TIMOTHY D. STARK, Ph.D., P.E., D.GE

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To: Ms. Brenda Ardrey, CGFM
Operations Section Chief
Solid Waste Management Program
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

From: Timothy Stark, Ph.D., P.E., D.GE

Date: September 16, 2014

RE: Slope Stability Inspection 13 May 2014 – Bridgeton Landfill – Permit No. 0118912

Pursuant to your request, I performed an inspection of the slope areas at the Bridgeton Landfill on 13 May 2014, including areas in which active smoldering or combustion is occurring.

My inspection consisted of walking over landfill slopes made available by Republic Services while being accompanied by representatives of Republic Services, including James Teeter, Brian J. Power, and their external engineering consultant Peter J. Carey. My slope inspection was limited by the presence of a geomembrane cap installed over the south quarry and part of the "neck area" to control odors. As a result, surface cracking, scarp formation, toe bulging, and leachate outbreaks were not readily visible.

This inspection did reveal evidence of slope movement in the southwest corner near the slope toe. This movement was manifested by a bulge in the slope toe towards the access road and corresponding closely spaced geomembrane wrinkles across the area. The movement appeared to be confined to the lower one-third of the slope.

Areas of future stability concern are the southeast and southwest slopes as the smoldering/combustion moves towards the south and the steep slopes around the "amphitheater" area of the landfill, especially if the smoldering/combustion keeps moving north. Slope stability is a concern when the smoldering/combustion moves to unaffected slopes because of the presence of high gas and leachate pressures, steep slopes, and thermal degradation of waste. As the waste is consumed by combustion/smoldering and the slope flattens, the potential for slope instability decreases.

If you have any questions or if I can provide any additional information, please contact me using the contact information shown above.

Sincerely yours,

Timothy D. Stark, Ph.D., P.E., F.ASCE, D.GE

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To: Ms. Brenda Ardrey, CGFM
Operations Section Chief
Solid Waste Management Program
Missouri Department of Natural Resources (MDNR)
P.O. Box 176
Jefferson City, MO 65102

From: Timothy Stark, Ph.D., P.E., D.GE

Date: August 10, 2015

RE: Field Reconnaissance: January 8, 2015–Bridgeton Landfill–Permit No. 0118912

Pursuant to your request, I performed an inspection of the Bridgeton Landfill on 8 January 2015 with representatives of the MDNR and Missouri Attorney General's Office after some concern about an apparent gas system overdraw issue.

My inspection consisted of walking over landfill slopes and areas made available by Republic Services while being accompanied by representatives of Republic Services, including Brian J. Power, their external engineering consultant Peter J. Carey, and other Republic Services personnel. My inspection was limited by the presence of a geomembrane cover installed over the south quarry and part of the "neck area" to control odors and other aspects of this elevated temperature event. As a result, surface cracking, scarp formation, toe bulging, sinkholes, erosion features, and leachate outbreaks were not readily visible in this area.

This site inspection started near the leachate treatment area and moved to the north and along the north slope of the north quarry. The walking reconnaissance rounded northwestern corner of the north quarry and moved to the east along the northern and eastern ends of the north quarry. The walking reconnaissance traversed the landfill near the "neck area" and then to the southwest corner of the south quarry. After viewing the southwest corner, the inspection moved to the east along the southern slope of the south quarry. The walking reconnaissance rounded the southeast corner of the south quarry and then went to the top and bottom of the south quarry, and eventually ended on the east side of the south quarry.

The main observations from this reconnaissance are summarized below and documented in other photographs that I took during my reconnaissance a few of which are included below as representative of others:

Figure 1 shows erosion gullies in the soil cover on the southwest side of the north quarry near the maintenance building. Erosion of the soil cover can lead to air/oxygen intrusion especially when gas extraction activities are occurring. Other instances of possible oxygen intrusion were encountered during my field reconnaissance and are discussed below. Introduction of oxygen to the waste mass in the presence of elevated temperatures can lead to a reduction in waste due to consumption and/or combustion. As a result, oxygen intrusion to the waste mass should be minimized if not eliminated. Landfill personnel during their quadrant checks should be alert for these erosion features and other sources of possible oxygen intrusion.

Figure 1. Photograph of erosion of the soil cover near the maintenance building on northwest side of north quarry.

- Figure 2 shows slope and soil cover repair on the southwest side of the north quarry near the maintenance building. It appeared the area was recently seeded to promote vegetation growth.

(a) (b)

Figure 2. Photographs near maintenance building on northwest side of north quarry showing: (a) overview and (b) close-up of slope and vegetation repair.

- Figure 3 shows geosynthetics not sealed to Perimeter Sump 35 (PS-35) near the transfer station. The opening around PS-35 is a source of oxygen intrusion, which could be significant if a vacuum is applied in this area. During my site visit I did not hear or feel a vacuum being applied around PS-35.

Figure 3. Photograph of geosynthetics around PS-35 not sealed to piping near maintenance building on northwest side of north quarry.

- Figure 4 shows excavations in soil cover on the north slope of north quarry. Excavation or erosion of the soil cover can lead to oxygen intrusion especially when gas extraction activities are occurring. Other instances of possible oxygen intrusion were encountered during my field reconnaissance and are discussed below.

Figure 4. Photograph of excavations in soil cover on the north slope of north quarry.

- Figure 5 shows soil cover repair at the top of north slope on north side of north quarry. The area was remediated with some additional cover soil (Figure 5(a)) but a nearby hole was not filled in. Holes in the soil cover can lead to oxygen intrusion especially when gas extraction activities are occurring.

(a) (b)

Figure 5. Photographs at top of north slope on north side of north quarry showing: (a) overview of repair area and (b) close-up of remaining hole in soil cover.

- Figure 6 shows slope repair and soil cover repair on the north side of the north quarry. It appeared the area was recently seeded to promote vegetation growth.

(a) (b)

Figure 6. Photographs on north side of north quarry showing: (a) overview and (b) side view of slope and vegetation repair.

- Figure 7 shows slope repair and soil cover repair along the northeast corner of the north quarry. It appeared the area was recently seeded to promote vegetation growth.

(b) (b)

Figure 7. Photographs on northeast corner of north quarry showing: (a) overview and (b) side view of slope and vegetation repair.

- Figure 8 shows a geomembrane panel not welded on northeast side of the north quarry near the large flare station. This opening is a source of oxygen intrusion, which could be significant if a vacuum is applied in this area. During my site visit I did not hear or feel a vacuum being applied at this location.

Figure 8. Photograph of unwelded geomembrane on northeast side of the north quarry near large flare station.

- In the southwest corner there is still evidence of slope movement near the slope toe that was observed in my 13 May 2014 slope reconnaissance. The movement still appeared to be confined to the lower one-third of the slope and it does not appear that significant additional movement has occurred since my 13 May 2014 site visit. Slope movement was also observed at the Countywide Recycling and Disposal Facility (CWRDF) near Cleveland.

- Along the southern end of the landfill, new slope movement and collapse features were observed (see Figure 9). The isolated collapse features are probably due to sinkholes developing due to waste consumption from below. The larger and longer features are probably due to slope movement but my inspection was limited by the presence of the geomembrane.

Figure 9. Photograph along south slope of south quarry showing slope collapse and/or slope movement features.

- In the southeast corner of the landfill, Figure 10 shows repair of an area where the geomembrane cover was burned/melted through near Surface Extraction Well 2 (SEW-2). This is an indication of elevated temperatures in this area.

(a) (b)

Figure 10. Photographs along south slope of south quarry showing: (a) overview of burned/melted geomembrane near Surface Extraction Well (SEW-2) and (b) close-up of burned geomembrane.

If you have any question or I can provide any additional information, please contact me using the contact information shown above.

Sincerely yours,

TD Stark

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To: Ms. Brenda Ardrey, CGFM
Operations Section Chief
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Missouri Department of Natural Resources (MDNR)
P.O. Box 176
Jefferson City, MO 65102

From: Timothy Stark, Ph.D., P.E., D.GE

Date: August 20, 2015

RE: Field Reconnaissance: July 21 and 22, 2015–Bridgeton Landfill–Permit No. 0118912

Pursuant to your request, I performed an inspection of the Bridgeton Landfill on 21 and 22 July 2015 with representatives of the MDNR, Missouri Attorney General's Office, and other experts.

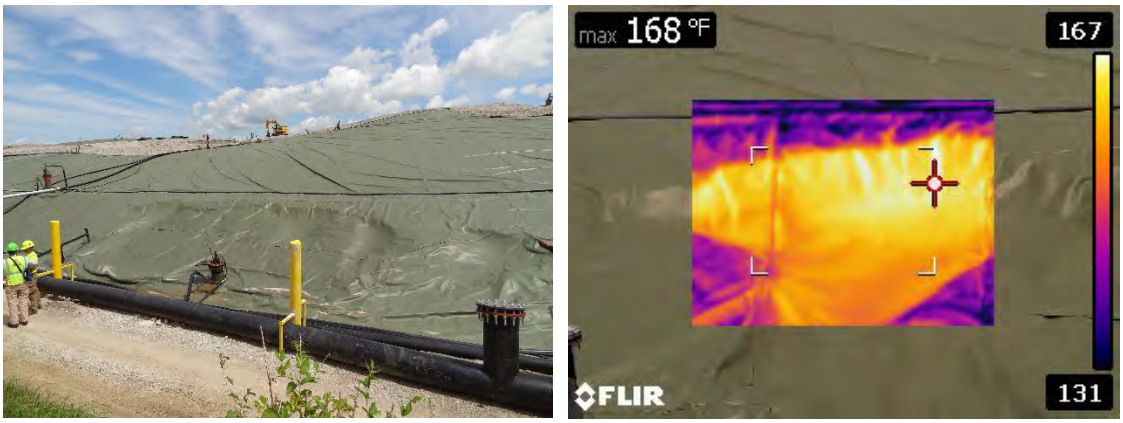
My inspection consisted of walking over landfill slopes and areas made available by Republic Services while being accompanied by representatives of Republic Services, including Brian J. Power, their external engineering consultant Peter J. Carey, and other Republic Services personnel. My inspection was limited by the presence of a geomembrane cover installed over the south quarry and part of the "neck area" to control odors and other aspects of this elevated temperature event. As a result, surface cracking, scarp formation, toe bulging, sinkholes, dead vegetation, erosion features, and leachate outbreaks were not readily visible in this area.

This site inspection spanned two days with each day discussed below. In general, the first day (July 21, 2015) focused on the south quarry and the second day (July 22, 2015) focused on the north quarry. The first day of reconnaissance started near the southwest corner and moved to the east along the southern slope of the south quarry. The walking reconnaissance rounded the southeast corner of the south quarry and then went to the top and bottom of the south quarry, and eventually ended near the "neck area" or transition to the north quarry. The second day of reconnaissance started at the northwestern corner of the north quarry and moved to the east along the northern and eastern ends of the north quarry. The walking reconnaissance rounded the southeast corner of the north quarry and then across the soil cover to the north of the north quarry, along the western side and slope of the north quarry, and eventually ended near the "neck area" or transition back to the south quarry.

The main observations from the first day of reconnaissance (July 21, 2015) are summarized below and documented in other photographs that I took during my reconnaissance a few of which are included below as representative of others:

- In the southwest corner there is still evidence of slope movement near the slope toe that was observed in my 13 May 2014 slope reconnaissance. The movement still appeared to be confined to the lower one-third of the slope and it does not appear that significant additional movement has occurred since my 13 May 2014 site visit. Slope movement was also observed at the Countywide Recycling and Disposal Facility (CWRDF) near Cleveland.

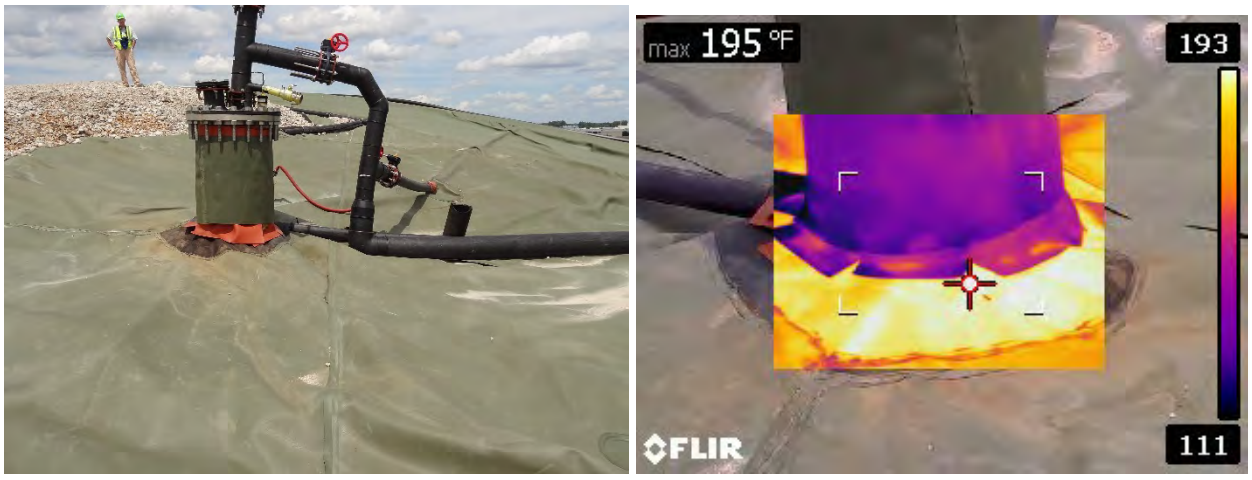
- Along the southern end of the landfill, larger slope movement and collapse features were observed (see Figure 1(a) and other photographs are available). Given the elevated temperatures measured using an infrared camera in the collapse zones (see Figure 1(b)), the isolated collapse features are probably due to sinkholes developing due to waste consumption from below. The larger and longer features are probably due to slope movement but my inspection was limited by the presence of the geomembrane. This is also an area of leachate outbreaks as evidenced by considerable liquid under the geomembrane as discussed below.



(a) (b)

Figure 1. Photographs along south slope of south quarry showing: (a) slope collapse and/or slope movement features and (b) measured elevated temperatures.

- In the southeast corner of the landfill, high elevated temperatures and large settlements were observed. Figure 2(a) shows Surface Extraction Well 2 (SEW-2) and temperatures of 195^0F measured using an infrared camera on the piping associated with SEW-2 (see Figure 2(b)).



(a) (b)

Figure 2. Photographs along south slope of south quarry showing: (a) overview of SEW-2 and (b) measured elevated temperatures.

- The elevated temperatures measured along the south slope are causing distress in some of the surrounding infrastructure as shown in Figure 3(a) and in the southeast corner. Elevated temperatures are also associated with elevated pressures that are causing leachate outbreaks along the slopes. Figure 3(b) shows liquid buildup underneath the geomembrane that felt like walking on a waterbed. Figure 4 shows remnants of leachate outbreaks around various wells and piping along the south slope. Similar leachate outbreaks and distressed infrastructure was observed at the CWRDF near Cleveland.

(a)

(b)

Figure 3. Photographs along south slope of: (a) distressed or leaning infrastructure and (b) liquid build-up below geomembrane.

- Another manifestation of elevated temperatures is the consumption of waste, which results in significant landfill settlements after the consumption. Figure 5(a) shows a profile of the south quarry and the highest point being the southeast corner on the left. The north end of the south quarry used to be at least the same height or elevation as the southeast corner (see dashed red line) which indicates the magnitude of waste consumption and settlement that has occurred during this heating event. This settlement is probably larger because soil has been added at the north end of this profile. Figure 5(b) shows a bulge at the top of the southeast corner because the elevated temperature have not consumed as much of the waste as towards the southwest. This progression of settlement was also observed at the CWRDF

near Cleveland where settlement progressed from east to west in the original portion of the landfill.

(a) (b)

Figure 4. Photographs along south slope of south quarry showing remnants of leachate outbreaks.

(a)

(b)

Figure 5. Photographs of south quarry showing: (a) settlement progression from north (right) to southeast corner (left) and (b) close-up of settlement progression from southwest to southeast corner.

Other examples of these features and other landfill behavior is documented in the other photographs that I took during my reconnaissance of the south quarry.

The main observations of the second day of reconnaissance (July 22, 2015) are summarized below and documented in the other photographs that I took during my reconnaissance a few of which are included below as representative of others:

- Along the northern end of the north quarry, a leachate outbreak and the associated dead vegetation was observed (see Figure 6) along the slope toe. The resulting leachate appeared to be flowing to a ponded area near the northeastern corner of the north quarry. Landfill personnel during their quadrant checks should be alert for these leachate outbreaks.

(a) (b)

Figure 6. Photographs along north slope of north quarry showing: (a) overview of leachate outbreak and (b) close-up of leachate outbreak.

- Figure 7 shows erosion gullies in the soil cover near the northeast corner of the north quarry. Erosion of the soil cover can lead to air/oxygen intrusion especially when gas extraction activities are occurring to control odors and other aspects of elevated temperatures. Other instances of possible air/oxygen intrusion were encountered and discussed below during my field reconnaissance. Introduction of oxygen to the waste mass in the presence of elevated temperatures can lead to a reduction in waste due to consumption and/or combustion. As a result, oxygen intrusion to the waste mass should be minimized if not eliminated as soon as possible to limit oxygen intrusion.

- Figure 8 shows dead vegetation and a leachate outbreak around Gas Extraction Well 3 (GEW-3). Figure 8(a) is an overview that shows the area of dead vegetation, which is probably due to fugitive gas. The temperatures measured using an infrared camera on and around GEW-3 approached 120^0F. Figure 8(b) shows a small leachate outbreak around the GEW. This is important because the well is located in the northeast corner of the north quarry, which is a significant distance from the south quarry.

(a) (b)

Figure 7. Photographs in north quarry showing erosion of soil cover: (a) near northeast corner and (b) on northeast side.

(a) (b)

Figure 8. Photographs of dead vegetation and leachate outbreak around GEW-3 in north quarry: (a) overview and (b) close-up.

- Figure 9 shows erosion gullies in the soil cover on the southwest side of the north quarry near the maintenance building. Erosion of the soil cover can lead to oxygen intrusion especially when gas extraction activities are occurring. Other instances of possible oxygen intrusion were encountered during my field reconnaissance and are discussed below.

(a) (b)

Figure 9. Photographs of erosion of the soil cover near the maintenance building on northwest side of north quarry.

- Figure 10 shows geosynthetics still not sealed to Perimeter Sump 35 (PS-35) near the transfer station. The opening around PS-35 is a source of oxygen intrusion, which could be significant if a vacuum is applied in this area. During my site visit I did not hear or feel a vacuum being applied at PS-35.

- Figure 11(a) shows a deep erosion gully near the transfer station. This erosion gully has a depth of over two feet. More importantly, a significant aroma of landfill gas was present which alerted me to further investigate this area. Landfill personnel during their quadrant checks should be alert for these erosion features and aromas. Upon clearing some of the vegetation that was covering the opening of the gully, a depth of over two feet was visible as shown in Figure 11(b). Figure 11(b) also shows partially buried waste at the bottom of the erosion gully. Given the presence of exposed waste and a significant landfill gas aroma, this area is probably a source of oxygen intrusion to the waste. Introduction of oxygen to

the waste mass in the presence of elevated temperatures can lead to a reduction in waste mass via consumption and/or combustion of the waste. As a result, this and other erosion features should be remediated as soon as possible to limit oxygen intrusion.

Figure 10. Photograph of geosynthetics around PS-35 not sealed to piping near maintenance building on northwest side of north quarry.

(a) (b)

Figure 11. Photographs of significant erosion of the soil cover near transfer building showing: (a) overview of erosion gulley and (b) depth of erosion of over two feet and exposed waste at the bottom of the erosion gulley.

- Finally alongside the transfer station, another erosion area (see Figure 12(a)) was observed but this erosion feature also exhibited a visible leachate outbreak. Figure 12(b) is a close-up of the outbreak with a scale. This area should also be remediated and is close to the erosion gully in Figure 11.

(a) (b)

Figure 12. Photographs along northwest slope of north quarry near transfer station: (a) overview of soil erosion and (b) close-up of leachate outbreak.

If you have any question or I can provide any additional information, please contact me using the contact information shown above.

Sincerely yours,

TD Stark

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