Solids Handling Alternatives Analysis and Cogeneration Evaluation – Master Plan Update

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Sign-off Sheet

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Table of Contents

1.0 BACKGROUND 1

2.0 SOLIDS DRYING ANALYSIS 2

3.0 HAULING COSTS AND CLASSIFICATION OF BIOSOLIDS 5
3.1 BIOSOLIDS DISPOSAL COST BENCHMARKING 5
3.2 BIOSOLIDS CLASSIFICATION ANALYSIS 8

4.0 COGENERATION EVALUATION 10
4.1 PLANT POWER DEMAND ANALYSIS 10
4.2 COGENERATION EVALUATION UPDATE 13
4.2.1 Unit Sizing 13
4.2.2 Pre-treatment and Monitoring 13
4.3 COGENERATION COST SUMMARY 15

5.0 CONCLUSIONS 17

LIST OF TABLES

Table 1 Sludge Drying Process Description 2
Table 2 Annualized Costs Comparison Summary 3
Table 3 Life Cycle Costs Comparison for Alternative 1A and 1B 4
Table 4 Life Cycle Costs Comparison for Alternative 2A and 2B 4
Table 5 Biosolids Handling Survey 6
Table 6 Annual Hauling Cost Comparison 8
Table 7 Co-generation Design Criteria 13
Table 8 Biogas Analysis 14
Table 9 Co-generation Capital and Annual O&M Cost 15
Table 11 Ten-year ROI Analysis Summary with Credit from IID 16
Table 12 Ten-year ROI Analysis Summary with No Credit from IID 16

LIST OF FIGURES

Figure 1 Alternative 1A - Existing Operation with Sludge Drying Bed 1
Figure 2 Alternative 2A – Proposed Operation with Sludge Drying Bed 1
Figure 3 Unit Cost for Hauling 8
Figure 4 Plant Monthly Power Consumption Profile 12
Figure 5 Energy Utilization Process Flow Diagram 15

LIST OF APPENDICES

Appendix A Solids Mass Balance Analysis
Appendix B Biosolids Regulations for Class A Requirements
Appendix C Biogas Sample Laboratory Report
Appendix D Energy Calculation and Cost Estimate

Appendix E Vendor Quotes and Additional Information
Appendix F Solids Handling Equipment Maintenance Record

1.0 BACKGROUND

In 2015, Stantec prepared a Water Reclamation Facility Master Plan (Master Plan), and provided treatment upgrade recommendations, phasing, and anticipated costs based on projected wastewater flow and load trends. The goal of this Technical Memorandum (TM) is to investigate further two key components of the Master Plan:

- Solids handling employing drying beds
- Co-generation incorporating the impact of solar panels installed after the Master Plan was complete

Currently the solids handling system processes primary sludge (PS) from the primary clarifiers, and waste activated sludge (WAS) from the activated sludge process (ASP). The PS and the WAS are currently pumped, respectively, to the digester and to Pond 2 for stabilization and solids reduction. The digested sludge (DS) from the digester is then pumped to the belt filter presses, and to the sludge drying beds. Dredges are used to move the stabilized WAS from the oxidation Pond 2 to the belt presses. Biosolids are dried for up to 16 to 18 months before being hauled by a solids contractor for ultimate disposal.

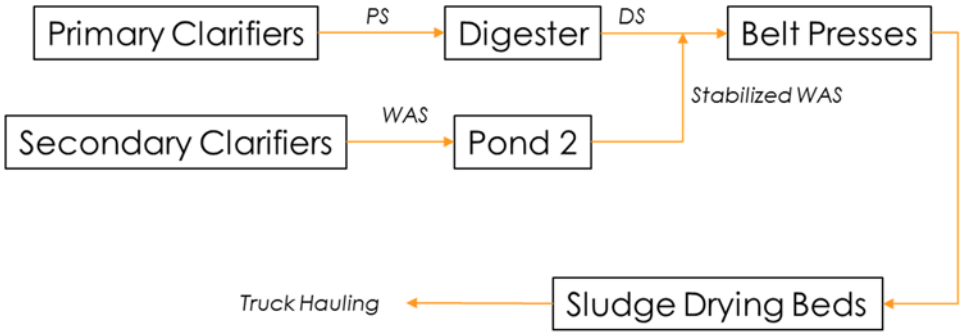


Figure 1 Alternative 1A - Existing Operation with Sludge Drying Bed

Operating the drying beds is labor intensive and requires heavy earth-moving equipment that is expensive to maintain and replace. In addition, per phase 2.b of the master plan, WAS thickeners will be installed to decommission Pond 2 during Phase 2.c and expand the sludge drying beds to the south of the existing drying bed (on the east side of the plant). One additional digester will be added, along with a sludge holding tank and a gas storage unit, and thickened WAS (TWAS) will be sent to the digesters.

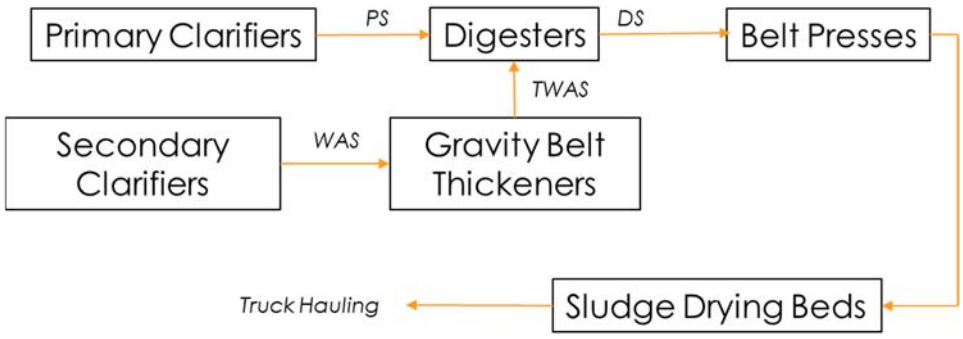


Figure 2 Alternative 2A – Proposed Operation with Sludge Drying Bed

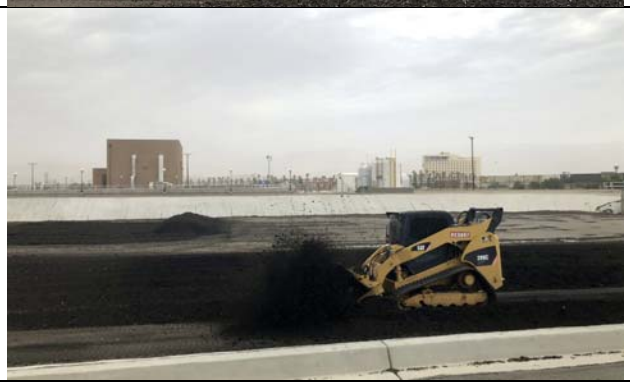
One alternative would be to haul dewatered sludge (wet cake) directly off the belt presses without drying. This would require less equipment and labor to operate and maintain on one hand, but also significantly increase the total mass of sludge to be hauled on the other hand, and hence its hauling cost.

This TM evaluates that alternative and compares it to using sludge drying beds both under current and future (post Phase 2.c) operations. It also provides benchmarking for cake (dried or wet) hauling costs for various Southern California wastewater agencies. Finally, it provides an update to the co-generation feasibility evaluation, and takes into account latest Plant improvements (solar power) and latest co-generation equipment capital costs. Digester gas sampling was conducted to refine the cost of gas treatment upstream of co-generation.

2.0 SOLIDS DRYING ANALYSIS

Current sludge drying operations are described in **Table 1**

Table 1 Sludge Drying Process Description

Equipment Description	Equipment
2009 Ford Dump Truck 750 Collects cake from beltpress conveyor and dumps it in to sludge drying bed. **Capital Cost: $30,085** **Annual O&M Cost: $2,022**	
2015 Kabota 4WD Tractor Spreads the cake sludge evenly on the drying beds **Capital Cost: $40,207** **Annual Operation Cost: $2,703**	
2009 CAT Skid Steer Utilized for disking the solids and turning them over on a daily basis to speed drying. **Capital Cost: $56,030** **Annual Operation Cost: $3,766**	

Equipment Description	Equipment
2017 CAT Loader 926M Used to collect dried sludge into piles or windrows. **Capital Cost: $168,278** **Annual Operation Cost: $11,311**	

Eliminating the sludge drying bed operations, and hauling wet cake instead of drying on-site will lead to:

- **Increased hauling cost:** Hauling wet sludge is more expensive than hauling dewatered sludge on a unit cost basis. Undigested wet cake typically falls under unclassified biosolids, with a $49.49/ton hauling cost under the current contract, compared to $44.49/ton for Class B biosolids (current operations). The percentage of solids in wet cake is only 16%, compared to 96% (and above) percentage solids for dried solids. Therefore, the total mass of wet cake to be hauled per year is:
    - Current operation: 6,720 tons wet cake compared to 1,100 tons[1] per year for dried solids
    - Post Phase 2C: 5,062 tons compared to 828 tons per year for dried solids. The yearly solids production is anticipated to be lower than the current production due to improved VSS reduction (compared to VSS reduction in the Ponds) for the thickened WAS sent to the digesters.
- **Decreased operational and equipment replacement costs:** A list of equipment required for sludge drying is represented in **Table 1.** Excluding sludge drying operations would reduce O&M costs, including labor for the equipment operations and maintenance. VSD engages approximately 800 hours per year for their current solids drying operations (assuming 16 hours per week), which would be halved to approximately only 400 hours per year without the sludge drying bed process.[2] It would also save the District future replacement cost of the equipment at the end of its useful life.

A complete life cycle cost analysis for current and future operations, with and without drying beds is summarized in **Table 2.** Further detail is provided in **Table 3** and **Table 4**. Operating without sludge drying beds would be less economical now, as well as after the implementation of Phases 2.b and 2.c.

Table 2 Annualized Costs Comparison Summary

	With sludge drying bed ($/year)	Without sludge drying beds ($/year)
Current operations	189,000	358,000
Future operations (TWAS sent to digesters)	177,000	276,000

[1] It should be noted that reported dried solids yearly production (600-700 tons/year) represents approximately 50% of the anticipated production calculated via a Plant mass balance. It is believed that an inventory of solids is slowly building up in the Ponds, which is consistent with observation from operation staff. For consistent costs comparison, calculated dried solids production quantities have been used in this TM instead of reported quantities. A detailed mass balance calculation is provided in **Appendix A**.

[2] For wet cake hauling option assumption is that hauler provides trailers for VSD staff to move as needed to level the load and move full and empty trailers.

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Table 3 Life Cycle Costs Comparison for Alternative 1A and 1B

		ALTERNATIVE 1A – CURRENT OPERATIONS					ALTERNATIVE 1B – CURRENT CONFIGURATION W/O SLUDGE DRYING			
ITEM	**UNITS**	**QUANTITY**	**COST PER UNIT**	**ITEM COST**	**LIFE SPAN (YEARS)**	**ANNUALIZED COST[3]**	**QUANTITY**	**COST PER UNIT**	**ITEM COST**	**ANNUALIZED COST**
CAPITAL COST										
Equipment										
2015 Kabota 4WD Tractor	ea	1	$ 40,207	$ 40,207	20	$ 2,703	0	$ 40,207	**$ -**	$ -
2009 CAT Skid Steer	ea	1	$ 56,030	$ 56,030		$ 3,766	0	$ 56,030	**$ -**	$ -
2009 Ford Dump Truck 750	ea	1	$ 30,085	$ 30,085		$ 2,022	0	$ 30,085	**$ -**	$ -
2017 CAT Loader 926M	ea	1	$ 168,278	$ 168,278		$ 11,311	0	$ 168,278	**$ -**	$ -
Equipment Subtotal				**$ 295,000**		**$ 20,000**			**$ -**	$ -
TOTAL COST				**$ 295,000**		**$ 20,000**			**$ -**	**$ -**
ANNUAL O&M COST										
Operations Labor	man hrs	832	$ 60	$ 49,920	N/A	$ 49,920	416	$ 60	$ 24,960	$ 24,960
Maintenance Labor	man hrs	42	$ 60	$ 2,520		$ 2,520	0	$ 60	$ -	**$ -**
Fuel Costs	gallons	220	$ 5	$ 990		$ 990	0	$ 5	$ -	**$ -**
Hauling Cost	ton	1100	$ 44	$ 48,939		$ 48,939	6720	$ 49	$ 332,573	$ 332,573
Maintenance Materials & Contracts				$ 65,763		$ 65,763			$ -	$ -
Total Annual O&M Cost				**$ 169,000**		**$ 169,000**			**$ 358,000**	**$ 358,000**
					Total Annualized Cost	$ 189,000			**Total Annualized Cost**	$ 358,000

Table 4 Life Cycle Costs Comparison for Alternative 2A and 2B

		ALTERNATIVE 2A – FUTURE CONFIGURATION (TWAS TO DIGESTERS)					ALTERNATIVE 2B – FUTURE CONFIGURATION (TWAS TO DIGESTERS) W/O SLUDGE DRYING BED			
ITEM	**UNITS**	**QUANTITY**	**COST PER UNIT**	**ITEM COST**	**LIFE SPAN (YEARS)**	**ANNUALIZED COST[2]**	**QUANTITY**	**COST PER UNIT**	**ITEM COST**	**ANNUALIZED COST**
CAPITAL COST										
Equipment										
2015 Kabota 4WD Tractor	ea	1	$ 40,207	$ 40,207	20	$ 2,703	0	$ 40,207	**$ -**	$ -
2009 CAT Skid Steer	ea	1	$ 56,030	$ 56,030		$ 3,766	0	$ 56,030	**$ -**	$ -
2009 Ford Dump Truck 750	ea	1	$ 30,085	$ 30,085		$ 2,022	0	$ 30,085	**$ -**	$ -
2017 CAT Loader 926M	ea	1	$ 168,278	$ 168,278		$ 11,311	0	$ 168,278	**$ -**	$ -
Equipment Subtotal				**$ 294,600**		**$ 19,802**			**$ -**	$ -
TOTAL COST				**$ 295,000**		**$ 19,802**			**$ -**	**$ -**
ANNUAL O&M COST										
Operations Labor	man hrs	832	$ 60	$ 49,920	N/A	$ 49,920	416	$ 60	$ 24,960	$ 24,960
Maintenance Labor	man hrs	42	$ 60	$ 2,520		$ 2,520		$ 60	$ -	$ -
Fuel Costs	gallons	220	$ 5	$ 990		$ 990		$ 5	$ -	$ -
Hauling Cost	ton	828	$ 44	$ 36,838		$ 36,838	5062	$ 49	$ 250,518	$ 250,518
Maintenance Materials & Contracts				$ 65,763		$ 65,763			$ -	$ -
Total Annual O&M Cost				**$ 157,000**	**$ -**	**$ 157,000**			**$ 276,000**	**$ 276,000**
					Total Annualized Cost	$ 177,000			**Total Annualized Cost**	$ 276,000

[3] Annualized cost evaluated based on an interest rate of 3 percent and a discount rate of 4 percent

3.0 HAULING COSTS AND CLASSIFICATION OF BIOSOLIDS

3.1 BIOSOLIDS DISPOSAL COST BENCHMARKING

A biosolids survey was conducted among publicly owned agencies in the same geographical area and/or similar capacity to Valley Sanitary District. The goal of this survey was to identify current trends in hauling costs in the Plant vicinity and provide insight to the District for upcoming hauling contract negotiation. Results of the survey pertaining to the disposal methods employed by agencies for biosolids management are reported in **Table 5** below. The on-site methods employed by agencies to dewater biosolids prior to final use included: belt presses only (15% - 18% solids), drying ponds (80% - 90% solids) and concrete drying pads (90% - 95% solids).

Additional information gathered from the agencies was for the type of biosolids being hauled and if they co-digested high strength feed stock with biosolids. Most of the agencies tested for Class B or Sub-Class B solids except for Victor Valley Water Reclamation Authority (VVWRA) which tested for Class A solids. VVWRA also responded that they currently perform co-digestion to enhance their methane gas production by adding Fats, Oils and Grease (FOG) and Anaerobically Digestible Materials (ADM), i.e., primarily food waste. The quantity of biosolids produced by agency is summarized **Table 5**

As shown in **Table 5,** the most prevalent technology or disposal method utilized by reporting agencies was composting and land application. Unit cost for hauling for each agency is represented in **Figure 3.** It is noted that VSD pays less for hauling when compared other agencies. However, hauling cost may increase in the future due to expiration of the current contract with the hauling company. New contract proposals will be solicited.

Finally, testing for Class A biosolids can help save on disposal cost as well. Biosolids classification is discussed in Section 3.23.1 .

Table 5 Biosolids Handling Survey

	Name of the Agency	Agency Contact Information	Facility Avg Flow, mgd	Type of Biosolids Hauled	Hauled Biosolids Percent Solids	Yearly Dry Solids, ton per mgd	No. of Trailers	Ownership of the Trailers	Hauling Services Contact Info	Unit Cost for Hauling	Where is Biosolids. Hauled	Sludge End Use	Fog Facility
1	Valley Sanitary District (VSD)	Joseph Glowitz General Manager 45-500 Van Buren, Indio CA 92201 (760) 58-5400	5.9 to 6.0	Primary - Anaerobically digested; WAS – stabilized Class B	90-95%	112	-	Terra Renewal (Solid Solutions), Garden Grove	Terra Renewal (Solid Solutions)	$44.49/ton	Yuma, Arizona	Desert Ridge Farms	No
2	Coachella Valley Water District (CVWD)	Armando Rodriguez (760) 398-2661 arodriguez@cvwd.org Jose Medina (760) 391-9600x3650 jpatmedina@cvwd.org	10	Undigested Sub-Class B	19%	234	28 trailers per week	Terra Renewal	Ed-Co-AZ-Soils	$50.64/ton	Arizona	Composting	No
3	City of El Centro	Felix Deleon Supervisor, WWT Division (760) 337-9053 fdeleon@ecpw.org	3.5	Anaerobically Digested Class B	15-18% from belt press, 90-95% from concrete pads	163	Solids are piled and hauled off annually	Western Express	Skousan Farms	Not disclosed	Arizona	Land Application	No
4	Elsinore Valley Municipal Water District (EVMWD)	Parag Kalaria Water Resources Manager Elsinore Valley Municipal Water District 31315 Chaney Street, Lake Elsinore, CA 92530 (951) 674-3146 Ext. 8201 pkalaria@evmwd.net	6	Undigested Sub-Class B	18%	455	55 trailers/ month	GIC Transport 2055 McKee Rd. Bakersfield, CA 93313 (661) 397 - 0605	Synagro 435 Williams Court, Set 100 Baltimore, MD 21220 (443) 489 - 9000	$52.00/ ton	Arizona	Co-Compost application	No
5	City of Palm Springs	Doug Loar Plant Manager (760) 459-6395 douglas.loar@veolia.com	5.861	Anaerobically digested Class B	86%	388	113 trailers per year	GIC Transport 2055 McKee Rd. Bakersfield, CA 93313 (661) 397 - 0605	Synagro 435 Williams Court, STE 100 Baltimore, MD 21220 (443) 489 - 9000	$45.97/ton	Arizona	Compost	No
6	Rancho California Water District (RCWD)	Randy A. Neff 42135 Inchester Road, Temecula, CA 92589-9017 (951) 296-6988 neffr@ranchowater.com	2.591	Aerobic Sludge Sub-Class B	13%	244	4 trailers per week	GSI (subcontractor for Nursery Products)	Synagro dba Nursery Products, 14479 Cougar Rd, Helendale, CA 92342	$50.00/ ton	Arizona Soils, 41326 McVay Rd, Vicksburg, AZ 85348	Composting	No

	Name of the Agency	Agency Contact Information	Facility Avg Flow, mgd	Type of Biosolids Hauled	Hauled Biosolids Percent Solids	Yearly Dry Solids, ton per mgd	No. of Trailers	Ownership of the Trailers	Hauling Services Contact Info	Unit Cost for Hauling	Where is Biosolids. Hauled	Sludge End Use	Fog Facility
7	Inland Empire Utilities Agency (IEUA)	Shaun Stone Manager of Engineering Inland Empire Utilities Agency 6075 Kimball Ave / Chino, California 91708 (909) 993-1622 sstone@ieua.org	41.7	Anaerobically digested Class B	15% (1st plant). 24% (2nd plant). 19-20% (Average)	257	10 trailer per day	Viramontes Express 17130 Hellman Ave Corona, CA 92880 909-597-7232	Viramontes Express 17130 Hellman Ave Corona, CA 92880 909-597-7232	$60/ton ($56 + tip fee $5-6)	Rancho Cucamonga, CA	Composting for Landscape and Agriculture	No
8	Victor Valley Water Reclamation Authority (VVWRA)	Logan Olds General Manager 20111 Shay Road Victorville CA 92394 (760) 246-8638 lolds@vvwra.com	10.5	Anaerobically digested Class A	87-92% solids from the drying ponds	429	---	Athens Services, Los Angeles	American Organics – Bakersfield, CA	Pays nothing.	---	Land Application	Yes, VVWRA has FOG and ADM facility. Source is primarily from restaurants and prison. No meat products added.
9	City of Rialto	Thomas Crowley (909) 820-2602 tjcrowley@rialtoca.gov	6.8	Anaerobically Digested Class B	13%	463	2 trailers per day	GIC	Synagro	$48/wet ton	Arizona	Agricultural use and Composting	Yes, 8000 gallons per day, contracted with Liquid Environmental

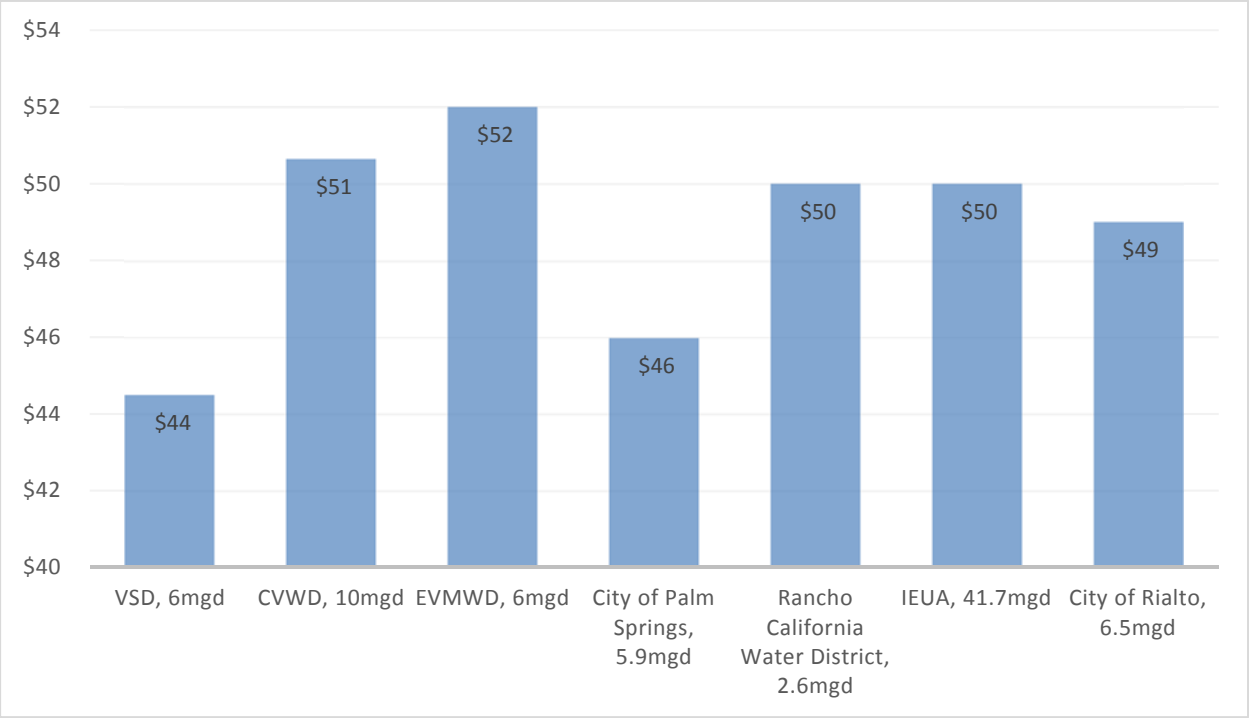

Figure 3 Unit Cost for Hauling

3.2 BIOSOLIDS CLASSIFICATION ANALYSIS

Higher level classification for biosolids is beneficial in reducing the hauling cost. VSD's current contract with hauling services indicate that it would cost $49.49/ton for unclassified solids, $44.49/ton for Class B solids and $35.49/ton for Class A solids. Anticipated yearly hauling cost with various biosolids classifications are summarized in Error! Reference source not found.**Table 6.**

Table 6 Annual Hauling Cost Comparison

	Sub-class B	Class B	Class A
Annual hauling cost	$54,000	$49,000	$39,000

Current operation at VSD produces Class B biosolids. Thanks to anaerobic digestion and solids air drying, the Environmental Protection Agency (EPA) Part 503 rule is met, i.e. pathogenic organisms are significantly reduced to less than two million Most Probably Number per gram of total dry solids (2,000,000 MPN/g TS) or less than two million Colony Forming Units per gram of total dry solids (2,000,000 CFU/g TS).

Complying with Class A biosolids, under the current rates, would save the District approximately $10,000/year, and could be met by testing and meeting the pathogen density limits in Part 503 rule. According to Part 503 rule, one of the following criteria must be met at the time of land disposal:

1. A Fecal coliform density less than 1,000 Most Probable Number (MPN) per gram of total dry solids (1,000 MPN/g TS) or

2. A Salmonella sp. density less than 3 Most Probably Number (MPN) per 4 grams of total dry solids (3 MPN/4g TS).

In addition, one of the following alternatives must be met:

1. Time/Temperature - An increased sewage sludge temperature should be maintained for a prescribed period according to the guidelines described in Part 503. One example required 130 deg F in a thermophilic anaerobic digester for 12 days, followed by a few more days at mesophilic temperatures (95 deg F) to achieve the required VSS reduction,[4] but the parameters are highly dependent on particle size, mixing, and other factors.

2. Alkaline Treatment - The pH of the sewage sludge is raised to greater than 12 for at least 72 hours. During this time, the temperature of the sewage sludge should be greater than 52°C for at least 12 hours. In addition, after the 72-hour period, the sewage sludge is to be air dried to at least 50% total solids.

3. Prior Testing for Enteric Virus/Viable Helminth Ova - The sewage sludge is analyzed for the presence of enteric viruses (Plaque-forming units) and viable helminth ova.

4. Biosolids have been treated by a Process to Further Reduce Pathogens (PFRP) or PFRP equivalent process. These include:

    a. Composting (certain time and temperature requirements must be met)

    b. Heat Drying

    c. Heat Treatment

    d. Thermophilic Aerobic Digestion (e.g. Autothermic Thermophilic Aerobic Digestion

    e. Beta Ray Irradiation

    f. Gamma Ray Irradiation

    g. Pasteurization – 158 deg F for 30 minutes

VSD meets Class B pathogen reduction by anaerobically digesting the sludge at 95 degrees F with a solids residence time of 15 days or more. However, VSD could explore the feasibility of producing Class A biosolids through solar

[4] Lee, Hansong, et. al, *Hyperion Thermophilic Experiment – Full Scale Thermophilic Sludge Dewatering* (white paper), 2001.

drying. The first step would be to test for both Salmonella and Fecal coliform of the dried solids. Refer to **Appendix B** for Biosolids Regulations for Class A requirements.

4.0 COGENERATION EVALUATION

The feasibility of co-generation at VSD's water reclamation facility depends on the following:

- The quantity of biogas available for power generation – this will significantly increase once WAS is thickened (via Gravity Belt Thickeners [GBTs]) and sent to the digesters for stabilization (per Alternatives 2.b and 2.c of the Master Plan). Biogas production has been stable since the Master Plan (approximately 63,0000 cf/day on average for primary sludge only) and is anticipated to increase to 106,000 cf/day once TWAS is sent to the digesters.

- The Plant power demand: The Plant power costs are currently offset by less expensive solar power bought from Tesla's solar facility (solar panels on VSD property) via a Purchase Power Agreement (PFA). An in-depth analysis of power demand is presented below.

- The capital cost, O&M cost, and power generation capacity of the co-generation engine installed. Based on recent equipment quotes, an updated Return-on-Investment (ROI) analysis is presented later in this section.

4.1 PLANT POWER DEMAND ANALYSIS

Plant energy consumption data collected is presented on **Figure 4**. It shows that even if a large amount of energy is provided by the solar power generation system, a significant amount of energy is purchased from the utility (Imperial Irrigation District [IID]) to meet the remaining monthly Plant energy demand. Some solar energy is also exported back to the grid most months, which indicates that solar power generation exceeds the Plant demand at times during the daylight hours.

Based on the data available[5], the following assumptions were made to evaluate the co-generation feasibility at a planning level:

- During prime solar production hours, i.e. from 8:00 am to 4:00 pm, solar is producing enough power to meet the Plant's demand. Any additional energy produced during that time (by a co-generation engine for instance) would have to be exported to the grid. Energy costs that given month could be offset by up to 9.3 cts/kWh, which is the demand charge currently billed by the utility to the District and is also the credit currently received for any excess solar power sent back to the grid. This assumes that VSD would receive the same credit from the power utility for any additional power exported to the grid, which would need to be verified with the utility.

- Outside of the solar-producing hours, from 4:00 pm to 8:00 am, the solar power generation system is not producing energy. Any energy produced during that time would be used by the Plant first, and any excess exported to the grid. This would offset the Plant energy costs that given month by 11.5 cts/kWh produced

[5] A more refined analysis would require hourly Plant power demand and solar generation data.

(assuming all power produced is consumed by the Plant), which is on average the unit cost paid by the District for the power purchased directly from the utility.

Based on the energy data received, the average net energy monthly consumption from the utility is 277,900 kWh. This is equivalent to an average power demand of 386 kW. This means that as long as the co-generation system size is smaller than 386 kW, the power generated would be used by the Plant during non-solar production. The Plant would save approximately $0.115/kWh 16 hours/day, and $0.093/kWh 8 hours/day[6].

In the worst case scenario, IID would not credit VSD for additional power (generated by co-gen) exported to the grid. In that case, the Plant would only save approximately $0.115/kWh 16 hours a day.

[6] Assumes that IID will reduce VSD's electricity bill for surplus power exported to the grid.

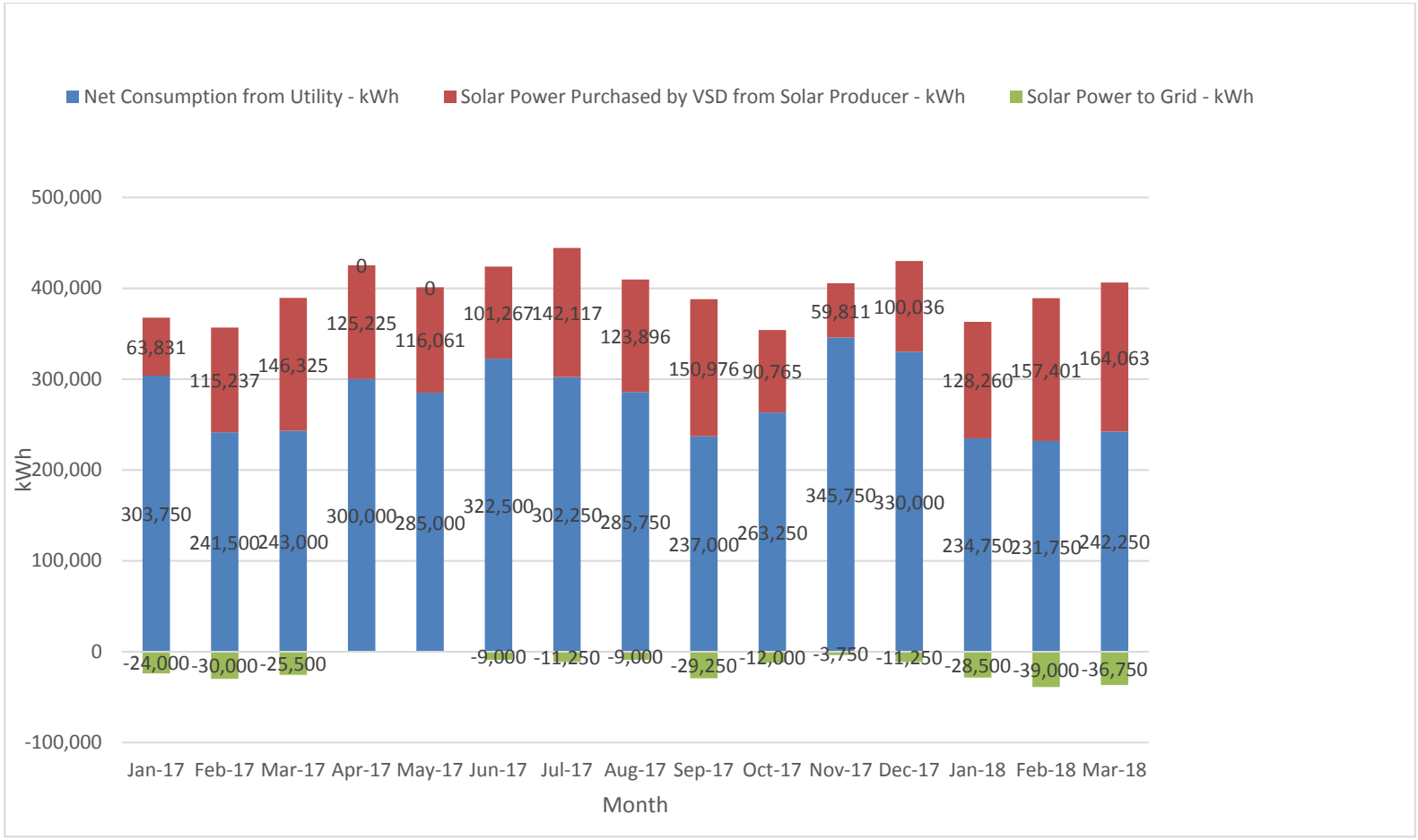

Figure 4 Plant Monthly Power Consumption Profile

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4.2 COGENERATION EVALUATION UPDATE

4.2.1 Unit Sizing

Under current operations, the anaerobic digestion of only primary sludge produces an average of 63,000 cubic foot per day of biogas. If used to run an Internal Combustion Engine (ICE), this fuel gas would generate enough heat to meet the heat demand of the digester and produce on average 177 kW. For this analysis, quotes from Western Energy Systems (vendor) were obtained for several sizes of 2G (system manufacturer) Containerized ICE. A 250-kW engine (smallest model available) was selected. ICE engines typically have a 50% turndown ratio, so the selected engine would be able to accommodate the current biogas production, as well as daily gas production fluctuations. However, digester gas storage as planned under Phase 2c would provide equalization of gas intake at the proposed ICE.

In the future, TWAS will be sent to the two digesters (one existing, one new) and will increase the biogas production to 106,000 cubic foot per day. If used to run an ICE, this would generate enough heat to meet the heat demand of two digesters and generate on average 295 kW. In that case, a larger ICE engine would be required, hence a 360kW ICE engine was selected for post-Phase 2c. Design criteria for the ICE engines used in this analysis are summarized in **Table 7**

Table 7 Co-generation Design Criteria

	Units	Current configuration	Future configuration (digested TWAS)
Biogas produced	cfd	63,000	106,000
Engine power capacity required (biogas fully utilized)	kW	177	295
Selected Engine Capacity	kW	250	360
Engine minimum power requirements (50% load)	kW	125	180
Recoverable Thermal Output (assume 38% efficiency)	BTU/hr	643×10^3	$1,075 \times 10^3$

4.2.2 Pre-treatment and Monitoring

Biogas generated in the anaerobic digesters is composed of primarily methane and carbon dioxide with the trace amounts of other gases and contaminants, such as hydrogen sulfide, nitrogen, water vapor, and siloxanes. Biogas samples after iron sponge treatment were tested for the concentration of compounds listed in **Table 8** below. (Refer to **Appendix C** for detailed lab results)

Table 8 Biogas Analysis

Compounds	Concentration
Oxygen	0.6 % Volume
Nitrogen	1.7 % Volume
Methane	60.7 % Volume
Carbon Dioxide	36.9 % Volume
H2S	80 ppm
Ammonia	<1 ppm
Siloxane	0.67 ppb

For economic and efficient biogas utilization by the ICE, it is important to provide a pretreatment system for biogas/fuel gas. This enables a long life time of the ICE and prevents downtime for damage due to presence of sulphur and siloxanes in the fuel gas. VSD currently operates an iron sponge media to remove hydrogen sulfides (H_2S). Therefore, it eliminates the need to have a full-fledged H_2S removal system as part of the bio-cogeneration system.

Presence of siloxane in the fuel gas is a significant issue in internal combustion engines. As siloxane is reduced to silica and oxygen, the free silica deposits on the hot surfaces in the form of white silica powder. These deposits can accumulate inside engines, greatly increasing maintenance costs and reducing efficiency. Additionally, siloxane deactivates the catalyst used in Nitrogen Oxides (NOx) capture. The technology employed to capture NOx is the selective catalytic reduction (SCR) system. An SCR system would be installed to meet South Coast Air Quality Management District (SCAQMD) Rule 1110.2 for reduction of NOx emission generated from the engine, and siloxanes can poison the catalyst present in this system making it impractical to use. Ultimately, performance of the engine is correlated to fuel type and the contaminants. Therefore, based on the siloxane concentration, and on input received by ICE manufacturers, gas conditioning carbon filters for gas pretreatment has been included. Gas conditioning system includes two carbon vessels each with a capacity of 1000 lbs. The media would last for approximately two years at normal levels of H_2S and Siloxane as listed in **Table 8.** A schematic of the system is provided in **Figure 5**.

Additionally, the chemical reactions in the SCR system requires a constant supply of ammonia to breakdown NOx in to nitrogen, oxygen and traces of carbon dioxide which is delivered by urea as represented in **Figure 5**. Finally, it is necessary to demonstrate through Continuous Emission Monitoring System (CEMS) data that the installed engine meets SCAQMDs Rule 1110.2 exhaust emission limits (NOx = 11 ppm; VOC = 30 ppm; CO = 250 ppm). Refer to **Appendix E** for additional information on CEMS.

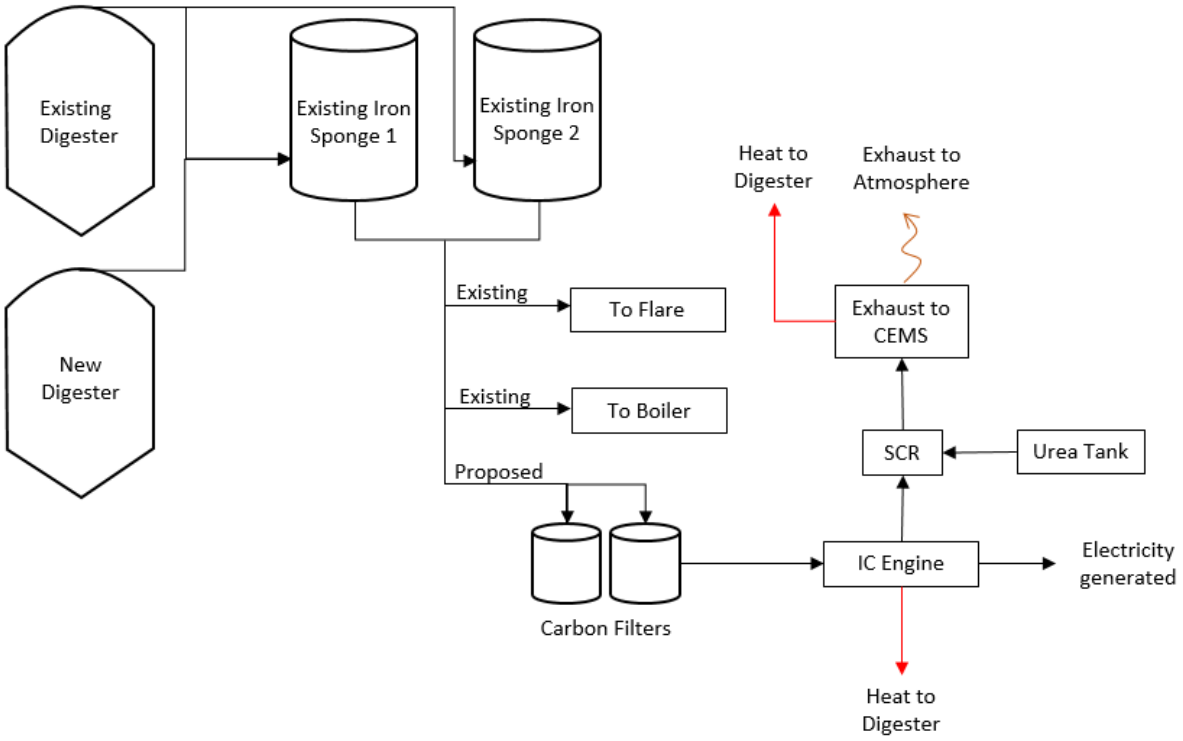

Figure 5 Energy Utilization Process Flow Diagram

4.3 COGENERATION COST SUMMARY

Total project cost to install the equipment was estimated based on the quotes (Refer to **Appendix E** for quotes) provided by 2G Containerized Engine (Refer to **Appendix E** for detailed estimate) and is presented in **Table 9** shown below. Additional costs included in the cogeneration equipment includes fuel conditioning (or pretreatment system) for siloxane removal, CEMS (for monitoring and emission compliance), and urea storage tanks (used for NOx treatment).

Table 9 Co-generation Capital and Annual O&M Cost

ITEMS	250 kW Engine	360 kW Engine
Capital Cost for Equipment[7]	$1,180,700	$1,245,700
Total Project Cost (Including Installation, Electrical / I&C, Civil and Contingencies)	$1,704,600	$1,798,500
Total Annual O&M Cost (Engine Maintenance, Pretreatment System Maintenance and Labor)	$59,800	$62,400

[7] Capital Cost for equipment comprises Engine, SCR, Fuel Conditioning System, Cooling system, Urea Tank, Commissioning Support and Software CEM® Solution to meet AQMD Rule 1110.2 and includes 30% of contingencies for taxes and equipment supplier scope allowances.

Using the larger engine (taking digester gas from digestion of TWAS) with the facility treating its current influent flow, the Plant would save approximately 930,000 kWh/year, and could export an additional 465,000 kWh to the grid. The value of that power depends on the rate that IID will allow for electricity export to the grid. Alternatively, VSD could shut down the ICE during the solar panel production period.

A 10-year Return on Investment (ROI)[8] analysis was performed, with details provided in **Appendix C**. The analysis assumed that the District would finance the construction (no potential additional grants were considered), operate, and maintain the facility. Results presented in **Table 10** show that installing a co-generation system would only be viable once Phases 2.b and 2.c are implemented (future configuration with TWAS digestion), and that the larger engine would have a higher ROI. Presented ROI also assumes constant influent flow (current), and would increase as the influent flow increases over time.

Table 10 Ten-year ROI Analysis Summary with Credit from IID

	250 kW ICE	360 kW ICE
Current Configuration	-47%	-51%
Future Configuration	-11%	5%

Alternatively, instead of funding the co-generation system installation and operations, VSD could enter a PPA with a service provider. That entity would fund the construction of the co-generation system, possibly operate and maintain it, and sell the power to VSD at a price lower than the utility power.

On the other hand, assuming that in the future IID does not provide credit for the excess power from co-gen sent to the grid, the payback period associated with investing in a co-generation system will be longer. One other 10-year ROI analysis was performed for this scenario, and results are presented in **Table 11.** In that case, investing in co-generation is less financially attractive.

Table 11 Ten-year ROI Analysis Summary with No Credit from IID

	250 kW ICE	360 kW ICE
Current Configuration	-72%	-75%
Future Configuration	-46%	-35%

[8] Quoting Investopedia.org: Return on Investment (ROI) is a performance measure, used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. ROI measures the amount of return on an investment, relative to the investment's cost. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment. The result is expressed as a percentage or a ratio.

The return on investment formula:

ROI = (Gain from Investment - Cost of Investment) / Cost of Investment

5.0 CONCLUSIONS

Based on the solids handling survey and cost analysis performed, it is recommended that VSD continue using sludge drying operations . Some cost savings can also be achieved by testing for micro-organisms to qualify for Class A solids.

Once Phases 2.b and 2.c are implemented, installing a cogeneration system, funded and operated by VSD, could be economical (10-year ROI of 5% with a 360 kW ICE engine), assuming that credit would be received from IID for additional power exported to the grid. In the worst-case scenario where no credit is received for the exported power, investing in a co-gen system would be less economical (10-year ROI of -35% with a 360 kW ICE engine). Alternatively, VSD could enter a PPA with a service provider willing to sell power to VSD at a lower price than utility power.

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APPENDIX

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Appendix A SOLIDS MASS BALANCE ANALYSIS

Mass Balance Calculations - Current Configuration

Plant flow	5.9	mgd

Cost per ton

Class A biosolids	$ 35.49
Class B biosolids	$ 44.49
Unclassified biosolids	$ 49.49

Data

Primary Sludge VS - 2017 (average)	6,450	lbs VS/day	
Primary Sludge VS - 2016 (average)	5,800	lbs VS/day	
Primary Sludge VS - 2015 (average)	6,900	lbs VS/day	
Primary Sludge VS - 2014 (average)	5,800	lbs VS/day	
average for 2014-2017	6,238		
Primary Sludge VS content	88%		actual 2017 average
Primary Sludge TS	7,080.02	lbs/day	
Primary Sludge TS	1,200	lbs/MG	

Primary Sludge

Digester Primary Sludge VS Reduction	73%		actual 2014 average
Load reduction	4,553.38	lbs/day	
Digested PS to Belt Press TS	2527	lbs/day	
	428	lbs/MG	
Belt Press Capture Rate	85%		
Cake Production from PS	392	ton/year	

WAS Sludge

Typicall solids WAS generation	1098	lbs/MG	range 0.6 - 0.8 lbs/1,000 gal per Metcalf and Eddy, use low range value. 1182 ton/year per 2017 report, equivalent of 1.1 lbs/1,000 gal
VS Content	80%		
VS reduction in Ponds	40%		
Solids from Ponds to BP	746	lbs/MG	
Cake Production from Ponds	683	tons/year	

Current solid management - haul dried sludge (98%)

Cake Solids %	16%		
Dried Solids %	98%		from Annual biosolids report 2017
Dried Solids Production Rate	1100	ton/year	Estimated 650 to 700 tons/year total solids production, model is valid
Actual Production Rate	600		Will use actual quantities in cost estimate to allow alternatives comparisons

Alternative solid management - haul cake (16%)

Total yearly cake production	6720	ton/year	
Yearly disposal cost - dried solids	$ 39,026		assume Class A
	$ 48,922		assume Class B
	$ 54,421		asume unclassified
Yearly disposal cost - cake	$ 238,480		assume Class A
	$ 298,957		assume Class B
	$ 332,555		asume unclassified

Mass Balance Calculations - Including Waste Activated Sludge (WAS) Digestion

Plant flow	5.9	mgd

Cost per ton

Class A biosolids	$ 35.49
Class B biosolids	$ 44.49
Unclassified biosolids	$ 49.49

Data

Primary Sludge VS - 2017 (average)	6,450	lbs VS/day	
Primary Sludge VS - 2016 (average)	5,800	lbs VS/day	
Primary Sludge VS - 2015 (average)	6,900	lbs VS/day	
Primary Sludge VS - 2014 (average)	5,800	lbs VS/day	
average for 2014-2017	6,238		
Primary Sludge VS content	88%		actual 2017 average
Primary Sludge TS	7,080	lbs/day	

Primary Sludge

Digester Primary Sludge VS Reduction	73%		actual 2014 average
Load reduction	4,553	lbs/day	
Digested PS to Belt Press TS	2527	lbs/day	
	428	lbs/MG	
Belt Press Capture Rate	85%		
Cake Production from PS	392	ton/year	

WAS Sludge

Typicall solids WAS generation	1098	lbs/MG	range 0.6 - 0.8 lbs/1,000 gal per Metcalf and Eddy, use low range value. 1182 ton/year per 2017 report, equivalent of 1.1 lbs/1,000 gal
VS Content	80%		
VS reduction in Digester	73%		
Solids from Ponds to BP	457	lbs/MG	
Cake Production from Ponds	418	tons/year	

Current solid management - haul dried sludge (98%)

Cake Solids %	16%		
Dried Solids %	98%		from Annual biosolids report 2016
Dried Solids Production Rate	828	ton/year	Slightly lower

Alternative solid management - haul cake (16%)

Total yearly cake production	5062	ton/year	
Yearly disposal cost - dried solids	$ 29,398		assume Class A
	$ 36,853		assume Class B
	$ 40,995		asume unclassified
Yearly disposal cost - cake	$ 179,646		assume Class A
	$ 225,203		assume Class B
	$ 250,513		asume unclassified

Appendix B BIOSOLIDS REGULATIONS FOR CLASS A REQUIREMENTS

EPA REGION VIII
999 18th St., Denver, CO 80202
Mr. Robert Brobst

PART 1 C BIOSOLIDS REGULATIONS

Federal regulations newly published in the *Federal Register* can be difficult to understand. Therefore, an "easy-to-read" summary of 40 CFR Part 503 has been developed by EPA and has been included in this handbook for your use (Section 1.1). See also *Part 503 Implementation Guidance* (EPA 833-R-95-001), 1995.

All of the information and requirements found in 40 CFR Part 503 are included in the provided summary. However, special attention should be paid to the Land Application and Surface Disposal sections and to the corresponding Pathogen and Vector Attraction Reduction requirements, since these practices are the most commonly used in EPA Region 8.

Section 1.2 is a paper that was presented at an international conference in 1994. It provides the recent history of biosolids management, improvements in biosolids quality, and improvements made in equipment, processes and management practices. With this background in place, the author discusses the implementation of the 503 regulations, the problems associated with the aging infrastructure in the U.S., and some predictions for future biosolids management trends.

Section	Topic	Page
1.1	Summary of 40 CFR Part 503 Standards for the Use or Disposal of Sewage Sludge	1.1-1
1.2	United States Regulations and Practical Experience on Biosolids Reuse and Disposal	1.2-1

SECTION 1.1 C SUMMARY OF 40 CFR PART 503 STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE

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The U.S. Environmental Protection Agency has been in the process of developing comprehensive federal sewage sludge (biosolids) use and disposal regulations for many years. The proposed regulation was published for public comment on February 6, 1989, and in final form in the *Federal Register* on February 19, 1993 (58 *FR* [32]:9248-9415).

The final regulation is organized into the following subparts: general provisions; land application; surface disposal; pathogens and vector attraction reduction; and incineration.

Subparts addressing standards for land application, surface disposal and incineration practices consist of sections covering: applicability and special definitions; general requirements; pollutant limits; operational standards; management practices; frequency of monitoring, recordkeeping, and reporting requirements.

The following summary of the 40 CFR Part 503 regulation is based on the final regulation. It is a simplified summary of the regulation and does not contain all details, requirements, or exceptions.

GENERAL PROVISIONS AND IMPLEMENTATION PLANS

The Part 503 addresses the use and disposal of sewage sludge generated from the treatment of domestic sewage and includes domestic septage. It does not apply to materials such as grease trap residues or other non-domestic wastewater residues pumped from commercial facilities, sludges produced by industrial wastewater treatment facilities, or grit and screenings from publicly owned treatment works (POTWs). Sewage sludge and other wastewater solids disposed of in municipal solid waste landfills for bulk disposal or used as landfill cover material are required to comply with the requirements of the 40 CFR Part 258 municipal solid waste landfill regulation (56 *FR* [196]:50978-51119; October 1991), which was co-promulgated under the Clean Water Act and the Resource Conservation and Recovery Act.

By statute compliance with the Part 503 standards is required within 12 months of publication of the regulation (*i.e.*, February 19, 1994). However, if new pollution control facilities need to be constructed to achieve compliance, then compliance is required within 2 years of publication (*i.e.*, February 19, 1995). Compliance with monitoring, recordkeeping and reporting requirements is required within 150 days of publication of the rule (*i.e.*, July 20, 1993).
For the most part, the rule is written to be "self implementing," which means that citizen suits or EPA can enforce the regulation even before permits are issued. As a result, treatment works must start monitoring and keeping records of sludge quality (and in many cases land appliers must start keeping records of loading rates and locations receiving sewage sludge), and must comply with pollutant limits and other technical standards, even in the absence of a federal permit.

The standards will be incorporated into National Pollution Discharge Elimination System (NPDES) permits issued by EPA or permits issued by states with approved sewage sludge management programs in accordance with 40 CFR Parts 122, 123, and 501 (promulgated in May 1989 {54 FR [83]:18716-18796}, and revised and published with the Part 503 rule in February 1993). EPA will work closely with the states to encourage their adoption of sewage sludge management programs that can be approved to carry out the federal program and avoid the need for separate EPA permits, compliance monitoring and enforcement activities. However, until a state applies for and is approved to carry out a delegated program, all involved parties will be dealing directly with their EPA Regional Office regarding federal permits, compliance monitoring and enforcement issues associated with the implementation of the Part 503 requirements--in addition to dealing with their state regulatory authorities and requirements.

Sewage sludge permitting requirements apply to "Treatment Works Treating Domestic Sewage" (TWTDS)--*i.e.*, facilities that generate, treat, or provide disposal of sewage sludge, including non-discharging and sludge-only facilities. A TWTDS must apply for a federal sewage sludge permit from EPA (or an approved state sludge program) if it manages a sewage sludge that

is ultimately subject to Part 503–that is, it is land applied, placed on a surface disposal unit, incinerated, or sent to a municipal solid waste landfill. TWTDS with existing NPDES permits get to apply for a sewage sludge permit as a part of their next NPDES permit renewal application, while facilities without existing NPDES permits must submit limited screening information (but not necessarily a full permit application) by February 19, 1994. All TWTDS involving sludge incinerators and certain surface disposal facilities seeking site specific limits were to have applied for permits by August 18, 1993.

While disposal facilities such as sewage sludge incinerators and surface disposal sites are clearly TWTDS and are required to apply for permits, commercial handlers that only distribute or land apply the sewage sludge without changing its quality are not automatically considered TWTDS and are not required to submit permit applications unless specifically requested to do so by the permitting authority – EPA or an approved state. Also the TWTDS definition does not extend automatically to areas such as farm land where sewage sludge is beneficially used; only under an unusual situation (such as a clear potential risk to human health and the environment) would the permitting authority designate such an area as a TWTDS. The permitting authority has the flexibility to cover both the generator and the treatment, use, or disposal facility in one permit or in separate permits (including general permits).

Due to the large number of potential permit applications that will be submitted under this program, EPA plans to initially focus on TWTDS required to have, or requesting, site-specific pollutant limits under Part 503. The permitting authority may request that permit applications be submitted earlier than the times noted above, with permit applications being due 180 days after such a request.

Annual reporting is required of all Class I sewage sludge management facilities (*i.e.*, the ~1,600 pretreatment POTWs and ~400 other "designated" TWTDS) and other "major" POTWs - those with a design flow $\geq$1MGD or serving a population of $\geq$10,000 people.

LAND APPLICATION

Land application includes all forms of applying bulk or bagged sewage sludge to land for beneficial uses at agronomic rates (rates designed to provide the amount of nitrogen needed by the crop or vegetation grown on the land while minimizing the amount that passes below the root zone). These beneficial use practices include application to: agricultural land such as fields used for the production of food, feed and fiber crops, pasture and range land; non-agricultural land such as forests; public contact sites such as parks and golf courses; disturbed lands such as mine spoils, construction sites and gravel pits; and home lawns and gardens. The sale or give away of sewage sludge products (such as composted or heat dried products) is addressed under land application, as is land application of domestic septage.

General Requirements

Responsibility for complying with the rule rests with the person who prepares sewage sludge for land application or applies sewage sludge to the land. These parties must obtain and provide the information necessary to comply with the rule. For example, the person who prepares bulk sewage sludge that is land applied must provide the person who applies it to the land all information necessary to comply with the rule, including the total nitrogen concentration of the sewage sludge.

The regulation establishes two levels of sewage sludge quality with respect to heavy metal concentrations–pollutant Ceiling Concentrations and Pollutant Concentrations ("high quality" sewage sludge); and two levels of quality with respect to pathogen densities–Class A and Class B; and two types of approaches for meeting vector attraction reduction–sewage sludge processing or the use of physical barriers. Under the Part 503 regulation, fewer restrictions are imposed on the use of higher quality sewage sludge.

To qualify for land application, sewage sludge or material derived from sewage sludge must meet at least the pollutant Ceiling Concentrations, Class B requirements for pathogens and vector attraction reduction requirements. Cumulative Pollutant Loading Rates are imposed on sewage sludge that meet the pollutant Ceiling Concentrations but not the Pollutant Concentrations. A number of general requirements and management practices apply to sewage sludge that is land applied unless it meets three criteria for "Exceptional Quality"–sewage sludge or derived material which meet the Pollutant Concentration limits, Class A pathogen requirements, and vector attraction reduction sewage sludge processing. However, in all cases the minimum frequency of monitoring, recordkeeping, and reporting requirements must be met.

Pollutant Limits

Pollutant limits for land application are listed in the following table:

Land Application Pollutant Limits
(all limits are on dry weight basis)

Table in 503 Rule	Table #1	Table #2	Table #3	Table #4
Pollutant	Ceiling Concentration Limits* (mg/kg)	Cumulative Pollutant Loading Rates (kg/ha)	"High Quality" Pollutant Concentration Limits** (mg/kg)	Annual Pollutant Loading Rates (kg/ha/yr)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	**C**	**C**	**C**
Nickel	420	420	420	21
Selenium	100	100	100	5.0
Zinc	7,500	2,800	2,800	140

* absolute values
** monthly averages

To be land applied, bulk sewage sludge must meet the pollutant Ceiling Concentrations and Cumulative Pollutant Loading Rates or Pollutant Concentration limits. Bulk sewage sludge applied to lawns and home gardens must meet the Pollutant Concentration limits. Sewage sludge sold or given away in bags or other containers must meet the Pollutant Concentration limits or meet the Ceiling Concentrations and be applied at an annual sewage sludge product application rate that is based on the Annual Pollutant Loading Rates.

Pathogen and Vector Attraction Reduction

Sewage sludge is classified into two categories, Class A and Class B, based upon the pathogen reduction criteria described later in this article. Restrictions placed on end uses of sewage sludge are impacted by the pathogen reduction classification of the sewage sludge. Bulk sewage sludge applied to agricultural and non-agricultural land (e.g., forest, public contact sites, and reclamation sites) must meet at least Class B requirements.

Bulk sewage sludge applied to lawns and home gardens, and sewage sludge sold or given away in bags or other containers must meet the Class A criteria and one of the vector attraction reduction sewage sludge processing options. One of the ten vector attraction reduction options described later also must be met when bulk sewage sludge is applied to the agricultural or non- agricultural land.

Management Practices

The following management practices apply to land applied sewage sludge (other than "Exceptional Quality" sewage sludge or sludge-derived products):

1) Bulk sewage sludge shall not be applied to flooded, frozen or snow-covered ground so that the sewage sludge enters wetlands or other waters of the U.S. unless authorized by the permitting authority.

2) Bulk sewage sludge shall not be applied at rates above agronomic rates, with the exception of reclamation projects when authorized by the permitting authority.

3) Bulk sewage sludge shall not be applied if likely to adversely affect a threatened or endangered species.

4) Bulk sewage sludge shall not be applied less than 10 meters from waters of the U.S., unless authorized by the permitting authority.

5) Sewage sludge sold or given away in a bag or other container shall have either a label affixed to the bag/ container, or an information sheet shall be provided to the person who receives the sewage sludge for application to the land that provides information on proper use, including the annual whole sludge application rate that does not cause any of the annual pollutant loading rates to be exceeded.

Furthermore, when sewage sludge that meets Class B pathogen reduction requirements, but not Class A, is applied to the land, the following site restrictions have to be met:

1) Food crops with harvested parts that touch the sewage sludge/soil mixture (such as melons, cucumbers, squash, etc.) shall not be harvested for 14 months after application.

2) Food crops with harvested parts below the soil surface (root crops such as potatoes, carrots, radishes) shall not be harvested for 20 months after application if the sewage sludge is not incorporated for at least 4 months.

3) Food crops with harvested parts below the soil surface (root corps such as potatoes, carrots, radishes) shall not be harvested for 38 months after application if the sewage sludge is incorporated in less than 4 months.

4) Food crops, feed crops, and fiber crops shall not be harvested for 30 days after sewage sludge application.

5) Animals shall not be grazed on a site for 30 days after sewage sludge application.

6) Turf shall not be harvested for 1 year after sewage sludge application if the turf is placed on land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.

7) Public access to land with high potential for public exposure shall be restricted for 1 year after sewage sludge application.

8) Public access to land with a low potential for public exposure shall be restricted for 30 days after sewage sludge application.

Monitoring

Monitoring for pollutants, pathogen densities and vector attraction reduction requirements shall be at a minimum frequency based on annual sewage sludge amounts used or disposed as listed in the table on the following page.

The permitting authority may impose more frequent monitoring requirements on permittees. In addition, After two years of monitoring at these frequencies, the permitting authority may allow the monitoring frequencies (for pollutants and pathogen densities in some cases) to be reduced to no less than once per year.

Monitoring Frequency

Sewage Sludge Amounts (dry metric tons* per year)	Monitoring Frequency
>0 to <290	Once per year
290 to <1,500	Once per quarter
1,500 to <15,000	Once per 60 days
$15,000	Once per month

* Note: 1.0 metric ton = 1.1 English tons

Recordkeeping

The recordkeeping requirements vary depending on which pollutant limits are met and the end use of the sewage sludge or sewage sludge derived material. In general the person who prepares the sewage sludge or product is responsible for certifications and maintaining records concerning pollutant concentrations and processing of the material to meet pathogen and vector attraction reduction requirements, while the applier is responsible for certifications and maintaining records concerning field operations, application rates, management practices, and site restrictions. Except as noted, records must be kept for five years. These requirements are summarized below.

If the sewage sludge or resulting product meets the pollutant Ceiling Concentration limits (Table 1 values), Pollutant Concentration limits (Table 3 values), Class A pathogen requirements, and one of the first 8 vector attraction reduction (process) requirements, the person preparing the "Exceptional Quality" sewage sludge (whether a bulk or bagged product) must certify through periodic sampling that the material meets these criteria and keep records describing the methods used to meet the Class A pathogen reduction and vector attraction reduction requirements.

However, if a bulk sewage sludge that meets the Pollutant Concentration limits and Class A pathogen requirements is injected or surface applied followed by incorporation to meet the vector attraction reduction requirements, the person applying the sewage sludge must certify that appropriate management practices have been followed and that vector attraction reduction has been performed in accordance with the rule. The person applying the sewage sludge must also describe how each of the applicable management practices and vector attraction reduction barrier requirements have been met for each site on which sewage sludge has been applied.

If a bulk sewage sludge meets the Pollutant Concentration limits but only Class B pathogen reduction requirements, the person preparing the sewage sludge must certify that the material meets these criteria and keep records describing the methods used to meet them. The person applying the sewage sludge must certify and keep records describing how the applicable management practices and the site restrictions have been met.

For bulk sewage sludges that meet the pollutant Ceiling Concentration limits, but do not meet the Pollutant Concentration limits, the person applying the sewage sludge must certify that the requirements to obtain information needed to determine the cumulative amount of each pollutant on each site were met (note that the Table 2 values for Cumulative Pollutant Loading Rates are not to be exceeded), as well as record and keep indefinitely a record of the cumulative amount of each pollutant applied to each site, information on the location of each application site, its size, the date and time of each sewage sludge application, amount of sludge applied, and how the requirements to obtain necessary pollutant loading rate information were met.

If a sewage sludge meets the Class A requirements and the Ceiling Concentrations, but not the Pollutant Concentration limits, and is to be sold or given away in a bag or other container, the person who prepares the sewage sludge shall determine and record the annual whole sludge application rate that does not cause the material to exceed the Annual Pollutant Loading Rates (Table 4 values). The concentration of each pollutant listed in Table 4 shall also be recorded. Furthermore, the

preparer shall keep a record describing how the Class A pathogen reduction and vector attraction reduction requirements have been met.

Reporting

The information contained in the required records shall be submitted to the permitting authority annually for all Class I sludge management facilities and POTWs with a design flow rate ≥1 MGD or a service population of ≥10,000 people. In addition, for sites where recordkeeping is required, the same group of facilities shall report annually when any cumulative metal loading reaches 90% of the allowed Cumulative Pollutant Loading Rates (Table 2 values).

Distributed and Marketed (D&M) Products

The regulation of products that are distributed and marketed is addressed as a part of land application rather than as a separate practice under Part 503. As outlined above, the sale or giveaway of sewage sludge in bulk, bags or other containers is regulated under land application in the final Part 503 rule. Bulk sewage sludge is frequently applied to farmland, forest and reclamation sites in liquid or dewatered cake forms at little or no cost to the land owner. At a minimum these materials must meet the pollutant Ceiling Concentrations, Class B pathogen reduction and vector attraction reduction criteria, and can be applied using the Cumulative Pollutant Loading Rates if they do not meet the Pollutant Concentration limits.

On the other hand, sewage sludge or material derived from sewage sludge that is considered suitable for distribution and marketing for uses on lawns and home gardens, either in bulk or bags and other containers, must meet the Class A pathogen reduction requirements, a vector attraction reduction processing option, and the Pollutant Concentration limits (with the exception that sewage sludge which meets the pollutant Ceiling Concentrations, but not the Pollutant Concentration limits, can be sold in bags or other containers for use at product application rates prescribed on a label that are based on not exceeding the Annual Pollutant Loading Rates). The Class A pathogen reduction requirements must be met at the time the bulk or containerized products are "sold or given away."

If sewage sludges or sludge derived products are of "Exceptional Quality"–meet the Pollutant Concentration limits, Class A pathogen reduction requirements and a vector attraction reduction sludge processing option–they are usually not subject to the general requirements and management practices applicable to land application practices.

Composted Sewage Sludge Products

Composting can achieve compliance with Class A pathogen reduction requirements by operating under the PFRP conditions (included as Appendix B of Part 503, but originally issued under the Part 257 regulations) and monitoring for regrowth:

- With Invessel Composting or Static Aerated Pile systems, the temperature of the sewage sludge is maintained at 55°C or higher for 3 days.

- With Windrow Composting, the temperature of the sewage sludge is maintained at 55°C or higher for 15 days or longer, during which the windrow will be turned a minimum of 5 times.

Other operating conditions may be able to meet Class A pathogen reduction requirements based on meeting time/temperature or pathogen testing requirements. Careful monitoring of process operations will be necessary to ensure that pathogen reduction requirements are achieved. For vector attraction reduction only, composting must achieve temperatures of greater than 40°C for 14 days and achieve an average temperature during that period of 45°C. These are well within the typical composting facility operating parameters and should be achievable by properly designed and operated facilities.

Heat Dried Sewage Sludge Products

There are few aspects of the new rule that will cause changes to established heat dried sewage sludge D&M programs. The temperatures used in sewage sludge drying systems which aim at producing a marketable product are typically in excess of 50°C, and retention times in the dryer are 30 minutes or longer. Using the equations provided and a nominal processing temperature of 80°C (the PFRP definition for sewage sludge drying), the product residence time in the dryer required to meet the Class A pathogen reduction is in the order of magnitude of seven seconds, while the rule requires a minimum residence time in the dryer of 15 seconds. Vector attraction reduction will similarly be easily met by dryers that produce a product for marketing. The degree of dryness required is >75% solids if the product does not contain unstabilized primary sewage sludge, and >90% solids if the product does contain unstabilized primary sewage sludge. The marketplace is typically looking for products of >90% solids so that the sewage sludge product is compatible with other dry fertilizer products.

Alkaline Stabilized Sewage Sludge Products

Certain alkaline stabilization practices comply with the Class A pathogen reduction requirements, which include a combination of elevating pH to above 12 for 72 hours and temperature to above 52°C for 12 hours or longer during the period that pH is above 12, along with air drying to >50% solids. Other alkaline stabilization approaches may qualify the sewage sludge as Class A based on meeting the elevated time/temperature criteria alone or PFRP equivalency.

SURFACE DISPOSAL

Types of Disposal Operations

The Surface Disposal subpart of the regulation applies to sewage sludge and domestic septage disposal operations such as the following:

> Monofills (sewage sludge-only landfills). This could be a trench system, area-fill system, or similar bulk disposal operation, usually involving a cover material over the deposited sewage sludge.
>
> Dedicated disposal surface application sites. At some sites, sewage sludge pollutants are applied at higher than the Cumulative Pollutant Loading Rates (Table 2 values) for disposal purposes even though there also may be beneficial use aspects. Application of sewage sludge nitrogen at higher-than-acceptable agronomic rates may also be included as surface disposal sites. Potential pollutant leaching to groundwater or excessive plant uptake levels are controlled in a site-specific manner. Such sites are usually owned or leased by the wastewater authority and are highly controlled for access and operations.
>
> Piles or mounds. At many treatment plants, sewage sludges have been placed in piles or otherwise mounded on a portion of the property as final disposal.
>
> Impoundments or lagoons. At many treatment plants sewage sludge or domestic septage has been discharged to lagoons or impoundments as final disposal, with the excess liquid evaporated or recycled for treatment.

This subpart deals with surface disposal sites and sewage sludge placed on such sites for final disposal. Surface Disposal does not include sewage sludge placement for storage or treatment purposes.

EPA does not intend to regulate under Part 503 wastewater treatment lagoons in which sewage sludge is generated during treatment or lagoons in which sewage sludge is being treated. However, when such sewage sludges are removed from wastewater treatment lagoons or sewage sludge treatment lagoons, their use or disposal will be regulated under Part 503, if applicable.

There are many sewage sludge lagoons or places where sewage sludges have been piled that no longer are receiving sewage sludge (*i.e.*, they are no longer "active" units). These would probably not be regulated under Part 503, especially if they have been "closed" in a proper manner. However, If these sites or operations are still active in 1993, the date they become inactive could be critical in determining whether they are regulated under Part 503. If sites that were inactive have the old sewage sludge removed from them in the future, the use or disposal of the sewage sludge at that time would likely fall within the

jurisdiction of Part 503 if the material is used or disposed of through a practice covered by Part 503. Of course if previously closed sites become active again and receive sewage sludge after the Part 503 requirements became effective, such facilities would be subject to Part 503.

Storage vs. Disposal

The Part 503 regulation allows sewage sludge to be stored for up to two years without any restrictions or control. However, if sewage sludges remain on the land beyond 2 years, EPA may consider this "disposal" and regulate it as a surface disposal site. If the wastewater authority can provide an adequate explanation concerning why the material has to remain on the land for longer than 2 years, EPA will not regulate these operations as surface disposal sites. A common example would be a sewage sludge lagoon that has a 4 or 5 year cycle time between sludge cleanout operations. In this example, the lagoon may be considered "treatment" or "storage," and not "disposal."

General Requirements

There are a few general requirements that apply to surface disposal of sewage sludge on active sewage sludge units. These include compliance with all applicable Part 503 requirements; closure by [one year after the effective date of the rule] of active sewage sludge units located within 60 meters of a fault with displacement in Holocene time, in an unstable area, or in a wetland, unless authorized by the permitting authority; and the need for closure and post-closure plans at least 180 days prior to closing any active sewage sludge unit. Also, site owners are required to provide written notification to the subsequent owner that sewage sludge was placed on the land.

Pollutant Limits

Where surface disposal sites use liners and leachate collection systems, there are no pollutant concentration limits because pollutants leaching from the solids mass will be collected in the leachate and treated as necessary to avoid a pollution problem. For the site liner to qualify, it must have a hydraulic conductivity of #1 x 10^{-7} centimeters per second.

For surface disposal sites with no liner and leachate collection system, limits on 3 pollutants are established in the rule. While these vary based on the distance of the active sewage sludge unit boundary from the site property line, the most extreme values allowed are listed in the following table.

Maximum Allowable Pollutant Concentrations in Sewage Sludge for Disposal in Active Sewage Sludge Units without a Liner and Leachate Collection System

Unit Boundary to Property Line	Pollutant Concentrations*		
Distance (meters)	Arsenic (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)
0 to # 25	30	200	210
25 to # 50	34	220	240
50 to # 75	39	260	270
75 to # 100	46	300	320
100 to # 125	53	360	390
125 to # 150	62	450	420

Unit Boundary to Property Line	Pollutant Concentrations*		
Distance (meters)	Arsenic (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)
$ 150	73	600	420

* Dry weight basis

The three pollutants listed present the greatest threat of leaching to groundwater and causing exceedances of the Maximum Contaminant Level (MCL) for that pollutant. The allowable concentrations of the 3 pollutants are reduced if the active sewage sludge unit boundary is less than 150m from the site property line. The table shows the worst case limits if the site boundary is located from 0 to <25m from the disposal site property line. Different limits for these 3 pollutants can be developed through a site-specific assessment, as specified by the permitting authority, that shows the site has different parameters than the ones EPA used in establishing the maximum allowable concentration limits.

Nitrate Contamination

As a management practice, the rule requires that surface disposal operations not cause the groundwater MCL for nitrate to be exceeded or to cause the existing concentration to be exceeded if it already exceeds the MCL. Either results of groundwater monitoring or a statement from a qualified groundwater scientist must be used to demonstrate compliance.

Other Management Practices

There are several other management practices dealing with siting/ location, construction/design, and operation/maintenance that must be met for surface disposal facilities including but not limited to the following:

- Active disposal sites shall not be located within 60m of a Holocene-period fault or in a wetland unless authorized by the permitting authority; when located in a seismic impact zone, an active disposal site shall be designed to withstand the maximum recorded horizontal ground level acceleration.
- Surface runoff from a 24-hr, 25-yr storm event shall be controlled according to an NPDES permit.
- Active disposal sites shall not restrict flow of a base flood, adversely affect threatened or endangered species, or be located in a structurally unstable area.
- The leachate collection system for active surface disposal units with a liner and leachate collection systems shall be operated and maintained, and the leachate collected shall be disposed of in accordance with applicable requirements, during the period the unit is active and for 3 years after the unit is closed.
- If cover is placed on active units, methane gas concentrations must be monitored in all site structures and at the property line at the surface disposal site to avoid explosive conditions; if final cover is placed on the site, this monitoring continues for 3 years after site closure.
- Crops shall not be grown, nor animals grazed, on such sites unless the permitting authority specifically authorizes this based on site specific management practices to be implemented.
- Public access is restricted during operations and for 3 years following site closure.

Pathogen and Vector Attraction Reduction Requirements

Surface disposal of sewage sludge requires that one of the Class A or Class B pathogen control alternatives be met unless the sewage sludge is covered with soil or other material daily. One of the first 11 vector attraction reduction options is also required for surface disposal. While there are no specific pathogen reduction requirements for domestic septage placed on surface disposal sites, it must be incorporated or injected into the soil, covered with material daily, or treated with alkaline materials to raise the pH to 12 or higher for at least 30 minutes to meet vector attraction requirements.

Monitoring, Recordkeeping and Reporting

Monitoring for the 3 pollutant concentrations, pathogen densities and vector attraction reduction is required on the same minimum frequency based on annual sewage sludge amounts involved as required for land application and incineration. Methane gas monitoring of air in any on-site structures and at the property site boundary is required continuously if the surface disposal site contains an active disposal unit that is covered daily and for 3 years after a disposal unit that is covered is closed.

Records must be kept for at least 5 years. Certification statements are required by the person who prepares the sewage sludge for disposal and/or by the site owner/operator. The statements certify that the various management practices have been met and that the monitoring data have been collected properly. Data, information, and certification need to be submitted annually to the permitting authority for all Class I sludge management facilities and POTWs with a design flow rate $\geq$1MGD or that serve $\geq$10,000 population.

PATHOGENS AND VECTOR ATTRACTION REDUCTION

The pathogen reduction requirements (which apply only to land application and surface disposal practices) are operational standards for two classes of pathogen reduction: Class A and Class B. All sewage sludges that are to be sold or given away in a bag or other container for application to the land, or applied to lawns or home gardens must meet Class A pathogen requirements. All sewage sludge that is land applied or placed on surface disposal sites must meet at least the Class B pathogen requirements, except sewage sludge placed on a surface disposal site that is covered with soil or other material daily. The specific requirements for the two classes of pathogen reduction and the rationale for these requirements are noted in the following paragraphs.

CLASS "A" PATHOGEN REQUIREMENTS

Class A sewage sludge must meet one of the following criteria at the time of use or disposal, when prepared for sale or give away and passes on to the user for land application or producing other products:

1) A Fecal coliform density less than 1,000 Most Probable Number (MPN) per gram of total dry solids (1,000 MPN/g TS)

OR

2) A Salmonella sp. density less than 3 Most Probably Number (MPN) per 4 grams of total dry solids (3 MPN/4g TS).

In Addition: The requirements of **one** of the following alternatives must be met:

1) Time/Temperature - An increased sewage sludge temperature should be maintained for a prescribed period of time according to the following guidelines:

Time and Temperature Guidelines

Total Solids	Temp. (t)	Time (D)	Equation	Notes
$ 7%	$ 50°C	$ 20 min.	$D = \frac{131,700,000}{10^{0.14t}}$	No heating of small particles by warmed gases or immiscible liquid.
$ 7%	$ 50°C	$ 15 sec.	$D = \frac{131,700,000}{10^{0.14t}}$	Small particles heated by warmed gases or immiscible liquid.
< 7%	> 50°C	$ 15 sec. to < 30 min.	$D = \frac{131,700,000}{10^{0.14t}}$	
< 7%	$ 50°C	$ 30 min.	$D = \frac{50,070,000}{10^{0.14t}}$	

* in no case would temperatures calculated using the appropriate equation be less than 50°C

- OR -

2) Alkaline Treatment - The pH of the sewage sludge is raised to greater than 12 for at least 72 hours. During this time, the temperature of the sewage sludge should be greater than 52°C for at least 12 hours. In addition, after the 72-hour period, the sewage sludge is to be air dried to at least 50% total solids.

- OR -

3) Prior Testing for Enteric Virus/Viable Helminth Ova - The sewage sludge is analyzed for the presence of enteric viruses (Plaque-forming units) and viable helminth ova. If the sewage sludge is analyzed before the pathogen reduction process and is found to have densities of enteric virus <1 pfu/4 g TS and viable helminth ova <1 /4 g TS, the sewage sludge is Class A with respect to enteric virus and viable helminth ova until the next monitoring episode. If the sewage sludge is analyzed before the pathogen reduction process and found to have densities of enteric virus ≥1 pfu/4 g TS or viable helminth ova ≥1 /4 g TS, and tested again after processing and found to meet the same enteric virus and viable helminth ova levels [as listed under 4) below], then the processed sewage sludge will be Class A with respect to enteric viruses and viable helminth ova when the operating parameters for the pathogen reduction process are monitored and shown to be consistent with the values or ranges of values documented at all times:

4) No Prior Testing for Enteric Virus/Viable Helminth Ova - If the sewage sludge is not analyzed before pathogen reduction processing for enteric viruses and viable helminth ova, the sewage sludge must meet the enteric virus and viable helminth ova levels noted below to be Class A at the time the sewage sludge is used or disposed, prepared for sale or given away in a bag or container for application to the land, or when the sewage sludge or derived material

meets "exceptional quality" requirements--Pollutant Concentration limits, Class A pathogen reduction and any of the 8 sewage sludge processing options for meeting vector attraction reduction:

- The density of enteric viruses must be less than 1 Plaque-forming unit per 4 grams of total dry solids (1 PFU/4 g TS).

- The density of viable helminth ova must be less than 1 per 4 grams of total dry solids (1/4g TS).

- OR -

5/6) The sewage sludge is treated by a **PFRP** or a **PFRP equivalent** process.

CLASS "B" PATHOGEN REQUIREMENTS

Class B is the minimum level of pathogen reduction for land application and surface disposal. The only exception to achieving at least Class B occurs when sewage sludge is placed in a surface disposal unit that is covered daily. Sewage sludge that does not qualify as Class B cannot be land applied.

Class B sewage sludge must meet one of the following pathogen requirements:

1) The sewage sludge must be treated by a PSRP or PSRP equivalent process.

- OR -

2) At least seven sewage sludge samples should be collected at the time of use or disposal and analyzed for Fecal coliforms during each monitoring period. The geometric mean of the densities of these samples will be calculated and should meet the following criteria:

- Less than 2,000,000 Most Probably Number per gram of total dry solids (2,000,000 MPN/g TS).

- OR -

- Less than 2,000,000 Colony Forming Units per gram of total dry solids (2,000,000 CFU/g TS).

In addition, for any land applied sewage sludge that meets Class B pathogen reduction requirements, but not Class A, the site restrictions described on p.6 must be met.

PATHOGEN TREATMENT PROCESSES
Processes to Significantly Reduce Pathogens (PSRP)
1) Aerobic Digestion - Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a mean cell residence time and temperature between 40 days at 20°C and 60 days at 15°C.
2) Air Drying - Sewage sludge is dried on sand beds or on paved or unpaved basins for a minimum of three months. During two of the three months, the ambient average daily temperature is above 0°C.
3) Anaerobic Digestion - Sewage sludge is treated in the absence of air for a mean cell residence time and temps. between 15 days at 35 to 55°C and 60 days at 20°C.
4) Composting - Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40°C or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 55°C.
5) Lime Stabilization - Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after 2

hours of contact.

PATHOGEN TREATMENT PROCESSES
Processes to Further Reduce Pathogens (PFRP)
1) Composting - Using either within-vessel or static aerated pile composting, the temperature of the sewage sludge is maintained at 55·C or higher for three days. Using windrow composting, the temperature of the sewage sludge is maintained at 55°C or higher for 15 days or longer. During this period, a minimum of five windrow turnings are required.
2) Heat Drying - Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10% or lower. Either the temperature of the gas in contact with the sewage sludge exceeds 80°C or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80°C.
3) Heat Treatment - Liquid sewage sludge is heated to a temperature of 180°C or higher for 30 minutes.
4) Thermophilic Aerobic Digestion - Liquid dewatered sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time for the sewage sludge is 10 days at 55 to 60°C.
5) Beta Ray Irradiation - Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20°C).
6) Gamma Ray Irradiation - Sewage sludge is irradiated with gamma rays from certain isotopes such as ^{60}CO and ^{137}Ce, (at dosages of at least 1.0 megarad) at room temperature (ca. 20°C).
7) Pasteurization - The temperature of the sewage sludge is maintained at 70°C or higher for at least 30 minutes.

Vector Attraction Reduction Requirements

Vector attraction reduction reduces the potential for spreading of infectious disease agents by vectors (*i.e.*, flies, rodents, and birds). The alternative methods for meeting the vector attraction reduction requirement imposed by Part 503 include the following:

1) Aerobic or Anaerobic Digestion - Mass of volatile solids (VS) are reduced by 38% or more. VS reduction is measured between the raw sewage sludge prior to stabilization and the digested sewage sludge ready for use or disposal. This criterion should be readily met by properly designed and operated anaerobic digesters, but not as readily by typical aerobic digesters. POTWs with aerobic digesters may need to meet vector attraction reduction requirement through Alternative 3 or Alternative 4 below.

2) Anaerobic Digestion - If 38% VS cannot be achieved, vector attraction reduction can be demonstrated by further digesting a portion of the digested sewage sludge in a bench scale unit for an additional 40 days at 30 to 37°C or higher and achieving a further VS reduction of less than 17%.

3) Aerobic Digestion - If 38% VS cannot be achieved, vector attraction reduction can be demonstrated by further digesting a portion of the digested sewage sludge with a solids content of 2% or less in a bench scale unit for an additional 30 days at 20°C and achieving a further VS reduction of less than 15%.

4) Aerobic Digestion - Specific oxygen uptake rate (SOUR) is less than or equal to 1.5 mg O_2/hr-gram of total solids (TS) at 20°C. If unable to meet the SOUR criteria, POTWs may be able to satisfy Alternative 3.

5) Aerobic Processes - (e.g., composting) Temperature is kept at greater than 40°C for at least 14 days and the average temperature during this period is greater than 45°C.

6) Alkaline Stabilization - pH is raised to at least 12 by alkali addition and, without the addition of more alkali, remains at 12 or higher for 2 hours and then at 11.5 or higher for an additional 22 hours [when pH is measured at 25°C].

7/8) Drying - Total Solids (TS) is at least 75% when the sewage sludge does not contain unstabilized primary solids and at least 90% when unstabilized primary solids are included. Blending with other materials is not allowed to achieve the total solids percent.

9) Injection - Liquid sewage sludge (or domestic septage) is injected beneath the surface with no significant amount of sewage sludge present on the surface after 1 hour; sewage sludges that are Class A for pathogen reduction, must be injected within 8 hours of discharge from the pathogen reduction process. This alternative is applicable to bulk sewage sludge land applied to agricultural land, forest, public contact sites or reclamation sites; domestic septage land applied to agricultural land, forest or reclamation sites; and sewage sludge or domestic septage placed in a surface disposal site.

10) Incorporation - Sewage sludge (or domestic septage) that is land applied or placed in a surface disposal site shall be incorporated into the soil within 6 hours of application; sewage sludge that is Class A for pathogen reduction and is land applied must be applied to or placed on the land within 8 hours of discharge from the pathogen reduction process.

This alternative is applicable to bulk sewage sludge land applied to agricultural land, forest, public contact sites or reclamation sites; domestic septage land applied to agricultural land, forest or reclamation sites; and sewage sludge or domestic septage placed in a surface disposal site.

11) Surface Disposal Daily Cover - Sewage sludge or domestic septage placed in a surface disposal site shall be covered with soil or other material at the end of each operating day.

12) Domestic Septage Treatment - The pH of domestic septage is raised to 12 or higher by alkali addition, and without the addition of more alkali, remains at 12 or higher for 30 minutes. This alternative is applicable to domestic septage applied to agricultural land, forest or reclamation sites or placed in a surface disposal site.

One of the vector attraction reduction alternatives 1-10 must be met when bulk sewage sludge is applied to agricultural land, forest, public contact or reclamation sites. One of alternatives 1-8 must be met when bulk sewage sludge is applied to lawns or home gardens or when sewage sludge is sold or given away in a bag or other container for land application. One of alternatives 1-11 must be met when sewage sludge is placed in a surface disposal site. Although domestic septage can be treated the same as sewage sludge, when it is handled as "domestic septage" rather than sewage sludge, one of alternatives 9, 10 or 12 must be met when septage is applied to agricultural land, forest or reclamation sites, and one of alternatives 9-12 must be met when it is placed in a surface disposal site.

INCINERATION

The Part 503 regulation establishes requirements for sewage sludge-only incinerators. The rule covers the sewage sludge feed, the furnace itself, the operation of the furnace and the exhaust gases from the stack. It does not apply to facilities incinerating hazardous wastewater solids (as defined by 40 CFR Part 261) or wastewater solids containing $\geq$50 ppm concentrations of PCBs. It also does not apply to facilities that co-fire sewage sludge with other wastes (although up to 30% MSW as auxiliary fuel is not considered "other wastes"). Furthermore, this rule does not apply to the ash produced by a sewage sludge incinerator.

The rule indirectly limits emissions of heavy metals and directly limits total hydrocarbon emissions from sewage sludge incinerator stacks, and establishes management practices, frequency of monitoring, recordkeeping and reporting requirements. The rule contains equations to calculate the allowable concentration of metals in the sewage sludge fed to the incinerator, and contains a limit on Total Hydrocarbons (THC) in the emissions from a sewage sludge incinerator stack. Federal permits issued to sewage sludge incinerators will include site-specific pollutant limits based upon the results of

performance testing and air dispersion modeling. Permit applications for sewage sludge incinerators were due to EPA (or a delegated state) by August 16, 1993 (within 180 days of publication of the final Part 503 regulation). The frequency of monitoring, recordkeeping and reporting requirements for everything except THC become effective July 20, 1993 (150 days from the date of publication of the final rule). Notwithstanding the permitting process, sewage sludge incinerator facilities are required to be in compliance with all of the requirements of the rule within 1 year. Facilities that need to construct new pollution control facilities to comply with requirements will have two years to achieve compliance.

Preparation of permit applications requires that sewage sludge incineration facilities conduct performance tests of their existing systems to determine pollution control efficiencies for heavy metals, and to conduct air dispersion modeling for site-specific conditions. Continuous emissions monitoring equipment will also need to be installed.

Pollutant Limits

Pollutant limits for sewage sludges fired in a sewage sludge incinerator are imposed for the following heavy metals: beryllium, mercury, lead, arsenic, cadmium, chromium, and nickel. The limits for beryllium and mercury are those that already exist under the National Emission Standards for Hazardous Air Pollutants (NESHAPS; 40 CFR Part 261). Pollutant limits for the remaining metals will be determined using site-specific performance characteristics and emission dispersion modeling results.

Incinerators must also meet a monthly average limit of 100 ppm for total hydrocarbons (THC), corrected for moisture level (for zero percent) and oxygen content (to 7%). This limit is an indicator to control toxic organic compound emissions. The limit is based on the arithmetic mean of hourly readings for the month, with a requirement for at least two readings during each hour of operation. The THC measuring device used must be a flame ionization detector with a heated sample line maintained at 150°C or higher at all times, and be calibrated at least once every 24-hour operating period using propane. Operating parameters, such as oxygen concentrations and information to determine moisture content, in the stack exhaust gases and furnace combustion temperature must be continuously monitored.

Management Practices

The rule specifically bans sewage sludge incineration "if it is likely to adversely affect a threatened or endangered species listed under the Endangered Species Act, or its designated critical habitat." If threatened or endangered species are known to be present in the vicinity of the incinerator, an ecological risk assessment may be needed to verify lack of likely impact.

Frequency of Monitoring

Monitoring frequencies depend on the pollutant/parameter being monitored. Minimum monitoring frequencies for arsenic, cadmium, chromium, lead, and nickel are the same as for land application, based on the incinerator's throughput of sewage sludge; those for beryllium and mercury are tied to the NESHAPS rule.

The permitting authority may impose more frequent monitoring requirements on permittees. In addition, after two years of monitoring at these frequencies, the permitting authority may allow the monitoring frequencies for arsenic, beryllium, cadmium, chromium, lead, mercury and nickel to be reduced to no less than once per year. Continuous monitoring is required for THC, oxygen content, information to determine moisture level, and combustion temperature. Monitoring frequency for air pollution control device (APCD) operating parameters (*i.e.*, scrubber pressure drop or afterburner operating temperature) will be determined by the permitting authority.

Recordkeeping/Reporting

Sewage sludge incinerators must keep records of their operations for a five-year period. Records will include: metal content in the sewage sludge feed, THC concentrations in the exhaust, verification of compliance with NESHAPS, results from the continuous emissions monitors and APCD monitors, results from the control efficiency tests and dispersion modeling, and the calibration and maintenance logs. Many of these records have to be reported to the permitting authority each year (initially on the anniversary of the date of publication of the Part 503 rule - February 19, 1994) if the permittee is a Class I sewage sludge management facility, has a design flow of 1 MGD or more, or it serves a population of at least 10,000.

DOMESTIC SEPTAGE

The Part 503 regulation addresses management of septage generated from domestic sources only. If commercial or industrial wastes are combined with the domestic wastes, Part 503 does not apply to the use or disposal of the resulting septage. Domestic septage is defined as "liquid or solid material removed from a septic tank, cesspool, portable toilet, Type III marine sanitation device or similar system that receives only domestic (non-commercial) septage." Substances often referred to as septage, such as grease trap residues, as well as grit and screenings, are not included in this definition.

The final Part 503 regulation provides a simplified regulatory scheme for the land application of domestic septage that is applicable only if the domestic septage application is applied to "non-public contact sites," where the potential for public exposure is minimal, such as agricultural fields, forests, and disturbed sites in need of reclamation. Allowable land application rates are based upon the nitrogen requirement of the crop grown and yield expected.

Management of domestic septage in other ways (*i.e.*, land application to public contact sites, surface disposal or incineration) must be performed in accordance with the same provisions that govern management of sewage sludge through the various options, with a major exception–there is no requirement to analyze domestic septage for pollutant concentrations for land application or surface disposal, unless the user/disposer chooses to treat it the same as sewage sludge.

Land Application of Domestic Septage to Non-Public Contact Sites

Under the Part 503 regulation, domestic septage appliers are required to:

1) Meet (and certify) applicable pathogen and vector attraction reduction requirements
2) Follow specific management practices
3) Apply domestic septage at rates based on nitrogen requirement of the crops
4) Ensure that the septage is from domestic sources only
5) Keep site application records

Septage tank pumpers who land apply domestic septage to agricultural land, forest, or reclamation sites are generally not required to obtain federal permits for these activities, but are subject to the same enforcement actions as other "sewage sludge" use or disposal operators if they fail to comply with applicable Part 503 requirements. The Clean Water Act makes the Part 503 regulation enforceable without a permit being issued.

Pathogen Reduction

Pathogen reduction requirements applicable to land application of domestic septage can be achieved either through strict site restrictions or through stabilization of the domestic septage with alkaline materials and less limiting site restrictions. The site restrictions (including restrictions on crop harvesting, animal grazing and public access) vary depending on how pathogens are addressed. If domestic septage is not stabilized prior to application to agricultural land, forest, or reclamation sites, the same site restrictions as imposed on Class B sewage sludge are required. If domestic septage is stabilized prior to application by mixing with enough alkali material to raise its pH to at least 12 for at least 30 minutes, only the first four crop harvesting restrictions are applicable. No pathogen reduction requirements are imposed on surface disposal of domestic septage.

Vector Attraction Reduction

As described earlier, three vector attraction reduction options (#9 - Injection, #10 - Incorporation, or #12 - Septage Treatment) may be employed when domestic septage is applied to agricultural land, forest, or reclamation sites. Four vector attraction reduction options (#9 - Injection, #10 - Incorporation, #11 - Daily Cover, or #12 - Domestic Septage Treatment) may be employed when domestic septage is placed in a surface disposal site. The treatment of domestic septage by pH adjustment to meet pathogen and vector attraction reduction requirements involves the same treatment process - mixing with enough alkali material to raise its pH to at least 12 for at least 30 minutes to meet pathogen reduction and vector attraction reduction requirements

Application Rate

The maximum volume of domestic septage that can be applied to agricultural land, forest or reclamation sites in any year depends on the amount of nitrogen required by the crop grown and expected yield. The following equation is provided in the regulation to calculate annual domestic septage application rates:

$$\text{Annual Application Rate (gallons per acre year)} = \frac{\text{lbs. N Required by Crop}}{0.0026^{*}}$$

* based on estimated available N (in mg/l) in domestic septage times a conversion factor

Frequency of Monitoring/Record Keeping/Reporting

When domestic septage pathogen reduction is achieved by pH adjustment with alkali materials, pH levels in every container (truck load) must be monitored. Although there are no formal reporting requirements, the regulation does specify records that must be maintained by land appliers of domestic septage.

The following table lists the information that must be recorded and saved by the domestic septage land applier. These records must be kept for five years following application. Sample forms for recordkeeping have been developed and are available from EPA. They are included in a guidance document entitled "Simplified Federal EPA Rules for Land Application of Domestic Septage to Non-Public Contact Sites."

For domestic septage placed in surface disposal sites, if vector attraction reduction is achieved by pH adjustment, monitoring of each container is required. Methane gas monitoring requirements for covered surface disposal sites is the same as for surface disposal of sewage sludge. Also, records must be kept by the owner/operator of the surface disposal site for at least 5 years concerning the surface disposal site management practices and vector attraction reduction practices employed.

REQUIRED RECORDS
1) Location of the application site (either the street address, or the longitude and latitude of the site).
2) Number of acres on which domestic septage is applied at each site.
3) Date and time of each application.
4) Nitrogen requirement for the crop or vegetation grown on each site during a 365-day period.
5) Gallons of domestic septage applied to each site.
6) Required certification statement.
7) Description of pathogen reduction measures used.
8) Description of vector attraction measures used.

Compliance

As with other provisions of the regulation, domestic septage appliers were to begin maintaining records of their activities on July 20, 1993 (within 150 days of publication of the rule in the *Federal Register*). Compliance with other provisions must be achieved within one year of publication of the rule in the *Federal Register* if no construction of new pollution control facilities is required.

THE LIKELY FUTURE DIRECTION OF BIOSOLIDS MANAGEMENT IN THE U.S.

The biosolids management needs of municipalities in the U.S. should offer many opportunities for innovation in the future. The actual direction that biosolids management practices will take in the future is likely to hinge on gaining public acceptance, the creativeness of the consultants and project planners, and the political will of elected officials. If the past is any sign of the future, it is likely that no one practice will dominate biosolids management. Both recycling and disposal practices will likely continue in various forms. Most municipal authorities will look for multiple methods rather than rely upon only one option. More dependence upon contracted services will likely result from efforts to reduce operating costs. Opportunities for more energy recovery programs as well as direct recycling of biosolids by land application and the production of products for marketing are likely to occur as a result of:

- municipal authorities and their rate payers becoming more comfortable with paying higher rates for the ultimate disposal of this byproduct of wastewater treatment,
- continued improvements in biosolids quality as a result of pretreatment and source control programs,
- continued improvements in available biosolids treatment processes and handling equipment (including drying, thermal processing, energy recovery, stabilization, ash handling, land application equipment, etc.),
- increased interest in and opportunities for recycling solid waste and other residuals as a result of tighter landfilling requirements and public opposition to disposal practices,
- increased regulatory attention as a result of EPA's implementation of the new Part 503 technical standards through Federal permits.

However, a failure to work with all of the interests involved in establishing acceptable biosolids recycling programs will likely lead to strong opposition to the establishment of such projects due to concerns over the potential for threats to public health, environmental contamination and future liability. Efforts to better educate the environmental groups and the general public as well as wastewater officials and their consultants, contractors, public officials and regulators of the benefits and safety of biosolids recycling practices will continue to be an important factor in determining what practices become acceptable at any given location.

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LIST OF ABBREVIATIONS

CFR	Code of Federal Regulations
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
EQ	Exceptional Quality
FDA	Food & Drug Administration
I/A	innovative and alternative
MSW	municipal solid waste
NOAEL	No Observed Adverse Effects Level
NPDES	National Pollution Discharge Elimination System
NSF	National Science Foundation
NSSS	National Sewage Sludge Survey
O&M	operation and maintenance
POTW	Publicly Owned & Operated Treatment Works
R&D	research and development
TWTDS	treatment works treating domestic sewage
USDA	U.S. Department of Agriculture

Appendix C BIOGAS SAMPLE LABORATORY REPORTS

2655 Park Center Dr., Suite A
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www.alsglobal.com

LABORATORY REPORT

September 4, 2018

Anna Bell
Valley Sanitary District
45500 Van Buren St.
Indio, CA 92201

RE: Biogas 2018

Dear Anna:

Enclosed are the results of the samples submitted to our laboratory on August 18, 2018. For your reference, these analyses have been assigned our service request number P1804292.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

By Sue Anderson at 5:02 pm, Sep 04, 2018

Sue Anderson
Project Manager

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Client: Valley Sanitary District
Project: Biogas 2018

Service Request No: P1804292

CASE NARRATIVE

The samples were received intact under chain of custody on August 18, 2018 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

BTU and CHONS Analysis

The results for BTU and CHONS were generated according to ASTM D 3588-98. The following analyses were performed and used to calculate the BTU and CHONS results. This method is not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

C2 through C6 Hydrocarbon Analysis

The Silonite canister samples were analyzed according to modified EPA Method TO-3 for C2 through >C6 hydrocarbons using a gas chromatograph equipped with a flame ionization detector (FID). This method is included on the laboratory's DoD-ELAP scope of accreditation, however it is not part of the NELAP accreditation.

Fixed Gases Analysis

The Silonite canister samples were also analyzed for fixed gases (hydrogen, oxygen/argon, nitrogen, carbon monoxide, methane and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD). This method is included on the laboratory's DoD-ELAP scope of accreditation, however it is not part of the NELAP accreditation.

Hydrogen Sulfide Analysis

The silonite canister samples were also analyzed for hydrogen sulfide per modified SCAQMD Method 307-91 and ASTM D 5504-12 using a gas chromatograph equipped with a sulfur chemiluminescence detector (SCD). Method ASTM D 5504-12 is included on the laboratory's NELAP scope of accreditation, however it is not part of the DoD-ELAP accreditation. Method SCAQMD 307-91 is not included on the laboratory's NELAP or DoD-ELAP accreditation.

Siloxanes Analysis

The tube samples were analyzed for siloxanes according to laboratory SOP SVO-Siloxanes using an analytical system comprised of a gas chromatograph/mass spectrometer (GC/MS). This

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www.alsglobal.com

Client: Valley Sanitary District
Project: Biogas 2018

Service Request No: P1804292

CASE NARRATIVE

method is not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

Use of ALS Environmental (ALS)'s Name. Client shall not use ALS's name or trademark in any marketing or reporting materials, press releases or in any other manner ("Materials") whatsoever and shall not attribute to ALS any test result, tolerance or specification derived from ALS's data ("Attribution") without ALS's prior written consent, which may be withheld by ALS for any reason in its sole discretion. To request ALS's consent, Client shall provide copies of the proposed Materials or Attribution and describe in writing Client's proposed use of such Materials or Attribution. If ALS has not provided written approval of the Materials or Attribution within ten (10) days of receipt from Client, Client's request to use ALS's name or trademark in any Materials or Attribution shall be deemed denied. ALS may, in its discretion, reasonably charge Client for its time in reviewing Materials or Attribution requests. Client acknowledges and agrees that the unauthorized use of ALS's name or trademark may cause ALS to incur irreparable harm for which the recovery of money damages will be inadequate. Accordingly, Client acknowledges and agrees that a violation shall justify preliminary injunctive relief. For questions contact the laboratory.

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ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
Alaska DEC	http://dec.alaska.gov/eh/lab.aspx	17-019
Arizona DHS	http://www.azdhs.gov/preparedness/state-laboratory/lab-licensure-certification/index.php#laboratory-licensure-home	AZ0694
Florida DOH (NELAP)	http://www.floridahealth.gov/licensing-and-regulation/environmental-laboratories/index.html	E871020
Louisiana DEQ (NELAP)	http://www.deq.louisiana.gov/page/la-lab-accreditation	05071
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/professionals/labCert.shtml	2016036
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	1347317
New Jersey DEP (NELAP)	http://www.nj.gov/dep/enforcement/oqa.html	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://www.oregon.gov/oha/ph/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	4068-005
Pennsylvania DEP	http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx	68-03307 (Registration)
PJLA (DoD ELAP)	http://www.pjlabs.com/search-accredited-labs	65818 (Testing)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/agency/qa/env_lab_accreditation.html	T104704413-18-9
Utah DOH (NELAP)	http://health.utah.gov/lab/lab_cert_env	CA016272018-9
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Valley Sanitary District
Project ID: Biogas 2018

Service Request: P1804292

Date Received: 8/18/2018
Time Received: 10:20

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	ALS AQL 111 - Siloxanes Tube	TO-3 Modified - C1C6+ Can	3C Modified - Fxd Gases Can	ASTM D5504-01 - H2S Can
After IS D1S1	P1804292-001	Air	8/14/2018	08:37				X			
Before IS D1S1	P1804292-002	Air	8/14/2018	13:10				X			
After IS D1S1	P1804292-003	Air	8/14/2018	13:05	SSC00205	-1.45	3.92		X	X	X
Before IS D1S1	P1804292-004	Air	8/14/2018	09:06	SSC00392	-1.44	3.70		X	X	X
After IS D2S1	P1804292-005	Air	8/15/2018	08:55				X			

Air - Chain of Custody Record & Analytical Service Request

Page 1 of 1

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle:
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day-Standard

ALS Project No. P1804292

Company Name & Address (Reporting Information)	Valley Sanitary District 45.500 Van Buren St. Indio, CA 92201
Project Manager	Anna Bell
Phone	760.238.5402
Fax	800.750.2280
Email Address for Result Reporting	abell@valley-sanitary.org
Project Name	Biogas 2018
Project Number	
P.O. # / Billing Information	PO # 6988
Sampler (Print & Sign)	Anna Bell
ALS Contact:	SUE ANDERSON

	Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method: SILOXANE/SORBENT	Analysis Method: BTU, SILONITE CANISTER	Comments e.g. Actual Preservative or specific instructions: Duration
1	AFTER IS DIS1		8/14/18	0837						X		30 MIN
2	BEFORE IS DIS1		"	1310						X		30 MIN
3	AFTER IS DIS1		"	1305	SSC 00205	SFC 00251	17.5	5.0	6L		X	4HR
4	BEFORE IS DIS1		▽	0906	SSC 00392	SFC 00157	18.0	1.0	6L		X	4HR
5	AFTER IS DIS1		8/15/18	0855						X		30 MIN

Report Tier Levels - please select

Tier I - Results (Default if not specified) ____ Tier III (Results + QC & Calibration Summaries) ____
Tier II (Results + QC Summaries) ____ Tier IV (Data Validation Package) 10% Surcharge ____

EDD required Yes / No
Type: _____ Units: _____

Chain of Custody Seal: (Circle) INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

	Date:	Time:		Date:	Time:
Relinquished by: (Signature)	08/17/18	1100	Received by: (Signature)	8/18/18	1020
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Cooler / Blank Temperature ____ °C

ALS Environmental
Sample Acceptance Check Form

Client: Valley Sanitary District Work order: P1804292

Project: Biogas 2018

Sample(s) received on: 8/18/18 Date opened: 8/18/18 by: AARON GONZALEZ

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

		Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Did **sample containers** arrive in good condition?	☒	☐	☐
3	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
4	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
5	Was **sample volume** received adequate for analysis?	☒	☐	☐
6	Are samples within specified holding times?	☒	☐	☐
7	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
8	Were **custody seals** on outside of cooler/Box/Container?	☐	☒	☐
	Location of seal(s)? _____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
9	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
10	**Tubes:** Are the tubes capped and intact?	☒	☐	☐
11	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1804292-001.01	Tube, Siloxane					
P1804292-002.01	Tube, Siloxane					
P1804292-003.01	6.0 L Silonite Can					
P1804292-004.01	6.0 L Silonite Can					
P1804292-005.01	Tube, Siloxane					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **After IS D1S1** ALS Project ID: P1804292
Client Project ID: **Biogas 2018** ALS Sample ID: P1804292-003

Test Code: ASTM D3588-98
Analyst: Gilbert Gutierrez/Magaly Rodriguez Date Collected: 8/14/18
Sample Type: 6.0 L Silonite Canister Date Received: 8/18/18
Test Notes: Date Analyzed: 8/22/18
Container ID: SSC00205

Container Dilution Factor: 2.68

Components	Result Volume %	Result ppmV	MRL ppmV	Data Qualifier
Hydrogen	< 0.01	ND	2,700	
Oxygen	**0.82**	**8,200**	2,700	
Nitrogen	**2.12**	**21,200**	2,700	
Carbon Monoxide	< 0.01	ND	2,700	
Methane	**60.84**	**608,000**	2,700	
Carbon Dioxide	**36.21**	**362,000**	2,700	
Hydrogen Sulfide	< 0.01	**0.14**	0.013	
C2 as Ethane	< 0.01	ND	13	
C3 as Propane	< 0.01	ND	13	
C4 as n-Butane	< 0.01	ND	13	
C5 as n-Pentane	< 0.01	ND	13	
C6 as n-Hexane	< 0.01	ND	13	
> C6 as n-Hexane	< 0.01	ND	27	
TOTALS	**99.99**			

Components	Mole %	Weight %	Data Qualifier
Carbon	**23.18**	**43.90**	
Hydrogen	**58.12**	**9.24**	
Oxygen	**17.69**	**44.63**	
Nitrogen	**1.01**	**2.24**	
Sulfur	< 0.10	< 0.10	

Specific Gravity (Air = 1)		**0.9168**
Specific Volume	ft3/lb	**14.29**
Gross Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/ft3	**616.3**
Net Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/ft3	**554.9**
Gross Heating Value (Water Saturated at 0.25636 psia)	BTU/ft3	**603.7**
Net Heating Value (Water Saturated at 0.25636 psia)	BTU/ft3	**543.6**
Gross Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/lb	**8,807.9**
Net Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/lb	**7,930.6**
Compressibility Factor "Z" (60 F, 14.696 psia)		**0.9970**
WOBBE Index		**643.7**

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **Before IS D1S1** ALS Project ID: P1804292
Client Project ID: **Biogas 2018** ALS Sample ID: P1804292-004

Test Code: ASTM D3588-98
Analyst: Gilbert Gutierrez/Magaly Rodriguez Date Collected: 8/14/18
Sample Type: 6.0 L Silonite Canister Date Received: 8/18/18
Test Notes: Date Analyzed: 8/22/18
Container ID: SSC00392

Container Dilution Factor: 2.64

Components	Result Volume %	Result ppmV	MRL ppmV	Data Qualifier
Hydrogen	< 0.01	ND	2,600	
Oxygen	**0.85**	**8,450**	2,600	
Nitrogen	**2.28**	**22,800**	2,600	
Carbon Monoxide	< 0.01	ND	2,600	
Methane	**60.91**	**609,000**	2,600	
Carbon Dioxide	**35.88**	**359,000**	2,600	
Hydrogen Sulfide	**0.06**	**640**	0.26	
C2 as Ethane	< 0.01	ND	13	
C3 as Propane	< 0.01	ND	13	
C4 as n-Butane	< 0.01	ND	13	
C5 as n-Pentane	< 0.01	ND	13	
C6 as n-Hexane	< 0.01	ND	13	
> C6 as n-Hexane	< 0.01	ND	26	
TOTALS	**99.99**			

Components	Mole %	Weight %	Data Qualifier
Carbon	**23.12**	**43.88**	
Hydrogen	**58.23**	**9.27**	
Oxygen	**17.54**	**44.35**	
Nitrogen	**1.09**	**2.41**	
Sulfur	< 0.10	< 0.10	

Specific Gravity (Air = 1)		**0.9149**
Specific Volume	ft3/lb	**14.32**
Gross Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/ft3	**617.5**
Net Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/ft3	**556.0**
Gross Heating Value (Water Saturated at 0.25636 psia)	BTU/ft3	**604.9**
Net Heating Value (Water Saturated at 0.25636 psia)	BTU/ft3	**544.7**
Gross Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/lb	**8,843.8**
Net Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/lb	**7,963.0**
Compressibility Factor "Z" (60 F, 14.696 psia)		**0.9970**
WOBBE Index		**645.6**

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **After IS D1S1**
Client Project ID: **Biogas 2018**

ALS Project ID: P1804292
ALS Sample ID: P1804292-001

Test Code: GC/MS
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2
Analyst: Wade Henton/Evelyn Alvarez
Sample Type: Siloxane Tube
Test Notes: **BC, DE**

Date Collected: 8/14/18
Date Received: 8/18/18
Date Analyzed: 8/21/18
Desorption Volume: 3.0 ml
Volume Sampled: 6 Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	0.92	**150**	54	**48**	17	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	ND	47	ND	16	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	ND	50	ND	19	
107-51-7	Octamethyltrisiloxane (L_3)	< 0.29	ND	48	ND	17	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	1.7	**280**	48	**100**	18	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	ND	48	ND	17	
541-02-6	Decamethylcyclopentasiloxane (D_5)	0.60	**100**	47	**38**	18	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	ND	48	ND	18	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	ND	48	ND	18	
	Total Silicon				**190**		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **Before IS D1S1**
Client Project ID: **Biogas 2018**

ALS Project ID: P1804292
ALS Sample ID: P1804292-002

Test Code: GC/MS
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2
Analyst: Wade Henton/Evelyn Alvarez
Sample Type: Siloxane Tube
Test Notes: **BC, DE**

Date Collected: 8/14/18
Date Received: 8/18/18
Date Analyzed: 8/21/18
Desorption Volume: 3.0 ml
Volume Sampled: 6 Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	0.85	**140**	54	**44**	17	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	ND	47	ND	16	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	ND	50	ND	19	
107-51-7	Octamethyltrisiloxane (L_3)	0.33	**54**	48	**19**	17	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	7.5	**1,200**	48	**470**	18	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	ND	48	ND	17	
541-02-6	Decamethylcyclopentasiloxane (D_5)	6.3	**1,000**	47	**400**	18	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	ND	48	ND	18	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	ND	48	ND	18	
	Total Silicon				**930**		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **After IS D2S1**
Client Project ID: **Biogas 2018**

ALS Project ID: P1804292
ALS Sample ID: P1804292-005

Test Code: GC/MS
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2
Analyst: Wade Henton/Evelyn Alvarez
Sample Type: Siloxane Tube
Test Notes: **BC, DE**

Date Collected: 8/15/18
Date Received: 8/18/18
Date Analyzed: 8/21/18
Desorption Volume: 3.0 ml
Volume Sampled: 6 Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	0.90	**150**	54	**47**	17	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	ND	47	ND	16	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	ND	50	ND	19	
107-51-7	Octamethyltrisiloxane (L_3)	< 0.29	ND	48	ND	17	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	1.8	**290**	48	**110**	18	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	ND	48	ND	17	
541-02-6	Decamethylcyclopentasiloxane (D_5)	1.1	**190**	47	**70**	18	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	ND	48	ND	18	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	ND	48	ND	18	
	Total Silicon				**230**		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **Method Blank**
Client Project ID: **Biogas 2018**

ALS Project ID: P1804292
ALS Sample ID: P180821-MB

Test Code: GC/MS
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2
Analyst: Wade Henton/Evelyn Alvarez
Sample Type: Siloxane Tube
Test Notes: **BC, DE**

Date Collected: NA
Date Received: NA
Date Analyzed: 8/21/18
Desorption Volume: 3.0 ml
Volume Sampled: NA Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	< 0.32	NA	NA	NA	NA	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	NA	NA	NA	NA	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	NA	NA	NA	NA	
107-51-7	Octamethyltrisiloxane (L_3)	< 0.29	NA	NA	NA	NA	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	< 0.29	NA	NA	NA	NA	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	NA	NA	NA	NA	
541-02-6	Decamethylcyclopentasiloxane (D_5)	< 0.28	NA	NA	NA	NA	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	NA	NA	NA	NA	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	NA	NA	NA	NA	
	Total Silicon				NA		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
NA = Not applicable.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE / DUPLICATE LABORATORY CONTROL SAMPLE SUMMARY

Client: **Valley Sanitary District**
Client Sample ID: **Duplicate Lab Control Sample** ALS Project ID: P1804292
Client Project ID: **Biogas 2018** ALS Sample ID: P180821-DLCS

Test Code: GC/MS Date Collected: NA
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2 Date Received: NA
Analyst: Wade Henton/Evelyn Alvarez Date Analyzed: 8/21/18
Sampling Type: Siloxane Tube Volume(s) Analyzed: NA Liter(s)
Test Notes:

CAS #	Compound	Spike Amount LCS / DLCS µg/ml	Result LCS µg/ml	Result DLCS µg/ml	% Recovery LCS	% Recovery DLCS	ALS Acceptance Limits	RPD	RPD Limit	Data Qualifier
1066-40-6	Trimethylsilanol	11.3	11.5	11.6	**102**	**103**	73-112	1	13	
107-46-0	Hexamethyldisiloxane	12.2	12.7	13.3	**104**	**109**	92-123	5	11	
541-05-9	Hexamethylcyclotrisiloxane	12.0	12.4	12.3	**103**	**103**	90-119	0	10	
107-51-7	Octamethyltrisiloxane	11.7	12.9	12.2	**110**	**104**	93-123	6	10	
556-67-2	Octamethylcyclotetrasiloxane	11.9	12.7	12.8	**107**	**108**	94-123	0.9	10	
141-62-8	Decamethyltetrasiloxane	11.7	12.5	12.7	**107**	**109**	94-123	2	10	
541-02-6	Decamethylcyclopentasiloxane	11.1	12.5	12.3	**113**	**111**	94-123	2	10	
141-63-9	Dodecamethylpentasiloxane	11.3	12.5	12.6	**111**	**112**	92-126	0.9	12	
540-97-6	Dodecamethylcyclohexasiloxane	11.4	12.6	12.7	**111**	**111**	91-126	0	13	

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LABORATORY REPORT

September 6, 2018

Anna Bell
Valley Sanitary District
45500 Van Buren St.
Indio, CA 92201

RE: Biogas 2018

Dear Anna:

Enclosed are the results of the samples submitted to our laboratory on August 22, 2018. For your reference, these analyses have been assigned our service request number P1804351.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

By Sue Anderson at 2:57 pm, Sep 06, 2018
Sue Anderson
Project Manager

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Client: Valley Sanitary District
Project: Biogas 2018

Service Request No: P1804351

CASE NARRATIVE

The samples were received intact under chain of custody on August 22, 2018 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

BTU and CHONS Analysis

The results for BTU and CHONS were generated according to ASTM D 3588-98. The following analyses were performed and used to calculate the BTU and CHONS results. This method is not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

C2 through C6 Hydrocarbon Analysis

The Silonite canister sample was analyzed according to modified EPA Method TO-3 for C2 through >C6 hydrocarbons using a gas chromatograph equipped with a flame ionization detector (FID). This method is included on the laboratory's DoD-ELAP scope of accreditation, however it is not part of the NELAP accreditation.

Fixed Gases Analysis

The Silonite canister sample was also analyzed for fixed gases (hydrogen, oxygen/argon, nitrogen, carbon monoxide, methane and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD). This method is included on the laboratory's DoD-ELAP scope of accreditation, however it is not part of the NELAP accreditation.

Hydrogen Sulfide Analysis

The Silonite canister sample was also analyzed for hydrogen sulfide per modified SCAQMD Method 307-91 and ASTM D 5504-12 using a gas chromatograph equipped with a sulfur chemiluminescence detector (SCD). Method ASTM D 5504-12 is included on the laboratory's NELAP scope of accreditation, however it is not part of the DoD-ELAP accreditation. Method SCAQMD 307-91 is not included on the laboratory's NELAP or DoD-ELAP accreditation.

Siloxanes Analysis

The tube samples were analyzed for siloxanes according to laboratory SOP SVO-Siloxanes using an analytical system comprised of a gas chromatograph/mass spectrometer (GC/MS). This

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Client: Valley Sanitary District
Project: Biogas 2018

Service Request No: P1804351

CASE NARRATIVE

method is not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

Use of ALS Environmental (ALS)'s Name. Client shall not use ALS's name or trademark in any marketing or reporting materials, press releases or in any other manner ("Materials") whatsoever and shall not attribute to ALS any test result, tolerance or specification derived from ALS's data ("Attribution") without ALS's prior written consent, which may be withheld by ALS for any reason in its sole discretion. To request ALS's consent, Client shall provide copies of the proposed Materials or Attribution and describe in writing Client's proposed use of such Materials or Attribution. If ALS has not provided written approval of the Materials or Attribution within ten (10) days of receipt from Client, Client's request to use ALS's name or trademark in any Materials or Attribution shall be deemed denied. ALS may, in its discretion, reasonably charge Client for its time in reviewing Materials or Attribution requests. Client acknowledges and agrees that the unauthorized use of ALS's name or trademark may cause ALS to incur irreparable harm for which the recovery of money damages will be inadequate. Accordingly, Client acknowledges and agrees that a violation shall justify preliminary injunctive relief. For questions contact the laboratory.

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ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
Alaska DEC	http://dec.alaska.gov/eh/lab.aspx	17-019
Arizona DHS	http://www.azdhs.gov/preparedness/state-laboratory/lab-licensure-certification/index.php#laboratory-licensure-home	AZ0694
Florida DOH (NELAP)	http://www.floridahealth.gov/licensing-and-regulation/environmental-laboratories/index.html	E871020
Louisiana DEQ (NELAP)	http://www.deq.louisiana.gov/page/la-lab-accreditation	05071
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/professionals/labCert.shtml	2016036
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	1347317
New Jersey DEP (NELAP)	http://www.nj.gov/dep/enforcement/oqa.html	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://www.oregon.gov/oha/ph/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	4068-005
Pennsylvania DEP	http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx	68-03307 (Registration)
PJLA (DoD ELAP)	http://www.pjlabs.com/search-accredited-labs	65818 (Testing)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/agency/qa/env_lab_accreditation.html	T104704413-18-9
Utah DOH (NELAP)	http://health.utah.gov/lab/lab_cert_env	CA016272018-9
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Valley Sanitary District
Project ID: Biogas 2018

Service Request: P1804351

Date Received: 8/22/2018
Time Received: 09:15

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	ALS AQL 111 - Siloxanes Tube	TO-3 Modified - C1C6+ Can	3C Modified - Fxd Gases Can	ASTM D5504-01 - H2S Can
After IS W2D1	P1804351-001	Air	8/20/2018	00:00				X			
After IS W2D1	P1804351-002	Air	8/20/2018	00:00	SSC00407	-0.48	3.58		X	X	X
After IS W2D2	P1804351-003	Air	8/21/2018	00:00				X			

Air - Chain of Custody Record & Analytical Service Request

Page 1 of 1

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Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle:
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day-Standard

ALS Project No. P1804351

ALS Contact: SUE ANDERSON

Company Name & Address (Reporting Information)	Project Name	Analysis Method		
Valley Sanitary District 45-500 Van Buren St Indio, CA 92201	Biogas 2018			
Project Manager: Anna Bell	Project Number			
Phone: 760-238-5402 / Fax: 800-750-2280	P.O. # / Billing Information: PO # 6988			
Email Address for Result Reporting: abell@valley-sanitary.org	Sampler (Print & Sign): Anna Bell			

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	SILOXANE, SORBENT	BTU, SILONITE CANISTER	Comments e.g. Actual Preservative or specific instructions
											Duration
AFTER IS W2D1		9/20/18	0745						X		30 MIN
AFTER IS W2D1		↓	0820	SSC 00407	SFC 00325	19.0	1.0	16L		X	4HR
AFTER IS W2D2		9/21/18	0820						X		30MIN

6 of 12

Report Tier Levels - please select

Tier I - Results (Default if not specified) ____ Tier III (Results + QC & Calibration Summaries) ____
Tier II (Results + QC Summaries) ____ Tier IV (Data Validation Package) 10% Surcharge ____

EDD required Yes / No
Type: _____ Units: _____

Chain of Custody Seal: (Circle) INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
	9/21/18	1100		9/22/18	0915
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Cooler / Blank Temperature ____ °C

ALS Environmental
Sample Acceptance Check Form

Client: Valley Sanitary District Work order: P1804351

Project: Biogas 2018

Sample(s) received on: 8/22/18 Date opened: 8/22/18 by: AARON GONZALEZ

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

		Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Did **sample containers** arrive in good condition?	☒	☐	☐
3	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
4	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
5	Was **sample volume** received adequate for analysis?	☒	☐	☐
6	Are samples within specified holding times?	☒	☐	☐
7	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
8	Were **custody seals** on outside of cooler/Box/Container?	☐	☒	☐
	Location of seal(s)? _____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
9	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
10	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
11	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1804351-001.01	Tube, Siloxane					
P1804351-002.01	6.0 L Silonite Can					
P1804351-003.01	Tube, Siloxane					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **After IS W2D1** ALS Project ID: P1804351
Client Project ID: **Biogas 2018** ALS Sample ID: P1804351-002

Test Code: ASTM D3588-98
Analyst: Gilbert Gutierrez/Magaly Rodriguez Date Collected: 8/20/18
Sample Type: 6.0 L Silonite Canister Date Received: 8/22/18
Test Notes: Date Analyzed: 8/23/18
Container ID: SSC00407

Container Dilution Factor: 2.31

Components	Result Volume %	Result ppmV	MRL ppmV	Data Qualifier
Hydrogen	< 0.01	ND	2,300	
Oxygen	**0.49**	**4,870**	2,300	
Nitrogen	**1.31**	**13,100**	2,300	
Carbon Monoxide	< 0.01	ND	2,300	
Methane	**60.62**	**606,000**	2,300	
Carbon Dioxide	**37.57**	**376,000**	2,300	
Hydrogen Sulfide	< 0.01	**6.5**	0.12	
C2 as Ethane	< 0.01	ND	12	
C3 as Propane	< 0.01	ND	12	
C4 as n-Butane	< 0.01	ND	12	
C5 as n-Pentane	< 0.01	ND	12	
C6 as n-Hexane	< 0.01	ND	12	
> C6 as n-Hexane	< 0.01	**27**	23	
TOTALS	**99.99**			

Components	Mole %	Weight %	Data Qualifier
Carbon	**23.41**	**44.04**	
Hydrogen	**57.82**	**9.13**	
Oxygen	**18.15**	**45.46**	
Nitrogen	**0.63**	**1.37**	
Sulfur	< 0.10	< 0.10	

Specific Gravity (Air = 1)		**0.9249**
Specific Volume	ft3/lb	**14.17**
Gross Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/ft3	**614.3**
Net Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/ft3	**553.1**
Gross Heating Value (Water Saturated at 0.25636 psia)	BTU/ft3	**601.7**
Net Heating Value (Water Saturated at 0.25636 psia)	BTU/ft3	**541.8**
Gross Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/lb	**8,703.1**
Net Heating Value (Dry Gas @ 60 F, 14.696 psia)	BTU/lb	**7,836.3**
Compressibility Factor "Z" (60 F, 14.696 psia)		**0.9969**
WOBBE Index		**638.8**

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **After IS W2D1**
Client Project ID: **Biogas 2018**

ALS Project ID: P1804351
ALS Sample ID: P1804351-001

Test Code: GC/MS
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2
Analyst: Wade Henton
Sample Type: Siloxane Tube
Test Notes: **BC, DE**

Date Collected: 8/20/18
Date Received: 8/22/18
Date Analyzed: 9/4 - 9/5/18
Desorption Volume: 3.0 ml
Volume Sampled: 6 Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	1.8	**300**	54	**94**	17	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	ND	47	ND	16	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	ND	50	ND	19	
107-51-7	Octamethyltrisiloxane (L_3)	< 0.29	ND	48	ND	17	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	2.9	**480**	48	**180**	18	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	ND	48	ND	17	
541-02-6	Decamethylcyclopentasiloxane (D_5)	1.6	**270**	47	**100**	18	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	ND	48	ND	18	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	ND	48	ND	18	
	Total Silicon				**380**		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **After IS W2D2**
Client Project ID: **Biogas 2018**

ALS Project ID: P1804351
ALS Sample ID: P1804351-003

Test Code: GC/MS
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2
Analyst: Wade Henton
Sample Type: Siloxane Tube
Test Notes: **BC, DE**

Date Collected: 8/21/18
Date Received: 8/22/18
Date Analyzed: 9/4 - 9/5/18
Desorption Volume: 3.0 ml
Volume Sampled: 6 Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	1.9	**320**	54	**99**	17	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	ND	47	ND	16	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	ND	50	ND	19	
107-51-7	Octamethyltrisiloxane (L_3)	< 0.29	ND	48	ND	17	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	4.9	**810**	48	**310**	18	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	ND	48	ND	17	
541-02-6	Decamethylcyclopentasiloxane (D_5)	4.2	**690**	47	**260**	18	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	ND	48	ND	18	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	ND	48	ND	18	
	Total Silicon				**670**		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Valley Sanitary District**
Client Sample ID: **Method Blank** ALS Project ID: P1804351
Client Project ID: **Biogas 2018** ALS Sample ID: P180904-MB

Test Code: GC/MS Date Collected: NA
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2 Date Received: NA
Analyst: Wade Henton Date Analyzed: 9/4/18
Sample Type: Siloxane Tube Desorption Volume: 3.0 ml
Test Notes: **BC, DE** Volume Sampled: NA Liter(s)

CAS #	Compound	Result µg/Tube	Result µg/m³	MRL µg/m³	Result as Silicon µg/m³	MRL µg/m³	Data Qualifier
1066-40-6	Trimethylsilanol	< 0.32	NA	NA	NA	NA	
107-46-0	Hexamethyldisiloxane (L_2)	< 0.28	NA	NA	NA	NA	
541-05-9	Hexamethylcyclotrisiloxane (D_3)	< 0.30	NA	NA	NA	NA	
107-51-7	Octamethyltrisiloxane (L_3)	< 0.29	NA	NA	NA	NA	
556-67-2	Octamethylcyclotetrasiloxane (D_4)	< 0.29	NA	NA	NA	NA	
141-62-8	Decamethyltetrasiloxane (L_4)	< 0.29	NA	NA	NA	NA	
541-02-6	Decamethylcyclopentasiloxane (D_5)	< 0.28	NA	NA	NA	NA	
141-63-9	Dodecamethylpentasiloxane (L_5)	< 0.29	NA	NA	NA	NA	
540-97-6	Dodecamethylcyclohexasiloxane (D_6)	< 0.29	NA	NA	NA	NA	
	Total Silicon				NA		

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
NA = Not applicable.
BC = Results reported are not blank corrected.
DE = Results reported are corrected for desorption efficiency.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE / DUPLICATE LABORATORY CONTROL SAMPLE SUMMARY

Client: **Valley Sanitary District**
Client Sample ID: **Duplicate Lab Control Sample** ALS Project ID: P1804351
Client Project ID: **Biogas 2018** ALS Sample ID: P180904-DLCS

Test Code: GC/MS Date Collected: NA
Instrument ID: Tekmar AUTOCAN/HP5972/HP5890 II+/MS2 Date Received: NA
Analyst: Wade Henton Date Analyzed: 9/04/18
Sampling Type: Siloxane Tube Volume(s) Analyzed: NA Liter(s)
Test Notes:

CAS #	Compound	Spike Amount LCS / DLCS µg/ml	Result LCS µg/ml	Result DLCS µg/ml	% Recovery LCS	% Recovery DLCS	ALS Acceptance Limits	RPD	RPD Limit	Data Qualifier
1066-40-6	Trimethylsilanol	11.8	11.6	10.4	**98**	**88**	73-112	11	13	
107-46-0	Hexamethyldisiloxane	12.2	12.9	12.1	**106**	**99**	92-123	7	11	
541-05-9	Hexamethylcyclotrisiloxane	12.1	11.8	11.5	**98**	**95**	90-119	3	10	
107-51-7	Octamethyltrisiloxane	11.7	12.1	11.7	**103**	**100**	93-123	3	10	
556-67-2	Octamethylcyclotetrasiloxane	11.8	12.3	12.0	**104**	**102**	94-123	2	10	
141-62-8	Decamethyltetrasiloxane	11.8	12.2	11.6	**103**	**98**	94-123	5	10	
541-02-6	Decamethylcyclopentasiloxane	11.7	11.8	11.7	**101**	**100**	94-123	1	10	
141-63-9	Dodecamethylpentasiloxane	11.8	12.0	11.2	**102**	**95**	92-126	7	12	
540-97-6	Dodecamethylcyclohexasiloxane	12.1	12.3	12.5	**102**	**103**	91-126	1	13	

In-House Gas Analysis

			Test	
			H2S	**Ammonia, NH3**
Week	**Day**	**Location**	In-house (VSD)	In-house (VSD)
1	1	Before iron sponge		2
1	1	After iron sponge		<1
1	2	Before iron sponge	1050	
1	2	After iron sponge	75	<1
2	1	After iron sponge	80	
2	2	After iron sponge	80	

Appendix D ENERGY CALCULATION AND COST ESTIMATE

Bio-Cogeneration System

2G Containerized Engine rate at 250kW

S.NO.	ITEM	UNITS	QUANTITY	COST PER UNIT	ITEM COST	NOTES
CAPITAL COST						
1	**Equipment**					
	360 kW energy system	ea	1	710,000	710,000	Quote from Western Energy System
	Heat recovery exhaust	ea	1	10,000	10,000	Use heat from com
	Biogas/Natural gas blending desired	ea	0	45,000	-	
	Continuous Emission Monitoring System (CEMS)	ea	1	158,000	158,000	Quotes from Rockwell Automation. Includes consulting services and Travel Expenses
	Combustion air inlet cooling	ea	1	10,000	10,000	
	Urea tank	ea	1	18,000	18,000	
	Battery back up	ea	0	16,000	-	
	Additional switchgear or gas skid vendor commissioning support	day	1	2,200	2,200	
	Equipment Allowance (taxes)		30%		272,460	
				Equipment Subtotal	**$ 1,180,660**	
2	**Civil**					
	Infrastructure (Concrete, piping, etc)		5%		$ 59,033	
				Civil Subtotal	**$ 59,033**	
				Equipment and Civil Subtotal	**$ 1,239,693**	
	Electrical/I&C Allocation*		15%		$ 185,954	
	Contractor Contingency (profit, risk allocation)		10%		$ 123,969.30	
				Subtotal	$ 1,549,616	
	Project Contingency (Admin, CM, etc…)		10%		$ 154,961.63	
				TOTAL PROJECT COST	**$ 1,704,578**	
ANNUAL O&M COST						
1	Engine Maintenance (2% equipment and 20 year life)		2%		$ 47,226	
2	Gas Pretreatment system		2%		$ 23,613	2% of the equipment
3	Labor costs	man hrs	208	60	$ 12,480	1/2 day per week
				Total Annual Cost	**$ 59,706**	

* Includes data acquisition system for CEMS

2G Containerized Engine rate at 360kW

S.NO.	ITEM	UNITS	QUANTITY	COST PER UNIT	ITEM COST	NOTES
CAPITAL COST						
1	**Equipment**					
	360 kW energy system	ea	1	760,000	760,000	Quote from Western Energy System
	Heat recovery exhaust	ea	1	10,000	10,000	
	Biogas/Natural gas blending desired	ea	0	45,000	-	
	Continuous Emission Monitoring System (CEMS)	ea	1	158,000	158,000	Quotes from Rockwell Automation. Includes consulting services and Travel Expenses
	Combustion air inlet cooling	ea	1	10,000	10,000	
	Urea tank	ea	1	18,000	18,000	
	Battery back up	ea	0	16,000	-	
	Additional switchgear or gas skid vendor commissioning support	day	1	2,200	2,200	
	Equipment Allowance (scope contingency, taxes)		30%		287,460	
				Equipment Subtotal	**$ 1,245,660**	
2	**Civil**					
	Infrastructure (Concrete, piping, etc)		5%		$ 62,283	
				Civil Subtotal	**$ 62,283**	
				Equipment and Civil Subtotal	**$ 1,307,943**	
	Electrical/I&C Allocation*		15%		$ 196,191	
	Contractor Contingency (profit, risk allocation)		10%		$ 130,794.30	
				Subtotal	$ 1,634,929	
	Project Contingency (Admin, CM, etc…)		10%		$ 163,492.88	
				TOTAL PROJECT COST	**$ 1,798,422**	
ANNUAL O&M COST						
1	Engine Maintenance (2% equipment and 20 year life)		2%		$ 49,826	
2	Gas Pretreatment system		2%		$ 24,913	2% of the equipment
3	Labor costs	man hrs	208	60	$ 12,480	1/2 day per week
				Total Annual Cost	**$ 62,306**	

* Includes data acquisition system for CEMS

Financial Analysis Parameters			
Biogas Production			
Parameter	**UNITS**	**Value**	
Primary Solids Production	lb/MG Treated	1,200	*From Plant data*
Waste Activated Sludge Production	lb/MG Treated	1,098	*From Plant data*
Biogas Production			
Parameter	**UNITS**	**Value**	
Volatile Solids % - PS	%	88%	*PS*
Volatile Solids % - TWAS	%	80%	*TWAS*
Biogas Yield - PS only	ft^3/lb VS Dest.	17.0	
Biogas Yield - PS & TWAS combined	ft^3/lb VS Dest.	15.5	*range is 12 to 18, mid-range used*
Methane %	%	60%	*Typical - conistent with Plant data*
Heating Value	BTU/ft^3	600	*Typical - consistent with Plant data*
Volatile Solids Destruction - PS only or PS & TWAS combined	%	60%	*Calculated assuming 20 days SRT*
Internal Combustion Engine (ICE) Parameters			
Parameter	**UNITS**	**Value**	
ICE Engine Electrical Efficiency	%	38%	per manufacturer - see 2G quote
ICE Heat Recovery Efficiency	%	45%	per manufacturer - see 2G quote
ICE Run time	%	90%	
Digesters Parameters			
Parameter	**UNITS**	**Value**	
Heat Need per Digester under current conditions (5.9 mgd)	MBTU/year	3,861	*Calculated using NOAA weather data, see VSD Cogen Calcs spreadsheet*
Heat Need per Digester when WAS digested	MBTU/year	4,076	*Calculated using NOAA weather data, see VSD Cogen Calcs spreadsheet*
Energy Cost Parameters			
Parameter	**UNITS**	**Value**	
Electricity Cost	$/kWh	0.115	*From 2017 Plant energy data - low end. Power costs from Grid.*
		0.093	*From 2017 Plant energy data - low end. Credit recived for exported excess e*

Return on Invenstement for 250 kW ICE (including credits for exporting power to the grid)

To Digesters

TWAS digested?	No. of digesters	Plant Flow	TS Load	VS Load	VS Destroyed	Biogas production				Heat Needed	Engines Required	Engine Capacity Required	Design Engine Capacity	Electrical Production	Energy used on-site	Energy sent to the grid	ICE Heat Recovery	Electrical Revenue	10 YR ROI
-	-	MGD	lb/day	lb/day	lb/day	ft3/day	CFH	BTU/hr	MBTU/yr	BTU/hr		kW	kW	kWh/year	kWh/year	kWh/year	BTU/hr	$/year	%
no	1	5.9	7,080	6,230	3,738	63,550	2,648	1,588,752	13,917	440,753	1	177	250	1,393,711	929,141	464,570	643,445	$ 150,056	-47%
yes	2	5.9	13,558	11,413	6,848	106,141	4,423	2,653,513	23,245	930,594	1	295	250	1,971,000	1,314,000	657,000	1,074,673	$ 212,211	-11%
yes	2	6.84	15,718	13,231	7,939	123,051	5,127	3,076,276	26,948	1,078,858	1	342	250	1,971,000	1,314,000	657,000	1,245,892	$ 212,211	-11%

Return on Invenstement for 360 kW ICE (including credits for exporting power to the grid)

To Digesters

TWAS digested?	No. of digesters	Plant Flow	TS Load	VS Load	VS Destroyed	Biogas production				Heat Needed	Engines Required	Engine Capacity Required	Design Engine Capacity	Electrical Production	Energy used on-site	Energy sent to the grid	ICE Heat Recovery	Electrical Revenue	10 YR ROI
-	-	MGD	lb/day	lb/day	lb/day	ft3/day	CFH	BTU/hr	MBTU/yr	BTU/hr		kW	kW	kWh/year	kWh/year	kWh/year	BTU/hr	$/year	%
no	1	5.9	7,080	6,230	3,738	63,550	2,648	1,588,752	13,917	440,753	1	177	360	1,393,711	929,141	464,570	643,445	$ 150,056	-51%
yes	2	5.9	13,558	11,413	6,848	106,141	4,423	2,653,513	23,245	930,594	1	295	360	2,327,759	1,551,839	775,920	1,074,673	$ 250,622	5%
yes	2	6.84	15,718	13,231	7,939	123,051	5,127	3,076,276	26,948	1,078,858	1	342	360	2,698,622	1,799,081	899,541	1,245,892	$ 290,552	27%

	PS only - 250 kW	PS + WAS - 360 kW
Total Cogen Capital C	$ 1,704,578	$ 1,798,422
Annual O&M Cost	$ 59,706	$ 62,306

Return on Invenstement for 250 kW ICE (excluding credits for exporting power to the grid)

To Digesters

TWAS digested?	No. of digesters	Plant Flow	TS Load	VS Load	VS Destroyed	Biogas production				Heat Needed	Engines Required	Engine Capacity Required	Design Engine Capacity	Electrical Production	Energy used on-site	Energy sent to the grid	ICE Heat Recovery	Electrical Revenue	10 YR ROI
-	-	MGD	lb/day	lb/day	lb/day	ft3/day	CFH	BTU/hr	MBTU/yr	BTU/hr		kW	kW	kWh/year	kWh/year	kWh/year	BTU/hr	$/year	%
no	1	5.9	7,080	6,230	3,738	63,550	2,648	1,588,752	13,917	440,753	1	177	250	1,393,711	929,141	464,570	643,445	$ 106,851	-72%
yes	2	5.9	13,558	11,413	6,848	106,141	4,423	2,653,513	23,245	930,594	1	295	250	1,971,000	1,314,000	657,000	1,074,673	$ 151,110	-46%
yes	2	6.84	15,718	13,231	7,939	123,051	5,127	3,076,276	26,948	1,078,858	1	342	250	1,971,000	1,314,000	657,000	1,245,892	$ 151,110	-46%

Return on Invenstement for 360 kW ICE (excluding credits for exporting power to the grid)

To Digesters

TWAS digested?	No. of digesters	Plant Flow	TS Load	VS Load	VS Destroyed	Biogas production				Heat Needed	Engines Required	Engine Capacity Required	Design Engine Capacity	Electrical Production	Energy used on-site	Energy sent to the grid	ICE Heat Recovery	Electrical Revenue	10 YR ROI
-	-	MGD	lb/day	lb/day	lb/day	ft3/day	CFH	BTU/hr	MBTU/yr	BTU/hr		kW	kW	kWh/year	kWh/year	kWh/year	BTU/hr	$/year	%
no	1	5.9	7,080	6,230	3,738	63,550	2,648	1,588,752	13,917	440,753	1	177	360	1,393,711	929,141	464,570	643,445	$ 106,851	-75%
yes	2	5.9	13,558	11,413	6,848	106,141	4,423	2,653,513	23,245	930,594	1	295	360	2,327,759	1,551,839	775,920	1,074,673	$ 178,462	-35%
yes	2	6.84	15,718	13,231	7,939	123,051	5,127	3,076,276	26,948	1,078,858	1	342	360	2,698,622	1,799,081	899,541	1,245,892	$ 206,894	-20%

	PS only - 250 kW	PS + WAS - 360 kW
Total Cogen Capital C	$ 1,704,578	$ 1,798,422
Annual O&M Cost	$ 59,706	$ 62,306

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Appendix E VENDOR QUOTES AND ADDITIONAL INFORMATION

Appendix E.1 Bio-Cogeneration System

WESTERN ENERGY SYSTEMS
Power Systems Specialists

Gaseous Fueled Power Generation Systems
Co-Generation ● Landfill ● BioGas

Stantec
Attn: Pooja Sinha, Environmental Engineer-In-Training
300 N Lake Avenue Tel: +1 626 568-6079
Suite 400 Cell: +1 213 880-1107
Pasadena, CA 91101

June 28th, 2018

Quotation# 06282018-002

Dear Pooja,

Western Energy Systems (WES) is pleased to submit the following budget proposal for your Biogas project located in Indio, California. We understand the fuel source to be BioGas from an onsite wastewater plant digester.

This proposal is for One (1) 2G containerized Agenitor 406 unit 480V engine generator, rated at 250kW, 480 volt, 3 phase, and equipped with an engine heat rejection system (radiator), engine control system, engine jacket water heat recovery only, carbon polishing vessles for light H2S and Siloxaine scrubbing, a moisture removal and reheating system, fully integrated in a containerized package. An SCR system to meet Rule 1110.2 is included in the base price. Optional scope like urea tanks, exhaust gas heat recovery, and blending of biogas and natural gas are available at added cost.

Pricing assumes a purchase by an entity in California, is FOB job site and includes all ocean and inland shipping costs and U.S. Custom duties. The engine is equipped for natural gas operation. The following presents our proposed equipment and services scope, performance and pricing.

1.0 Scope of Equipment and Performance (See Attachments)

1. Genset

	50 %	75 %	100 %	Load
Electrical power	125	188	250	kW (5)
Recoverable thermal output	546	723	888	MBTU/hr (2)
Fuel cosumption	1128	1606	2067	MBTU/hr (1)
Efficiency Electrical	37,8	39,8	41,3	% (1)
Efficiency Thermal	48,4	45,0	42,9	% (1), (2)
Efficiency Combined (el. + th.)	86,2	84,8	84,2	% (1), (2)

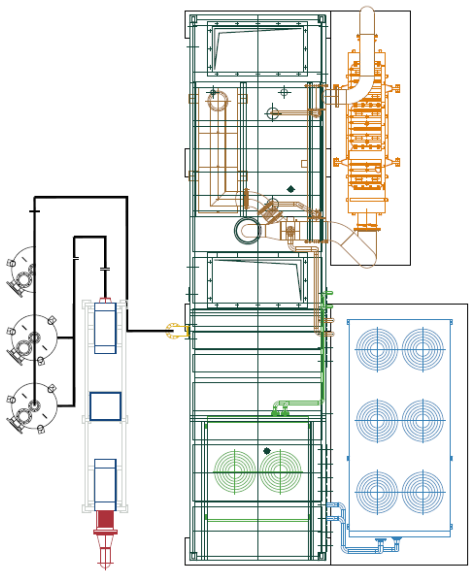
Guaranteed Emissions Limits Per Engine At Startup (natural gas) --		
Emission	**Untreated**	**Treated (SCR/Oxidation Catalyst)**
NOx	<1.0 g/BHP/hr	Rule 1110.2
CO		Rule 1110.2
NMHC		Rule 1110.2

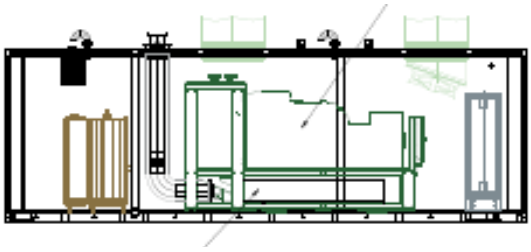
WESTERN ENERGY SYSTEMS
Power Systems Specialists

Gaseous Fueled Power Generation Systems
Co-Generation ● Landfill ● BioGas

Basic CHP Module Agenitor 406 (250kW) (open Frame mounted) -Intra-Cage-Structure Frame Design -including all basic CHP Components & Accessories -Oscillation Decoupling & Vibration Protection -Auto Lube-Oil System including Day Tank for automatic refill during operation -Gas Connection pre-flanged -Gas Pressure Regulator -Gas Train -Gas Mixer -Air/Fuel Ratio Control -Auxiliary Controls for all System Components -Multi-Level Heat Extraction & Thermal Circulation Pumps -Plate Heat Exchanger incl. Insulation -3 Way Mixing Valves for Jacket Water, Gas Mix, Hot Water and Dump Radiator Circuit -Expansion Vessels for Jacket Water and Gas Mix Circuit -Closed Loop Heat Recovery & Thermal Energy Circulation Technology Package -Controls & Safety Devices (Safety Temperature Limiter, Min & Max Pressure Sensors) -Double Bearing Generator incl. Voltage Regulator -Generator Switchgear Cabinet (52-G breaker) including Generator Protection Relay -Total Electronic Management (TEM) combining all System Controls (Engine, CHP, and all Aux. Control Functions incl. Remote Monitoring via Internet, -Factory Test Run (The complete package will be 100% Factory tested incl. Load Run) -Initial Fill of Lubricants (Oil and Glycol) (Glycol Pump to be provided by others) -Handbooks & Manuals -Packaging & Loading -Project Management -First E10 service after commissioning	1
Installation Menu	
Fully Containerized Module 9m x 3m x 3m (30' x 10' x 10') **All-In-One & Connection Ready (Plug & Play)** Standard Version 9m Special, Extra Large CHP Container Design, Sound-attenuated (<65dBA) Power Generation Module incl. all Piping, Plumbing, Insulation, Conduits, Wiring , Connections, Space Ventilation, Smoke & Gas Detection. Complete System Factory installed and Factory tested".	1
Options Menu	
Exhaust Gas Heat Exchanger incl. Insulation	0
Stainless Steel Exhaust Silencer	1
Jacket Water Table Cooler	1
Mixture Table Cooler	1
Lube Oil Supply incl. Waste and Fresh Oil Tank	1
Gas Flow Meter	1
Extension of Crankcase Oil Volume for Longer Oil Change Interval	1
Oxidation Catalyst	1
SCR System incl. Insulation and Connections for customer supplied Urea Storage Tank	1
Slam Shut Valve for Gas Supply to Container	0
Container Room Heater	0
Air Inlet & Outlet Louver with Actuator	1
Combustion Air Cooling for High Ambient Temperature Regions	0
AC for Control Cabinet	1
High Ambient Temperature Upgrade for Jacket Water Coolers	1
Island Mode Option	1
Electric Load Following Option	1
Dust Filter for Air Inlet	0
SEL Relay (if required by local utility, to be determined during project management)	0
Net Generation Meter	0
BTU Meter incl. Temperature Sensors for Heating Circuit (water based)	1
Hydronic Junction with Sinus Manifold & Thermal Heat Distribution	0
Active Circuits for Thermal Heat Distribution	0
Gas Blower	1
Gas Treatment Active Carbon Filter 650 lbs incl. Initial Fill	2
Gas Treatment Active Carbon Filter 1000 lbs incl. Initial Fill	0
Gas Treatment Active Carbon Filter 2000 lbs incl. Initial Fill	0
Insulation for Active Carbon Filter 650 lbs	0
Insulation for Active Carbon Filter 1000 lbs	0
Insulation for Active Carbon Filter 2000 lbs	0
Gas Dehumidification System incl. Re-Heating System	0
Biogas Flare rated for System	0
Biogas Analyzer	1
Hot Water Upgrade in Lieu to Standard Config. (Supply Temp. 95°C, Return Temp. 75°C)	0
Dual Fuel Option (Natural Gas Backup)	0
Natural Gas Fuel Blending Option	0
Cold Installation Assistance of Equipment (Crane and Lifting Equipment to be provided by others) + Commissioning & Operators Training (max 5 Days per engine)	1
Transport Costs (unloading not included)	1

(Graphics are representative)





Diesel Allison LLC

Energy Systems

PITTSBURGH
21260 Route 19
Cranberry, PA 16066-3505
724-631-1260
Fax: 724-631-1206

SYRACUSE
7044 Interstate Island Road
Syracuse, NY 12089-9799
315-451-3838
Fax: 315-461-8662

BUFFALO
350 Bailey Avenue
Buffalo, NY 14210-1737
716-822-0051
Fax: 716-826-1544

Authorized Distributor
GE Energy

Philadelphia, PA 19136-2986
215-335-5010
Fax: 215-335-2163
www.weesys.com

Brea, CA 92821
714-529-9700
Fax: 714-529-9701

e Unit 2
Weymouth, MA 02188
781-340-9640
Fax: 781-340-9649
www.neesys.com

NOTE: Tables and thermal calculations (see separate attachments) are taken from manufacturer supplied information and subject to their tolerances and restrictions. The above equipment come as sections, or as loose components, and will require customer contractor assembly/installation.

2. Technical Support Services

1. Provide emissions data and support for air permitting and certified emission testing (by others)
2. Customize panel operating systems for site specific conditions and parameters.
3. Develop and provide two (2) sets of submittal documentation in hard copy and CD format for review by construction managers and sub-contractors.
4. Develop and provide two (2) sets of as-built documentation, following final startup and commissioning, in hard copy and CD format for the owners use.

3. Startup and Commissioning and Training Services

Western Energy Systems provide startup and commissioning services. Startup personnel will include a startup engineer and service technician provided by WES or 2G. Services will be scheduled after receipt of completed installation checklists. A complete startup and commissioning work scope will be provided 6 weeks prior to start-up date and customer will provide a "Checklist for Site Readiness". Customer will fill out a pre-commissioning inspection form will occur 3 weeks prior to planned commissioning. The Operation and Maintenance manual provided will be for WES/2G supplied major equipment only.

4. Commercial Proposal

All prices are quoted F.O.B. jobsite on a truck with rigging and removal required by others. No provisions are made for local sale taxes, bonds, permits, or fees. The following presents our clarifications and exceptions.

4.1 Clarifications & Exceptions

1. This quotation shall be considered a BUDGET QUOTATION until all technical details are clarified
2. Ship loose components with engine and generator must be assembled on site (see Technical Description). All insulation and loose item assembly are the responsibility of the customer.
3. WES supplied equipment will have a one year limited warranty (described below).
4. Product Manufacturer provides complete shop drawings & equipment data sheets 6 weeks after acceptance of approved purchase order, submittals follow at 10 weeks.
5. When fuel is other than pipeline Natural Gas, generator set maintenance and performance may be impacted by the performance of customer gas cleanup. 3-way catalyst/SCR/Oxycat sensitive to contaminants.
6. Proposal excludes reporting grade CEMS (may not be required), unless otherwise noted below in options.
7. Siloxaine Removal equipment & media, proposal doesn't cover siloxaine treatment as fuel content is unknown.
8. No Site Engineering or Civil or Structural, unless otherwise noted in scope or below in options.
9. Base offering supports utility mains parallel operations from a single utility service, simple load sharing, simple load following, non-export, only; multiple utility service or complex load following requires additional equipment.
10. Proposal does not include utility interconnection, interconnection switchgear, or additional commissioning support that may be required by switchgear vendor unless otherwise noted in scope or below in **options.**
11. Specific Exclusions (unless otherwise noted)
    a. Seismic calculations & restraints for engines, radiators, heat recovery equipment provided by installation contractor
    b. Loop Diagrams
    c. Motor Control Cabinet
    d. Taxes or Fees (sales, local, any)

e. Insurance after delivery to site
f. Storage (if required)
g. Maintenance of Unit if installation is delayed
h. Installation & Piping
i. Insulation, except as noted
j. Miscellaneous equipment beyond what is explicitly stated herein
k. Third Party Independent Testing Agencies, unless otherwise noted
l. Short Circuit Analysis and Coordination Studies
m. Protective Relay Settings or Programming
n. Load Bank (if required)
o. Field Hi-Pot Testing
p. Modifications to Equipment O&Ms
q. Witness Testing Travel Costs
r. Crane and riggers for all equipment offload, movement to site and landing.
s. SGIP Monitoring equipment package and services not included.
t. CO2 monitoring/reporting equipment and flare not included.
u. Does not include equipment, supplies and plumbing to and from heat recovery equipment scope and customer thermal load/drying process equipment.

WES will provide the equipment and services identified in this proposal for a price of:

Seven Hundred Ten Thousand Dollars……..……..……...$710,000.00
--(Base price, budget, subject to clarification of technical details)

Optional equipment, continued, ADD to the base price above:

If Heat recovery form exhaust is desired, add to the above……..……..$10,000.00

If Biogas/Natural gas Blending desired, add to the above……..……...……..$45,000.00

If additional Siloxaine removal equipment is required, add to the above……....….$XX,XXX.XX

If you wish to add Combustion Air Inlet Cooling (decreases derate during hot days adding an estimated ~10-20*F of tolerance, depending on local climate variations) ADD to the above price…….……...…….$10,000.00

Urea Tank, 1000 gallon capacity, Insulated and Heat Traced, ADD to the above price…….....$15,000.00
Urea Tank, 2000 gallon capacity, Insulated and Heat Traced, ADD to the above price…….....$18,000.00

If you wish to add Battery Backup of relays (batteries/rack/charger/boxes/spill containment, gas detector) ADD to the above price…….……...…….$16,000.00

Additional Engineering and support options (if desired, add to base price above):
Additional Switchgear or Gas Skid Vendor Commissioning support, per additional day…….……....$2,200.00

All prices are FOB jobsite with rigging and removal by others. **Price is valid for 60 days.**
All US Customs duties are pre-paid. Local, state, and Federal taxes, permits and fees are by others.

WESTERN ENERGY SYSTEMS
Power Systems Specialists

Gaseous Fueled Power Generation Systems
Co-Generation ● Landfill ● BioGas

Firm delivery is confirmed after PO is received.

Delivery FOB Flatbed truck at site is 24-26 weeks after receipt of order.

Terms:

This proposal is subject to Western Energy Systems Contract for Sale of Equipment.
See attached WES NEGOTIATED TERMS AND CONDITIONS FOR SALE OF EQUIPMENT 10-4-16

WES administers factory warranties. The 2G Manufacturer Limited Warranty is for a period of twenty four (24) months (unlimited hours) for the CHP system; for the engine, twelve (12) months (unlimited hours) from the time of commissioning and start-up, or eighteen (18) months from the date of delivery (ready for shipment notification), whichever occurs first. Factory warranty terms vary depending on equipment supplied. Please request and review all manufacturer warranties before purchase of equipment.

We sincerely appreciate the opportunity to submit this proposal for your review. 2G is one of the world's leading manufacturers of gaseous fueled engines with over 5,000 in operation worldwide. As part of the Penn Detroit Diesel organization, Western Energy Systems brings over 50 years of experience in reciprocating engine power applications and product support and services. If you have any questions please don't hesitate to call me at 559-246-4045 or email tmarihart@weesys.com.

WES looks forward to working with Stantec on this exciting project.

Sincerely Yours,

Thomas Marihart
Sales Engineer
Western Energy Systems

cc Steve Hall, Western Region Sales Manager
cc Fred Farrand, National Sales Manager
cc Al Clark, President and General Manager

WESTERN ENERGY SYSTEMS
Power Systems Specialists

Gaseous Fueled Power Generation Systems
Co-Generation ● Landfill ● BioGas

Stantec
Attn: Pooja Sinha, Environmental Engineer-In-Training
300 N Lake Avenue Tel: +1 626 568-6079
Suite 400 Cell: +1 213 880-1107
Pasadena, CA 91101

June 28th, 2018

Quotation# 06282018-001

Dear Pooja,

Western Energy Systems (WES) is pleased to submit the following budget proposal for your Biogas project located in Indio, California. We understand the fuel source to be BioGas from an onsite wastewater plant digester.

This proposal is for One (1) 2G containerized Agenitor 408 unit 480V engine generator, rated at 360kw, 480 volt, 3 phase, and equipped with an engine heat rejection system (radiator), engine control system, engine jacket water heat recovery only, carbon polishing vessles for light H2S and Siloxaine scrubbing, a moisture removal and reheating system, fully integrated in a containerized package. An SCR system to meet Rule 1110.2 is included in the base price. Optional scope like urea tanks, exhaust gas heat recovery, and blending of biogas and natural gas are available at added cost.

Pricing assumes a purchase by an entity in California, is FOB job site and includes all ocean and inland shipping costs and U.S. Custom duties. The engine is equipped for natural gas operation. The following presents our proposed equipment and services scope, performance and pricing.

1.0 Scope of Equipment and Performance (See Attachments)

1. Genset

	50 %	75 %	100 %	Load
Electrical power	180	270	360	kW [5]
Recoverable thermal output	836	1041	1308	MBTU/hr [2]
Fuel cosumption	1620	2303	3004	MBTU/hr [1]
Efficiency Electrical	37,9	40,0	40,9	% [1]
Efficiency Thermal	51,6	45,2	43,6	% [1], [2]
Efficiency Combined (el. + th.)	89,5	85,2	84,4	% [1], [2]

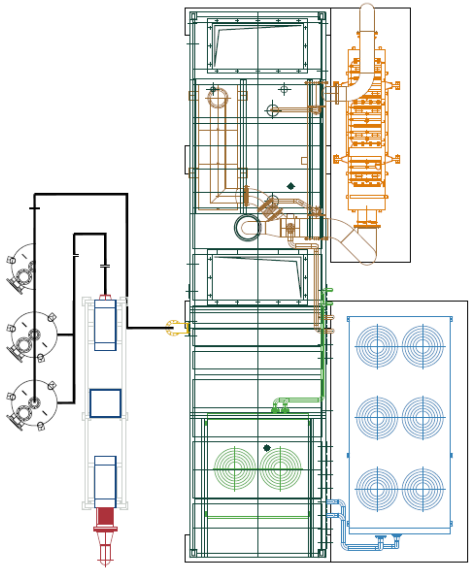
Guaranteed Emissions Limits Per Engine At Startup (natural gas) --		
Emission	**Untreated**	**Treated (SCR/Oxidation Catalyst)**
NOx	<1.0 g/BHP/hr	Rule 1110.2
CO		Rule 1110.2
NMHC		Rule 1110.2

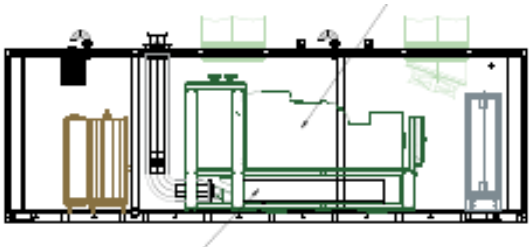
WESTERN ENERGY SYSTEMS
Power Systems Specialists

Basic CHP Module Agenitor 408 (360kW) (open Frame mounted) -Intra-Cage-Structure Frame Design -including all basic CHP Components & Accessories -Oscillation Decoupling & Vibration Protection -Auto Lube-Oil System including Day Tank for automatic refill during operation -Gas Connection pre-flanged -Gas Pressure Regulator -Gas Train -Gas Mixer -Air/Fuel Ratio Control -Auxiliary Controls for all System Components -Multi-Level Heat Extraction & Thermal Circulation Pumps -Plate Heat Exchanger incl. Insulation -3 Way Mixing Valves for Jacket Water, Gas Mix, Hot Water and Dump Radiator Circuit -Expansion Vessels for Jacket Water and Gas Mix Circuit -Closed Loop Heat Recovery & Thermal Energy Circulation Technology Package -Controls & Safety Devices (Safety Temperature Limiter, Min & Max Pressure Sensors) -Double Bearing Generator incl. Voltage Regulator -Generator Switchgear Cabinet (52-G breaker) including Generator Protection Relay -Total Electronic Management (TEM) combining all System Controls (Engine, CHP, and all Aux. Control Functions incl. Remote Monitoring via Internet, -Factory Test Run (The complete package will be 100% Factory tested incl. Load Run) -Initial Fill of Lubricants (Oil and Glycol) (Glycol Pump to be provided by others) -Handbooks & Manuals -Packaging & Loading -Project Management -First "M0" service after commissioning	1
Installation Menu	
Fully Containerized Module 9m x 3m x 3m (30' x 10' x 10') **All-In-One & Connection Ready (Plug & Play)** **Standard Version 9m** Special, Extra Large CHP Container Design, Sound-attenuated (<65dBA) Power Generation Module incl. all Piping, Plumbing, Insulation, Conduits, Wiring , Connections, Space Ventilation, Smoke & Gas Detection. Complete System Factory installed and Factory tested".	1
Fully Containerized Module 15m x 3m x 3 m (50 'x 10' x 10') **All-In-One & Connection Ready (Plug & Play)** **TWINPACK Container for 2 Modules** Special, Extra Large CHP Container Design, Sound-attenuated (<65dBA) Power Generation Module incl. all Piping, Plumbing, Insulation, Conduits, Wiring , Connections, Space Ventilation, Smoke & Gas Detection. Complete System Factory installed and Factory tested".	0
Options Menu	
Exhaust Gas Heat Exchanger incl. Insulation	0
Stainless Steel Exhaust Silencer	1
Jacket Water Table Cooler	1
Mixture Table Cooler	1
Lube Oil Supply incl. Waste and Fresh Oil Tank	1
Gas Flow Meter	1
Extension of Crankcase Oil Volume for Longer Oil Change Interval	1
Oxidation Catalyst	1
SCR System incl. Insulation and connections for customer supplied Urea Storage Tank	1
Slam Shut Valve for Gas Supply to Container	0
Container Room Heater	0
Air Inlet & Outlet Louver with Actuator	1
Combustion Air Cooling for High Ambient Temperature Regions	0
AC for Control Cabinet	1
High Ambient Temperature Upgrade for Jacket Water Coolers	1
Island Mode Option	1
Electric Load Following Option	1
Dust Filter for Air Inlet	1
SEL Relay (if required by local utility, to be determined during project management)	0
Net Generation Meter	0
BTU Meter incl. Temperature Sensors for Heating Circuit (water based)	1
Hydronic Junction with Sinus Manifold & Thermal Heat Distribution	0
Active Circuits for Thermal Heat Distribution	0
Gas Blower	1
Gas Treatment Active Carbon Filter 1000 lbs incl. Initial Fill	2
Gas Treatment Active Carbon Filter 2000 lbs incl. Initial Fill	0
Insulation for Active Carbon Filter 1000 lbs	0
Insulation for Active Carbon Filter 2000 lbs	0
Gas Dehumidification System incl. Re-Heating System	1
Biogas Flare rated for System	0
Biogas Analyzer	1
Hot Water Upgrade in Lieu to Standard Config. (Supply Temp. 95°C, Return Temp. 75°C)	0
Dual Fuel Option (Natural Gas Backup)	0
Natural Gas Fuel Blending Option	0
Cold Installation Assistance of Equipment (Crane and Lifting Equipment to be provided by others) + Commissioning & Operators Training (max 5 Days per engine)	1
Transport Costs (unloading not included)	1

1S

(Graphics are representative)





RGH
19
PA 16066-3505
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1-1206

SYRACUSE
7044 Interstate Island Road
Syracuse, NY 12089-9799
315-451-3838
Fax: 315-461-8662

BUFFALO
350 Bailey Avenue
Buffalo, NY 14210-1737
716-822-0051
Fax: 716-826-1544

NOTE: Tables and thermal calculations (see separate attachments) are taken from manufacturer supplied information and subject to their tolerances and restrictions. The above equipment come as sections, or as loose components, and will require customer contractor assembly/installation.

2. Technical Support Services

1. Provide emissions data and support for air permitting and certified emission testing (by others)
2. Customize panel operating systems for site specific conditions and parameters.
3. Develop and provide two (2) sets of submittal documentation in hard copy and CD format for review by construction managers and sub-contractors.
4. Develop and provide two (2) sets of as-built documentation, following final startup and commissioning, in hard copy and CD format for the owners use.

3. Startup and Commissioning and Training Services

Western Energy Systems provide startup and commissioning services. Startup personnel will include a startup engineer and service technician provided by WES or 2G. Services will be scheduled after receipt of completed installation checklists. A complete startup and commissioning work scope will be provided 6 weeks prior to start-up date and customer will provide a "Checklist for Site Readiness". Customer will fill out a pre-commissioning inspection form will occur 3 weeks prior to planned commissioning. The Operation and Maintenance manual provided will be for WES/2G supplied major equipment only.

4. Commercial Proposal

All prices are quoted F.O.B. jobsite on a truck with rigging and removal required by others. No provisions are made for local sale taxes, bonds, permits, or fees. The following presents our clarifications and exceptions.

4.1 Clarifications & Exceptions

1. This quotation shall be considered a BUDGET QUOTATION until all technical details are clarified
2. Ship loose components with engine and generator must be assembled on site (see Technical Description). All insulation and loose item assembly are the responsibility of the customer.
3. WES supplied equipment will have a one year limited warranty (described below).
4. Product Manufacturer provides complete shop drawings & equipment data sheets 6 weeks after acceptance of approved purchase order, submittals follow at 10 weeks.
5. When fuel is other than pipeline Natural Gas, generator set maintenance and performance may be impacted by the performance of customer gas cleanup. 3-way catalyst/SCR/Oxycat sensitive to contaminants.
6. Proposal excludes reporting grade CEMS (may not be required), unless otherwise noted below in options.
7. Siloxaine Removal equipment & media, proposal doesn't cover siloxaine treatment as fuel content is unknown.
8. No Site Engineering or Civil or Structural, unless otherwise noted in scope or below in options.
9. Base offering supports utility mains parallel operations from a single utility service, simple load sharing, simple load following, non-export, only; multiple utility service or complex load following requires additional equipment.
10. Proposal does not include utility interconnection, interconnection switchgear, or additional commissioning support that may be required by switchgear vendor unless otherwise noted in scope or below in **options.**
11. Specific Exclusions (unless otherwise noted)
    a. Seismic calculations & restraints for engines, radiators, heat recovery equipment provided by installation contractor
    b. Loop Diagrams
    c. Motor Control Cabinet
    d. Taxes or Fees (sales, local, any)

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Seven Hundred Sixty Thousand Dollars……..…….……...$760,000.00
--(Base price, budget, subject to clarification of technical details)

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WES looks forward to working with Stantec on this exciting project.

Sincerely Yours,

Thomas Marihart
Sales Engineer
Western Energy Systems

cc Steve Hall, Western Region Sales Manager
cc Fred Farrand, National Sales Manager
cc Al Clark, President and General Manager

Technical specification

agenitor 408 BG

Design:

360 kW el.

60 Hz / 480 V

biogas (50% CH4, 50% CO2)

Calorific Value = 481 BTU/ft³

NOx < 1,0 g/BHP-h

Exhaust cooling to 356 °F

1. Genset	3
1.1 Engine	3
1.2 Generator (utility planning data)	4
2 Mixture composition	4
2.1 Combustion air	4
2.2 Fuel	5
3 Integrated heat extraction	5
3.1 Customer Heat Recovery Circuit	5
3.2 Engine circuit	5
3.3 Mixture cooling water circuit - low temperature (LT)	5
4. Exhaust system	6
5 Ventilation	6
6 Operating fluids	6
7 Electronics and software	6
8 Interfaces	7
8.1 Dimensions and weights	7
8.2 Mechanical Connections	8
8.3 Electrical connections / utility interface	8
8.4 Data interfaces	8
9 Technical boundary conditions	9

Subject to technical changes!

Note: Figure on cover page may differ

1. Genset

	50 %	75 %	100 %	Load
Electrical power	180	270	360	kW [5]
Recoverable thermal output	836	1041	1308	MBTU/hr [2]
Fuel cosumption	1620	2303	3004	MBTU/hr [1]
Efficiency Electrical	37,9	40,0	40,9	% [1]
Efficiency Thermal	51,6	45,2	43,6	% [1], [2]
Efficiency Combined (el. + th.)	89,5	85,2	84,4	% [1], [2]

	NOx	CO	VOC [8]	
Exh. emissions without catalytic converter	< 1,0	< 2,2	< 0,7	g/BHP-h
	< 244	< 801		ppm [4],[6]
Exh. emissions with catalytic converter	< 1,0	< 0,7	< 0,7	g/BHP-h
	< 244	< 240		ppm [4],[6]

Engine surface noise **	105	dB(A) [7]
Engine surface noise with sound enclosure (optional) ***	70	dB(A) [7]

1.1 Engine

Engine manufacturer	2G	
Engine type	agenitor 408	
Type	V - Motor	
No. of cylinders	8	
Operating method	4-stroke	
Engine displacement	16670	ccm
Bore	5,12	in
Stroke	6,18	in
RPM	1800	1/min
ISO standard power (mech.)	504	bhp
compression ratio	14 : 1	
average effective pressure	218,2	psi
average piston speed	30,9	ft/s
body of balance wheel	SAE 1	
Direction of rotation (based on balance wheel)	left	
tooth rim with number of teeth	137	
Engine dead weight	3748	lbs
Mixture cooling to	122	°F

** Total sound power level at full engine load in accordance with DIN EN ISO 3746

*** Average sound pressure level under open area conditions at distance of 1 m in accordance with DIN 45635
An increased noise load must be taken into account with fresh air intake from the installation room.

1.2 Generator (utility planning data)

Manufacturer	Leroy Somer	
Type	LSA 47.2 S4/4p	
Generator type	Synchronous, directly coupled	
Voltage regualtor (AVR)	D510C	
Rated speed	1800	1/min
Frequency	60	Hz
Effective electrical power	360	kW
Apparent electrical power (cos φ 0.8)	450	kVA
Apparent electrical power (cos φ 1.0)	360	kVA
Rated generator current (cos φ 0.8)	541	A
Rated generator current (cos φ 1.0)	433	A
Rated generator voltage (± 10 %)	480	V
Subtransient reactance X"d	15,1	%
Short-circuit current Ik"3	5,1	kA
Power factor cos φ (lagging / leading)	0.8 / 0.95	
Generator circuit breaker	600	A
Additional section switch (VDE-AR-N 4105)	600	A
Efficiency (full load) at Cos φ = 1	95,7	%
Mass moment of inertia	158,99	lb · ft²
Ambient air temperature	104	°F
Stator circuit	star	
Protection class	IP 23	
Generator weight	2482	lbs
Compensation	not available	
Engine startup	not available	

2 Mixture composition

2.1 Combustion air

Combustion air mass flow	4091	lbs/hr
Combustion air volume flow (25 °C, 1013 mbar)	922	SCFM

2.2 Fuel

Fuel requirements in accordance with 'TA-004 Gas'		
Reference methane number - minimum methane number	150 / 130	
Combustible mass flow	524,6	lbs/hr (1)
Combustible volume flow	104,0	SCFM (6),(1)
Gas pressure at rated load min. *	0,435	psig
Gas flow pressure at rated load max. *	1,015	psig
Gas regulation line safety pressure	7,252	psig

* At the inlet to the gas regulation line

3 Integrated heat extraction

3.1 Customer Heat Recovery Circuit

Heating water requirements in accordance with 'TA-002 Heating circuit'		
Heating water volume flow (at Δt = 59 °F)	96,7	gpm
Internal pressure loss in heating circuit (approx.) *	4,35	psig
Pressure reserve (approx.) *	20,10	ft
Heating water return temperature (max)	158	°F
Heating water flow temperature (max) **	194	°F
Safety valve	87,02	psi

3.2 Engine circuit

Coolant requirements in accordance with 'TA-001 Coolant'		
Jacket Water Heat	486,279	MBTU/hr
Exhaust Gas Heat up to 356°F	659,834	MBTU/hr
Engine inlet temperature (min.)	176	°F
Engine outlet temperature (max.)	190	°F
Differential inlet / outlet (max.)	10,8	°F
Engine jacket water flow (min.)	104,6	gpm
Total cooling water circulation volume	174,3	gpm
Operating pressure (max.)	29,0	psi
Safety valve	43,5	psi
Safety temperature limiter	230	°F
Intercooler heat high temperature circuit	162,093	MBTU/hr
Intercooler inlet high water temperature (max.)	180	°F
Intercooler coolant flow high temperatue circuit (min.)	69,7	gpm

3.3 Mixture cooling water circuit - low temperature (LT)

Coolant requirements in accordance with 'TA-001 Coolant'		
Intercooler heat low temperature circuit	123,877	MBTU/hr
Intercooler inlet low water temperature (max.)	100	°F
Intercooler outlet low water temperature (max.)	106	°F
Intercooler coolant flow low temperature circuit (min.)	53,3	gpm
Safety valve	44	psi

* Up to / from module interface

** Heating water supply temperature in partial load operation < 90°C

4. Exhaust system

Exhaust gas temperature after turbo charger	887	°F (3)
Exhaust temperature after exhaust heat exchanger	356	°F
exhaust gas volume flow wet	942	SCFM (6)
exhaust gas volume flow dry	844	SCFM (6)
exhaust gas mass flow wet	4616	lbs/hr
exhaust gas mass flow dry	4302	lbs/hr
Exhaust back pressure downstream of turbine max.	0,73	psig
Pressure reserve approx. (with catalytic converter) *	0,52 (0,41)	psig
Exhaust outlet noise **	125	dB (7)

5 Ventilation

Radiation heat of engine and generator (approx.)	208,740	MBTU/hr
Supply air volume flow min. (at Δt = 15 K)	8185	SCFM

6 Operating fluids

Lubricating oil approvals, see 'TA-003 Lubricating oil'		
Lubrication oil consumption (max.)	0,20	g/kWh
Filling capacity lubricant (max.)	15,85	gallons
Lubricating oil filling tank fill capacity ***	9,25	gallons
Lubricating oil volume extension tank (optional)	31,70	gallons
Coolant approvals, see 'TA-001 Coolant'		

7 Electronics and software

Generator Protection Relay	Deif GPC 3 | optional redundant Relay SEL 700GT	
Touchscreen display	10	"
Protection class Control cabinet	Type 12	
Protection class Power switch cabinet	Type 1	
Switch cabinet environmental temperature	32 - 95	°F
Switch cabinet relative air humidity (max.)	65	%

* From module interface (exhaust heat exchanger / catalytic converter in standard version and new condition)

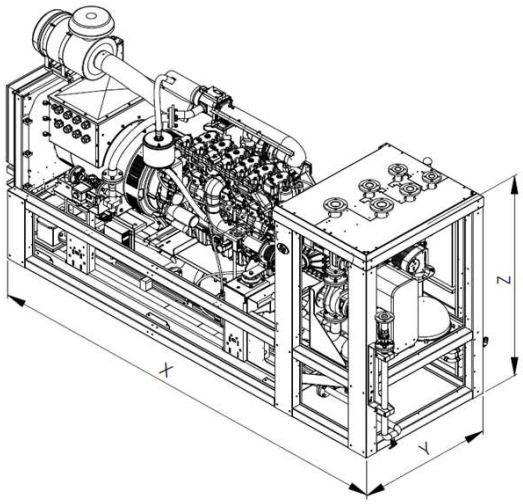
** Total sound power level at full engine load in accordance with DIN 45635-11 Annex A

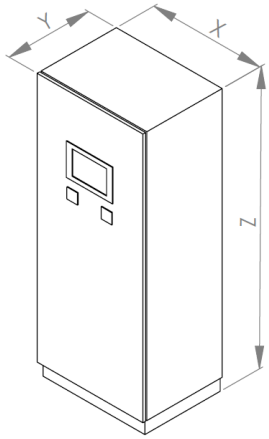
*** Filling tank omitted with installation of a lubricating oil volume auxiliary tank

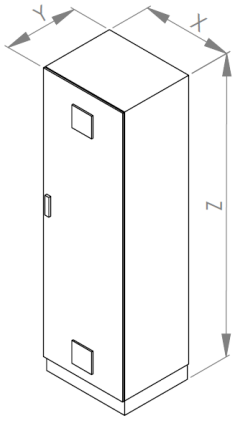
8 Interfaces

8.1 Dimensions and weights

(Figures may differ)







Length Module	X	155,12	in
Width Module	Y	59,06	in
Height Module	Z	86,61	in
Weight Module		12258	lbs
Weight Module with sound enclosure (optional)		14242	lbs
Powder-coated CHP frame		RAL 6002	

Width Control cabinet	X	39,37	in
Depth Control cabinet	Y	23,62	in
Height Control cabinet	Z	82,68	in
Weight Control cabinet		441	lbs
Control cabinet powder coated		RAL 7035	

Width Power switch cabinet	X	23,62	in
Depth Power switch cabinet	Y	19,69	in
Height Power switch cabinet	Z	78,74	in
Weight Power switch cabinet		331	lbs
Power switch cabinet powder coated		RAL 7035	

8.2 Mechanical Connections

Interface Gas	80 / 10	DN / PN
Interface Exhaust	200 / 10	DN / PN
Interface Heating circuit	65 / 16	DN / PN
Interface Emergency cooling circuit	80 / 16	DN / PN
Interface Mixture cooling circuit LT	40 / 16	DN / PN

8.3 Electrical connections / utility interface

Grid connection with pre-fuse (customer-provided)	60 Hz / 480 V	
Grid system	Y	
Short-circuit proof Icc (max.)	50	kA

8.4 Data interfaces

Remote maintenance access (optional) *	DSL / UMTS (SIM)	
Interfaces / Data interfaces (optional):	-	Profibus
	-	Profinet
	-	Modbus RTU
	-	Modbus TCP
	-	Ethernet IP
	-	Hardware signals
Access virtual power plant (optional)	Possible after technical clarification (bus or hardware signals)	

* Access for remote maintenance must be provided by the customer

9 Technical boundary conditions

Unless otherwise specified, all data is based on full engine load with the respective indicated media temperatures and subject to technical improvements. The generator output measured at the generator terminals serves as the basis for the delivered electrical power. All power and efficiency specifications are gross specifications. The fuel gas quality must conform to the specifications of 'TA-004 Gas'. The operating fluids and plant system layout must conform to the 'Technical instructions' of 2G.

(1) Performance conditions in accordance with DIN ISO 3046. Tolerance for specific fuel use amounts to + 5% of nominal performance. Efficiency specifications are based on an engine in new condition. An abatement in efficiency over the service life is reduced with observance of the maintenance requirements.

(2) The tolerance for usable heat output is +/- 8 % under normal load.

(3) The tolerance for the exhaust temperature is +/- 8 %.

(4) Corresponding to a residual oxygen concentration in the exhaust of 5 %.

(5) Electrical generator terminal power at cos φ = 1.0

(6) Volume specifications for normal status:

Pressure	14,69	psig
Temperature	32	°F

(7) Standard deviation of reproducibility 4 dB in accordance with DIN EN ISO 3746

(8) Assumed gas composition (VOC calculated as NMHC):
CH4=50 %, CO2=50 %

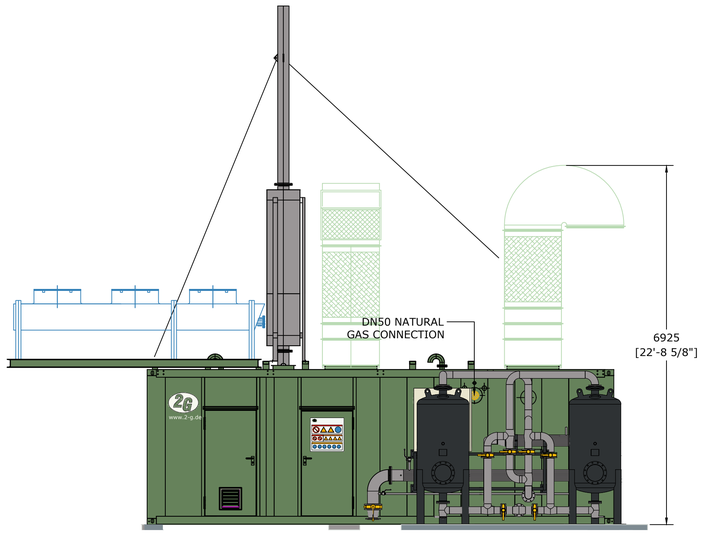
Power specifications in this document relate to standard reference conditions.

Standard reference conditions in accordance with DIN ISO 3046-1:

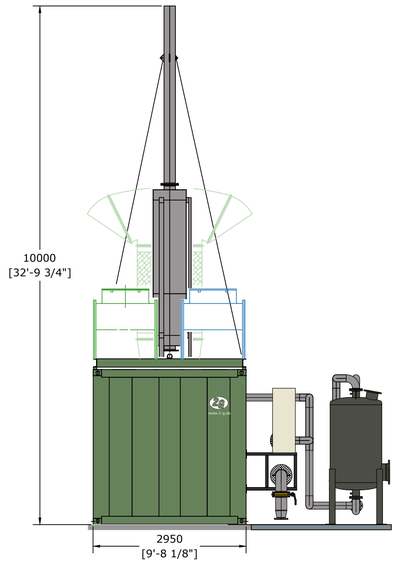
Air pressure	14,50	psig
Air temperature	77	°F
Relative air humidity	30	%

Power reduction

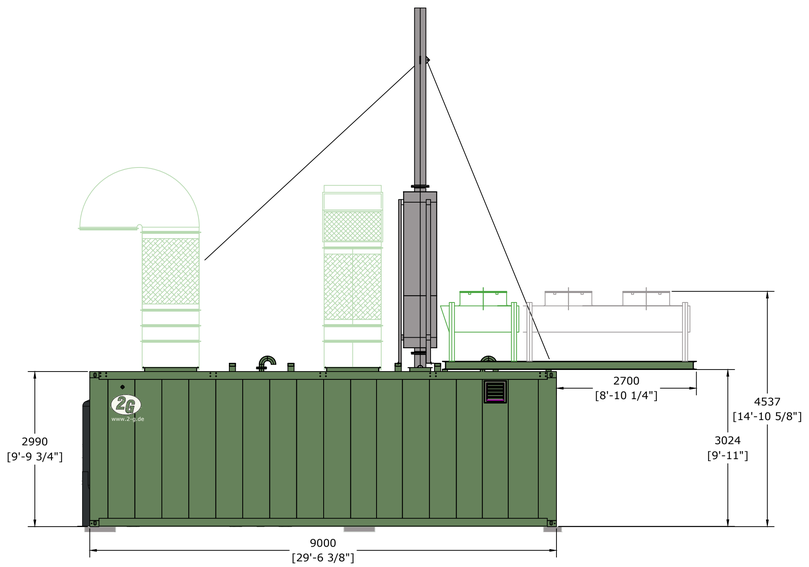
Power reduction due to installation at altitude > 958ft a.s.l. and/or air suction temperature > 77°F shall be determined specifically for each project according "TI-049 Load reduction".



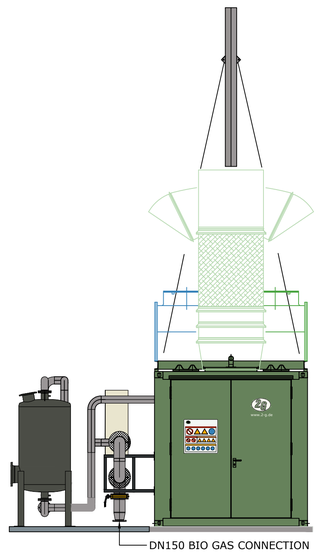
LEFT SIDE VIEW



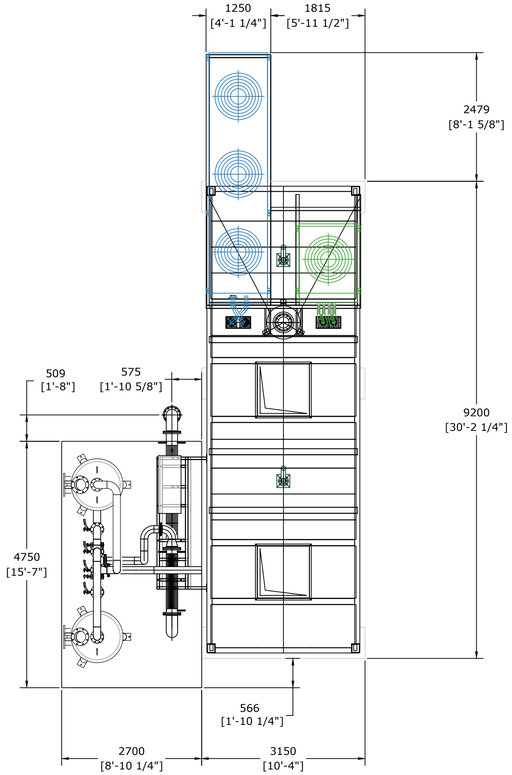
BACK VIEW



RIGHT SIDE VIEW



FRONT VIEW



TOP VIEW

PRIMARY COMPONENTS LIST

ID Nr.	Art. Nr.	DESCRIPTION	Qty.	WEIGHT Lbs

NOTES:

1. REFER TO THE FOUNDATION DRAWING FOR CIVIL WORK.
2. IF SITE PIPE PREPARATION IS TO BEGIN BEFORE THE CHP'S ARRIVAL, IT IS RECOMMENDED TO KEEP ALL PIPE CONNECTIONS TO THE CHP TACK WELDED IN THE X, Y, AND Z AXIS'S.
3. MACHINE TOLERANCES

L (MTR)	TOL. (MM)
0-3	4
3-5	5
5-7	7
7-10	10
OVER 10	15

4. ALTERNATE ARCHITECTURAL DIMENSIONS ARE ROUNDED TO THE NEAREST $\frac{1}{4}$"
5. RECOMMENDED MINIMUM CONTAINER INSTALLATION CLEARANCE, DOUBLE DOOR (FOUNT) FOR ENGINE REMOVAL: 8M
   ALL OTHER SIDES: 1.5M
6. RADIATORS REQUIRE A CLEARANCE ON ALL FOUR SIDES OF: 1.5M
7. DESIGNED TO A SOUND PRESSURE LEVEL OF 65dBa IN A DISTANCE OF 10M (MEAN VALUE, OPEN FIELD CONDITIONS)
8. CONTAINER COLOR RAL 6005 MOSS GREEN
9. APPROXIMATE WEIGHTS ARE SHOWN
10. DRAWING ONLY SHOWS KEY COMPONENTS FOR DRAWING CLARITY.
11. ALL FLANGE CONNECTIONS ARE METRIC DIN FLANGES. MATING DIN FLANGES ARE PROVIDED BY 2G ENERGY INC. FOR ALL CUSTOMER CONNECTIONS.

EXAMPLE ONLY NOT FOR CONSTRUCTION!!!

2G Energy Inc.
205 Commercial Drive
St. Augustine, FL 32092
www.2g-energy.com

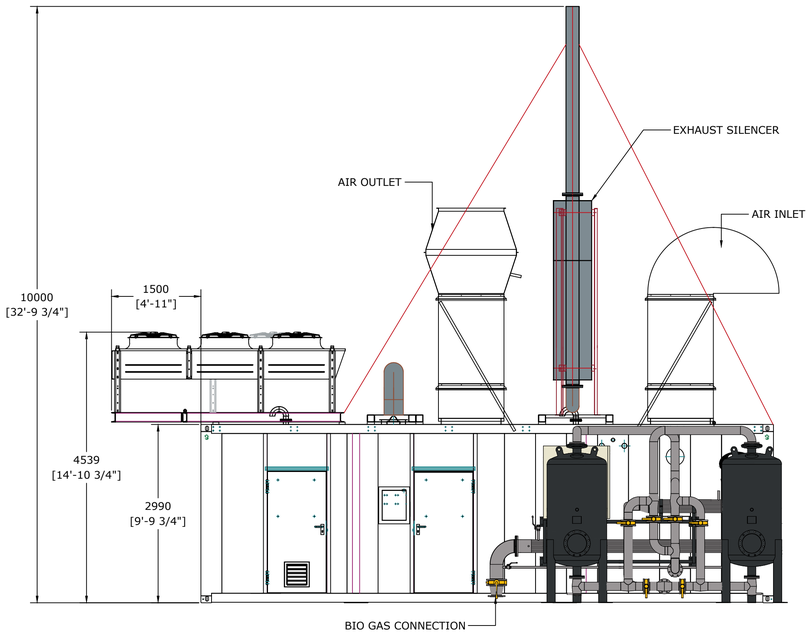
CUSTOMER NAME:	DELIVERY ADDRESS:

DRAWING / FILE NAME:
170418_9mCO_AGENITOR 212_EXAMPLE.dwg

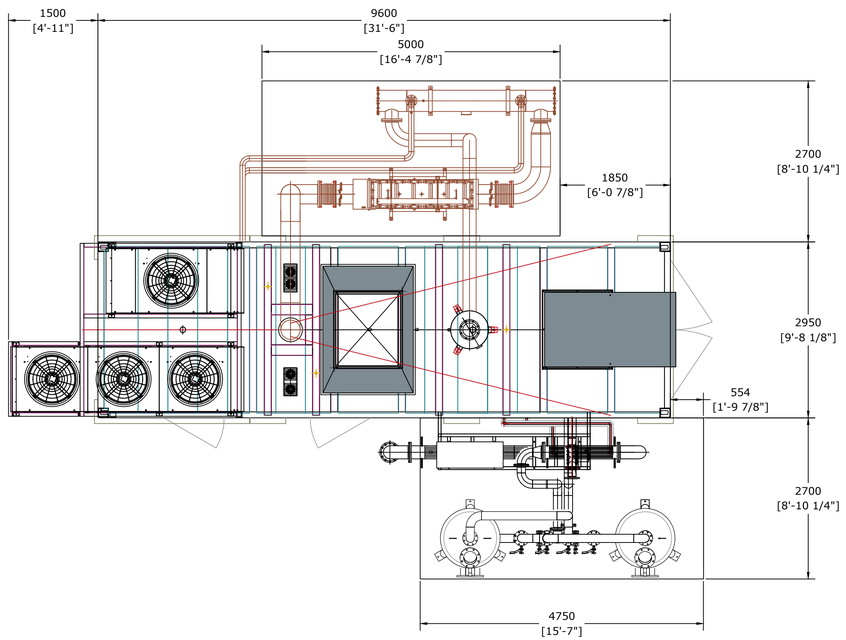
SCALE:	COMMISSION NUMBER:	ID NUMBER:	PROJECT MANAGER:
NA	NA	NA	NA

DRAWN BY:	DATE DRAWN:	CHECKED BY:	DATE CHECKED:
NA	4-18-2017	NA	NA

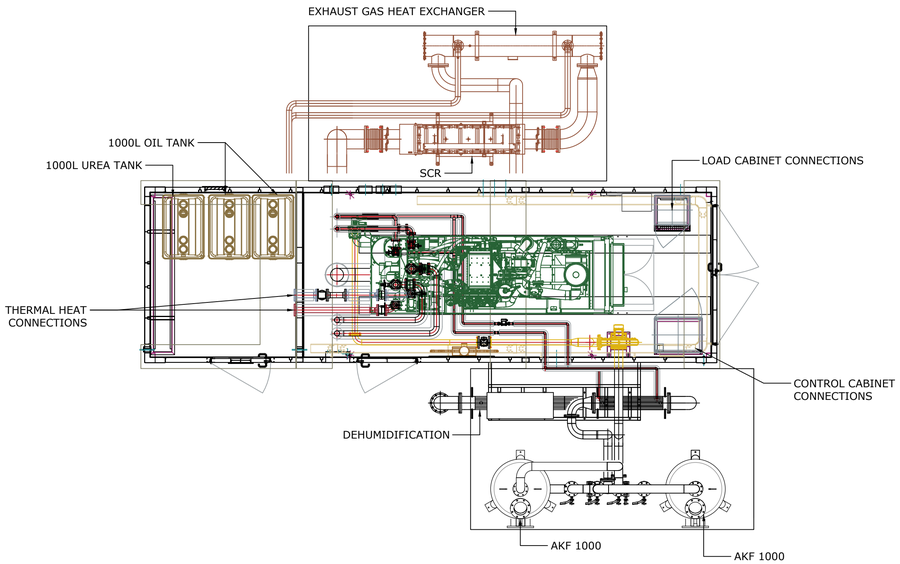
DATE:	NAME:	CHANGE:	REV:	CHECKER:



LEFT SIDE VIEW



TOP VIEW



TOP VIEW INTERNAL

PRIMARY COMPONENTS LIST

ID Nr.	Art. Nr.	DESCRIPTION	Qty.	WEIGHT Lbs

NOTES:

1. REFER TO THE FOUNDATION DRAWING FOR CIVIL WORK.
2. IF SITE PIPE PREPARATION IS TO BEGIN BEFORE THE CHP'S ARRIVAL, IT IS RECOMMENDED TO KEEP ALL PIPE CONNECTIONS TO THE CHP TACK WELDED IN THE X, Y, AND Z AXIS'S.
3. MACHINE TOLERANCES

L (MTR)	TOL. (MM)
0-3	4
3-5	5
5-7	7
7-10	10
OVER 10	15

4. ALTERNATE ARCHITECTURAL DIMENSIONS ARE ROUNDED TO THE NEAREST $\frac{1}{4}$"
5. RECOMMENDED MINIMUM CONTAINER INSTALLATION CLEARANCE, DOUBLE DOOR (FOUNT) FOR ENGINE REMOVAL: 8M
   ALL OTHER SIDES: 1.5M
6. RADIATORS REQUIRE A CLEARANCE ON ALL FOUR SIDES OF: 1.5M
7. DESIGNED TO A SOUND PRESSURE LEVEL OF 65dBa IN A DISTANCE OF 10M (MEAN VALUE, OPEN FIELD CONDITIONS)
8. CONTAINER COLOR RAL 6005 MOSS GREEN
9. APPROXIMATE WEIGHTS ARE SHOWN
10. DRAWING ONLY SHOWS KEY COMPONENTS FOR DRAWING CLARITY.
11. ALL FLANGE CONNECTIONS ARE METRIC DIN FLANGES. MATING DIN FLANGES ARE PROVIDED BY 2G ENERGY INC. FOR ALL CUSTOMER CONNECTIONS.

EXAMPLE ONLY NOT FOR CONSTRUCTION!!!

2G Energy Inc.
205 Commercial Drive
St. Augustine, FL 32092
www.2g-energy.com

CUSTOMER NAME:	DELIVERY ADDRESS:

DRAWING / FILE NAME:
2018_9,6m-CO_BASIC_agenitor408_BG_EXAMPLE ONLY.dwg

SCALE:	COMMISSION NUMBER:	ID NUMBER:	PROJECT MANAGER:
NA	NA	S-0289	NA

DRAWN BY:	DATE DRAWN:	CHECKED BY:	DATE CHECKED:
GJB	9-18-2018	NA	NA

DATE:	NAME:	CHANGE:	REV:	CHECKER:

NOTES:

1.

FLANGED BIO GAS CONNECTION

OPTIONAL GAS DEHUMIDIFICATION

GAS COOLING TUBE BUNDLE

CHILLER

GAS REHEATING TUBE BUNDLE

GAS MIXTURE RADIATOR

GAS MIXTURE CIRCUIT PUMP

EXHAUST SILENCER

EXHAUST GAS HEAT EXCHANGER

OXIDATION CATALYST

INTERNAL COMBUSTION ENGINE

HEATING CIRCUIT PUMP

OPTIONAL THERMAL HEAT DISTRIBUTION

HYDRONIC JUNCTION

JACKET WATER RADIATOR

ENGINE CIRCUIT PUMP

OPTIONAL GAS FLARE

GAS FLARE

OPTIONAL CARBON FILTERS

ACTIVE CARBON FILTER

ACTIVE CARBON FILTER

ACTIVE CARBON FILTER

TREATED BIO-GAS

OPTIONAL GAS BLOWER

GAS BLOWER

OPTIONAL PRE-PRESSURE REGULATOR (NEEDED IF GAS BLOWER IS NOT IN 2G's SCOPE)

PRE-PRESSURE REGULATOR

DOUBLE SOLENOID GAS REGULATION TRAIN INCLUDING FLAME ARRESTOR

GAS BLENDING

ZERO PRESSURE REGULATOR

BIOGAS ANALYZER

CH4-
CO2-
02-
H2S-

RAW BIO-GAS

OPTIONAL BIO GAS ANALYZER

OIL PUMP

WASTE OIL TANK

FRESH OIL TANK

OPTIONAL OIL TANKS AND PUMP

FLANGED NATURAL GAS CONNECTION

PRE-PRESSURE REGULATOR

DOUBLE SOLENOID GAS REGULATION TRAIN INCLUDING FLAME ARRESTOR

PROPORTIONAL GAS MIXING VALVE

2G Energy Inc.
205 Commercial Drive
St. Augustine, FL 32092
www.2g-energy.com

DRAWING / FILE NAME: SALES P&ID.dwg			
SCALE: NA	SHEET NUMBER: NA	ITEM NUMBER: NA	
DRAWN BY: NA	DATE DRAWN: 2-2-2016	CHECKED BY: NA	DATE CHECKED: NA

DATE:	NAME:	CHANGE:	REV:	CHECKER:

Appendix E.2 Continuous Emission Monitoring System (CEMS)

Software CEM®

Advanced Emissions Monitoring

Pavilion8® Software CEM® is a predictive emissions monitoring system (PEMS), developed on the Pavilion8 platform, which provides highly accurate measurements of NO_x, CO, O_2 and other emissions as an alternative to costly hardware based Continuous Emissions Monitors (CEM).

The Software CEM system continuously monitors emissions by developing an online model using historical and real-time data from existing plant sensors. The Rockwell Automation Hybrid Modeling technology incorporates nonlinear empirical models as well as first principles models to provide the most accurate prediction models available in the industry. These models are executed online using the Pavilion8 Model Analytic Engine to provide real-time predictions of emissions from a wide range of sources and fuels. Model validation is a routine that applies known values to the sensor inputs and verifies the values against known outputs. Predetermined input values are applied to the PEMS and output values are then calculated. These values are compared to the known output values from known input values (developed during modeling and RATA). Values are compared and determined via the Software CEMS that confirms they are in accuracy compliance. This process in an equivalency to a EPA mandated Quarterly audit.

Software CEM Model Development

Software CEM has been certified and is in continuous operation monitoring NO_x, CO, O_2, and other emissions, at more than 270 sources in the US. Software CEM has been proven to meet the PEMS requirements of the EPA on boilers, furnaces, reciprocating engines, turbines, and other emissions sources.

A kick-off meeting to discuss the scope of the Software CEM project is held prior to initiating any onsite activities, and at this meeting the functional design of the Software CEM is established and the necessary process sensors are identified. Appendix A provides a list of typical sensors used for wood, oil or natural gas fired combustors.

If no existing process is in place (i.e. hardware CEMS or other monitoring system), process data is obtained from the process's data historian or the Pavilion8 Data Logger. If no emissions data is available from existing hardware CEMS, stack emissions data is collected concurrently by an environmental testing firm.

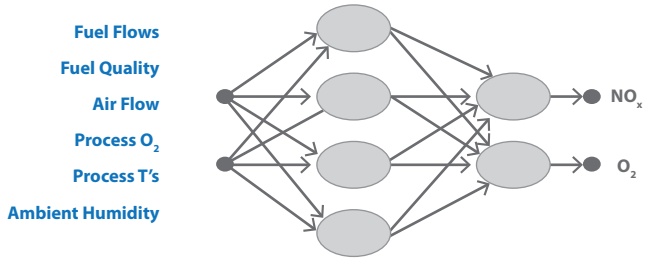
The emission unit is operated through its applicable range of operation over a 2 to 7 day period (depending upon the complexity of the unit) while data is collected. This process and stack data is then utilized to construct a highly accurate emissions model.

Sensor Validation System

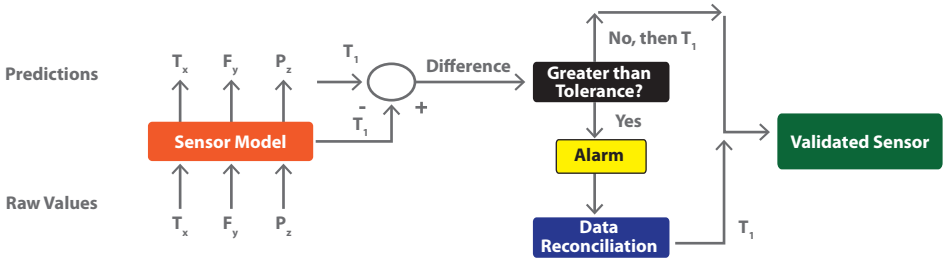
The Software CEM is utilized to construct a Sensor Validation System for the process sensors. This system is used to determine variable inputs (e.g. air flow, process O_2, etc.) and emissions output (NO_x, CO, O_2 and CO_2). The Sensor Validation System consists of models that can detect failed (or drifting) instruments and will automatically reconstruct an appropriate value to be used in place of the failed instrument by the Software CEM to determine accurate emissions. If during normal operation an input sensor fails, the Sensor Validation System has the capability to use information from the remaining sensors to reconstruct the value of the failed sensor. In addition to continuing to predict emissions accurately, the Software CEM will also issue an alarm alerting the operator of a failed sensor.

Predictive Emissions Monitoring System Consists of:

An emission model that reflects the relationship between process operations and ambient conditions to emissions.

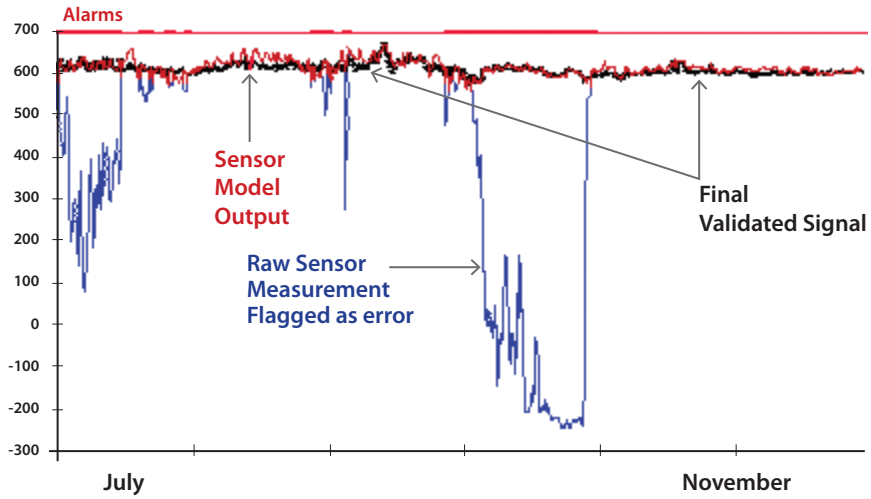


A patented sensor validation system to ensure the accuracy of the predicted emissions data.



A key regulatory requirement for most PEMS is 95% uptime. The Software CEM typically achieves >99% uptime through the use of the Rockwell Automation Sensor Validation System.

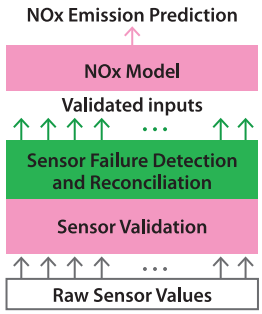
Sensor Validation Model Output and Validated Signal for Failed Temperature Transducer



Emissions Prediction On-line

The Software CEM system (including the sensor validation routine) is initiated on-line by interfacing to the process distributed control system or data historian. The Software CEM acquires current process data, passes the data to the model for execution, and returns the emission prediction back in the form of a tag value. This approach allows existing operator console interfaces to be used to present information from the models to operations or engineering staff. The Software CEM can then be integrated with commercially available reporting packages.

Software CEM with Sensor Validation



Environmental Regulations and the Software CEM

The EPA and State agencies have approved the Software CEM to perform continuous emission monitoring of NO_x, CO, O_2 and other emissions on more than 270 emission units in the US. Environment Canada and Provisional agencies also accept Software CEM as a Predictive Emissions Monitoring System (PEMS).

EPA Emission Measurement Center's PEMS Evaluation

The EPA Emission Measurement Center has developed 5 PEMS Protocols and Performance Specifications that have been published on EPA's TTN website (www.epa.gov/ttn/emc/monitor.html) based on data from 5 Software CEM installations. The EPA hired an independent consultant to evaluate PEMS, and from this counsel, the EPA determined that PEMS requires sensor validation to eliminate the possibility of erroneous predictions due to failed sensor indications. The EPA also determined that expert personnel must construct a sensor validation system. The Emission Measurement Center now recognizes PEMS as a viable alternative to hardware CEMS and most states follow the EPA's recommendation.

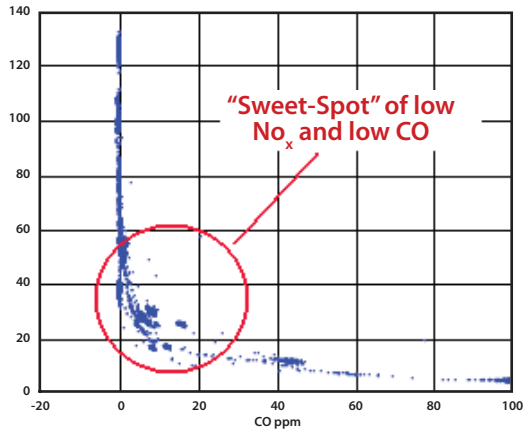
The basic EPA requirements for PEMS are:

- Initial 9 Test Run RATA:
  - 3 Test Runs at Low Emission Rates,
  - 3 Test Runs at Normal Emission Rates
  - 3 Test Runs at High Emission Rates
- Demonstration of Sensor Validation System
- Ability to Detect Failed and Drifted Sensors
- Ability to Reconcile Bad Sensor Values
- Quarterly "Golden Diskette" Check
- Annual 9 Test Run RATA

Emission Reduction and Process Optimization

In addition to the reduced costs of regulatory compliance, the Software CEM provides another cost saving benefit - the power to control the process to reduce emissions while optimizing production, thereby improving operations. The figure below depicts the inverse relationship between NO_x and CO for a gas turbine unit. While developing the Software CEM, the engineer using Pavilion8 located a "sweet-spot" where both NO_x and CO are low and operations are optimal to achieve reduced emissions and improved production. Reference Appendix B for details.

Emission Reduction: NO_x versus CO



Appendix A – Process Sensors Examples

Process Sensors

The following sensor inputs have been used to develop Software CEMs for natural gas, oil and wood fired combustors. All sensors available are evaluated for development of the Software CEM.

Boiler Sensors

- Feedwater Flow Rate
- Grate Temperature (if applicable)
- Steam Flow Rate
- Air Flow Rate
- Air Inlet Temperature
- Economizer Outlet Flue Gas Temperature
- Economizer Inlet Flue Gas Temperature
- Economizer Outlet Water Temperature
- Economizer Inlet Water Temperature

Fuel Conditions

- Natural Gas Flow Rate
- No. 2 Oil Flow Rate
- Wood Feeder Master Rate

Ambient Conditions

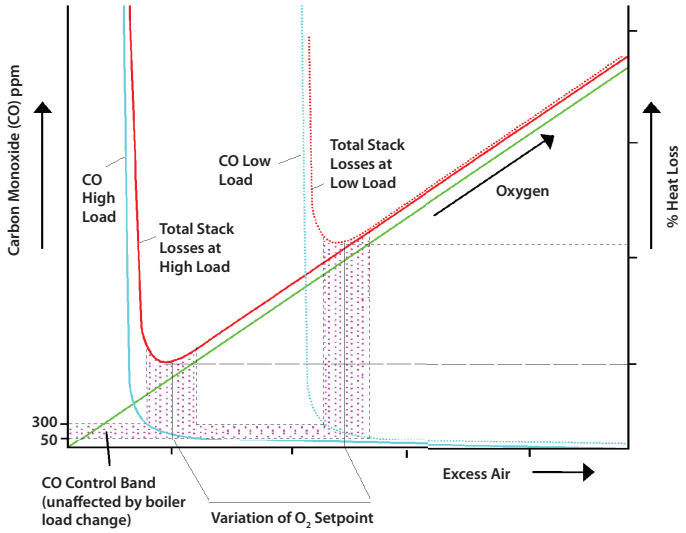
- Relative Humidity (testing firm required to monitor)
- Barometric Pressure (testing firm required to monitor)
- Temperature (air preheat temperature or after flue gas recirculation)

Appendix B – Combustor Optimization with Software CEM

Industrial/Commercial/Institutional (I/C/I) Combustors and Process Heaters (P/H) are fired via a carbon based fuel such as natural gas, oil, coal or some form of biomass that is continuously fed into the combustor chamber. During this process complete combustion of the fuel occurs. However, the use of these fuels can be minimized by optimizing burner efficiency, thus reducing fuel consumption and emissions output.

Efficiency is a direct correlation of data derived from the measurement of flue gas temperature and oxygen (O_2). The combustion chamber of an Industrial/Commercial Boiler introduces the primary air and fuel. The fuel is introduced through a burner nozzle and is designed to produce a flame front over the full range of operating conditions. Complete combustion is a function of oxygen and temperature: the greater the amount of excess oxygen, the less fuel efficient the boiler will be. Reducing the excess oxygen improves efficiency. Conversely, as oxygen is reduced, CO can start to form. Excess levels of CO indicate incomplete combustion and increased emissions. The use of CO monitoring can help emission levels remain within limited parameters and maximize the efficiency of the burner operation. Monitoring O_2 and CO as a process application for burner/boiler control has been widely accepted in the utility and industrial source market and has played a strong role in optimization of burner/boiler efficiency. The figures included present a graphic representation of the relationship of O_2 and CO with efficiency.

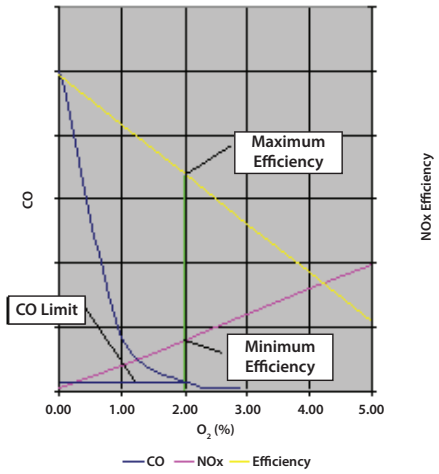
To Optimize Fuel/Air Ration and combustion Efficiency



Combustion Optimization

Figure 1 shows the formation of NO_x and CO as a function of excess O_2 in a typical combustion application. Efficiency is also shown as a function of excess O_2. As excess O_2 decreases, NO_x decreases while CO and efficiency increase. To minimize NO_x production and maximize efficiency, excess O_2 needs to be minimized. However, equipment safety limitations and environmental regulations limit the amount of CO that can be produced. As a result, excess O_2 can only be reduced until the CO constraint is reached. At this point, combustion has been optimized, with the unit operating at the maximum allowable CO production, which corresponds to the minimum NO_x production and maximum efficiency.

NO_x and CO Efficiency



Disturbances such as changes in fuel composition, equipment conditions, ambient conditions, and load cause these variables to shift. As a result, it is not possible to determine an optimal excess O_2 arch as a function of load. Most operators use an input that guarantees that the CO limit will not be exceeded, which respects the CO constraint but fails to minimize NO_x or maximize efficiency. Combustion optimization uses a real-time CO indication and a model of the combustion process to constantly update the excess O_2. The optimal curve is recalculated each time the software application runs (every 15 to 30 seconds).

In more complex units, other variables in addition to excess O_2 have a significant impact on NO_x and CO formation and can be useful in minimizing NO_x and maximizing efficiency. Examples of these manipulated variables include: burner and overfire air dampers, burner and overfire air tilts, and windbox to furnace differential pressure. Additionally, adjustments to the combustion optimization manipulated variables can affect other important unit variables such as flue gas exit temperature, steam temperature, or attemperating spray flows. It is important that the combustion optimization system respect constraints for these variables as well.

Modeled operating parameters applied to a well defined and verifiable Neural Network can be applied to the real-time operation of the combustor source and maximize the efficiency without additional hardware and maintenance costs. Typical (but not limited to) operating parameters (sensors) are:

- Operating O_2 values
- Outlet Temperature
- Ambient Air Temperature
- Windbox Differential Pressure
- Fuel Flow
- Combustion Air Flow
- Inlet Air Damper Position
- ID Fan Speed

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Publication RSWP11-WP001B-EN-P – July 2016
Supersedes Publication RSWP11-WP001A-EN-P – May 2011

Appendix F SOLIDS HANDLING EQUIPMENT MAINTENANCE RECORD

Sludge Drying Bed

Vendor Name	Date	Description	Account #	Amount $	
Air & Hose Source, Inc.	4/12/2017	Hydraulic Hose for Skid Steer	11-5700410-1	$116.13	$116.13
Billy Parham	7/22/2015	Brown Bear Repair	11-5710411-1	$1,150.55	
	9/14/2015	Repair Seal Leak in Brown Bear	11-5710411-1	$1,150.55	
	11/4/2015	Brwon Bear Repair	11-5710411-1	$2,292.40	
	12/1/2015	Hydraulic Leak Repair	11-5710411-1	$390.00	
	4/4/2016	Hydraulic Pump Repair	11-5710411-1	$628.16	$5,611.66
Brown Bear Corp.	11/5/2015	Fittings for Brown Bear	11-5710411-1	$364.49	
	1/14/2016	Skidshoe & Blade	11-5710411-1	$363.20	
	2/27/2017	Parts for Brown Bear	11-5700410-1	$165.64	
	3/6/2017	Skidshoe for Skid Steer	11-5700410-1	$48.14	
	3/16/2017	Hydraulic Motor for Brown Bear	11-5700410-1	$2,057.21	
	4/6/2017	Seal	11-5700410-1	$211.41	
	4/1/2017	Parts Book	11-5700410-1	$43.60	
	4/5/2017	Drive Hub	11-5700410-1	$1,642.83	
	4/5/2017	Skid Steer Parts	11-5700410-1	$388.41	
	5/10/2018	Wear Pads & Paddles for Skid Steer	11-5700410-1	$464.07	$5,749.00
Carquest Auto Parts	7/31/2015	Air Filters, Oil Filters, Etc.	11-5700410-1 11-5710411-1	$58.90 $139.67	
	5/31/2017	Oil, Oil Filters, Air Filters, Receiver Pin, Etc.	11-5700410-1	$302.84	
	1/31/2018	New charges for January 2018	11-5710411-1	$506.71	$1,008.12
Clairemont Equipment	9/15/2015	Dump Truck Rental	11-5710411-1	$635.59	$635.59
Farwest Hydraulics	3/22/2016	Reseal Brown Bear Hydraulic Pump	11-5710411-1	$999.50	$999.50
Fiesta Ford	8/31/2016	Repairs to Dump Truck	11-5700410-1	$889.21	
	11/29/2017	Repair to Truck #7	11-5700410-1	$1,096.01	$1,985.22
Franklin Truck Parts, Inc.	9/8/2015	Pump for Dump Truck	11-5710411-1	$589.28	
	3/20/2017	Parts for Skid Steer	11-5700410-1	$169.14	
	11/22/2017	Radiator Fluid	11-5700410-1	$22.82	
	6/1/2018	Hub Site Glass & Oil	11-5700410-1	$17.18	$798.42
Jim's Desert Radiator & Fu	9/1/2015	Brown Bear A/C Repair	11-5710411-1	$1,530.13	
	10/1/2015	AC Repair for Brown Bear	11-5710411-1	$627.17	$2,157.30
Johnson Machinery Co.	8/25/2015	Filters	11-5710411-1	$128.89	

	4/13/2016	Skidsteer Filters	11-5710411-1	$114.85	
	4/30/2016	Priming Pump for Forklift	11-5710411-1	$79.74	
	7/19/2016	Air Filters	11-5700410-1	$50.51	
	8/11/2016	Battery for Skidsteer	11-5700410-1	$138.52	
	8/22/2016	A/C Repair for Skidsteer	11-5700410-1	$2,286.81	
	4/21/2017	Skidsteer Filters	11-5700410-1	$51.87	
	6/12/2017	Oil & Fuel Filters	11-5700410-1	$60.87	$2,912.06
Parkhouse Tire Services, Ir	10/6/2017	Dump Truck	11-5700410-1	$525.31	$525.31
Pete's Road Service, Inc.	11/20/2015	Battery for Brown Bear	11-5710411-1	$197.32	
	5/9/2017	Tire for Dump Truck	11-5700410-1	$256.29	$453.61
Quinn Company	8/6/2017	Loader Rental July 2017	11-5700410-1	$10,365.46	
	8/31/2017	Oil & Filter Change for Skidsteer	11-5700410-1	$920.79	
	9/21/2017	Skidsteer Repairs	11-5700410-1	$951.60	
	10/1/2017	Loader Rental for Sept. 2017	11-5700410-1	$10,265.46	
	11/6/2017	Loader Rental	11-5700410-1	$2,925.75	
	1/1/2018	Wheel loader rental	11-5700410-1	$10,264.46	
	2/1/2018	Service Call for Skid Steer	11-5700410-1	$1,018.38	
	2/5/2018	Fittings for Skid Steer	11-5700410-1	$150.47	
	2/6/2018	Fittings for Skid Steer	11-5700410-1	$24.35	
	2/23/2018	Repairs for Skidsteer	11-5700410-1	$1,218.00	
	2/26/2018	Skidsteer Rental	11-5700410-1	$3,710.84	
	3/16/2018	Haul Charge	11-5700410-1	$400.00	
	3/22/2018	Filters for Loader	11-5700410-1	$389.36	
	4/27/2018	Parts for Skid Steer	11-5700410-1	$35.77	$42,640.69
Torrence Farm Implements	2/1/2016	Oil Filters for Kabota Tractor	11-5710411-1	$82.56	
	12/20/2017	Cart Service	11-5700410-1	$87.86	$170.42
		TOTALS		65763.03	65763.03

Belt Press Building Maintenance

Repair	Description	Frequency	Personnell Required	Time Required (HRS)	Total Working Hours	Total Yearly Hours
Belt Press Belt Replacement	Replace Upper and Lower Belts on Press	Yearly	2	4	8	8
Belt Press Steering Ram Replacement	Replace Steering Ram on upper and Lower Steering Rollers	Yearly	2	2	4	4
Monthly Belt Press Greasing	Grease all bearings on belt press	Monthly	1	2	2	24
Monthly Exhaust Fan Maintenance	Grease and inspect all Belt Press exhaust fans	Monthly	2	2	4	48
Monthly Conveyor Greasing	Grease both Belt Press Conveyors	Monthly	2	1	2	24
Replace Belt Press Chicanes	Remove and Replace Loading zone Chicanes on Belt Press	Yearly	2	8	16	16
Monthly Deragging of Monyo Pump	Remove cover and Derag driveshaft of pump	Monthly	1	1	1	12
Weekly removal of polymer basket	Remove basket from polymer strainer and inspect for debri	Weekly	1	0.5	0.5	26
Monthly inspection of grinder	Remove cover and inspect cutter teeth of grinder	Monthly	1	1	1	12
Replace Zipper Wire on Press	Replace Zipper Wire on upper and lower belt	Quarterly	2	1	2	8
Replace troughing rollers	Replace troughing rollers on conveyor for slude transpertation	Monthly	2	0.25	0.5	6
Replace tail pully on conveyor	Inspect and replace tail pully on conveyor	Biennial	4	6	24	12
Replace scrapper blades on press	Replace upper and lower scrapper blades on belt press	Yearly	2	6	12	12

Replace scrapper blades on conveyor	Replace upper and lower scrapper blades conveyors	Yearly	2	2	4	4
					Total	216

Sludge Storage Bed

Clean out Drainlines	Locate and clean out drainlines of debri in sludge storage bed	Monthly	1	1.5	1.5	18
Grease Skidsteer	On a monthly basis grease the Skidsteer's lube points	Monthly	1	0.5	0.5	6
Refueling of all equipment	Depending on usage refill the 100 gallon tank in the sludge storage bed	Monthly	1	0.5	0.5	6
Grease Loader	On a monthly basis grease the loader's lube points	Monthly	1	0.5	0.5	6
Grease Kubota Tractor	On a monthly basis grease the tractor's lube points	Monthly	1	0.5	0.5	6
					Total	42