King County Department of Natural Resources and Parks

Solid Waste Division

Phase 1 – Interim Actions

CONTRACT NO. E00286E12

Cedar Hills Regional Landfill – East Perched Zone Landfill Gas Optimization Assessment Update

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King County
Department of
Natural Resources and Parks
Solid Waste Division

Waste Prevention	Resource Recovery	Waste Disposal

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EAST PERCHED ZONE LANDFILL GAS OPTIMIZATION ASSESSMENT UPDATE

Cedar Hills Regional Landfill

Prepared for: King County Solid Waste Division

Project No. 130088-820 • September 1, 2020 FINAL

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In collaboration with BHC Consultants, LLC

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1 Introduction

This Technical Memorandum (Memorandum) summarizes progress made in 2019 with landfill gas (LFG) collection optimization at a portion of the Cedar Hills Regional Landfill Facility (CHRLF; Figure 1) and provides recommendations for optimization efforts to improve LFG migration control. Also, this Memorandum summarizes findings from an extensive monitoring program conducted at and around the Passage Point facility. The focused area for the LFG optimization is near the East Perched Zone (EPZ), located east of the East Main Hill, where groundwater quality impacts were suspected to have resulted from interaction with LFG. Figure 2 shows the site layout and focused project area.

This Memorandum was prepared for King County Solid Waste Division (KCSWD) and addresses Task 820 – Optimize Existing LFG System under contract number E00286E12 for Engineering Services for Cedar Hills Regional Landfill Environmental Control System Modifications. Activities described in this Memorandum were part of Phase I of the phased approach for completing the EPZ Remedial Investigation and Feasibility Study (RI/FS) activities. The Phased Action Approach Matrix diagram presenting a summary of the phased activities, as presented to regulatory agencies on July 20, 2020, is included as Attachment 1.

Recommendations for LFG optimization efforts implemented in 2019 were provided in a previous technical memorandum (Aspect, 2019). The 2019 technical memorandum (Aspect, 2019) included Phase 1 and Phase 2 recommendations, as well as Phase 3 considerations that depend on LFG system conditions following implementation of the Phase 1 and Phase 2 recommendations.

Results from LFG monitoring indicated Phase 1 optimization was not completed during 2019, based on methane observed beyond the extent of waste. Additional changes in operations and infrastructure during Phase 2 will be necessary to complete optimization within a reasonable timeframe, as discussed later in this Memorandum.

The remaining sections of this Memorandum include a summary description of the LFG collection optimization process for the EPZ area (Section 2), a summary of Phase 1 optimization activities implemented in 2019 (Section 3), evaluation of Phase 1 LFG collection optimization through 2019 (Section 4), a summary of Phase 1 soil gas sampling near the Passage Point facility through 2019 (Section 5), and recommended next steps for LFG collection optimization, monitoring, and infrastructure modifications (Section 6).

2 Landfill Gas Optimization Description for the EPZ

LFG collection optimization is the ongoing process of adjusting valves at existing collection infrastructure to maximize collection of methane and carbon dioxide. LFG collection for the EPZ area is physically separated from the Bio Energy Washington (BEW) system at CHRLF, which is operated under a different set of LFG collection criteria. Benefits of LFG collection optimization include improving LFG migration control, protecting air quality in nearby structures, and protecting groundwater quality from landfill gas-to-groundwater transport mechanisms.

One constraint in LFG collection optimization is maintaining reliable flare operation and LFG treatment. The Migration Control Flare is used for treatment of low-quality LFG collected from the EPZ, other portions of the East Main Hill, and the Southeast Pit (SE Pit), among other older areas of the landfill. Figure 3 provides a schematic representation of the benefits and constraint of LFG collection optimization for the EPZ.

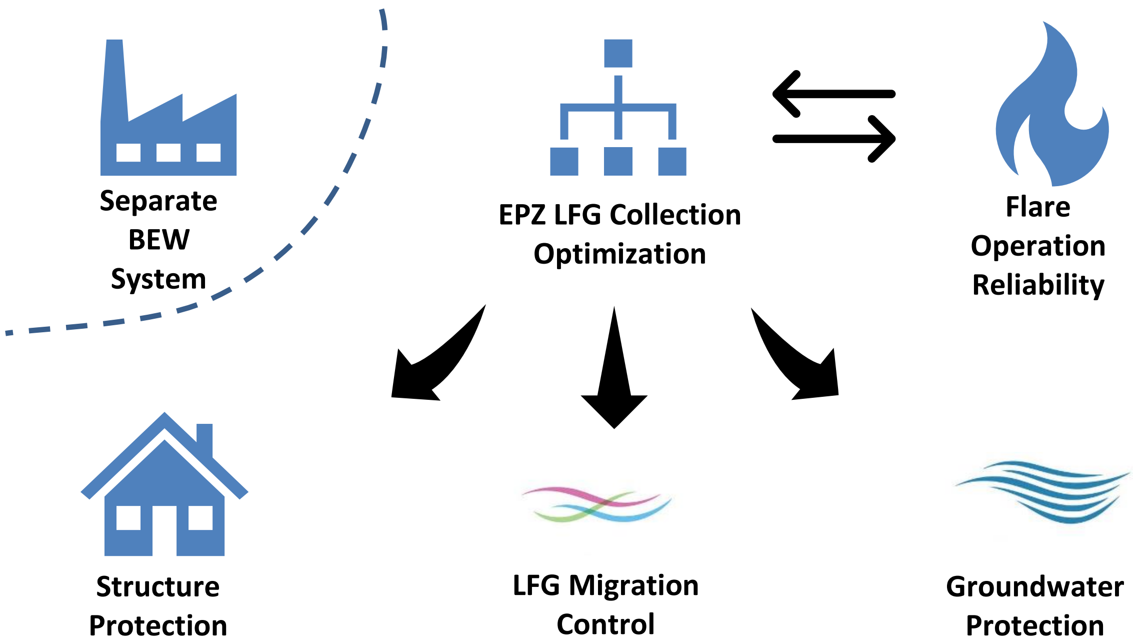

Figure 3: Schematic of LFG Collection Optimization Benefits

2.1 Objectives

Per the May 2019 technical memorandum (Aspect, 2019) and the preferred alternative in the RI/FS (Alternative 2), LFG collection optimization at the EPZ should focus on the following:

1. Changing operating conditions from relaxed/moderate to aggressive/very aggressive as defined in the Solid Waste Association of North America

(SWANA) *Landfill Gas Operation and Maintenance Manual of Practice* (herein referred to as LFG Operations and Maintenance Manual; 1997).

2. Adding selected flow-control devices on collection laterals tied in to the East and Central Header series.

The primary objective identified in the May 2019 technical memorandum (Aspect, 2019) was to reduce methane concentrations at gas probes GP-57 and GP-58 to zero percent—consistently over time—by methodically increasing LFG collection from locations within the waste extent. An additional objective was to address LFG migration at other locations and groundwater impacts in the EPZ.

A summary of the Phase 1 recommendations provided in the May 2019 technical memorandum (Aspect, 2019) is provided below.

- Precision control valves (PCVs) were installed without orifice plates at LFG collection wells in December 2018. Wells with high flow rates and low methane concentrations were identified as highest priority for receiving PCVs. Wells with higher methane concentrations were middle priority, and wells that were “shut in” or had little to no flow due to low methane concentrations were lowest priority.
- Continue monitoring twice per month to allow for steady optimization of the LFG collection system.
- Adjust flow and valve settings based on monitoring data. It was assumed that methane would decrease at GP-57 and CHSE29-series wells to less than 25 percent.

Guidelines were provided in the May 2019 technical memorandum for implementing data collection and LFG flow/valve adjustments, and were consistent with guidance for maximizing LFG migration control provided in the SWANA LFG Operations and Maintenance Manual.

2.2 Extraction Point Valve Adjustments

Valve adjustments at extraction points in the EPZ (and other areas where migration control is the priority) are different from criteria for LFG collection for the BEW facility. The SWANA LFG Operations and Maintenance Manual provides LFG criteria for various objectives, as illustrated on Figure 4 showing stacked concentrations of methane (CH_4), carbon dioxide (CO_2), oxygen (O_2), and balance gas (N_2).

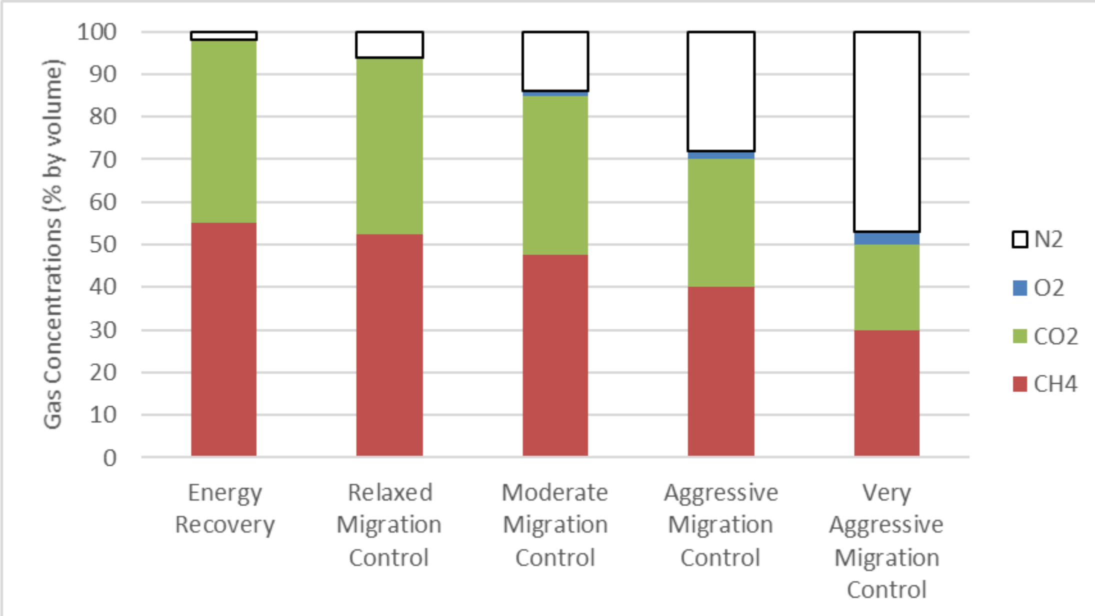

Figure 4: Target LFG Concentrations Based on SWANA Guidance

The left two columns on Figure 4 closely reflect the targets for LFG collection operations related to the BEW facility. The right column on Figure 4 reflects the target for LFG collection optimization associated with the EPZ. Specifically, valve adjustments should target a methane range between 25 and 35 percent (Aspect, 2019).

3 Optimization Activities

The Phase 1 activities implemented to support LFG collection optimization are summarized below. The full list of Phase 1 elements for completing the RIFS activities is shown on Attachment 1.

3.1 Precision Control Valve Installations

PCVs (2-inch diameter) were installed across the EPZ at the end of 2018, and were all adjusted to 15 percent open. The PCVs provide 10 full turns between completely closed and fully open. To directly read how much the valve is open, the valve stem is marked at 10 percent intervals. A one-turn adjustment changes the valve position by 10 percent and a half-turn adjustment changes the valve position by 5 percent. For better assessment of wellfield performance, the initial and final valve positions during routine monitoring and adjustments should be recorded.

The PCVs were installed without orifice plates, resulting in KCSWD continuing to rely on the existing pitot tube assemblies for flow readings during 2019. The measured flow rates are accurate to +/- 8 standard cubic feet per minute (scfm) for 2-inch-diameter monitoring assemblies. Due to the coarseness of flow measurement, valve adjustments should be based on valve position, not flow rate changes. If accurate flow rates are desired, orifice plates should be installed, per the manufacturer’s specifications.

3.2 Monitoring Data Collection

LFG collection monitoring and valve adjustments at CHRLF is performed by KCSWD staff and occurs approximately twice monthly. This operational frequency allows for steady optimization of the LFG collection system.

Data collected during each monitoring event provides the basis for determining if flow should be decreased or increased at each extraction well. Monitoring data that are collected are listed below and are referenced in the guidelines for LFG optimization monitoring (Attachment 2; Aspect, 2019).

The following parameters were recorded at gas probes and/or extraction wells and maintained in the operations database:

- LFG concentrations (initial)
- Flow (initial and adjusted)
- Pressure/vacuum (initial and adjusted)

Control valve settings (percent open, initial, and adjusted) at each extraction well were not maintained in the operations database in 2019. Moving forward, we suggest maintaining PCV settings in the database as recommended in the 2019 technical memorandum.

Operational parameters and LFG monitoring data were also recorded by KCSWD at the inlet of the Migration Control Flare throughout 2019. EPZ and Migration Control Flare monitoring data collected throughout 2019 were provided to Aspect for review. Evaluation of the 2019 LFG collection optimization monitoring data are evaluated in Section 4.

4 Evaluation of 2019 LFG Collection Optimization

2019 LFG collection optimization was evaluated based on observations at gas probes, the LFG extraction wellfield, and the Migration Control Flare. The LFG monitoring network and LFG extraction wellfield in the EPZ area are shown on Figure 5. In summary, the following observations were made based on LFG optimization data collected through 2019.

- Gas probes generally showed continued control of lateral LFG migration. Methane concentrations remained elevated at gas probe GP-57. KCSWD provided manual measurement data for 142 probes across the CHRLF, of which 42 probes are located within the EPZ at 17 locations. Records date back to 2010 at most locations.
- The LFG extraction wellfield showed consistent LFG concentrations at most locations as system pressure, which is the vacuum measured at the flare, decreased from approximately 15 inches water column to 11 inches water column during 2019. KCSWD provided manual measurement data for 107 extraction

points connected to the East Header and SE Pit Header, of which 47 extraction points are associated with the EPZ. Records date back to 2015 at most locations.

- The Migration Control Flare showed LFG concentrations consistent with previous years under declining system pressure. KCSWD provided manual measurement data for the Migration Control Flare dating back to 2015.

4.1 Gas Probe Observations

During 2019, lateral LFG migration control was provided, consistent with previous years, and methane concentrations were consistently less than 5 percent by volume at all probes in the EPZ, except three deep probes: GP-55, GP-57, and GP-59. Figure 6 shows maximum methane concentrations observed in 2019 at each probe in the EPZ, along with corresponding gas concentrations and average static pressures.[1] A maximum methane concentration of over 50 percent by volume was observed at GP-57, which was connected to the active LFG system to improve migration control. The nearest deep gas probes, GP-55 and GP-59, both had maximum methane concentrations above 20 percent.

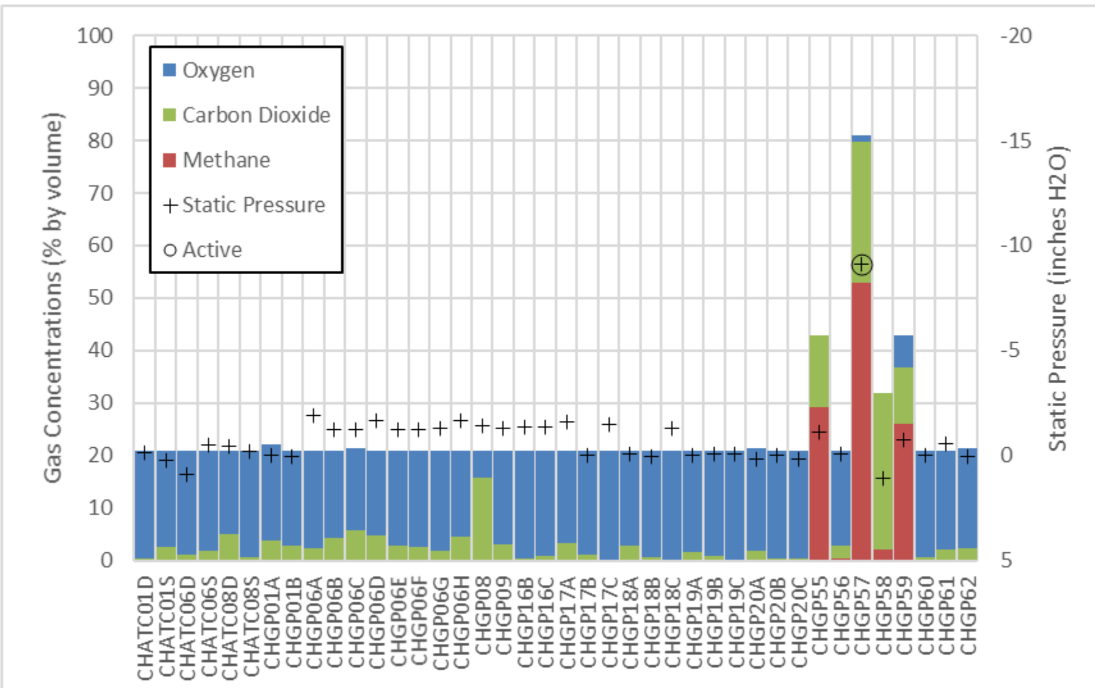

Figure 6: 2019 Maximum Methane Concentrations Observed in EPZ Gas Probes

To focus on locations where methane concentrations were observed above 5 percent, Figure 7 shows time-series gas concentrations and static pressures at deep probes GP-55, GP-57, and GP-59, and co-located shallow probes GP-56, GP-58, and GP-60, respectively. The methane concentrations at deep gas probe GP-57 were normally greater than 40 percent by volume, as in previous years. Methane exceedances at deep gas probes GP-55 and GP-59 were infrequently observed, similar to previous years. Methane was

[1] Static pressure is in units of inches water column (inches H_2O) on the right side of the chart. Negative static pressure reflects vacuum. For purposes of this analysis, the static pressure axis values are reversed to show maximum vacuum at the top of the graph.

detected at shallow gas probe GP-58 (located near GP-57) for only a few months and at concentrations of less than 5 percent. Data on Figure 7 are discussed in more detail below in the context of LFG collection at GP-57, static pressures at GP-58, and shallow versus deep LFG migration.

4.1.1 LFG Collection at GP-57

Since the end of 2011, LFG has been actively collected from gas probe GP-57. The lateral to GP-57 is connected to the end of the SE Pit Header (approximately 500 feet away). With active LFG collection, methane concentrations dropped from over 70 percent to less than 50 percent. During 2018 and 2019, less vacuum was applied at GP-57 than during previous years, and methane reached its highest concentration since LFG collection began.

4.1.2 High Static Pressure at GP-58

Static pressures at GP-58 steadily exceeded the range of expected values, which indicates the screen has been potentially blocked by water. If water is trapped inside the gas probe and the screen is saturated, gas concentrations inside the probe should be qualified as not reflecting soil gas concentrations outside the probe. We recommend monitoring water levels at GP-58 to confirm the screen is not blocked by water. To avoid influencing measurements, water levels should be measured after gas concentrations are recorded.

4.1.3 LFG Migration at Shallow vs. Deep Probes

During 2019, methane concentrations were uniformly less than 5 percent at shallow probes, including GP-56, GP-58, and GP-60. Elevated carbon dioxide at GP-58 was the only indicator of LFG migration in the shallow zone, and those measurements may be influenced by water blockage in the probe. Therefore, LFG migration was controlled in the shallow zone, except potentially at GP-58.

During 2019, methane concentrations were occasionally greater than 5 percent at deep probes GP-55 and GP-59. Elevated methane concentrations were typically observed during positive static pressures, indicating decreasing barometric pressures. Therefore, LFG migration was controlled in the deep zone, except during dropping barometric pressures, and except at GP-57.

We understand KCSWD’s gas probe monitoring procedures include purging gas probes for 60 seconds. However, this limited purge time may not be sufficient to collect a representative sample from the screened portion of the probe. To ensure reliable data is collected, we recommend purging gas probes to evacuate two casing volumes, consistent with industry standard guidelines provided in SWANA’s LFG Operations and Maintenance Manual.

4.2 LFG Extraction Wellfield

During 2019, a wide range of gas concentrations were observed at extraction wells connected to the East Header and SE Pit Header. Figure 8 shows average gas concentrations, with each column representing an individual well. Figure 8 also shows static pressures and whether the well was active (i.e., had flow). The right axis is scaled to reflect historically observed static pressures. The gray symbols indicate those wells outside the EPZ. Refer to Table 1 for locations that exhibited high vacuum with no methane, resulting in reduced system pressure and limiting effectiveness of optimization for the EPZ collection network.

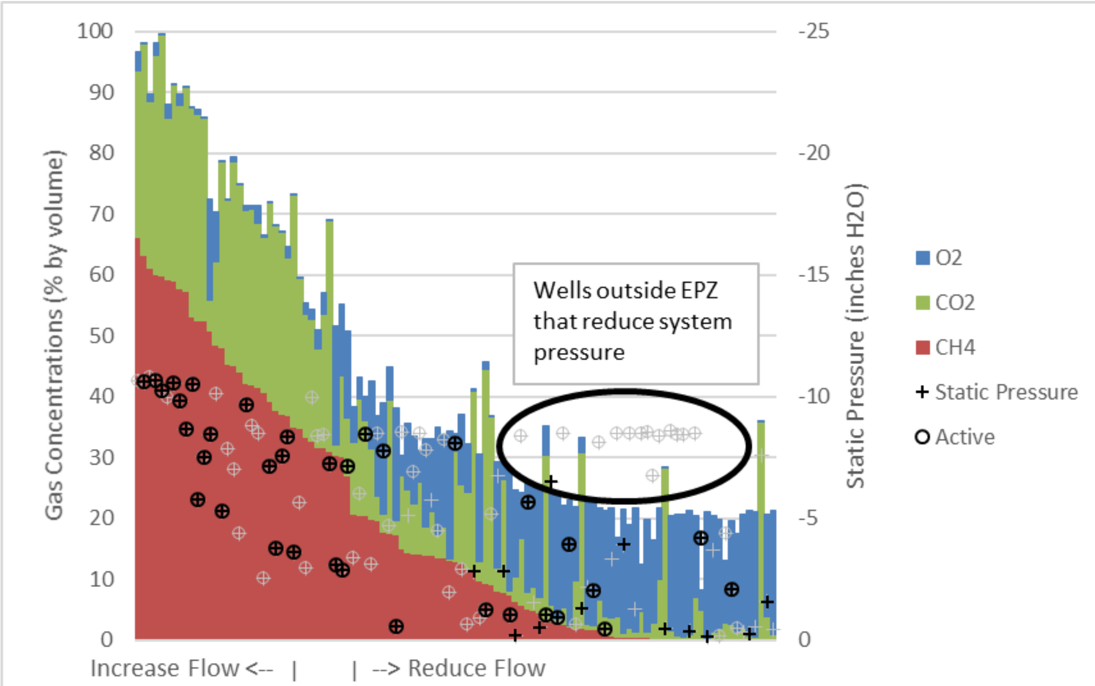

Figure 8: 2019 Average LFG Concentration and Static Pressure – All Wells Connected to East and SE Pit Headers

Based on high static pressure at wells with no methane, it appears many wells outside the EPZ were operated with valves wide open. Conversely, based on relatively low static pressure at wells with high methane concentrations, it appears many wells inside the EPZ were operated with valves partly closed. As LFG collection optimization proceeds, flows from wells with less than 25 percent methane should be reduced by incrementally closing the valve. This will result in greater system vacuum, and greater flow at wells with more than 35 percent methane.

The annual average landfill gas conditions observed at each extraction well in 2015 through 2019 are provided in Table 1. Well IDs that are bold in Table 1 indicate extraction wells located in the EPZ. Attachment 2 shows time-series graphs of monthly gas concentrations, static pressures, and active status for LFG extraction wells associated with the EPZ.

In 2019, LFG collection from the EPZ accounted for 71 percent of the methane collected from the East Main Hill and the SE Pit Area. During 2019, flows from low-methane wells increased compared to 2018.

LFG collection optimization is limited by the available flow and vacuum of the existing Migration Control Flare. While total flows measured at the flare have not varied significantly, the system pressure has decreased over the last few years. Recommendations for LFG collection optimization in the EPZ should be applied to other areas connected to the Migration Control Flare to redirect available flow from low-methane wells to high-methane wells.

4.3 Migration Control Flare

Average annual LFG concentrations observed at the Migration Control Flare from 2015 through 2019 represent very aggressive migration control, per SWANA guidance. The stacked representation of LFG concentrations on Figure 9 were compared to the target LFG concentrations on Figure 4 to evaluate operations based on gas concentrations.

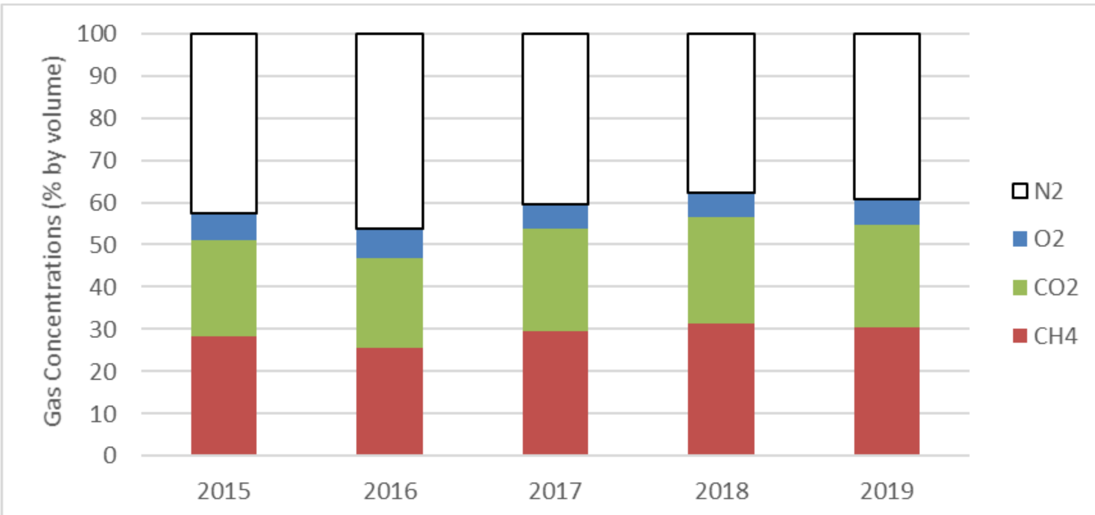

Figure 9: Average Annual LFG Concentrations at Migration Control Flare

During 2019, methane concentrations at the Migration Control Flare remained relatively stable, indicating that LFG collection optimization in the EPZ did not negatively affect flare performance. Figure 10 shows a time-series plot of daily LFG concentrations at the Migration Control Flare. The flare has a target inlet methane concentration of 30 percent by volume, which provides lower risk of flare shutdown than operating close to 25 percent (prior to 2017). The increase in methane concentrations during 2015 was reportedly a result of wellfield adjustments to reduce flare shutdown frequency.

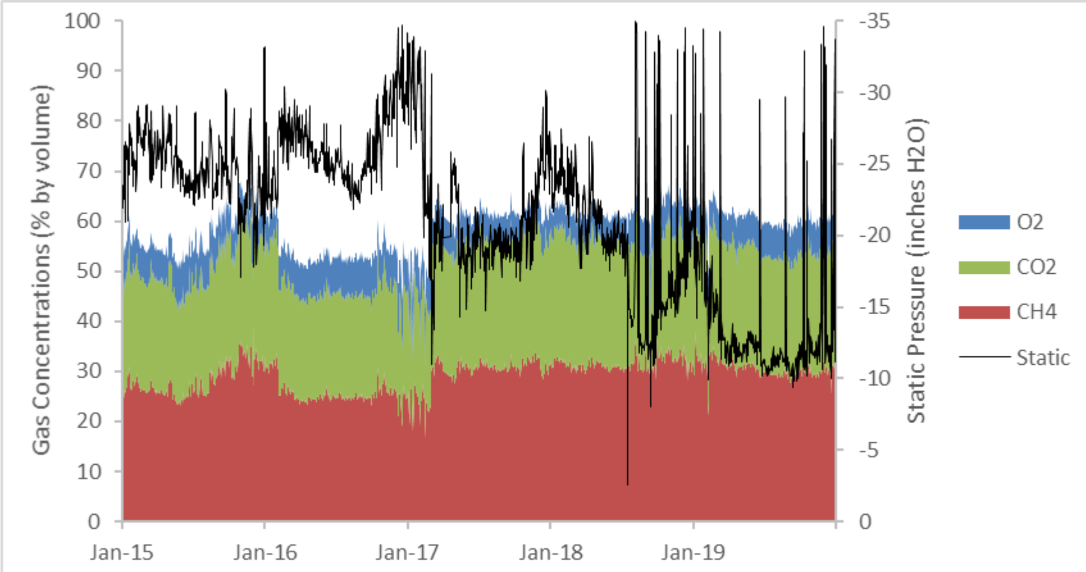

Figure 10: Time-Series (Daily) LFG Concentrations at Migration Control Flare

5 Soil Gas Sampling

In conjunction with LFG collection optimization for the EPZ, soil gas was sampled quarterly at monitoring probes and wells in the EPZ and the east-adjoining Passage Point facility. The soil gas sampling was performed as prescribed in the "East Perched Zones Remedial Investigation and Feasibility Study" (RI/FS Report; Aspect, 2016 DRAFT) to assess the potential for LFG migration from the EPZ. The quarterly sampling events occurred in December 2018, February 2019, May 2019, and August 2019. The graphs below show the average LFG concentrations observed, grouped by shallow gas probes and deep gas probes.

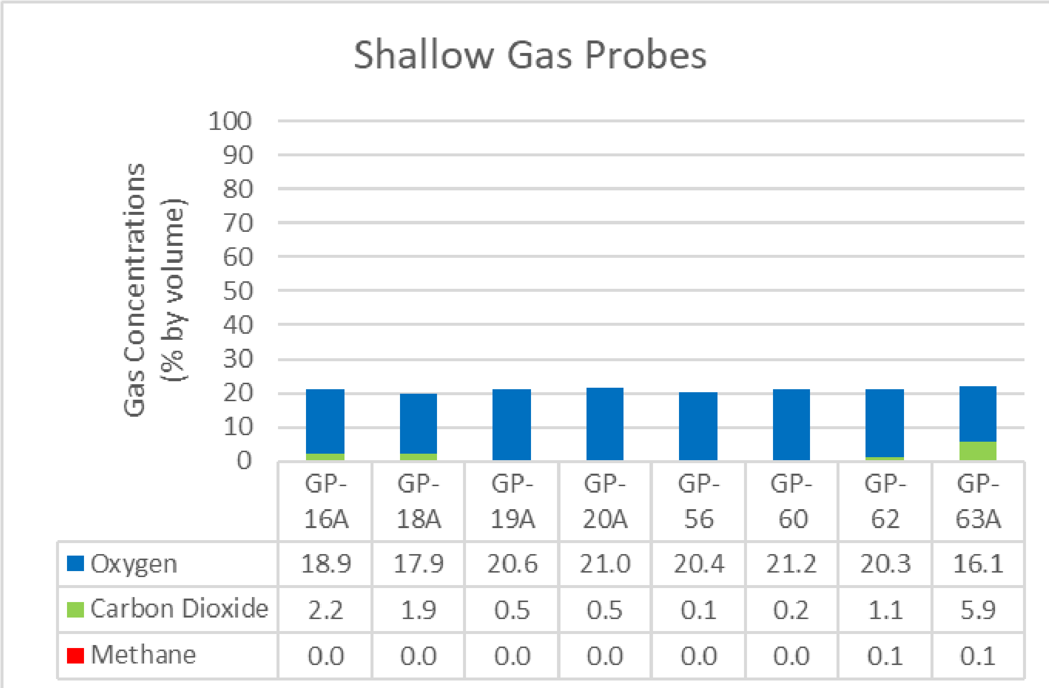

Figure 11: Average LFG Concentrations at Shallow Gas Probes in the EPZ and near Passage Point

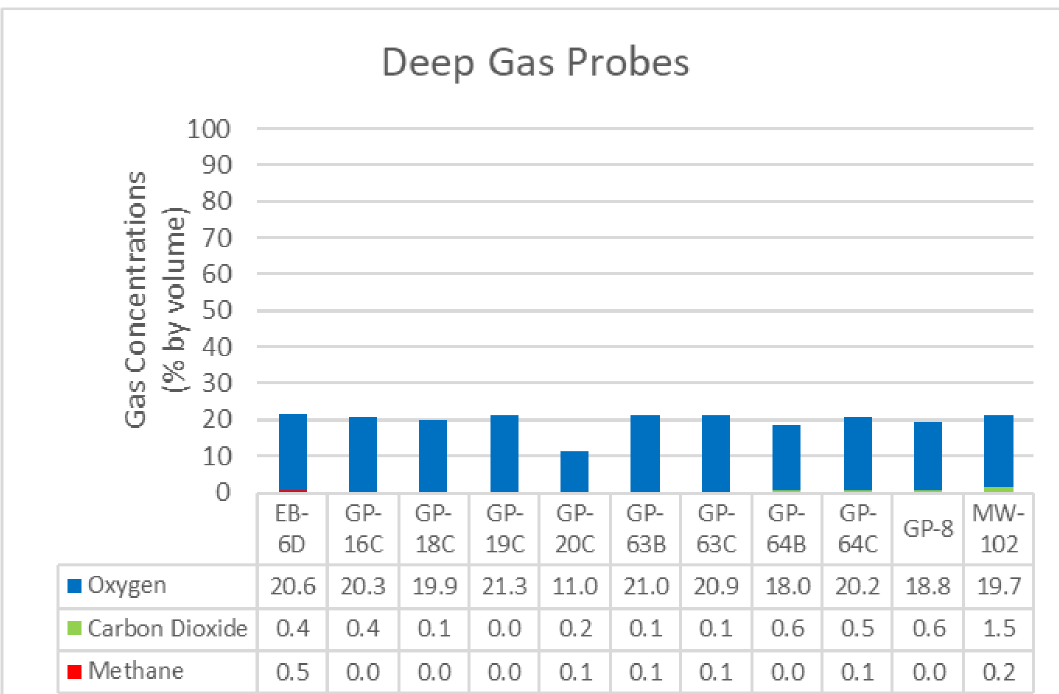

Figure 12: Average LFG Concentrations at Deep Gas Probes in the EPZ and near Passage Point

The technical memorandum documenting the August 2019 sampling event (Aspect, 2020) and subsequent soil gas sampling events associated with the RI/FS concluded that soil gas sampling results indicate that initiating optimization of the LFG collection system in the EPZ has reduced LFG in soil gas.

6 Recommendations

This section summarizes recommendations for LFG collection optimization next steps for the EPZ. Overall, recommendations in the May 2019 technical memorandum (Aspect, 2019) remain valid, with updates and additions described below. The Phase 2 and 3 recommendations presented below are also summarized in Attachment 1.

6.1 Phase 2 Recommendations

Recommendations during Phase 2 include refining LFG collection optimization and ensuring sufficient LFG collection infrastructure is available to reduce LFG migration beyond the extent of waste. Phase 2 is expected to take 2 to 5 years, although operational changes may be appropriate for future operation beyond Phase 2.

Operational recommendations focus on providing effective LFG migration control from wells within the waste mass, in general. Updated guidelines for implementing data collection and LFG migration control adjustments are listed below and summarized in Attachment 3.

- We recommend remaining on the current monitoring and valve adjustment schedule (biweekly) for LFG collection optimization.
- With the current PCV setup at wellheads, we recommend the following criteria for LFG optimization valve adjustments in the EPZ Area.
    - If the methane concentration is greater than 35 percent by volume, then the valve should be adjusted open by one turn or less. Making small valve adjustments should help avoid major changes in gas concentrations between monitoring events.
    - If the methane concentration is less than 25 percent by volume, then the valve should be adjusted closed by one turn or less.
    - If the methane concentration is between 25 and 35 percent by volume, then the valve is not adjusted.
- We recommend recording the valve position at each well as prescribed in the 2019 technical memorandum—it is important for understanding the potential for improving LFG collection efficiency and can support assessment of LFG collection infrastructure.
- Considering the interdependence of LFG collection within and outside the EPZ, we recommend applying the valve adjustment criteria for all locations connected to the Migration Control Flare.

- We recommend the County add GP-63A/B/C and GP-64A/B/C to the monthly compliance LFG monitoring program to monitor the presence of methane, as these are the closest probes to Passage Point. If probes at GP-63A/B/C or GP-64A/B/C have detections of methane in the future during three consecutive months, then this may trigger additional LFG control measures.
- To ensure reliable compliance data is collected, we recommend the following:
  - Purging gas probes to evacuate two casing volumes, consistent with industry standard guidelines provided in SWANA's LFG Operations and Maintenance Manual.
  - Measuring and recording the water level at each gas probe and disqualifying gas probe monitoring data if the water level is above the top of the screened interval.
  - Using consistent gas probe monitoring procedures across the entire CHRLF.

Infrastructure recommendations focus on assessing, rehabilitating, and expanding the LFG collection infrastructure to prevent LFG migration. These recommendations are summarized below, and additional details are provided in the 2019 technical memorandum for "intermediate-term" recommendations.

- Aspect recommends inspecting the integrity of the existing LFG collection and monitoring infrastructure to aid in LFG optimization efforts and prioritize rehabilitation efforts, if warranted. Wells and laterals that exhibit clogging, saturated screens potentially due to clogging, and/or silt build-up should be cleaned out. All potential LFG collection locations should be inspected and rehabilitated or replaced, including those locations not currently part of the extraction network (E-16, E-20 and E-25, for example).
- Following inspection and rehabilitation, we recommend installing four new shallow LFG collection wells inside the extent of waste and near the perimeter road, and connecting them to the extraction system. These new wells should be located to support existing infrastructure where LFG collection appears maximized, such as E-27, E-34, and E-36 for example.
- We recommend installing four new deep LFG collection wells inside the extent of waste near the perimeter road, and connecting them to the extraction system. These new wells should penetrate through a shallow, relatively thin layer of waste and be completed in the same unit as deep gas probes GP-55, GP-57, and GP-59 and deep extraction wells SE-29A, SE-29B, SE-29C, and SE-29D. Accordingly, LFG collection from the new wells should prevent LFG migration in the deep unit from reaching the existing deep gas probes or collection wells.

6.2 Phase 3 Considerations

Phase 3 considerations include alternative infrastructure changes. The purpose of providing these long-term considerations is to inform KCSWD of potential system improvements to complete optimization in a timely manner and expand optimization efforts if needed in the future. These are presented as considerations, and not recommendations, to allow for success of Phase 2 recommendations at addressing the overall LFG objectives as part of the RI/FS process. Phase 3 considerations lag Phase 2 implementation, and the timeframe is approximately 3 to 7 years, pending progress of Phase 2.

- When leachate and condensate accumulate in LFG wells, especially over the long-term, screen openings can become blocked or clogged, thereby reducing gas flow from the well and influencing a smaller area. To reduce liquid accumulation in wells and promote effective gas collection, adjustments to flow and vacuum can be made or in-well pumps can be installed to manage the liquids. Treatment requirements should be considered when evaluating alternatives for liquid management.
- LFG extraction wells operated with little to no methane may be connected to a separate blower and treatment system. This would increase operational reliability of the Migration Control Flare by preventing dilution of the gas stream. It would also increase system vacuum available to LFG extraction wells with greater than 35 percent methane, where additional flow is desirable.

7 References

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Aspect Consulting, LLC (Aspect), 2020, Cedar Hills Regional Landfill – EPZ Phase I Interim Actions – Fourth Round, August 2019 Soil Gas Sampling Technical Memorandum, DRAFT, Prepared for King County Department of Natural Resources and Parks, Solid Waste Division, May 2020.

King County Solid Waste Division (KCSWD), 2015, Page 2 from Cedar Hills Regional Landfill Migration Flare Commissioning Document, version 2.0, August 2015.

Solid Waste Association of North America (SWANA), 1997, Landfill Gas Operation and Maintenance Manual of Practice, March 1997.

TABLE

Table 1. 2015 - 2019 Observed Conditions by Location

Project No. 130088, Cedar Hills Regional Landfill
King County, Washington

Well ID	Average Flow (SCFM)					Average Methane (% by vol)					Average Oxygen (% by vol)					Average Carbon Dioxide (% by vol)					Average Static Pressure (inches H2O)					Average Diff. Pressure (inches H2O)					Max. Temperature (F)				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
CHE00004	42	77	23	33	24	46	42	45	51	42	1	1	2	3	6	29	28	27	27	23	-22	-23	-19	-16	-9	0.08	0.13	0.03	0.03	0.03	91	87	96	95	97
CHE00006	0	0	0	0	0	10	11	10	13	14	15	16	16	16	14	4	4	3	4	5	-15	-17	-15	-12	-8	0.03	0.03	0.05	0.02	0.03	99	96	102	102	98
CHE00008	5	6	2	2	2	35	30	25	29	17	5	8	11	9	12	22	18	15	16	11	-9	-8	-7	-9	-5	0.02	0.01	0.00	0.01	0.01	94	113	103	111	114
CHE00009	35	31	16	29	22	20	23	19	31	33	2	1	2	1	1	20	22	20	22	23	-6	-3	-6	-4	-3	0.07	0.04	0.02	0.08	0.03	95	97	102	102	96
CHE00010	19	31	14	27	31	21	20	25	27	33	2	1	1	2	1	20	21	21	20	21	-21	-22	-19	-16	-10	0.02	0.04	0.01	0.02	0.04	95	99	93	97	90
CHE00013	21	26	18	24	23	20	14	26	31	21	4	9	2	2	9	19	13	23	21	13	-18	-14	-18	-16	-6	0.04	0.03	0.02	0.02	0.02	101	108	105	112	104
CHE00014	0	0	0	0	0	0	2	3	11	2	20	18	18	13	20	1	3	3	9	2	-2	-4	-6	-9	-2	0.00	0.00	0.00	0.00	0.00	104	98	103	114	124
CHE00016	13	19	16	25	37	2	6	6	12	10	18	16	17	14	16	3	6	5	8	7	-1	-1	-1	-1	-1	0.05	0.08	0.09	0.12	0.30	93	81	89	97	83
CHE00017	7	6	0	0	6	39	33	12	3	45	0	5	17	19	6	27	21	6	1	22	-22	-15	-4	0	-8	0.04	0.02	0.02	0.00	0.03	92	88	102	98	110
CHE00018	8	10	6	8	10	39	39	41	40	42	1	1	1	1	1	29	28	28	27	29	-16	-19	-16	-14	-10	0.03	0.03	0.02	0.02	0.03	98	103	108	97	104
CHE00019	18	12	34	28	11	65	63	63	58	53	0	0	1	2	3	34	35	34	31	29	-23	-24	-21	-17	-11	0.21	0.05	0.57	0.26	0.05	96	108	111	105	100
CHE0001B	0	0	0	0	0	5	4	0	5	6	14	16	21	11	11	4	3	0	5	4	-2	0	0	0	0	0.00	0.00	0.00	0.00	0.00	100	104	118	117	111
CHE0001C	0	0	0	3	2	0	0	0	0	0	18	19	21	20	21	2	2	1	0	0	-1	0	0	0	0	0.00	0.00	0.00	0.00	0.01	113	105	118	115	104
CHE0001D	0	0	1	0	4	9	6	11	16	21	6	9	10	8	4	12	10	9	12	16	-5	-5	-4	-2	-3	0.02	0.02	0.01	0.01	0.02	98	100	113	117	121
CHE00021	10	14	4	8	11	58	61	60	62	66	3	2	2	2	0	27	29	28	28	31	-23	-24	-20	-17	-11	0.05	0.07	0.01	0.02	0.04	95	100	114	110	106
CHE00022	8	14	10	12	12	40	37	42	38	37	0	0	0	0	0	30	29	29	28	27	-9	-11	-8	-16	-8	0.03	0.05	0.05	0.04	0.04	90	88	114	97	93
CHE00023	12	14	2	0	0	36	35	17	0	0	0	0	12	20	21	28	28	12	0	0	-8	-8	-4	-1	0	0.04	0.05	0.01	0.00	0.00	100	94	116	113	101
CHE00024	14	16	15	15	17	41	42	40	47	39	0	0	2	0	1	33	34	30	33	29	-8	-8	-8	-10	-7	0.04	0.08	0.07	0.05	0.10	94	91	99	99	97
CHE00026	6	9	9	6	7	52	53	56	57	63	0	0	0	1	0	35	34	34	33	34	-22	-24	-20	-16	-11	0.02	0.03	0.04	0.01	0.01	97	97	80	77	69
CHE00027	9	12	9	11	12	49	45	51	57	59	0	0	0	0	0	32	31	32	32	32	-15	-21	-14	-15	-11	0.03	0.04	0.03	0.02	0.03	100	94	78	77	67
CHE00028	0	0	0	0	0	1	3	4	4	1	18	18	18	17	20	3	3	3	4	1	-1	-1	0	0	0	0.00	0.00	0.00	0.02	0.01	92	91	69	83	71
CHE00030	15	15	15	11	2	55	56	59	55	35	0	1	0	1	7	38	38	39	37	23	-21	-24	-20	-16	-4	0.04	0.05	0.05	0.02	0.02	96	92	79	77	72
CHE00031	5	13	7	0	0	46	49	30	14	3	5	2	11	16	20	27	30	18	8	2	-8	-9	-4	-2	-1	0.02	0.05	0.07	0.02	0.01	100	102	86	77	68
CHE00032	7	24	24	54	20	54	57	55	60	60	2	1	2	0	0	36	38	37	38	39	-22	-25	-19	-14	-11	0.02	0.44	0.37	0.96	0.37	105	105	89	76	70
CHE00032A	0	0	0	0	1	12	14	11	8	27	14	15	16	15	11	9	10	9	6	19	-20	-22	-13	-8	-7	0.01	0.01	0.03	0.00	0.00	96	99	78	78	70
CHE00033	10	14	9	10	9	59	59	59	60	60	0	0	0	0	0	40	40	40	40	40	-23	-25	-20	-16	-10	0.03	0.05	0.03	0.02	0.06	93	93	85	71	68
CHE00034	36	38	42	45	47	45	47	51	53	53	0	0	0	0	0	33	34	35	36	36	-6	-7	-6	-7	-8	0.20	0.23	0.34	0.31	0.40	86	78	69	69	66
CHE00035	16	19	18	15	18	44	46	48	49	57	0	0	0	3	0	33	34	35	33	38	-9	-9	-8	-7	-9	0.05	0.07	0.09	0.05	0.06	93	88	80	69	67
CHE00035A	0	0	0	0	0	0	0	0	0	0	17	18	18	15	19	4	3	2	3	2	-9	-15	-12	-5	-2	0.00	0.00	0.00	0.00	0.00	99	105	84	81	68
CHE00036	8	13	11	12	13	48	49	46	49	38	0	0	1	0	2	30	31	30	32	28	-3	-3	-3	-3	-4	0.03	0.04	0.05	0.04	0.11	98	102	82	68	67
CHE00036A	9	12	16	0	0	0	0	0	0	0	20	20	21	21	21	1	1	1	1	0	-1	-1	-1	-1	0	0.04	0.06	0.19	0.00	0.00	103	91	94	67	67
CHE00037	6	0	0	0	0	18	1	2	5	8	3	20	20	20	18	18	1	1	2	5	-11	-3	-2	-1	-3	0.02	0.00	0.00	0.00	0.00	103	101	85	74	67
CHE00038	3	0	0	5	5	1	1	2	17	17	19	16	19	13	9	2	5	2	12	17	-1	-1	0	-1	-1	0.17	0.00	0.00	0.29	0.19	99	98	95	72	66
CHE00038A	0	0	0	0	0	0	0	1	1	0	21	20	19	20	21	0	1	2	2	1	-1	-1	-1	0	0	0.00	0.00	0.00	0.00	0.00	95	96	94	72	66
CHE00039	0	0	0	0	0	0	0	2	5	7	20	20	17	17	17	1	1	3	5	6	-2	-1	-1	-1	-1	0.00	0.00	0.01	0.00	0.08	98	98	91	72	67
CHE00040	27	21	8	0	0	40	43	23	5	2	2	3	12	19	20	29	29	16	4	2	-4	-3	-3	-2	-1	0.25	0.11	0.09	0.01	0.00	87	91	84	69	66
CHE00040A	10	15	11	0	0	59	56	57	22	31	0	0	1	13	10	38	37	37	13	18	-21	-23	-19	-10	-7	0.04	0.06	0.04	0.00	0.01	94	91	81	77	66
CHE00042	0	4	2	4	3	10	7	12	29	30	12	11	11	8	6	13	13	15	23	26	-5	-4	-3	-2	-3	0.04	0.06	0.05	0.03	0.08	96	99	86	68	66
CHE00042A	0	0	1	0	0	1	0	1	1	1	20	20	21	21	21	1	0	1	1	1	-6	-7	-5	-4	-4	0.00	0.00	0.00	0.00	0.00	103	96	89	71	66
CHE00043	20	26	26	40	46	38	46	47	54	48	0	0	0	0	1	30	33	34	37	35	-3	-2	-3	-4	-5	0.08	0.11	0.14	0.26	0.46	85	82	95	71	72
CHE00043A	1	7	6	19	23	3	21	35	51	51	17	7	3	0	0	5	19	28	37	38	-1	-1	-1	-3	-8	0.00	0.04	0.07	0.17	0.10	98	101	93	68	66
CHE00044	0	0	0	0	1	1	4	3	3	3	21	18	20	20	21	1	3	2	2	2	-1	-1	-1	-1	-1	0.00	0.00	0.00	0.00	0.01	98	99	84	70	66
CHE00046A	0	0	1	0	0	0	0	0	0	0	21	20	21	21	22	1	0	0	1	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	97	98	90	69	67
CHE00047	0	0	0	0	0	4	4	3	7	3	19	18	19	17	19	3	3	3	6	2	-17	-19	-16	-12	-6	0.00	0.00	0.00	0.07	0.00	96	97	81	69	67

Bold: EPZ

Native Soil
Near Edge
Bottom Tier
Middle Tier
Top Tier

Methane

- >50%
- >45% and <50%
- >35% and <45%
- >25% and <35%
- <25%

Oxygen

- <0.1%
- >0.1% and <0.5%
- >0.5% and <1%
- >1% and <3%
- >3%

Table 1. 2015 - 2019 Observed Conditions by Location

Project No. 130088, Cedar Hills Regional Landfill
King County, Washington

Well ID	Average Flow (SCFM)					Average Methane (% by vol)					Average Oxygen (% by vol)					Average Carbon Dioxide (% by vol)					Average Static Pressure (inches H2O)					Average Diff. Pressure (inches H2O)					Max. Temperature (F)				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
CHE0047A	8	12	10	10	0	60	61	62	36	0	0	0	0	9	22	36	36	36	21	0	-23	-25	-20	-15	-8	0.04	0.04	0.03	0.07	0.00	96	97	86	69	67
CHE00048	9	14	4	14	11	30	37	38	48	41	0	1	1	1	0	26	28	27	30	30	-3	-2	-2	-3	-3	0.03	0.05	0.10	0.24	0.17	94	86	87	65	64
CHE0048A	0	0	0	0	0	2	14	18	16	5	17	14	13	12	16	4	9	11	10	5	-2	-6	-3	-2	-2	0.00	0.00	0.00	0.00	0.00	98	105	87	71	67
CHE00049	9	13	9	5	8	40	40	44	50	44	0	0	0	0	0	31	31	32	33	32	-7	-6	-4	-4	-4	0.02	0.04	0.03	0.01	0.05	94	90	84	62	64
CHE0049A	1	0	0	0	0	0	0	0	0	0	20	20	21	21	21	1	1	1	1	1	-1	0	0	0	0	0.01	0.00	0.00	0.00	0.00	98	97	69	67	67
CHE00050	13	15	11	9	8	45	46	52	58	61	1	1	0	0	0	27	27	29	30	31	-19	-17	-13	-12	-11	0.04	0.08	0.03	0.02	0.02	97	97	88	65	65
CHE00052	0	0	0	0	2	0	0	1	15	13	21	21	21	15	14	0	0	1	8	10	-2	-2	-2	-2	-2	0.00	0.00	0.00	0.00	0.05	95	90	88	65	66
CHE00053	0	0	0	0	0	1	1	2	5	0	20	20	21	20	21	1	1	1	3	1	-2	-2	-1	-1	-1	0.00	0.00	0.00	0.00	0.00	96	96	87	66	67
CHE00054	0	1	1	0	0	19	17	14	17	20	11	12	13	12	12	12	10	10	10	10	-7	-8	-6	-5	-3	0.01	0.02	0.01	0.02	0.00	98	101	88	67	67
CHE00055	3	4	2	0	2	9	15	16	26	12	8	9	8	6	10	13	14	16	20	14	-1	0	0	0	-1	0.26	0.09	0.06	0.07	0.19	98	95	88	67	67
CHE00056	0	0	0	0	0	0	0	0	0	0	19	19	18	18	19	2	2	3	3	2	-1	-1	0	0	0	0.00	0.00	0.00	0.00	0.00	99	97	75	67	68
CHE0056A	7	13	13	16	1	71	71	72	64	9	0	0	0	3	15	28	28	27	23	5	-23	-25	-20	-17	-5	0.02	0.04	0.10	0.59	0.02	99	94	90	66	67
CHE0056B	0	0	0	0	0	0	0	0	0	0	21	21	21	21	21	0	1	1	1	1	0	0	-1	-1	-1	0.00	0.00	0.00	0.00	0.00	97	92	87	66	67
CHE00057	0	0	0	0	0	0	0	0	0	0	19	18	16	18	20	1	2	3	3	2	-13	-10	-5	-5	-4	0.00	0.00	0.00	0.00	0.00	99	97	88	66	67
CHE00066	0	0	0	0	0	21	14	12	20	14	11	12	15	11	14	10	9	5	7	5	-9	-8	-6	-8	-5	0.00	0.00	0.00	0.00	0.00	98	93	104	100	94
CHE00067	0	0	0	0	0	3	13	13	17	14	18	13	13	11	15	4	11	10	13	10	-14	-12	-9	-9	-4	0.04	0.01	0.00	0.00	0.01	102	96	103	104	103
CHE00068	13	9	8	9	16	33	32	29	38	35	0	0	0	0	1	24	24	24	25	24	-5	-5	-7	-7	-6	0.07	0.04	0.07	0.03	0.08	108	111	110	114	107
CHE00069	0	0	28	41	38	1	0	17	29	30	20	21	9	1	2	2	0	15	25	23	-2	-1	-4	-5	-3	0.00	0.00	0.24	0.37	0.51	91	103	85	97	82
CHE00070	9	7	12	7	8	36	31	50	51	58	2	9	1	1	0	30	23	37	38	41	-3	-2	-7	-5	-10	0.03	0.02	0.09	0.02	0.02	98	97	81	77	70
CHE00071	35	25	13	12	20	40	45	49	53	53	1	2	3	1	2	34	35	36	38	38	-7	-4	-2	-2	-6	0.22	0.14	0.09	0.08	0.11	98	88	84	77	73
CHE00E1A	2	3	1	4	3	16	18	15	22	20	4	4	6	5	5	16	15	14	16	16	-12	-11	-9	-9	-8	0.01	0.01	0.01	0.01	0.01	87	95	96	102	96
CHEGL059	28	31	20	20	38	40	42	48	43	45	1	1	1	3	0	33	35	37	31	35	-4	-5	-4	-3	-7	0.13	0.18	0.13	0.14	0.28	97	91	79	76	80
CHEGL060	9	9	0	0	0	42	29	5	10	11	0	6	19	17	17	30	21	3	5	5	-8	-6	-3	-3	-3	0.03	0.03	0.02	0.02	0.00	102	98	77	79	83
CHEGL061	21	19	12	5	2	48	51	29	18	9	1	2	10	14	18	35	36	21	13	7	-4	-4	-3	-2	-1	0.11	0.09	0.21	0.12	0.06	87	83	88	74	69
CHEGLSE1	0	0	0	0	0	3	9	8	5	4	18	17	18	19	20	3	4	4	2	2	-13	-7	-6	-2	-1	0.00	0.00	0.00	0.00	0.00	93	88	106	99	85
CHEGLSE2	0	0	0	0	0	7	8	10	10	8	17	18	17	17	18	4	4	4	4	3	-17	-16	-14	-12	-7	0.00	0.00	0.00	0.00	0.00	93	93	95	99	93
CHEGLSE3	0	0	1	7	4	35	36	33	45	48	8	8	8	4	5	14	15	14	17	17	-13	-15	-11	-14	-10	0.01	0.02	0.01	0.02	0.01	94	101	105	95	91
CHEGLSE4	0	0	0	0	0	19	23	24	19	14	12	12	11	14	16	7	8	8	6	5	-12	-18	-15	-13	-6	0.01	0.00	0.00	0.00	0.01	95	101	95	98	93
CHEGLSE5	0	0	0	0	0	12	14	2	10	14	15	16	20	18	17	5	5	1	3	4	-16	-21	-14	-10	-8	0.00	0.01	0.00	0.00	0.00	92	85	101	95	96
CHEGLSE6	1	0	0	0	0	25	22	19	18	14	11	11	12	14	16	8	8	6	6	4	-13	-18	-13	-13	-7	0.00	0.00	0.00	0.00	0.01	94	100	96	98	93
CHEGLSE7	1	0	1	2	0	23	25	28	36	13	12	12	12	7	17	13	14	15	19	7	-16	-18	-15	-12	-3	0.00	0.00	0.00	0.01	0.00	97	90	96	98	94
CHEGLSE8	7	0	0	3	10	51	35	43	45	59	2	9	7	7	3	26	18	21	20	25	-21	-15	-15	-14	-10	0.04	0.02	0.02	0.02	0.04	97	92	103	105	97
CHEMHFC1	0	0	0	0	0	2	1	2	2	1	18	17	18	18	20	3	4	3	4	2	-2	-2	-2	-4	-3	0.00	0.01	0.02	0.00	0.00	96	100	82	76	70
CHSE29AD	4	8	4	5	5	4	3	1	1	2	15	16	19	17	17	5	4	2	3	4	-14	-13	-12	-10	-8	0.01	0.02	0.01	0.01	0.02	88	85	82	97	87
CHSE29AS	9	10	6	9	6	0	0	1	2	2	20	20	19	17	17	0	0	1	2	3	-7	-7	-7	-5	-4	0.05	0.03	0.03	0.05	0.02	67	64	66	85	67
CHSE29BD	7	7	4	5	5	14	14	10	13	13	3	4	5	2	4	18	17	15	20	17	-16	-16	-12	-13	-8	0.04	0.02	0.01	0.02	0.02	78	87	70	92	85
CHSE29BS	16	20	8	6	8	0	0	0	1	2	20	20	20	19	19	1	1	1	1	2	-6	-6	-6	-4	-2	0.06	0.07	0.04	0.01	0.02	67	61	66	70	65
CHSE29CD	0	0	1	5	5	3	2	3	16	18	18	19	18	7	7	3	2	3	18	18	-3	-2	-3	-9	-8	0.00	0.00	0.00	0.02	0.02	93	98	85	82	79
CHSE29CS	6	12	6	4	6	2	6	5	5	5	18	17	17	17	18	3	5	4	4	4	-10	-8	-7	-5	-6	0.02	0.03	0.02	0.01	0.02	71	65	70	86	74
CHSE29DD	6	9	5	4	5	26	30	28	35	37	2	2	0	0	1	26	27	28	29	29	-11	-15	-13	-13	-8	0.02	0.02	0.02	0.01	0.02	74	72	75	81	78
CHSE29DS	0	0	0	0	4	0	0	0	0	0	17	16	17	16	20	2	3	2	3	1	-2	-1	-1	-2	-2	0.00	0.00	0.00	0.00	0.02	91	97	83	88	81
CHSEP065	3	10	4	7	7	0	0	0	0	0	3	3	4	4	5	5	5	5	5	4	-5	-4	-4	-7	-4	0.01	0.02	0.01	0.02	0.02	94	80	87	88	79
CHSEP0B4	12	30	19	15	26	0	0	0	0	0	14	13	14	15	15	7	7	7	6	6	-16	-16	-14	-14	-8	0.01	0.02	0.02	0.01	0.02	116	103	102	103	93
CHSEP0E8	14	27	27	11	21	39	36	42	43	42	3	6	4	3	4	27	22	26	25	24	-16	-16	-14	-14	-9	0.01	0.02	0.04	0.01	0.02	108	117	107	110	93

Bold: EPZ

- Native Soil
- Near Edge
- Bottom Tier
- Middle Tier
- Top Tier

Methane

- >50%
- >45% and <50%
- >35% and <45%
- >25% and <35%
- <25%

Oxygen

- <0.1%
- >0.1% and <0.5%
- >0.5% and <1%
- >1% and <3%
- >3%

Bold: EPZ

Table 1. 2015 - 2019 Observed Conditions by Location

Project No. 130088, Cedar Hills Regional Landfill
King County, Washington

Well ID	Average Flow (SCFM)					Average Methane (% by vol)					Average Oxygen (% by vol)				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
CHSEP58D	4	9	4	6	7	7	8	12	12	15	3	3	2	3	4
CHSEP58S	0	0	0	6	8	0	0	0	0	0	18	18	19	20	21
CHSEP59D	4	10	6	6	7	16	17	3	1	0	12	11	19	20	21
CHSEP59S	0	0	1	0	3	0	0	0	0	0	16	18	18	18	17
CHSEP60D	3	8	5	5	6	10	12	14	14	14	5	5	3	3	3
CHSEP60S	3	9	5	5	7	5	6	7	12	19	13	15	14	11	11
CHSEP61D	4	11	6	5	8	41	39	33	33	32	4	5	5	4	5
CHSEP61S	4	9	6	8	10	28	26	28	27	32	3	4	5	4	5
CHSEP62D	4	8	4	4	11	1	1	0	0	1	13	14	13	13	13
CHSEP62S	2	10	4	5	9	7	2	2	2	3	17	19	19	18	19
CHSEP63D	5	10	6	6	7	0	0	0	0	0	20	20	20	20	21
CHSEP63M	5	9	6	5	9	3	2	2	4	6	8	8	8	7	9
CHSEP63S	3	7	5	6	8	0	0	0	0	0	20	19	21	20	20
CHSEP64D	44	44	59	43	41	0	0	0	0	0	10	10	11	11	12
CHSEP64M	4	8	7	9	7	0	0	0	0	0	14	16	18	16	16
CHSEP64S	4	8	4	4	6	1	1	0	0	0	17	16	18	16	18
CHSEPE11	13	19	15	10	21	0	0	0	0	0	19	19	21	19	20
CHSEPE14	11	18	10	17	17	1	0	0	0	0	8	9	10	9	10
CHSEPVLT	8	33	17	23	32	5	1	1	2	2	12	12	13	10	12

Well ID	Average Carbon Dioxide (% by vol)					Average Static Pressure (inches H2O)					Average Diff. Pressure (inches H2O)					Max. Temperature (F)				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
CHSEP58D	12	12	13	12	12	-17	-16	-14	-14	-9	0.01	0.03	0.01	0.01	0.02	99	92	91	94	89
CHSEP58S	1	1	1	0	0	-3	-5	-6	-14	-9	0.00	0.00	0.00	0.01	0.02	97	107	93	95	91
CHSEP59D	10	10	2	1	0	-16	-16	-14	-14	-8	0.01	0.03	0.02	0.02	0.02	93	93	97	95	93
CHSEP59S	1	1	1	1	1	-1	-4	-3	-3	0	0.00	0.01	0.00	0.00	0.01	98	104	94	102	98
CHSEP60D	12	13	13	13	12	-16	-16	-14	-14	-8	0.01	0.02	0.02	0.01	0.02	104	91	102	104	99
CHSEP60S	4	4	4	6	8	-16	-16	-14	-14	-8	0.01	0.02	0.02	0.01	0.02	92	94	87	95	83
CHSEP61D	22	19	17	17	16	-16	-16	-14	-14	-8	0.01	0.03	0.02	0.01	0.03	93	96	89	95	88
CHSEP61S	16	15	15	14	14	-16	-16	-14	-14	-8	0.01	0.02	0.02	0.02	0.04	100	92	94	94	94
CHSEP62D	3	3	3	3	3	-16	-16	-14	-14	-8	0.01	0.02	0.02	0.02	0.06	100	90	91	98	87
CHSEP62S	3	1	1	1	1	-16	-16	-14	-14	-8	0.01	0.04	0.02	0.01	0.04	91	86	91	93	88
CHSEP63D	0	0	1	0	0	-16	-16	-14	-14	-8	0.02	0.03	0.03	0.01	0.02	84	86	80	86	83
CHSEP63M	11	10	10	10	8	-16	-16	-14	-14	-8	0.02	0.02	0.02	0.01	0.03	92	90	84	88	86
CHSEP63S	0	1	0	0	1	-16	-16	-14	-14	-8	0.01	0.02	0.02	0.01	0.03	92	92	88	95	88
CHSEP64D	3	3	3	3	3	-6	-5	-7	-6	-4	0.34	0.30	0.67	0.41	0.35	64	69	62	66	66
CHSEP64M	2	2	2	2	3	-8	-4	-3	-6	-7	0.01	0.02	0.04	0.03	0.02	87	90	85	96	83
CHSEP64S	1	2	1	2	1	-16	-16	-14	-14	-8	0.01	0.02	0.01	0.02	0.02	95	94	90	97	93
CHSEPE11	1	1	1	0	1	-16	-16	-14	-14	-9	0.01	0.01	0.01	0.01	0.02	105	98	95	95	82
CHSEPE14	4	4	4	4	4	-16	-16	-14	-14	-8	0.01	0.02	0.01	0.01	0.02	108	103	93	103	91
CHSEPVLT	8	7	6	8	7	-2	-1	-1	-1	-1	0.02	0.03	0.03	0.02	0.04	105	98	93	99	93

Native Soil
Near Edge
Bottom Tier
Middle Tier
Top Tier

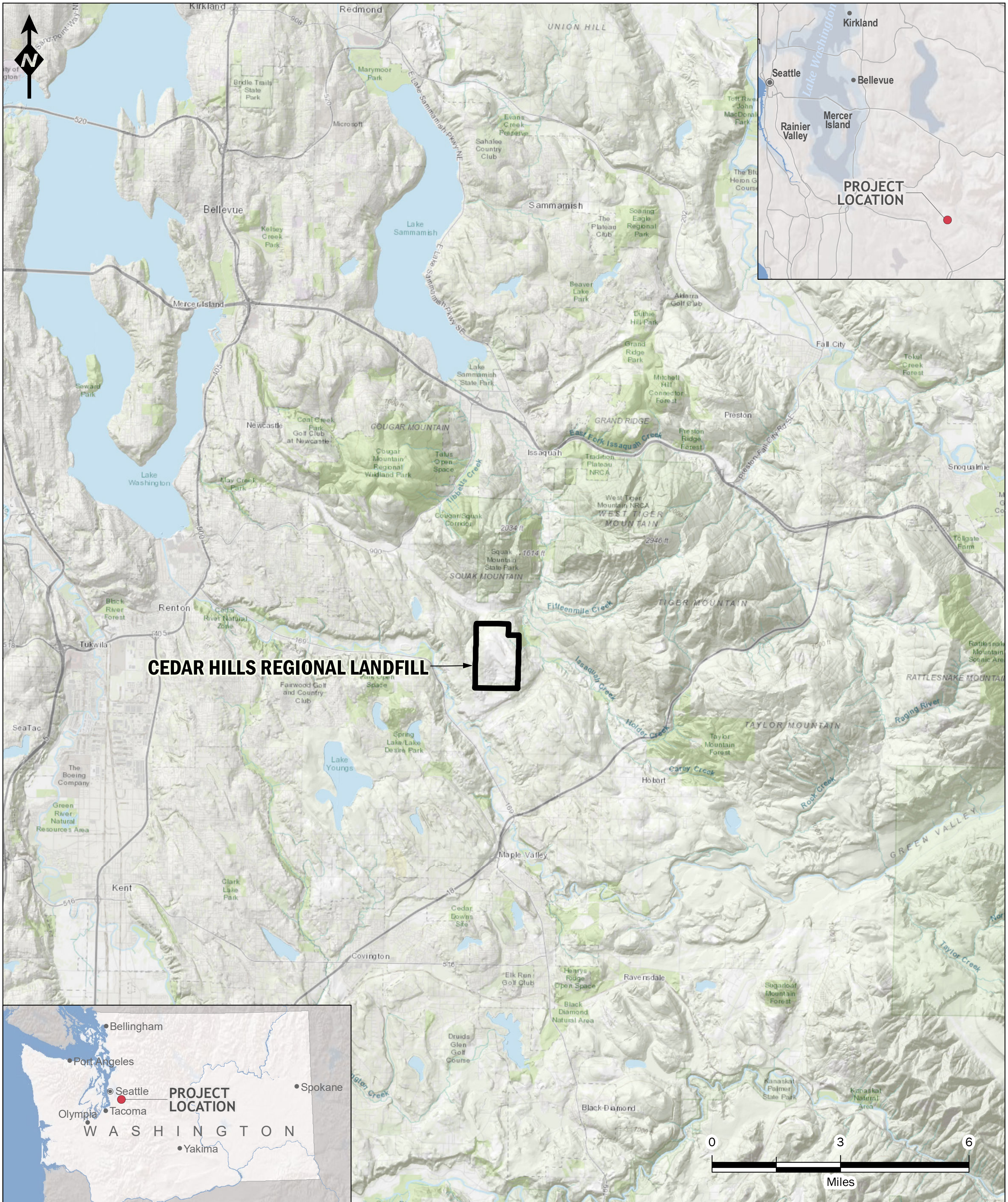
Methane

>50%
>45% and <50%
>35% and <45%
>25% and <35%
<25%

Oxygen

<0.1%
>0.1% and <0.5%
>0.5% and <1%
>1% and <3%
>3%

FIGURES

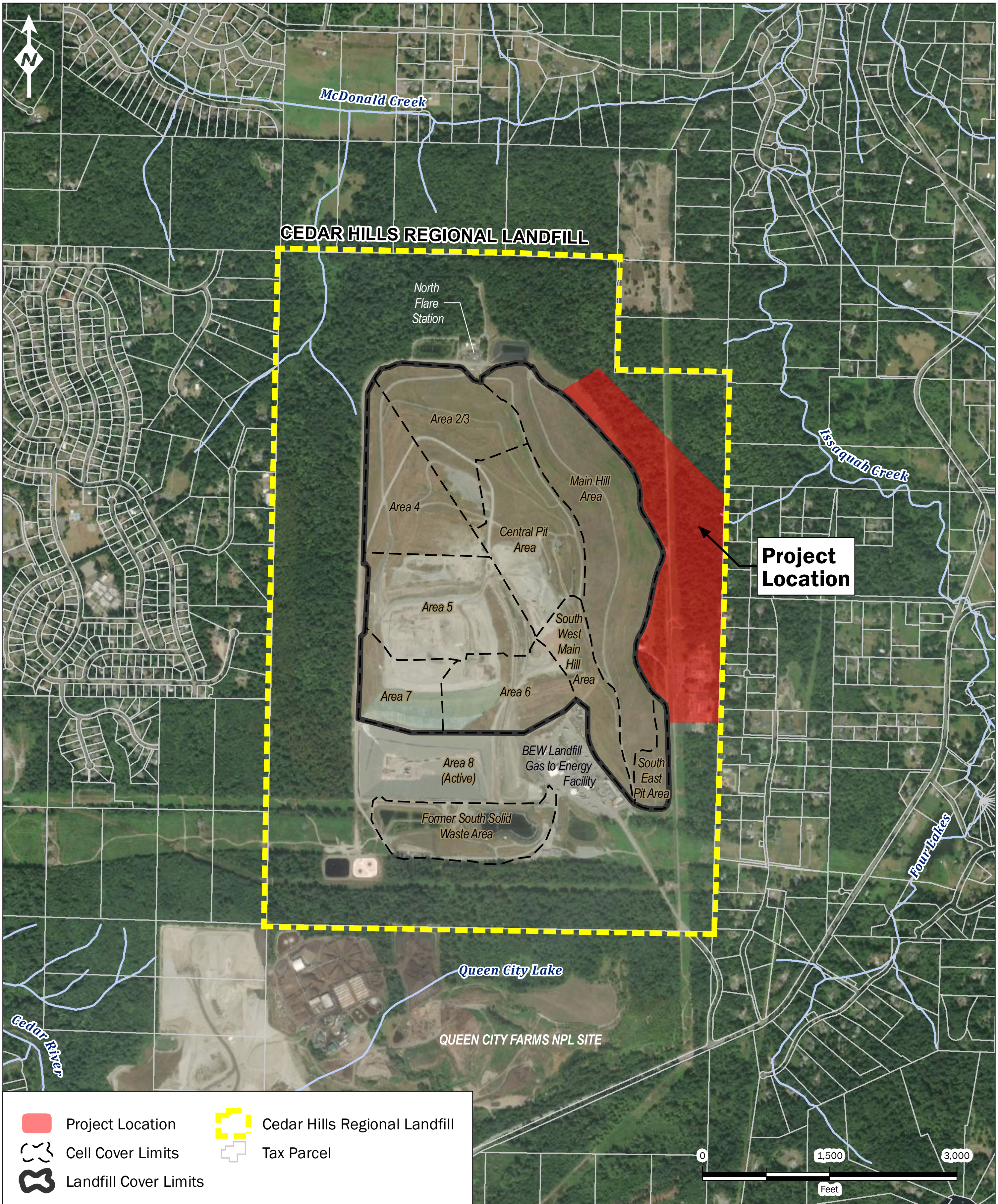


Project Location Map

Cedar Hills Regional Landfill

King County, Washington

DATE: Jun-2020	PROJECT NO. 130088
DESIGNED BY: KSL/RAP	
DRAWN BY: KSL/RAP	FIGURE NO. 1
REVISED BY: - - -	



King County

Aspect CONSULTING

Site Features Map
Cedar Hills Regional Landfill
King County, Washington

DATE: Jun-2020	PROJECT NO. 130088	
DESIGNED BY: KSL/RAP		
DRAWN BY: KSL/RAP	FIGURE NO. 2	
REVISED BY: PPW		

Gas Extraction/Dual-Phase/Leachate Well	Perched Zone Monitoring Well	Surface Water Monitoring Station	East Shallow Perched Zone[1]	Stream	Project Location
Gas Probe	Perched Zone Piezometer	Non-Potable Water Well	Northeast Shallow Perched Zone[1]	Approximate Extent of Wetland Area	Landfill Cover Limits
Leachate Sampling Manhole	Regional Aquifer Monitoring Well	Borehole/Geoprobe (Decommissioned)			Property Boundary
Manhole	Staff Gauge				

[1]Uncertainty in zone boundary indicated by dashed line
[2]Gas probe locations could not be field verified

0 200
Feet

Aspect CONSULTING

King County

EPZ Features and Monitoring Locations

Cedar Hills Regional Landfill
King County, Washington

Date: Jun-2020
Designed by: KSL/RAP
Drawn by: KSL/RAP
Revised by: SDM / RAP

Project No. 130088

Figure No. 5

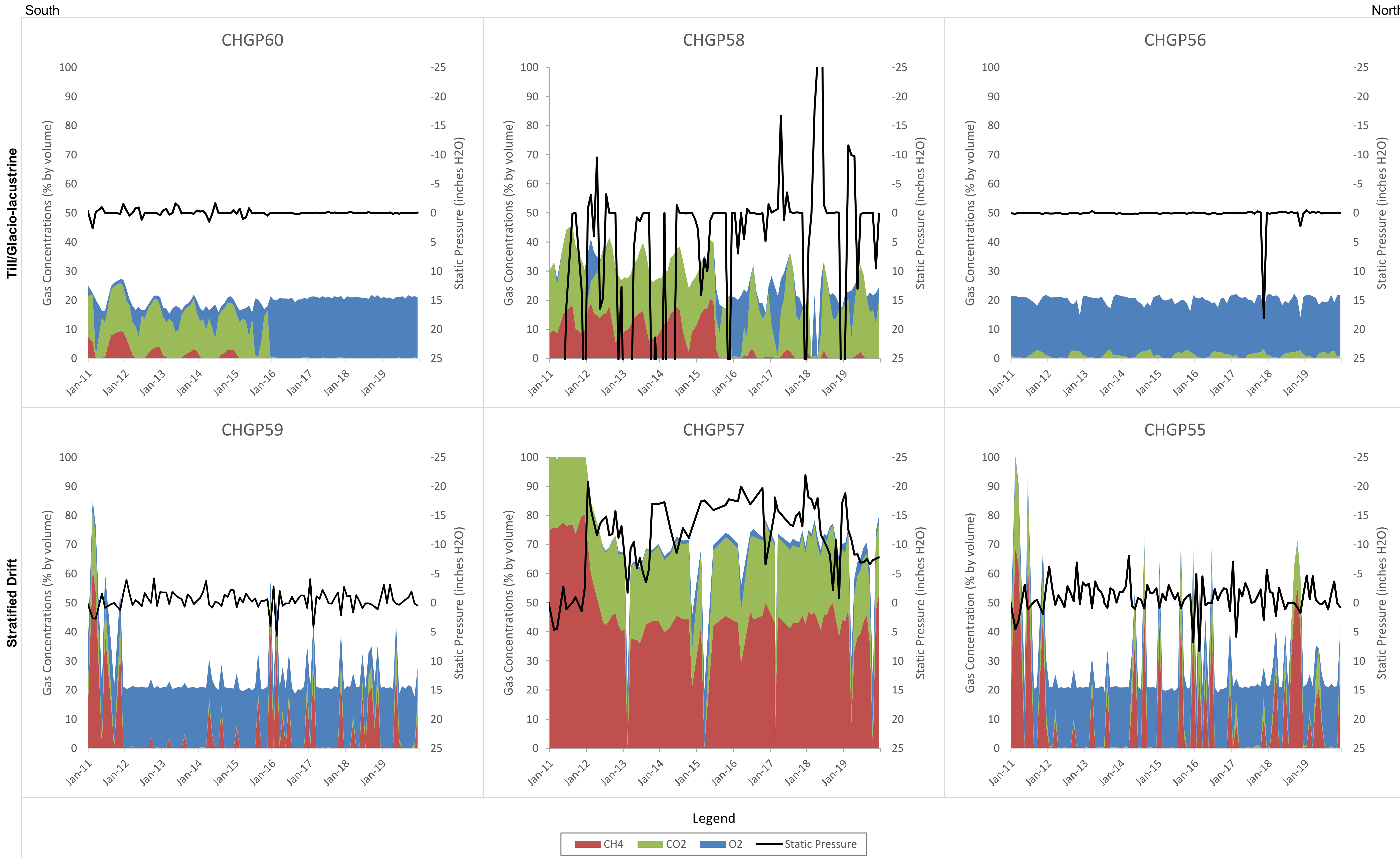


Figure 7
Observed LFG Concentrations at Selected Gas Probes
EPZ LFG Optimization Memo
1 of 1

Aspect Consulting
6/17/2020
P:\AECOM Cedar Hills Env Controls E00286E12\Data\Analyses\LFG\CH probes_Aspect.xlsx

ATTACHMENT 1

RI/FS Completion: Phased Action Approach Matrix

RI/FS Completion
Phased Action Approach Matrix
(v4 - updated July 2020)

Phase 1	Year 1-2	**Decommissioning GW Extraction Wells** *-Decommission existing 'EW' groundwater extraction wells and replace with 6 new wells for compliance monitoring.* **Optimize Existing LFG System** **Compliance Gas Probes** *(1a) Install 2 nested gas probes (6 total) to replace GP-ATC-5 and GP-ATC-7* *(1b) Sample 6 new gas probes and select previously sampled probes Quarterly (baseline and three post-optimization events)* **Passage Point Methane Monitoring** *-Evaluate existing Passage Point methane monitoring data* *-Review Passage Point construction information* *-Evaluate need for sub-slab sampling at Passage Point.* **Groundwater Monitoring** *-County conduct expanded groundwater monitoring*	Interim Action - Alternative 2 Components **COMPLETED**
Decision Gate - July 2020			
Phase 2	Year 2-3	**Perimeter Gas Collection** *-Install 4 new deep LFG extraction wells inside waste and connect to extraction system. See figure.* *-Evaluate the location for and install 4 new shallow LFG extraction wells inside waste and connect to extraction system.* **LFG Extraction System & Monitoring** *-Implement intermediate-term recommendations presented in LFG Optimization Update Tech Memo (Aspect, 2020). Evaluate and modify routine LFG monitoring locations.* *-County conduct routine LFG optimization activities and implement near term recommendations presented in LFG Optimization Update Tech Memo (Aspect, 2020).* **Groundwater Monitoring** *-County continue conducting expanded groundwater monitoring* *-Initiate groundwater trending (see Ecology comment 20). Will support identifying if new wells are needed and if optimization is helping.*	Interim Action - Alternative 3 Components
Decision Gate			
Phase 3	Year 5+	**Influence Testing** *-Connect GP-58 to extraction system, if needed.*	Interim Action - Alternative 3 Components (if needed)
		Influence Testing *- Conduct LFG well field influence tests to evaluate extraction facilities in the EPZ.* **Lining Stormwater Ditches** *-Line ditch from Wetland B to main stormwater line as per Option 1 from AMEC 2011*	Additional Investigations
Decision Gate			
Phase 4	Year ++	**Ecology's Requested Additional Investigations** *-Wetland staff gauges* *-Trend analysis for inorganics* *-LandGEM analysis - LFG generation*	Additional Investigations
		Finalize RI/FS Report *-see additional reporting comments to be addressed* **Prepare Cleanup Action Plan**	RI/FS
Agency Review & Approval			
Phase 5	Year +++	**Load Data to EIM**	RI/FS
		Implement Preferred Alternative & Long-Term O&M *-TBD (based on results from Phases 1 and 2) Implement expanded LFG collection with East Main Hill Refuse extraction wells* *-Long-term O&M activities: groundwater and LFG monitoring, continued LFG optimization.*	Remedial Action - Alternative 4 Components (if needed)

ATTACHMENT 2

2015 - 2019 LFG Collection Assessment by Location

Attachment 2
2015 - 2019 LFG Collection Assessment By Location
CHRLF LFG Optimization

ATTACHMENT 3

Updated Guidelines for LFG Collection Optimization Monitoring - EPZ

Updated Guidelines for LFG Collection Optimization Monitoring – EPZ

These guidelines summarize monitoring data collection and flow and valve adjustments recommended for optimizing landfill gas (LFG) migration control in the East Perched Zone (EPZ) area of Cedar Hills Regional Landfill (CHRLF). Refer to the May 2019 Technical Memorandum (Aspect, 2019) and Section 6 of this Memorandum for additional details.

Step 1: Initial Readings: Measure and record stabilized LFG concentrations, pressure readings, calculated flow, and valve position.

Step 2: Evaluate initial readings for basis of determining valve adjustments, as described below.

Flow and Valve Adjustment Guidelines

Methane (% vol)	Flow Adjustment	Control Valve Adjustment
> 35%	Increase Flow	Open by 1 turn (10%) or less
25–35%	Maintain Flow	Do not adjust
< 25%	Decrease Flow	Close by 1 turn (10%) or less

Additional Monitoring Parameters and Criteria

LFG Parameter	Primary Potential Concern(s)	Condition	Action(s)
Hydrogen sulfide (H_2S)	Odor control	Is odor present?	If odor observed, monitor for H_2S to confirm source. If H_2S is not present in LFG, inspect wellhead for damage to boot or cover.
Oxygen (O_2)	Air leaks, subsurface fires	If O_2 > 3%, this could indicate potential air leak	Inspect monitoring assembly, lateral, and wellhead for atmospheric leaks. Address leaks.
Carbon monoxide (CO)	Subsurface fire	If CO is less than 100 ppm, subsurface fire is unlikely	Adjust valve according to methane concentration.
		If CO is between 100 ppm and 1,000 ppm, there is potential for subsurface fire	Decrease flow to reduce potential for subsurface fire, notify manager.
		If CO_2 > 1000 ppm, subsurface fire is likely	Close valve to minimize potential for subsurface fire, notify manager.

Step 3: Adjust valve at extraction well based on valve adjustment criteria described above.

Step 4: Adjusted Readings: Measure and record pressure readings, calculated flow, and valve position as “% Open”.