January 6, 2021

Project No. 13213023.00

MEMORANDUM

TO: Jacob Schmidt and Randy Deardorff, P.G.

FROM: Bret Clements, P.E. (KS 22717), Christopher Woloszyn, E.I.T., Eric Peterson, P.E., Robert Gardner, P.E., and Michael McLaughlin, P.E. (VA 020671)

SUBJECT: Monroe Township Landfill Leachate Sewer Discharge

INTRODUCTION

The Monroe Township Landfill (Landfill) discharged its leachate to the public sewer for decades almost without incident or complaint. Before 2020, only one odor complaint was received; the cause of the complaint was a defective trap in a residential laundry tub that was quickly repaired by BFI Waste Systems of New Jersey, Inc. (BFI).

RECENT ODOR OBSERVATIONS

Odor observations in 2020 were first received by the Township on August 4, 2020. A series of emails from the Township and EPA led to an on-site meeting to observe the odors and to meet with residents.

On August 13, 2020, SCS met with USEPA representatives John Osolin and Pat Seppi at the Landfill regarding odor complaints from local homeowners. Approximately nine homeowners attended the meeting with SCS and EPA. Intermittent odors were reported to have been observed in early August. SCS and USEPA spoke with Monroe Township Utility Department's Robert Noel regarding flows and the history of the neighborhood.

On September 16 and 17 residents observed additional odors and reported them to the Township's office. These events led to the Township's September 23 meeting with all involved parties to review Landfill operations and current conditions. That evening, after the Township meeting, odors were again observed and reported by the residents. No leachate has entered into the sewer system since that evening.

On September 26, BFI contracted with a liquid waste hauler to transport leachate offsite to be disposed at a wastewater treatment facility.

Odor reports related to odors entering residences from the sewer system are believed to be limited to residences on Michelle Street and a house east of Michelle Street on Lori Street.

Since discontinuing the discharge of leachate into the sewer system, no odor reports have been reported at the homes near the landfill.

RECENT CHANGES IN LEACHATE MANAGEMENT

Due to the aforementioned odors (believed to be infiltrating homes through the sewer system), discharges of leachate from the Landfill to the sewer system have been discontinued since September 23, 2020. Instead, tanker trucks currently are hauling leachate to Chester, Pennsylvania (75 miles one way) and to Baltimore, Maryland (157 miles one way)

The change to hauling leachate by truck came during October and November, which are historically the months with the fewest gallons of leachate generated at the Landfill, see Figure 1. Relatively few trucks (up to eight per day) were needed to haul leachate in October and November. Generally, March has seen the highest volumes of leachate, by a factor of 3.5 to 4 compared to October/November volumes. This will correspond to an increased number of trucks per day that will be needed to haul leachate to a wastewater treatment plant, if leachate is unable to return to the sewers soon.

The operational goal while trucking leachate from the site is to keep the leachate underground storage tank (UST) at the landfill as close to empty as is practical (to reduce the potential for overfilling the UST). This is why additional temporary above ground storage tanks have been added near the site entrance, and ten additional tanks near have been mobilized near Pump Station B, to increase the site's ability to store leachate between trucking of loads offsite. See the summary below for details on the tank mobilization timeline.

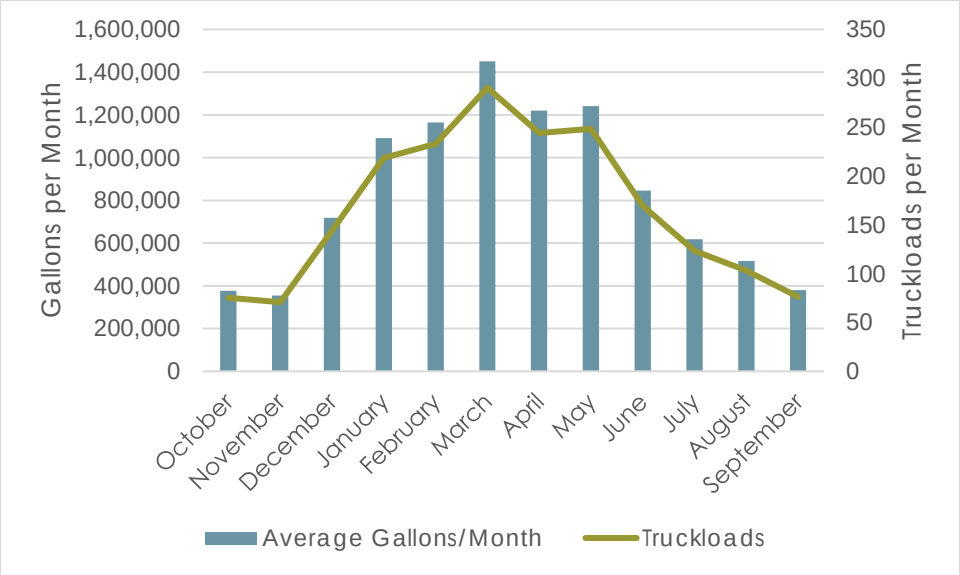

Figure 1. Average Monthly Leachate Production, 2013-2019

The landfill generates 10 million gallons of leachate in the typical year. To carry that much leachate in 6,000-gallon tanker trucks would require 1,667 tanker truck trips each year. If each truck travels 100 miles round trip and trucks average 6 miles per gallon, that is about 28,000 gallons of fuel—and more than 250 metric tons of carbon dioxide-equivalent greenhouse gases—every year, just to haul leachate. Discharging leachate directly to the sewer reduces the potential for accidents and spills, reduces truck traffic on neighborhood streets, and produces fewer greenhouse gas emissions.

LEACHATE QUANTITY AND QUALITY CHARACTERISTICS HAVE NOT CHANGED

In the first eight months of 2020, the landfill discharged 7.9 million gallons of leachate to the sewer. This is a little less (3% less) than the average amount of leachate discharged from the landfill in the January through August period since 2013—in other words, leachate is being produced in 2020 at about the same rate as the last seven years. Similarly, the chemical characteristics of the leachate have remained about the same over the last three years.

ODOR SOURCES

Odor reports from several home owners indicated that odors were suspected of entering their home through their sewer systems. The most likely explanation for these odors is that surges of leachate displaced sewer gases through plumbing traps in affected homes. The small concentrations of aromatics in the leachate might be a secondary factor, and might explain a more chemical-like (as opposed to a sewage-like) odor.

Since discontinuing the discharge of leachate into the sewer system, the only odors reported (via comments during the public meeting) have been limited to the street and sidewalk near the landfill driveway.

- Residents and other personnel who have reported odors along the streets and sidewalks were likely observing odors from one of the Landfill's temporary leachate tank vents.

- Odors are most likely to occur when the tanks are filling up with leachate as the air from the tank is being pushed out of the tank as it fills. The operational staff are making changes to keep these vents as closed as possible. However, these vents cannot be fully closed off while they are being filled or emptied as it may damage the tank.

- The Landfill intends to remove these temporary above ground storage tanks after resuming leachate discharge to the sewer at sufficient capacity.

SPECIFIC ODOR EVENT ASSESSMENTS

August 4-13, 2020 - 1st Series of Intermittent Odor Events being reported

There is no continuous flow graph available for this period. However, the pumping records for this period were reviewed and there was no indication of an abnormal event.

The exact time and locations where the odors were observed on these days is unknown. The amount of sanitary sewer usage during these periods of observed odors is also unknown.

September 16, 2020

Monroe Township was able to provide the continuous flow monitoring records for 9/16/20. A snip of it has been provided as Figure 2, which documents the discharges from the UST to the sanitary sewer system on September 16, 2020. The records indicate the UST Pump was working as follows:

- 12:00 AM - 11:30 AM - 80 gallons per minute (gpm) for 6-8 min. durations with about 2 hrs. between cycles.
- 11:30 AM - 2:30 PM - 80 gpm for 12-23 min. durations with 5-8 min. between cycles
- 3:00 PM - 11:59 PM - 85 gpm for 51-83 min. durations with 15 min. between cycles

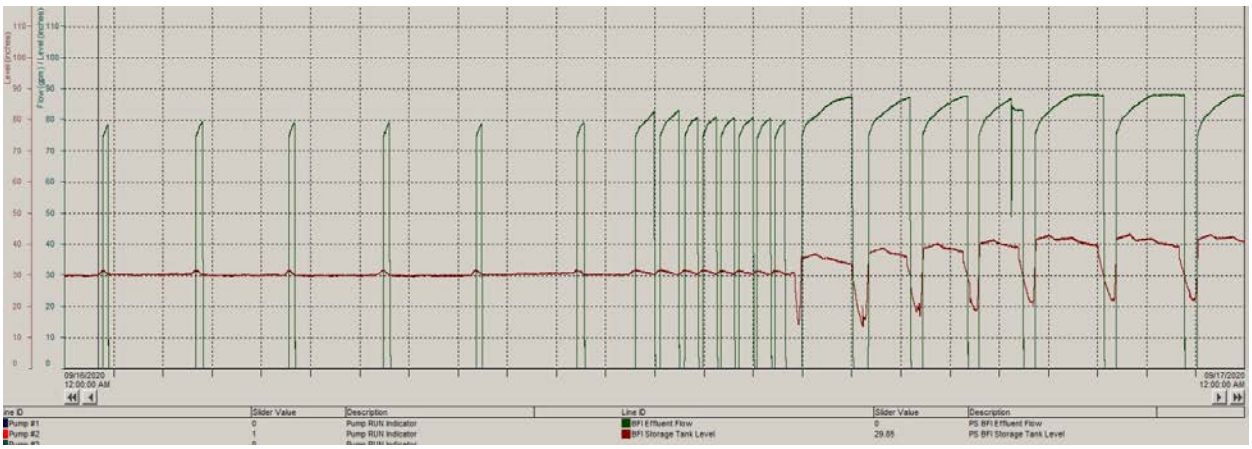

Figure 2. Snip from 9/16/2020 Flow Discharge from UST (Provided by Monroe Township)

The exact time and locations where the odors were observed on these days is unknown. The amount of sanitary sewer usage during these periods of observed odors is also unknown.

However, the following maintenance activities occurred at the landfill on this date:

9/16/2020	The pump that discharges to the UST was replaced. This likely lead to the change/increase in pumping rate at 2:30 in the afternoon.

<u>September 17, 2020</u>

<u>In addition, there were pump activities on the following day at the AB sump involving the removal of a blockage from one of the pump discharge pipes</u>. This likely resulted in additional liquids being freed up to be discharged at a higher rate than had been previously discharging. There is no continuous flow graph available for this period.

<u>September 23, 2020</u>

Monroe Township was able to provide the continuous flow monitoring records, a snip of which has been provided as Figure 3. Figure 3 documents the discharges from the UST to the sanitary sewer system on September 23, 2020. The records indicate the UST Pump was working as follows:

- 12:00 AM - 2:30 PM - 80 gpm for 8-9 min. durations with about 2 hrs. between cycles.

- 2:30 PM - 6:10 PM - 80 gpm for 15 min. durations followed by 65 gpm for 2.5 hr period; pausing for a half hour, and then pumping 80 gpm for 18 minutes before being turned off.

The exact location where the odors were observed on this day are unknown. At least one odor report was believed to have been observed around 5:30 PM, which corresponds to one of the longer durations of pumping. The amount of sanitary sewer usage during these periods of observed odors is also unknown.

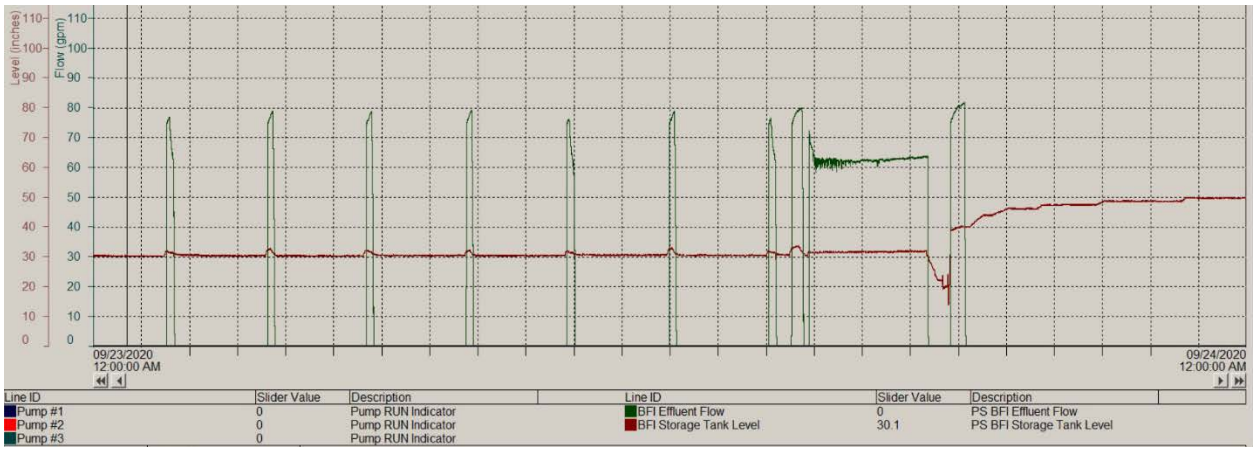

Figure 3. Snip from 9/23/2020 Flow Discharge from UST (Provided by Monroe Township)

SCHEDULE TO RESUME DISCHARGE TO SEWER

Resuming discharges of leachate to the sewer as soon as possible is important for the reasons previously summarized, and because the volume of leachate generated by the Landfill is expected to increase significantly between December 2020 and March 2021 (see Figure 1 above). Should increases in leachate volume occur before leachate is returned to the sewer system, more truck traffic through the neighborhood will be required.

Prior to discharging leachate back into the sanitary sewer system, the Landfill will first begin an initial monitoring period to document the background pressures and flows (i.e., when the landfill is not contributing to the sewer system). The Landfill will then perform an initial clean water injection test as proposed in Attachment B. Following the clean water injection test, the Landfill will submit a plan to reintroduce leachate into the sewer system that will allow safe pressure and flow to be maintained within the sewer system.

PUMP IMPROVEMENTS

Recent modifications to the leachate UST pump and controls have been implemented. These modifications include addition of a variable frequency drive (VFD) to allow different flow rates for the leachate discharge. The controls modifications also include provisions for remote access to the data and the pump controller. This effort will be completed in mid-January. These remote controls will allow the landfill to immediately reduce the leachate discharge rate or temporarily cease flows to the sewer system if issues arise.

The UST pump previously operated at only one speed—leachate into the sewer was either full on at approximately 80 gpm or full off. As noted above, improved pump controls will allow leachate to be discharged at different rates. The discharge flow rate of the pump will be adjusted to account for the normal levels of sanitary sewer expected throughout the day. The goal is to keep any changes in the liquid levels in the sewer gradual and to not cause pressurization events within the sewer system.

SITE HISTORY

The Landfill is a closed landfill owned by Monroe Township (Township), New Jersey. The Landfill was operated for 23 years, from 1955 to 1978, covering 86 acres before its closure. The Township operated the landfill for the first 13 years until 1968 when it was leased to Princeton Disposal Service. In 1972, the company now known as BFI Waste Systems of New Jersey, Inc. (BFI), currently a subsidiary of Republic Services, Inc., acquired Princeton Disposal Services. BFI maintains the closed Landfill with onsite operations conducted by SCS Engineers and SCS Field Services (SCS) and other subcontractors.

In 1979 the state of New Jersey ordered the Landfill to undergo closure and required installation of a liquids collection system after leachate outbreaks occurred in 1978. The Landfill was placed on EPA's National Priorities List (NPL) in September 1983. It was removed from the list in February 1994. Since that time, the U.S. Environmental Protection Agency (EPA) has conducted five "Five Year Reviews."

The Landfill has continued safe operations since its removal from the NPL in 1994. Prior to the summer of 2020, only one previous complaint of odor was reported to BFI. This particular complaint was related to a malfunctioning trap in a residential laundry room that, once repaired, eliminated the odors for the residence. Including the years prior to the removal from the NPL, the Landfill has maintained over 40 years of compliant operations.

EPA REVIEW OF LANDFILL

Five-Year Reviews provide EPA an opportunity to evaluate the implementation and performance of a remedy to determine whether it remains protective of human health and the environment. The last review was conducted in 2019. In the latest EPA review the following was noted:

Site Inspection: "No significant issues were identified during the inspection. All the engineering controls appeared intact and in good condition".

Protective Statement: "The remedy at the Monroe Township Landfill site is protective of human health and the environment".

LANDFILL LIQUID CONTROL INFRASTRUCTURE

Under typical operations, the Landfill collects liquids through underground perforated piping and discharges them into the AB Sump. Liquids are pumped out of the AB Sump into the UST. From the UST, a level-controlled pump periodically pumps the liquids out of the tank and into a pipeline that flows through the flow meter. After passing through the flow meter the liquid discharges into the sanitary sewer system. See Figure 4 for a site layout.

The Township has direct (remote) access to the data recorded by the flow meter.

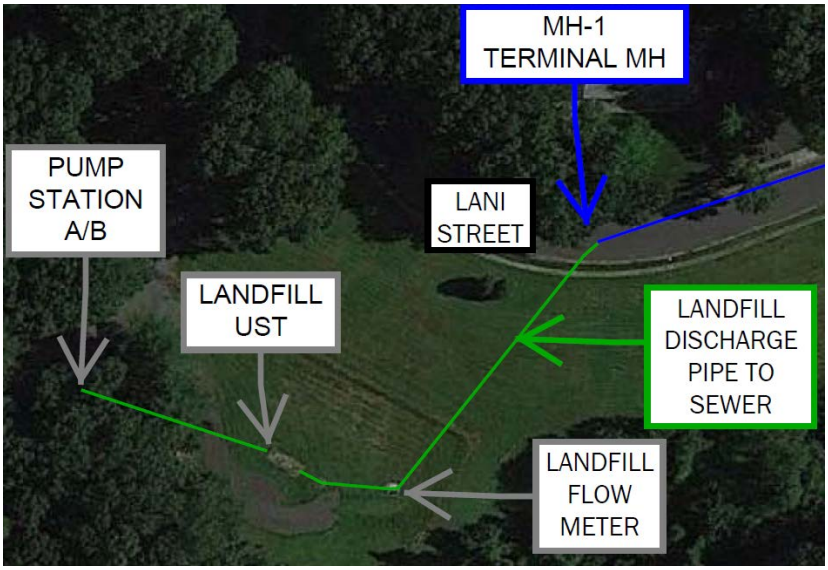

Figure 4. Landfill Leachate Discharge Site Layout

SANITARY SEWER INFRASTRUCTURE

As shown on Figure 5, downstream from the flow meter, liquids are discharged into the Township's sanitary sewer system. Liquids travel in an 8-inch pipe that gravity drains east along Lani Street. Several homes along Lani Street and Guinevere Road discharge into this sewer line. Ultimately, this line flows to a manhole (MH-4) located at the intersection of Lani Street and Michelle Street. This manhole also collects liquids from homes along Launcelot Lane.

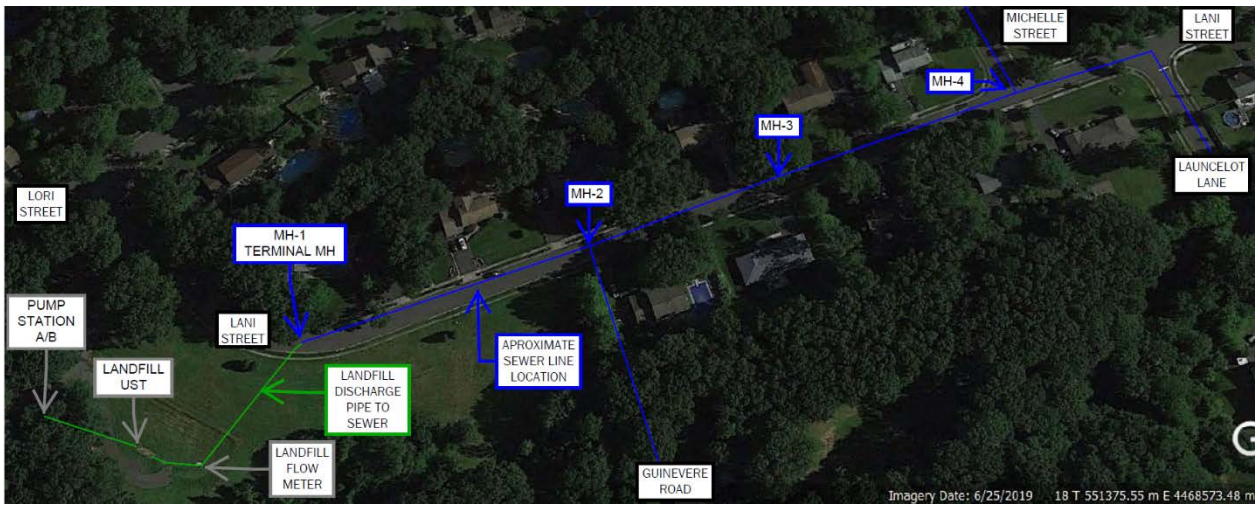

Figure 5. Landfill Discharge to Sewer Pipe from MH-1 to MH-4

From MH-4 an 8-inch gravity sewer flows north under Michelle Street through additional manholes (MH-5 and MH-6). Homes on either side of Michelle discharge into this sewer line. Ultimately, this 8-inch pipe discharges into a manhole (MH-7) located at Lori Street and Michelle Street.

Because a number of residents along Michelle Street reported odors from the sewer, this section of the sewer system was the focus of analysis and inspection by SCS and the Township.

The sewer pipe beneath Michelle Street from MH-4 to MH-5 had the steepest slope of the pipes reviewed as part of this assessment: nearly 4%. The slope of the pipe from MH-5 to MH-6 was flatter at about 1% and from MH-6 to MH-7 became even flatter at about 0.5%.

Also of note is that at MH-5, the first manhole north of Michelle Street and Lani Street, there is a relatively steep slope of liquid within the manhole (the influent sewer pipe is above the bottom of the manhole). Both of these factors (steep slope feeding the manhole and steep slope within the manhole) likely create turbulent conditions. Turbulent flow can cause vaporization and atomization of volatile compounds, increasing the likelihood of odorous compounds escaping sewer liquids. During the proposed clean water injection test, increased headspace pressures will be closely monitored at MH-5 and MH-6 due to the flatter slopes on the subsequent sewer reaches.

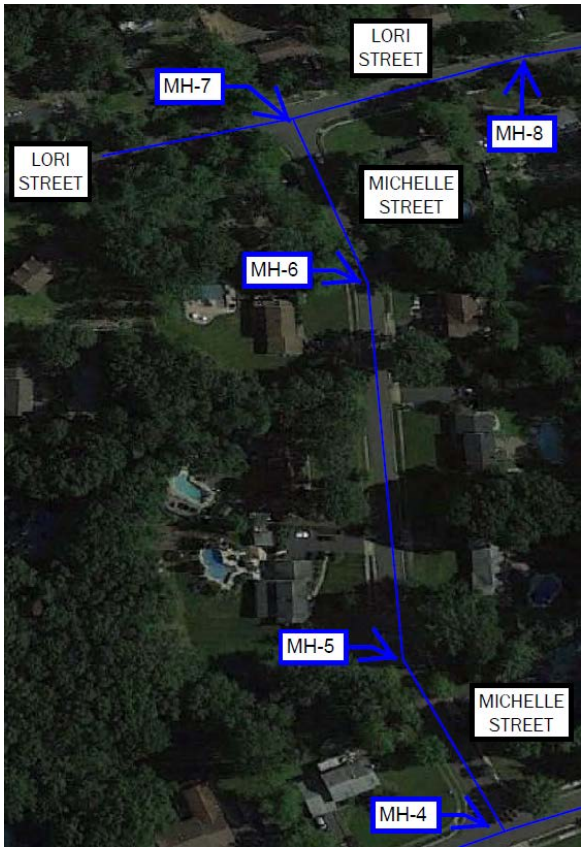

Figure 6. MH-4 through MH-8 Site Layout

Once sewer liquids from Michelle Street are discharged into MH-7, the manhole at Michelle Street and Lori Street, the liquid is mixed with any liquids that are being conveyed by the sewer line that is serving Lori Street west of this manhole. The co-mingled sewage in this manhole is then discharged to an 8-inch pipe that drains the liquid east along Lori Street. The video inspection of this sewer, conducted on October 13, revealed that there are multiple homes along Lori Street discharging into this line. During video inspection of the sewer, the sewer pipe beneath Lori appeared to have cobwebs on the crown of the pipe, indicating that high flows are not regularly observed along this reach.

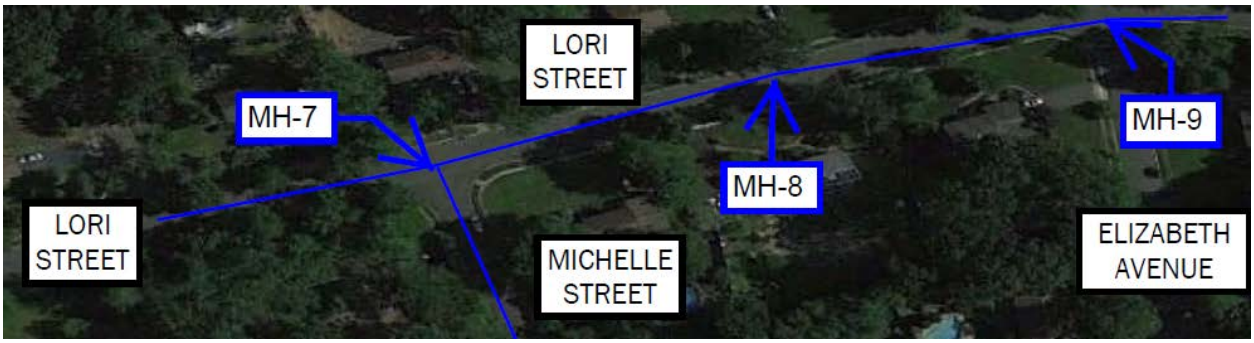

Figure 7. MH -7 Discharge to Lori Street through MH-9

TIMELINE AND SUMMARY OF INVESTIGATION AND RESPONSE ACTIONS

Date	Investigation and/or Response Action
9/23/2020	Evaluated pump operations and discharge into sewer system; last day the Landfill discharged into public sewer system
9/26/2020	Landfill commenced use of tanker trucks to haul liquids to wastewater treatment plant.
10/1/2020	Public Meeting
10/8-9/2020	Cleaned AB Sump, Discharge lines from UST to sewer, and other on-site sewers feeding the AB Sump. This cleaning is required by the facility's permit.
10/13/2020	MTUD inspected select sewer lines along Lani and Lori Streets and all of Michelle Street.
	An evaluation of the sewer size has been provided in Attachment A. Attached to this memo are calculations showing that the sewer system is sufficiently sized to handle both the design residential sewer system loading event at diurnal peak flows plus the Landfill's liquids.
10/19/2020	Collected Air and Liquid Samples at UST to try to identify cause of odor.
	The Landfill contracted with a toxicology specialists, Stantec, to evaluate its leachate and to try to identify components within the leachate that may be causing the chemical smell. Chemical smells are quite often associated with Volatile Organic Compounds (VOCs). VOCs get their name because of their ability to volatilize out of liquid and emit into the air.
	Stantec collected air and liquid samples at the underground storage tank (UST) which is the final location for leachate to be stored on-site prior to being discharged to piping which flows through the metering station. After the flow metering station the station then discharges the liquid into the sanitary sewer system at the termination manhole on Lani Street. See the Stantec report for results and additional information.
	In Summary and Conclusions of the Stantec Technical Memo, it is stated that the odors detected above American Industrial Hygiene Association odor thresholds

Date	Investigation and/or Response Action
	could be consistent with the residents' complaints of "turpentine" or "acetone" odors.
10/22/2020	Made improvement to the storm water channel located outside the fence to clear the channel of trees and vegetation; old stone and vegetation were deposited on landfill; new stone was installed.
10/26-30/2020	Mowing and site maintenance were completed as required by the Site's Permit.
10/30/2020	MTUD provided a link to the sewer inspection video completed on October 13, 2020.
	The camera inspection revealed that the monitored pipes appear to be in working order as no significant damage was observed.
	The pipe along Lori Street did not appear to be receiving flows that exceeded approximately 50% of the pipe capacity as spider webs were observed in the upper half of the pipeline. Flows along Michelle Street appear to be at least periodically using more than 50% of the pipe's capacity. It is unclear what caused the flows within the sewer line to exceed the design flow levels. Flows in excess of the design levels may contribute to elevated pressures which may cause odors being to be emitted to homes.
	Installed the first of two 21,000 gallon tanks to provide additional capacity and flexibility in matching liquid generation and discharge to sewer.
11/3/2020	A variable frequency drive (VFD) was installed in the UST pump control panel.
	This improvement will allow the facility to adjust the rate at which the pump discharges leachate to the sewer system. Previously the pump would operate at maximum capacity anytime the pump was turned on. The VFD will also allow the site to gradually increase the pumping rate for each start up event, which will also reduce the potential for immediate pressurization to occur during pump startup events.
11/4/2020	UST was cleaned out, completing the cleaning from 10/9/20.
11/5/2020	Additional liquid sampling occurred on-site.
	This additional sampling is being completed to try to identify the source of the potential odor causing compounds or determine if it was occurring near the UST.
11/6/2020	Gravel placement on site access road, expansion and grading.
	This will help aid in minimizing the amount of mud tracked onto the township's roads.
11/10/2020	Conducted first smoke test at resident's home.
	No smoke was found within the living area of the residence.

Date	Investigation and/or Response Action
11/11/2020	Additional air and liquid sampling was completed at the UST and other key structures on the site.
	Installed the second of two temporary 21,000-gallon tanks to provide additional capacity and flexibility in matching liquid generation and discharge to sewer.
12/2/2020	Additional liquid sampling was completed at the UST.
12/11/2020	Installed hard piping from UST to two above-ground tanks for protection against freezing
12/24/2020	Surcharge of liquids at Manhole 10, upstream of PS B. Emergency response team (First Call Environmental) mobilized to deploy oil booms and absorbent material along fence perimeter and along ditch outside of property. MTUD (Jet/Vacuum Truck and Crew) assisted with removing liquid from PS B.
12/25/2020	Surcharge of above-ground storage tank due to high flows during rain event. Cleanup on 12/26 included deployment of absorbent material. Emergency response team on site to assist with cleanup and to check MH-10 absorbent material.
12/28/2020	Second surcharge of MH-10. MTUD again assisted with removing liquid from PS B via vacuum truck. Emergency response team on site to assist with cleanup and deploy additional adsorbent materials around MH-10.
12/29/2020	DEP, EPA, MTUD, BFI, and SCS on site to review surcharge events and to evaluate site condition. Delivery of 11 temporary storage tanks to assist with removing liquids out of PS B and MH-10. Start of 24-hour observations and pumping at PS B and MH-10 to on-site storage tanks.
12/30/2020	Third temporary tank delivered to front of site to supplement two existing tanks. Start of second hauler company with transportation and treatment at Baltimore, Maryland treatment facility.
12/31/2020	Fourth temporary tank delivered to front of site to supplement three existing tanks. Second hauler company delivered two loads to MTUD's receiving facility. Second hauler focused on removing liquids from tanks near PS B.
1/4/2020	Smaller tanks were swapped for larger tanks near PS B. Daily trucking quantities increased.
Early January	Facility will be upgrading the site's SCADA system for the discharge pump.
	This will allow the facility to program the pump system to discharge at specified rates at various times of the day as necessary.

SAFE REINTRODUCTION OF LEACHATE

As summarized above, BFI evaluated several factors and completed response actions and upgrades to prepare to return to discharging liquids to the Township's sewer system, including retrofitting the Landfill's existing UST pump with a VFD and controlled by a SCADA system. These modifications will allow operators to program the UST pump to discharge at the rate desired depending on the time of

day. The VFD will be set to gradually increase flow each time the pump turns on, rather than going from 0 gpm to approximately 80 gpm almost instantaneously. Reducing the rate at which the site discharges liquids, during increased residential flow periods, will also have the beneficial result of reduced headspace pressure and turbulence, thereby reducing the potential for leachate odors exiting the sewer.

Prior to reintroduction of leachate to the sanitary sewer system, the Township's sewers will be cleaned between MH-1 through MH-8 to remove any buildup in the sewer system. Next, a monitoring period will be conducted to establish background conditions in the sewer system without landfill leachate contributions. Finally, clean water injection testing will be performed. Please see Attachment B for further details. Once these tests are completed, a leachate reintroduction protocol will be proposed for consideration.

RESIDENCE INSPECTIONS

Residents that have detected odors from the sewer system should contact a plumber to evaluate their sanitary sewer system. A properly functioning home sanitary sewer system with proper vents and traps will aid homeowners in protecting their homes from odorous sewer gases.

DIURNAL FLOW DISCUSSION

Residents of a particular neighborhood are known to use water in their daily activities. Since a significant proportion of the water use in each household is discharged to the sewer system, monitoring sewer flow in a neighborhood sewer can be generally representative of the combined behavior of the population served. What was considered "normal" behavior in neighborhoods prior to 2020 was reflective of a population where a significant portion of the residences left for work or school outside the home. Sewage flow from these neighborhoods would rise in the early morning hours as residents readied for work and fall off during the work/school hours, only to rise again in the evening when workers and students returned to their homes.

A flow pattern of rising flow in the morning, dropping off until evening when flow increases again, then falling off during overnight hours, is referred to a *diurnal flow pattern*. Diurnal sewer flow patterns, or normal daily rhythms, changed significantly once residents were encouraged to work from home, and participate in remote learning. Monroe Township reports the diurnal rhythm of sewer flow prior to 2020 included a peak flow in the morning and again in the evening. However, under COVID-19 conditions sewer flow patterns are characterized by sustained flow throughout the day and less flow in the hours when residents are sleeping, without significant peaks or valleys.

Other factors can impact peak sewer flowrate, including activities, such as water softener flush/recharge or pool draining/filtering that is subsequently discharged to a sanitary sewer. Sewer systems subject to wet weather influences like infiltration and inflow from leaky sewers and manholes can also bring peak flows into sewers during wet weather events. These activities and events have the potential of creating conditions that limit what capacity is available at any time for landfill discharges to the sewer system. Since the landfill and residents must share the sewer system, it is important to understand the sewer use pattern of the neighborhood so the landfill flows can be accommodated without negatively impacting residents and vice versa.

ATTACHMENT A

SEWER SIZE EVALUATION

This sewer size evaluation disregards sewer air dynamics to determine the theoretical limiting size of the sewer solely based solely on liquid flow mechanics. The clean water injection plan in Attachment B will attempt to identify if there are any localized sewer headspace air restrictions within the sewer system that may cause air pressurization during leachate pumping events.

Table 1 shows the calculated capacity for the sanitary sewer system pipes filled to half their depth along Lani, Michelle and Lori Streets using the Manning Equation:

$$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$$

Where Q is the discharge, n is the Manning roughness coefficient, A is the cross-section area, R is the hydraulic radius, and S is the pipe slope.

As shown in Table 1 the capacity of half-full sewer pipes in the system range from a low of 217 gallons per minute (gpm) to a high of 625 gpm. The section with the lowest flow capacity may limit the flow through the sewer system unless another reach of the sewer is determined to be the limiting factor due to air restrictions within the sewer. Upon first review it appears that the sewer reach between MH-6 and MH-7 on Michelle Street has the most limited ability to transmit sanitary sewer flows.

FLOW BASED RESTRICTIONS

This section disregards sewer air dynamics to determine the theoretical limiting size of the sewer solely based solely on liquid flow mechanics. To calculate how much the Landfill can discharge without exceeding the capacity of the sewer system, we must first calculate the expected residential loading of the sewer system. New Jersey Administrative Code (NJAC), Title 7 - Environmental Protection, Chapter 14A, Subchapter 23.3, states that the criteria for estimating the volume of sanitary sewage from single residential occupancy activities shall be based on assuming 300 gallons per day (gpd) for a 3 bedroom unit or larger.

Residential listings along the contributing sewers include a number of 4 and 5 bedroom homes; therefore, to be conservative, we assumed all homes have at least 3 bedrooms and thus contribute approximately 300 gpd for design purposes.

NJAC 7:14A-23.6 (Sanitary sewer design) requires gravity sewers to be designed to carry at least twice the average projected flow when flowing half full. This requirement recognizes that peak sewer flows occur when a neighborhood wakes up and takes a shower to start the day, or washes dinner dishes and takes baths at the end of the day. A number of studies have been performed to

map this diurnal pattern. Table 2 is based on one such study;[1] it shows the diurnal flow pattern in half hour intervals to allocate the percentage of daily flow that is expected to occur during each half hour period. This Table shows that the highest percent of daily discharge from residential homes is expected in the 8:00 AM to 8:30 AM interval when 4.6% of the total daily flow is discharged. For a single home this works out to an average discharge rate of 0.5 gpm for this half an hour period.

As discussed above, the sewer pipe between MH-6 and MH-7 on Michelle Street is the most limiting section. Thirty-six homes contribute to this section and thus peak diurnal residential loading is expected to be 36 X 0.5 gpm = 18 gpm. In other words, even if this section of sewer pipe contained 18 gpm (4.6% of the total daily flow from 36 houses), it still would have about 200 gpm of available capacity. This is more than double and in some cases quadruple the rate at which the landfill currently intends to inject leachate.

SEWER EVALUATION

After reviewing the video and profile information provided by the Township the following was inferred. Based upon residue observed on the upper portion of the sewer pipe along Michelle Street during the camera inspection, it appears that flows in the sewer pipe might have exceeded the design flow capacity of the sewer pipe. The cause of the residue observed on the ceiling is unknown; it may be due to the pipe being temporarily or partially blocked or to abnormally high flows. Either cause would increase the likelihood of odors being emitted from a sewer system.

The evaluation of the sewer system did not conclusively reveal why some residents experienced odors in their homes. However, the most likely scenario involves flow conditions that exceeded the existing operating range of the sewer system. As discussed above, this scenario could have been caused either by excessive sewer flow and/or a temporary blockage within the sewer system and is partially supported by the observance of residue on the ceiling of the sewer pipe along Michelle Street. However, it is also possible that elevated flows for extended duration within the sewer system made localized air pressure points within the sewer system that then pushed sewer gases into residences. This second theory will be tested in the proposed clean water injection plan included in Attachment B.

---

[1] Gurung, T.R. Stewart, R.A. Sharma, A.K. Beal, C.D. (2014) Smart meters for enhanced water supply network modelling and infrastructure planning, Resources, Conservation and Recycling, 90, 34-50. http://dx.doi.org/10.1016/j.resconrec.2014.06.005.

Table 1 - Monroe Township - Sewer Evaluation along Lani, Michelle and Lori Streets

Street Name	Pipe Run	Dia D (ft)	Flow Area (Half Full) A (sf)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Slope s (4) (ft/ft)	Manning's Coefficient n	Half Full Pipe Capacity (See Note 3) (cfs)	Half Full Pipe Capacity (See Note 3) (gpm)	Residential Contribution to Sewer Segment: Number of Residences flowing into segment (homes)	Design Daily Flow per NJAC (1) (gpd)	Average Daily Flow (gpm)	Peak Diurnal Flow (2) (gpm)	Remaining Capacity: Sewer Capacity Remaining available for the Landfill (gpm)
Lani	MH 1-2	0.67	0.17	1.05	0.17	0.005	0.011	0.5	230.4	1	300	0.2	0.5	229.9
	MH 2-3	0.67	0.17	1.05	0.17	0.016	0.011	0.9	398.6	17	5,100	3.5	7.8	390.8
	MH 3-4	0.67	0.17	1.05	0.17	0.004	0.011	0.5	206.6	21	6,300	4.4	9.7	196.9
Michelle	MH 4-5	0.67	0.17	1.05	0.17	0.039	0.011	1.4	625.1	29	8,700	6.0	13.3	611.8
	MH 5-6	0.67	0.17	1.05	0.17	0.013	0.011	0.8	360.0	33	9,900	6.9	15.2	344.8
	MH 6-7	0.67	0.17	1.05	0.17	0.005	0.011	0.5	217.4	36	10,800	7.5	16.6	200.8
Lori	MH 7-8	0.67	0.17	1.05	0.17	0.007	0.011	0.6	267.2	60	18,000	12.5	27.6	239.6

(1) Design Daily Flow per NJAC 7:14A-23.3 requires: 150 GPD - 1 Bedroom, 225 GPD - 2 Bedrooms, 300 GPD - 3 Bedrooms or larger

(2) Diurnal Flow distribution based on publication by Rodney Stewart; Maximum 1/2 hour interval was reported at 4.6% of Total Daily Usage

(3) Manning's equation was used to determine pipe flow capacity. Manning's "n" value was assigned to 0.011 for asbestos cement pipe.

(4) Slope for each segment of pipe was calculated based on the sewer profile provided by the Township.

Table 2 - Diurnal Flow Prediction

Time of Day		Percent of Residential Daily Flow expected for each 1/2 hour period assuming Diurnal Flow *	Grouping of Residential Usage Periods
6:00	AM	2.0%	>2.0% - 3.0%
6:30	AM	3.1%	>3.0%
7:00	AM	3.8%	>3.0%
7:30	AM	4.4%	>3.0%
8:00	AM	4.6%	>3.0%
8:30	AM	4.5%	>3.0%
9:00	AM	4.1%	>3.0%
9:30	AM	3.7%	>3.0%
10:00	AM	3.3%	>3.0%
10:30	AM	3.0%	>3.0%
11:00	AM	2.7%	>2.0% - 3.0%
11:30	AM	2.5%	>2.0% - 3.0%
12:00	PM	2.2%	>2.0% - 3.0%
12:30	PM	2.0%	>2.0% - 3.0%
1:00	PM	1.9%	>2.0% - 3.0%
1:30	PM	1.9%	>2.0% - 3.0%
2:00	PM	1.8%	0 - <2%
2:30	PM	1.7%	0 - <2%
3:00	PM	1.7%	0 - <2%
3:30	PM	1.8%	0 - <2%
4:00	PM	2.0%	>2.0% - 3.0%
4:30	PM	2.4%	>2.0% - 3.0%
5:00	PM	2.7%	>2.0% - 3.0%
5:30	PM	3.1%	>3.0%
6:00	PM	3.5%	>3.0%
6:30	PM	3.5%	>3.0%
7:00	PM	3.4%	>3.0%
7:30	PM	2.9%	>3.0%
8:00	PM	2.6%	>2.0% - 3.0%
8:30	PM	2.3%	>2.0% - 3.0%
9:00	PM	2.1%	>2.0% - 3.0%
9:30	PM	1.9%	>2.0% - 3.0%
10:00	PM	1.9%	>2.0% - 3.0%
10:30	PM	1.6%	0 - <2%
11:00	PM	1.1%	0 - <2%
11:30	PM	0.8%	0 - <2%
12:00	PM	0.7%	0 - <2%
0:30	AM	0.5%	0 - <2%
1:00	AM	0.3%	0 - <2%
1:30	AM	0.3%	0 - <2%
2:00	AM	0.3%	0 - <2%
2:30	AM	0.2%	0 - <2%
3:00	AM	0.2%	0 - <2%
3:30	AM	0.3%	0 - <2%
4:00	AM	0.3%	0 - <2%
4:30	AM	0.4%	0 - <2%
5:00	AM	0.6%	0 - <2%
5:30	AM	1.0%	0 - <2%

ATTACHMENT B

This attachment addresses testing requirements to establish the safe re-introduction of leachate from the Monroe Township Landfill into the Township's sewer system. This document incorporates comments and suggestions from the Technical Meeting held on December 14, 2020.

1 BACKGROUND

Leachate flow rates and durations appear to be key contributing factors to pressures being induced within the sewer system that could result in odors infiltrating certain homes along the sewer line. These induced pressures can exceed the normal design limits of a traditional home P-trap which is one component of a home sewer gas protection system. The P-trap holds water in the inverted "P" of the trap which forms a water seal to prevent gas in the sewer from entering the home. By building code, building sewers must be vented through the roof to avoid pressure in the sewer from pushing sewer gas through the trap. For example, some P-traps are designed to withstand a pressure of as little as 2 inches of water column (in of w-c).

This document presents a plan to test the sewer system to determine what leachate discharge conditions are likely to approach these pressure limits. As a conservative measure, testing design will create conditions not exceeding 75% of the capacity of a traditional home sewer gas protection system to inhibit sewer gases from entering residences during testing.

2 AREA OF INVESTIGATION

This investigation will mimic leachate flow from the Landfill's Underground Storage Tank (UST) through the sanitary sewer system as it travels from manhole one (MH-1) through MH-7, as shown on Figure 1. Beyond MH-7 sanitary sewer liquids drain to MH-9 and beyond. Figure 1 was created to show the general path of alignment for the landfill discharge piping and sanitary sewer systems being investigated as part of this work.

The landfill discharges into a termination manhole (MH-1), which is the first manhole of this sewer segment. The only liquids that pass through this manhole are liquids coming from the landfill. The overall sewer segment under investigation primarily receives flow from homes along Lani Street, Guinevere Road, Launcelot Lane, and Michelle Street; these flows then mix with flows along Lori Street.

The Township camera inspection of the sewer pipes along the route, documented that no sewers were blocked off with debris or sewer liquids during normal background operating conditions for the time of the day of the inspection for each segment. It is also currently understood that odors from the sewer system have not been detected/reported by residents since the time the landfill discontinued discharging liquids into the sewer system. Therefore, the background pressures and flows are believed to be operating at relatively low pressure gradients and are not exceeding residents' home sanitary sewer gas protection systems.

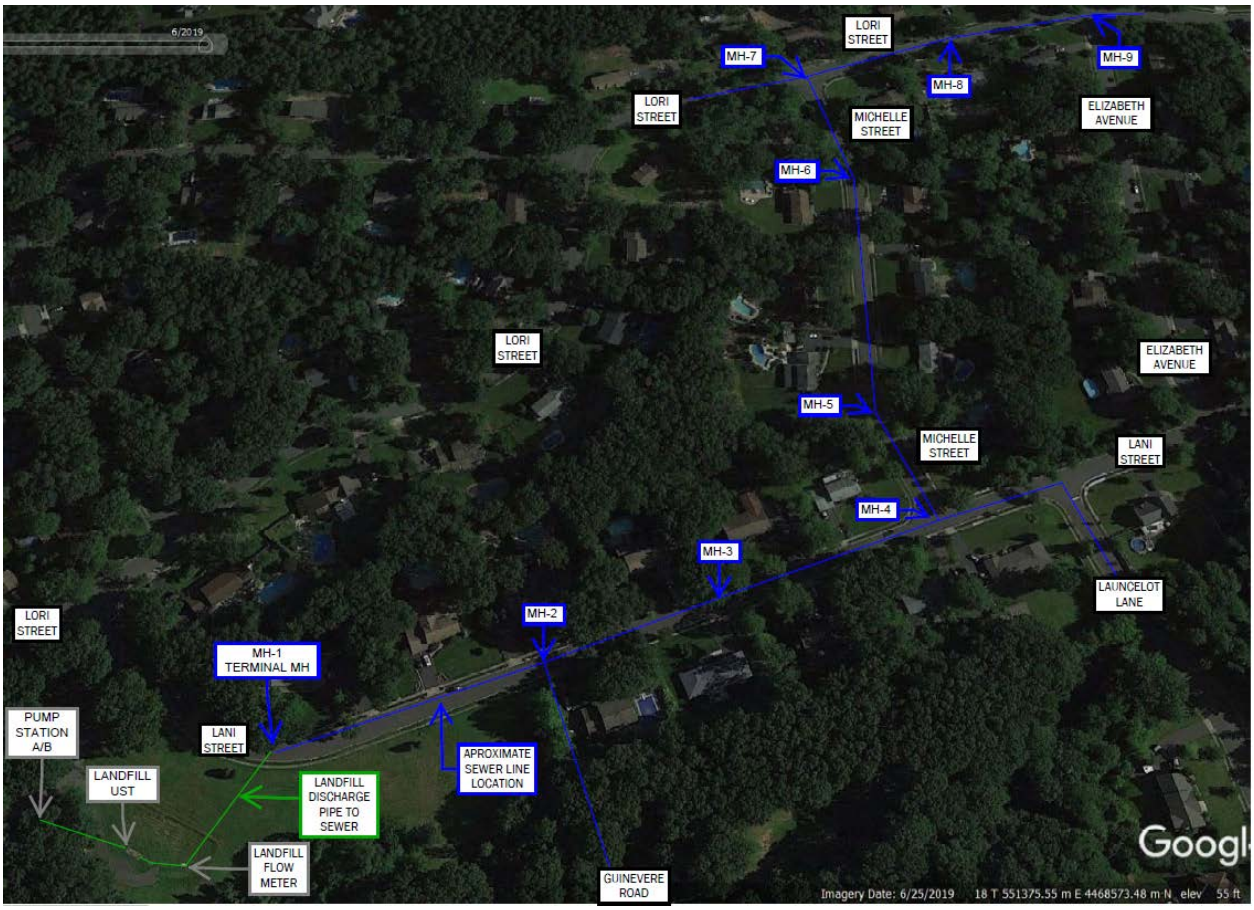

Figure 1. Limits of Sewer Investigation (Image taken from Google Earth)

3 HOME SEWER GAS PROTECTION SYSTEMS

Residential plumbing includes multiple fixtures (sinks, toilets, showers, etc.) all combining to a single sewer discharge line below grade and sloped toward the sewer main. This allows waste water to drain away from the home and toward the sewer main, but it also allow sewer vapors to migrate back up this sewer pipe toward the home. Home sanitary systems have components in place to prevent sewer gases from entering the living area of the home. As shown in Figure 2, each fixture within the home should be protected by a trap, which uses the water discharged from that fixture as a seal to prevent sewer gases from entering the home from the sewer. The home's sanitary sewer is also connected to a vent stack penetrating the roof that allows atmospheric air to be drawn in or pushed out as needed to minimize pressure/vacuum buildups within the home's sanitary lines and keep the system operating as designed.

A more detailed view of a traditional P-trap that might be found in a home is shown in Figure 3. A home P-trap is expected to be able to handle at least 2 in of w-c pressure before sewer gases are able to push through the trap into the home. Traps similar to this will likely be found on sinks, tubs, floor drains, and laundry washing machines. Toilets have traps integrated into their design and a good connection between the toilet and the sanitary pipe needs to be completed to prevent odors from entering the home. Because these traps rely on the water discharged from the fixture, some traps will be subject to failure due to evaporation of the liquids in the trap. This is often seen on floor drains where there is not a regular addition of new water to the trap. This may also occur on any other trap within the home where the water might evaporate quicker than new water is added to the trap. A licensed plumber might be able to recommend a waterless trap or other retrofit if this occurs in a home.

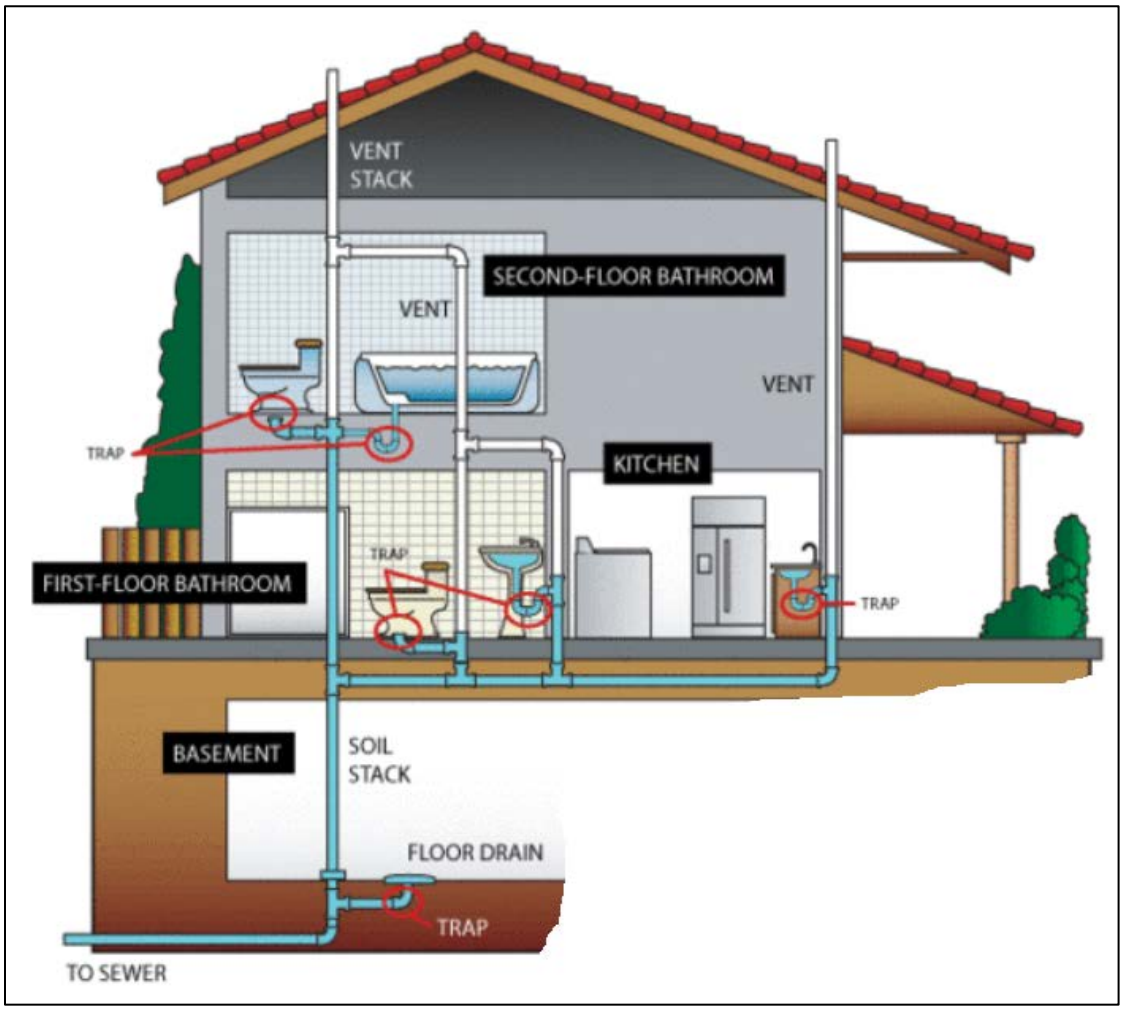

Figure 2. Home Sewer System Gas Protection (Image from Northeast Ohio Regional Sewer District), https://www.neorsd.org/work-made-to-odor-smell-may-annoy-bu/

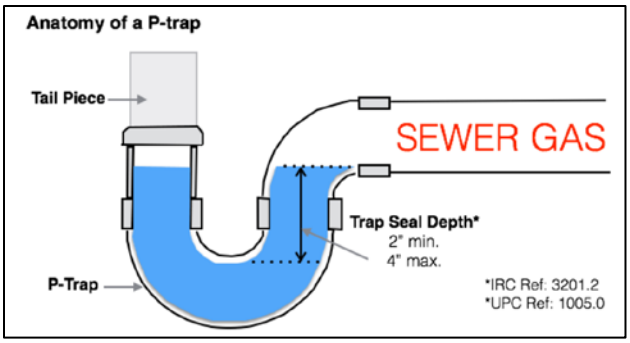

Figure 3. Home Sanitary Trap (https://www.hammerpedia.com/how-to-plumb-a-bathroom/)

Standards for plumbing and venting have changed over the years and traps other than those described above might be in use. For example, some older homes have a whole house trap which may have a trap seal that offers greater than 2 in of w-c of pressurization protection. These house traps also require proper venting and may need to be vented on both sides of the trap to allow the system to operate as designed. Therefore, homes with a house trap may have a vent located in their yard as well as penetrating through their roof. If either of these vents become clogged or blocked off the home's sewer system may not be operating at its designed capacity. If a home owner has questions about their home sewer system they should contact a licensed Plumber who will be able to asses a home's sewer system and inform the owner if the system is currently operating as designed.

For this investigation, it was assumed that the sanitary sewer system for each home is capable of preventing sewer gas infiltration into the home from the sewer system from pressurizations up to 2 in-w.c. at each trap; 75% of that assumed minimum capacity was used as a design threshold. These design assumptions result in a conservative estimate of the ability to introduce liquids into the sewer system without causing sewer gas to be released into the homes connected to the sewer system.

4 UNDERSTANDING THE SANITARY SEWER SYSTEM

The sanitary sewer system can be described simply as a pipe that drains liquids and some solids from one point to another. The act of draining liquids causes air to be displaced within the sewer through a combination of water drag and the fact that water is physically displacing air within the pipe.

Air within the sewer generally will move in the same direction as water due to the water drag force. If the volume of air in a subsequent section of sewer is moving at a slower rate than the previous section, then the excess air will try to escape at the first available opportunity (such as a manhole or perhaps a lateral vent.) This also applies in extreme cases when the entire pipe might become blocked off with liquids forcing the air to escape the sewer system. This scenario is more likely to occur when pipe segments within the sewer system transition from a steeper segment to a flatter section, causing water levels in the pipe to rise and reducing the ability of the sewer pipe to transmit air. Air movement is further hindered as water in the flatter section flows at a slower speed, thus dragging the air at a slower speed. The above scenario can and does occur in the reverse as well and will cause the opposite effect with atmospheric air being drawn into the sewer system.

Sewers may transmit liquids through drop structures. Plunge drop structures allow liquids to free fall to a lower elevation which leads to increased velocities and may cause air to be pulled into the sewer system through the manhole. If flows increase too much, the drop structure manhole may quickly transition from drawing air into the manhole to pushing air out of the manhole due to the downstream pipe being fully blocked off by the flow of the liquids. Replacing plunge drop structures with vortex structures would allow the flow to spiral down the elevation decline and minimize the disruption to the liquid flow. Vortex structures also draw air into the sewer with the liquid, reducing pressurization of the manhole.

Air exchange between the sewer and ambient atmosphere also occurs. Sewers are generally warmer than atmospheric air during the cooler parts of the year and the denser cooler air will push the less-dense warmer air out of the sewer. This can result in driving odors out of the sewer system.

5 PROPOSED INITIAL MONITORING OF THE SEWER SYSTEM

This plan proposes to monitor the sanitary sewer system using flow meters, pressure transducers and photo-ionization detectors to document liquid flows, sewer gas pressures, and the presence of volatile gases in the sewer on a typical day.

The initial phase of background monitoring will assess the current day-to-day activities of the community's sanitary sewer usage. This initial phase will employ a number of data collection devices to monitor sanitary flows for at least 24 hours. At the end of the data collection period, the sanitary sewer lids will be opened to allow connection to the data ports of the devices to download the collected data.

FLOW METER

Three temporary flow meters will be installed and monitored along the sewer path that leachate normally flows. During the initial background phase, no liquids will be discharged from the landfill. Thus, there will be no flow through the Landfill's existing flow meter. The three temporary flow meters will be installed along the sewer route as follows:

1. Two temporary flow meters will be installed in MH-4:

    a. one to monitor flows coming from the Landfill, Guinevere Road, and the houses located west of this manhole along Lani Street, and

    b. the second to monitor flows that come from east of MH-4 and from Launcelot Lane.

2. The third temporary flow meter will be installed at MH-7 and will monitor the flows being discharged from Michelle Street.

These meters will provide information on the community usage during background conditions; they will be used to generate a background diurnal curve for flow through MH-7.

The Teledynce Isco, Inc. Isco 2150 Area Velocity Flow Module will be scheduled for installation by a specialty subcontractor and will be coordinated with the Township to allow for oversight of the installation process. The installation and operation manual for this equipment can be found here:

https://www.teledyneisco.com/en-us/waterandwastewater/Flow%20Meter%20Documents/Manuals/2150%20Flow%20Module%20User%20Manual.pdf

The unit will be programmed to record the level, velocity and flow rate in the sewer at least every 5 minutes. During periods when flows within the sewer system exceed 2 inches in depth, the flow meter will automatically start recording these parameters every 15 seconds. Total flow and input voltage will be recorded once a day.

PRESSURE TRANSDUCERS

A total of seven pressure transducers will be temporarily placed in each manhole along the route from MH-1 to MH-7.

Pressure readings within each manhole will document the pressures being observed in the sewers system and will provide indications if flow patterns within the sewer system are causing pressurization/depressurization events that are exceeding permissible limits or have otherwise changed from the background phase flow and pressure dynamics during later testing.

The Acrulog differential pressure logger will be the pressure transducer utilized. The pressure logger will be able to monitor 0-10 in of w-c. Each pressure transducer will be hung in a manhole suspended above expected flow elevations. The unit will be programmed to record data at one second intervals.

PHOTO-IONIZATION DETECTOR

A Photo-ionization detector (PID) will be handheld and used to periodically inspect around the manhole lids to test for evidence of pressurized sewer gas escaping the sanitary sewer system during the initial background phase. PID readings will be recorded and elevated concentrations above background monitoring will be compared to pressure transducer readings near that location.

REVIEW OF DATA

Once the data are recorded and collected for the background monitoring period, these data points will be analyzed to determine a baseline of sewer operations. Abnormalities detected in the pressure data will be correlated to flows. If pressures are significant enough, the clean water injection plan described below may be modified to adjust to account for these conditions.

6 CLEAN WATER INJECTION TESTING

The intent of injecting clean water into the sanitary sewer system is to find the points at which the sanitary sewer is stressed, causing excessive sewer air pressurization/depressurization. As discussed previously, localized parts of the sewer system may become stressed under certain conditions. The stress point at which this testing will be stopped will be at 75% of the minimum expected capacity of the home sanitary sewer gas protection system (i.e., 1.5 inches of water column).

During the clean water injection test, a clean water source will be connected to the 2-inch discharge line at an existing junction point located in the UST tank which will then flow through the Landfill's

flow meter as shown on Figure 1 prior to discharging to the sanitary sewer system. In addition to monitoring the flow through the Landfill's flow meters, the clean water injection test will employ the same monitoring devices employed in the initial background testing (i.e., three temporary flow meters, pressure transducers and PID).

Water for the clean test will either be supplied by a nearby fire hydrant with a backflow preventer, flow meter, and control valve or a water truck with a flow meter and control valve. The source will then be connected to the UST 2-inch discharge line. The control valve will then be adjusted until the desired rate is reached. Once the desired flow is reached the test may commence.

CLEAN WATER TEST RATES[1]

1. 45 gpm for 60 minutes
2. 60 gpm for 60 minutes
3. 75 gpm for 60 minutes
4. 90 gpm for 60 minutes

Each of the initial clean water tests will be held at a duration of at least 60 minutes which is well beyond the time it should take for water to travel from the UST to MH-7. This amount of time should allow for the sewer system to become stabilized barring abnormal flow disruptions.

Prior to each subsequent test, transducer data will be extracted and peak, minimum, and average pressures will be recorded. The background flow patterns for the day shall also be considered so that the flow rate between tests will not be excessively increased. The pressure data from each test will be compared to the previous set of data collected at lower flow rates. If the relative difference between the latest test data and the previous data does not suggest that the next higher flow rate will exceed the defined maximum stress point, then the next test will proceed.

Test data gathered during the initial day of clean water rate testing will be downloaded for analysis and review. Pressure and flow data will be provided to the EPA, NJDEP and Monroe Township. The overall flow in the sewer system for each test will be correlated with the pressures recorded by the transducers.

If a flow rate is determined to be continuously safe (not exceeding maximum allowable air pressure) for a period of over 60 minutes, then a maximum pumping rate will be established based on the diurnal curve for this sewer segment that will not exceed the total sewer safe flow rate during the clean water injection test. Permission will be requested to reintroduce leachate at the total sewer capacity rate established during the test from the EPA, NJDEP, and Monroe Township. No limits on continuous pumping time will need to be set if the system can safely pump for a 60 minute interval. The initial leachate reintroduction will be performed during daylight hours, if possible, to facilitate observation of the event.

If a differential pressure is observed in the field during the first day of testing that causes concern then testing will be performed to determine if a shorter duration with a defined interval and

[1] These flow rates may be adjusted for expected diurnal flow rates on the day of testing.

maximum flow rate for the sewer can be established. This would be accomplished in the field by making modifications to the duration and rate of the pumping. The pumping duration would be reduced to a time period shorter than the observed elevated pressures during the previous testing event. If shorter durations of water discharge are successfully tested then intervals between pumping events should be tested and established as well. The interval between pumping cycles should not have to be any longer than the time observed for a slug of water from the landfill to pass MH-7. A diurnal curve will be prepared that will limit the rate at which the landfill may pump throughout the day. A limitation on the specified duration and interval between pumping events also will be established. Once these initial reintroduction criterion are approved, the initial leachate reintroduction will be performed during daylight hours, if possible, to facilitate observation of the event.

If no safe differential pressure can be maintained during the initial day tests, then clean water injection testing will be performed between the hours of 10 PM and 6 AM at the clean water rates proposed above. If safe sewer flow can be established, then pumping hours will be limited to this time interval at the rates that are proven during the clean water rate tests. No limits on continuous pumping time will need to be set if the system can safely pump for a 60-minute interval.

7 RETURNING LEACHATE TO THE SEWER SYSTEM

Once testing is completed with clean water, the results and proposed landfill pumping rate will be provided to the EPA, NJDEP, and Monroe Township. Once a safe rate of leachate discharge has been approved, the Landfill will program its equipment to deliver flow at the prescribed rates. The Landfill will then begin discharging leachate at the approved rates and monitor and record the amount of leachate being discharged from the Landfill into the sanitary sewer system.

During this initial leachate reintroduction the Landfill will continue to monitor the sewer system with the temporary flow meters and pressure transducers and periodically check for gases escaping from the manholes with the PIDs. Monitoring will continue for at least one full cycle for each proposed pumping rate and, if applicable, interval.

Test data gathered will be downloaded for analysis and review. Pressure and flow data will be provided to the EPA, NJDEP and Monroe Township. Once the safe leachate discharge rate has been approved, the temporary monitoring equipment will be removed from the sanitary sewer system. The Landfill will continue to monitor and record the amount of leachate that is being discharged from their facility into the sanitary sewer system.

BFI is committed to continuing working with the EPA, NJDEP, and the Monroe Township to address any future issues that may arise.