LANDFILL METHANE OUTREACH PROGRAM

LMOP Webinar

LFG Electricity PPA Ending Soon? Learn What You Can Do

June 13, 2023

Welcome and Agenda

AGENDA

LMOP's Toolkit for Expiring LFG Electricity Power Purchase Agreements (PPAs)
Lauren Aepli, U.S. EPA LMOP

Welcome to MCAS Miramar
Mick Wasco, Utilities & Energy Management Director, Marine Corps Air Station (MCAS) Miramar

After the Flare Shuts Off: Biofilters Applied to Landfill Gas Treatment
Peter Bannister, Aspect Consulting

Questions and Answers

Wrap Up

Expiring LFG Electricity PPA Toolkit

- WHAT?
  - Compilation of options to consider when an LFG electricity project PPA's term is coming to an end; will add more options as they present themselves
- WHY?
  - LMOP has received multiple requests for information/resources on negotiating a PPA or seeking a new PPA
  - Increasing trend of LFG electricity projects shutting down / lower rates being paid for LFG-generated power
  - LMOP wants to help owners continue mitigating methane emissions
- WHERE?
  - epa.gov/lmop/toolkit-expiring-landfill-gas-electricity-power-purchase-agreements

Landing page

- Three main choices with various options
- Presents criteria, pros and cons, economic considerations, project examples and other resources for more information

If conditions are feasible for LFG energy project operations:

Continue to generate electricity

Develop new LFG energy project type

Or, if conditions are not feasible for LFG energy project operations:

Shut down your LFG energy project

Expiring LFG Electricity PPA Toolkit

Develop New Power Purchase Agreement

Back to Toolkit for Expiring LFG Electricity PPAs | Back to Electricity-Related Options

A power purchase agreement (PPA) is a contract between a renewable energy generator and purchaser that defines all the business terms of the agreement between the parties. If continuing to sell electricity to the existing buyer is desired, the landfill gas (LFG) electricity project owner may want to renegotiate their PPA. Consulting firms can provide services in this area, if needed.

Criteria:

- In regulated states*, power would need to be sold to a utility.
- In states with competitive power markets*, power could be sold to a commercial or municipal customer or a wholesale electricity buyer.

Pros:

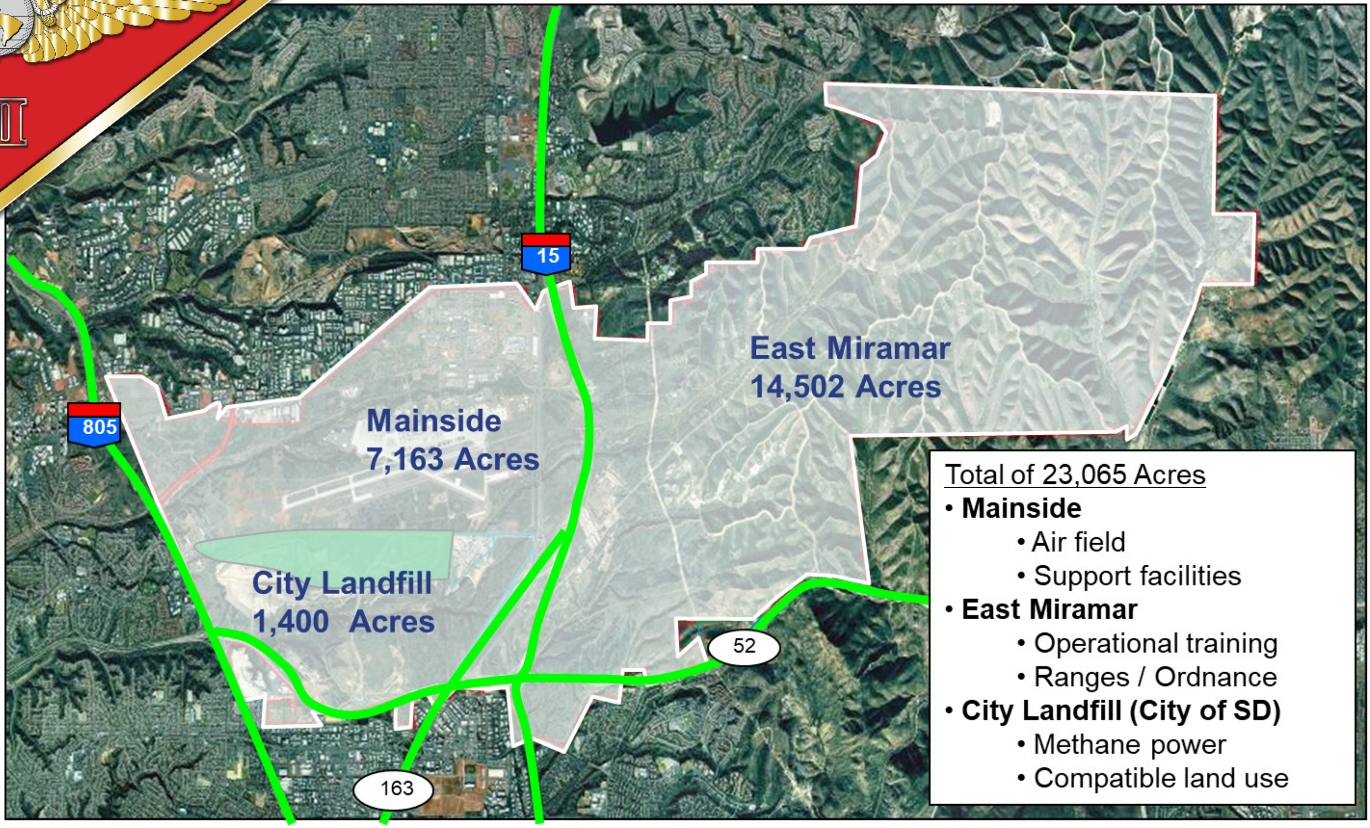
- Some purchasers may prefer a common source for electricity and renewable energy certificates (RECs) to meet internal greenhouse gas reduction or renewable energy goals.
  - In 2019, 360 off-takers obtained 42.3 million megawatt-hours of green power through PPAs and retained the RECs, a 33 percent growth over 2018.[1]
- A new PPA offers an opportunity to have more favorable pricing or other terms with a new buyer who may have differing priorities from the original buyer.

Example

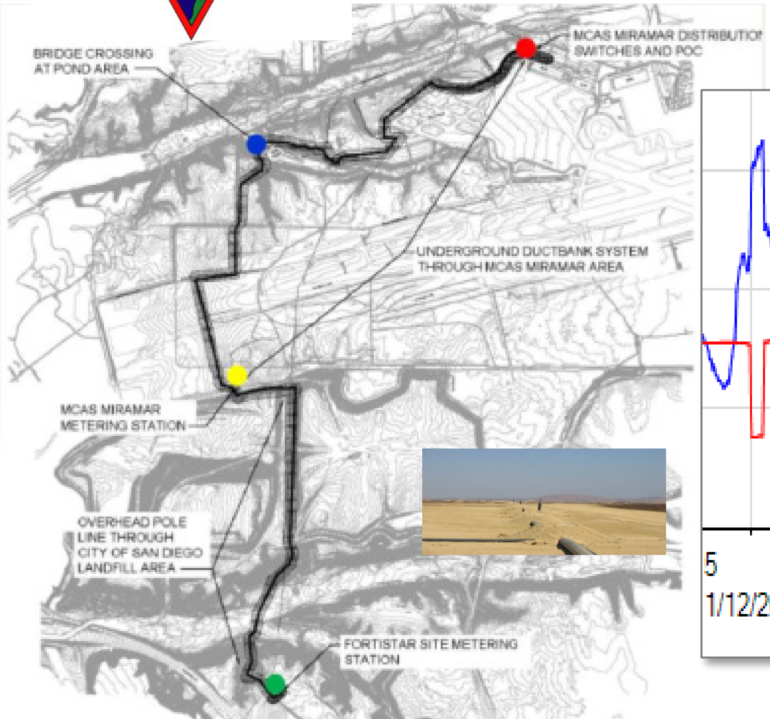
LFG-fired engines at Western Regional Landfill, California. Used with permission from Energy 2001.

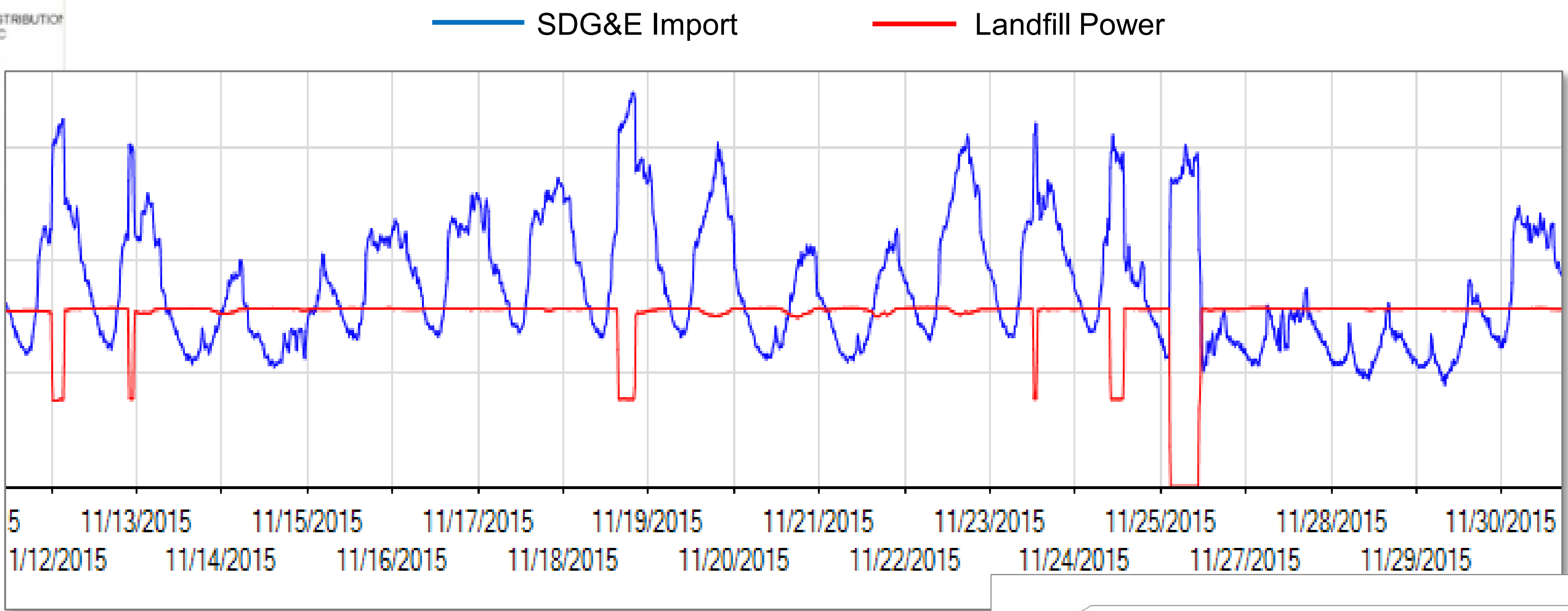
Western Regional Landfill, California [2, 3, 4, 5]

Welcome to MCAS Miramar



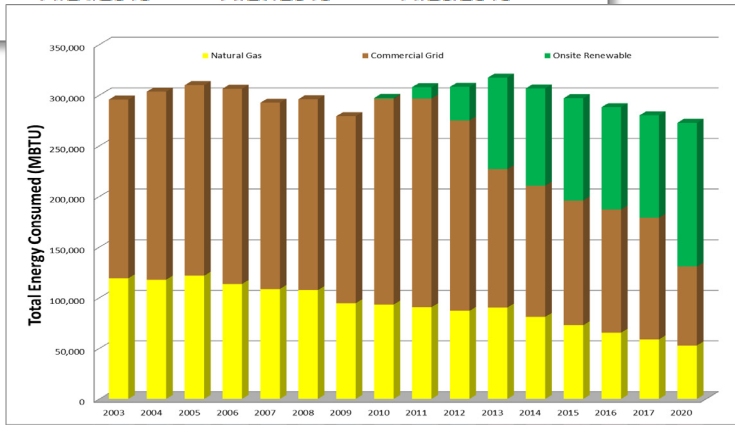
Landfill Power





Project Details

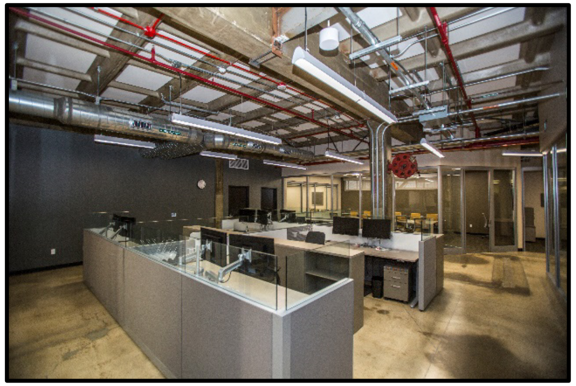
- Power Purchase Agreement (PPA)
- Began production 2012, Contract ends 2026
- Estimated savings = $50 – $350K
    - Depending on availability during demand



Solar

NEM			
Projects	Gen. Type	Net NPR (kW)	Expect AnnualEnergy Production (kWh)
1	Photovoltaic	10	19,000
2	Photovoltaic	201.2	382,280
3	Photovoltaic	26.3	49,970
4	Photovoltaic	49.6	94,240
5	Photovoltaic	151.9	288,610
6	Photovoltaic	72.7	138,130
7	Photovoltaic	309.5	588,050
8	Photovoltaic	104.3	198,170
9	Photovoltaic	7.3	13,870
10	Photovoltaic	9.1	16,380
11	Photovoltaic	462.4	877,800
12	Photovoltaic	118.6	225,340
13	Photovoltaic	131.8	237,240
14	Photovoltaic	36.1	64,980
15	Internal Combustion Engine	2930	20,533,440
	NEM TOTAL	**4620.8**	**23,727,500**
	Solar Total	**1,691**	**3,194,060**

Installation Microgrid Project Overview (P-906)



Project Details

- FY2014 ECIP Project
  - Programmed Cost $18M
  - Awarded in May 2016 for $20M
  - Projected Completion 2020
- 2018 California Energy Commission Grant
  - Awarded $5M to UCSD in 2018
  - Project Completion 2022

Project Description

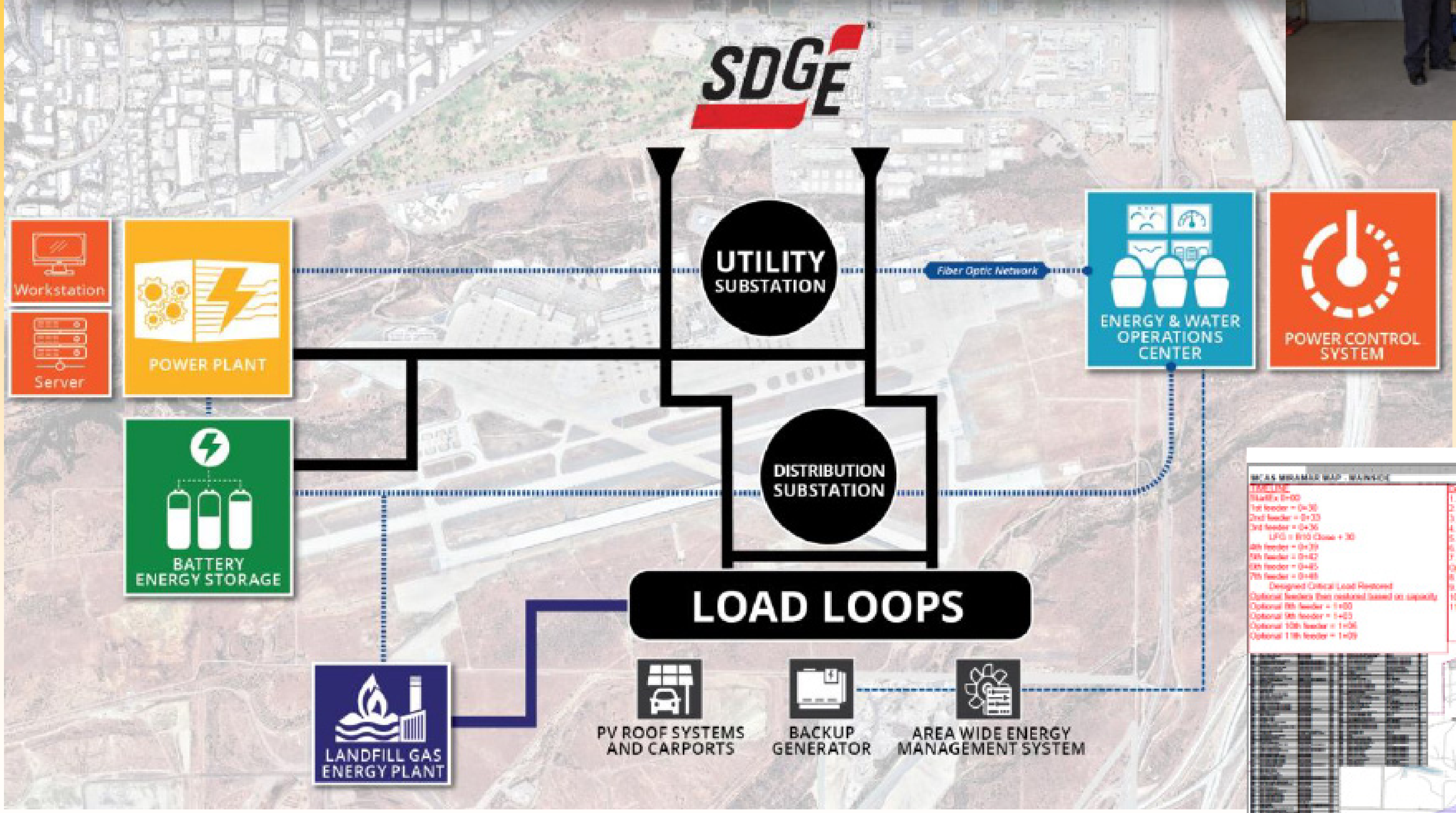
- Install diesel (4 MW) and natural gas (3 MW) generation with the ability to power 100% of the flight line and support facilities (100+ facilities = 4 – 6 MW, represented by the red island outline above)
- Incorporate existing onsite landfill power generation (3.2 MW) and existing PV generation (1.3 MW) into microgrid islanding as much as feasible
- Build “Energy & Water Operations Center” at B6311
- Economic Mode creates costs savings through grid connected generation
- Cyber Security accreditation through Risk Management Framework
- Grid Scale Energy Storage (CEC EPIC Grant)
- Base-wide HVAC Demand Response (CEC EPIC Grant)

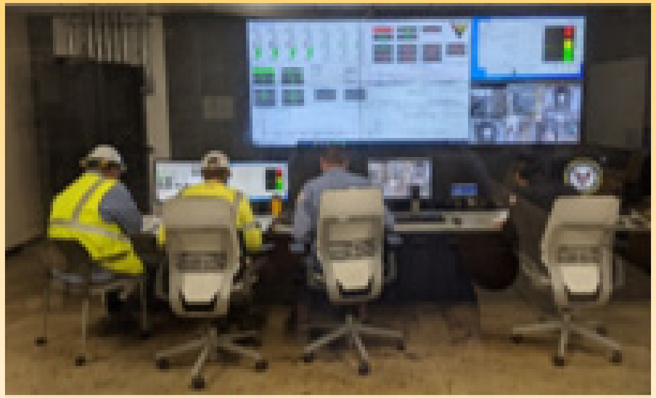
Project Goals

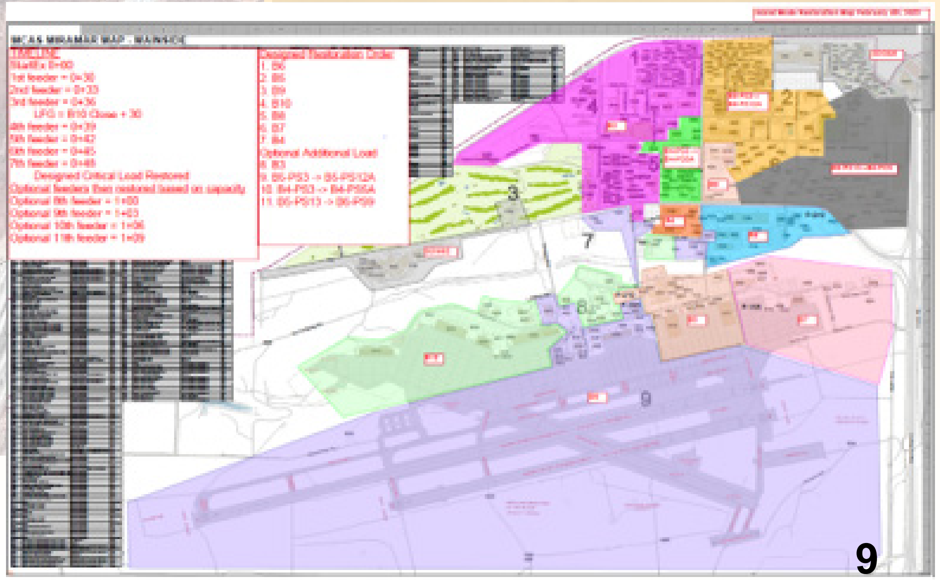
1) Energy Resilience (Fully Redundant Utility Power)
2) Maximize Onsite Energy Resource Integration
3) Cost Savings/Grid Support

MCAS MIRAMAR

INSTALLATION MICROGRID



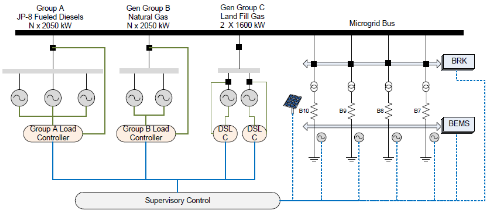


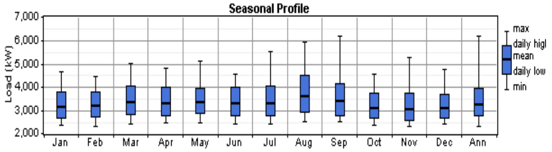


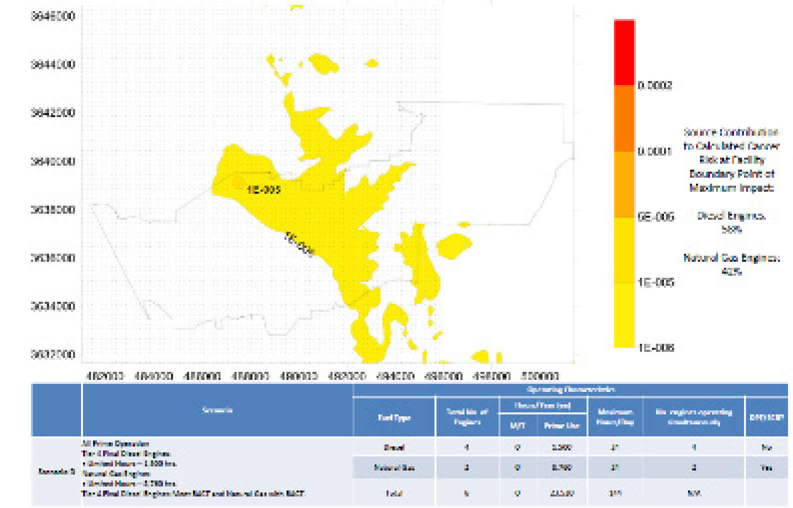
Modes of Operation

Economic **Island** **Test Mode**

Microgrid Power Plant



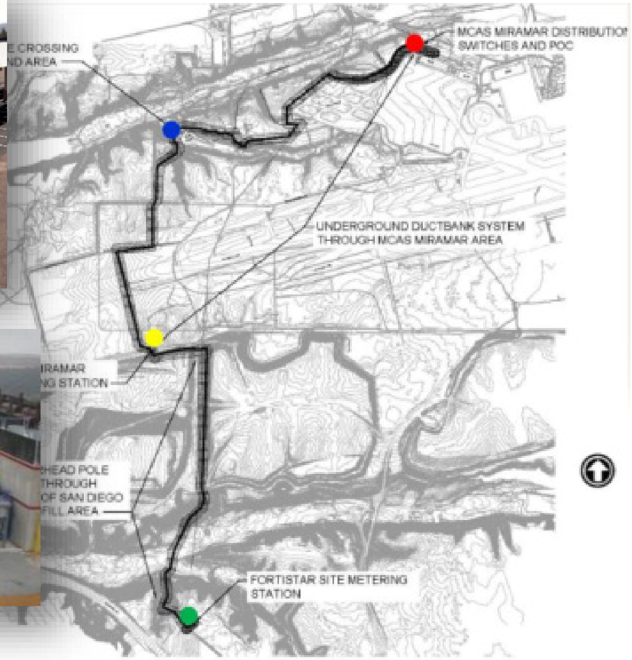


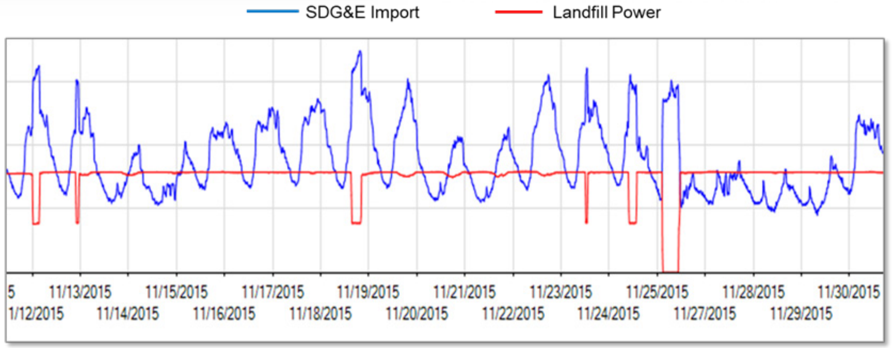


Generation

- Two 1400 kW BACT Natural Gas Reciprocating Engines
  - Prime permitted for 8760 hours per year
- Two Tier 4 Certified 1825 kW Diesel Reciprocating Engines
  - Prime permitted for 2000 hours per year
- Total Generation = 6.45 MW
- Building contains Microgrid Server
- BESS in design

Installation Microgrid DER Summary





<u>Base Load</u>

- 7-8 MW average
- 14 MW peak
- Est 3-6 MW critical loads

<u>Currently Operational</u>

- 3.2 MW Landfill Gas
- 3.6 MW Tier 4 Diesel
- 2.8 MW Prime Nat Gas
- 1.9 MW Photovoltaic
- 1.5 MW B7777 Generator (emergency use only)

Total = 13 MW

<u>Funded / Pending Install/Cx</u>

- 1.5 MW / 2MWH Li-Ion Battery
- Est 500 kW from 10 bldg. HVAC load shedding

<u>Future Planned (unfunded)</u>

- Additional 1.6 MW Landfill Gas
- Est 1500 kW from 70 addition HVAC load shedding
- 1 MW addition PV (P-283 FY24 ERCIP)
- 1.5 MW addition battery energy storage (P-283 FY24 ERCIP)
- 1.4 MW addition distributed generation (P-283 FY24 ERCIP)

Microgrid History

- 2011: PPA for LFG project signed with Fortistar LLC
- NREL receives award to conduct Microgrid Design Analysis on the air station
- Southwestern US power outage highlights vulnerabilities
- 2012: Microgrid approved for FY 2014 ERCIP
- 2014: Project awarded to Schneider Electric and Black & Veatch

2016 to 2017
Microgrid Design

- 2017: Groundbreaking for two power plants and microgrid
- 2018: $5M California Energy Commission grant for storage; advanced demand response controls
- Energy and Water Operations Center opens (Oct)

2019 to 2020
Program Testing

- 2019: First planned installation-wide outage (Aug)
- 2020: Full islanding tested
- Commission complete (Jun)
- Summer heatwave SDG&E grid support (Aug/Sep)

2021

- **E**nergy **R**esilience **R**eadiness **E**xercise During Winter Fury (Feb)
- Test Mode Exercises + Black start microgrid test (Apr)
- 2nd Heatwave Microgrid Grid Support + Test Mode Training Exercises (Jun)
- Official **E**mergency **L**oad **R**eduction **P**rogram Event Est value $20k (Jul 10 for 4 hours)
- **M**iramar **S**ummer **G**eneration **I**ncentive for MCAS Miramar approved w/ CPUC & SDG&E (Aug)
- Black start microgrid exercise (Nov 19th)
- Test Mode Exercises planned with Landfill Power (Dec 1+2)

**Microgrid program effort began in 2007 with discussions for MCAS Miramar reaching net-zero*

Microgrid History

Black start microgrid exercise
(Jan 30th)

Test Mode Exercises
+
Black start microgrid test
(Apr)

First Request for **M**iramar **S**ummer **G**eneration **I**ncentive for MCAS Miramar
(Aug 17th)

Largest Official **E**mergency **L**oad **R**eduction **P**rogram Event to date:
10 days
(Aug 31 to Sep 9th)
Received $327k bill credit on SDGE Jan statement

2022

2023

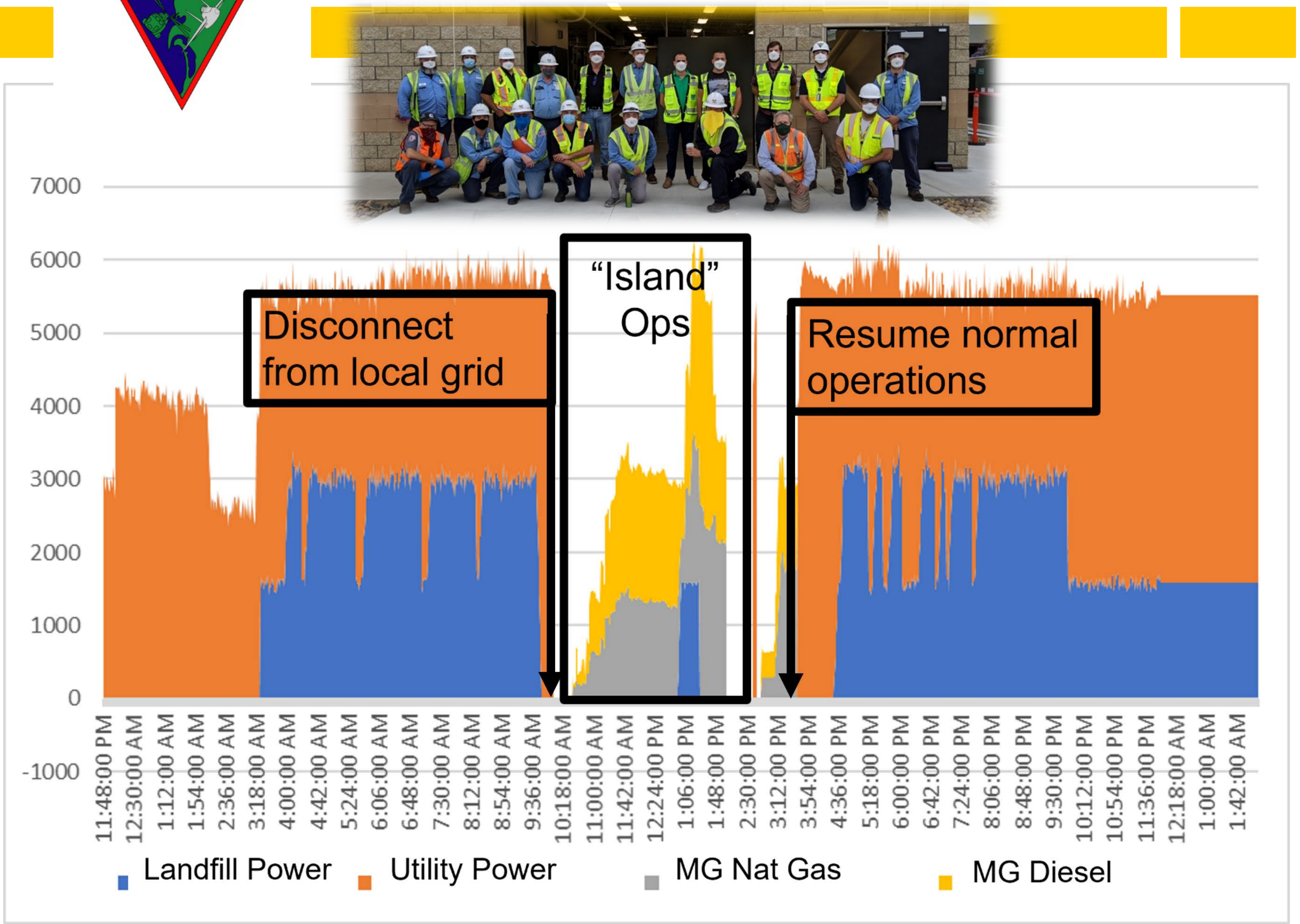
Microgrid Island Test Mode Cx of B7777 Generator Paralleling Capability
(Jan 13th)

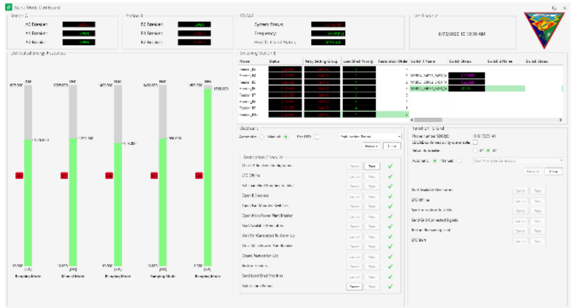
Microgrid Black Start / Full Island Mode Test
(Saturday Feb 4th)

- Evaluation of fully automated island mode (no operator / software only)
- Final Performance Testing of B7777 Generator
- Integration w/ Landfill Power
- Evaluation of “5G Energy Comms” project for back up generator monitoring and PV Control
- Initial building level load management Cx through MBCS at B2273 (47kW reduction)

Energy **R**esilience **R**eadiness **E**xercise During Sempur Durus (Planned Monday Apr 10th)

Island Testing





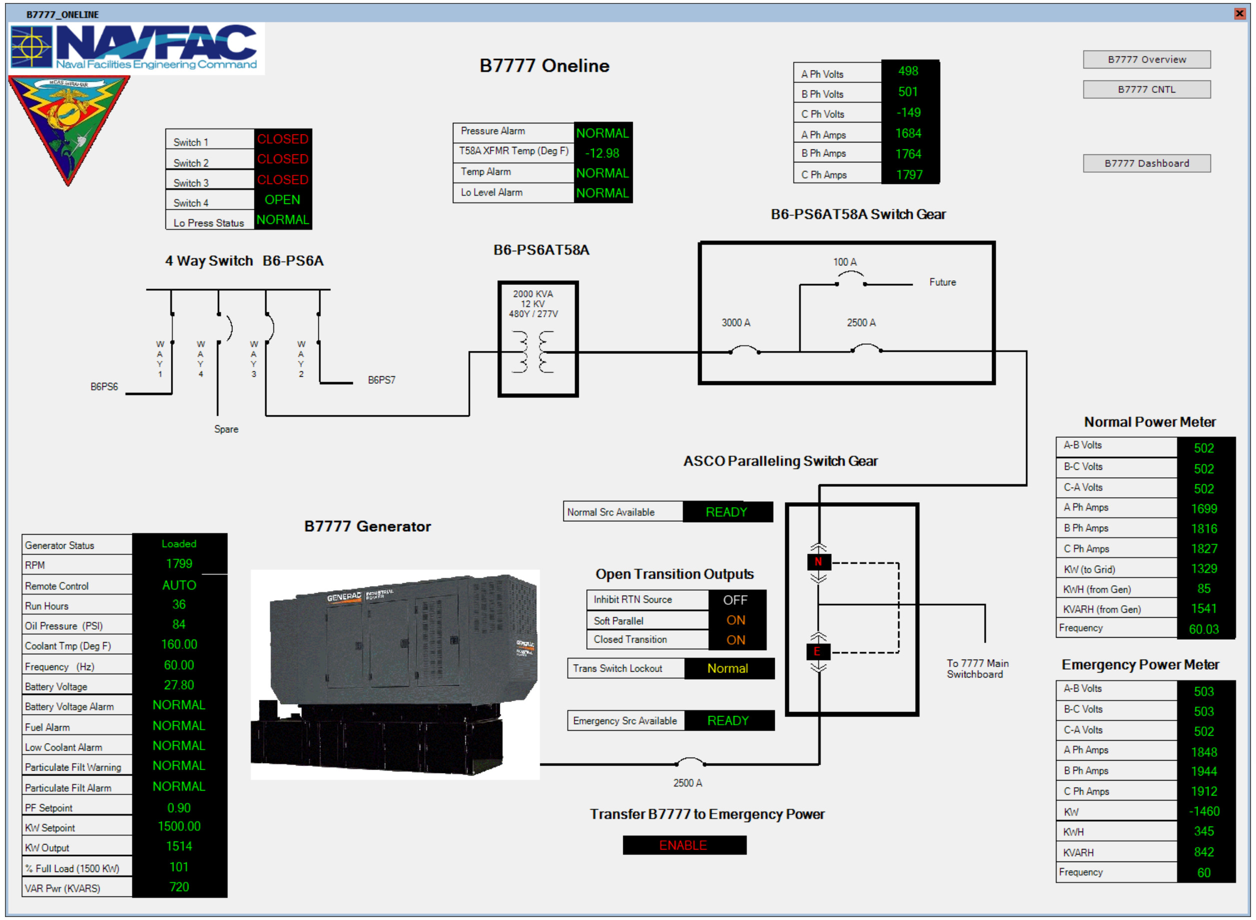
<u>June 2020 Commissioning Accomplishments</u>

- ✓ First full black start test of the microgrid
- ✓ Powered entire installation with power plant (non-op/COVID/low load)
- ✓ Successfully integrated landfill power for the first time in island
- ✓ Successfully accomplished various extreme "stress tests" and maintained island stability

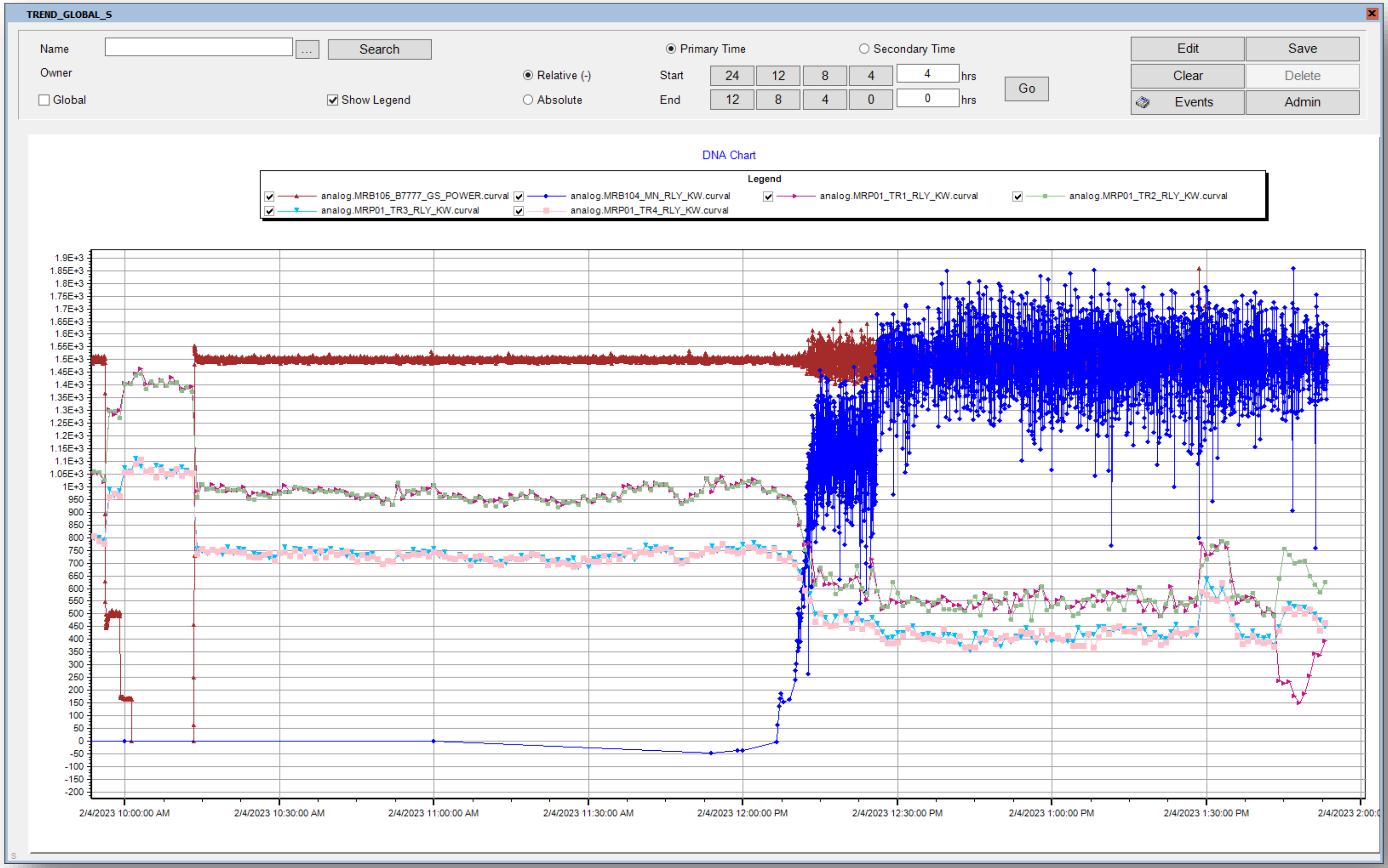
<u>Microgrid Tests Accomplished to Date</u>

- ✓ First planned base-wide outage August 2019
- ✓ 13 Microgrid tests involving base wide outages
- ✓ 2 Microgrid island tests involving outages to limited areas
- ✓ 17 Microgrid island tests to limited areas with seamless transition (no outage)

B7777 Generator - Island Testing



B7777 Generator - Island Testing



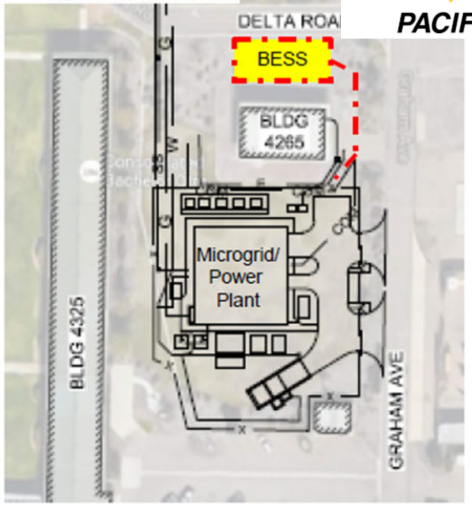
CEC Epic Grant

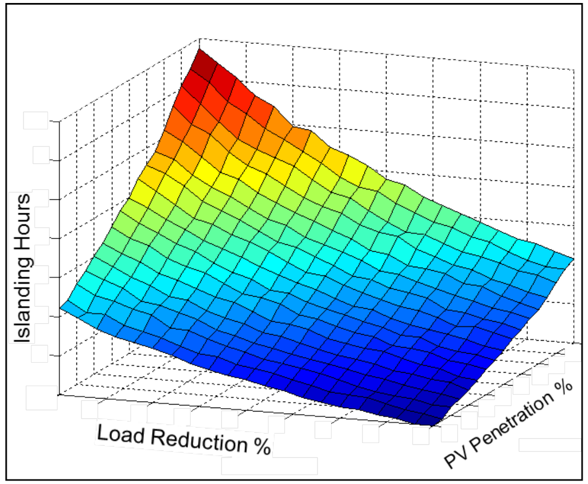
Naval Information Warfare Center PACIFIC

Schneider Electric

Center for Energy Research

University of California San Diego





Addition of 3 MW Battery Energy Storage System

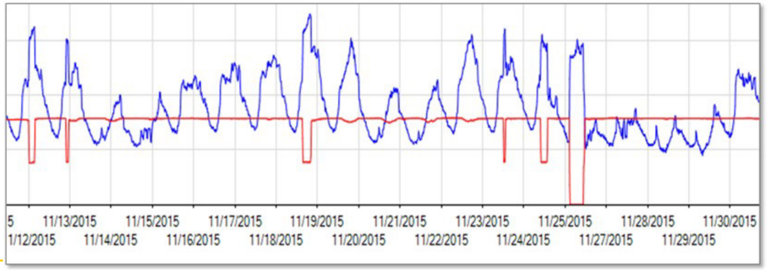
- Displacing diesel generators as the primary source of backup power for the LFG
- Reducing demand charges when SDG&E is utilized as backup power for the LFG
- Allowing for increased renewable penetration in microgrid
- Improving power reliability and quality to allow 3.2 MW of LFG to be integrated into the DoD-funded microgrid when operating in islanded mode

Johnson Controls

Enhanced Demand Response from Basewide HVAC Controls

- Up to 1.6 MW of controllable building load
- Priority customization of over 80 connected bldgs.
- 3 available load shed levels
  - Thermostat adjustment
  - Compressor shut down
  - Complete Shutdown

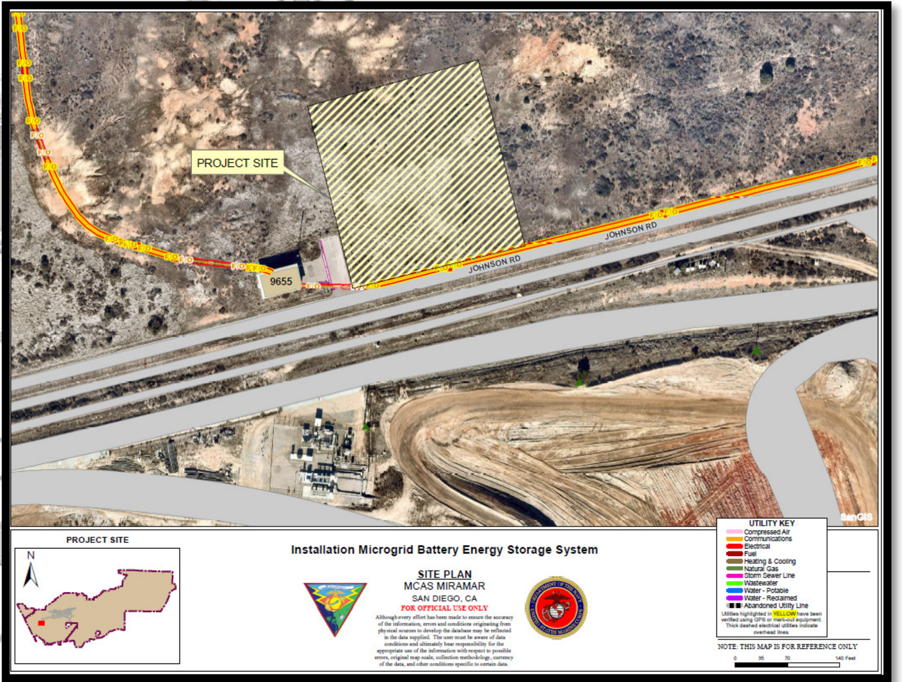
MCAS MIRAMAR MBCS



BESS Use Cases

MARINE CORPS ENERGY

NAVFAC



Use case 1 - Defining the schedule of BESS

- New PCS functionality will be developed that will provide the operator with an interface to define the schedule for how the BESS will manage charging or discharging in the future. This functionality will be called the "BESS Scheduler". Using the defined schedule, PCS can update the active power set point of battery at the beginning of each hour.

Use Case 2 – Landfill Gas/other generators Backup in Island Mode

- Existing PCS applications can be adapted to include the BESS in Island Mode for LFG backup or other backup generators (natural gas, diesel – NG1, NG2, DG1, DG2). An LFG trip while in Island Mode can create a load shedding event resulting in an outage affecting critical customers. The PCS can regulate energy storage to provide additional base energy when any generator trips. A generator trip will be recognized when a trip signal is received from any PCS and SCADA monitored generator.

Use Case 3 – Peak shaving and Loss of LFG in Grid Connected Mode

- With the installation of the BESS, the PCS will have an additional resource for peak shaving. The BESS will provide a better and cleaner alternative than diesel generators, especially when factoring in energy price and the reaction time of the BESS. To support this feature, the PCS microgrid control software will be modified to take energy storage into account when calculating peak shaving alternatives during grid connected mode.

Use Case 4 – Charging the batteries in low load scenario in grid connected mode

- New functionality will be developed to provide battery charging when a low load scenario is detected while in Grid Connected Mode. This functionality will be similar to the real time peak shaving that was described above. The difference is that it will be activated only if the load is below some predefined minimum value. This functionality will run only while PCS is in Economic Mode. When a low load is detected and the PCS is in Normal Mode, an alarm will be triggered to notify the operator that PCS should start charging the batteries.

Use Case 5 – BESS in a Low load Condition in island operation

- The existing low load functionality can be extended using the BESS. This use case will start charging the batteries as part of remedial actions for overgeneration. When low load conditions are met, the PCS will first start to charge the batteries.

Use Case 6 – Frequency Response of BESS

This use case is considered an emergency operation and is intended to use the battery when there is a sudden load change on the microgrid in the Island Mode. The battery can work in two modes: Frequency – Watt mode and Constant Power. The PCS will provide an indication to the operator as to which of these modes it is in. In Frequency – Watt mode, the battery has a fast response and will react in order to maintain the system frequency. This case is not controlled by the PCS. The BESS controller monitors system frequency and will respond if the system frequency varies by more than what is allowed in the BESS settings. This will be the how the BESS will normally operate in Island Mode. When there is a low load condition or LFG backup condition (Use Case 2 and Use Case 5), the PCS will first turn the battery to Constant Power mode and then send a calculated set point. Once the low load condition or LFG backup conditions have passed in Island Mode, the PCS will put the battery into Frequency – Watt mode.

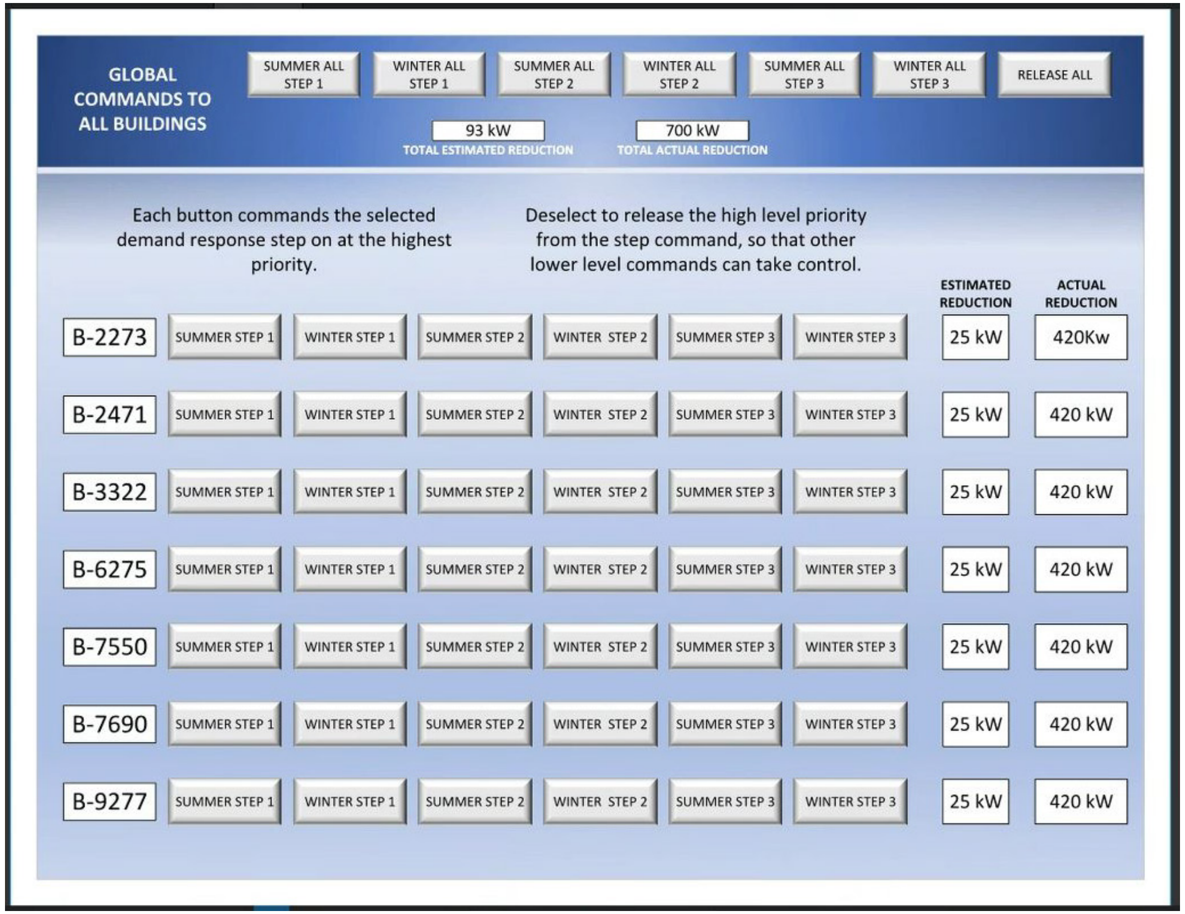
Use Case 7 – Voltage Support

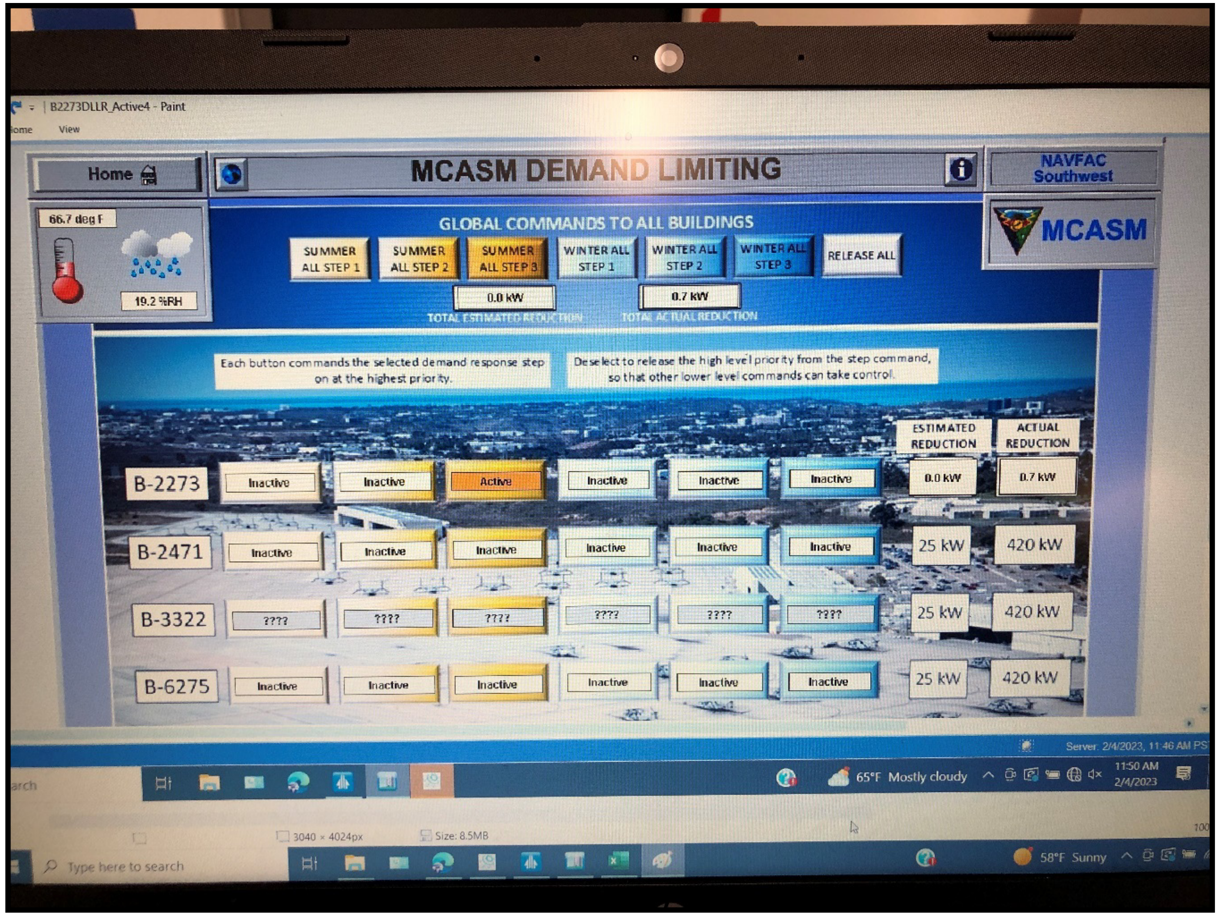
This use case is intended to use the battery to produce reactive power and provide voltage support. This case is not managed by the PCS system. The BESS controller monitors the system voltage and when a low voltage condition is detected, the BESS will immediately switch to VAR production to support the system voltage. The BESS will send an alarm to the PCS indicating when voltage control mode was initiated and terminated.

CEC Epic Grant

Center for Energy Research

University of California San Diego

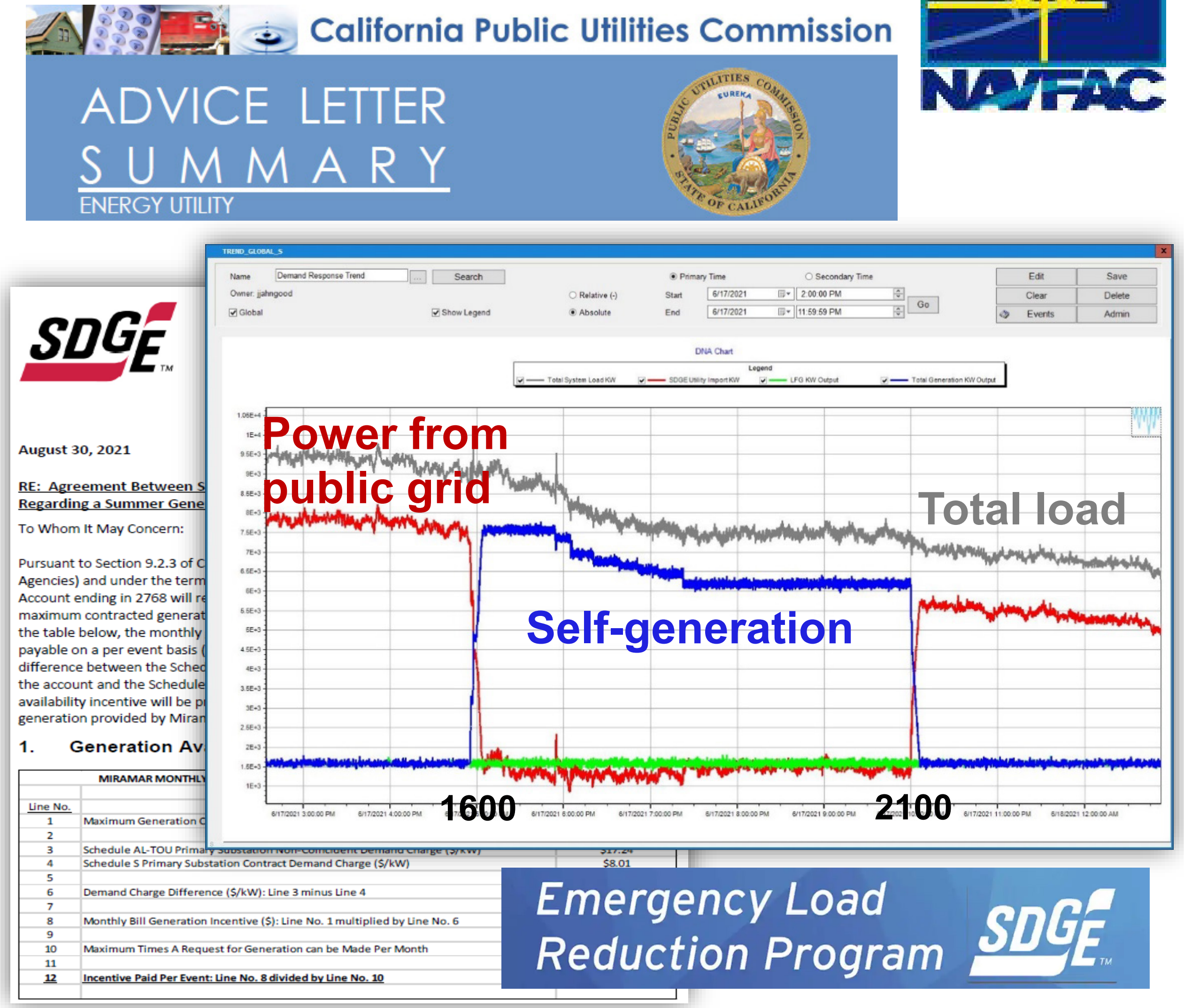




Microgrid Demand Response (Heatwave)

<u>Demand Response</u> = Using onsite energy resources (generators) or reducing load while grid-connected to reduce utility import of power so that power can be used in other areas, thus mitigating rolling blackouts.

- In the summer heatwave of 2020, at the request of the local utility, MCAS Miramar used the microgrid to reduce load on the commercial grid for 5 hours per day for 4 days, avoiding rolling blackouts to approximately 3000 homes in the community (no incentive programs available at this time).
- In 2021, The California Public Utilities Commission (CPUC) established demand response incentive programs such as the Emergency Load Reduction Program (ELRP) and the first of a kind microgrid-specific "Miramar Summer Generation Incentive" (MSGI).
  - MCAS Miramar responded to 1 of 3 ELRP emergencies during that summer
- On 17 August 2022, the local utility called an MSGI event for the first time, and MCAS Miramar used microgrid generation capability to avoid an emergency in California. In the weeks that followed, California saw the highest recorded electrical load in history, bringing the state to an emergency.
  - MCAS Miramar responded to 10 of 10 ELRP emergencies in summer 2022.
  - The incentive for MCAS Miramar's support is estimated at around $300K.



MCAS Miramar ERRE FSX – 18 FEB 2021

Key Lessons Learned

- Non-critical facilities may need power for routing of communication or other associated equipment that may be tied to a separate critical operation.
- Significant communication or network issues occur with systems that do not have an adequate uninterruptible power supply (UPS), causing lengthy network outages even when electricity has been restored.
- Need to improve communication in contingency environment and preserve copper phone lines.
- Turnstile/gate access functionality requiring network access.
- Complete resilience will require more training, coordination, improvements, and more exercises.
- Base-wide outages became normal and less disruptive through the process.

U.S. EPA Landfill Methane Outreach Program

After the Flare Shuts Off: Biofilters Applied to Landfill Gas Treatment

June 13, 2023

Presented by

Peter Bannister, PE

Aspect CONSULTING

The flare at the Jefferson County landfill has run since 1993, until this year when owners, regulators, and Aspect partnered to turn it off–a rare milestone in the life cycle of closed landfill operations.

Getting a Good Night's Sleep

Moving on from "active" to "passive" landfill gas treatment

BY PETER BANNISTER

In the world of landfills, the transition from active to closed status is much like the transition from feast to bed. When a community is done "feeding" the landfill, i.e., finished actively adding waste to it, owners pull a cover from the toe to the crown of these giants and allow the necessary digestive processes to take place. The digestive process in this analogy equates to solid waste degrading over time until the landfill can move into a "post-closure" care step and, eventually, into productively reusing the land.

Often, the landfill flare—the controlled flame that burns off excess landfill gas—is the most conspicuous sign of the digestive process. Flares, in tandem with a landfill's post-closure slumber, may operate for several decades during which time owners diligently keep watch. Some landfills sleep soundly, while others may suffer indigestion—often in the manner of excess landfill methane and other contaminants impacting landfill area groundwater, soil, and gas—and require special attention.

When the flare or "Night Light" goes out, landfill owners and operators can move on from active to passive landfill gas treatment, which means being one step closer to ending post-closure activities and considering potential future land uses.

AFTER NEARLY 30 YEARS, JEFFERSON COUNTY CELEBRATES A RARE LANDFILL MILESTONE

Near Port Townsend on the Olympic Peninsula in Washington State, the flare at the Jefferson County landfill has run since 1993, until this year when owners, regulators, and Aspect partnered to turn it off—a rare milestone in the life cycle of closed landfill operations.

Those responsible for watching and caring for these sleeping giants rarely see true milestone moments as the years roll on. Aspect has supported the team at Jefferson County for more than 10 years with monitoring and reporting post-closure care at this landfill. Over the last year, Aspect has guided the Jefferson County team toward

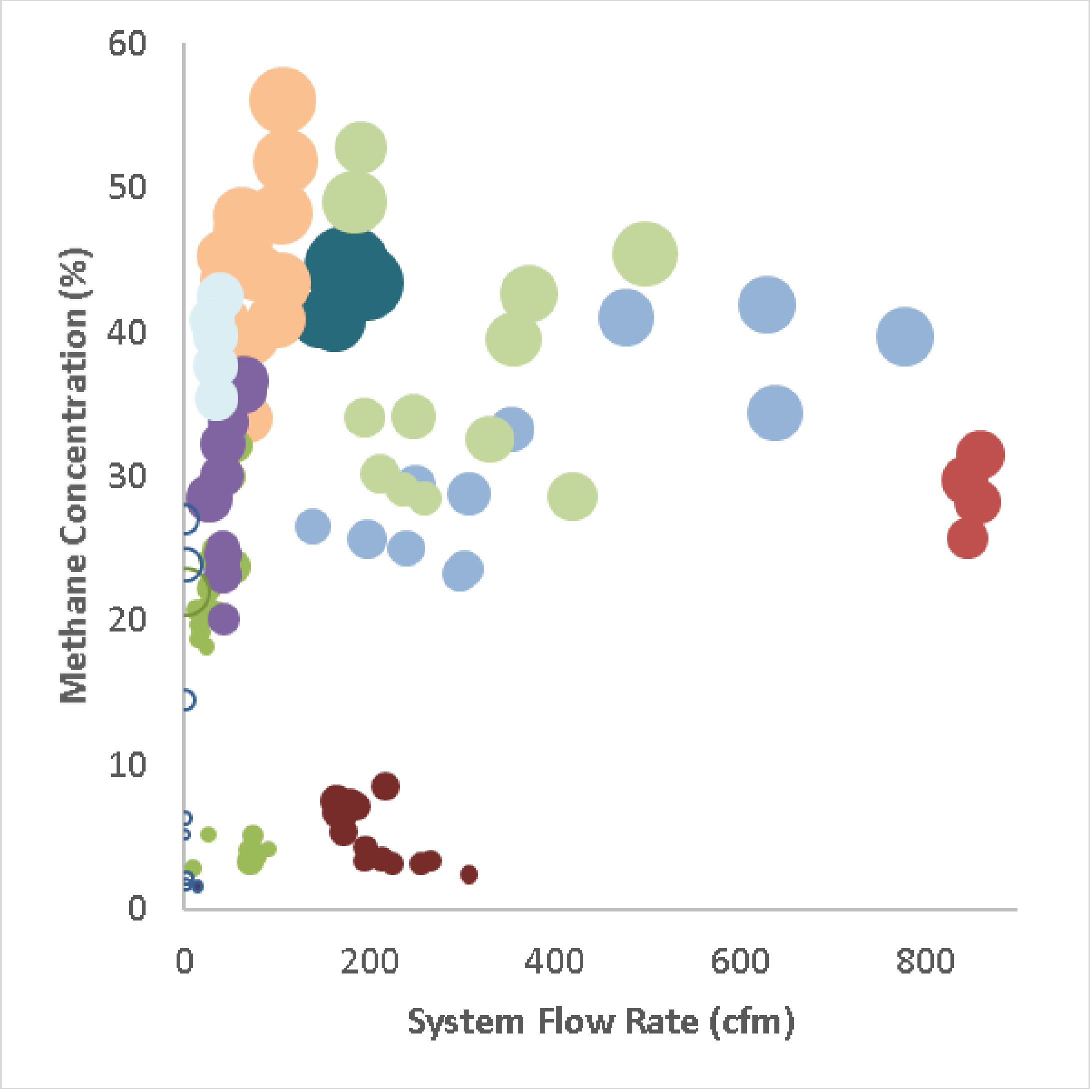
www.mswmanagement.com 19

Backstory: Coordination Between Landfill Owner and Regulator Achieves Something Better

Background to Biofilter Solutions

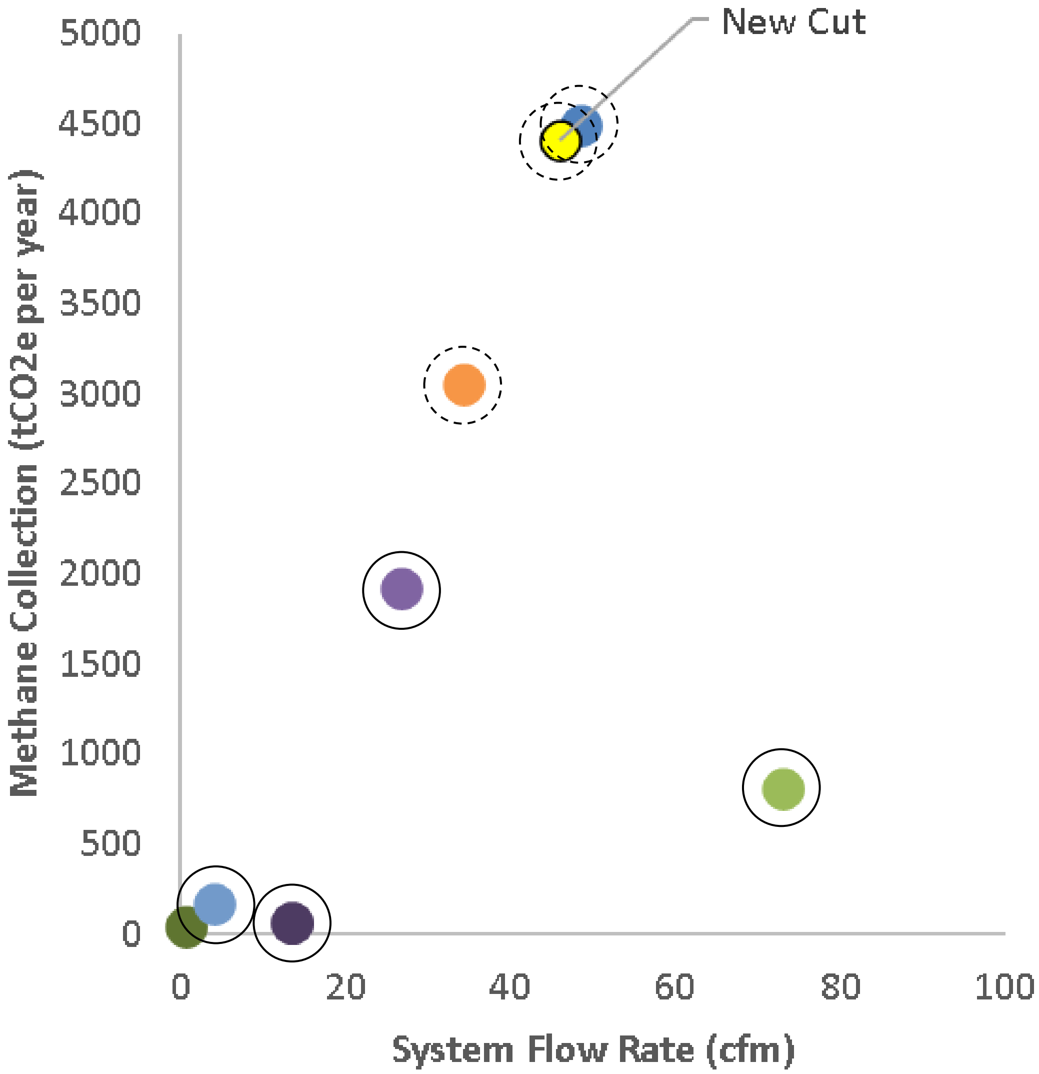
- Perspective
- Common Objectives
- Common Operational Solutions
- Common Infrastructure Solutions

Perspective – Landfill Experience



- Each color represents a different landfill
- Each circle represents a different year
- Circle size represents carbon dioxide in landfill gas (biogenic)

Perspective – Reducing Risks



Risks for landfills with low methane concentrations and flare shutdown:

1. cover emissions
2. lateral migration
3. groundwater impacts

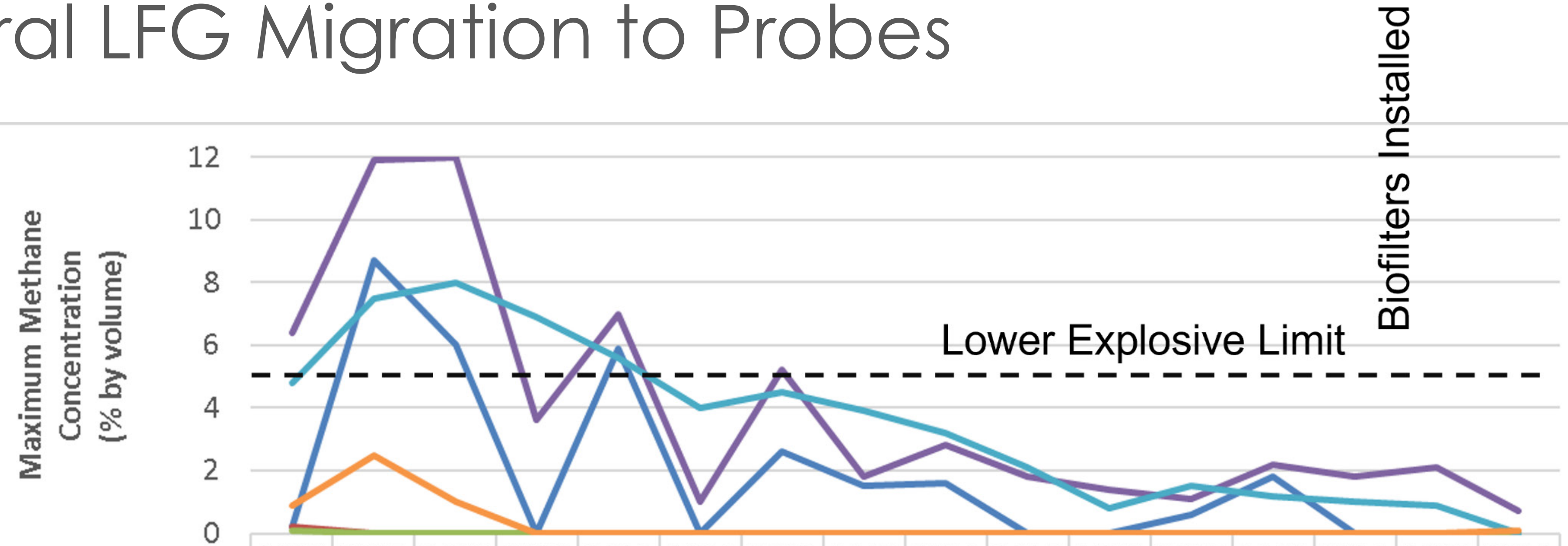
○ biofilter installed
◌ biofilter designed

Common Objectives

- Protect Human Health and the Environment
- Taking Steps toward Ending Post-Closure Care
- Make Life Easier

Common Problems

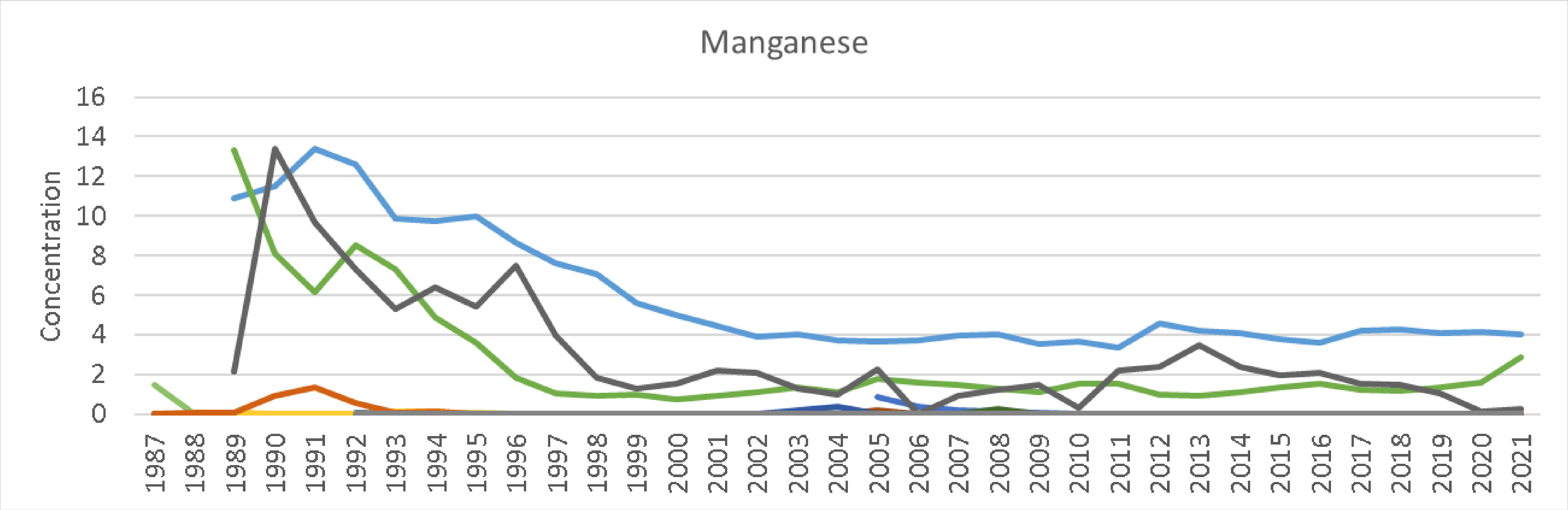
- Lateral LFG Migration to Probes



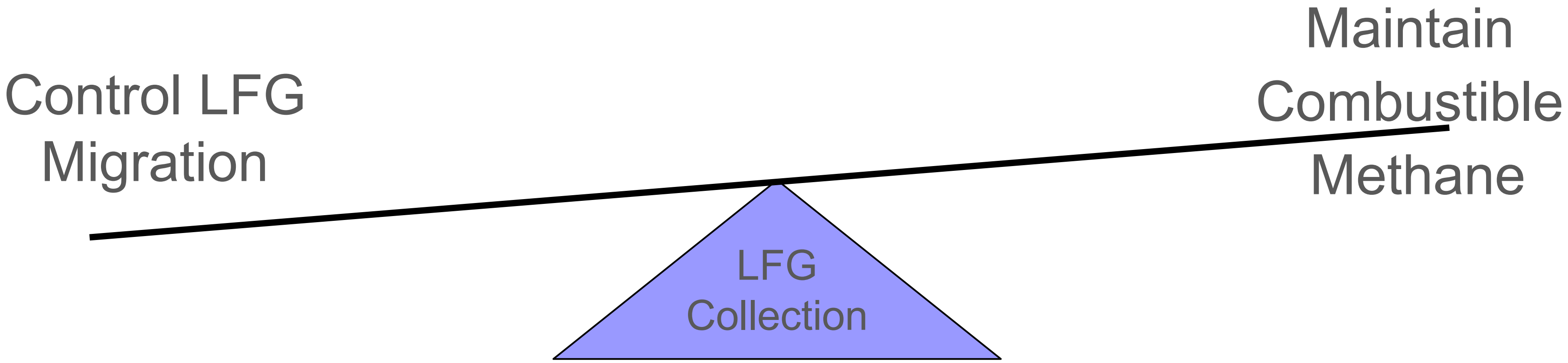
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GMonW1.9	0.2	8.7	6	0	5.9	0	2.6	1.5	1.6	0	0	0.6	1.8	0	0	0
GMonW2.9	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GMonW3.9	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GMoW1.45	6.4	11.9	12	3.6	7	1	5.2	1.8	2.8	1.8	1.4	1.1	2.2	1.8	2.1	0.7
GMoW2.45	4.8	7.5	8	6.9	5.6	4	4.5	3.9	3.2	2.1	0.8	1.5	1.2	1	0.9	0
GMoW3.45	0.9	2.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0.1

Common Problems

- Vertical LFG Migration to Groundwater



Common Operational Solutions

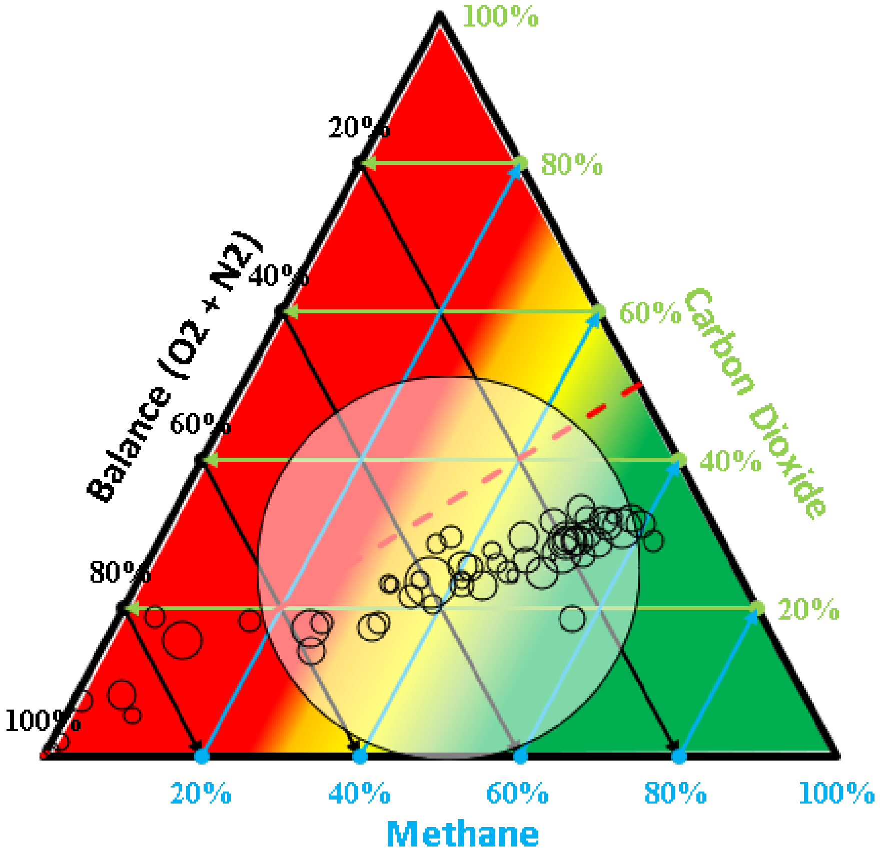


Migration Control	Methane
Relaxed	>50%
Moderate	>45% and <50%
Aggressive	>35% and <45%
Very Aggressive	>25% and <35%
Over Aggressive	<25%

SWANA "Landfill Gas Operations & Maintenance, Manual of Practice"

Common Operational Solutions

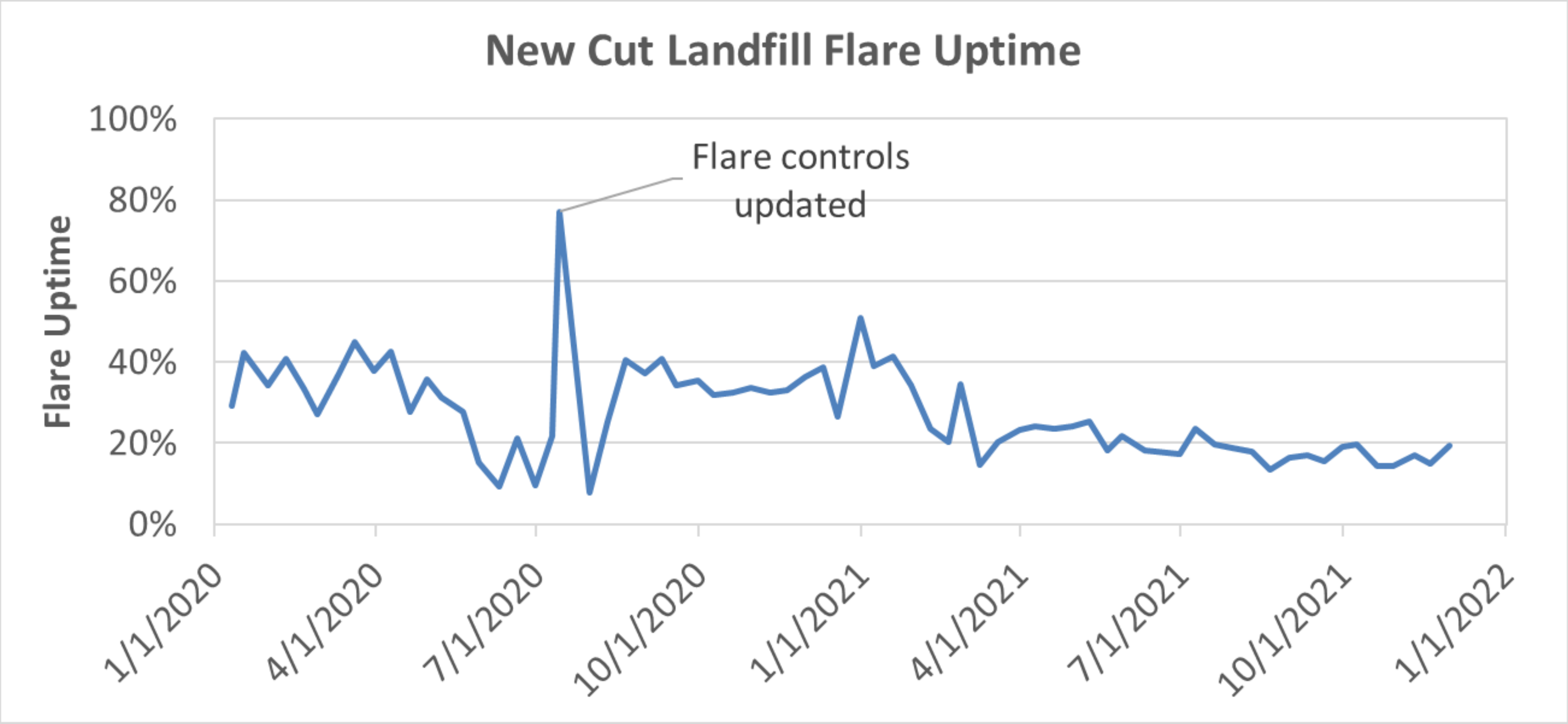
- New Cut Landfill – 2021 Observed



- Smaller open circles represent different LFG extraction well in the wellfield; large circle represents flare inlet
- Circle size represents observed flow rate
- Monitoring occurred during intermittent flare operation

Intermittent LFG Collection

- Flare operated 20% of the time



Problems with Intermittent Operation

- Increased periods for **fugitive emissions**
- Flare restart subject to **adverse weather**
- **Wellfield balancing** is challenging due to limited period of operation
- **Increased costs** to respond and maintain

Common Solutions to Flare Shutdown

- Modify/Downsize Flare Systems

Common Solutions to Flare Shutdown

- Supplemental Fuel

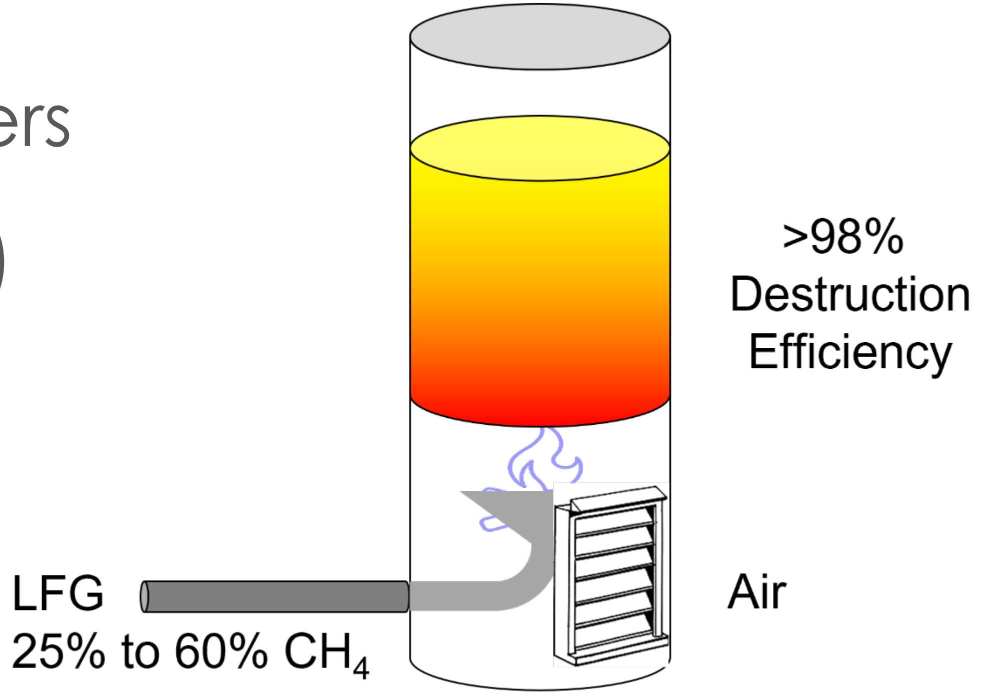
Biofilter Technology

- Treatment Equivalency
- Documented Demonstrations
- Scalable Design
- Simple Performance Monitoring
- Long-term Solution

Treatment Equivalency

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

- Enclosed Flare Design Parameters
  - Temperature (Autoignition + 400°F)
  - Residence Time (>0.5 seconds)
  - Turbulence/Mixing (Re>10,000)
  - Excess Oxygen (>3% at outlet)



New Cut Flare designed with 1-second retention time and operated at 1600-1700°F

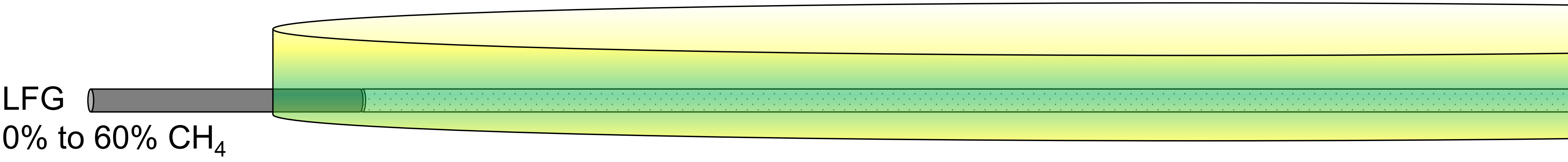
Treatment Equivalency

$$CH_4 + O_2 \rightarrow CH_3OH \rightarrow HCHO \rightarrow HCOOH \rightarrow CO_2 + H_2O$$

- Biofilter Design Parameters
  - Temperature (80°F optimum)
  - Residence Time (EBRT > 10 minutes)
  - Turbulence/Mixing (diffusion-dominated)
  - Excess Oxygen (diffusion-dominated)

Design methane oxidation potential
200 g $CH_4/m^3/d$

1 cfm CH_4 = 175 cy biofilter media



Documented Biofilter Demonstration

Los Angeles, London, New Delhi
and Singapore
http://www.sagepub.com

wm&r

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Biotic systems to mitigate landfill methane emissions

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Landfill gases produced during biological degradation of buried organic wastes include methane, which when released to the atmosphere, can contribute to global climate change. Increasing use of gas collection systems has reduced the risk of escaping methane emissions entering the atmosphere, but gas capture is not 100% efficient, and further, there are still many instances when gas collection systems are not used. Biotic methane mitigation systems exploit the propensity of some naturally occurring bacteria to oxidize methane. By providing optimum conditions for microbial habitation and efficiently routing landfill gases to where they are cultivated, a number of bio-based systems, such as interim or long-term biocovers, passively or actively vented biofilters, biowindows and daily-used biotarps, have been developed that can alone, or with gas collection, mitigate landfill methane emissions. This paper reviews the science that guides bio-based designs; summarizes experiences with the diverse natural or engineered substrates used in such systems; describes some of the studies and field trials being used to evaluate them; and discusses how they can be used for better landfill operation, capping, and aftercare.

Keywords: landfill gas, methane oxidation, biocover, biofilter, bio-window, landfill aftercare, wmr 1317–2

Documented Biofilter Demonstration

Mitigation of methane and trace gas emissions through a large-scale active biofilter system at Glatved landfill, Denmark

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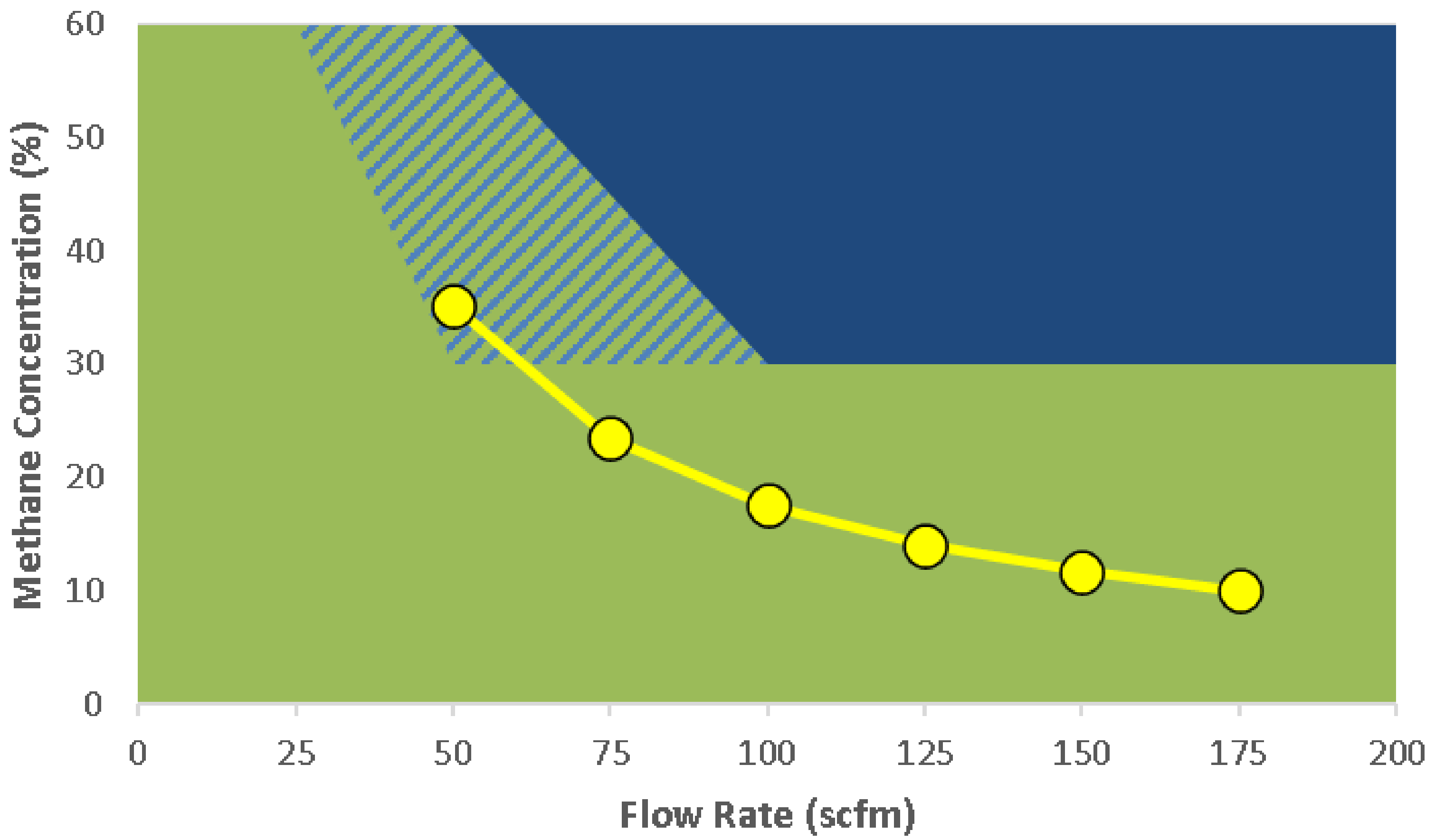
Surface concentration
Emission flux
Vertical gas profile
Mitigation efficiency

A B S T R A C T

Biocover systems are a cost-effective technology utilised to mitigate methane (CH_4) and trace gas emissions from landfills. A full-scale biofilter system was constructed at Glatved landfill, Denmark, consisting of three biofilters with a total area of 3950 m^2. Landfill gas collected mainly from shredder waste cells was mixed with ambient air and fed actively into the biofilter, resulting in an average load of 60–75 $g\ m^{-2}\ d^{-1}$ for CH_4 and 0.15–0.21 $g\ m^{-2}\ d^{-1}$ for trace gases (e.g., aromatics, chlorofluorocarbons (CFCs), aliphatic hydrocarbons). The initial CH_4 surface screening showed uneven gas distribution into the system, and elevated surface concentrations were observed close to the gas inlet. Both positive and negative CH_4 fluxes, ranging from −0.36 to 4.25 $g\ m^{-2}\ d^{-1}$, were measured across the surface of the biofilter. Total trace gas emissions were between −0.005 and 0.042 $g\ m^{-2}\ d^{-1}$, and the emission flux of individual compounds were generally small (10^{-8} to 10^{-3} $g\ m^{-2}\ d^{-1}$). Vertical gas concentration profiles showed that the oxidation of CH_4 and easily degradable trace compounds such as aromatics and aliphatic hydrocarbons happened in the aerobic zones, while CFCs were degraded in the anaerobic zone inside the compost layer. In addition, oxidation/degradation of CH_4 and trace gases also occurred in the gas distribution layer, which contributed significantly to the overall mitigation efficiency of the biofilter system. Overall, the biofilter system showed mitigation efficiencies of nearly 100% for both CH_4 and trace gases, and it might have the potential to work under higher loads.

Documented Biofilter Demonstration



Adapted from:

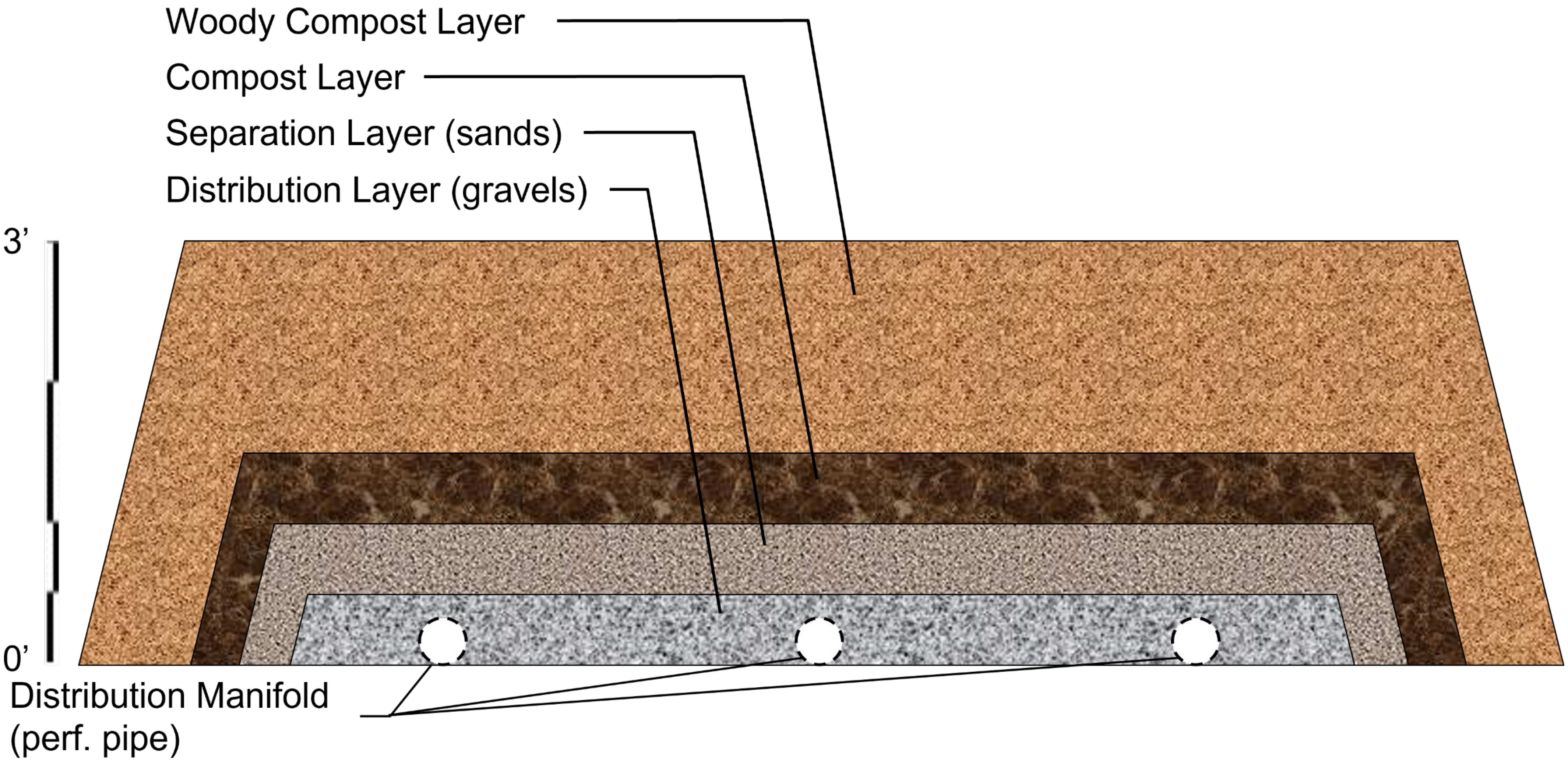
Management of Low Levels of Landfill Gas

Prepared by Golder Associates Ireland Limited

On behalf of the Environmental Protection Agency

(Office of Environmental Enforcement)

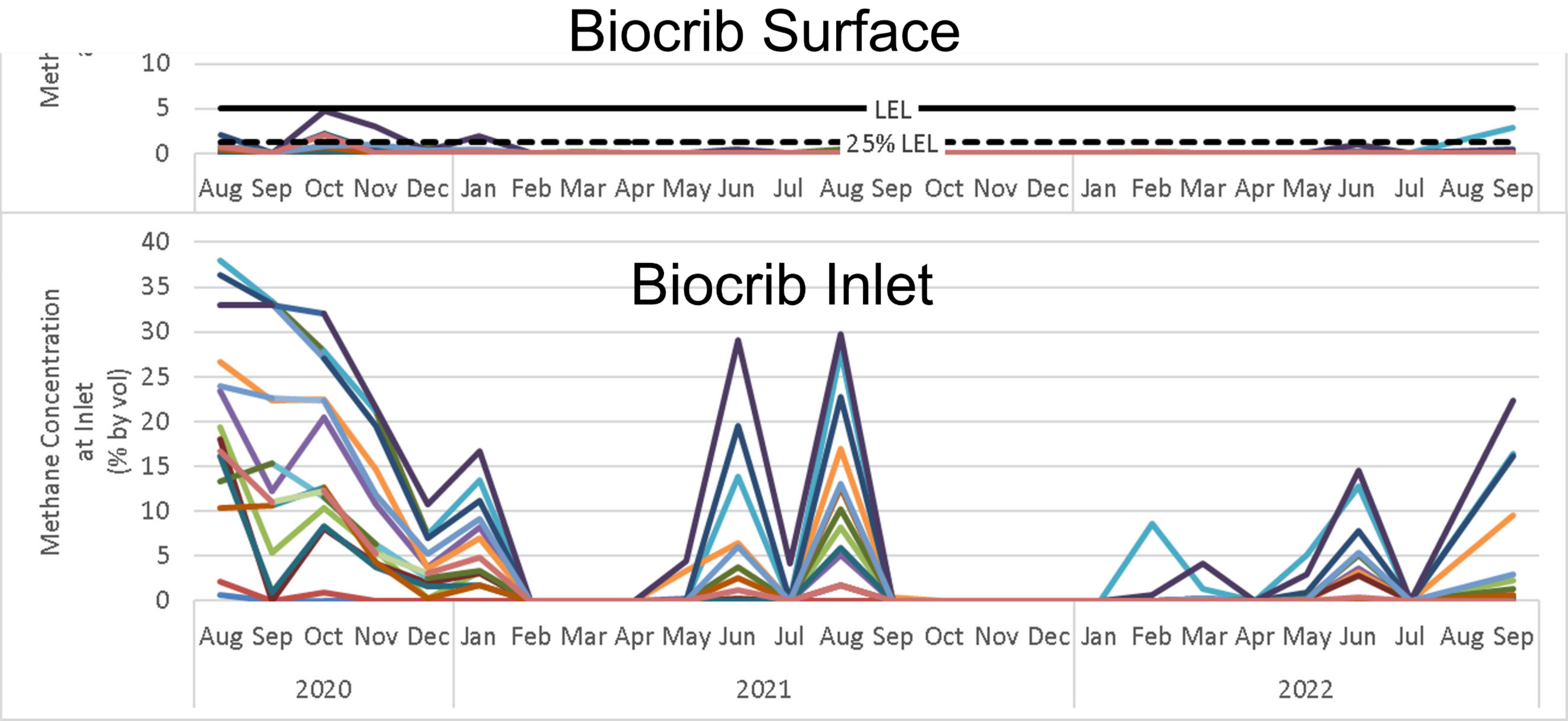
Biofilter Design – Cross-section



Biocrib Construction

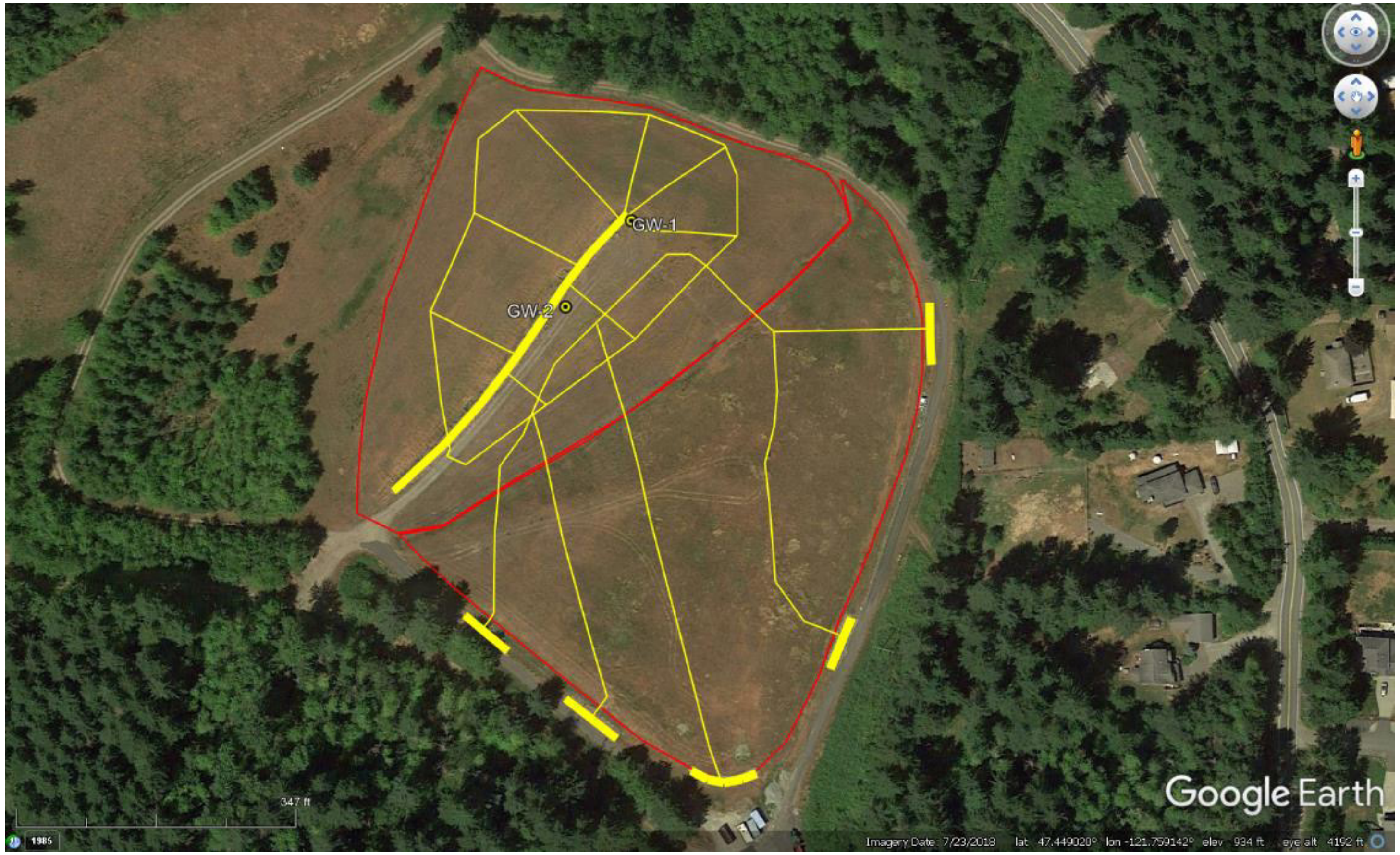
- Treatment at Wellheads

Biocrib Construction



Bioberm Construction

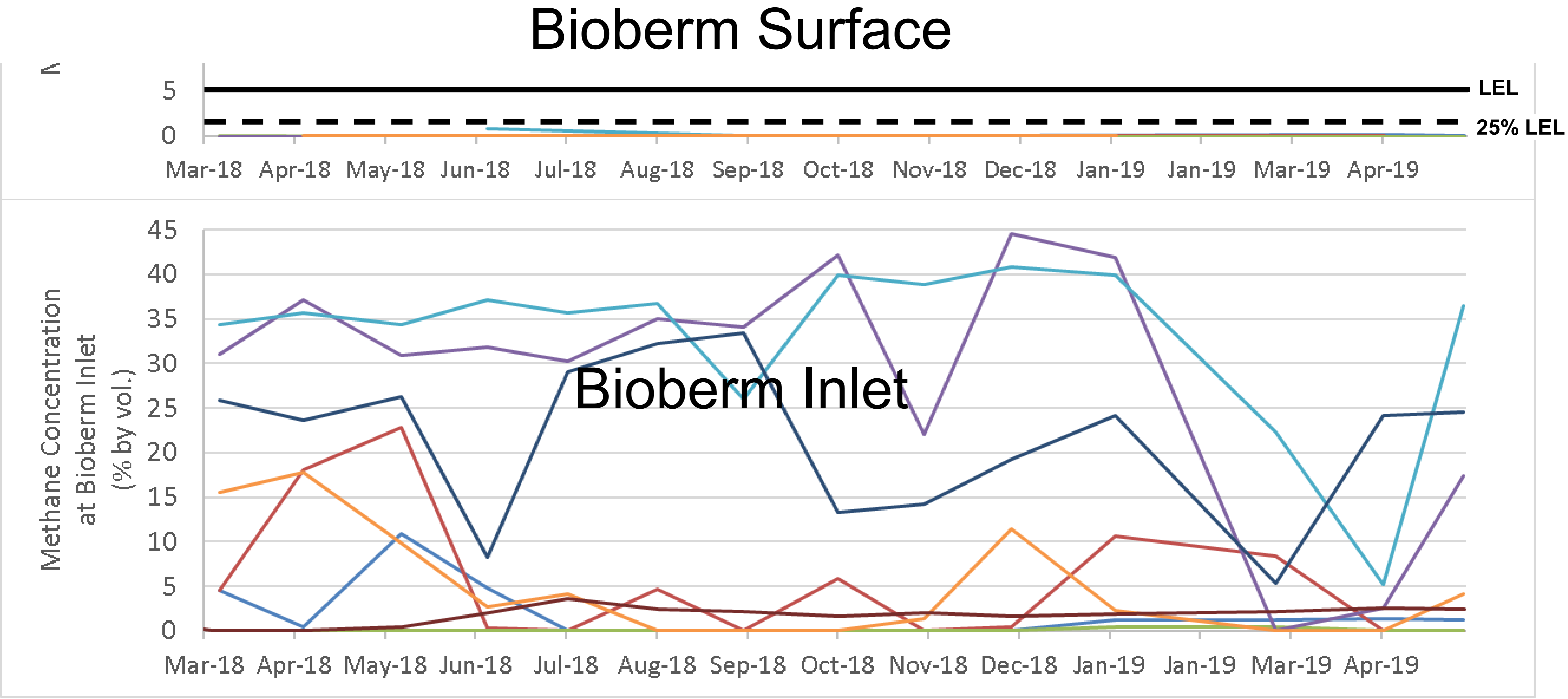
- Treatment at Laterals



Bioberm Construction

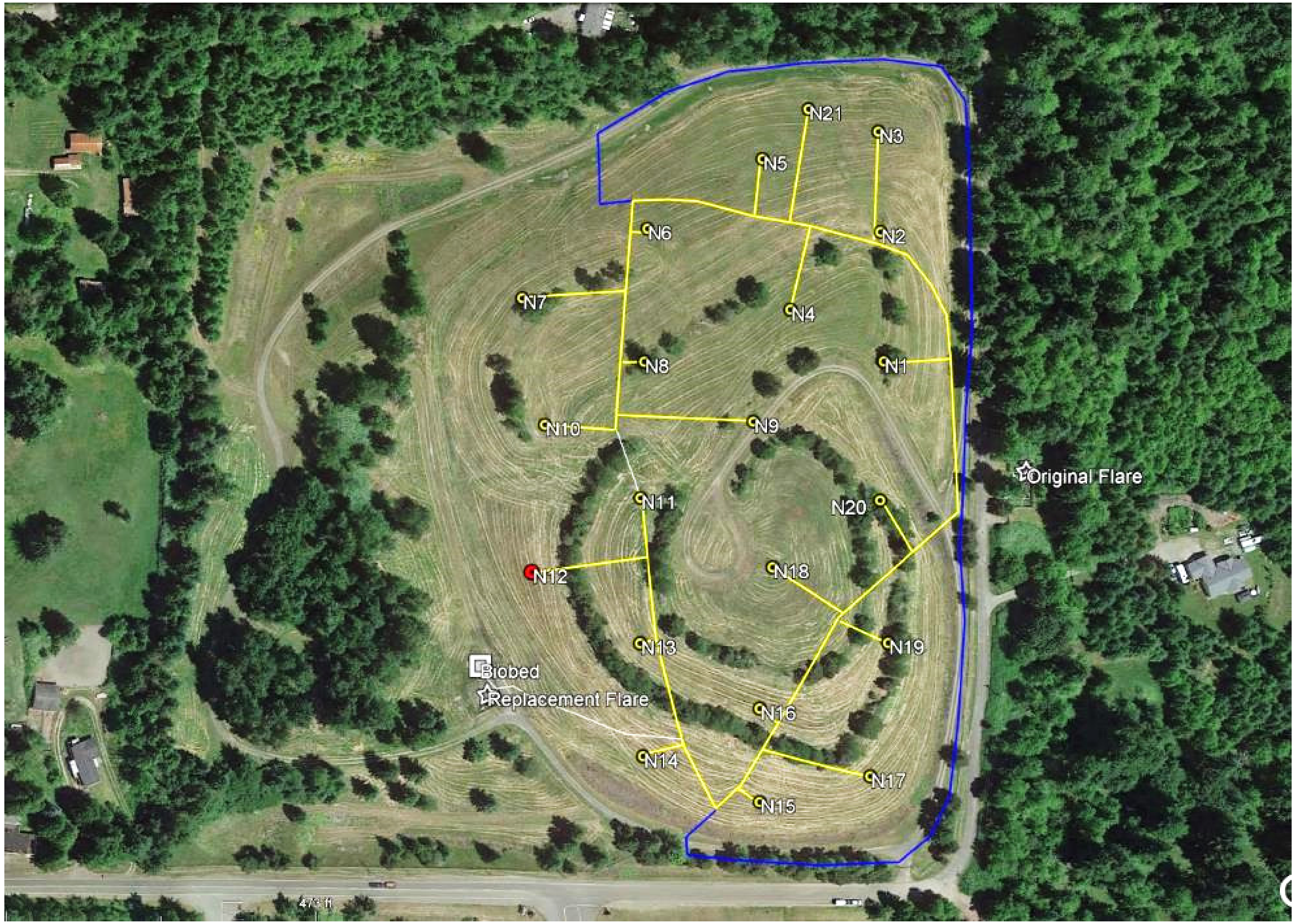
- Active Perimeter SVE

Bioberm Performance



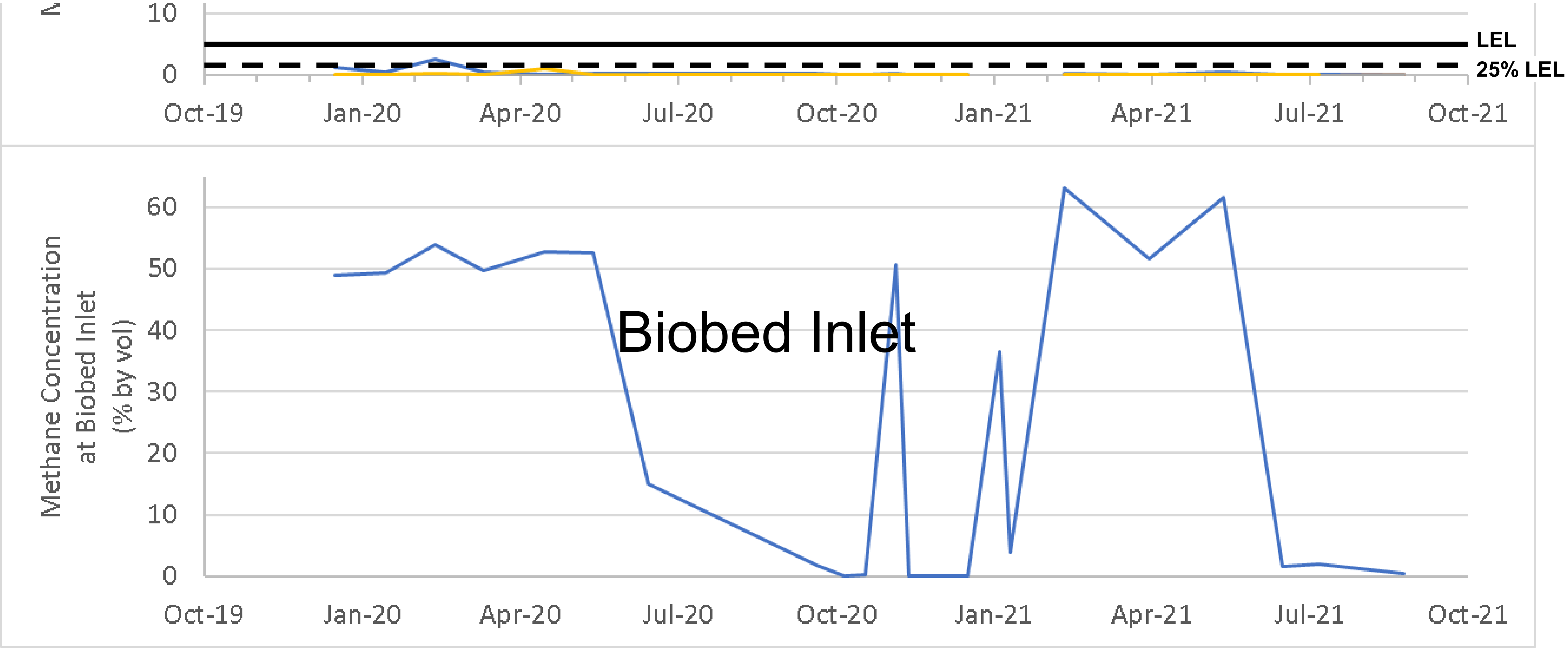
Biobed Construction

- Treatment at 1 Location



Biobed Performance

Biobed Surface



Advantages of Biofilter vs. Intermittent Flare

- Continuous Treatment
  - Reduced Fugitive Emissions
  - Better LFG Migration Control
- Operational Flexibility
  - Active/Passive LFG Collection
- Safe levels of methane at discharge
  - Less than 25% of LEL

Long-term LFG Treatment Solution

- Consistent with Diversion Strategy
- Performance Monitoring
- Scalable Design

Questions?

Special Thanks

Maryland

Howard County Department of Public Works, Bureau of Environmental Services

Washington

Jefferson County Public Works, Solid Waste

Kitsap County Public Works, Solid Waste Division

King County Natural Resources and Parks, Solid Waste Division

City of Port Angeles Public Works and Utilities

Pasco Sanitary Landfill, Inc.

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Questions

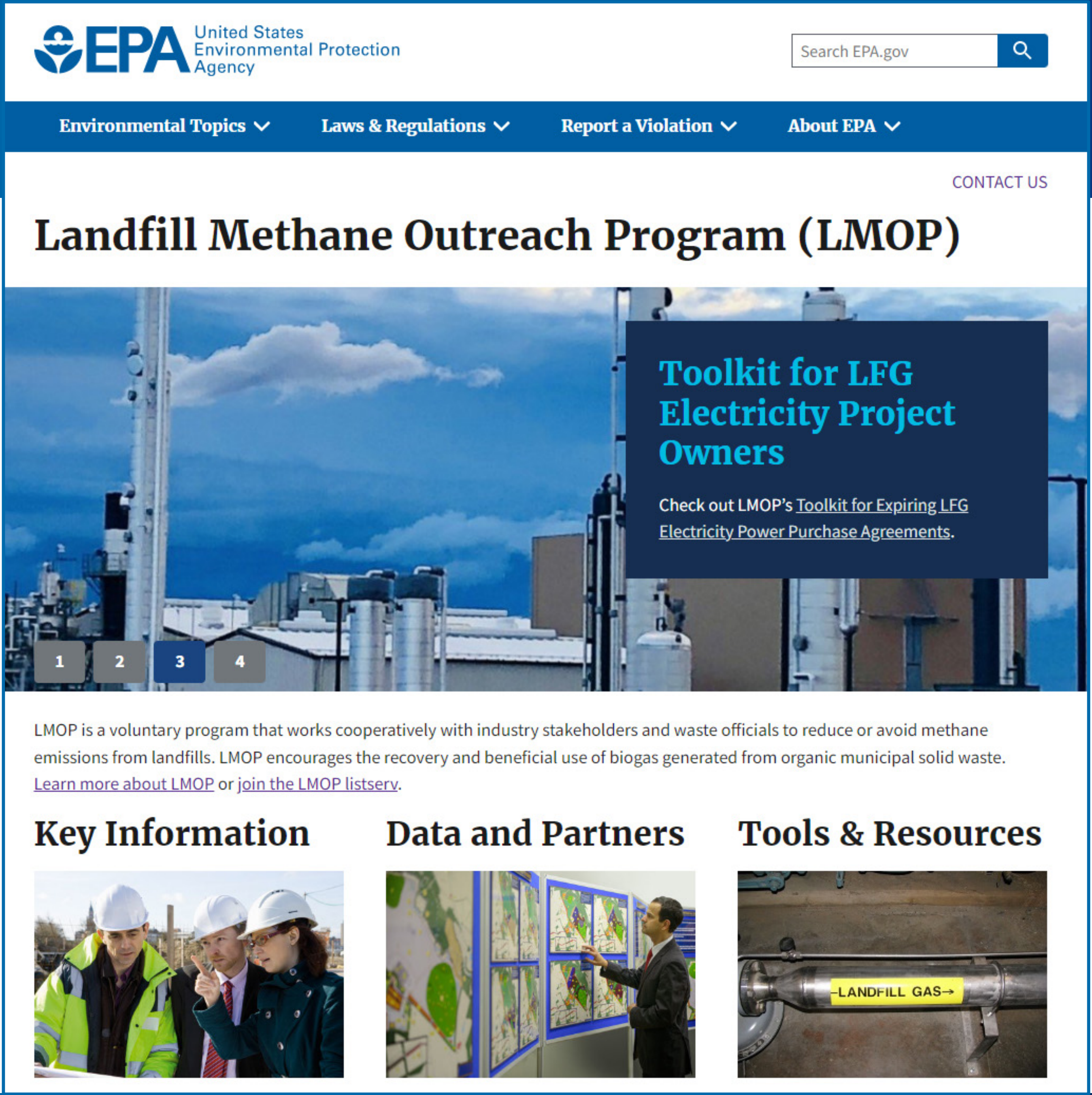
Q&A

Wrap Up

Contact Information

Wrap Up

- The slides and recording from today's webinar will be posted on the LMOP website
- To learn more about LMOP or LFG energy, visit our website at epa.gov/lmop
- Have a webinar idea? Drop us a note with your email in the Q&A box or email lmop@epa.gov



Thank You

Please reach out with any questions or comments

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epa.gov/lmop/forms/contact-us-about-landfill-methane-outreach-program