
kW to hp	1.341
lb/MMbtu to Btu/hr-hr	7000
engine efficiency	0.9
4 cycle air intake flow constant	3456
deg F to R	460.00
standard temp, R	540.00
liter to cubic inches	61.02
GWP	
CO2 to CO2	1.00
10^3 gal to gal	0.001
g/bhp-hr to gkW-hr	1.34