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MEMORANDUM

To: Angus West & Hampden Town Council
From: Matt Reynolds & Steve Rabasca
Date: August 7, 2017
Subject: Pine Tree Landfill –Post-Closure Monitoring Review & Update

This memorandum has been prepared to provide the Town with an overview of 2016 and April 2017 monitoring data and associated corrective actions and post-closure conditions at the Pine Tree Landfill (PTL). The review is based on data provided in the 2016 Annual Report, and the May 2017 memoranda prepared by Richard Heath of the Maine Department of Environmental Protection (MDEP).

Our memorandum dated November 21, 2016 provided the Town with a general overview of conditions associated with the landfill since closure in 2010. This memorandum provides an update on 2016 operations and data, but the reader is referred to the November 2016 memorandum for additional information about historical conditions, closure status, etc.

Figure 1-1 from Attachment C of the 2016 Annual Report (prepared by Sevee & Maher Engineers) is attached to this memorandum for reference and shows the configuration of the landfill and location of the monitoring points and other site features. Consistent with previous update memoranda, this update does not include detailed graphs and figures, however, we would be glad to prepare these if it would assist the Town and/or address specific questions.

I. Landfill Closure Status

In accordance with the October 2006 Schedule of Compliance agreed to by the Maine Department of Environmental Protection (MDEP) and the Town of Hampden, PTL completed closure of the landfill in 2010. Since that time, monitoring of water quality, gas, settlement, etc. has continued in accordance with the Environmental Monitoring Plan (EMP) for the site. In 2016 several adjustments were made to the sampling frequency and parameters as discussed in Section IV of the November 2016 memorandum and summarized in Table 1 of this memorandum.

Landfill gas containing methane has also been collected and used to fuel the Landfill Gas to Energy (GTE) facility constructed in 2007. Additionally, some of the leachate collected by the leachate collection system and groundwater extracted from wells at the

perimeter of the landfill is being recirculated into the landfill with the approval of the MDEP.

II. Corrective Action Summary

Prior to closure, corrective actions systems were implemented to control and/or mitigate impacts to groundwater and surface water include the following.

- Gas collection systems were installed in the Conventional Landfill and Secure Landfills to collect a portion of the landfill gas generated by decomposition of waste. Both gas collection systems are connected to the GTE plant.
- The Secure landfill liner system functions as a cover for the Conventional Landfill and the cover system for the Secure Landfills was completed in 2010;
- The perimeter drain (PDPS) borders the west, south and east sides of the Conventional Landfill and intercepts some shallow groundwater;
- Six groundwater extraction wells have been installed near the edge of the landfill (shown on Figure 1-1). Wells EW-2R and EW-3R are located adjacent to the southeast corner of the landfill. Wells EW-5R, EW-6R, EW-101 and EW-102 are located adjacent to the northeast corner of the landfill. The gallons of leachate and groundwater extracted by these wells and drain during 2013 to 2016 are summarized below.

Year	Northeast (EW-5R, -6R, -101, -102)	South (EW-2R, -3R)	PDPS	Total (gallons)
2013	2,687,000	1,121,000	3,721,000	7,529,000
2014	1,857,000	506,000	3,802,000	6,165,000
2015	3,112,039	781,344	3,356,269	7,249,652
2016	2,328,767	475,324	2,705,609	5,509,700

According to the Annual Report, the lower extraction volume in 2016 was due primarily to mechanical issues which included plugged and/or frozen discharge lines that required time to repair.

- PTL also collects gas migrating away from the landfill in collection wells located west and south of the landfill. This external landfill gas (LFG) collection system consists of 6 gas collection wells and a passive gas collection trench. The gas extracted from the collection wells (shown in Figure 1-1) during 2013 to 2016 is summarized below.

Year	PTGW08-1 (MMSCF/Tons)	PTGW08-11 (MMSCF/Tons)	PTGW08-12 (MMSCF/Tons)	PTGW08-13 (MMSCF/Tons)
2013	20.8/218	2.0/17	0.5/2	0.6/4
2014	19.7/220	2.6/22	0.1/0.3	0.4/6
2015	19.2/200	2.5/19	2.1/10	1.7/8
2016	13.9/144	2.8/18	1.1/2.6	0.1/0.2

Notes: 1. MMSCF = Million Standard Cubic Feet. Tons = Tons of Methane Extracted
2. Estimate of Tons is Based on Volume Extracted and Percent Methane
3. No Gas Was Extracted from PTGW08-3, -9 during 2013to 2016 Due to Low Gas & Methane

In 2015 and 2016 gas extraction was increased (compared to 2013 & 2014) at PTGW08-12. This has generally resulted in lower dissolved methane concentrations in downgradient monitoring wells located southwest of the landfill (e.g., MW-03-802A, -802B, -803B).

III. Water Quality Target Criteria

The MDEP Closure Order identified 5 specific criteria for determining "successful corrective action" at PTL under the MDEP Solid Waste Regulations. These criteria incorporate the state Maximum Exposure Guideline (MEG) values and the federal Maximum Contaminant Level (MCL) and Ambient Water Quality Criteria (AWQC) values.

These criteria are as follows.

- Groundwater Quality on PTL Property:
  - Specific Conductance must be less than 500 umhos/cm

- Groundwater Quality off of PTL Property:
  - Groundwater must be below the applicable MCLs and MEGs;
  - Specific Conductance must be less than 400 umhos/cm
  - Dissolved Methane must be below 700 ug/L

- Surface Water Quality:
  - Surface water quality must meet the federal AWQC and Maine water quality classification established in 38 MRSA Section 465 and 465-B.

These criteria must be met at the PTL monitoring locations during the 30 year post-closure period in order for the MDEP to determine that corrective actions have been successful. The 30-year post-closure period began in 2010, so it is premature to expect that monitoring locations will meet these criteria currently. However, tracking data against these criteria allows PTL, the MDEP and the Town to judge whether the existing corrective actions will be sufficient to meet these criteria over time, or whether supplemental corrective actions may be necessary in the future.

IV. Water Quality Overview

In accordance with the Post-Closure Environmental Monitoring Plan, water quality is monitored two (formerly three) times each year at a network of sampling locations around PTL. These monitoring points are located in different regions around the landfill and include groundwater monitoring wells, residential wells and surface water, as summarized in Table 1.

Discussion of Water Quality Monitoring. As noted in Table 1, the majority of monitoring locations have improved (i.e., a downward trend) since 2008, although the improvements have generally been gradual.

Table 1
PTL 2014 to 2016 & April 2017 Water Quality Monitoring Summary

Monitoring Pt	2011-2015 Analysis[1] (Frequency/yr)	2016-2020 Analysis[1] (Frequency/yr)	Specific Cond. Range[2] (umhos/cm)	Predominant Trend Since 2008[3]
South/Southeast				
200*	F, L (3)	F, L (2)	362 - 691	Down
641	F, L (3), M (2)	F, L (2), M (1)	822 – 1368	Down
MW-906B*	F, L (3), M (2)	F, L (2)	382 - 513	Down
MW02-801A	F, L (3), M (2)	F, L (2), M (1)	2537 – 3530	Down
MW02-801B	F (3)	F (2)	2097 – 3700	Down
MW03-802A	F, L (3), M (2)	F, L (2), M (1)	470 – 837	Down
MW03-802B	F (3), M (1)	F (2), M (1)	1077 – 1587	Up
MW03-803A	F (3), M (1)	F (2), M (1)	1264 – 1691	Up
MW-03-803B	F, L (3), M (2)	F, L (2), M (1)	1157 – 1497	Up
West & North				
MW03-804A	F (3)	F (2)	682 – 1070	None**
P-914A	F, L (3)	F, L (2)	683 – 850	Up Since 2014
P-914B	F (3)	F (2)	589 – 776	Up Since 2014
516B-B	F, L (3)	F, L (2)	981 – 1141	Up Since 2014
Northeast & East				
MW98-601A	F (2)	F (2)	2158 – 2880	None
MW96-601B	F (2)	F (2)	1176 – 1730	None
MW01-602B*	F (2)	F (2)	259 - 660	None Since 2012
MW97-123	F, L (3)	F, L (2)	780 – 1414	Down
509A	F (3)	F (2)	841 – 1234	None
509B	F, L (3), M (2)	F, L (2)	827 – 1249	Up
P-911B	F (3)	F (2)	768 – 959	Down
916	F, L (3), M (2)	F, L (2), M (1)	257 – 883	None
917	F, L (3), M (2)	F, L (2), M (1)	354 – 1007	Down
Residential				
DW04-109*	F (3), L (1), M (3)	F (2), L (1), M (2)	215 – 793	
DW-103	F (3), L (1), M (3)	F (2), L (1), M (2)	409 – 482	
Surface Water				
SW-A	F, L (3)	F, L (2)	86 – 180	
SW-C	F, L (3)	F, L (2)	66 – 200	
SW-D	F, L (3)	F, L (2)	197 – 890	
SW-E	F, L (3)	F, L (2)	241 – 914	

Notes: 1. Analyses: F=Field Parameters, L=Laboratory Parameters, M= Methane
2. SC Range Reflects Data from 2014, 2015, 2016 & April 2017
3. Wells in **BOLD*** are close to or below Corrective Action Criteria for Specific Conductance.
4. Values in RED Represent a New Low or High Concentration measured in October 2016 or April 2017
5. ** = Increase in October 2016 Specific Conductance, But Decreased in April 2017

Comparison of Recent (2014 to April 2017) Data to the Target Criteria

- Prior to 2013, all on-site groundwater was above the 500 umhos/cm criteria. Since 2014 several wells have begun to approach or meet the 500 umhos/cm criteria.
  - MW-906B has had specific conductance below 500 since July 2014.
  - MW-200 groundwater was below the 500 umhos/cm target criteria for 6 of the 9 sampling events since April 2014.
  - MW01-602B was below 500 umhos/cm for 5 of 7 sampling events since April 2014.

- MW-916, which is an off-site well with a target criteria of 400 umhos/cm, was below this concentration for 3 of 9 events since 2014.

- Groundwater at off-site well DW04-109 was below the 400 umhos/cm target criteria during the 6 sampling rounds in since April 2015.

- At the off-site residential well DW-103, groundwater equals the MCL and/or MEG for arsenic and exceeds these criteria for sodium. At off-site monitoring well MW-916 the MCL and MEG for arsenic was equaled in April 2017. At off-site monitoring well MW-917 groundwater exceeded the arsenic MCL/MEG during the 2016 and April 2017 sampling events. Secondary drinking water criteria of iron and manganese are also exceeded at MW-916 and MW-917.

- Residential well DW-103 has been below the 700 ug/L methane off-site target criterion since April 2014. Well DW04-109 has been below this criterion since September of 2014. Off-site monitoring wells MW-917 and MW-917 were both below the methane criterion in October 2016.

- Surface water meets the applicable classification criteria and AWQC standards.

Discussion of Data Trends

As reflected in Table 1, there has been an improving trend in specific conductance and related cations and anions in many of the locations included in the monitoring network at the PTL site. This improving trend has generally been gradual and at many locations, the specific conductance remains significantly above the target criteria of 500 umhos/cm.

The area where there has been the most pronounced upward trend has been to the south-southwest of landfill in wells MW03-802B and MW03-803A & B. During 2012, PTL began operation of 2 gas extraction wells PTGW08-12 and -13 in the vicinity of the 802 and 803 wells. In response to the gas extraction, the methane concentrations in these wells have decreased, particularly since 2015, when an effort was made to extract landfill gas on a more consistent basis. However the decrease in methane concentration in these wells has not resulted in a significant decrease in specific conductance. In June 2016, PTL discovered leachate leaking from a cover defect onto soils in this area. This condition was repaired promptly and PTL has suggested that this leachate leakage may

have contributed to the rising trend observed in the MW-03-802 and -803 wells. As shown in Table 1, new high conductivity values were measured in these wells in October 2016 or April 2017, after the repairs were complete. However, it may be too soon to observe improvements and future sampling data in 2017 and 2018 should provide better insight in the possible role of the leachate leak in this area.

Discussion of Arsenic in Groundwater.

During 2014 and 2015, data from the PTL monitoring program showed increasing arsenic concentrations at on-site monitoring locations. During 2014, PTL conducted supplemental sampling at off-site residential wells. The June 2014 arsenic concentrations were below the detection limit at all off-site wells except DW-103, where the concentration was 0.012 mg/L, slightly above the MCL and MEG concentrations for arsenic of 0.010 mg/L. Arsenic was detected at concentrations below the MCL & MEG at the PTL office well and the well at the Gas to Energy plant. After reviewing the data, the MDEP concluded that the arsenic sampling program "did not suggest widespread impact of the closed landfill on water quality of the surrounding residential wells included in the investigation".

In 2015 the MDEP requested and PTL agreed to include the historically sampled residential wells in the three rounds of sampling planned for 2015. Wells identified as DW-103 and DW04-109 (east), DW-104 (south) and DW-105 (west) were sampled and analyzed for arsenic in April, July and October 2015. Arsenic concentrations were generally below the MCL/MEG in these wells in 2015 except at DW-103 where the concentration was in the 0.014 to 0.019 mg/L range.

In 2016 arsenic was sampled at DW04-109 and DW-103 in October and was below the detection limit and 0.010 mg/L (equal to the MCL/MEG), respectively.

Arsenic was analyzed in 12 on-site and 2 off-site monitoring wells in October 2016 and in April 2017. These samples had lower arsenic concentrations compared to April 2016 in all locations except for a small increase in MW-916, where arsenic was 0.008 mg/L in April 2016 and 0.010 mg/L in April 2017. While 8 of the on-site monitoring wells and 2 of the off-site monitoring wells sampled in April 2017 had arsenic concentrations above the MCL/MEG, the data no longer suggest an increasing trend in arsenic concentration.

V. Geotechnical Monitoring

The geotechnical monitoring program for the landfill is summarized in a report prepared by Dr. Richard Wardwell, PE, who has been involved with the geotechnical monitoring at that site for many years. The observational approach is utilized in the monitoring, based primarily on topographic surveying of the surface and surveying of multiple survey monuments that were embedded in the surface of the landfill cover system. The primary purposes of the geotechnical monitoring are to assess if the internal waste mass and foundation soils are stable, and to assess if the cover system is performing as-designed.

Internal and Waste Mass Stability: The internal and waste mass stability is assessed by an evaluation of the horizontal and vertical deformation of four displacement monuments at the toe of the landfill along the east side. The horizontal and vertical movements measured do not indicate that there are any detrimental large-scale movements occurring that would be indicative of large-scale waste-mass or foundation soil movements. There is a significant amount of scatter in the horizontal deflection data, but the overall trends indicate that the foundation soils and waste mass are not undergoing detrimental horizontal displacements. The vertical displacement at these four displacement monuments has leveled off since December 2014.

Cover System Monitoring: The performance of the cover system is also assessed using survey measurements of embedded displacement monitors. Several monuments are installed in each phase of the closure, and horizontal and vertical deflections have been made at least quarterly since those phases were closed. The report includes the plots of horizontal and vertical deformation.

- The horizontal deformation plots for all phases do not indicate any trends that would be indicative of large scale movements that would be detrimental to the cover system integrity. The data are scattered, and some general downslope creep is evident but this is expected given the overall large deformation of the waste mass due to secondary settlement.
- The vertical displacement plots all indicate that the rate settlement is diminishing with time. This is also expected especially since waste loading has stopped and the landfill is now covered. These vertical displacement plots are also used to calculate strain that has likely occurred in the liner. Excessive strain could result in a rupture of the primary geomembrane liner, therefore these periodic assessments of liner strain are important to demonstrate that the movements that are occurring are within those originally predicted during the design phase. The strain calculations are summarized in a table and indicate that the likely strain incurred to date is well within the allowable strain for this type of membrane. The current rate of strain is also extrapolated over the 30-year closure period and those extrapolations are also well within the allowable strain for the liner.

Leachate Recirculation System: During 2016 there were three incidences of leachate seeping through the cover system. In investigating the seeps, PTL concluded that they were caused by the leachate recirculation system. The three incidents are summarized as follows:

Seep1: Seep 1 was located on the southeast corner of the landfill and associated with a loose clamp on a cleanout boot. The loose clamp created a void that allowed a path for leachate to seep from under the cover system.

Seep 2: Seep 2 was located on the east side of the landfill between the external soil gas extraction wells PTGW8-12 and PTGW8-13. The leachate seepage occurred through a two foot long tear in the liner system at this location.

Seep 3: Seep three was located on the east side of the landfill across the access road towards the top of the landfill. The seepage occurred through another tear in the liner, located beneath the riprap lined drainage swale.

It appears that the root cause of the seepage was associated with the recirculation system. PTL tested each of the four leachate recirculation trenches by pumping clean water into the trenches. Shortly after introducing this water into trenches LRT-1 and LRT-4 leakage was observed through the same seeps. The tears in the liner were then repaired and PTL has discontinued the use of LRT-1 and LRT-4 for the foreseeable future.

These seeps indicate that the two trenches LRT-1 and LRT-4 are likely plugged due to either biological growth, chemical precipitation or particulate accumulation, or a combination of the three. The leachate introduced into these trenches indicates that the trenches are clogged, and the fluid partially or fully flowed along a path of least resistance which, according to the Maine DEP staff, was into the gas collection layer between the clay layer and the LLHDPE layer of the cover system. Once the leachate hit these defects in the cover system, the leachate had a path to exit, rather than travel into the leachate collection system.

These incidents highlight the potential for the remaining 2 recirculation trenches to clog and for recirculated leachate to flow into the cover system to unintended areas of the landfill. Build-up of leachate within the cover system could limit the effectiveness of gas collection and might create cover stability issues. In light of this, we will contact PTL to review the status of the recirculation system, understand current operational practices and determine whether additional monitoring is being conducted or is appropriate to prevent a re-occurrence of this condition.

VI. Closing

Overall, the water quality monitoring data from PTL reflected in the 2016 Annual Report and April 2017 water quality data indicate that there continues to be gradual improvement at many monitoring locations. At this time PTL is in the 7th year of the 30 year post-closure monitoring period and is not required to meet the target criteria. Yet there are several on-site locations that are close to or meet the corrective action criteria. Additionally, the trend of increasing arsenic concentrations appears to have abated and lower concentrations have been measured in most wells recently. While this is positive, there is still evidence of significant landfill impact at many on-site monitoring wells. Groundwater in several wells south and southwest of the landfill continue to exhibit increasing concentration trends, despite the cover repair conducted in this area in June 2016.

Continued operation of the corrective action systems (groundwater extraction and external gas extraction) are necessary to maintain and extend the improvement observed to date. If the trend of increasing conductivity in the MW03-802 and MW03-803 wells on the south side of the landfill continues, it may also be appropriate for PTL to consider additional corrective actions in this area in the future.

The geotechnical monitoring at the landfill indicates that the cover system is performing as designed, and that there are no indications of large-scale waste mass foundation instabilities. We will contact PTL to gather additional information about the performance of the leachate recirculation and update the Town on our findings.

We hope that the information summarized in this memorandum is helpful to the Town. If there are any questions or a more detailed review would be appropriate, please give me a call at your convenience.

Figure 1-1