



March 25, 2026

Mr. Thomas Hull - Interim Administrator/Controller
St. Clair County - Administrator/Controller Department
200 Grand River Avenue, Suite 203
Port Huron, Michigan 48060

**RE: Smiths Creek Landfill, St. Clair County, Michigan
Independent Peer Review and Evaluation Report
CEC Project 353-805**

Dear Mr. Hull:

Please find enclosed twelve bound copies of Civil & Environmental Consultants, Inc.' (CEC) independent peer review and evaluation report for the Smiths Creek Landfill to provide to your County Board of Commissioners in advance of our presentation to the County Board of Commissioners on April 2, 2026.

If you have questions or require clarification regarding this submittal, please contact the undersigned at (630) 963-6026.

Sincerely,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

Michael R. Beaudoin, P.E.
Senior Consultant

Pamela C. Thomas
Senior Project Manager

Enclosures: Independent Peer Review and Evaluation Report

**SMITHS CREEK LANDFILL
INDEPENDENT ENGINEERING PEER REVIEW AND
EVALUATION OF SEPTAGE APPLICATION**

**Prepared For:
COUNTY OF ST. CLAIR, MICHIGAN
200 GRAND RIVER AVENUE
PORT HURON, MICHIGAN 48060**

**Prepared By:
CIVIL & ENVIRONMENTAL CONSULTANTS, INC.
51229 CENTURY COURT
WIXOM, MICHIGAN 48393**

CEC Project 353-805

MARCH 2026



Civil & Environmental Consultants, Inc.

DOCUMENT CERTIFICATION

PREPARER SIGNATURE & MICHIGAN PROFESSIONAL ENGINEER STAMP:

I hereby certify that this document has been prepared/revised under my direct supervision and that it has been prepared in accordance with good engineering practices and regulatory requirements.



A handwritten signature in cursive script, appearing to read "Michael R. Beaudoin", written over a horizontal line.

Michael R. Beaudoin, P.E. – Project Principal
Signature

Michigan Professional Engineer
Stamp

3/20/26

Date

TABLE OF CONTENTS

EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION.....	1
1.1 Purpose of Review	1
1.2 Scope of Review	2
2.0 LANDFILL BACKGROUND AND OPERATIONS	3
2.1 Daily Operations	3
2.2 Leachate Management	5
2.3 Gas Collection and Control System.....	5
2.4 CEC’S Observations During October 22, 2025 Site Visit.....	5
3.0 SEPTAGE APPLICATION.....	7
3.1 Basis For Septage Application Process.....	8
3.1.1 RDDP Construction Permits.....	8
3.1.2 RDDP Operating Licenses.....	9
3.2 Description of Septage Application Process.....	9
3.2.1 Receipt and Processing of Septage	9
3.2.2 Application of Septage.....	10
3.2.3 Volume of Applied Septage.....	10
4.0 BIOREACTOR SYSTEM EVALUATION.....	11
4.1 Evaluation Process	11
4.2 Bioreactor Application Areas	11
4.3 Waste Moisture Changes	11
4.3.1 Review of CTI Calculations.....	12
4.3.2 CEC Opinion on Waste Moisture Calculations	13
4.4 Effect on Waste Settlement.....	14
4.4.1 Review of Airspace Utilization Factor Results.....	15
4.4.2 Discussion of AUF Results.....	17
4.4.3 Review of Settlement Monitoring Results.....	18
4.4.4 Discussion of Settlement Monitoring Results.....	21
4.4.5 CEC’s Opinion on Settlement Monitoring Results.....	21
4.5 Impact on Landfill Gas Generation.....	21
4.5.1 Industry Landfill Gas Volume Prediction Model	21
4.5.2 CTI Application of Gas Volume Prediction Model.....	22
4.5.3 Application of Septage versus Leachate	24
4.6 Opinion of Bioreactor Effectiveness.....	26
5.0 LANDFILL ODORS.....	27
5.1 Common Landfill Odor Contributors	27
5.1.1 Active Working Face Odors	27
5.1.2 Landfill Gas Odors.....	27
5.1.3 Leachate Management Odors	28
5.2 Odor Mitigation Techniques	28
5.2.1 Active Working Face Odors	28

5.2.2	Landfill Gas Odors.....	28
5.2.3	Leachate Management Odors	28
5.3	Smiths Creek Odors	29
6.0	OPINION ON CONSULTANT’S EFFORTS	30
7.0	RECOMMENDATIONS.....	31
7.1	General Landfill Operations and Aesthetics	31
7.2	Landfill Gas Collection and Control System.....	31
7.3	Septage Application	32
7.4	Waste Approval Process	32
7.4.1	Wet Waste.....	33
7.4.2	Heat Producing Waste.....	33
7.4.3	Sulfate Containing Waste	34
7.5	Mitigation of Smiths Creek Landfill Odors.....	34
8.0	SUMMARY AND CONCLUSIONS	35

FIGURES

Figure 1	Facility Site Plan
Figure 2	Existing GCCS Layout
Figure 3	Cells 3A, 3B, 4, and 8 Horizontal Gas Extraction Lines
Figure 4	CEC’s Proposed Modifications/Additions to CTI’s Southern Loop Expansion Plan

APPENDICES

Appendix A	List of Electronic Documents Provided by St. Clair County to CEC for Review
Appendix B	Photographic Logs and Observations for October 22, 2025 Site Visit
Appendix C	CEC’s Calculated Gas Generation Due to Added Liquids and CEC Questions/CTI Responses
Appendix D	Sniffer Drone Surveys of Fugitive CH ₄ and H ₂ S Gas (Drawings 1–6)
Appendix E	CEC’s GCCS Infrastructure Review and Recommendations

EXECUTIVE SUMMARY

Smiths Creek Landfill (SCL) experienced odors in the surrounding community starting in the summer of 2023. As a result of the odors, the Michigan Department of Environment, Great Lakes, and Energy (EGLE), issued several violation notices alleging that odors and gas system operations violated environmental rules and regulations. Although SCL and its engineering consultant (CTI and Associates, Inc. [CTI]) worked diligently to resolve these violation notices throughout 2023 and 2024, the State of Michigan ultimately issued a Consent Order effective July 8, 2025.

The County of St. Clair, Michigan requested proposals “seeking a consultant specializing in landfill engineering and operations to provide an independent and impartial assessment of the current consulting firm’s approaches, findings and recommendations” for SCL. Civil & Environmental Consultants, Inc. (CEC) was selected to perform the work and received authorization to proceed on October 1, 2025.

A project kickoff meeting was held at the landfill site on October 22, 2025. Senior CEC landfill experts toured the site and found the facilities to be in good condition and the operation was observed to be better than average for landfills of comparable size and setting. No uncontrolled surface emissions or odors along the landfill perimeter and interior were detected by CEC staff during the site visit.

The SCL facility license contains a special provision as a research, development, and demonstration project (RDDP) that allows the facility to apply liquid septage waste into the landfilled waste. The intent of the septage application is to provide the St. Clair County community an effective septage disposal outlet and to create a “bioreactor” that accelerates waste decomposition and the production of landfill gas for beneficial energy production. It had been suggested by EGLE that the septage application contributed to the odor issues experienced at the site.

CEC examined data reported annually by CTI, including settlement rates, gas production, and moisture content and has concluded that it is possible that some local pockets of bioreactor activity have occurred where near-optimal moisture content was reached. However, CEC finds no compelling evidence of prevalent bioreactor conditions at the SCL. Additionally, the organic content present in septage provides little to no contribution to landfill gas production.

CEC concludes that the odors detected in the community were due to fugitive landfill gas emissions caused by insufficiency in vacuum supply to the south end of the landfill which has since been corrected. The fugitive gas emissions were particularly unpleasant because of the presence of relatively high concentrations of hydrogen sulfide in the landfill gas, which is an odorous constituent with a rotten egg smell. The relatively high concentrations of hydrogen sulfide

were caused primarily by the acceptance of a large volume of sulfate-containing special waste (Domtar paper mill sludge). Receipt of septage had little to nothing to do with the odor issues that occurred.

At present, the odors appear to be sufficiently mitigated based on CEC's site visit and lack of recent community odor complaints. Production of odorous hydrogen sulfide will decrease with time, so maintaining adequate vacuum to the site gas collection and control system (GCCS) should prevent fugitive gas emissions and odors in the community. To reduce the possibility that the conditions that caused the odors could occur again, CEC has provided recommendations for improving the site GCCS. In addition, improvements are proposed for waste acceptance and tracking procedures.

CEC has not attempted to review the cost-benefit of septage application. However, it appears that septage application was not a factor in the causation of odors and otherwise did not cause discernable harm to the landfill. Therefore, CEC believes that septage application could resume at similar quantities and using similar methods as previously employed.

Based on the body of work reviewed for this report, CEC finds that CTI is a competent landfill design firm. CTI's strengths are in the areas of landfill design for environmental protection, research and development, and innovation. While the circumstances that resulted in the odors were avoidable in hindsight, a reasonable level of due care was exhibited by CTI and SCL before, during, and after the odor issues occurred.

1.0 INTRODUCTION

On May 23, 2025 Civil & Environmental Consultants, Inc. (CEC) received the Invitation to Bid No. RFP-AD-0525-549 (RFP) issued by the County of St. Clair, Michigan (County) for an “Independent Landfill Engineering Peer Review” of the Smiths Creek Landfill (SCL). RFP requested proposals from “a consultant specializing in landfill engineering and operations to provide an independent and impartial assessment of the current consulting firm’s approaches, findings and recommendations” for SCL.

CEC submitted a proposal on July 7, 2025, and was interviewed by County representatives on July 31, 2025. CEC was subsequently selected to perform the work and received authorization to proceed on October 1, 2025.

1.1 PURPOSE OF REVIEW

The community surrounding the SCL had been experiencing odors since the summer of 2023. Among the potential causes of odor were insufficiency of the gas collection system design and operation and application of septage to the solid waste, as well as issues related to other accepted waste streams.

As a result of the odors, the Michigan Department of Environment, Great Lakes, and Energy (EGLE), issued several Violation Notices alleging that odors and gas system operations violated environmental rules and regulations. Although SCL staff and its engineering consultant (CTI and Associates, Inc., [CTI]) worked diligently to resolve these Violation Notices throughout 2023 and 2024, the State of Michigan ultimately issued a Consent Order effective July 8, 2025.

The Consent Order contained twenty-six specific actions to be implemented by SCL and required payment of fines and performance of a Supplemental Environmental Project. Although many of the specific actions required by the Consent Order were already voluntarily in the works, the overall impact of the Consent Order placed a heavy burden on the SCL staff, and the County and its constituents.

County representatives have expressed a desire to understand whether the work of the County’s engineering consultant (CTI) was sufficient to prevent and remedy the odors and gas system issues, and whether their work was consistent with industry standard state-of-the-practice for landfill engineering services.

1.2 SCOPE OF REVIEW

For this review CEC started with the question “what caused the landfill odors observed in the community.” CEC then examined the hypothesis that “landfill odors were caused directly or indirectly by the application of septage liquid waste to stimulate bioreactor conditions.”

CEC’s review proceeded with the study of many documents provided by the County, and independent calculations and evaluation of the efforts made prior to, during, and after the occurrence of the problematic odors. CEC’s review was limited to information relevant to odors, Violation Notices, and related work as an effort to determine whether the odors were caused by improper or inadequate advice provided by the County’s consultant (CTI).

CEC requested from SCL a list of documents and data needed prior to the October 22, 2025 project kickoff/site visit and made follow-up requests for additional data and documents needed at various points throughout the project review process. SCL provided the requested documents and data in electronic format files. A compiled list of the electronic files provided to CEC are presented in **Appendix A**.

The County RFP proposed that multiple interim reports be prepared focusing on distinct aspects of the issues. CEC suggested that the work would be conducted more efficiently if a single, holistic report were prepared which covered all of the relevant topics. The County agreed to this approach and this report was prepared to meet that objective.

2.0 LANDFILL BACKGROUND AND OPERATIONS

SCL is a Type II municipal solid waste (MSW) landfill that consists of 265.4 acres located at 6779 Smiths Creek Road, Kimball Township, St. Clair County, Michigan. It is licensed to operate by EGLE under License No. 9776. The facility site plan obtained from the most recent license (dated July 10, 2025) is presented as **Figure 1** (provided in the Figures section of this report).

The facility license contains a special provision as a research, development, and demonstration project (RDDP). This provision allows the facility to apply liquid septage waste to the landfilled waste in an attempt to accelerate decomposition, thereby increasing volume utilization efficiency and potentially recovering additional landfill gas for beneficial energy production.

The older, 56.2-acre northern portion of the site utilizes a favorable geological setting as the site is located over an ancient clay lake deposit, resulting in a competent underlying surface for groundwater protection. The newer 98.1-acre southern portion of the site is also located in this favorable geological setting but includes an engineered liner system and leachate collection system constructed in accordance with Federal and State regulations.

2.1 DAILY OPERATIONS

The SCL accepts approximately 1,000 tons of waste per day. Operating hours are 8:00 a.m. to 4:00 p.m., Monday through Friday, and 8:00 a.m. to 1:00 p.m. on Saturday. The site accepts MSW collected from residential and commercial customers, construction and demolition (C&D) waste, and “special waste” from industrial customers. Special waste can include soils from remedial clean-up projects, industrial process waste, and wastewater treatment sludge.

Essentially all waste originates from St. Clair County except for the years 2014–2023 when a substantial quantity of MSW was accepted from Canada. In addition to standard solid waste disposal, the SCL accepts septage waste and applies it to the landfill as described in Section 3.0 of this report. **Table 1** on the following page presents a breakdown of the waste received since 2003.

Table 1							
Waste Volumes, Septage Volumes, and Septage Volumes Per Ton of Waste							
Year	Annual Solid Waste Volumes				Annual Septage Volumes		
	Municipal Solid Waste		Other Solid Waste		TOTAL SOLID WASTE (tons)	Septage Applied (gals)	Septage Applied Per Ton of MSW (gals/ton)
	U.S. Origin (tons)	Canadian Origin (tons)	C&D (tons)	Special Waste (tons)			
2003	131,734	0	30,237	219,297	381,269	0	0.00
2004	141,322	0	30,070	90,371	261,763	0	0.00
2005	139,631	0	31,541	68,445	239,617	0	0.00
2006	138,886	0	28,733	40,226	207,845	0	0.00
2007	126,564	0	30,472	70,064	227,100	0	0.00
2008	118,252	0	28,139	32,710	179,101	515,238	4.36
2009	110,871	0	25,889	25,762	162,522	845,238	7.62
2010	109,101	0	31,908	32,416	173,425	682,619	6.26
2011	116,937	0	46,754	31,553	195,244	1,389,286	11.88
2012	113,948	0	33,316	26,198	173,463	613,095	5.38
2013	118,337	0	27,536	29,445	175,318	1,501,190	12.69
2014	158,585	0	26,119	25,292	209,996	1,454,524	9.17
2015	216,504	0	29,699	47,729	293,932	1,247,619	5.76
2016	121,605	92,976	31,760	32,770	279,111	1,227,857	5.72
2017	123,203	143,681	33,201	66,770	366,854	1,218,333	4.57
2018	126,911	113,640	35,134	43,278	318,963	1,197,619	4.98
2019	129,603	92,275	37,188	27,579	286,644	1,856,190	8.37
2020	126,537	101,775	35,031	65,391	328,734	2,137,233	9.36
2021	133,750	131,523	33,290	46,564	345,127	1,871,905	7.06
2022	128,169	119,283	33,477	37,181	318,110	1,635,952	6.61
2023	123,662	74,588	38,000	66,280	302,530	1,057,381	5.33
2024	121,583	3,448	43,781	54,395	223,206	0	0.00
TOTALS:	2,875,693	873,189	721,274	1,179,716	5,649,872	20,451,281	-

Source: Data provided by St. Clair County, Michigan.

As with all permitted Class II landfills, the site is required to:

- Apply daily cover on waste,
- Monitor groundwater quality and surface water quality, and
- Install an engineered final cover system as final waste grades are achieved.

2.2 LEACHATE MANAGEMENT

Leachate is liquid that infiltrates through the waste and is collected on the low permeability liner or native soil surface that underlies the waste. A significant part of the environmental management of a landfill is the collection and treatment of leachate. In the past, a portion of leachate was recirculated into the southern area of the landfill (i.e., the area with the liner and leachate collection system installed) as permitted by the Operating License, but that practice was halted in 2018. SCL currently collects leachate, pretreats it on-site, and then discharges it to the City of Port Huron wastewater treatment plant.

2.3 GAS COLLECTION AND CONTROL SYSTEM

Within the landfill waste mass, GCCS functions by providing a vacuum on a large system of buried perforated pipes using a vast network of solid pipe to deliver collected gas to a combustion system. The GCCS combusts the landfill gas to reduce greenhouse gas emissions and odors while destroying trace gas constituents. The GCCS also acts to prevent the off-site migration of underground landfill gas.

The existing GCCS employs two distinct methods. The first method consists primarily of vertical extraction wells, which address most of the northern waste disposal cells. The second method consists of horizontal landfill gas collectors which are used primarily in the southern portion of the landfill.

The extracted and collected landfill gas is delivered by the primary blower to the process utility flare station (Flare 1) for combustion, or to the electrical power generation facility operated by Blue Water Renewables for beneficial utilization. In addition, a temporary supplemental treatment system and secondary blower and process utility flare station (Flare 3) is employed for hydrogen sulfide removal and combustion. The existing GCCS Layout is presented on **Figure 2** (provided in the Figures section of this report).

2.4 CEC'S OBSERVATIONS DURING OCTOBER 22, 2025 SITE VISIT

A senior landfill review team conducted a comprehensive site visit on October 22, 2025, to familiarize the CEC team with site conditions, operational procedures, and general compliance conditions. The CEC team included Mr. John E. Hock, P.E., Mr. Michael R. Beaudoin, P.E., and Mr. Kenneth R. Kruszynski, P.E., CEM — all experienced registered professional engineers that collectively have been involved with hundreds of landfill facilities across the United States and worldwide.

An initial driving tour with the CEC team was guided by Mr. Matt Williams, environmental director and landfill manager. Following this guided tour, CEC performed a detailed, unaccompanied walkover of the entire landfill.

CEC found the landfill facility to be in good condition and the operation was observed to be better than average for landfills of comparable size and setting. No uncontrolled surface gas emissions/odors were detected along the landfill perimeter and interior during CEC's visit. Adequate daily cover was observed stockpiled to cover the working face. Minor odor was detected near the landfill working face, but the odor was not thought to be strong enough to be detected off-site. No leachate seeps were observed during the visit, which suggests that leachate collection efforts are adequate.

Photographic logs and noted observations made by CEC are provided in **Appendix B** of this report.

3.0 SEPTAGE APPLICATION

Typical MSW moisture content is assumed to be between 20% to 30% as received at a landfill. CTI assumed that the initial waste moisture content was 25%, which is consistent with typical values. This initial moisture content is enough to support the process of methanogenesis, which is the result of the interaction of organic material in the waste, moisture, and microorganisms (although this moisture content is not optimum for biological activity). Methanogenesis results in the production of methane (natural gas) and carbon dioxide, and is a desirable process as it indicates that decomposition of the waste material is occurring, eventually leading to environmental stability.

Infiltration of rainfall increases the moisture content of the waste after deposition, which leads to an increased rate of methanogenesis. Purposeful addition of moisture beyond natural precipitation can further speed up the methanogenic process and temporarily increase the volumetric rate at which gas is generated. An MSW landfill subject to this process is often referred to as a “bioreactor.” Federal rules prohibit the addition of liquids into an MSW landfill unless special permits are received to deliberately create a bioreactor. Bioreactors are usually created by collecting leachate from the landfill and then reintroducing the leachate back into the waste mass, thereby increasing the moisture content.

Benefits of a bioreactor system may include:

- Faster decomposition of waste which accelerates the time for the waste to become inert and display “functional stability;”
- Increased volumetric rate of methane production resulting in early beneficial use of decomposition gas; and
- Rapid reduction of landfill waste volume due to settlement thereby increasing the available disposal “airspace” and potentially reducing operating costs prior to closing portions of the landfill.

However, deliberate addition of moisture to the MSW landfill is fraught with challenges and can be counterproductive if not properly implemented and managed. Too much moisture can overly saturate the MSW and partially fill the gas extraction system with liquid making it difficult to extract the decomposition gas in a controlled manner.

3.1 BASIS FOR SEPTAGE APPLICATION PROCESS

Introduction of moisture (typically leachate) can change the trajectory of methane production as described above. If the added moisture also contains a biological substrate, it may provide nutrients and other organic material that further enhances the methane production process. This is the premise behind adding septage waste rather than leachate to the disposed MSW.

Septage is primarily liquid and sludge waste that is removed from residential and commercial septic tanks. Septage can also originate from outhouses and portable toilet systems. Septage is simply the term for all of the fecal sludge, water, liquids, fats, grease, oils, and other materials that enter these systems. Septage is usually pumped into tanker trucks and disposed of at a wastewater treatment plant.

In 2004, St. Clair County and Macomb County commissioned a feasibility study for siting a septage disposal facility. The SCL was identified as a potential receiver for septage in the study. Recognizing the potential benefit of adding nutrient-rich liquid into the landfill, Patent No. 7,347,648 B2 was issued on March 25, 2008. The inventors of the patent include principal employees of CTI and St. Clair County. The patent is jointly owned by both CTI and the County. The patent states (on page 8 of 11):

The present invention provides a method of reducing the volume of waste in a landfill to increase capacity and landfill gas generation, provide a beneficial use for septage waste and a business method for operating a landfill to achieve greater profitability.

The annual RDDP reports state that an objective of septage application is to “evaluate the general effectiveness of the bioreactor landfill approach at SCL.”

3.1.1 RDDP Construction Permits

The septage application process requires an RDDP Construction Permit from EGLE. The SCL has been issued three RDDP construction permits from EGLE:

- RDDP Permit No. 4085: In February 2007, SCL was issued its first RDDP construction permit - Permit No. 4085, for the construction of the septage receiving facility and bioreactor cells - Cells 3A and 3B.
- RDDP Permit No. 4125: In 2012, SCL applied for and received a modification to Permit No. 4085 to allow for the injection of septage into Cell 3B (previously a leachate bioreactor) and the permit modification was granted in July 2012 under RDDP Construction Permit No. 4125.

- RDDP Permit No. 4137: In July 2013, SCL submitted a new RDDP construction permit application for the septage addition in existing Cells 2, 2B, 6 and 7, and new Cell 4 that was later approved in December 2013 under RDDP Construction Permit No. 4137. In July 2019, SCL applied for an extension of Permit Number 4137 and a modification to include new waste disposal area Cell 8. In December 2019, the extension and modification were approved and authorized under RDDP Construction Permit No. 4137.

3.1.2 RDDP Operating Licenses

Operation of the SCL septage receiving facility and bioreactor cells require an RDDP operating license from EGLE. SCL has been issued four operating licenses from EGLE:

- RDDP Operating License No. 9177: In March 2008, SCL was issued its first license authorizing the operation of the septage receiving facility and bioreactor cells - Cells 3A and 3B.
- RDDP Operating License No. 9342: In January 2013, SCL was issued License No. 9342 authorizing septage injection in Cell 3B.
- RDDP Operating License No. 9387: In May 2014, SCL was issued License No. 9387 authorizing operation of RDDP activities under RDDP Permits 4085 and 4137.
- RDDP Operating License No. 9561: In June 2019, SCL was issued License No. 9561 authorizing operation of the entire RDDP through June 20, 2024.
- RDDP Operating License No. 9776: In July 2025, SCL was issued License No. 9776 authorizing operation of the entire RDDP through July 10, 2030.

Under the RDDP operating license, SCL is required to conduct significant tracking and reporting on the progress and performance of the septage operations. These activities are required to determine if the project is meeting the objectives or conversely causing harm to the condition of the landfill. CTI provides annual reports to EGLE on behalf of the County to comply with the requirements of their RDDP operating license.

3.2 DESCRIPTION OF SEPTAGE APPLICATION PROCESS

3.2.1 Receipt and Processing of Septage

Septage is carried to the site by licensed haulers in tanker trucks. Acceptance of septage is subject to pH analyses to prevent receipt of overly acidic or alkaline liquid which could negatively affect methanogenesis. Solid material is screened out of the septage and then the filtered material is transferred by a lifting pump into large storage bladders that hold the septage near the top of the landfill.

3.2.2 Application of Septage

Septage is applied to the landfill by pumping from the storage bladders into a series of leach beds. The leach beds consist of near-horizontal perforated pipes surrounded by permeable gravel. Liquid is introduced into the leach beds and then allowed to infiltrate into the waste mass by gravity. New leach beds are constructed as the MSW fill area moves both laterally and vertically. This is intended to prevent oversaturation of a particular area and to spread the septage application to larger areas.

3.2.3 Volume of Applied Septage

The volume of septage received at the landfill varied from a low of just under 500,000 gallons during 2008 (the first year of septage additions) to a high of just over 2,200,000 gallons in 2020. Septage applications occurred in Cells 2B, 3A, 3B, 4, and 8 and were halted in 2023 while attempts were made to determine the cause of odors that were originating at the landfill. Quantities of annual septage received are provided in **Table 1** in Section 2.1.

4.0 BIOREACTOR SYSTEM EVALUATION

4.1 EVALUATION PROCESS

CEC performed a detailed review and evaluation of the operation and performance of the septage application process to “evaluate the general effectiveness of the bioreactor approach at SCL” as stated in the annual RDDP reports.

Performing this evaluation, CEC reviewed design and permit documents, annual RDDP reports to EGLE, regulatory compliance correspondence, waste and septage records, reports on landfill gas and leachate generation, construction records, and other pertinent data files (see **Appendix A** for a complete list). In addition, CEC senior project team members visited the site for a thorough walkover as described in Section 2.4.

4.2 BIOREACTOR APPLICATION AREAS

The SCL is constructed as a series of “cells” corresponding to segmental liner construction events as shown on **Figure 1** (provided in the Figures section of this report). The bioreactor zones were created in Cells 2, 2B, 3A, 3B, 4, 6, 7, and 8. When filling had advanced in elevation, fill areas were designated by zone titles that incorporated underlying cell limits as such:

- CW East - fill over the area designated Cells 3A, 3B, and 4; and
- CW West - fill over the area designated by Cells 2, 2B, 6, 7, and 8.

4.3 WASTE MOISTURE CHANGES

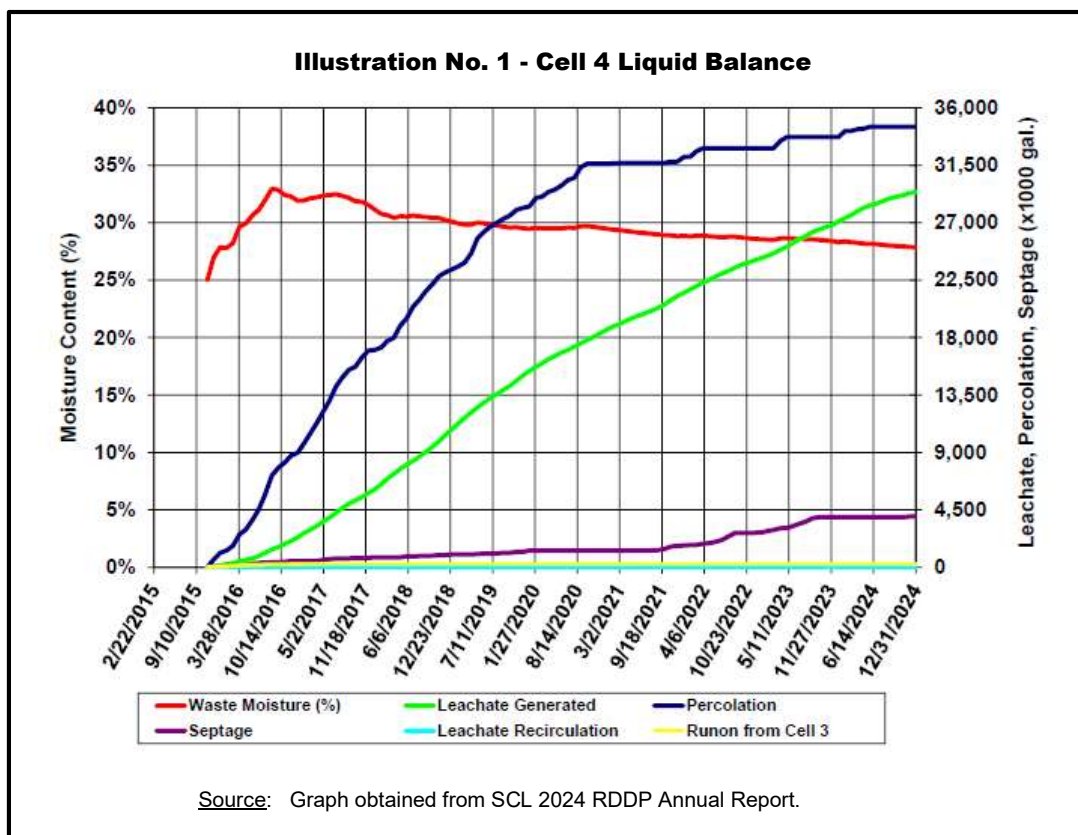
As discussed in Section 3.0, MSW typically arrives at a landfill containing 20–30% moisture by weight. CTI assumed an initial moisture content of 25% at the time of waste placement. The United States Environmental Protection Agency (USEPA) recommends that moisture content be increased to at least 40% to create bioreactor conditions (USEPA, “Bioreactor Performance,” August 15, 2007, EPA530-R-07-007); however, SCL did not consider reaching 40% moisture to be a primary goal.

Records of rainfall, leachate recirculation, and septage addition have been collected throughout the septage application process. Using these records, CTI performed detailed annual moisture calculations.

CEC has reviewed CTI’s moisture calculations and determined that they are based on appropriate science and performed with a detailed and functionally accurate method. The following sections present a review and interpretation of moisture balance calculations performed for Cell 4 as a *representative example* of the moisture balance calculations.

4.3.1 Review of CTI Calculations

CEC performed a detailed review of the Cell 4 waste moisture calculations for the period November 3, 2015 through December 31, 2024. CEC selected Cell 4 as a representative example for its review. The graph presented as **Illustration No. 1** below presents the liquid balance for Cell 4 and was excerpted from the SCL 2024 RDDP Annual Report.



As shown in **Illustration No. 1** above, the moisture contents in Cell 4 (expressed as total weight of liquid as a percentage of total weight of waste received) exhibited the trajectory listed below.

- Assumed Initial Moisture Content: ~25% in November 2015
- Peak Moisture Content: ~33% in June 2016
- Most Recent Moisture Content: ~28% in December 2024

The peak moisture content occurred well before most of the septage had been applied. Since the peak was attained, the calculated moisture content has steadily decreased as leachate drains from

the cell and is removed, despite the continued introduction of septage. Another way to look at CTI’s data for Cell 4 is presented in **Table 2** below, as summarized by CEC. The values shown in **Table 2** were derived from leachate generation, septage addition, and precipitation records for Cell 4 from 2015 through 2024 and as shown in **Illustration No. 1** on the previous page.

Table 2 Cell 4 Collective Liquid Balances 2015–2024	
Liquid / Moisture Source	Volume (million gals)
Moisture As-Delivered in Waste (25% of total weight of waste)	81.7
Precipitation Infiltration	35.6
Septage Application	4.0
Leachate Extracted	-30.7
Total Existing	90.6
<u>Source:</u> Data above derived from Figure 5-3 in the SCL 2024 RDDP Annual Report.	

Presented in this manner, it is apparent that the moisture applied as septage is minor (4 million gallons) compared to the moisture that comes in with the waste and to the amount of precipitation that infiltrates the waste mass (117.3 million gallons). A similar analysis for other cells receiving septage leads to the same conclusions.

4.3.2 CEC Opinion on Waste Moisture Calculations

In Cell 4, added moisture via septage application only accounts for ~10% of the added moisture (septage plus precipitation), and a little over 4% of the total moisture in the cell, according to the above calculations. Moisture content changes are almost entirely driven by infiltration of rainfall rather than application of septage. It does not appear to CEC that the septage application in Cell 4 is a significant driver of the overall moisture content in the cell.

In addition, CTI’s calculations show that only one cell approached the minimum moisture content of 40% required to result in a bioreactor. The peak moisture content calculated for Cell 3A approached 40% in 2015. However, it is likely that moisture content was not uniform throughout a given cell, thereby resulting in some zones that were above 40% moisture content and some zones that were below. While moisture content in Cell 3A peaked approaching 40%, this level did not persist long. Further, based on observations of other bioreactor projects, it is likely that

moisture was unevenly distributed throughout the subject cell — that is while some portions of the landfill were quite wet, other areas were below the optimum level.

The calculated peak moisture contents in all other cells were below the 40% minimum desired moisture content as recommended by the USEPA. However, it is likely that moisture content was not uniform throughout a given cell, thereby resulting in some zones that were above 40% moisture content and some zones that were below.

The peak moisture contents reported by CTI are as follows:

- Cell 3A - 39.2% was reached in mid-2015,
- Cell 3B - 34.3% was reached in mid-2015,
- Cell 4 - 33.6% was reached in mid-2016,
- Cell 8 - 26.4% was reached in January 2022, and
- CW West - 38.9% was reached in 2011.

4.4 EFFECT ON WASTE SETTLEMENT

After waste is placed and compacted in a landfill, it further compresses and densifies due to self-weight consolidation, forces from overlying waste added to the fill, and decomposition. Generally, at MSW landfills with liquids added to create bioreactor conditions, higher-than-typical rates of settlement are observed and suggest that accelerated decomposition is occurring.

For several years after placement and rigorous compaction, and after cessation of filling in an area, MSW typically settles at a rate of 0.5% to 2% of the waste height per year. As an example, if the waste height is 100 feet, it is expected to settle and compress by approximately 0.5- to 2-feet per year beneath the location the waste height is 100 feet.

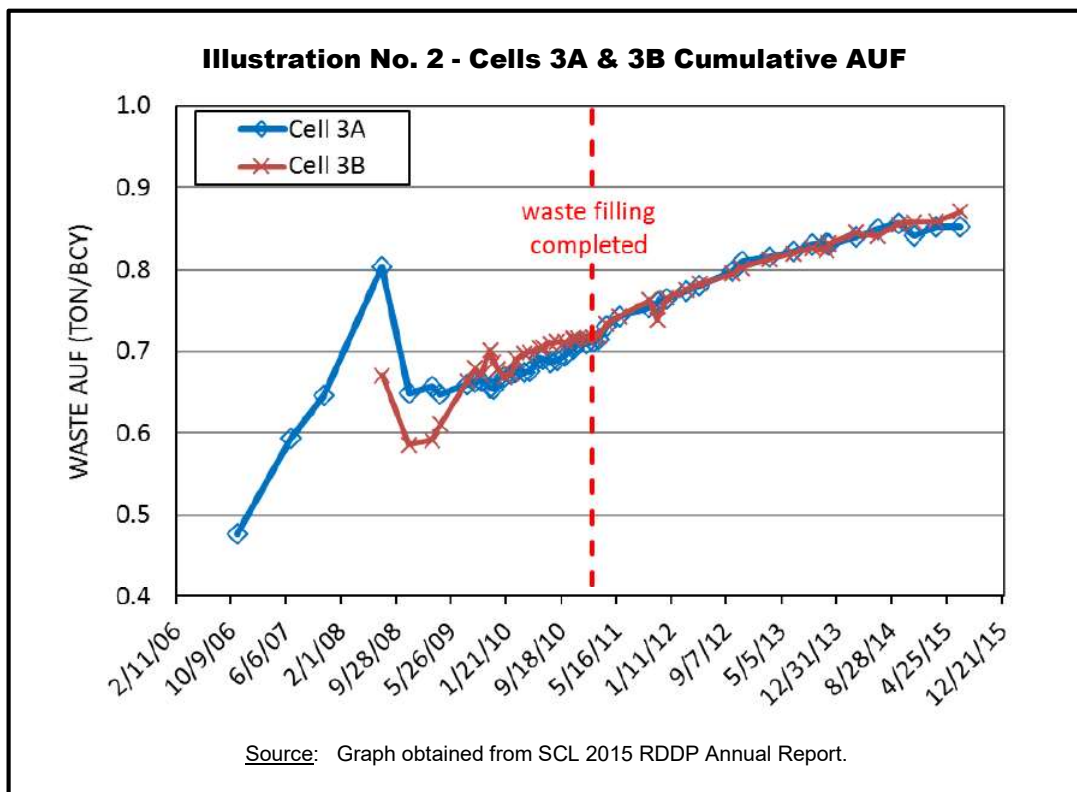
CTI used a combination of settlement point monitoring and aerial topographic flyovers to monitor settlement in “bioreactor” areas (Cells 3A, 3B, 4, 8, CW East, and CW West). The methods relied upon were:

- Airspace Utilization Factor: This is also known as waste density and is calculated by the weight of waste (tons) divided by the space occupied by that waste (bank cubic yards). As waste compresses and decomposes, its volume decreases; therefore, an increasing airspace utilization factor (AUF) can indicate the amount of compression and decomposition occurring. This method can be used even as waste is being placed in a given area by tracking the weight of added waste disposed of along with the added volume used.

- **Settlement Point Monitoring:** After waste filling has been paused in a given area, specific settlement survey points can be placed and measured on a period basis. This is a more precise way to monitor settlement and decomposition as there are fewer variables affecting the calculations.

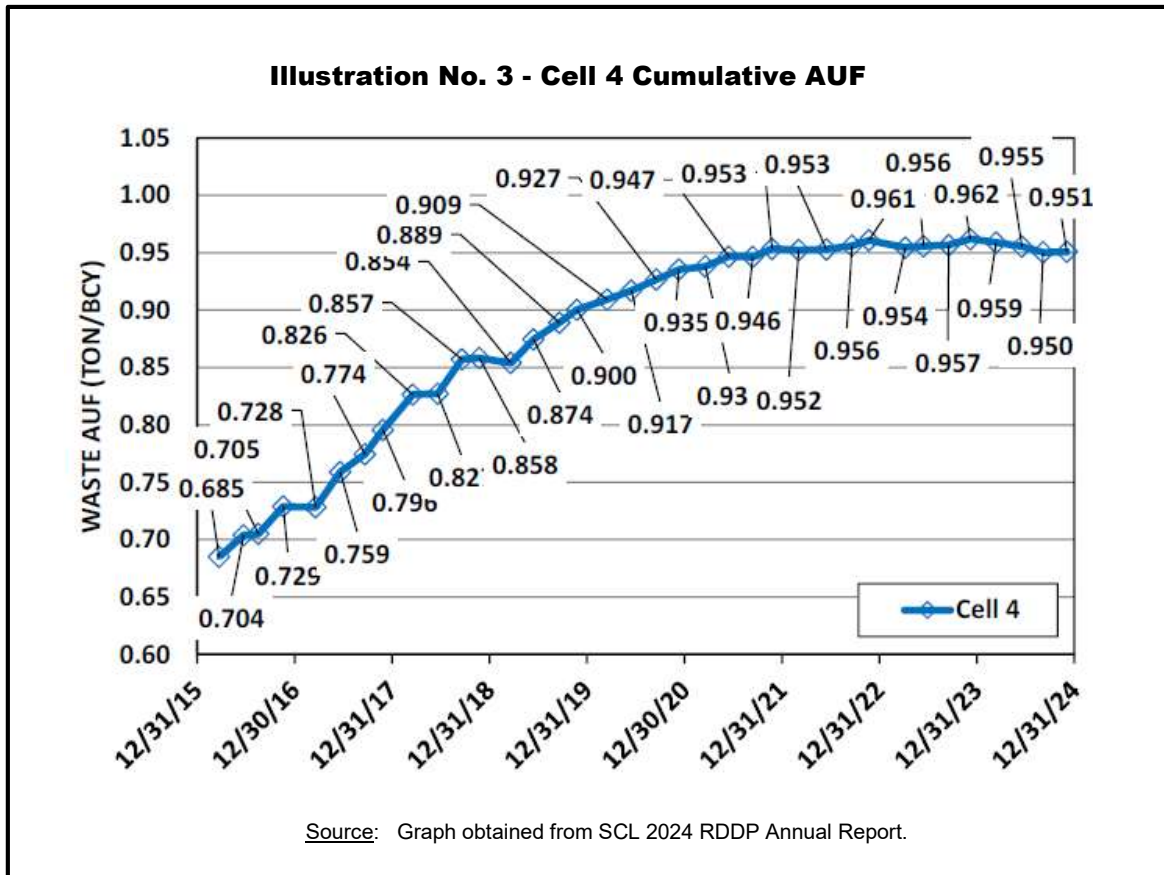
4.4.1 Review of Airspace Utilization Factor Results

Cells 3A and 3B: The graph presented as **Illustration No. 2** below was excerpted from the 2015 RDDP Annual Report. From the data presented below, it can be calculated that the cumulative AUF for Cells 3A and 3B between 2010 and 2013 (during the course of septage and leachate application) increased at a rate of approximately 4.5% per year. By years 2014 to 2015, the AUF increase rate had dropped to 1% to 2% per year. Both Cell 3A and Cell 3B contained only MSW, and C&D and special waste were disposed of in another Cell working face.



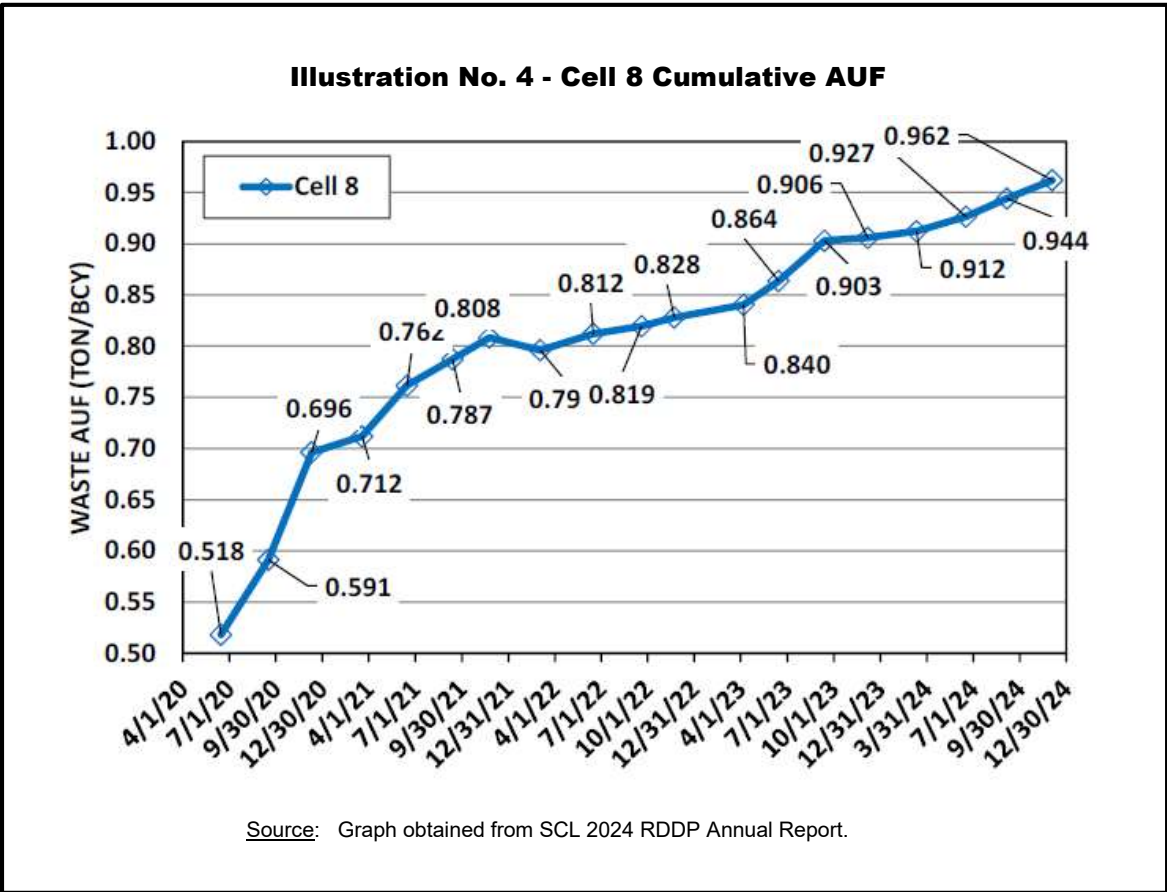
Cell 3A received 5.4 million gallons of septage, and 0.45 million gallons of leachate (92% of the added liquid was septage). Cell 3B, which has less waste than Cell 3A, received less liquid; specifically, Cell 3B received 1.6 million gallons of septage and 1.0 million gallons of leachate (62% septage). Despite the significant difference in the proportion of septage received, both cells exhibited similar increases in AUF, suggesting that septage was not more effective at enhancing settlement than leachate.

Cell 4: The graph presented as **Illustration No. 3** below was excerpted from the 2024 Annual RDDP Report. It shows high initial gains in AUF of about 9% per year and tapered to 0% per year. Cell 4 contains a commingled waste stream with MSW, C&D, and special waste all disposed of together.



Cell 4 received approximately 4.0 million gallons of septage with no leachate recirculation (100% septage). This includes 2021–2023 when approximately 2.7 million gallons of septage were disposed of without any gain in AUF.

Cell 8: The graph presented as **Illustration No. 4** on the following page was excerpted from the SCL 2024 RDDP Annual Report. It shows high initial gains in AUF of about 30% per year and tapered to 6% per year, four years after disposal began. Cell 8 contains a commingled waste stream with MSW, C&D, and special waste all disposed of together. No septage or leachate were introduced into Cell 8. Only approximately 0.6 million gallons of liquid pit sludge (sludge that settled out of the septage in the holding reservoirs) were disposed of in Cell 8.



4.4.2 Discussion of AUF Results

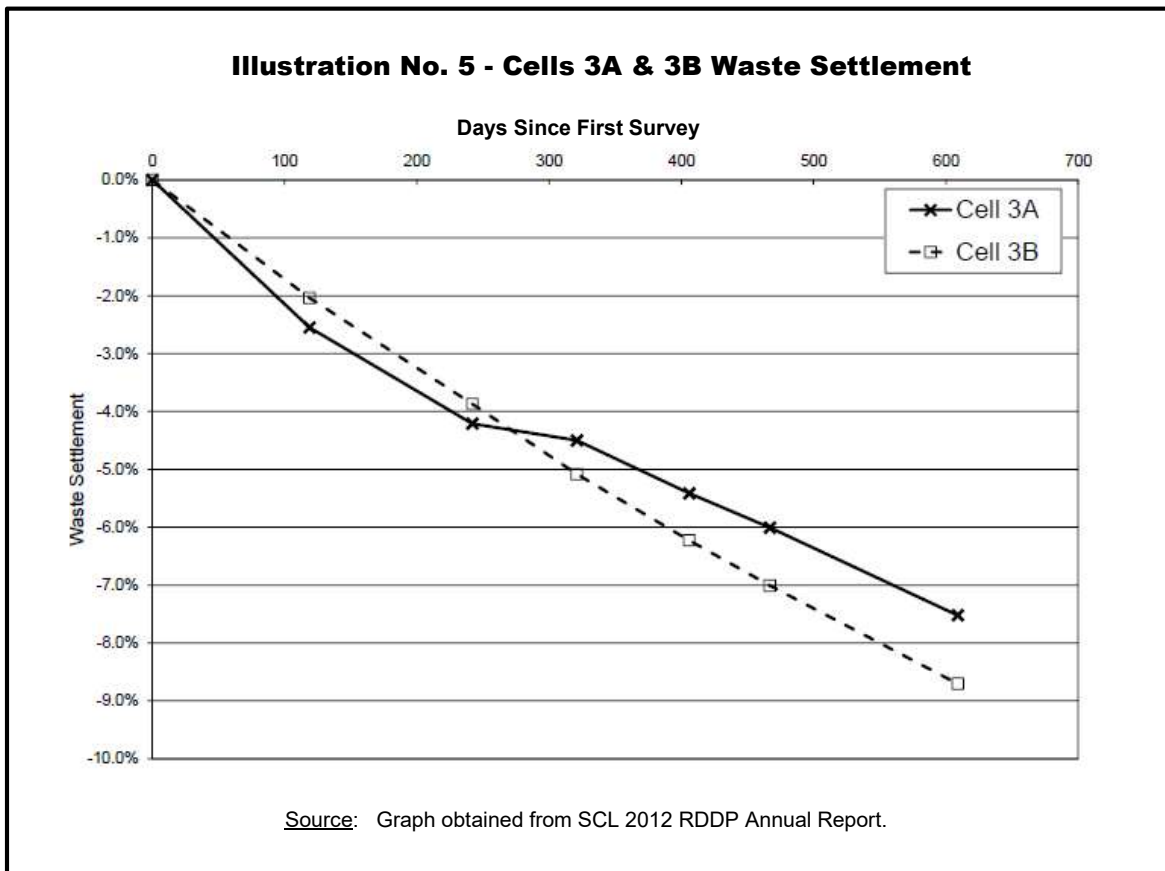
AUF, otherwise known as waste density, is expected to rapidly increase, especially as additional waste is placed over previously placed waste. In the case of Cells 3, 4, and 8, the initial densities of approximately 0.5 to 0.7 tons per cubic yard are somewhat low (typical as-compacted MSW densities range from approximately 0.7 to 0.8 tons per cubic yard) and suggest a moderate compaction effort during placement of waste in these cells. Therefore, the rapid increase in AUF with the longer-term leveling off is to be expected with, or without, added leachate or septage.

In addition, the increasing rate of AUF does not appear to be related to the quantity or proportion of septage applied in the cells. In CEC’s opinion, the AUF results presented do not support the accelerated decomposition expected in a bioreactor.

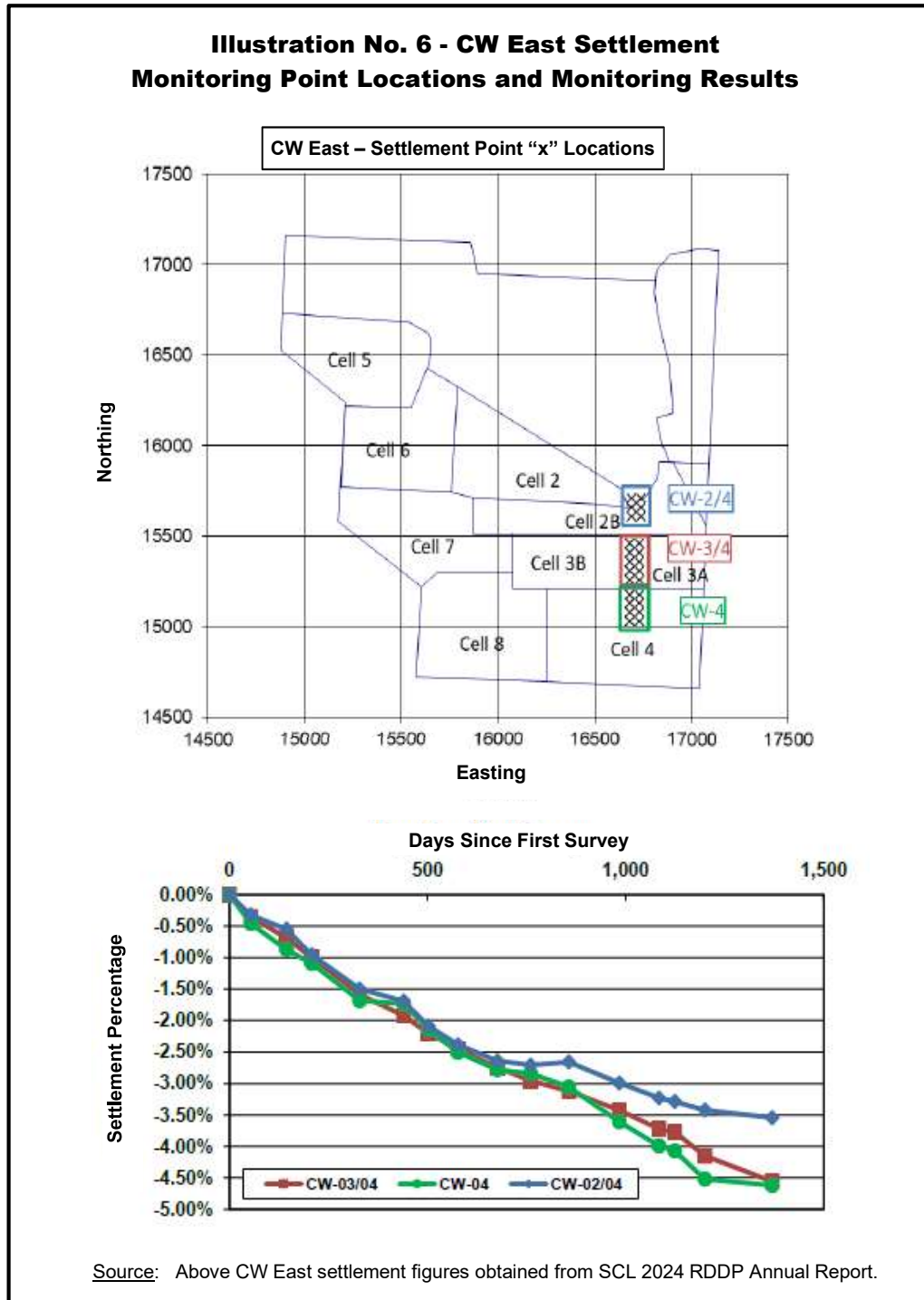
4.4.3 Review of Settlement Monitoring Results

Settlement rate is sometimes expressed as the settlement measured at a particular point divided by the total waste column height beneath that point. The result can be expressed in percent of waste height.

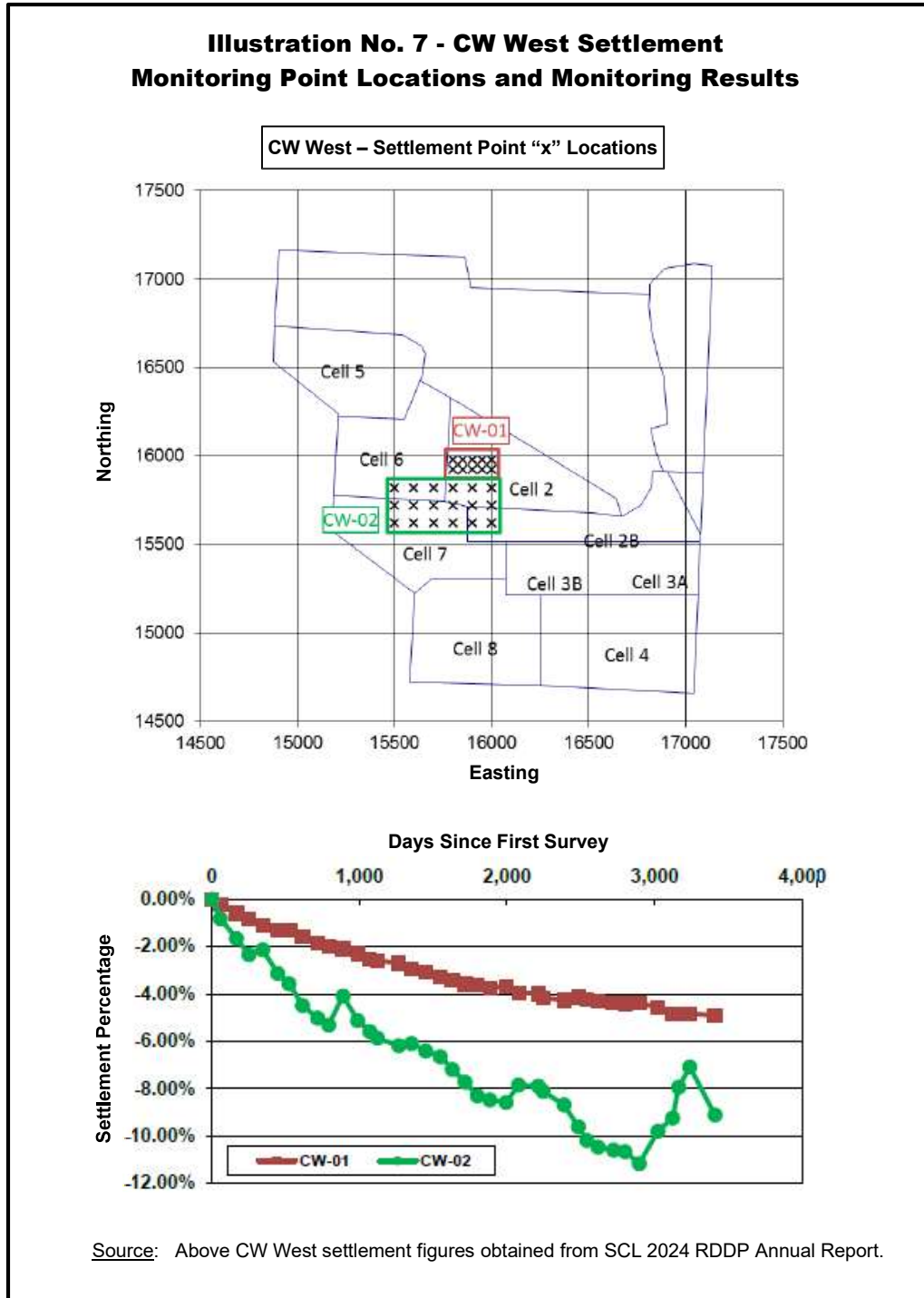
Cells 3A and 3B: The graph presented as **Illustration No. 5** below shows the average settlement rates (expressed as a percentage of the underlying waste thickness or waste height) for Cells 3A and 3B. The average rate of waste settlement is approximately 4.4% per year to 5.1% per year, which is faster than what is considered typical for MSW landfills; however, it correlates well with the 4.5% average increase in AUF for the same period. Despite the fact that Cell 3A received much more septage than Cell 3B, Cell 3B actually settled faster than Cell 3A during the same monitoring periods.



CW East Area: **Illustration No. 6** below presents the CW East settlement monitoring point locations (at top) and the settlement monitoring results directly below. **Illustration No. 6** shows measured settlements ranging from approximately 0.91% per year to 1.17% per year in the CW East bioreactor area.



CW West Area: **Illustration No. 7** below presents the CW West settlement monitoring point locations (at top) and settlement monitoring results directly below. **Illustration No. 7** shows measured settlements ranged from approximately 0.96% per year to 1.49% per year in the CW West bioreactor area.



4.4.4 Discussion of Settlement Monitoring Results

For the MSW-only Cells 3A and 3B, the settlement rate for Cell 3A is slightly lower than that of Cell 3B, despite the higher proportion of septage application to Cell 3A. This suggests that the greater septage application did not cause a higher rate of decomposition than the lower proportion of septage application. Both Cell 3A and Cell 3B did settle at a higher rate than what is considered typical for MSW, however, the initial low placement density (between approximately 0.5 to 0.7 tons per cubic yard versus a typical density of 0.7 to 0.8 tons per cubic yard), allowed a large amount of self-weight compression to occur which may have been inadvertently attributed to accelerated decomposition.

4.4.5 CEC's Opinion on Settlement Monitoring Results

Based on CEC's experience at scores of landfills across the country, after the initial few years of filling a cell, normal self-compression and decomposition typically causes settlement of 0.5% to 1.5% per year at non-bioreactor landfills. The settlement rates measured by CTI in the disposal "bioreactor" areas at Smiths Creek generally fall within this non-bioreactor range; therefore, there appears to be little, or no accelerated waste decomposition (i.e., additional settlement) related to the septage application.

4.5 IMPACT ON LANDFILL GAS GENERATION

4.5.1 Industry Landfill Gas Volume Prediction Model

Introducing septage into the waste mass is intended to stimulate gas production and decomposition, by creating a bioreactor which enhances energy production and increases airspace utilization. Evidence that this is occurring should be found in the data by examining the volumetric rate of gas generated per ton of waste generating that gas. If the volumetric rate of gas generated is higher than that generated elsewhere in non-bioreactor areas, or is faster than predicted, then it is possible that the septage application is having the desired effect.

A universal tool for predicting gas production at a landfill is the Landfill Gas Emissions Model (LandGEM) issued by the USEPA. LandGEM predicts methane generation flow rate (Q) per unit of waste mass (M) with the following variables:

- n = years elapsed since waste acceptance,
- k = methane generation rate constant, and
- L₀ = potential methane generation capacity.

LandGEM is a first-order (exponential) model that basically predicts the gas generation from each parcel of waste disposed during a one month period over the timeframe of gas generation, then sums all the predicted gas generation from each parcel for each time period. The potential methane generation capacity “ L_0 ” is related to the type of wastes received at the landfill and the proportions of those waste materials. For instance, MSW has a higher “ L_0 ” than C&D waste because C&D has less organics available for decomposition. “ L_0 ” is constant for a particular landfill or portion of a landfill because it is dependent only on the initial waste composition.

The methane generation rate constant, “ k ” is a function of (a) waste moisture content, (b) availability of nutrients, (c) pH, and (d) temperature. The constant “ k ” controls the time frame over which gas will be generated.

The value for “ k ” is usually assigned based on local climatic conditions as temperature is an important factor for microbial activity and precipitation is a surrogate for waste moisture. However, when moisture is introduced through other means (e.g., septage application), the value for “ k ” can and should increase due to increased moisture content beyond what precipitation rates would suggest.

4.5.2 CTI Application of Gas Volume Prediction Model

In the Annual RDDP Reports, CTI applied the principles of the LandGEM model in ways that are different from the approach the USEPA intended. Note that one of the key CEC project team members (Ms. Debra Reinhart, Ph.D., P.E., BCEE) contributed to the current version of LandGEM. CEC’s review of the calculations provided by CTI results in the following observations:

- No control data was available for areas that did not receive leachate recirculation or septage. Therefore, no data was presented to establish a baseline “ k ” value to which calculated “ k ” values could be compared.
- The only comparison presented was between a cell that received leachate and a cell that received both septage and leachate instead of a comparison to a dry cell.
- The variable “ L_0 ” was allowed by CTI to change over the time for each modeled cell even though this variable is related only to the initial composition of the waste. Typical application of the LandGEM model does not allow the value of “ L_0 ” to vary after an initial value has been established.
- CTI’s gas modeling included assumptions of lag times in gas production, established during an initial calibration phase, which varied from one cell to another and gas collection efficiencies that were not directly related to cover conditions.

- Once “k” was established for Cell 3B, the model parameter “k” for other cells was estimated by varying it as septage was added and moisture content increased. The method for estimation, therefore, was dependent on previous gas generation, the cumulative amount of septage introduced, and L_0 (which was assumed to change with time).
- The modeling is repeated, with different assumed “ L_0 ” and “k” values, over short periods of time as septage is added and waste degrades. This introduces numerous opportunities for inaccuracies and becomes a data-fitting exercise with two fitting parameters (“k” and “ L_0 ” as a function of time). Thus, the approach is a curve-fitting approach to make the calculated landfill gas generation rates match measured gas flow rates.

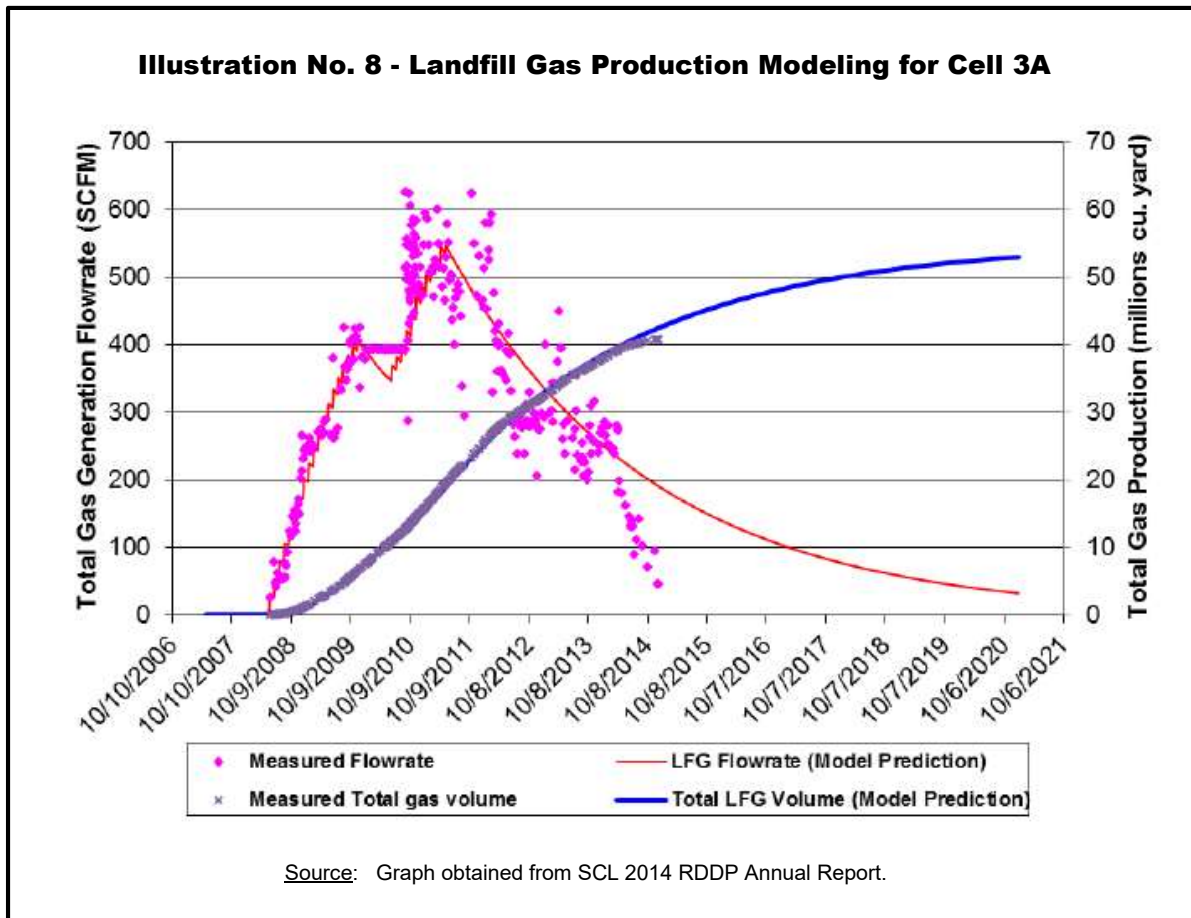
The Annual RDDP Reports repeatedly compared these calculated “k” values to LandGEM values for conventional (non-bioreactor) landfills, concluding that the septage addition enhanced gas generation. Because the approach used to calculate “k” in the RDDP reports is quite different, no such comparison is possible.

CTI also presented a comparison of “k” values for Cells 3A and 3B over the period that Cell 3A received leachate and septage and Cell 3B received only leachate. Estimated moisture content for the two cells was quite similar. The “k” value Cell 3A was considerably higher than Cell 3B, suggesting that septage had stimulated gas production, contradicting settlement, and AUF data. However, there are several possible explanations for this. First, the model fit for Cell 3A appears to be much better than 3B, particularly during the post peak period which occurred at the point of adding septage.

Further, one of the greatest factors influencing a back-calculation of the value of “k” is the assumed volume of waste from which the measured gas is generated. If the volume of waste contributing to the gas production is underestimated, the resulting calculated “k” value will be too high. Conversely, if gas is extracted over several cells, but attributed to the waste volume in only one cell, then the resulting calculated “k” value will be too high.

As shown in **Figure 3** (provided in the Figures section of this report), the perforated (dashed) sections of the horizontal gas collectors extend well beyond the cells to which they are assigned and overlap significantly. This may result in a large overestimation and/or double counting of gas attributed to a given cell’s waste volume. This was clearly shown in the high “k” value of 0.8 per year estimated for Cell 8, despite no leachate or septage addition. CTI attributed the high “k” value to “waste stream-specific factors affecting gas generation in that zone, such as waste composition, historical disposal practices, or atypical biodegradable inputs.” However, it is just as likely that the amount of extracted gas assigned to Cell 8 was overestimated due to the large overlapping of Cell 8 gas collection assets with adjacent cells.

In addition, volume flow rate measured from cells experienced dramatic reductions in very brief periods of time. As seen in **Illustration No. 8** below for Cell 3A on the following page (taken from the SCL 2014 RDDP Annual Report), landfill gas generation appeared to drop from approximately 600 cubic feet per minute to less than 100 cubic feet per minute in the matter of three years. Such a drop would result in calculation of a high value of “k.” This steep drop is not believed to be totally related to “bioreactor” conditions but rather partly due to a failing horizontal gas well infrastructure (due to settlement and subsequent water-locking of the extraction piping) and loss of applied vacuum.



These issues lead to the CEC conclusion that using a back-calculated “k” may not be indicative of enhanced gas generation rates from septage addition.

4.5.3 Application of Septage versus Leachate

To assess the contribution to the overall methane gas generation of the accepted septage volume, the methane generation from the accepted septage volumes in Cells 3A and 3B was calculated over the period of septage addition to these cells (2008-2016). As previously discussed, the methane generation potential is based on the organic content of the waste, which can be measured as

chemical oxygen demand (COD). The “L₀” or methane generation potential of septage is assumed to be ~5.6 cubic feet of methane per pound of COD.

Based on this value and the added septage and leachate through 2016, **Table 3** below presents an estimate of gas generation potential by added liquids and compares this value to actual gas generation reported by CTI.

Table 3 Cells 3A & 3B Actual Gas Generated Compared to Calculated Gas Generation Due to Added Liquids 2008-2016			
Variable	Units	Cell 3A	Cell 3B
From CTI Reported Data:			
Waste Added through 2016 <i>(from CTI 2020 RDDP Annual Report)</i>	tons	245,029	139,207
Septage Added through 2016 <i>(from CTI's SCL Injection Data Excel File)</i>	gallons	5,568,956	1,515,611
Leachate Addition through 2016 <i>(from CTI's SCL Injection Data Excel File)</i>	gallons	623,057	1,003,451
Total Actual Gas Generated through 2016 <i>(from CTI 2016 RDDP Annual Report)</i>	million cy	49	20
From CEC Calculations:			
Gas Generation Potential from Added Leachate and Septage, Calculated by CEC	million cy	0.20	0.067
“L ₀ ” for Waste Added through 2016, Calculated by CEC	m ³ methane/ kg waste	75	54
Notes: 1. “L ₀ ” for Waste Added through 2016 - calculated by dividing total methane produced (assumed equal to 50% of total actual gas generated) by the total waste added. 2. “L ₀ ” for Septage and Leachate Added - assumed equal to 5.6 cubic feet of methane per pound of COD. 3. CEC calculations are provided in Appendix C .			

As can be seen from the data in **Table 3** above, the gas generation potential from added liquids that was calculated by CEC is 0.41% of the total actual gas generated for Cell 3A and 0.34% of the total gas generated for Cell 3B:

- Cell 3A = (0.20)/(49) x (100%) = 0.41%
- Cell 3B = (0.067)/(20) x (100%) = 0.34%

The above analysis confirms that the methane generation from the biological substrate present in the accepted septage does not significantly contribute to the overall landfill methane generation within the bioreactor waste disposal area.

A breakdown of CEC's calculations is provided in **Appendix C**, along with questions submitted to SCL by CEC's project team members (i.e., Ms. Debra Reinhart, Ph.D., P.E., BCEE and Mr. Michael R. Beaudoin, P.E.) regarding CTI's calculations and assumptions, and CTI's responses to these questions provided by SCL.

4.6 OPINION OF BIOREACTOR EFFECTIVENESS

CEC concludes that the data, calculations, and observations do not support the presence of prevalent bioreactor conditions at any of the cells at SCL, nor that the use of septage had advantages over leachate in creating bioreactor conditions. Additionally, the organic content present in septage provides little to no advantage to leachate recirculation with respect to gas generation.

5.0 LANDFILL ODORS

5.1 COMMON LANDFILL ODOR CONTRIBUTORS

There are three primary sources of landfill odors:

- Active Working Face Odors;
- Landfill Gas Odors; and
- Leachate Management Odors.

These sources are described in the following paragraphs.

5.1.1 Active Working Face Odors

When MSW is delivered to a landfill, it is dumped out of trucks and spread in a thin lift for compaction. During this process, the waste is stirred and exposed to adjacent air. The resulting odor resembles those that residents experience when disposing and managing of their own household waste. Additionally, some industrial waste and biosolids (sludge from a wastewater treatment plant) can exhibit strong odors when placed and managed at the active working face of the landfill.

Typically, workplace odors diffuse rapidly and are not observed off-site.

5.1.2 Landfill Gas Odors

As waste decomposes in a landfill it produces gas which creates a positive pressure in the waste mass. Landfill gas is mostly carbon dioxide and methane — both of which are odorless. However, trace constituents can contribute to typical landfill gas odors, including:

- Ammonia;
- Fatty acids; and
- Hydrogen sulfide.

Of these, the most common constituent to contribute to off-site odors is hydrogen sulfide because its odor threshold (concentration at which odor can be detected) is very low.

5.1.3 Leachate Management Odors

Infiltration of precipitation through waste materials produces leachate. Leachate typically is odorous due to the presence of ammonia, fatty acids, decomposed organics, and other trace compounds. Leachate is collected from the bottom of the landfill and pumped out of the landfill into above ground storage tanks. During this process, odorous constituents in leachate can be volatilized and released into the air.

5.2 ODOR MITIGATION TECHNIQUES

Landfill operators have a number of measures that can be used to reduce odors and prevent them from being detected off-site. The methods are specific to the type of odor as described below.

5.2.1 Active Working Face Odors

The active working face odors can be minimized by proper use of daily cover. Rules require the use of 6 inches of soil material or approved alternative cover at the end of every day to prevent blowing litter, animal vectors, and odors. If a particularly odorous material is received, the operator may immediately cover the waste with soil rather than wait until the end of the day.

5.2.2 Landfill Gas Odors

If not controlled, the positive pressure caused by gas generation within the landfill can result in “fugitive emissions” which can carry the odorous compounds discussed in Section 5.1.2. Typically, these emissions are minimized by installing or expanding a gas extraction system to create a vacuum within the landfill. The gas collected is combusted through a flare or collected for creation of energy. Both processes destroy the odorous compounds in the gas.

Improving landfill cover can also help minimize fugitive emissions. Adding thicker soil or placing an impermeable synthetic cover can improve the efficiency of the gas collection system and provide a barrier to migration.

5.2.3 Leachate Management Odors

Leachate odors can most easily be controlled by keeping transfer and storage vessels closed. Since venting is needed to relieve pressure inside these vessels, it may be beneficial to collect the off-gassed vapors and direct the vapors through an activated carbon system or a thermal destruction device.

5.3 SMITHS CREEK ODORS

CEC has reviewed many sources of information to determine the type and cause of odors detected in the Smiths Creek community. These include the following records: regulatory correspondence (violation notices), SCL responses to violation notices prepared by CTI, landfill gas extraction system design and performance, waste receipts, application of septage location and quantity, drone gas emission surveys, and leachate management and disposal.

Based on observations made from review of the records, it appears that the odors reported near SCL were primarily related to landfill gas fugitive emissions as described in Section 5.1.2. Fugitive landfill gas odor is detected off the landfill property when it is either released in significant quantity, or when it contains a particular constituent that has an extremely low odor threshold. At SCL, we believe the odor detected in the community was due to both factors as detailed below.

- Insufficiency in vacuum supply to the south end of the landfill prevented effective capture of landfill gas; and
- Acceptance of a large volume of sulfate-containing special waste (Domtar paper mill sludge) which produced odorous hydrogen sulfide, which was carried to the neighboring communities by fugitive gas emissions.

Evidence for this conclusion is based on the following:

- Domtar paper mill sludge was disposed of in Cell 8 between June 2020 and March 2021.
- Off-site odor complaints decreased significantly after the late 2023/early 2024 installation of the Cell 8 perimeter toe-gas collector, cover improvements in the side slopes of Cell 8, and commissioning of the supplemental flare to improve vacuum conditions to the southern part of the landfill.
- Drawings presented in **Appendix D** show methane and hydrogen sulfide drone survey results which indicate that methane emissions and hydrogen sulfide levels significantly decreased after remedial efforts were undertaken in the Cell 8 area (where the Domtar paper mill sludge was disposed).
- No odor was present during CEC's site visit on October 22, 2025.

6.0 OPINION ON CONSULTANT'S EFFORTS

CEC reviewed CTI's response to the Environmental Information Logistics implementation plan report, dated July 2025. In general, we believe that CTI has done a very good job in addressing the operational and maintenance issues of the existing GCCS system identified by Environmental Information Logistics and EGLE, and in explaining the approaches proposed and implemented, and their effectiveness in responding to the identified issues.

Based on the body of work reviewed for this report, CEC finds that CTI is a competent landfill engineering and design firm. CTI's strengths include the areas of landfill design for environmental protection, research and development, and innovation. While the circumstances that resulted in the odors were avoidable in hindsight, a reasonable level of due care was exhibited by CTI and SCL staff before, during, and after the odor issues occurred.

7.0 RECOMMENDATIONS

7.1 GENERAL LANDFILL OPERATIONS AND AESTHETICS

The landfill is well operated and maintained. During CEC's site visit, we observed the following issues that could use attention and improve the operation and aesthetics of the landfill. We understand that some of these proposed improvements are already underway.

- All landfill control features should be clearly labeled (e.g., gas wellheads, manholes, pump stations, and pipes with flow direction indicated).
- Directional signs for customers and visitors could be increased.
- Bare spots (i.e., areas of landfill with exposed waste) should be supplemented with low-permeability soil and topsoil and seeded.
- All erosion rills should be filled with low-permeability soil and reseeded.

7.2 LANDFILL GAS COLLECTION AND CONTROL SYSTEM

CEC agrees with the CTI suggestion that the GCCS should be looped with an additional southern vacuum header pipeline. The proposed perimeter exterior vacuum header pipeline system extending along the western and southern perimeters of the bioreactor waste disposal areas would extend vacuum distribution to the furthest areas of the Cell 8 waste disposal areas.

It is recommended that the proposed southern perimeter exterior vacuum header pipeline be constructed for 18-inch HDPE PE 4710 SDR 17 pipe and fittings and include in the common excavated trench a 2-inch HDPE SDR 9 compressed airline, and a 2-inch HDPE SDR 11 force main within a 4-inch HDPE SDR 17 containment pipe dual containment force main. CEC recommends enhancement of the proposed southern perimeter exterior vacuum header pipeline system included have header access risers with control valve assemblies installed every 250 feet to provide interconnection access for future expansion. It would be then possible to install manifold units at each end of a series of horizontal lateral extractors and provide the ability to apply vacuum from both ends of the horizontal lateral extractors. This would enhance vacuum application to the waste mass at both ends of horizontal lateral extractors and increase the zone of influence. Further, this would facilitate overall landfill gas extraction and prevent uncontrolled surface emissions with their associated odors.

In addition, it is recommended that the supplement blower, process utility flare skid (Flare 3) and the Interra Ferrosorp hydrogen sulfide adsorption treatment vessel components be moved to the southern perimeter for stability and access and interconnected to the proposed southern perimeter exterior header pipeline. The existing location of these components is located within the Cell 8 waste disposal area where they are subject to differential settlement, and therefore would need to

be eventually moved to claim additional waste disposal airspace in the future. The installation of a header access riser with tee and isolation valves assembly at the high point of the proposed perimeter exterior vacuum header pipeline system would provide access and interconnection for the relocation of the Flare 3 and hydrogen sulfide equipment. CEC's proposed modifications/additions to CTI's Southern Loop Expansion Plan are presented on **Figure 4** (provided in the Figures section of this report).

Detailed recommendations related to the GCCS are provided in **Appendix E**. Brief descriptions of other recommendations are provided below:

- Implement measures to reduce and minimize air intrusion into the waste mass.
- Improve the tightness of soil seals at places where pipes penetrate through soil cover.
- Install additional vertical gas wells in the southern portion of the landfill to augment and then replace the horizontal extractors which may fail with time due to settlement and watering-in.
- Install compressed air supply and leachate laterals to all future vertical gas collection wells to enable placement of liquid extraction pumps when needed.
- Add a redundant multi-stage centrifugal blower unit to the landfill gas equipment skid.
- Consider upsizing the perimeter collection header to meet recommended gas velocity guidelines.

7.3 SEPTAGE APPLICATION

CEC finds no evidence that septage application caused a significant or sustained bioreactor condition and does not believe that septage application improved the landfill operation and management. In addition, application of septage appears to create significant operational challenges and expense, as well as the burden and expense of substantial tracking and reporting as required by the RDDP License.

CEC has not attempted to review the cost-benefit of septage application. However, it appears that septage application was not a factor in the causation of odors and otherwise did not cause discernable harm to the landfill. Therefore, CEC believes that septage application could resume at similar quantities and using similar methods as previously employed.

7.4 WASTE APPROVAL PROCESS

The objective of a landfill operator is to maintain a "healthy" fill. A healthy fill has no off-site odors, yields gas with optimal methane content, and has stable slopes, free from seeps or bulges. A key component of a healthy landfill is management of incoming waste types.

A significant contributor to the odors experienced at SCL was the lack of a rigorous special waste approval process, resulting in the acceptance of a large quantity of a wet sulfate-containing paper mill waste. Therefore, CEC recommends that SCL implement criteria for waste acceptance, procedures for waste screening and approval, and a tracking process that can minimize the potential for future landfill distress. The screening process should focus on three particular waste streams that can adversely impact the health of a landfill. Potential effects and management strategies for each of these types of waste are described in the following sections.

7.4.1 Wet Waste

Certain non-MSW types of waste carry moisture in amounts that could be released into the fill after disposal. If a waste mass in a landfill becomes too wet, slope stability and gas extraction can be negatively affected. Therefore, it is recommended to separately track, approve, and manage the amount of “wet waste” that can be accepted.

Examples of wet waste include sludge, tank bottoms, dredge spoil, and drill cuttings. Typical MSW can absorb some of the liquid released by wet waste, but C&D and most industrial or special wastes cannot. For this reason, it is advisable to restrict the volume of wet waste as a percentage of the MSW received at the landfill. A typical limit for wet waste is 10–15% of the MSW received. However, if liquid is added through leachate recirculation or septage application, the percentage of wet waste should be reduced below these typical limits.

7.4.2 Heat Producing Waste

Over the past 20 years, a number of MSW landfills have experienced severe heating events. These events are sometimes called a subsurface reaction (SSR) and can raise the internal temperature of the landfill to over 300 degrees Fahrenheit (as opposed to typical temperatures of 100 to 130 degrees Fahrenheit). An SSR can cause significant odor complaints, destroy the quality of landfill gas, and destabilize slopes. A regulatory agency may close a landfill experiencing an SSR.

Certain special wastes exhibit heat-releasing properties that can contribute to an SSR. Examples include ash materials, metal production byproducts (especially aluminum), lime-containing materials, and baghouse waste.

These wastes can be safely managed by limiting the quantity disposed of as a fraction of the total waste received. A typical upper limit of 5% of total waste is recommended; however, some heat releasing wastes are so strongly exothermic that they should be prohibited. Tests can be performed to determine how strongly exothermic a particular special waste is.

7.4.3 Sulfate Containing Waste

Waste that contains sulfur compounds (e.g., calcium sulfate) can be utilized by landfill microorganisms in the presence of moisture and organic material to produce hydrogen sulfide. Typical wastes that contain sulfur compounds include drywall, sludge waste, and industrial process waste including paper production waste.

Hydrogen sulfide is distinctive in common landfill gas because it has an extremely low odor threshold and can be detected at the part per billion by volume concentration. Landfill gas typically has relatively low concentrations of hydrogen sulfide (100 to 500 parts per million volume) which disperses rapidly when released as a fugitive emission. Hydrogen sulfide has a distinct “rotten egg” smell that may be altered when present as one of several odorous landfill gas constituents.

Sulfur compound tests can be performed on waste before it is approved for disposal at the landfill. Placing limits on total sulfate loading in the landfill, expressed as parts per million sulfate per ton of total waste can minimize the potential for excessive production of odorous hydrogen sulfide. The acceptable sulfate limit will depend on the quantity of waste to be received as well as the quantity of other sulfate-containing waste accepted at the landfill.

7.5 MITIGATION OF SMITHS CREEK LANDFILL ODORS

Odors have significantly reduced due to natural attenuation of hydrogen sulfide production and GCCS improvements. Production of hydrogen sulfide will continue to decrease with time as the finite amount of sulfate present in the waste is converted. Further improvements to the GCCS as described in Section 7.2 of this report should prevent off-site odors due to fugitive gas surface emissions.

8.0 SUMMARY AND CONCLUSIONS

CEC offers the following summary and conclusions of our review efforts.

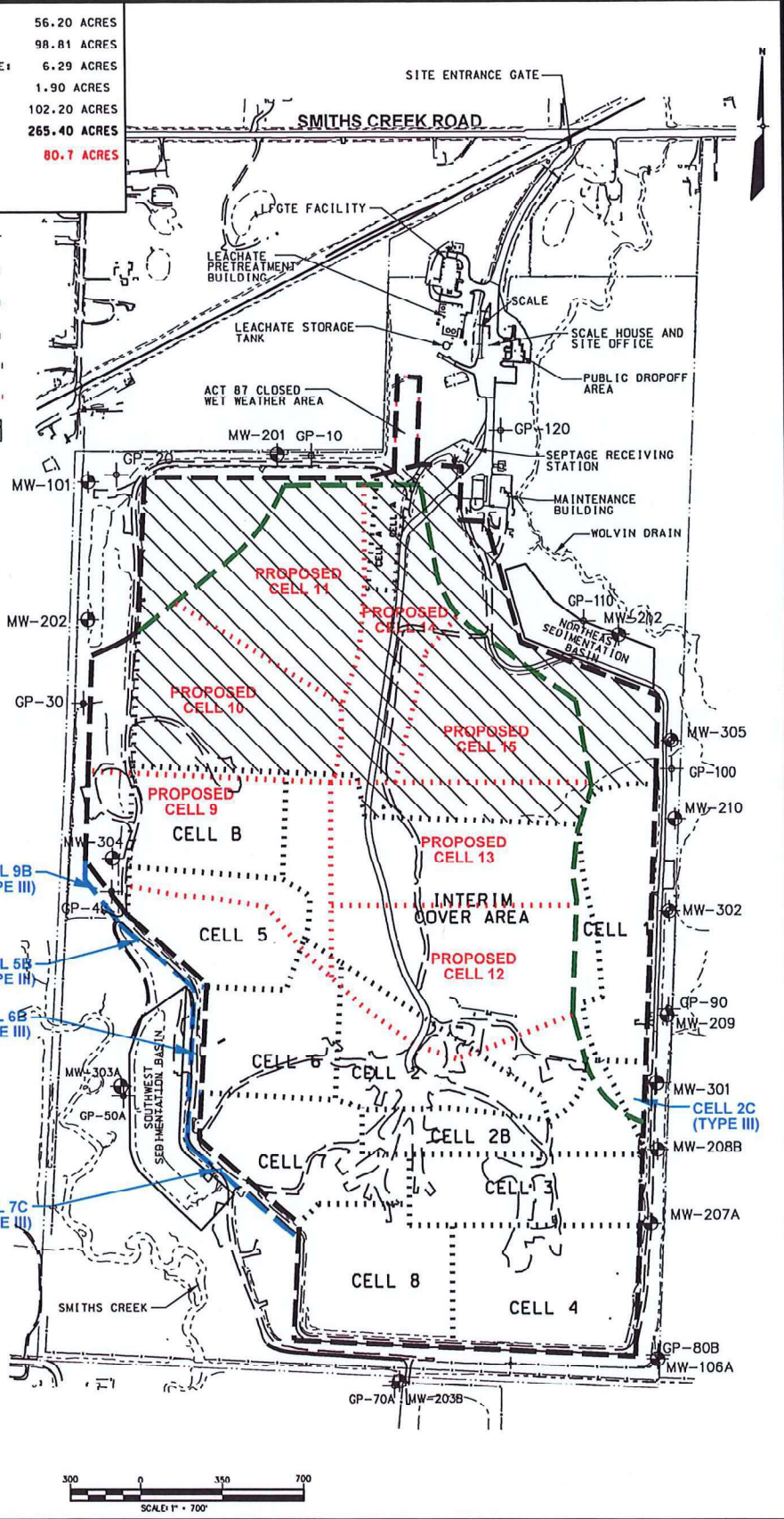
1. SCL is a well-operated and maintained landfill.
2. The odors detected in the community were the result of fugitive landfill gas emissions caused by insufficiency in GCCS vacuum applied to the landfill, especially in the southern end of the site.
3. Acceptance of a large volume of sulfate-containing special waste (Domtar paper mill sludge) produced high levels of odorous hydrogen sulfide providing a very detectable and noticeable odor note to the fugitive gas emissions.
4. SCL has made significant GCCS system improvements.
5. GCCS improvements, together with natural attenuation of the Domtar paper mill sludge impact have mitigated odors at the facility.
6. Septage application was likely not a contributor to the odor issues, but rather the GCCS issues and Domtar paper mill sludge as listed above.
7. Further GCCS improvements to enhance delivery of vacuum to the wellfield and provide additional gas collection coverage should be made over the next two to three years to further improve performance.
8. Improvements are recommended and detailed in the report for the site waste acceptance and tracking procedures.
9. Septage application may have created local “bioreactor” zones but did not significantly improve waste decomposition or landfill gas generation at the site.
10. Resumption of septage application is possible at similar rates and using similar processes as previously employed.
11. CTI is a competent landfill design firm. While the circumstances that resulted in the odors were avoidable in hindsight, a reasonable level of due care was exhibited by CTI and SCL before, during, and after the odor issues occurred.

FIGURES

FIGURE 1 - SITE PLAN

PRE-EXISTING CERTIFIED CLOSED AREA:	56.20 ACRES
ACTIVE TYPE II CELLS:	98.81 ACRES
UNCONSTRUCTED TYPE II CELLS WITHOUT FINANCIAL ASSURANCE:	6.29 ACRES
UNCONSTRUCTED TYPE II CELLS WITH FINANCIAL ASSURANCE:	1.90 ACRES
ISOLATION AND ANCILLARY AREAS:	102.20 ACRES
TOTAL FACILITY AREA:	265.40 ACRES
OVERLAY AREA (NOT COUNTED IN TOTAL FACILITY AREA):	80.7 ACRES

- PROPERTY LINE
- PERMIT TYPE II LIMIT OF WASTE
- PERMIT TYPE III LIMIT OF WASTE
- PERMITTED VERTICAL EXPANSION LIMIT OF WASTE
- PERMITTED CELL BOUNDARY
- PROPOSED CELL BOUNDARY
- CLOSED AREA
- TYPE II CELL CELL 8
- TYPE III WASTE ONLY CELL 2C
- PROPOSED OVERLAY CELL CELL 11
- GROUNDWATER MONITORING WELL
- GAS PROBE
- PAVED ROAD
- GRAVEL ROAD



12:58:25 PM
 6/25/2025
 C:\Shared\Box\Municipal\ST. Clair County\Smiths Creek Landfill\CAD\permit\2021 Permit\drawings\facility map 2025.dgn

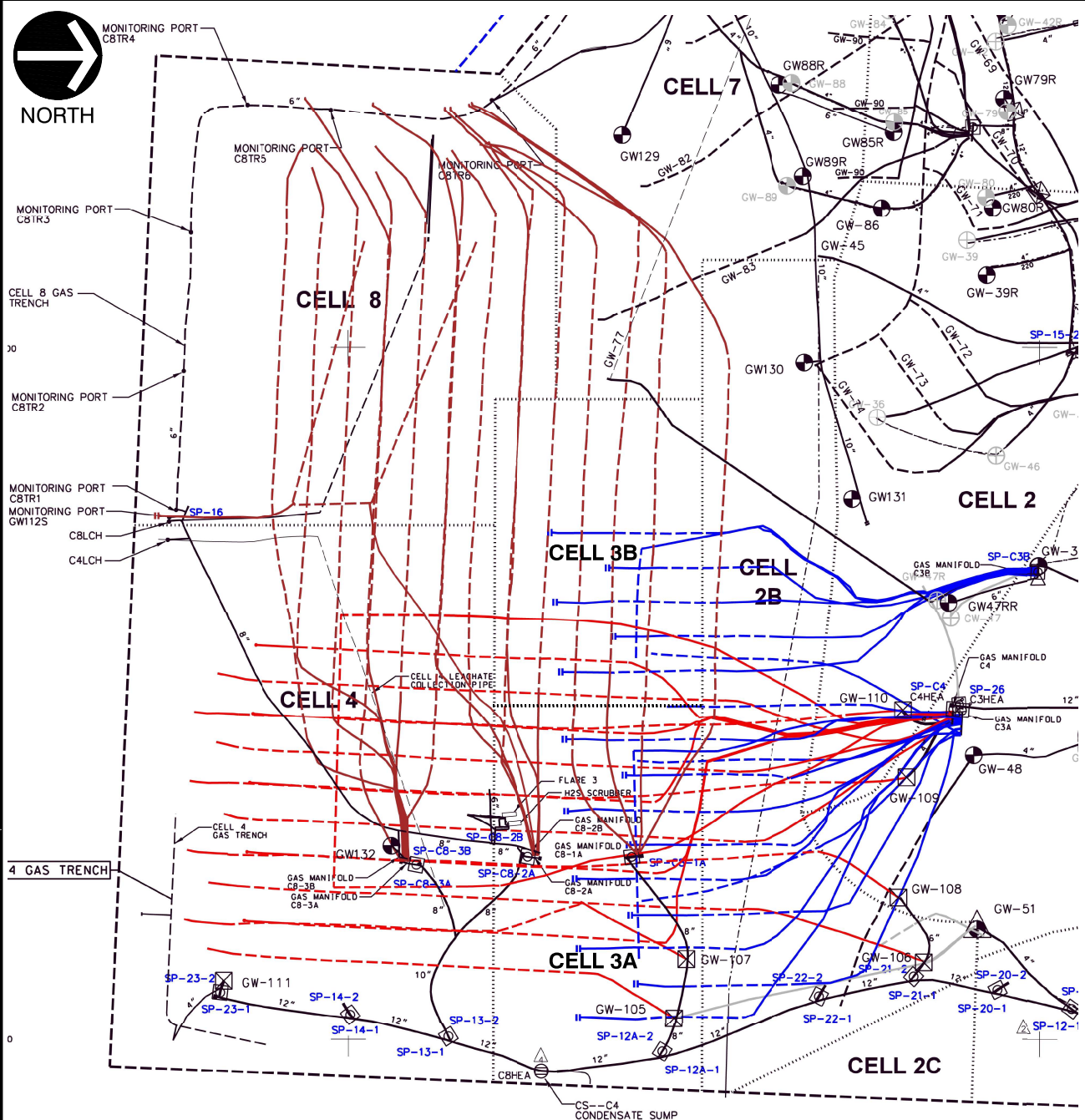


CTI and Associates, Inc.
 34705 W. 12 Mile Rd, Suite 230
 Farmington Hills, Michigan 48131
 248.486.5100 (fax) 248.486.5050
 www.cticompanies.com

ATTACHMENT A
FACILITY MAP
 SMITHS CREEK LANDFILL
 ST. CLAIR COUNTY, MICHIGAN

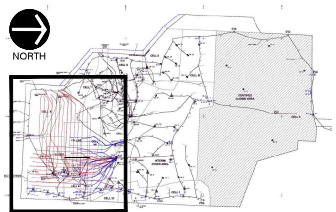
JUNE 2025

25L002.002



LEGEND

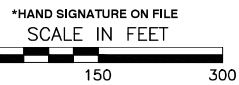
-----	SOLID WASTE BOUNDARY		GAS EXTRACTION WELL WITH PNEUMATIC PUMP
.....	CELL BOUNDARY		GAS EXTRACTION WELL WITH WINDMILL PUMP
---	CONTOUR	-----	AIR AND CONDENSATE LINES (2" SDR-9/2" SDR-11)
	BLIND FLANGE	-----	GAS HEADER PIPE
	GAS EXTRACTION WELL	-----	GAS EXTRACTION LINE
	DECOMMISSIONED GAS EXTRACTION WELL	-----	GAS WELL/PIPING INSTALLED NOT CONNECTED TO SYSTEM
	REMOTE WELL HEAD		SAMPLING PORT
	CONTROL VALVE AND RISER	-----	CELL 3 GAS EXTRACTION LINE
	DRIPLEG	-----	CELL 4 GAS EXTRACTION LINE
	CONDENSATE PUMP	-----	CELL 8 GAS EXTRACTION LINE
	LATERAL EXTRACTION LINE WELL HEAD		
	HEADER ACCESS POINT		
	STAND-ALONE FLARE		



SUBJECT AREA
N.T.S.

REFERENCE

- BASE EXISTING GAS SYSTEM PROVIDED BY ST. CLARE COUNTY, MICHIGAN. DRAWING DEVELOPED BY CTI AND ASSOCIATES, INC, FARMINGTON HILLS, MICHIGAN, CTI PROJECT NUMBER 25L002, DRAWING 1, DATE OF LAST REVISION SEPTEMBER 2, 2025.



ENGINEERING, SURVEYING AND LANDSCAPE ARCHITECTURE IN THE STATE OF NORTH CAROLINA WILL BE PROVIDED BY CEC SURVEYING AND LANDSCAPE ARCHITECTS OF NC, PLLC. SERVICES IN PUERTO RICO WILL BE PROVIDED BY CEC ENGINEERS & CONSULTANTS, LLC. LANDSCAPE ARCHITECTURE SERVICES IN THE STATE OF OHIO WILL BE PROVIDED BY CEC LANDSCAPE ARCHITECTS, LLC.

CEC
Civil & Environmental Consultants, Inc.

1230 East Diehl Road
Suite 200
Naperville, IL 60563
Ph: 630.963.6026
www.cecinc.com

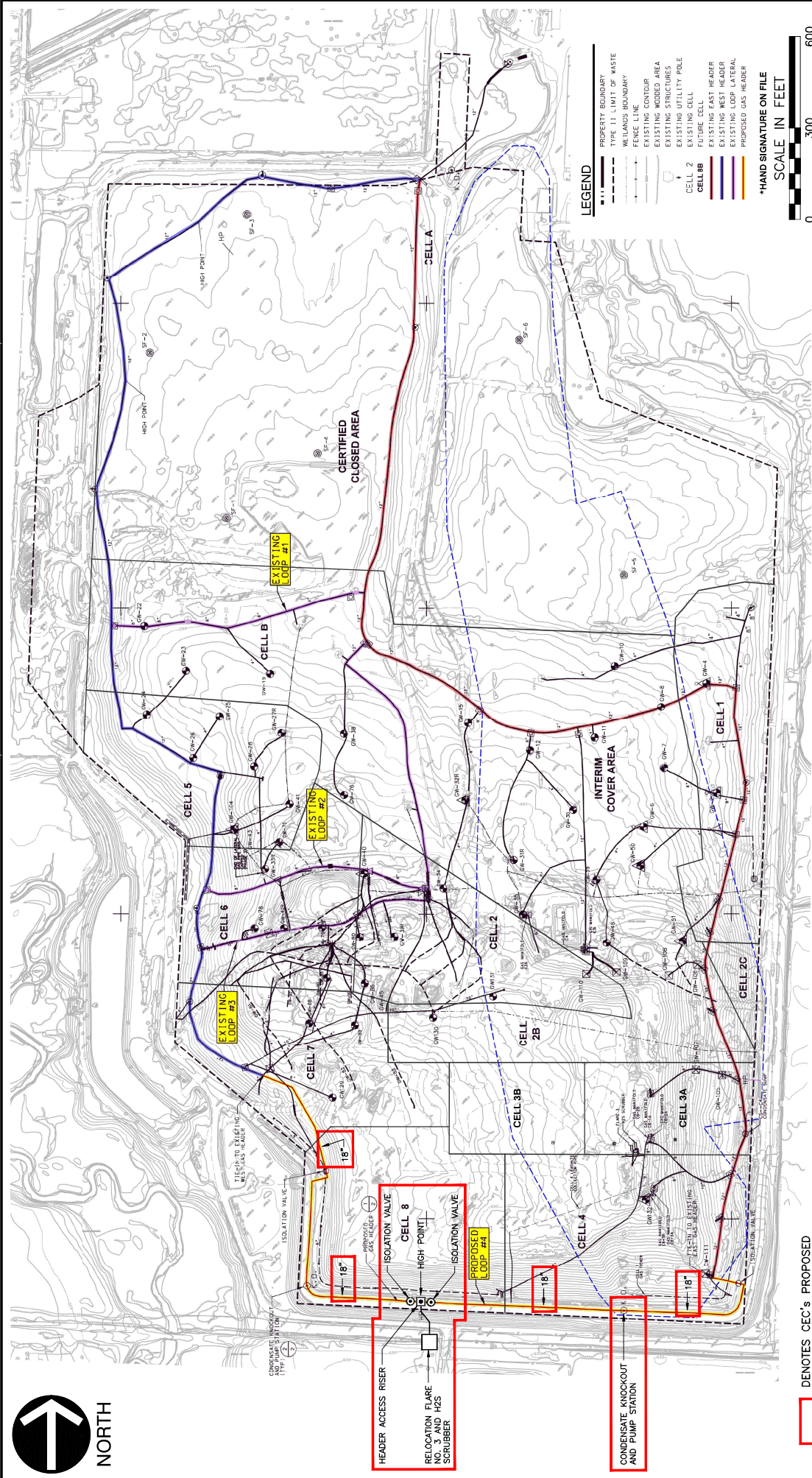
DRAWN BY: MSK CHECKED BY: PCT
DATE: 01/27/2026 DWG SCALE: 1"=150'

SMITHS CREEK LANDFILL
ST. CLARE COUNTY, MICHIGAN

CELLS 3A, 3B, 4, AND 8 HORIZONTAL GAS COLLECTION PIPING (EXTRACTION LINES)

APPROVED BY: MRB* FIGURE NO.:
PROJECT NO: 353-805.0007

3



- LEGEND**
- PROPERTY BOUNDARY
 - TYPE 11 LIMIT OF WASTE
 - WETLANDS BOUNDARY
 - FENCE LINE
 - EXISTING UTILITY
 - EXISTING STRUCTURES
 - EXISTING UTILITY POLE
 - CELL 2
 - EXISTING CELL
 - FUTURE CELL
 - EXISTING EAST HEADER
 - EXISTING WEST HEADER
 - EXISTING LOOP LATERAL
 - PROPOSED GAS HEADER
- *HAND SIGNATURE ON FILE



SMITHS CREEK LANDFILL
ST. CLAIR COUNTY, MICHIGAN

CEC'S PROPOSED MODIFICATIONS/ADDITIONS
TO CCI'S SOUTHERN LOOP EXPANSION PLAN

DATE: 01/27/2026 PCT APPROVED BY: MSK (CHECKED BY: MFB*)
DRAWN BY: MSK (CHECKED BY: MFB*)
PROJECT NO.: 353-805.2506
FIGURE NO.: 4

1230 East Diehl Road
Suite 200
Naperville, IL 60563
Ph: 630.963.6026
www.cecinc.com

CEC
Civil & Environmental
Consultants, Inc.

ENGINEERING, SURVEYING AND LANDSCAPE ARCHITECTURE IN THE STATE OF NORTH CAROLINA WILL BE PROVIDED BY CEC SURVEYING AND LANDSCAPE ARCHITECTS OF NC, PLLC. SERVICES IN PUERTO RICO WILL BE PROVIDED BY CEC ENGINEERS & CONSULTANTS, LLC. LANDSCAPE ARCHITECTURE SERVICES IN THE STATE OF OHIO WILL BE PROVIDED BY CEC LANDSCAPE ARCHITECTS, LLC.

□ DENOTES CEC'S PROPOSED MODIFICATIONS/ADDITIONS

REFERENCE

1. BASE EXISTING GCCS SYSTEM AND PROPOSED GAS HEADER PROVIDED BY CCI and ASSOCIATES, INC. FARMINGTON HILLS, MICHIGAN. PROJECT NUMBER 24L005, DRAWING 1 DATED JUNE 2, 2025.

APPENDIX A

**LIST OF ELECTRONIC DOCUMENTS
PROVIDED BY ST. CLAIR COUNTY
TO CEC FOR REVIEW**



**APPENDIX A
ELECTRONIC DOCUMENTS PROVIDED
BY ST. CLAIR COUNTY, MICHIGAN TO CEC FOR REVIEW**

Flash Drive Documents Provided 09.30.2025	
1. Permits and Licenses:	
Licenses -	
	2019 06-20 452546 Smiths Creek Operating License.pdf
	2025 07-10 452546 Smiths Creek Operating License.pdf
Permits (Expansion) -	
	SCL Expansion Permit 2013 Drawings.pdf
	SCL Expansion Permit 2013 Forms.pdf
	SCL Expansion Permit 2013 Reply to EGLE Comments.pdf
	SCL Expansion Permit 2013 TOC.pdf
	SCL Expansion Permit 2013 Vol_1 HI.pdf
	SCL Expansion Permit 2013 Vol_2 EA.pdf
	SCL Expansion Permit 2013 Vol_3 Eng.pdf
	SCL Expansion Permit 2013 Vol_4 Plans.pdf
	SCL EXPANSION PERMIT 2021 DESIGN CHANGE PKG.pdf
Permits (RDDP) -	
	2007 RDDP Application.pdf
	2013 RDDP Application.pdf
	2018 RDDP Application.pdf
	2019 02-20 SMITHS CREEK LANDFILL RDDP PERMIT 4085 EXTENSION.pdf
	2019 RDDP Permit Modification_LowRes.pdf
	2022 02-23 SMITHS CREEK LANDFILL Extension to RDDP 4085.pdf
	2022 12-13 452546 SMITHS CREEK LANDFILL Extension to Permit Number 4137.pdf
	4085 Renewal Ext 022725.pdf
	452546 Smiths Creek Construction Permit Admin Complete 1-19-2022.pdf
	452546 Smiths Creek Landfill RDDP Ext Admin Comp Rev 10-12-2022.pdf
	Smiths Creek Landfill RDDP Permit 4137 Renewal_091322.pdf
Permits (ROP) -	
	Appendix A Landfill Gas and NMOC Output.xls
	curve 2 landgem-v303.xlsm
	LandGEM Out SM Curve 1.xlsx
	LandGEM Out SM Curve 2.xlsx
	landgem-v303.xlsm
	LF_HAPS.xls
	marked up N6207 Final 06-07-18.docx
	N6207_Smiths Creek ROP Renewal Application Nov 16 2022.pdf
	ROP Renewal SCL Fugitive Dust.xls
	SM Fed plan temp ROP Landfills NMOC.docx
	SM ROP Renewal Application Form.docx
	SM Temp ROP Landfills MACT AAAA.docx
	SmithCreek_Leachate_Water9.xlsx



2. Regulatory Correspondence:

SCL Consent Order MMD No. 115-04-2025 AQD No. 2025-07.pdf

EGLE Violations -

- 452546 Smiths Creek LF VN 2023-10-25.pdf
- 452546 Smiths Creek LF VN 2023-11-14.pdf
- 452546 Smiths Creek LF VN 2024-01-16.pdf
- N6207 Smiths Creek Landfill VN 2023-10-25.pdf
- N6207 Smiths Creek Landfill VN 2023-11-07.pdf
- N6207 Smiths Creek Landfill VN 2023-12-19.pdf
- N6207 Smiths Creek Landfill VN 2024-03-20.pdf
- N6207 Smiths Creek Landfill VN 2024-07-19.pdf
- N6207 Smiths Creek Results Final 2023-10-31.pdf

SCL Responses -

- SCL AQD VN Response 20231129.pdf
- SCL AQD VN Response 20240109.pdf
- SCL AQD VN Response 20240808.pdf
- SCL MMD CC Response 112123.pdf
- SCL MMD CC Response Letter 120723 Attachments.pdf
- SCL MMD CC Response Letter 120723.pdf
- SCL MMD VN Response 20231115 Addendum.pdf
- SCL MMD VN Response 20231115.pdf
- SCL MMD VN Response 20240206.pdf
- SCL MMD VN Response 20240410.pdf

3. GCCS:

Gas Well Information -

- SCL Cell 8 Lateral Extraction Wells.pdf
- SCL GCCS Expansion Summary.pdf
- SCL GCCS Monitoring_2022_20250811.xlsm

Gas Well Information (As-Built) -

- SCL As Built GCCS Data 20241003.xlsx
- SCL As Built GCCS Plan 20241003.pdf
- SCL Phase I Boring Logs 1 thru 28.pdf
- SCL Phase I Well Logs 1 thru 28.pdf
- SCL Phase II Boring Logs 29 thru 34.pdf
- SCL Phase II Well Logs 29 thru 34.pdf
- SCL Phase III Boring Logs 35 thru 43.pdf
- SCL Phase III Well Logs 35 thru 43.pdf
- SCL Phase IV Well & Boring Logs 32R, 34R, 44 thru 51.pdf
- SCL Phase IX Interceptor Trench Drawings.pdf
- SCL Phase V Well & Boring Logs 27R, 29R, 31R, 33R, 47R, 75, 76.pdf
- SCL Phase VI Well & Boring Logs 39R, 42R, 78 thru 80.pdf
- SCL Phase VII Well & Boring Logs 84 thru 89.pdf
- SCL Phase X Well & Boring Logs Multiple Replacements, 129 thru 132.pdf

Flares and LFGTE -

- Supplemental Flare and H2S Scrubber Layout.pdf
- Supplemental Flare Operating Manual.pdf
- Supplemental Flare PTI 139-24.pdf



Liquid Levels -
<i>no files</i>
Well Pumps -
SCL GCCS Phase IV 2011 Report.pdf
Well Pump Summary.pdf
SEM -
SCL 2022 1Q SEM Report.pdf
SCL 2022 2Q SEM Report.pdf
SCL 2022 3Q SEM Report.pdf
SCL 2022 4Q SEM Report.pdf
SCL 2023 1Q SEM Report.pdf
SCL 2023 2Q SEM Report.pdf
SCL 2023 3Q SEM Report.pdf
SCL 2023 4Q SEM Report.pdf
SCL 2024 1Q SEM Report.pdf
SCL 2024 2Q SEM Report.pdf
SCL 2024 3Q SEM Report.pdf
SCL 2024 4Q SEM Report.pdf
SCL 2025 1Q SEM Report.pdf
SCL 2025 Q2 SEM Report.pdf
Drone Reports -
2023 09 Smiths Creek SnifferDRONE Verification Report.pdf
2024 02 Smiths Creek Letter.pdf
2024 02 Smiths Creek SnifferDRONE Verification Report.pdf
2025 07 Smiths Creek SnifferDRONE Emission Study Final Report.pdf
2025 08 Industry Perspective Report - Smiths Creek.pdf
4. Septage Injection:
SCL Injection data.xlsx
5. Leachate:
<i>no files</i>
6. Bioreactor Calculation:
2020 RDDP Annual Report Final.pdf
2021 RDDP Annual Report Final.pdf
2022 RDDP Annual Report Final.pdf
2023 RDDP Annual Report Final.pdf
2024 RDDP Annual Report Final.pdf
7. Waste Composition:
Yards and Tons 2020.xlsx
Yards and Tons 2021.xlsx
Yards and Tons 2022.xlsx
Yards and Tons 2023.xlsx
Yards and Tons 2024.xlsx
Yards and Tons 2025.xlsx
Yards and Tons by the Year.xlsx
8. Landfill Design:
<i>no files</i>



9. CQA Documentation:

452546 Smiths Creek Cell 8C Cert 2-7-2022.pdf
SCL Asphalt Paving 2021 Construction Report.pdf
SCL Asphalt Paving 2022 Construction Report.pdf
SCL Cell 4 CQA 2015 Report.pdf
SCL Cell 4B CQA 2016 Report.pdf
SCL Cell 8 2019 CQA Report.pdf
SCL Cell 8B 2019 CQA Report.pdf
SCL Cell 8C 2021 CQA Report.pdf
SCL Certified Closed Area 2024 Repair Report.pdf
SCL GCCS Phase IV 2011 Report.pdf
SCL GCCS Phase IX 2023 Drawings.pdf
SCL GCCS Phase VIII 2020 Report.pdf
SCL GCCS Phase X 2024 Report.pdf

Supplemental Documents Provided 10.18.2025

2024 Liquid Levels.pdf
Cell_4 Moisture calculation.xls
Cell_8 Moisture calculation.xls
CW_West Moisture calculation.xls
Final SCL Liquid Mngmt Plan 20250714.pdf
SCL Leachate Monthly data.xlsx

GCCS - As-Built & Other Files Provided 10.22.2025 - 10.29.2025

site gas systems constructed SHEET 1 emailed 10-29-25.dgn
site gas systems constructed SHEET 1.dgn
site gas systems constructed SHEET 1 emailed 10-29-25.dwg
12 2024 GCCS Assessment Report - Final.pdf
1322_001.pdf
051624_E.B. Eddy LLC_Compost and papermill sludge_Forton's Express.pdf
Air Port 20240627.pdf
Gas System Technical Memorandum.pdf
Memo SCL GW Liquid Level FINAL w App.pdf
Memo SCL Lateral Ext Line Evaluation FINAL w App.pdf
SCL Flare 3 Update 20251019 rev00.xlsx
SCL Flare 3 Weekly F&T 20251019 rev00.pdf
SCL GCCS Weekly F&T 20251019 rev00.pdf
SCL GCCS Weekly Update 20251019 rev00.xlsx
SCL GEM data 20251001-1017.xlsx
SCL GW Tuning Notes 20250929.xlsx
Septage_H2S_Evaluation 20250418 w fig.pdf



SCL Annual RDDP Reports Provided 11.17.2025

2008 SCL RDDP Annual Report all.pdf
2009 SCL RDDP Annual Report all.pdf
2010 SCL RDDP Annual Report all.pdf
2011 SCL RDDP Annual Report all.pdf
2012 SCL RDDP Annual Report all.pdf
2013 SCL RDDP Annual Report all.pdf
2014 SCL RDDP Annual Report all.pdf
2015 SCL RDDP Annual Report all.pdf
2016 SCL RDDP Annual Report all.pdf
2017 SCL RDDP Annual Report all.pdf
2018 RDDP Ann Rpt_final_all.pdf
2019 RDDP Annual Report_Final.pdf
2020 RDDP Ann Rpt_final_all.pdf
2021 RDDP Ann Rpt_Final_ALL.pdf
2022 RDDP Ann Rpt_final_all.pdf
2023 RDDP Ann Rpt_final.pdf
2024 RDDP Ann Rpt_final_all.pdf

GCCS - Reports & Drawing Provided 12.04.2025

12 2024 GCCS Assessment Report - Final.pdf
SCL EIL Report Implementation Plan 20250722.pdf
SCL Southern Loop#4.pdf

SCL Sniffer Drone Survey Files Provided 12.11.2025

penetrations_202309.csv
verifications_202309.csv
penetrations_202310.csv
verifications_202310.csv
penetrations_202402.csv
verifications_202402.csv
verifications_202507.csv
verifications_202510.csv

SCL Sniffer Drone Survey Files Provided 01.09.2026

202309 Smiths Creek Flight Path.jpg
202310 Smiths Creek Flight Path.jpg
202402 Smiths Creek Flight Path.jpg
202507 Smiths Creek Flight Path.jpg
202510 Smiths Creek Flight Path.jpg
202601 Smiths Creek Flight Path.jpg

APPENDIX B

**PHOTOGRAPHIC LOGS AND OBSERVATIONS FOR
OCTOBER 22, 2025 SITE VISIT**

APPENDIX B.1

**KEN KRUSZYNSKI'S
PHOTOGRAPHIC LOGS AND OBSERVATIONS**



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Photograph 1

Additional Process Utility Flare and Hydrogen Sulfide Removal System.

- High sulfur landfill gas stream control with the capacity of treating 1,000 SCFM.
- Should probably be relocated to the southern perimeter for stability and access.



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Photograph 2

Additional Process Utility Flare and Hydrogen Sulfide Removal System.

- High sulfur landfill gas stream control with the capacity of treating 1,000 SCFM.
- Should probably be relocated to the southern perimeter for stability and access.



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Repaired Barometric Condensate Dripleg and Associated 12-inch Perimeter Header Control Valve.

- 2024 repairs helped with overall GCCS vacuum distribution.
- 12-inch HDPE western perimeter header pipeline undersized for anticipate total.
- Barometric driplegs require constant maintenance to keep liquid trap in take to prevent air intrusion, and can be obstructed with debris causing condensate backups into the adjacent perimeter header pipeline system disrupting vacuum distribution.

Photograph 3



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Photograph 4

Spark-Ignited Flare Installation on No Flow Extraction Well.

- Installed within the certified closed landfill area.
- Effective for odor and emissions control on low flow vertical extraction wells.
- If inoperable, can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality.



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Capped 6 Inch PVC Well In Closed Landfill Area.

- Installed within the certified closed landfill area.
- If PVC cap is not properly installed and sealed, can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality.

Photograph 5



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Typical QED Wellhead Assembly.

- QED wellhead assembly design with precision calibrated plug valve allowing greater control of extracted landfill gas quality.
- Allows quick changes to the internal orifice plate to match actual extracted landfill gas flow rates.
- Recommended for landfill gas to electrical power generation facility and renewable natural gas facility applications.

Photograph 6



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Open Lid On Perimeter Leachate Pump Access Riser.

- Installed within the landfill Cell 5 waste disposal area.
- Provides a drainage point interconnection to the leachate collection system for generated and accumulated landfill gas condensate.
- Open lid not sealed properly providing a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality.

Photograph 7



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan	Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan
Project No.: 353-805	Photos Taken by: Ken Kruszynski
	Date of Photo: October 22, 2025



Future HDPE Vertical Extraction Well Casings Installed with PVC Caps.

- Installed within the landfill Cell 6 waste disposal area.
- Installed within the liquid recirculation bioreactor area, where the probability that internal liquid levels are high.
- Because of the flexibility of HDPE pipe, not suitable for future installation of pneumatic displacement pumps for liquid removal. For dual landfill gas and leachate extraction wells, PVC schedule 80 ridged pipe casing is recommended in order to access and maintain the pumps.
- If PVC cap is not properly installed and sealed, can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality. PVC caps should not be used with HDPE pipe casings.

Photograph 8



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Compressed Air Compressor Equipment.

- Ingersol Rand rotary screw air compressor unit with coalescing filters, desiccant dryers, and accumulation tank.
- Observed in good condition, well maintained, and available to provide compressed air for additional pneumatic displacement pumps.

Photograph 9



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Compressed Air Compressor Building.

- Located on the eastern perimeter adjacent to Cell 2C, contains the Ingersol Rand rotary screw air compressor unit with coalescing filters, desiccant dryers, and accumulation tank equipment.
- Observed in good condition and well maintained.

Photograph 10



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Photograph 11

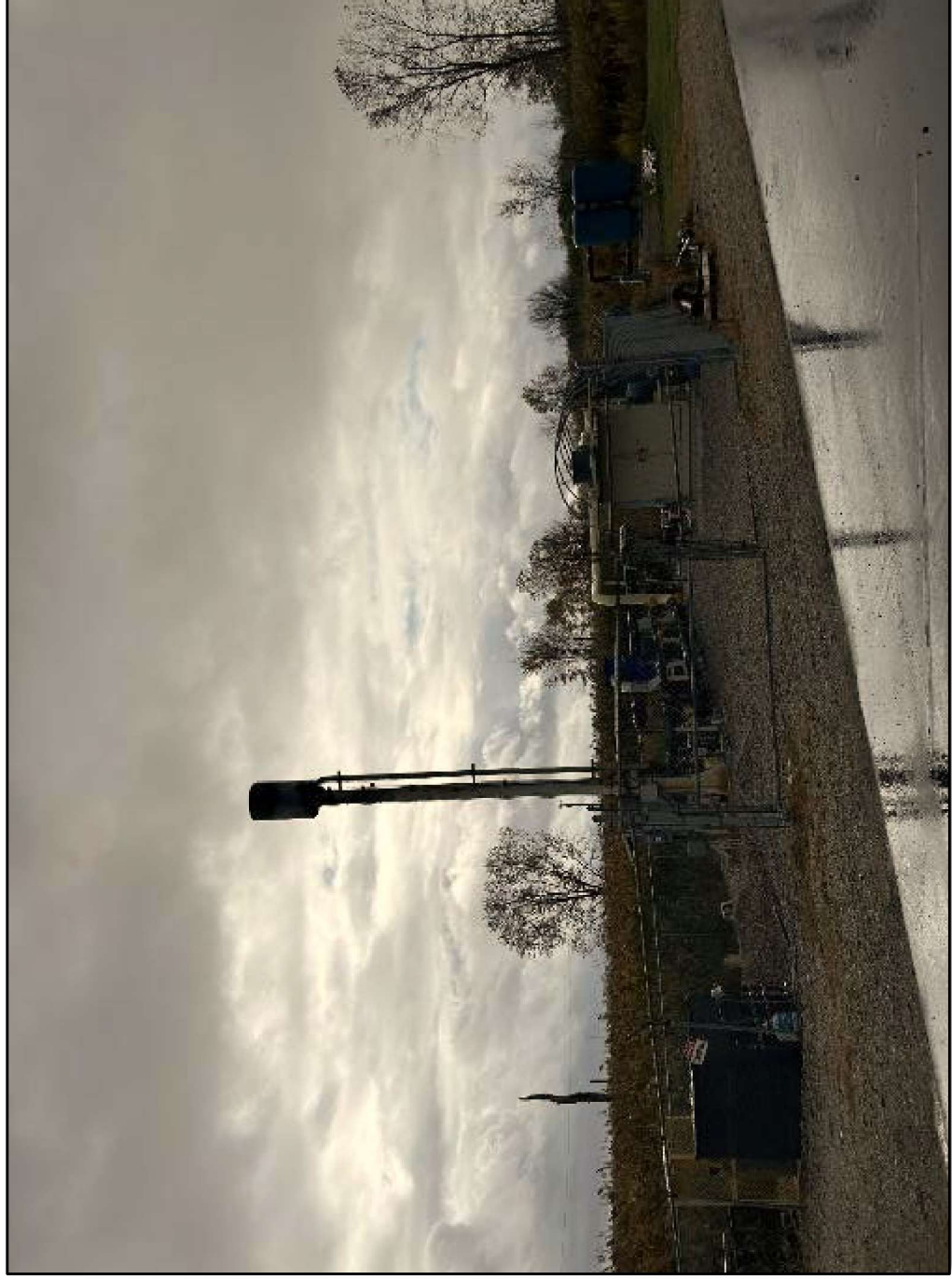
Perimeter Ambient Air Monitoring Equipment - East Perimeter.
• Located on the eastern perimeter contains the methane ambient air sensor.



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan	Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan
Project No.: 353-805	Photos Taken by: Ken Kruszynski
	Date of Photo: October 22, 2025



Main Blower and Process Utility Flare Station.

- Long distance from the active landfill gas collection system components (1,600 lineal feet)
- Main delivery header pipeline is 12-inch nominal diameter - undersized for potential landfill gas extraction flow rate.
- Pressure and velocity design criteria and vacuum distribution concerns.

Photograph 12



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Landfill Owned Main Fan Blower Equipment.

- New York Blower - high pressure blower /fan equipment rated at 2,000 CFM at 50 inches of water column static pressure.
- Main delivery header pipeline is 12-inch nominal diameter - undersized for potential landfill gas extraction flow rate.
- Allowable pressure loss design criteria and vacuum distribution concerns if relied upon for flaring the extracted landfill gas.

Photograph 13



Civil & Environmental Consultants, Inc.

Photographic Record

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Main Condensate Knockout and Pump Station Vessel.

- Sized for the knockout and accumulation of condensate from the entire landfill gas extraction flow rate.
- Observed in good condition and well maintained.

Photograph 14



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photos Taken by: Ken Kruszynski

Date of Photo: October 22, 2025



Developer Owner Multistage Centrifugal Blower Compressor Equipment.

- HSI multistage centrifugal blower with 125 horsepower motor.
- Space available on equipment skid for a second redundant multistage centrifugal blower unit.
- Second redundant unit to have landfill gas if initial blower is inoperable due to potential vibration bearing, impeller, alignment problems.

Photograph 15



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan	Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan	
Project No.: 353-805	Photo Taken by: Ken Kruszynski	Date of Photo: October 22, 2025



Photograph 16	Landfill Owned Process Utility Flare Equipment. <ul style="list-style-type: none">• Combustion capacity of 2,000 SCFM of landfill gas with a methane concentration of 50%.
----------------------	--



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan	Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan	
Project No.: 353-805	Photo Taken by: Ken Kruszynski	Date of Photo: October 22, 2025



Photograph 17	<p>Horizontal Lateral Extractors Wellfield Manifold.</p> <ul style="list-style-type: none">• Applies available vacuum to the horizontal lateral extractors pipes that are approximately 450-lineal feet or more in length.• Only applies vacuum to one end of the horizontal lateral extractors, where the vacuum would dissipate quickly at the beginning of the perforated pipe and no vacuum available at the far ends.• Effective designs typically include wellhead assemblies at both ends of the horizontal lateral extractors, providing the ability to apply vacuum from both ends of the horizontal lateral extractors.• Effective designs typically include a series of nested horizontal lateral extractors, each with difference lengths where the perforated pipe begins in order to project applied vacuum to the farthest waste disposal regions.
----------------------	--

APPENDIX B.2

**MIKE BEAUDOIN'S
PHOTOGRAPHIC LOGS AND OBSERVATIONS**

Mike Beaudoin's Observations from October 22, 2025 Site Visit:

- Impressed with overall aesthetics and operation of site during visit.
- Observed no discernable odors that could migrate off-site.
- Review of water balance calculations shows reasonable analyses of average moisture content by CTI and Associates, Inc. (CTI). However, moisture will not be uniformly distributed, and it is possible that highly saturated zones exist in the septage application zones.
- Review of the waste vertical settlement rates represented by CTI indicate 0.94% to 1.42% of waste height per year in the bioreactor areas. These measurements are typical of self-compression and biological decomposition in normal, non-bioreactor landfills in CEC's experience.
- Only five of the fifteen gas wells visited were flowing gas.
- Simple labeling is recommended for many of the observed pipe features.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 1

Disconnected well with contrasting labels.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 2

Disconnected well with loose cap.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 3

Overgrowth on pump controls.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 4

Septage storage bladder.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 5

Unlabeled pipe box with overgrowth.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 6

Unlabeled pipe.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 7

Unlabeled pipes.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 8

Unlabeled pipes.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 9

Unlabeled pipes.



Photographic Record

Civil & Environmental Consultants, Inc.

Client: St. Clair County, Michigan

Site Name / Location: Smiths Creek Landfill, Smiths Creek, Michigan

Project No.: 353-805

Photo Taken by: Mike Beaudoin

Date of Photo: October 22, 2025



Photograph 10

Loss of vegetation on landfill final cover.

APPENDIX C

**CEC'S CALCULATED GAS GENERATION DUE TO ADDED LIQUIDS
AND CEC QUESTIONS/CTI RESPONSES**

Smiths Creek Landfill - Cell 3A																
Methane Volume Per COD Mass ^{1,2,3}				Methane Generated Due to Leachate Addition 2008-2016				Methane Generated Due to Septage Addition 2008-2016				Total Gas Generated Due to Leachate + Septage Addition 2008-2016				
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
Methane / COD (ft ³ / lb)	m ³ / ft ³	lb/ton	Methane / COD (m ³ / ton)	Methane / COD (m ³ / g)	Leachate Addition ⁴ (gal)	Leachate Addition ⁵ (L)	Avg. COD (g) per Liter of Leachate ⁶ (g/L)	Avg. COD Addition ⁷ (g)	Methane Generated due to Leachate ⁸ (CF)	Septage Addition ⁹ (gal)	Septage Addition ¹⁰ (L)	Avg. COD (g) per Liter of Septage ¹¹ (g/L)	Avg. COD Addition ¹² (g)	Methane Generated due to Septage ¹³ (CF)	Total Methane Generated ¹⁴ (M CY/Day)	Total Gas Generated Due to Leachate + Septage Addition ¹⁵ (M CY/Day)
5.6	0.0283	2,000	316.96	0.0003522	623,057	2,358,271	4	9,433,083	117,389	5,568,956	21,078,498	10	210,784,985	2,623,102	0.10	0.20

Notes:

- Assumed 5.6 cubic feet of methane (CH4) per pound of COD (5.6-ft³ Methane / lb- COD), based on stoichiometric calculations from methane fermentation reaction (CH4 + 2O2 → CO2 + 2H2O). At standard temperature and pressure (0°C, 1 atm), 1 mole of CH4 occupies 22.414 L, and the molar mass of CH4 is 16 g/mol. This results in the empirical yield of ~5.6ft³ CH4 per lb COD when all COD is converted to methane.
- Methane (m³) per COD (ton) = (D) = (A) x (B) x (C)
- Methane (m³) per COD (g) = (E) = (D) x (10⁻⁶) / (0.9)
- Leachate addition in gallons (F) obtained from the 2016 RDDP Annual Report.
- Leachate addition in liters = (G) = (F) x (3.785)
- Average grams COD per liter of leachate added (4 g COD/L) estimated from graph presented in the 2024 RDDP Annual Report.

Abbreviations:

- CH4 = Methane
- COD = Chemical Oxygen Demand
- ft³ = cubic feet
- m³ = cubic meter
- lb = pound
- g = gram
- gal = gallon
- L = liter
- CF = cubic feet
- M CY = million cubic yards
- 1 ft³ = 0.0283 m³
- 2,000 lbs = 1 ton
- 1 ton = 907,185 grams
- 1 gallon = 3.785 liters
- 1 CY = 1 CF / 27

- Average COD addition due to leachate added = (I) = (H) x (G)
- Methane generated due to leachate addition = (J) = (I) x (E) / (B)
- Septage addition in gallons (K) obtained from the 2016 RDDP Annual Report.
- Septage addition in liters = (L) = (K) x (3.785)
- The average grams COD per liter of septage added (10 g COD/L) estimated from graph presented in the 2024 RDDP Annual Report.
- Average COD addition due to septage added = (N) = (M) x (L)
- Methane generated due to septage added = (O) = (N) x (E) / (B)
- Total methane generated due to leachate and septage addition = (P) = [(J) + (O)] / [(27) / 1,000,000]
- Total landfill gas generated due to leachate and septage addition = (Q) = (P) x (2), based on assumption. (total landfill gas) = (2 x methane).

Smiths Creek Landfill - Cell 3B																
Methane Volume Per COD Mass ^{1,2,3}			Methane Generated Due to Leachate Addition 2008-2016				Methane Generated Due to Septage Addition 2008-2016				Total Gas Generated Due to Leachate + Septage 2008-2016					
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
Methane / COD (ft ³ / lb)	m ³ / ft ³	lb/ton	Methane / COD (m ³ / ton)	Methane / COD (m ³ / g)	Leachate Addition ⁴ (gal)	Leachate Addition ⁵ (L)	Avg. COD (g) per Liter of Leachate ⁶ (g/L)	Avg. COD Addition ⁷ (g)	Methane Generated due to Leachate ⁸ (CF)	Septage Addition ⁹ (gal)	Septage Addition ¹⁰ (L)	Avg. COD (g) per Liter of Septage ¹¹ (g/L)	Avg. COD Addition ¹² (g)	Methane Generated due to Septage ¹³ (CF)	Total Methane Generated ¹⁴ (M CY/Day)	Total Gas Generated Due to Landfill Gas ¹⁵ (M CY/Day)
5.6	0.0283	2,000	316.96	0.0003522	1,003,451	3,798,060	4	15,192,241	189,059	1,515,611	5,736,587	10	57,365,866	713,886	0.0334	0.067

Notes:

- Assumed 5.6 cubic feet of methane (CH4) per pound of COD (5.6 ft³ Methane / lb. COD), based on stoichiometric calculations from methane fermentation reaction (CH4 + 2O2 → CO2 + 2H2O). At standard temperature and pressure (0°C, 1 atm), 1 mole of CH4 occupies 22.414 L, and the molar mass of CH4 is 16 g/mol. This results in the empirical yield of ~5.6 ft³ CH4 per lb COD when all COD is converted to methane.
- Methane (m³) per COD (ton) = (D) = (A) x (B) x (C)
- Methane (m³) per COD (g) = (E) = (D) x (10⁶) / (0.9)
- Leachate addition in gallons (F) obtained from the 2016 RDDP Annual Report.
- Leachate addition in liters = (G) = (F) x (3.785)
- Average grams COD per liter of leachate added (4 g COD/ L) estimated from graph presented in the 2024 RDDP Annual Report.
- Average COD addition due to leachate added = (I) = (H) x (G)
- Methane generated due to leachate addition = (J) = (I) x (E) / (B)
- Septage addition in gallons (K) obtained from the 2016 RDDP Annual Report.
- Septage addition in liters = (L) = (K) x (3.785)
- The average grams COD per liter of septage added (10 g COD/ L) estimated from graph presented in the 2024 RDDP Annual Report.
- Average COD addition due to septage added = (N) = (M) x (L)
- Methane generated due to septage added = (O) = (N) x (E) / (B)
- Total methane generated due to leachate and septage addition = (P) = [(J) + (O)] / [(27) / 1,000,000]
- Total landfill gas generated due to leachate and septage addition = (Q) = (P) x (2), based on assumption, (total landfill gas) = (2 x methane).

Abbreviations:

- CH4 = Methane
- COD = Chemical Oxygen Demand
- ft³ = cubic feet
- m³ = cubic meter
- lb = pound
- g = gram
- gal = gallon
- L = liter
- CF = cubic feet
- CY = cubic yard
- M CY = million cubic yards
- 1 ft³ = 0.0283 m³
- 2,000 lbs = 1 ton
- 1 ton = 907,185 grams
- 1 gallon = 3.785 liters
- 1 CY = 1 CF / 27

CEC QUESTIONS (DRR)

11/07/2025

1. Why are there no control data? Conclusions are based on a comparison of estimated k to EPA k, but not a k derived at SCL for a conventionally operated cell. Perhaps compare k estimates to baseline prior to injection, although no gas collection generally occurs prior to injection? Or other areas without septage input?
2. The method for estimating k is strange:
 - a. Model parameter k is allowed to vary as septage is added, MC increases, and waste methane potential declines. k falls as a new and lower L_o (compared to initial L_o) is assigned over time, which seems counterintuitive because this coincides with increasing moisture content.
 - b. Septage contribution to L_o is not considered; septage impacts are only related to moisture which contributes to a greater k, compared to a theoretical conventional landfill.
 - c. The method for estimating k is dependent on previous gas generation, the cumulative amount of septage introduced, and L_o (which changes with time). The approach is more or less a data-fitting exercise.
 - d. Seem to be using two fitting parameters (a and L_o as a function of time).
3. However, conventionally, k is independent of the amount of waste present. Studies show that k increases as conditions become optimal, such as moisture content, pH, temperature etc. k also is dependent on the degradability of the waste. For example, k for food waste is much higher than the k for paper or textiles. Perhaps the logic is that as waste degrades, the easier and more rapidly degrading waste is gone and only the difficult material remains and therefore k is lower.

$$\frac{dM_r}{dt} = -kM_r$$

Where:

- dM_r/dt = rate of change of waste mass with respect to time, Mg/year;
M_r = remaining mass of refuse at time t, Mg;
t = time elapsed; and
k = first-order rate constant; year⁻¹.

4. This approach leads to many questions:
 - a. Shouldn't the declining degradability of the waste be captured in the first-order equation that relates the rate of waste removal to the amount of waste remaining by the first order decay coefficient?
 - b. How is L_o as a function of time calculated? Note: **Details of the coefficient estimation for Cell 3A and Cell 3B were presented in the 2015 and 2016 annual reports.**

- c. How can k be the same for C&D and MSW (only L_0 is assumed to be different)?
 - d. Why isn't the estimate for k provided in annual reports 2021 – 2024 for cells other than 3a and 3b.
 - e. Why is lag time less in CW West than in CW East?
 - f. Why is the lag time less in the “nonbioreactor” area of Cell 8?
5. In Annual Report 2024 the following was observed, casting doubt on the approach for k estimations:

“The volume from this combined volume were fitted with the combined models results (from both Bioreactor and Non Bioreactor Zones) by adjusting “ k ” value for the Non-Bioreactor zone. The best fit was found when the k is equal to 0.8 1/yr.”

6. Collection efficiency is assumed to be 0.75, which is high for cells without interim cover. Not clear if all LFG data are from times after interim cover placement. For example, Cell 4 was being filled in 2016-2020, with an interim cover installed in 2020.
7. Well field may not be isolated to cells analyzed.
8. How do cold temperatures affect k ?
9. Is MC optimum?

From 2020 Annual Report:

For CW East:

k value in our model was estimated using the following coefficients:

when $L_0 \geq 0.8L_0^{initial}$:

$$k = 0.05S + 0.08$$

when $0.5L_0^{initial} \leq L_0 < 0.8L_0^{initial}$:

$$k = 0.03S + 0.06$$

when $L_0 < 0.5L_0^{initial}$:

$$k = 0.02S + 0.04$$

For CW West:

when $L_0 \geq 0.8L_0^{initial}$:

$$\text{If } S \leq 6.5 \text{ gal/ton: } k = 0.05S + 0.08$$

$$\text{If } S > 6.5 \text{ gal/ton: } k = 0.41$$

when $0.5L_0^{initial} \leq L_0 < 0.8L_0^{initial}$:

$$\text{If } S \leq 6.5 \text{ gal/ton: } k = 0.03S + 0.06$$

$$\text{If } S > 6.5 \text{ gal/ton: } k = 0.26$$

when $L_0 < 0.5L_0^{initial}$:

$$\text{If } S \leq 6.5 \text{ gal/ton: } k = 0.01S + 0.04$$

$$\text{If } S > 6.5 \text{ gal/ton: } k = 0.11$$

↓ 6 I

Responses to the Questions from 3rd Party Reviewers

Prepared by CTI

Nov. 12, 2025

1. *The modeling approach allows L_0 to vary over time and incorporates moisture (septage) addition in the k determination. Is this approach described in more detail in peer-reviewed literature? Is the approach described in early annual reports or other materials that would clarify the method to calculate model parameters (i.e., k , a , lag time, and L_0 over time)?*

Response:

The methane generation modeling approach was developed by our team and published in the Journal of Hazardous, Toxic, and Radioactive Waste (J. Hazard. Toxic Radioact. Waste, 2013, 17:295–306). This method allows the methane potential (L_0) to vary over time and incorporates the influence of septage or leachate additions into the determination of the decay constant (k). Parameters such as factors (a and b) for the calculation of k as function of the septage or leachate additions and lag time were calibrated by fitting the model predictions to measured field data. The initial L_0 was set at 100 m^3 per 1,000 kg of MSW waste (excluding C&D), and subsequent L_0 values were updated based on the estimated gas production between time steps.

Additional information on this approach can be found in the RDDP Annual Reports.

2. *Were there attempts to model non-bioreactor cells (other than Cell 8) that would serve as a control for the septage addition demonstration?*

Response:

Yes. During the initial operation of Cells 3A and 3B, Cell 3B was designated as the control cell, receiving only leachate recirculation without septage addition. The details of this comparison are also documented in the Journal of Hazardous, Toxic, and Radioactive Waste (2013, 17:295–306). Comparative modeling between Cells 3A and 3B was used to assess the effect of septage addition on methane generation rates (k values).

3. *What are k values calculated for other bioreactor cells beyond Cells 3A and 3B?*

Responses:

The most recent RDDP Annual Report (2024) presents k values for several areas, including Cell 4, CW East, CW West (excluding Cell 8), and Cell 8. The specific results and analysis are provided in Section 5.5 of that report.

Attachment:

Zhao et al, 2013, Full-Scale Field Research and Demonstration of Septage Bioreactor Landfill Technology; Journal of Hazardous, Toxic, and Radioactive Waste (2013, 17:295–306)

CEC QUESTIONS (DRR)
12/04/2025

CEC is conducting an investigation to examine the effects of adding septage to a landfill. We continue to have questions regarding the analysis done to date.

1. Landfill gas modeling

- a. How is the gas modeling approach justified, which deviates from published approaches? Model parameter k is allowed to vary as septage is added and MC increases. The method for estimation, therefore, is dependent on previous gas generation, the cumulative amount of septage introduced, and L_0 (which is assumed to change with time). The inclusion of S in the k estimation is an interesting way to account for a buildup of moisture. However, the modeling is repeated over short periods of time as septage is added, therefore, it becomes a data-fitting exercise with two fitting parameters (a and L_0 as a function of time).
- b. How is L_0 as a function of time calculated? Several documents suggest that there are explanations for this in other reports, but they have not been found. L_0 , by definition, is the initial methane potential, so it should not vary with time unless there is a dramatic change in waste composition.
- c. How can k be the same for C&D and MSW (only L_0 is assumed to be different)?
- d. Why does lag time vary from one cell to another?
- e. How were gas collection efficiencies determined? The surface emissions noted in multiple reports add to the uncertainty in gas modeling. The assumption of high collection efficiency in the modeling (0.75 – 0.9) may result in higher than actual k values.

2. There is conflicting evidence of accelerated waste degradation

- a. Septage and leachate addition does not achieve optimum moisture content for bioreactor operation (45% by weight). Cells 3a and 3b had similar moisture contents, but k values were much greater in 3a, attributed to the septage. Why would septage contribute greater effects on waste degradation than leachate?
- b. Documented settlement appears to be within expected range of well-operated landfill, rather than accelerated.
- c. Questions about k value determination, as stated above, may mean that k is not useful in demonstrating accelerated gas generation

3. Landfill gas collection

How certain are the individual cell reported gas flow rates? The complex design of the gas collection system and frequency of well failure does not ensure gas flows can be attributed to a specific cell. For example, the most recent annual report noted Cell 8 has a high k value (0.8 1/yr) that could not be explained. The 2023 EGLE report notes the following that probably explains the high k in Cell 8:

“Adequate cover is likely allowing the gas generated in this region to escape laterally to the south towards Cell 8 and/or nearby active areas.”

Response to Questions from 3rd Party Reviewers

Question: Email dated November 18, 2025

Responses: January 21, 2026

1. Why are there no control data? Conclusions are based on a comparison of estimated k to EPA k , but not a k derived at SCL for a conventionally operated cell. Perhaps compare k estimates to baseline prior to injection, although no gas collection generally occurs prior to injection? Or other areas without septage input?

Responses 1:

The reviewer's question regarding the absence of a conventional "control" dataset is understood. However, the approach used in this project reflects both the objectives of the Research, Development, and Demonstration Project (RDDP) and the practical limitations associated with landfill gas data collection.

Use of an Internal Control Cell

During the initial operation of Cells 3A and 3B, Cell 3B was intentionally designated as an internal control, receiving leachate recirculation only, while Cell 3A received septage in addition to leachate. This paired-cell configuration allowed for a controlled comparison under otherwise similar waste composition, gas collection system, liquid injection system, and operational conditions. Comparative modeling between these two cells was used to evaluate the effect of septage addition on methane generation rates (k values). This methodology and its results are documented in the peer-reviewed literature (Journal of Hazardous, Toxic, and Radioactive Waste, 2013, 17:295–306).

Rationale for the Comparative Framework

The primary objective of the RDDP is to evaluate the incremental impact of septage addition on waste degradation, rather than to contrast a bioreactor landfill with a dry, conventionally operated landfill. It is well established in the literature that increased moisture accelerates waste decomposition. Accordingly, SCL focused on comparing gas generation behavior between cells receiving different liquid amendments (leachate versus septage), while carefully managing liquid application rates to maintain comparable moisture conditions relative to waste placement. As shown in the referenced publication, leachate injection volumes were adjusted to ensure similar moisture levels between Cells 3A and 3B.

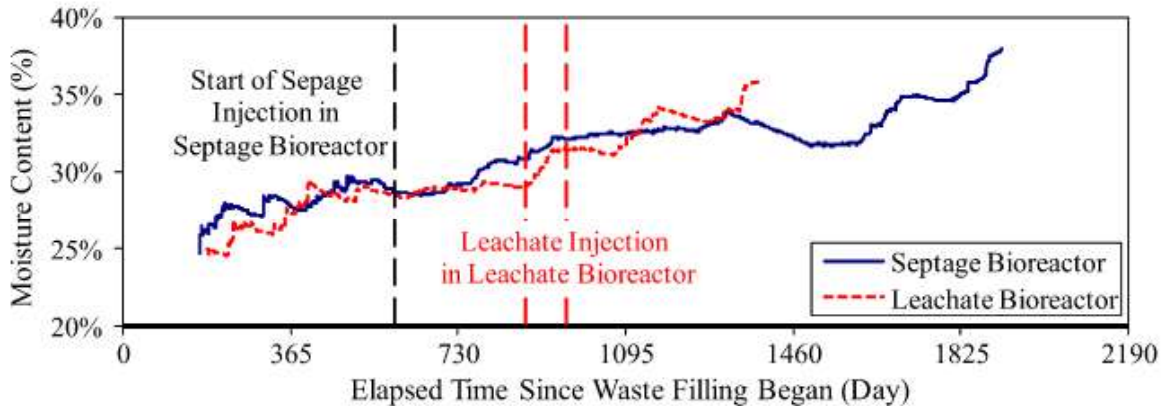


Fig. 4. Calculated waste-moisture content (wet-weight basis) in bioreactor landfills

Source: Zhao, et al, 2013

Limitations of Using Pre-Injection Periods as Baseline Controls

In theory, the period between the initiation of gas extraction and the commencement of liquid addition (approximately 5 months for Cell 3A and 7 months for Cell 3B) could be considered a baseline condition. However, these periods are not suitable as control datasets for the following reasons:

- a. The duration of available data is short and insufficient to support reliable estimation of gas generation parameters.
- b. Waste placement was ongoing during these periods, making gas collection efficiency highly uncertain. Without a defensible estimate of collection efficiency, back-calculated gas generation rates would be unreliable.
- c. These periods correspond to the early stages of microbial development in newly placed waste and are not representative of the stabilized or developed phase of waste decomposition used to estimate long-term k values.

	Cell 3A	Cell 3B
Start waste filling	11/4/2006	3/20/2008
Stop waste filling	11/13/2010	2/3/2011
Start gas extraction	6/3/2008	1/11/2010
Start leachate injection	11/12/2008	8/13/2010
Stop leachate injection	4/30/2010	11/9/2010
Start septage addition	5/19/2008	4/8/2013
Stop septage addition	12/13/2016	7/1/2016

Limitations of Using Other Non-Septage Areas at SCL as Controls

While other landfill areas at SCL have not received septage, they are not suitable as control areas for k-value comparison due to the following factors:

- a. The waste in these areas is substantially older and at a different stage of decomposition.
- b. Historical gas data was not reliable due to the uncertainty on the quality control.
- c. Gas collection systems in these areas are of minimal design, resulting in highly uncertain and likely variable collection efficiencies.
- d. Gas flow measurements need to be collected at individual gas heads, where flow rates are often very low. Given the limitations of available measurement devices (e.g., pitot tubes), the resulting flow data would not be sufficiently reliable for quantitative modeling.
- e. Historically, SCL conducted significant leachate recirculation in those area.

Conclusion

Given these constraints, the comparison between Cells 3A and 3B—one receiving septage and the other receiving leachate only—represents the most technically defensible control framework available for evaluating the effect of septage addition on methane generation rates at SCL. The resulting k values are therefore appropriately interpreted in the context of comparative performance rather than as absolute values derived from a conventional dry landfill baseline.

2. The method for estimating k is strange:
 - a. Model parameter k is allowed to vary as septage is added, MC increases, and waste methane potential declines. k falls as a new and lower L_0 (compared to initial L_0) is assigned over time, which seems counterintuitive because this coincides with increasing moisture content.
 - b. Septage contribution to L_0 is not considered; septage impacts are only related to moisture which contributes to a greater k , compared to a theoretical conventional landfill.
 - c. The method for estimating k is dependent on previous gas generation, the cumulative amount of septage introduced, and L_0 (which changes with time). The approach is more or less a data-fitting exercise.
 - d. Seem to be using two fitting parameters (a and L_0 as a function of time).

Responses 2:

The reviewer’s comments regarding the k -estimation methodology are acknowledged. The apparent disagreements arise primarily from misunderstandings of (i) how k is parameterized in the model, (ii) how remaining methane potential is handled, and (iii) the role of septage in the overall mass balance. The following clarifications are provided.

(a) Interpretation of k Variation with Time and Moisture Content

In the modeling framework used for this project, **k is not a direct function of moisture content (MC) or remaining methane potential ($L_0^{\text{remaining}}$) within each segment.** Instead, **k is parameterized solely as a function of cumulative septage addition** according to the relationship:

$$k = aS + k_0 \quad \text{Eq. 1}$$

where septage addition (S) is the cumulative septage addition per waste mass (gal/ton). “ a ” and “ k_0 ” are fitting parameters.

The value of the k does not change within each segment (see Responses 4a) if the decomposition of the waste process is divided into segments (see gas models for CW West and Cell 4).

(b) Septage Contribution to Initial Methane Potential (L_0)

Septage was evaluated for its potential contribution to L_0 , and it was determined to be **negligible** relative to the solid waste mass. This conclusion is supported quantitatively:

- Maximum septage addition: approximately **22 gal/ton of waste**
- Septage solids content: approximately **5%**
- Resulting dry solids addition: approximately **9 lb per ton of waste**
- Methane potential of septage solids:
 - 242 mL CH_4/g VS (literature value, Inatah 2021)
 - Assuming 60% VS \rightarrow approximately **145 mL CH_4/g dry solid**
- Assumed methane potential of combined municipal waste: **75 mL CH_4/g**

The incremental methane potential attributable to septage is therefore:

$$\frac{9 \text{ lb} \times 145 \text{ mL } \text{CH}_4/\text{g}}{2000 \text{ lb} \times 75 \text{ mL } \text{CH}_4/\text{g}} \approx 0.9\%$$

This contribution is well within modeling uncertainty and does not materially affect L_0 . Consequently, septage impacts were intentionally modeled **through kinetic enhancement** rather than through adjustment of methane potential.

(c) Nature of the k Estimation Methodology

The estimation of k is, by necessity, a **curve-fitting exercise**, as is the case for all first-order landfill gas generation models. In this project, k is estimated by fitting modeled cumulative gas generation to measured gas collection data through iterative adjustment of “a” and “ k_0 ” (see Eq. 1).

This approach does not constitute arbitrary parameter tuning; rather, it represents a **bounded inverse modeling process** consistent with standard landfill gas modeling practice.

(d) Model Fitting Parameters

Two parameters are **primarily fitted** in the model:

- **a**: coefficient representing the incremental impact of septage addition on k
- **k_0** : baseline first-order decay rate coefficient in the absence of septage addition

The remaining methane potential (L_0^{remainig}) is **not an independent fitting parameter**. It is calculated explicitly at each time step using a mass balance of cumulative gas generated. At each iteration:

- Remaining L_0 (L_0^{remainig}) is updated based on modeled gas production,
- The time counter is reset to reflect the updated waste condition.

Thus, L_0^{remainig} varies deterministically as a function of gas generation and is not used as an adjustable parameter.

In addition, a lag time parameter was also adjusted to improve agreement between modeled and measured gas collection data. This adjustment reflects the well-documented delay between waste placement, onset of anaerobic conditions, measurable methane generation and recovery.

Summary

- k is modeled as a function of septage addition only, not moisture content or remaining methane potential.
- Septage contribution to L_0 is quantitatively insignificant and appropriately excluded.
- k estimation follows a constrained inverse modeling (curve-fitting) approach consistent with accepted practice.
- Three fitting parameters (a , k_0 , and lag time) are used; Remaining L_0 (L_0^{remainig}) is derived through mass balance, not fitted.

This methodology is therefore internally consistent, physically defensible, and aligned with the objectives of evaluating septage-induced enhancement of methane generation kinetics rather than redefining total methane potential.

3. However, conventionally, k is independent of the amount of waste present. Studies show that k increases as conditions become optimal, such as moisture content, pH, temperature etc. k also is dependent on the degradability of the waste. For example, k for food waste is much higher than the k for paper or textiles. Perhaps the logic is that as waste degrades, the easier and more rapidly degrading waste is gone and only the difficult material remains and therefore k is lower.

$$\frac{dM_r}{dt} = -kM_r$$

Where:

dM_r/dt = rate of change of waste mass with respect to time, Mg/year;
 M_r = remaining mass of refuse at time t , Mg;
 t = time elapsed; and
 k = first-order rate constant; year⁻¹.

Responses 3:

The reviewer's statements regarding the interpretation of k are correct and are fully acknowledged. In standard first-order landfill gas models, k is independent of the total waste mass and instead reflects the combined effects of environmental conditions (e.g., moisture content, pH, temperature) and waste degradability. It is also well established that readily degradable waste fractions (e.g., food waste) exhibit higher k values than more recalcitrant materials such as paper and textiles.

The modeling approach used in this project is consistent with these principles and does **not** define k as a function of the amount of waste present within each segment for multiple degradation stages. Rather, k is allowed to vary to reflect **changes in septage addition**, which is a recognized limitation of single- k first-order models when applied to dynamically evolving systems such as septage bioreactor.

In this project, septage addition is treated analogously to changes in moisture content in conventional models, serving as an external driver that enhances microbial activity and accelerates degradation kinetics. Because septage injection continued over an extended period, k was allowed to vary in relation to cumulative septage addition, rather than being held constant.

At the same time, the model implicitly captures the declining reactivity of the waste mass as degradation progresses. As readily biodegradable fractions are consumed, the remaining waste becomes increasingly dominated by slowly degradable materials, which naturally results in lower effective k -values even under favorable moisture conditions. To reflect this behavior, the waste mass was conceptually divided into degradation stages (e.g., early, intermediate, and late stages), based on the fraction of remaining methane potential. Within each stage, " a " and " k_0 " is assumed to be uniform, while transitions between stages represent changes in dominant waste characteristics (remaining methane potential) rather than changes in waste quantity.

In summary:

- k is not modeled as a function of waste mass.
- Septage addition is treated as a kinetic enhancer, analogous to moisture effects in conventional models.
- Temporal variation in k reflects both improving environmental conditions and declining substrate degradability.
- The resulting k values represent **effective, stage-averaged decay rates**.

This framework allows the model to remain consistent with conventional landfill gas theory while accommodating the evolving biological and chemical conditions associated with septage-enhanced bioreactor operation.

4. This approach leads to many questions:

- a. Shouldn't the declining degradability of the waste be captured in the first-order equation that relates the rate of waste removal to the amount of waste remaining by the first order decay coefficient?
- b. How is L_0 as a function of time calculated? Note: **Details of the coefficient estimation for Cell 3A and Cell 3B were presented in the 2015 and 2016 annual reports.**
- c. How can k be the same for C&D and MSW (only L_0 is assumed to be different)?
- d. Why isn't the estimate for k provided in annual reports 2021 – 2024 for cells other than 3a and 3b.
- e. Why is lag time less in CW West than in CW East?
- f. Why is the lag time less in the “non-bioreactor” area of Cell 8?

Responses 4:

(a) Should declining waste degradability be captured by the first-order decay formulation?

Yes. The first-order decay model inherently captures declining waste degradability through the reduction of remaining methane potential ($L_0^{remaining}$). As gas is generated, the amount of biodegradable substrate decreases, and the modeled gas generation rate declines accordingly.

The unresolved question for this project is **whether the kinetic enhancement associated with septage addition (i.e., its effect on k) remains constant throughout waste decomposition**, or whether that enhancement itself diminishes as readily degradable fractions are depleted. To explore this, the model segregates the waste mass into no more than three degradation stages based on the fraction of remaining methane potential:

- Early stage: $L_0^{remaining} / L_0^{initial} > 0.8$

- Intermediate stage: $0.8 \geq L_0^{remaining} / L_0^{initial} > 0.5$
- Late stage: $L_0^{remaining} / L_0^{initial} \leq 0.5$

This segmentation improved model fitting and provides a practical way to reflect diminishing responsiveness to septage addition. However, it is acknowledged that this assumption is empirical and would require additional controlled research to be rigorously validated.

k-value in our model was estimated using the following coefficients:	
when $L_0 \geq 0.8L_0^{initial}$:	$k = 0.05S + 0.08$
when $0.5L_0^{initial} \leq L_0 < 0.8L_0^{initial}$:	$k = 0.045S + 0.06$
when $L_0 < 0.5L_0^{initial}$:	$k = 0.015S + 0.04$

(b) How is remaining L_0 calculated as a function of time?

The initial methane potential $L_0^{initial}$ is calculated based on the waste composition for each load which is either monthly or quarterly waste tonnage disposed of in the cell. The $L_0^{initial}$ is determined as:

Initial potential methane generation capacity (i.e., the “ $L_0^{initial}$ ” value) was calculated based on the recorded waste types and assumed L_0 for each waste type (100 m³/Mg for MSW and 30 m³/Mg for C&D):

$$L_0^{initial} = \frac{100W_{msw} + 30W_{CD}}{W_{total}} \quad (\text{in m}^3/\text{Mg})$$

Where: $L_0^{initial}$ = overall methane generation potential for all waste, m³/Mg;
 W_{msw} = waste mass in MSW, tons;
 W_{CD} = waste mass in C&D, tons;
 W_{total} = total waste mass, tons.

The remaining methane potential is calculated using a mass balance on cumulative methane generation:

$$L_0^{remaining} = \frac{(L_0^{initial} \times M_s) - V_{CH_4}}{M_s}$$

Where:

- $L_0^{remaining}$ = remaining methane potential at the time step
- $L_0^{initial}$ = initial methane potential based on waste composition
- M_s = waste mass (monthly or quarterly tonnage basis)
- V_{CH_4} = cumulative methane generated up to that time step

This approach is consistent with the methodology with the variable k based on the septage addition.

(c) How can k be the same for C&D and MSW, with only L_0 assumed to be different?

MSW and C&D gas generation were **not modeled separately** because the wastes are co-disposed within the same cells (CW West, Cell 4, and Cell 8), and gas collection data cannot be disaggregated by waste type. As a result:

- A single effective k-value is applied to the mixed waste mass;
- Differences in biodegradability between MSW and C&D are captured through **different L_0 assumptions**, which are weighted based on their respective tonnages.

The resulting k therefore represents an **effective decay coefficient for the mixed waste system (CW West, Cell 4 and Cell 8)**, rather than a material-specific kinetic constant. Noted that the k values obtained from Cell 3A and 3B are related only to MSW since only MSW was disposed in those cells.

(d) Why are k estimates not reported in annual reports (2021–2024) for cells 3A and 3B?

The reviewer’s question is not clearly framed. Methane generation rate constants (k-values) for CW West, Cell 4, and Cell 8 were reported in the annual modeling reports prepared between 2021 and 2024. Therefore, the comment was interpreted as referring to the absence of k-value estimation for Cells 3A and 3B during that period, as k-values for the other cells had already been established and reported.

Gas generation tracking for Cells 3A and 3B was discontinued in late 2016 for the following reasons:

- Gas generation rates in Cells 3A and 3B had declined substantially.
- Cell 4 waste placement (initiated in July 2015) overlaid Cells 3A and 3B, creating uncertainty regarding the source of collected gas.
- The gas collection infrastructure associated with Cells 3A and 3B may have captured gas generated from overlying waste, making cell-specific k-value estimation unreliable.

Given these limitations, k-value estimates for these cells were no longer considered defensible for reporting purposes.

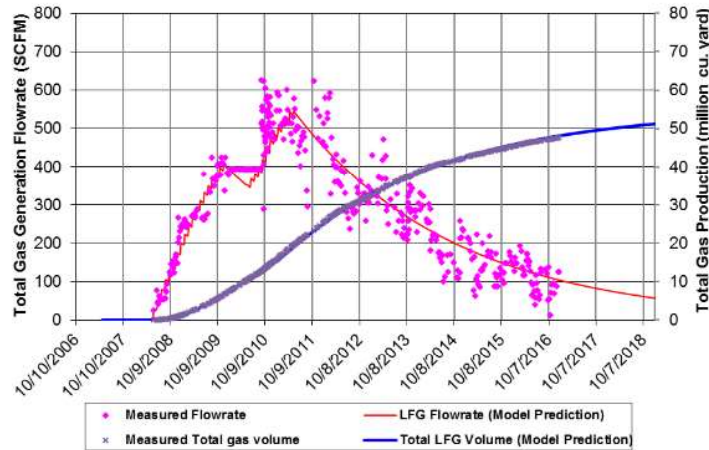


Figure 5-17B Landfill Gas Production Modeling for Cell 3A

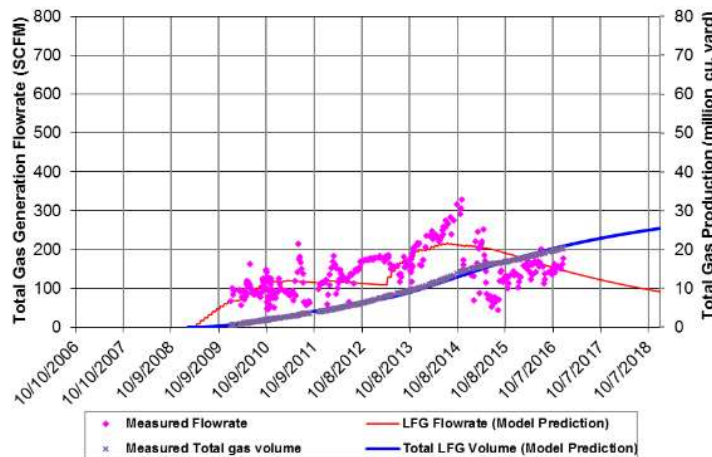


Figure 5-18B Landfill Gas Production Modeling for Cell 3B

Source: 2016 SCL RDDP Annual report

(e) Why is the lag time shorter in CW West than in CW East?

Lag time was adjusted during the **initial calibration phase** of each gas model. The CW East model is a composite of Cells 3A, 3B, and 4, each with distinct lag times:

- Cell 3A:
 - 19 months (Lifts 1–4)
 - 6 months (Lifts 5–6)
- Cell 3B: 11 months
- Cell 4: 8 months

CW West, by contrast, consists primarily of **older waste**, for which a lag time of approximately **2 months** provided the best fit. The most plausible explanation is that significant anaerobic

activity and methane generation had already commenced prior to septage addition and intensive gas monitoring, resulting in a shorter observed lag.

(f) Why is lag time shorter in the “non-bioreactor” area of Cell 8?

Gas production in Cell 8 exhibits atypical behavior, with elevated methane generation occurring earlier than expected and without septage addition. The underlying cause is uncertain. However, SCL disposed of a significant quantity of **paper mill sludge** in Cell 8, which is known to be highly biodegradable.

One plausible hypothesis is that this waste stream substantially accelerated microbial activity and methane generation, thereby reducing the apparent lag time. This explanation is offered as a reasonable interpretation rather than a definitive conclusion.

Summary

- Declining degradability is captured through reduction of remaining L_0 ; staged k values address changing responsiveness to septage.
 - Initial methane potential $L_0^{initial}$ is estimated based on the waste composition.
 - Remaining methane potential $L_0^{remaining}$ is calculated deterministically via mass balance, not curve fitting.
 - k represents an effective mixed-waste decay rate, while L_0 captures waste-type differences.
5. In Annual Report 2024 the following was observed, casting doubt on the approach for k estimations:

“The volume from this combined volume were fitted with the combined models results (from both Bioreactor and Non Bioreactor Zones) by adjusting “ k ” value for the Non-Bioreactor zone. The best fit was found when the k is equal to 0.8 1/yr.”

Responses 5:

The observation cited from the 2024 Annual Report is acknowledged. However, this finding does not cast doubt on the k -estimation methodology used for evaluating the septage bioreactor, for the reasons explained below.

The k value of 0.8 yr⁻¹ referenced in the 2024 Annual Report was derived **solely for the Non-Bioreactor Zone** as part of a **system-level reconciliation** between measured total gas collection and the combined output of multiple gas models (Bioreactor and Non-Bioreactor Zones). In this context, k was adjusted to achieve a best-fit match for overall gas recovery and **was not intended to represent a mechanistic or long-term decay rate** for that zone.

As stated in the report, it remains uncertain whether the elevated apparent k in the Non-Bioreactor Zone represents a sustained trend or a temporary fluctuation. Additional data is required before drawing conclusions regarding long-term degradation kinetics. Accordingly, the

report explicitly notes that continued model refinement will be necessary as more operational data becomes available.

Importantly, this abnormal behavior in the Non-Bioreactor Zone is **independent of septage addition**. No septage was applied in that area, and therefore the elevated apparent k cannot be attributed to septage-enhanced bioreactor operation. Instead, the fitted k reflects site-specific or waste-stream-specific factors affecting gas generation in that zone, such as waste composition, historical disposal practices, or atypical biodegradable inputs.

The modeling approach used for the septage bioreactor relies on **comparative analysis within controlled operational contexts** (e.g., Cells 3A and 3B, staged degradation conditions) and does not depend on k values inferred from unrelated or anomalous areas. Consequently, the use of a fitted k value for the Non-Bioreactor Zone in 2024 does not undermine the conceptual framework, assumptions, or conclusions of the septage bioreactor modeling.

In summary:

- The $k = 0.8 \text{ yr}^{-1}$ value was a **localized fitting parameter** used for system reconciliation, not a generalizable decay constant.
 - The behavior occurred in a **non-septage area** and is therefore unrelated to bioreactor performance.
 - The uncertainty and provisional nature of this estimate were explicitly acknowledged in the Annual Report.
 - The septage bioreactor modeling approach remains internally consistent and technically defensible.
6. Collection efficiency is assumed to be 0.75, which is high for cells without interim cover. Not clear if all LFG data are from times after interim cover placement. For example, Cell 4 was being filled in 2016-2020, with an interim cover installed in 2020.

Responses 6:

Interim Cover Placement and Data Periods

Interim cover was installed on all exterior slopes within approximately 90 days of waste placement in the adjacent areas, in accordance with site operating procedures. However, interim cover was generally not installed on the top of the working plateau until the area reached its design fill grade. As a result, during active filling periods (e.g., Cell 4 between 2016 and 2020), portions of the plateau may not have been covered at the time gas data were collected, while perimeter slopes were covered.

Accordingly, the LFG data used in the analysis represents a combination of conditions, including periods both before and after full interim cover placement on the plateau.

Basis for Assumed Collection Efficiency

A collection efficiency of 0.75 was selected as a representative, system-level value consistent with commonly applied assumptions in landfill gas modeling for sites with partial interim cover and an operational gas collection system. It is acknowledged that this value may be high for areas without full interim cover, particularly on active plateaus.

However, if the true collection efficiency were lower than 0.75, the modeled gas generation rates would be underestimated when back-calculated from measured gas collection data. As a result, the inferred enhancement of methane generation associated with septage addition would also be underestimated.

Conservatism of the Assumption

Therefore, the use of a 0.75 collection efficiency is conservative with respect to the study's conclusions. Any overestimation of collection efficiency biases the analysis toward lower calculated gas generation rates and smaller apparent effects of septage-enhanced biodegradation. This conservatism does not artificially inflate the modeled benefit of septage addition and instead reduces the likelihood of overstating its impact.

7. Well field may not be isolated to cells analyzed.

Responses 7:

The reviewer's comment regarding potential lack of isolation of the gas well field is valid and acknowledged. Complete hydraulic and pneumatic isolation of landfill gas collection systems is rarely achievable in practice, particularly as cells are sequentially constructed and overlaid.

Recognition of the Limitation and Corrective Action

This limitation is one of the primary reasons SCL discontinued cell-specific gas analysis for Cells 3A and 3B after 2016. Following the initiation of waste placement in Cell 4, portions of the waste in Cell 4 were placed over the slopes of Cells 3A and 3B, and the existing gas collection infrastructure for Cells 3A and 3B may have captured gas generated from newly placed overlying waste. Under these conditions, attribution of collected gas to specific cells was no longer reliable.

Justification for Separation of Other Modeling Areas

In contrast, separating areas such as Cell 4 and CW West remains technically reasonable due to:

- Distinct physical separation of waste masses;
- Independent or minimally interconnected gas collection infrastructure; and
- Distinct operational practices, including septage application.

These factors support treating these areas as separate modeling domains despite unavoidable boundary effects.

Rationale Against Site-Wide Aggregation

Modeling the entire site as a single, fully aggregated unit would obscure localized operational impacts, including the effects of septage addition. Such aggregation would dilute spatially distinct responses and reduce the ability to evaluate the performance of the septage bioreactor relative to non-bioreactor areas.

Complicating Factors

It is acknowledged that atypical gas production observed in Cell 8 further complicates site-wide modeling. This abnormal behavior introduces additional uncertainty that reinforces the need for spatially resolved modeling rather than wholesale aggregation.

Conclusion

While perfect isolation of gas well fields is not achievable, the analytical approach adopted strikes a reasonable balance between physical realism and interpretive clarity. Known limitations were explicitly recognized, and analytical boundaries were selected to minimize misattribution of gas while preserving the ability to assess septage-related effects.

8. How do cold temperatures affect k ? There were significant periods of time where temperatures in LFG wells were below 20o C.

Responses 8:

The reviewer's question regarding the influence of cold temperatures on k is acknowledged. Temperature is a known factor affecting microbial activity and methane generation rates, and lower waste temperatures can reduce degradation kinetics under certain conditions.

In this project, **temperature effects were not explicitly evaluated or incorporated into the k estimation** for the following reasons.

First, **gas well temperature is not a reliable proxy for in-situ waste temperature**. The measured temperature at a gas extraction well is strongly influenced by gas flow rate and system configuration. Under high flow conditions, gas temperature may more closely reflect waste temperature; however, under lower flow conditions, wellhead temperatures can be substantially influenced by ambient conditions and heat exchange within the well casing and lateral pipes for the lateral gas extraction lines.

Second, the gas collection system at the project areas (3A, 3B, 4 and 8) relies on **lateral gas extraction lines**, where solid lateral pipes can extend on the order of 100 feet or more. Gas traveling through these laterals exchanges heat with surrounding waste and pipe materials over a considerable distance. As a result, the measured gas temperature often reflects thermal conditions along the gas conveyance pathway rather than the temperature within the primary gas-producing zones of the waste mass.

Third, **thermistor temperature sensors were embedded in the waste mass** to directly monitor in-situ waste temperature. However, the performance of these sensors became unreliable over time due to factors such as sensor or cable damage. Consequently, the available thermistor data

was not considered sufficiently robust for quantitative incorporation into the gas generation model.

Finally, spatial and temporal variability in waste temperature within the landfill further complicates assignment of a single representative temperature for modeling purposes. Incorporating temperature-dependent corrections to k without reliable, depth-specific waste temperature data could introduce additional uncertainty and potentially bias the results.

Given these limitations, k was treated as an effective, lumped parameter that implicitly reflects average biological activity over time, rather than being explicitly corrected for short-term or localized temperature variations. Any transient reductions in methane generation associated with colder periods would be reflected in the measured gas collection data and therefore indirectly incorporated into the fitted k values.

In summary:

- Temperature effects on k were not explicitly modeled.
- Gas well temperature measurements are not a robust indicator of in-situ waste temperature.
- Long lateral gas collection lines further decouple measured gas temperature from gas generation zones.
- Embedded thermistor sensors were installed but did not provide reliable long-term data.
- Treating k as an effective parameter avoids introducing poorly constrained temperature corrections.

This approach is consistent with common landfill gas modeling practice when reliable, long-term waste temperature measurements are not available.

9. MC is fairly low for bioreactor cells, far below optimum MC levels. How does this affect LFG production?

Responses 9:

Yes, the calculated moisture content is relatively low. However, evaluation of the effect of absolute moisture content on landfill gas production was not an objective of this project.

10. From 2020 Annual Report:

For CW East (*West?*):

k value in our model was estimated using the following coefficients:

when $L_0 \geq 0.8L_0^{initial}$:

$$k = 0.05S + 0.08$$

when $0.5L_0^{initial} \leq L_0 < 0.8L_0^{initial}$:

$$k = 0.03S + 0.06$$

when $L_0 < 0.5L_0^{initial}$:

$$k = 0.02S + 0.04$$

Responses 10:

The cited values are from the **2024 Annual Report**, not the 2020 Annual Report, and they apply to **CW West**, with **Cell 8 explicitly excluded** from the analysis.

For **CW East**, no independent k estimation was performed. The CW East gas model represents a **composite of the individual gas models for Cells 3A, 3B, and 4**, with total gas generation calculated by summing the outputs of those cell-specific models rather than fitting a separate decay parameter.

For CW West (*East?*):

11. Initially, LFG modeling was ~ to LandGEM, k is adjusted to match gas flowrates, assuming a lag and $L_0 = 100$

Responses 11:

Yes. For MSW only cells (3A and 3B), the initial L_0 is assumed at 100.

12. In 3a (septage added) $k = 0.296$, In 3b where only leachate recirculated $k = 0.082$

Responses 12:

Correct.

13. There were concerns that 3 b LFG was not accurate, so eventually, septage added to both cell 3 units, and after 2013 k was estimated as a function of the amount of septage added ($k = 0.01395S + 0.082$) until sufficient S (15 gal/ton – why???) to ~ a septage bioreactor. $15 \times 0.01392 + 0.082 = 0.29$. Ultimately Cell 3 gas modeled instead of individual test units

Responses 13:

During Cell 3A operation, cumulative septage addition reached approximately **22 gal/ton** by the end of septage injection (2016). However, the estimated k value was not significantly changed after 2011 when the septage addition reached approximately 15 gal/ton. Noted that the Cell 3A

gas model **did not apply a variable k formulation**; k was estimated using a fixed approach for that test unit.

The **variable k relationship ($k = 0.01395S + 0.082$)** was implemented beginning with the **Cell 3B** gas model. An upper bound of **S = 15 gal/ton** was selected to represent a practical maximum septage loading consistent with septage bioreactor operation and to avoid extrapolation beyond observed impact by the septage addition. In practice, the **maximum septage addition in Cell 3B was approximately 11 gal/ton**, and the model did not exceed this value.

14. Other cells (4, 7) came on line and septage added to them. After 2017 all septage cells modeled as $k = 0.04S + 0.082$. Again, 0.082 = no septage. 0.04 was a fitting parameter. Once $S > 6.5$, $k = 0.342$. No explanation for why k increased.

when $L_0 \geq 0.8L_0^{initial}$:

$$\text{If } S \leq 6.5 \text{ gal/ton: } k = 0.05S + 0.08$$

$$\text{If } S > 6.5 \text{ gal/ton: } k = 0.41$$

when $0.5L_0^{initial} \leq L_0 < 0.8L_0^{initial}$:

$$\text{If } S \leq 6.5 \text{ gal/ton: } k = 0.03S + 0.06$$

$$\text{If } S > 6.5 \text{ gal/ton: } k = 0.26$$

when $L_0 < 0.5L_0^{initial}$:

$$\text{If } S \leq 6.5 \text{ gal/ton: } k = 0.01S + 0.04$$

$$\text{If } S > 6.5 \text{ gal/ton: } k = 0.11$$

Responses 14:

The variable methane generation rate constant relationship ($k = 0.01395S + 0.082$) was first implemented in the Cell 3B gas generation model. This same relationship was applied to predict gas generation in CW West for the period prior to 2017. Although septage addition in CW West began in 2014, the cumulative septage addition as of the end of 2016 was approximately 1.4 gallons per ton.

As septage addition increased and additional landfill gas monitoring data became available, a revised variable k relationship was subsequently developed to better reflect observed gas generation behavior.

15. In 2019, Modeling was changed to allow both L_0 and k to vary. No explanation provided and no indication of how L_0 is determined.

Responses 15:

The initial methane potential (L_0) is determined based on the weighted waste composition (MSW and C&D). **k was estimated as a function of septage addition** using the relationship $k = \alpha S +$

k_0 , while the **remaining methane potential**—more appropriately denoted as $L_0^{remaining}$ —was recalculated at each time step using a mass-balance approach.

- (3) Initial potential methane generation capacity (i.e., the “ $L_0^{initial}$ ” value) was calculated based on the recorded waste types and assumed L_0 for each waste type (100 m³/Mg for MSW and 30 m³/Mg for C&D):

$$L_0^{initial} = \frac{100W_{msw} + 30W_{CD}}{W_{total}} \quad (\text{in m}^3/\text{Mg})$$

Where: $L_0^{initial}$ = overall methane generation potential for all waste, m³/Mg;

W_{msw} = waste mass in MSW, tons;

W_{CD} = waste mass in C&D, tons;

W_{total} = total waste mass, tons.

The remaining methane potential was determined deterministically based on cumulative methane generation and waste mass, not through curve fitting. This calculation method has been consistently applied in all models where k is linked to septage addition and is described in detail in **Response 4(b)**.

REFERENCE

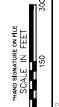
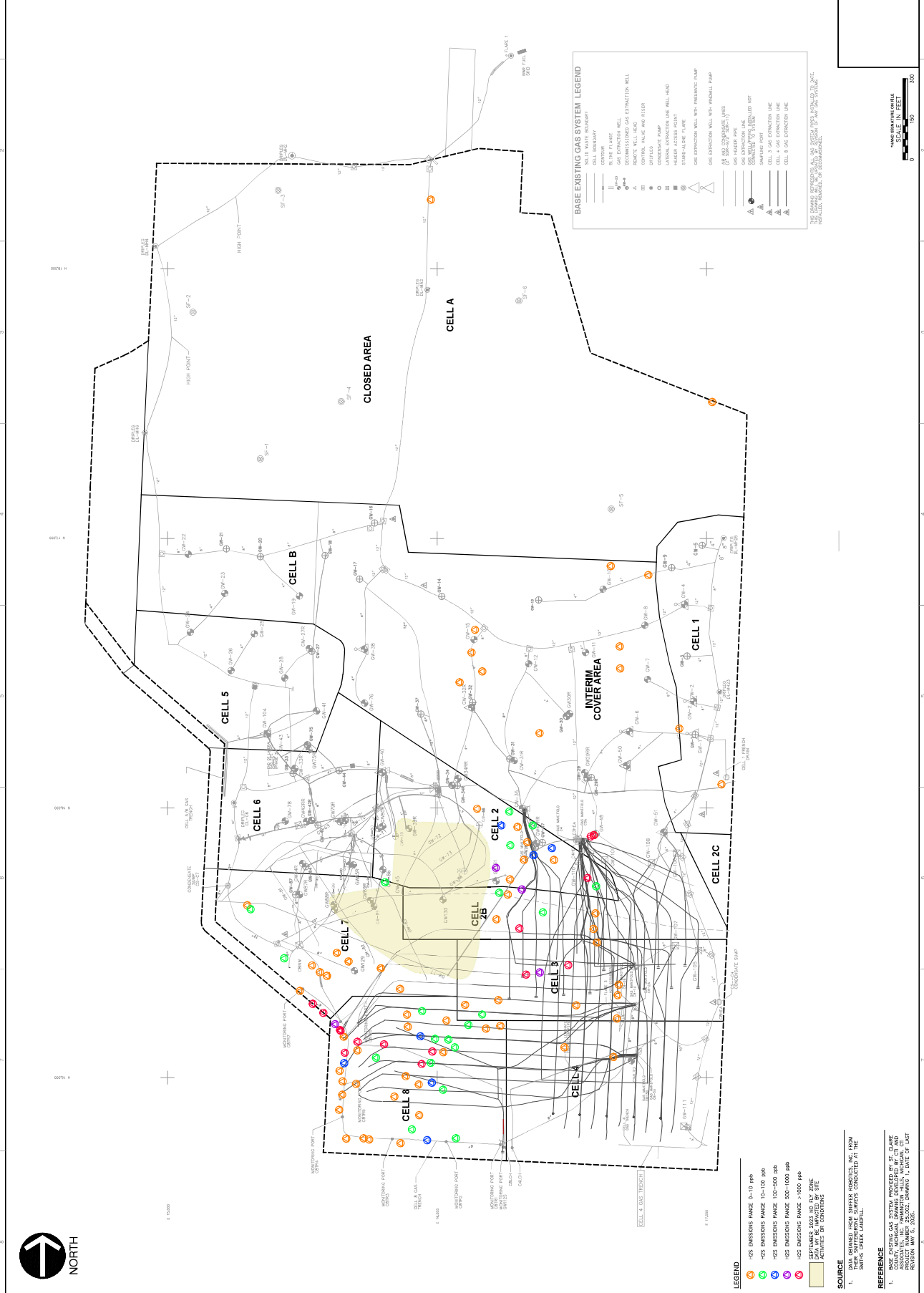
R. Inatah, et al, 2021, “Analysis of Methane Production from Septage Sludge of Various Age”, Poster Presentation, Sanitation Value Chain Vol. 5 (1) p.040.

X. Zhao, et al. 2013, “Full-Scale Field Research and Demonstration of Septage Bioreactor Landfill Technology”, J. Hazard. Toxic Radioact. Waste 2013.17:295-306

APPENDIX D

**SNIFFER DRONE SURVEYS OF CH₄ AND H₂S GAS
(DRAWINGS 1–6)**

NO.	DATE	REVISION DESCRIPTION



SCALE: 1" = 100'

- LEGEND**
- 1000 CONCENTRATION RANGE 0-10 ppb
 - 500 CONCENTRATION RANGE 10-100 ppb
 - 250 CONCENTRATION RANGE 100-500 ppb
 - 100 CONCENTRATION RANGE 500-1000 ppb
 - 50 CONCENTRATION RANGE 1000-1500 ppb
 - 25 CONCENTRATION RANGE 1500-2000 ppb
 - 10 CONCENTRATION RANGE 2000-3000 ppb
 - 5 CONCENTRATION RANGE 3000-4000 ppb
 - 2.5 CONCENTRATION RANGE 4000-5000 ppb
 - 1.25 CONCENTRATION RANGE 5000-6000 ppb
 - 0.625 CONCENTRATION RANGE 6000-7000 ppb
 - 0.3125 CONCENTRATION RANGE 7000-8000 ppb
 - 0.15625 CONCENTRATION RANGE 8000-9000 ppb
 - 0.078125 CONCENTRATION RANGE 9000-10000 ppb
- SOURCE**
- DATA OBTAINED FROM SHARLA KENNEDY, INC. FROM THEIR SNIFFER DRONE SURVEY CONDUCTED AT THE SMITHS CREEK LANDFILL.
- REFERENCE**
- BASE EXISTING GAS SYSTEM PRINTED BY ST. CLAIR COUNTY ENGINEERING DEPARTMENT, 11/15/2023, REVISION MAY 5, 2025.



APPENDIX E

CEC'S GCCS INFRASTRUCTURE REVIEW AND RECOMMENDATIONS

GAS COLLECTION AND CONTROL SYSTEM

KEN KRUSZYNSKI'S REVIEW AND RECOMMENDATIONS

OVERVIEW

Landfilling operations at the Smiths Creek Landfill are subject to Title 40 Code of Federal Regulations (CFR) Part 62 Subpart OOO (Federal Plan), and Title 40 CFR Part 63 Subpart AAAA (Landfill NESHAP). An active landfill gas collection and control system (GCCS) is in-place and operational in all portions of the active landfill that are subject to the Landfill NESHAP.

The existing landfill GCCS provides physical coverage and emission control for the active and closed waste disposal areas. The extracted and collected landfill gas is primarily sent to the electrical power generation facility operated by Blue Water Renewables for beneficial utilization or combusted in two available process utility flare units when the electrical power generation facility is offline. The rated design combustion capacity of the blower and process utility flare station (Flare 1) is 2,000 standard cubic feet per minute at a methane concentration of 50%. The electrical power generation facility operated by Blue Water Renewables consist of two Caterpillar G3520 reciprocating engine generation sets which the capacity of generation approximately 1,600 kilowatts of gross power output.

The existing landfill GCCS is divided into two distinct sections. The first section is a conventional GCCS section consisting primarily of vertical extraction wells interconnected to a network of header and lateral vacuum pipelines. This section addresses the Cell A, Cell B, Cell 1, Cell 2, Cell 5, Cell 6, and Cell 7 waste disposal areas. The wellfield density was observed to have sufficient coverage (more than one vertical extraction well per acre) to address the potential for uncontrolled surface emissions and associated odors.

The second section consists of a liquids injection and recirculation section and associated horizontal lateral collectors interconnected to a network of header and lateral vacuum pipelines. This section addresses the Cell 2B, Cell 3, Cell 4, and Cell 8 bioreactor waste disposal areas. The extracted and collected landfill gas is delivered to the temporary supplemental treatment system and secondary blower and process utility flare station (Flare 3) for hydrogen sulfide absorption removal and combustion. The rated design combustion capacity of the supplemental process utility flare unit is 1,300 standard cubic feet per minute at a methane concentration of 50%, however the permitted combustion capacity is reduced to 1,000 standard cubic feet per minute at a methane concentration of 50%. The current combustion flow rate at the supplemental process utility flare unit is approximately 615 standard cubic feet per minute.

Landfill gas vertical extraction well sizes range from 6-inch to 8-inch nominal diameter and are constructed from polyvinyl chloride (PVC) or high-density polyethylene (HDPE) pipe casing. The HDPE interior lateral pipelines were mostly 4-inch and 6-inch nominal diameter installed

underground. The HDPE perimeter and interior header pipelines were mostly 8-inch, 10-inch, and 12-inch nominal diameter installed underground.

GCCS EVALUATION OBJECTIVES

The Smiths Creek Landfill is considering starting the operations again of the septage and leachate recirculation system within the bioreactor waste disposal area, with the possible potential objective of developing a renewable natural gas (RNG) facility at the landfill. An objective of our professional landfill gas consulting services was to evaluate the existing GCCS and identify engineering design issues that would require improvements, modifications, and repairs if an RNG facility would be developed.

In general, RNG facilities cannot tolerate a landfill gas stream with high nitrogen and oxygen concentrations because of the need to meet high British thermal unit gas transmission pipeline specifications. Therefore, the GCCS wellfield is typically operated to minimize the intrusion of excess air into the GCCS system by not aggressively applying vacuum. However, by not aggressively applying vacuum to the wellfield, the potential for uncontrolled emissions and odors increases.

Civil & Environmental Consultants, Inc. (CEC) reviewed the CTI and Associates, Inc. (CTI) response to the Environmental Information Logistics (EIL) Implementation Plan Report dated July 2025. In general, we believe that CTI has done a good job in addressing the operational and maintenance issues of the existing GCCS system identified by EIL and the Michigan Department of Environment, Great Lakes, and Energy, and explaining the remediation approaches proposed, implemented and their effectiveness in responding to the identified issues.

Therefore, the objective of CEC's GCCS engineering design evaluation is to perform a detailed review of the GCCS component capacities and conditions of the existing landfill gas extraction, control, and process equipment in the context of supporting a RNG facility development project. This GCCS evaluation will result in recommended GCCS improvements, modifications, and repairs based on our technical engineering review and field observations.

GCCS WELLFIELD OBSERVATIONS AND RECOMMENDATIONS

The following section describes some of the GCCS issues identified during our site visit on October 22, 2025. These identified issues would need to be resolved if a RNG facility development project is considered.

Atmospheric Oxygen Intrusion Control

Installed within the certified closed landfill area, CEC identified several spark-ignited flare unit installation on vertical extraction wells. The spark-ignited flare units are effective for odor and emissions control on low flow vertical extraction wells. These units were observed not to be operational. However, if inoperable on low or no flow vertical extraction wells, these units can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality. Therefore, these units should be removed and the vertical extraction well should be capped and sealed.

Installed within the certified closed landfill area, CEC identified several abandoned capped 6-inch PVC well casings. There was evidence of the cap installation being sealed with duct tape. If PVC cap is not properly installed and solvent cement sealed, it can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality.

In 2025, there were two barometric condensate drip leg assemblies and the associated 12-inch perimeter isolation control valve repaired within the existing 12-inch interior perimeter pipeline aligned along the western perimeter of the certified closed landfill area. The 2024 repairs helped with overall GCCS vacuum distribution. Barometric condensate drip legs require constant maintenance to keep liquid trap in take to prevent air intrusion and can be obstructed with debris causing condensate backups into the adjacent perimeter header pipeline system disrupting vacuum distribution.

There is one 6-inch riser pipe and one 4-inch HDPE riser pipe associated with each barometric drip leg assembly for access and maintenance. Each HDPE riser pipe was capped with an associated sized PVC cap. If PVC cap is not properly installed and sealed, it can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality. PVC caps should not be used with HDPE pipe casings. HDPE and PVC are dissimilar materials and should not be connected together except by means of a mechanical connection such as a gasketed flange to flange connection. If the HDPE risers' pipes are not capped with a mechanical connection such as a blind flange assembly, it can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality.

Installed within the landfill Cell 5 waste disposal area, CEC identified an open lid on a perimeter leachate pump access riser. The leachate pump access riser provides a drainage point interconnection to the leachate collection system for generated and accumulated landfill gas condensate. It was observed that the open lid not sealed properly providing a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality and should be repaired or replaced.

External Southern Perimeter Main Header Pipeline

In February 2024, a supplemental interior perimeter gas collection trench system had been designed and installed for the Cell 8 waste disposal area. The supplemental interior perimeter gas collection

trench system consists of an 8-inch HDPE vacuum header pipeline supplying vacuum to a 6-inch HDPE perforated extraction traction trench. As a result of these efforts, a substantial increase in the available vacuum at the wells in Cell 8 has been documented.

However, this system is installed within the interior of the waste disposal area adjacent to the bioreactor area, which is subject to differential settlement. The resulting differential settlement can result in low points within the vacuum header pipeline, and the accumulation of condensate and other debris causing a disruption of vacuum distribution. For RNG facility GCCS systems, it is best practice to design and install a perimeter main header pipeline out of the waste disposal areas for future accessibility and expansion, and to prevent the potential for differential settlement and obstruction.

It is recommended to implement the proposed southern perimeter exterior header pipeline system along the southern perimeter to extend vacuum distribution to the furthest areas of the Cell 8 waste disposal areas. If septage and leachate recirculation is to begin again, then anticipated accelerated differential settlement is to be expected within the waste disposal areas where the interior components of the GCCS header and lateral pipeline systems would be affected. The proposed southern perimeter exterior header pipeline system would loop the existing GCCS system that would facilitate overall vacuum distribution. The proposed southern perimeter exterior header pipeline system should have header access risers with control valve assemblies installed every 250 feet to provide interconnection access for future expansion.

In addition, it is recommended that the supplement blower and process utility flare skid (Flare 3) and the Interra Ferrosorp hydrogen sulfide adsorption treatment vessel components be moved to the southern perimeter for stability and access and interconnected to the proposed southern perimeter exterior header pipeline. The existing location these components are located within the Cell 8 waste disposal area where they are subject to differential settlement, would need to be eventually moved to claim additional waste disposal airspace in the future.

Horizontal Lateral Extractors Wellfield Manifold

In order to extract and collect the anticipated accelerated landfill gas generation volumes due to the septage and leachate recirculation system within the bioreactor waste disposal area, a matrix of horizontal lateral extractors have been installed. The horizontal lateral extractors are oriented in a north to south and west to east alignments. The horizontal lateral extractors are then routed and grouped into several manifold units. An interior header pipeline distributes vacuum to each manifold unit. At the manifold unit, each horizontal lateral extractor is connected to the manifold unit with its own wellhead assembly. At each wellhead assembly, vacuum is applied to the individual horizontal lateral extractor, and the extracted landfill gas flow rate, temperature, and methane, carbon dioxide, and balance gas concentrations are monitored.

The manifold unit and associated individual wellhead assemblies applies available vacuum to the horizontal lateral extractors pipes that are approximately 450 lineal feet or more in length. However, the application of vacuum only occurs at only one end of the horizontal lateral extractors, where the vacuum would dissipate quickly at the beginning of the perforated pipe, and no vacuum would be available at the far ends. In its current design, there is no way of monitoring applied vacuum at the farthest ends of the horizontal lateral extractors, so there is no way of determining the actual applied vacuum and influence at these farthest locations.

The proposed perimeter exterior header pipeline system extending along the western and southern perimeters of the bioreactor waste disposal areas would extend vacuum distribution to the furthest areas of the Cell 8 waste disposal areas. It would be then possible to install manifolds units at each end of a series of horizontal lateral extractors and provide the ability to apply vacuum from both ends of the horizontal lateral extractors. This would enhance vacuum application to the waste mas at both ends of horizontal lateral extractors and increase the zone of influence. This would facilitate overall landfill gas extraction and prevent uncontrolled surface emissions with its associated odors.

Another effective design where installing manifolds at each end of a horizontal lateral extractor is not practical is the installation of a series of nested horizontal lateral extractors. A series of nested horizontal lateral extractors installed in a common trench, each with its own wellhead assembly. The nested horizontal lateral extractors would each have different lengths where the perforated pipe section begins in order to project the applied vacuum to the farthest waste disposal regions.

Future HDPE Vertical Extraction Well Casings

In 2024, four new vertical extraction and thirteen re-drilled replacement vertical gas wells were installed, with fourteen of those gas wells being located in the Cell 6 waste disposal areas. As part of the project, a new interior vacuum header pipeline was constructed to which four of the new gas wells in the bioreactor areas were connected during 2024, becoming part of the active gas extraction system.

Some of these vertical extraction wells were installed within the liquid recirculation bioreactor area, where the probability that internal liquid levels would be high. These new vertical extraction wells should have camera inspections to determine the level of accumulated liquids and the percentage of open perforations that are available. This would help in the determination whether a pneumatic displacement pump would be required to keep open the perforated well casing for vacuum application.

These new vertical extraction wells were constructed with 6-inch HDPE solid and perforated well casing pipe. Because of the flexibility of HDPE pipe, it is not suitable for future installation of pneumatic displacement pumps for liquid removal. For future dual landfill gas and leachate extraction wells installed in saturated waste disposal areas, PVC Schedule 80 rigid solid and

perforated pipe casing is recommended in order to install, access and maintain the pneumatic displacement pumps (if required).

In addition to the 6-inch well casing pipe, there is a 4-inch HDPE vacuum riser pipe associated with each new vertical extraction well. Each HDPE riser pipe was capped with an associated sized PVC cap. If PVC cap is not properly installed and sealed, it can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality. PVC caps should not be used with HDPE pipe casings. HDPE and PVC are dissimilar materials and should not be connected together except by means of a mechanical connection such as a gasketed flange to flange connection. If the HDPE riser pipes are not capped with a mechanical connection such as a blind flange assembly, it can be a conduit for atmospheric air intrusion within the landfill affecting landfill gas quality.

Located on the eastern perimeter adjacent to Cell 2C, contains the Ingersol Rand rotary screw air compressor unit with coalescing filters, desiccant dryers, and accumulation tank equipment installed within a storage building. The Ingersol Rand rotary screw air compressor unit is equipped with a 25-horsepower motor and has the capacity to deliver 92 actual cubic feet per minute of compressed air at a pressure of 150 pounds per square inch. Overall, the equipment was observed to be in good condition, well maintained, and available to provide compressed air for additional pneumatic displacement pumps. It is recommended that all future vacuum header and lateral vacuum pipeline installation include an additional 2-inch HDPE SDR 9 compressed airline pipe and 2-inch HDPE SDR 11 forcemain pipe, so that the infrastructure is in place to install pneumatic displacement pumps in existing and future vertical extraction wells.

Main Blower and Process Utility Flare Station

The main blower and process utility flare station is located north of the waste disposal area adjacent to the main equipment office. A 12-inch HDPE main header pipeline provides vacuum to the wellfield and feed the extracted landfill to the flare station. The extracted landfill gas enters the main blower and process utility flare through the main condensate knockout and pump station vessel. The main condensate knockout and pump station vessel has been sized for the knockout and accumulation of condensate from the entire landfill gas extraction flow rate. The main condensate knockout and pump station vessel was observed in good condition and well maintained.

The Smiths Creek Landfill owned main blower fan equipment is a New York Blower - high pressure blower/fan equipment rated at 2,000 cubic feet per minute at 50 inches of water column static pressure. The New York Blower is equipped with a 25-horsepower motor and is a single stage unit. If the collected and extracted landfill gas is not utilized in the electrical generation power facility, it is delivered to a process utility flare unit (Flare 1) for combustion. The process utility flare unit has a combustion capacity of 2,000 standard cubic feet per minute of landfill gas at a methane concentration of 50%.

Installed adjacent to the Smiths Creek Landfill owned main blower fan equipment is the Blue Water Renewables owned HSI multistage centrifugal blower equipped with a 125-horsepower motor and is a six-stage unit. The HSI multistage centrifugal blower is installed on an equipment skid with filtration, heat exchanger cooler, and dehydration treatment process units. The extracted landfill gas is routed through a separate hydrogen sulfide adsorption system after compression and monitored for hydrogen sulfide concentration to ensure compliance with the 1,300 parts per million volume limit established in the facility Renewable Operating Permit.

There is space available on the equipment skid for a second redundant multistage centrifugal blower unit. A second redundant unit is desirable for reliability to deliver extracted landfill gas to a proposed RNG facility if the initial multistage centrifugal blower unit is inoperable due to potential vibration bearing, impeller, alignment problems.

Main Header Vacuum Pipeline Sizing Criteria

The main delivery header pipeline is 12-inch nominal diameter, which may be undersized for potential landfill gas extraction flow rate. The engineering sizing of main header vacuum pipelines should consider the maximum pressure drop criteria or maximum velocity criteria. Under sizing of the header and lateral pipelines can cause excessive pressure losses throughout the landfill GCCS, which reduces vacuum distribution and extraction efficiency.

The generally accepted pressure drop design basis sizing criteria for header pipeline and lateral vacuum pipelines is that they should be sized to ensure that, for all anticipated design flow rates, the calculated pressure drop does not exceed 1 inch of water column per 100 feet of header pipeline length.

Landfill gas is approximately 100% saturated with water vapor. Liquid condensate is generated when landfill gas experiences a temperature and/or pressure decrease when extracted, and the saturated water vapor condenses out of the vapor state. All condensate generated from the system must be collected from the system and managed. The landfill GCCS header and lateral pipeline alignment is designed to utilize the vertical relief provided by the landfill contours for gravity flow of condensate. Condensate pump stations, condensate knockout vessels, or condensate barometric drip leg assemblies and drains are required at the strategic low points throughout the landfill GCCS.

Because the GCCS is conveying a two-phase flow stream, the generally accepted maximum velocity design sizing criteria for the header and lateral vacuum pipeline system are:

Maximum Con-Current Velocity:	35 feet per second
Maximum Counter-Current Velocity:	25 feet per second
Maximum Condensate Knockout Velocity:	15 feet per second

The header and lateral pipeline vacuum system should be designed in a single or multiple looped layout to provide continued removal of landfill gas if a section of the header and lateral pipeline becomes inoperative. Isolation control valves, header access tee risers, and blind flanges should be specified at several strategic locations so that certain sections of the header pipeline can be isolated for pressure integrity testing, addition of new sections or maintenance.

The minimum header and lateral pipeline slope is typically 4% to 5% when installed within the waste disposal area to provide gravity drainage of condensate, and to minimize blockages resulting from differential settlement. The minimum header and lateral pipeline slope is typically 1/2% to 1% when installed outside the waste disposal area to provide for gravity drainage of condensate, and to minimize blockages resulting from differential settlement.

GCCS Design Best Management Practices Recommendations

The Smiths Creek Landfill has been implementing what is considered best management practices for GCCS systems providing landfill gas to an RNG facility. These GCCS best management practices include using QED Environmental precision control valve wellhead assemblies. The QED Environmental wellhead assembly combine easy orifice plate exchanges for accurate flow rate measurements to match actual extracted landfill gas flow rates over a broad flow range. The QED Environmental wellhead assembly design includes a precision calibrated plug valve allowing greater applied vacuum control improving the extracted landfill gas quality. The QED Environmental precision control valve wellhead assembly are recommended for landfill gas to electrical power generation facility and renewable natural gas facility applications.

Some additional best management practices for landfill facilities planning on the RNG facility development project include the following:

- Apis Innovation Smart Well wellhead assemblies: These Apis Innovation Smart wellhead assemblies allow redefining landfill gas management with precision tuning, real-time monitoring, and intelligent diagnostics;
- Apis Innovation Header Monitor devices: These Apis Innovation Header Monitor devices are installed on header pipeline access risers and provide real-time data collection and proactive issue resolution primarily to monitor the oxygen concentration within a given header pipeline segment;
- More valved header pipeline segments;
- Wellbore seal boot installation;
- Caisson style extendable “slip” vertical extraction wells for GCCS implementation in new waste disposal cells; and
- Greater vertical extraction well density/coverage (1.5 to 2.5 vertical extraction wells per acre).

GCCS Maintenance Recommendations

The following are recommendations to the on-going GCCS maintenance program in order to capture more landfill gas with sufficient methane concentration for the RNG facility.

- Continue to attempt to identify the immediate causes of the pressure drop/vacuum loss issues within the vacuum header and lateral pipelines.
- Wellfield data should be monitored monthly and evaluated to determine trends, which can be used to define wellfield tuning modifications and additional required maintenance/inspection at wells.
- Based on the review of the GCCS implementation history, there were only sixteen pneumatic displacement pumps installed within vertical extraction wells. None of these pneumatic displacement pumps are currently operational. If possible, perform pneumatic pump maintenance (i.e., pull pumps from wells and provide service) at a minimum on an annual basis, but optimally quarterly to lower liquid levels within the well casing perforated casing section to facilitate vacuum distribution from these vertical extraction wells.
- Perform camera inspections of wells with installed pneumatic pumps that are not maintaining the water level such that over 20% of perforations are available to determine if the pump is installed correctly, or if wells are damaged or silted in.