EVOH Deployment Suitability Assessment No. 6

Bristol Integrated Solid Waste Management Facility

Solid Waste Permit No. 588

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SCS ENGINEERS

02218208.05 | July 10th, 2025

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EXECUTIVE SUMMARY

SCS Engineers (SCS) analyzed elevation data from settlement plates installed within the Solid Waste Permit (SWP) No. 588 Landfill to assess the suitability for deployment of the EVOH cover system. The settlement analysis considered three criteria established by the Virginia Department of Environmental Quality (VDEQ):

- **Criterion 1:** The rate of settlement of the waste has transitioned to a state of long-term secondary compression with the settlement varying approximately logarithmically with time.
- **Criterion 2:** Strain rate at all settlement plates is less than 1% per year, or a rate identified as consistent with secondary compression of municipal solid waste. Strain rate is defined here as the ratio of the change in vertical elevation of the surface of the waste at a given location to the thickness of the waste at that location per unit time.
- **Criterion 3:** Surface cracks due to settlement having a width less than 1-inch.

The EVOH deployment is to proceed once all three criteria have been satisfied or by the date of December 1, 2026, as outlined in the amendment to the Consent Decree between the Commonwealth of Viriginia and the City of Bristol, Virginia (Consent Decree).

To date, the analysis of the elevation data and inspection of the site condition show that none of the criteria have been fully satisfied. However, the proportion of settlement plates in compliance with Criterion 1 or Criterion 2 has increased since the start of the suitability assessments. Table 1 summarizes the findings for Criterion 1 and Criterion 2. Recent visual inspections of the site indicate that surface cracking is ongoing and Criterion 3 is also not satisfied. At this time, substantial ongoing settlement could compromise the integrity of the EVOH cover system.

Table 1 – Summary of Findings

Settlement Plate	Criterion 1	Criterion 2
SP-1	Satisfied	Not Satisfied
SP-2A	Undetermined[1]	Not Satisfied
SP-3A	Undetermined[1]	Satisfied
SP-4A	Undetermined[1]	Not Satisfied
SP-5	Not Satisfied	Satisfied
SP-6	Not Satisfied	Satisfied
SP-7A	Undetermined[1]	Satisfied
SP-8	Satisfied	Satisfied
SP-9A	Undetermined[1]	Satisfied
SP-10	Not Satisfied[2]	Satisfied[2]
SP-11	Not Satisfied	Satisfied
SP-12	Not Satisfied	Satisfied

[1] Given the limited elevation measurements for SP-2A, SP-3A, SP-4A, SP-7A, and SP-9A, SCS does not consider the regression analysis to be conclusive.
[2] The June survey was excluded from the settlement data for SP-10 because the plate was disturbed. The SP-10 criteria determinations are based on the May survey data, before the plate was disturbed.

1.0 INTRODUCTION

SCS has completed the sixth suitability assessment for deployment of the EVOH cover system at the City of Bristol, Virginia's (City's) Integrated Solid Waste Management Facility (ISWMF) SWP No. 588 landfill. The assessment is required by the Consent Decree as amended on March 21, 2024. Settlement data was analyzed based on the three criteria outlined in section 6.iv of Appendix A of the amended Consent Decree. The EVOH cover system deployment will proceed once all three settlement criteria are satisfied, indicating an acceptable rate of settlement, or by December 1, 2026, whichever date comes first.

Excessive settlement within the SWP No. 588 landfill will threaten the integrity of the EVOH geomembrane, which is the most important component of the EVOH cover system. Problems include the formation of voids underneath the geomembrane as localized depressions form due to differential settlement. The resulting low areas dispersed across the geomembrane surface will disrupt stormwater drainage, and repairs would require cutting the geomembrane to place soil fill. Additionally, the geomembrane surface will fall relative to the top elevation of vertical pipes installed within the waste mass. Landfill gas wells and temperature probes will be affected at a minimum. Excessive settlement can render the wells and probes unreachable, requiring widespread adjustments and repairs.

The long-term success of the EVOH cover system requires an acceptable rate of settlement to maintain the system's overall integrity. In accordance with the amended Consent Decree, the following three criteria are used to assess the landfill's suitability for the EVOH deployment:

- **Criterion 1:** The rate of settlement of the waste has transitioned to a state of long-term secondary compression with the settlement varying approximately logarithmically with time.
- **Criterion 2:** Strain rate at all settlement plates is less than 1% per year, or a rate identified as consistent with secondary compression of municipal solid waste. Strain rate is defined here as the ratio of the change in vertical elevation of the surface of the waste at a given location to the thickness of the waste at that location per unit time.
- **Criterion 3:** Surface cracks due to settlement having a width less than 1-inch.

The three criteria are evaluated using elevation data from settlement plates positioned throughout the landfill. The City has completed monthly elevation surveys of the settlement plates since their installation in November 2022, and the compiled elevation data have been plotted on graphs for each operational settlement plate. Regression analysis was used to assess Criterion 1 by considering whether the data shows a linear or logarithmic (decreasing rate with time) trendline. Calculations were completed and tabulated to consider if current strain rates satisfy Criterion 2. Additionally, the landfill surface was monitored by personnel for evidence of surface cracking to assess Criterion 3.

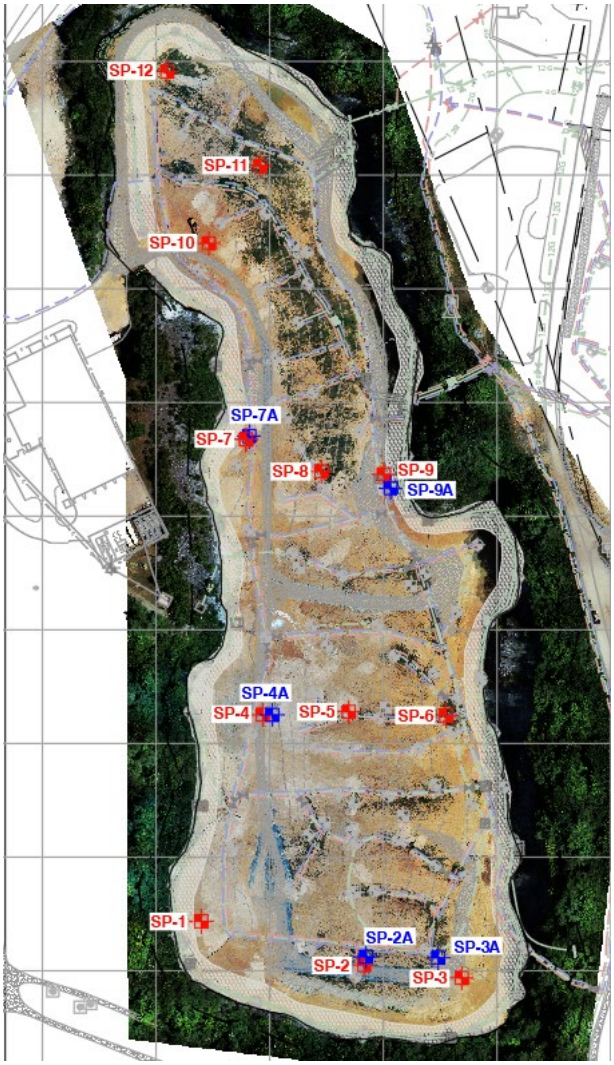
Overall, the analysis of the settlement plate elevation data and surface observations currently indicate ongoing excessive settlement. Criteria one, two, and three are not currently satisfied.

2.0 METHODS

During November 2022, SCS Field Services installed 12 settlement plates on the Solid Waste Permit No. 588 landfill. Five settlement plates were installed during June 2024 to replace settlement plates that had been damaged or were inaccessible. The settlement plates are located throughout the

landfill to include varying waste thickness and changes in the landfill's base grade (Figure 1). The City conducts monthly surveys of the settlement plates to monitor changes in elevation. Surveying is conducted on-foot using satellite-based GPS equipment. The surveyor uses a Topcon Hiper VR Base and Rover to take precise elevation data of the settlement plates.

Figure 1 - Settlement Plate Locations



Settlement plates are fixed points installed within the landfill surface that are used to measure changes in elevation and identify the magnitude of on-going settlement. Settlement plates consist of a buried steel base plate and a steel standpipe or rod that extends above ground and provides an elevation reference point. The rod indicates the center of the base plate, and the initial location and elevation is surveyed by a professional surveyor. Subsequent surveys of the settlement plate measure the change in the vertical direction.

2.1 SETTLEMENT PLATE SURVEYS

The locations of the settlement plates were surveyed by the City's surveyor on November 14, 2022. The settlement plates were surveyed again on the following dates:

- December 13, 2022;
- January 3, 2023;
- February 6, 2023;
- March 8, 2023;
- April 3, 2023;
- May 11, 2023;
- June 5, 2023;
- July 10, 2023;
- August 17, 2023;
- September 11, 2023;
- October 11, 2023;
- November 6, 2023;
- December 12, 2023;
- January 11, 2024;
- February 6, 2024;
- March 13, 2024;
- April 9, 2024;
- May 8, 2024;
- June 4, 2024;
- July 10, 2024;
- July 31, 2024;
- September 10, 2024;
- October 28, 2024;
- November 26, 2024;
- December 23, 2024;
- January 8, 2025;
- February 14, 2025;
- March 18, 2025;
- April 24, 2025;
- May 30, 2025, and
- June 27, 2025

The surveyed coordinates and elevation changes of the settlement plates are shown in Table 3.

2.2 STATUS OF SETTLEMENT PLATES

The City of Bristol monitors the landfill's settlement with monthly measurements of the settlement plate elevations. Not all settlement plates are available each month, and five of the original settlement plates were decommissioned due to damage and replaced with new settlement plates. Table 2 shows the current condition of each settlement plate, including replacement settlement plates installed during June 2024 (listed with suffix "A").

Five replacement settlement plates (SP-2A, SP-3A, SP-4A, SP-7A, and SP-9A) were installed during June 2024 in place of non-operational settlement plates. SP-2A, SP-3A, SP-4A, and SP-7A were installed to replace damaged settlement plates. SP-9A was installed due to the existing SP-9's location in a low area which is prone to flooding after rain. The first elevation survey of the replacement settlement plates was conducted July 24, 2024, and the first strain calculations were completed using the next survey's elevation data.

Table 2 - Settlement Plate Status

Settlement Plate	Condition
SP-1	Operational
SP-2	Decommissioned
SP-2A	Operational
SP-3	Decommissioned
SP-3A	Operational
SP-4	Decommissioned
SP-4A	Operational
SP-5	Operational
SP-6	Operational
SP-7	Decommissioned
SP-7A	Operational
SP-8	Operational
SP-9	Decommissioned
SP-9A	Operational
SP-10	Disturbed[3]
SP-11	Operational
SP-12	Operational

In some cases, elevation data can be collected from decommissioned settlement plates. However, some of the decommissioned plates (SP-2, SP-3, SP-4, and SP-7) have been damaged such that data may not accurately reflect the rate of settlement at the landfill. For this reason, decommissioned plates have been excluded from the criteria discussion.

3.0 SETTLEMENT DATA ANALYSIS

In accordance with the amended Consent Decree, the three criteria introduced in section 1.0 are used to assess the landfill's suitability for the EVOH deployment:

- **Criterion 1:** The rate of settlement of the waste has transitioned to a state of long-term secondary compression with the settlement varying approximately logarithmically with time.
- **Criterion 2:** Strain rate at all settlement plates is less than 1% per year, or a rate identified as consistent with secondary compression of municipal solid waste. Strain rate is defined here as the ratio of the change in vertical elevation of the surface of the waste at a given location to the thickness of the waste at that location per unit time.
- **Criterion 3:** Surface cracks due to settlement having a width less than 1-inch.

[3] The June survey was excluded from the settlement data for SP-10 because the plate was disturbed. The SP-10 criteria determinations are based on the May survey data.

The following sections analyze the settlement plate elevation data for conformance to the three criteria. Criterion 1 is considered using the cumulative settlement data, whereas Criteria 2 and 3 are considered using recent settlement data and site inspections. Table 3 provides the most recent position and elevation data (measured in feet) and calculated strain rates for the settlement plates. Non-operational or inaccessible settlement plates have been excluded from some analyses.

Table 3 - Elevation and Strain Data at Settlement Plate Locations

Settlement Plate	Northing (ft)	Easting (ft)	Elevation on June 27, 2025 (ft)	Elevation Change Between March 18, 2025, and June 27, 2025 (ft)	Strain[4] Between March 18, 2025, and June 27, 2025	Calculated Current Rate of Strain/Year[5]	Elevation Change Since Installation (ft)
SP-1	3,397,887.6	10,412,080.9	1,828.7	-0.26	-0.38%	-1.4%	-5.7
SP-2A	3,397,823.2	10,412,370.6	1,792.8	-0.68	-0.45%	-1.6%	-3.0
SP-3A	3,397,820.2	10,412,498.2	1,779.1	-0.20	-0.20%	-0.7%	-1.1
SP-4A	3,398,247.0	10,412,207.3	1,802.5	-0.68	-0.41%	-1.5%	-2.6
SP-5	3,398,255.8	10,412,339.7	1,788.2	-0.67	-0.26%	-0.9%	-12.6
SP-6	3,398,248.8	10,412,509.8	1,772.9	-0.14	-0.10%	-0.4%	-4.7
SP-7A	3,398,731.6	10,412,158.2	1,822.2	-0.34	-0.25%	-0.9%	-1.3
SP-8	3,398,678.1	10,412,290.9	1,799.7	-0.38	-0.15%	-0.6%	-7.7
SP-9A	3,398,644.2	10,412,416.1	1,788.2	-0.02	-0.02%	-0.1%	-0.6
SP-10[6]	3,399,080.1	10,412,093.3	1,836.8	-0.19	-0.07%	-0.4%	-3.4
SP-11	3,399,216.3	10,412,183.9	1,814.4	-0.17	-0.07%	-0.3%	-1.9
SP-12	3,399,381.7	10,412,019.7	1,809.6	-0.15	-0.13%	-0.5%	-1.0

3.1 CRITERION 1 – TRANSITION TO SECONDARY COMPRESSION

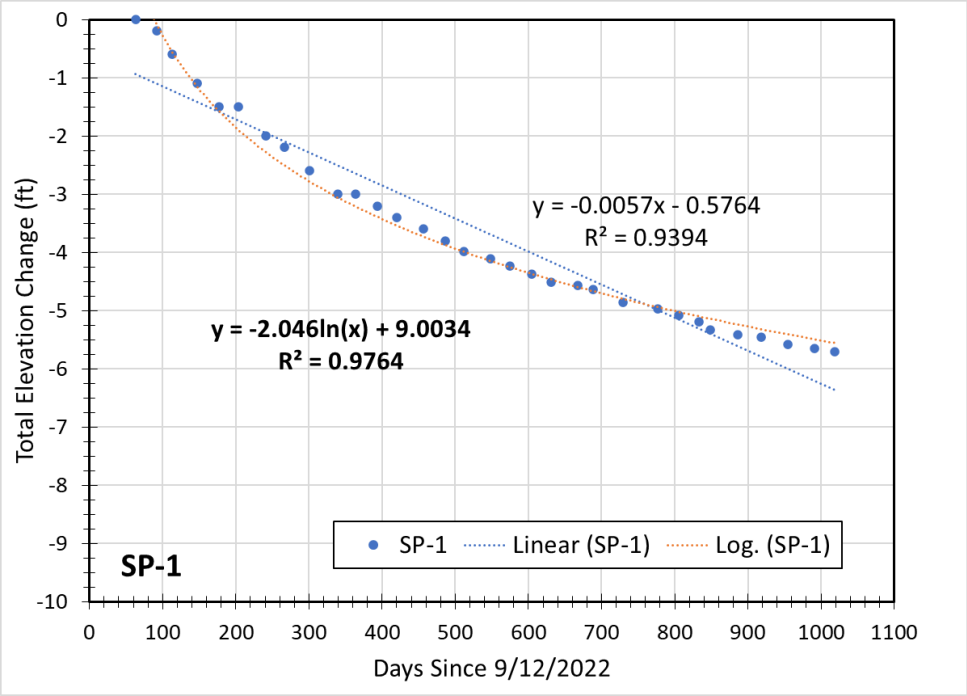
Secondary compression of municipal solid waste is typically characterized by long-term settlement at a decreasing rate due primarily to decomposition. Settlement data for secondary compression follows a logarithmic trend over time. Regression analysis of the complete elevation data for each operational settlement plate currently shows mostly linear trends for the older settlement plates. The replacement settlement plates show similar fits for linear and logarithmic trendlines and in SCS's opinion do not have sufficient data to establish a clear trend. Current measurements do not indicate

[4] Strain is defined as the change in elevation divided by the estimated original waste depth.
[5] Current yearly stain rate is calculated by dividing the strain since the previous suitability assessment survey by the number of days between the assessment surveys and multiplying by 365.
[6] The June survey was excluded from the settlement data for SP-10 because the plate was disturbed. The SP-10 criteria determinations are based on the May survey data.

a decreasing rate of settlement for SP-2A, SP-3A, SP-4A, SP-5, SP-6, SP-7A, SP-9A, SP-10, SP-11, and SP-12. The regression analysis results for the settlement plates are presented herein.

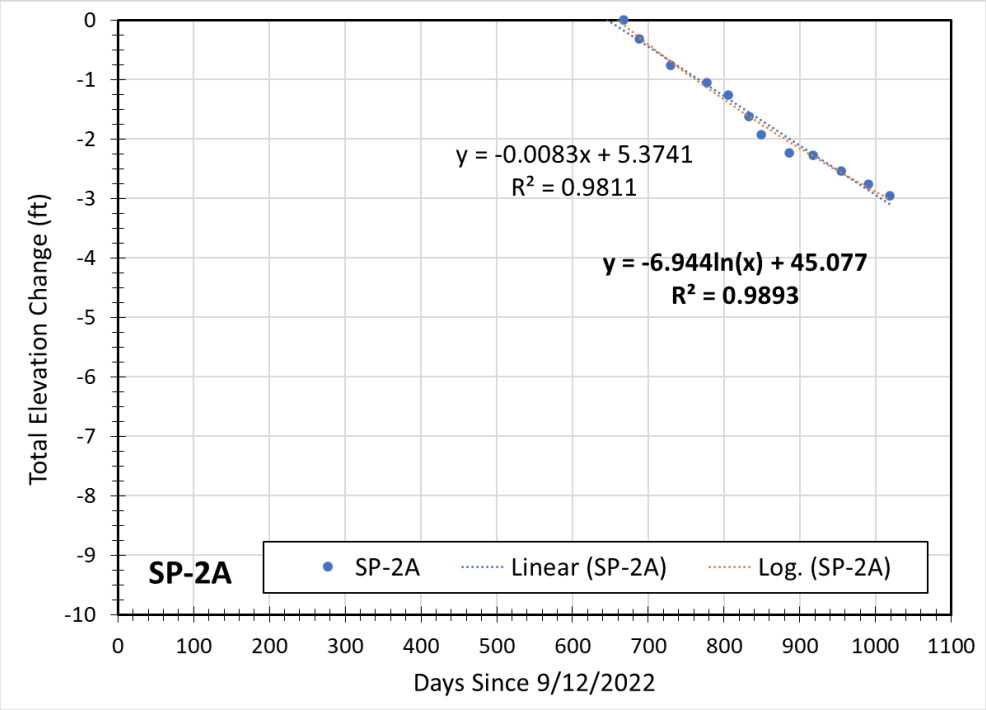
Figure 2 shows the plot of total elevation change versus elapsed time for SP-1. Linear and logarithmic trendlines were fitted to the data, and the coefficients of determination (R^2) were computed. SP-1 shows greater R^2 for the logarithmic trendline, indicating that settlement at SP-1 has transitioned to secondary compression.

Figure 2 - Settlement Plate SP-1



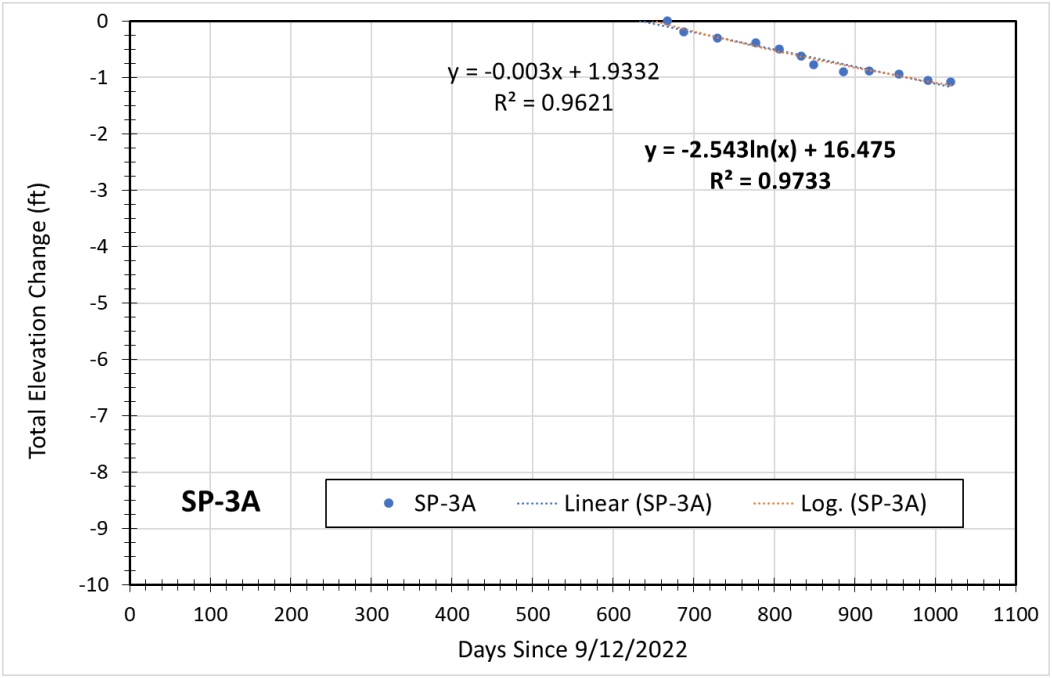
SP-2A replaced SP-2 as of July 2024 and is located near the southern central edge of the quarry. The SP-2A data fit the logarithmic and linear trendlines comparably, and the data set is short (R^2=0.989 vs 0.981, see Figure 3).

Figure 3 - Settlement Plate SP-2A



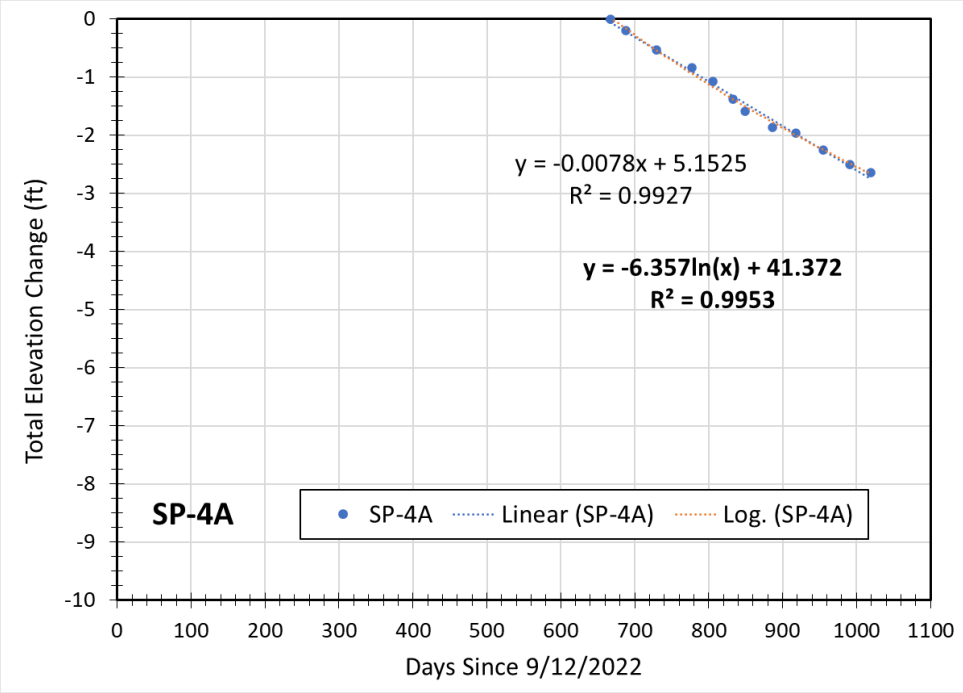
SP-3 was replaced by SP-3A as of July 2024. The elevation data for SP-3A fits the linear and logarithmic trendlines comparably, and the data set is short (see Figure 4).

Figure 4 - Settlement Plate SP-3A



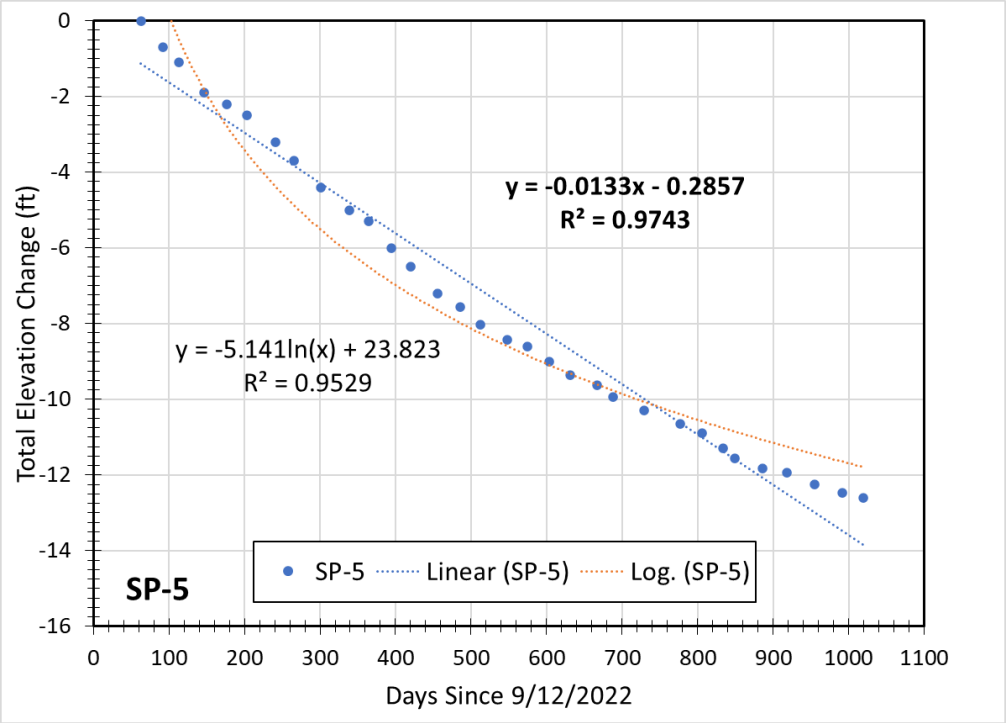
SP-4 was replaced by SP-4A as of the July 31, 2024 survey. The elevation data for SP-4A fits the linear and logarithmic trendlines comparably, and the data set is short (see Figure 5).

Figure 5 - Settlement Plate SP-4A



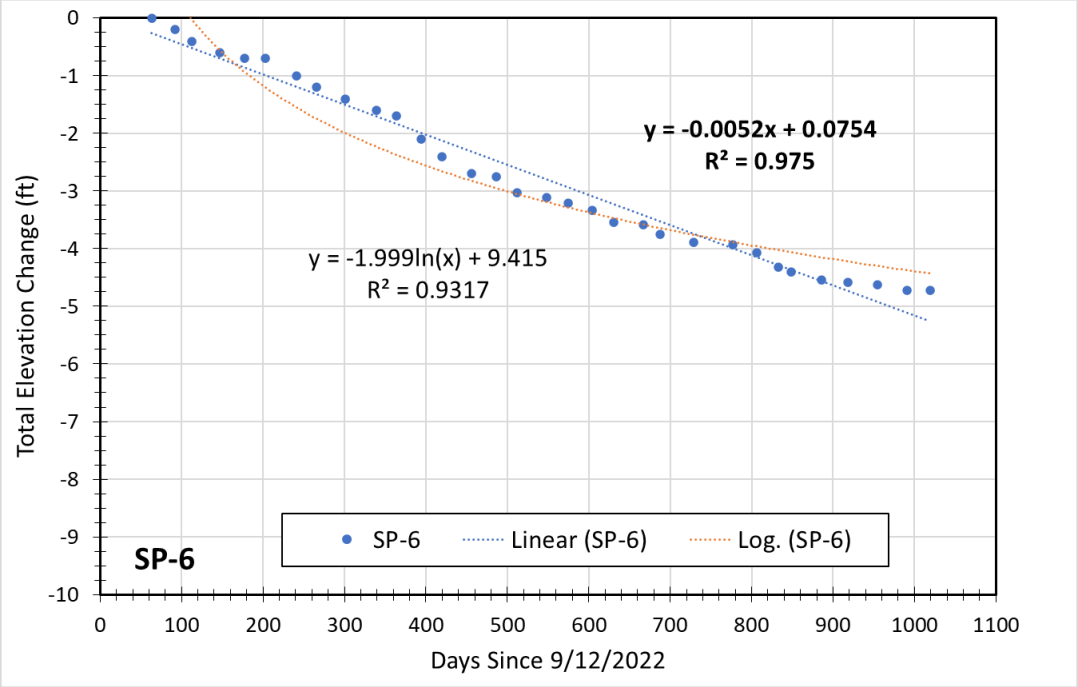
Applying a linear trendline to the data for SP-5 produces an R^2 equal to 0.974, indicating the strongest linear fit of all the settlement plate data (Figure 6). However, the data exhibit curvature towards the end of the record, and settlement in this area may be undergoing a transition in rate. Nevertheless, settlement appears steadily ongoing at SP-5, and the nearby temperature probes TP-4 and TP-5 continue to show elevated temperatures.

Figure 6 - Settlement Plate SP-5



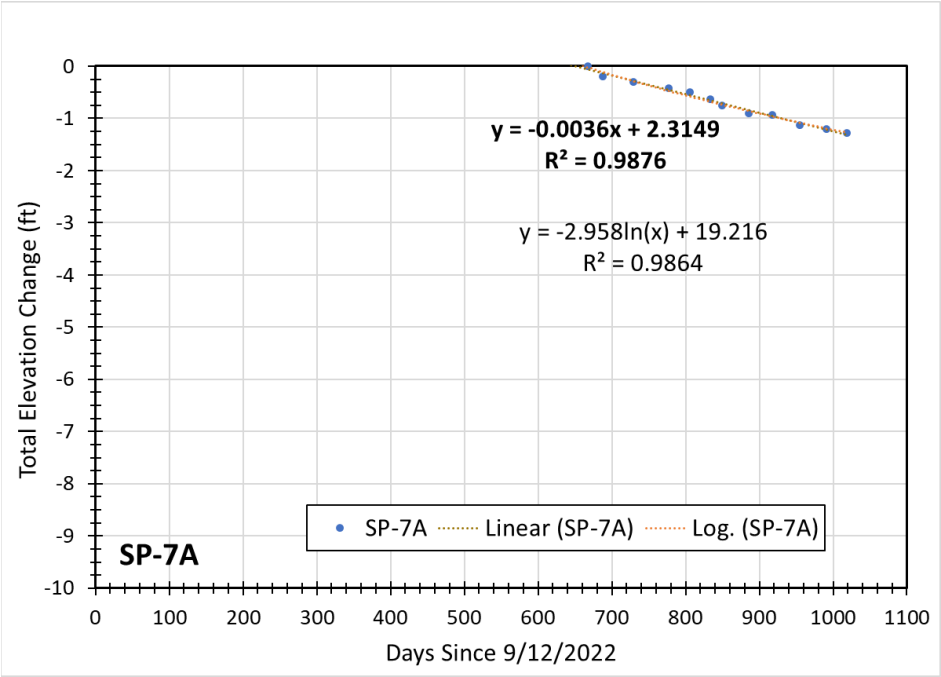
The data for settlement plate 6 follows a linear trendline (Figure 7). The elevated temperatures historically measured by TP-4, 100 feet east of SP-6, suggest that SP-6 may continue to settle significantly. The linear trendline for SP-6 shows an R^2 of 0.975.

Figure 7 - Settlement Plate SP-6



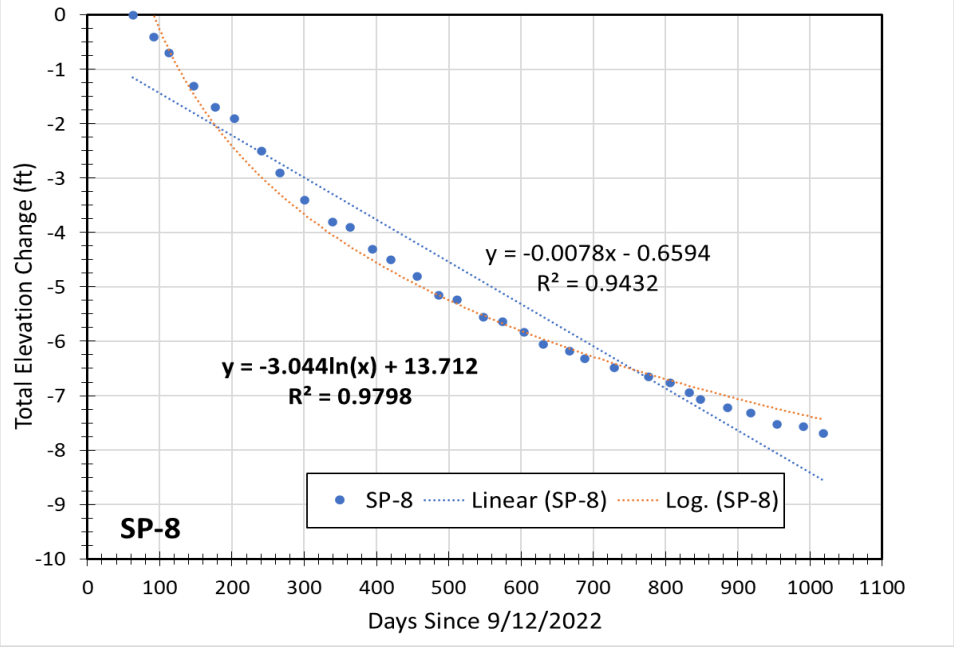
SP-7 was replaced by SP-7A for the July 31, 2024 survey. SP-7A was installed at the original position of SP-7. The elevation data for SP-7A follow linear and logarithmic trendlines comparably with R^2 of 0.988 and 0.986 (see Figure 8).

Figure 8 - Settlement Plate SP-7A



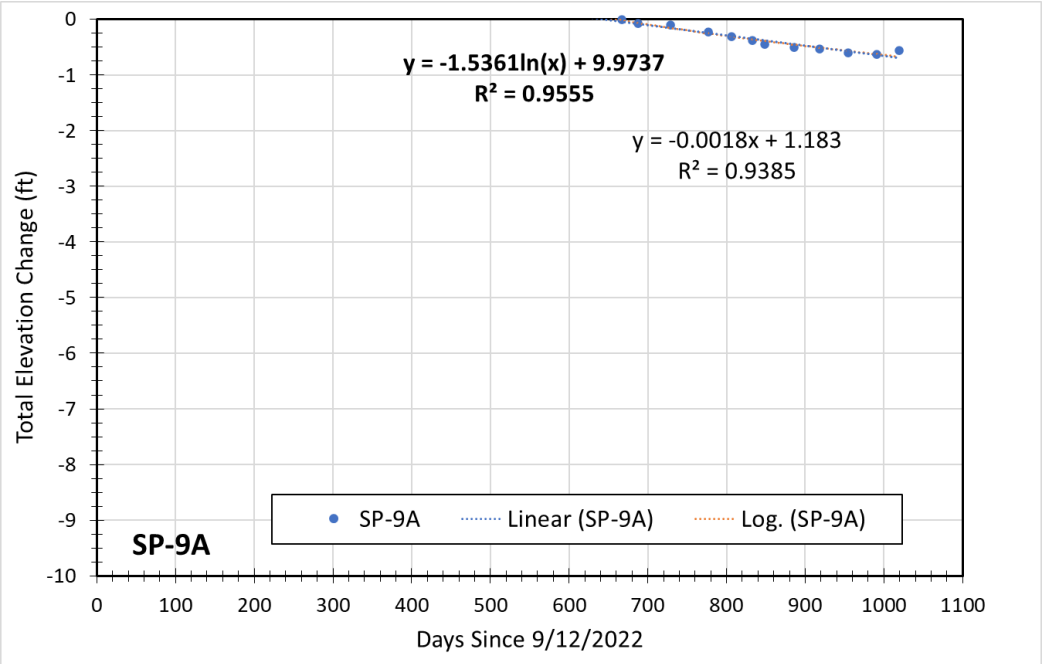
SP-8 is positioned north of the highest temperature area. The settlement data for SP-8 best fits a logarithmic trendline with an R^2 of 0.980 (Figure 9), indicating secondary compression.

Figure 9 - Settlement Plate SP-8



SP-9 was replaced by SP-9A for the July 31, 2024 survey. SP-9A is located 25 feet southeast of SP-9. The elevation data for SP-9A follow the linear and logarithmic trendlines comparably, and the data set is short (Figure 10).

Figure 10 - Settlement Plate SP-9A



SP-10, SP-11, and SP-12 are positioned in the north end of the quarry. The northernmost temperature probe (TP-9) indicates lower, more stable temperatures in this area relative to the southern end of the quarry. The elevation data from these settlement plates show lower overall settlement and appear to have lower strain rates (less than 1% per year) relative to the southern plates (Figure 11 through Figure 13). The temperature and elevation data together suggest the northern area, may be transitioning to secondary compression, but settlement remains linear with respect to time. Elevation variability, potentially due to vertical accuracy limitations of the GPS measurements, appears more noticeable for these settlement plates due to the smaller settlement rates.

Figure 11 - Settlement Plate SP-10

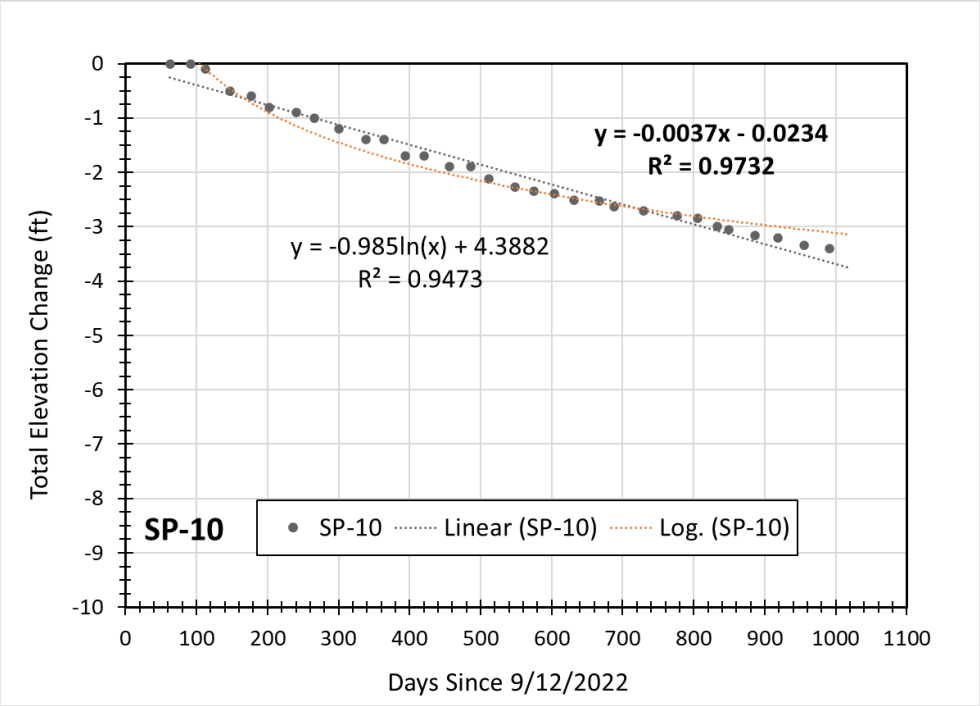


Figure 12 - Settlement Plate SP-11

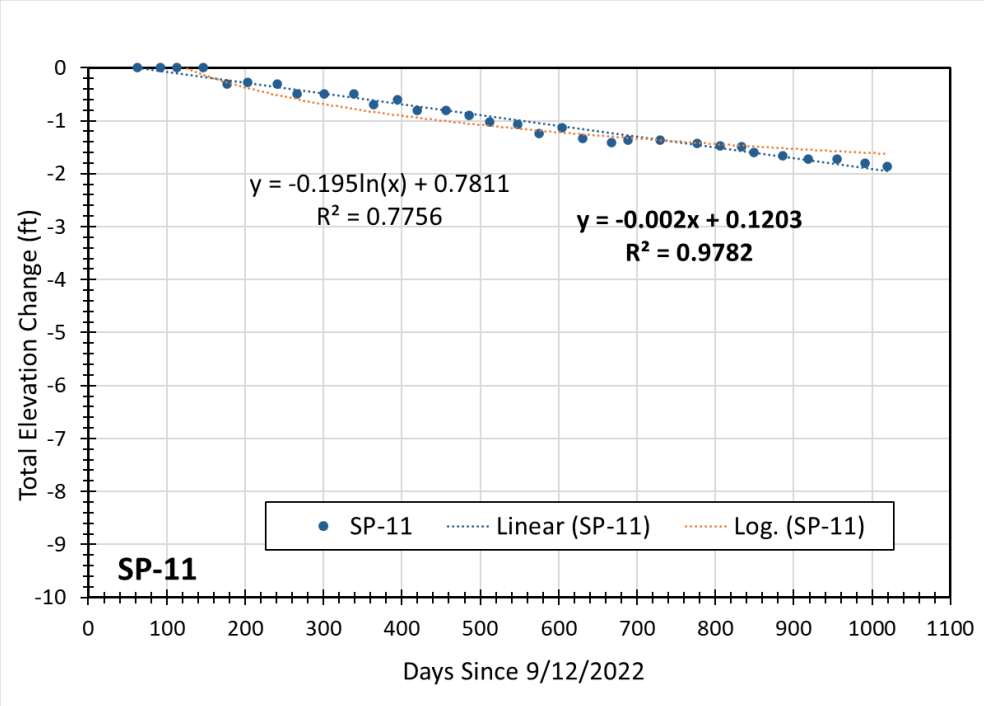
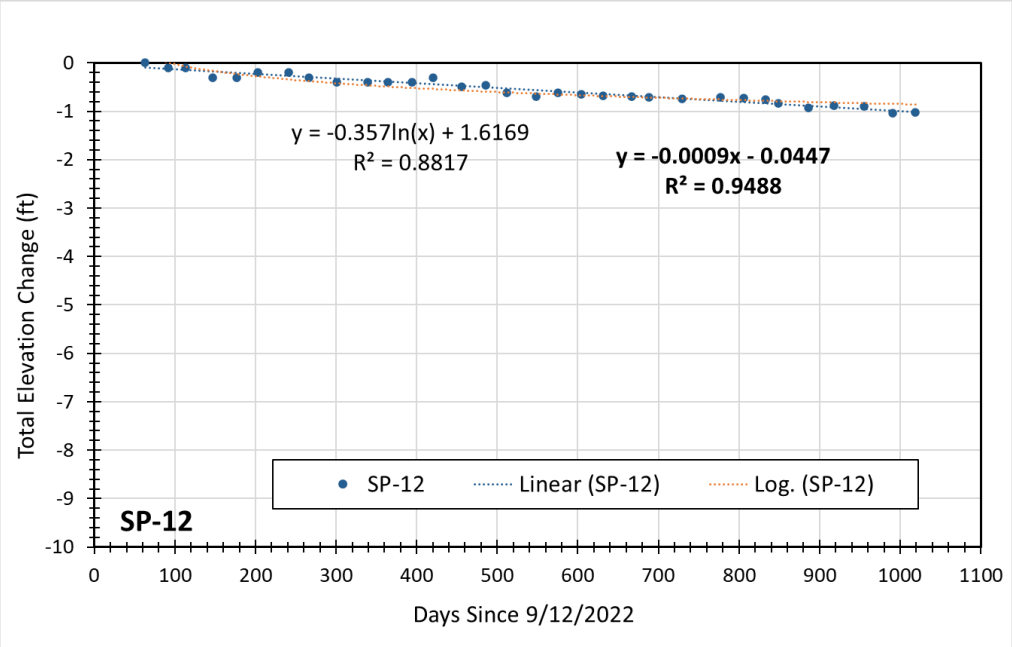


Figure 13 - Settlement Plate SP-12



A summary of the settlement trends is presented in Table 4 for the operational plates. The graphs of the elevation data for SP-2A, SP-3A, SP-4A, SP-5, SP-6, SP-7A, SP-9A, SP-10, SP-11, and SP-12 demonstrate prevalent linear trends, and the waste has not transitioned to an overall state of long-term secondary compression. Criterion 1 is not satisfied.

Table 4 - Settlement Trends

Settlement Plate	Apparent Settlement Trend (Linear or Logarithmic)
SP-1	Logarithmic
SP-2A	Inconclusive[7]
SP-3A	Inconclusive[7]
SP-4A	Inconclusive[7]
SP-5	Linear
SP-6	Linear
SP-7A	Inconclusive[7]
SP-8	Logarithmic
SP-9A	Inconclusive[7]
SP-10	Linear

[7] The differences in the coefficients of determination (R^2) between the linear and logarithmic trendlines are considered too minor to make a definite conclusion.

Settlement Plate	Apparent Settlement Trend (Linear or Logarithmic)
SP-11	Linear
SP-12	Linear

3.2 CRITERION 2 – STRAIN RATE

Table 3 lists *current* yearly strain rates for each settlement plate which were calculated using the change in elevation since the previous suitability assessment (comparing survey data from June 27, 2025, to March 18, 2025) divided by the original waste thickness and the elapsed time measured in years. Three settlement plates show a current yearly strain rate greater than or equal to 1% per year.

As an alternative to the above current yearly strain rate, Table 5 presents the calculated strain rate over the last year by comparing the June 2024 elevation data to June 2025. SP-1, SP-2A, and SP-4A exceeded 1% strain during this time period. These values are compared to the current annual strain rates in Table 3.

Table 5 also includes calculated 1-year settlement projections between June 27, 2025 (the most recent survey date) and June 27, 2026. The calculations used the most recent best-fit trendline for each settlement plate to project the one-year settlement depth (feet) and strain rate (%). The projections are relative to the June 27, 2025 survey measurements.

Table 5 – Comparison of Annual Average Strain Rate and Current Annual Strain Rate

Settlement Plate	Current Annual Strain Rate from Table 3	Average Strain Rate between 6/04/24 and 6/27/25	Projected Settlement between 6/27/2025 and 6/27/2026 (ft)	Projected Annual Strain Rate between 6/27/2025 and 6/27/2026
SP-1	-1.4%	-1.8%	-0.1	-0.1%
SP-2A	-1.6%	N/A	-2.2	-1.5%
SP-3A	-0.7%	N/A	-0.8	-0.8%
SP-4A	-1.5%	N/A	-2.0	-1.2%
SP-5	-0.9%	-1.3%	-6.1	-2.4%
SP-6	-0.4%	-0.9%	-2.4	-1.8%
SP-7A	-0.9%	N/A	-1.4	-1.0%
SP-8	-0.6%	-0.7%	-0.6	-0.2%
SP-9A	-0.1%	N/A	-0.6	-0.6%
SP-10[8]	-0.4%	-0.4%	-1.6	-0.6%
SP-11	-0.3%	-0.2%	-0.8	-0.3%
SP-12	-0.5%	-0.3%	-0.3	-0.2%

[8] The June survey was excluded from the settlement data for SP-10 because the plate was disturbed. The SP-10 criteria determinations are based on the May survey data.

The measurements indicate that the current strain rates for three of the twelve operational settlement plates meets or exceeds 1% per year. As a result, criterion 2 is not satisfied. The projected one-year settlement rate for five of the twelve settlement plates also meets or exceeds 1%.

3.3 CRITERION 3 – SURFACE CRACKS

Personnel working in the quarry continue to observe surface cracks due to settlement exceeding 1-inch width. Settlement cracks and depressions were observed during the assessment period, with cracking particularly notable in the southwest region of the quarry. The surface cracks appear to follow the abrupt change in the base grade elevations and corresponding waste thickness near the subgrade bench in the quarry sidewall.

Settlement cracking was also observed near the landfill gas well EW-77 with surface cracks exceeding 1-inch width. Figure 14 shows the surface crack prior to repair work by the City.

Figure 14 – Settlement Crack near EW-77

Figure 15 – Settlement Crack within the Quarry

Figure 16 – Settlement Crack within the Quarry

Figure 17 – Settlement Crack within the Quarry

4.0 CONCLUSION

The analyses of the settlement plate elevation data, strain rates, and presence of surface cracking together indicate that Criteria 1, 2, and 3 remain unsatisfied. The latest settlement trendline projections also suggest that Criterion 2 is unlikely to be satisfied within the next year.

However, the landfill has made progress towards an acceptable settlement condition since the start of the suitability assessments. In the first assessment, out of eight total operational settlement plates, one plate satisfied Criterion 1 and three other plates satisfied Criterion 2. In this current assessment, out of 12 operational settlement plates, at least two plates satisfy Criterion 1 and nine plates satisfy Criterion 2. Several additional plates appear to satisfy Criterion 1, but limited data precludes a determination.

SCS understands that if one settlement plate fails to meet Criterion 1 or Criterion 2, then these Criteria have not been met. The landfill has not reached an acceptable rate of settlement for the EVOH cover system deployment based on the established criteria. A subsequent assessment will be completed by September 23rd, 2025 and submitted to VDEQ within 10 business days.