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October 16, 2014

County of Maui
Department of Environmental Management
Solid Waste Division
2200 Main Street, Suite 225
Wailuku, Hawaii 96793

Attention: Mr. Michael Kehano

Subject: Phase I of Post Closure Services for the Closed Kalamaula Landfill Island of Molokai, Hawaii

Dear Mr. Kehano:

Element Environmental, LLC (E2) is pleased to submit this letter report documenting Phase 1 of post closure services for Kalamaula Landfill. E2, along with A-Mehr Inc., have been retained by the County of Maui (hereafter referred to as the County), Department of Environmental Management to facilitate post-closure planning services for the Closed Kalamaula Landfill on the Island of Molokai, Hawaii (Figure 1).

1.0 INTRODUCTION

The purpose of Phase 1 of the post-closure services was to achieve the following:

- **Obtain and review available documents and information, including, but not limited to closure/post-closure plans, construction reports, monitoring plans/data, correspondence, aerial photographs, etc.** Documents were obtained through the County Department of Environmental Management and through the State of Hawaii Department of Health (HDOH). A complete list of documents reviewed is provided in the Bibliography in Attachment A. Scanned documents are included on an attached CD for your records.

- **Interview current and former County of Maui employees and knowledge of the landfill.** Rogelio (Rudy) Cabanting, Working Supervisor responsible for maintenance and upkeep at the Kalamaula Landfill was interviewed on October 3, 2014 prior to the site walk. Mr. Cabanting met our field staff onsite and was able to locate site features such as groundwater monitoring wells, gas wells, provide historical documents and verify site information.

- **Conduct site investigations to locate/map and inspect the status and conditions of gas and groundwater monitoring wells, drainage systems, cover, roads, security, etc. Document existing post-closure uses.** E2's site investigation was conducted on October 13, 2013. Existing site features were documented with a GPS unit and are shown on Figure 2. Photos documenting field observations are shown in Attachment B.

- **Provide a brief list of findings and recommendations based on completion of the above tasks.** Findings and recommendations were based on historical documents

reviewed, site information obtained via site walks and information obtained from the County of Maui. Recommendations are provided in Section 3.

- **Identify options for interim and final post-closure uses and evaluate relative to County objectives.** Uses were identified based on records reviewed and are summarized in Section 3.

- **Identify and quantify, to extent possible, County resources and costs to implement Phases 2 and 3.** County resources are summarized in Section 4 and were based on the recommendations provided through research and assessment of the closed landfill.

2.0 SITE INFORMATION

General Background Information

The Kalamaula Landfill is located approximately two miles west of the town of Kaunakakai on the southern coast of Molokai. The landfill is surrounded on three sides by the Ohiapilo Wetlands. Figure 1 shows the location and the vicinity of the landfill. The site is bound by red mangroves to the south and, pickleweed, mudflats and standing water to the west. A drainage channel runs along the southern and western boundary of the Landfill that empties onto the surrounding reef flat. Hoawa Road bounds the northern side of the landfill. Scrub and woodlands are located along the other side of Hoawa road and along eastern boundary. Department of Hawaiian Home Lands (DHHL) owns the landfill property and the wetlands around the landfill.

According to the landfill's Closure Plan, it was opened in the early 1970s and stopped accepting waste October 8, 1993. The property is owned by DHHL and leased to the County. The lease agreement stated that the landfill was not to exceed 6.9 acres in size. The landfill occupies approximately 19.2 acres (County of Maui, 1992). The volume of the waste at closure was approximately 326,500 cubic yards (County of Maui, 1992). The landfill is unlined and does not have a leachate collection system. The area fill method was used for waste placement.

The County did not maintain formal records of waste types disposed at the landfill; however, County employees who had worked at the landfill said that the landfill received primarily residential and agricultural solid wastes. Site inspections conducted under the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) found wastes that may include paints, paint thinners, lead batteries, empty pesticide containers, empty transformer shells, junked car, and asbestos containing materials (ACM) (Brown and Caldwell, 1993).

Wetlands

The landfill has encroached upon 11 acres of the Ohiapilo wetland. The U.S. Department of Fish and Wildlife Services estimated that 6.55 acres of the landfill encroachment occurred after the Section 404 of the Clean Water Act was enacted. The County had violated Section 404(a) of the federal Clean Water Act (CWA) by placing wastes on a CWA-regulated wetlands without

permits. As a result, the County agreed to an Administrative Order on Consent (AOC) for Wetlands Mitigation Program with the United States Environmental Protection Agency (EPA) in 1994 following closure of the landfill. The AOC specified that the County must do the following:

- Install final cover system;
- Remove all surface accumulation of waste material along 1.39 acres along the eastern site of the landfill and prevent future unauthorized dumping;
- Enhance and create off-site wetlands of sufficient acreage and environmental wildlife values to compensate for the 6.55 acres;
- To preserve, conserve, maintain and protect the mitigation site in its restored state; and
- Ensure that the post-closure landfill does not adversely affect the surrounding wetlands.

Prior to the AOC, an initial study conducted by Brown and Caldwell in 1992 assessed whether contaminants had leached or were leaching from the Kalamaula Landfill and impacting aquatic biological resources in the area. The study concluded that evidence of arsenic contamination was found in the area; however, the landfill did not appear to be the source of contamination.

The County developed a Wetlands Monitoring Program and outlined requirements to comply with the AOC (Brown and Caldwell, 1994). Five years of monitoring were conducted to determine the effects of the landfill on the adjacent wetland. A series of studies by AECOS followed the 1992 Brown and Caldwell study to assess how the elevated arsenic levels were distributed in the south Molokai coastline, whether other commonly eaten reef organisms are similarly high in arsenic, and the source of arsenic. Annual studies of aquatic environments supported the earlier conclusion that the landfill is not a significant source of arsenic to the adjacent aquatic environments. The report stated that the more likely source is agriculture (AECOS, 1995; AECOS, 2000; AECOS, 2001).

Wetlands Monitoring Plan (WMP) Annual Reports dated 1997 through 2001 were prepared for the County in accordance with Appendix C of the AOC. Monitoring wells were sampled according to the approved WMP. The reports concluded that, based on the analytical monitoring results, the landfill had not demonstrated a significant increase in concentration of any constituent and that, based on the five years of data, the Kalamaula Landfill is not adversely affecting downgradient groundwater or wetlands (Brown and Caldwell, 2002).

In February 2012, the EPA sent a letter to County terminating the AOC issued in 1994 which released the County from any further obligation to comply with its terms. The EPA would not provide written approval of the County's certification that they had complied with the AOC's requirements because they had not created a "conservation easement or other binding mechanism" to preserve the adjacent Ohiapilo Wetlands. The EPA recommends the long-term and permanent protection of the wetland area (EPA, 2012).

Groundwater

The groundwater gradient onsite is very flat (0.05% to 0.07%) and tidally influenced. Groundwater flow direction is believed to be in the west or southwest direction. According to the

regional groundwater study, the site is located within the Manawainui Aquifer System of the Central Aquifer Sector (Mink and Lau, 1992). Two distinct aquifers underlie the site. The upper aquifer is basal where fresh water is in contact with seawater, unconfined, located in sedimentary rock (nonvolcanic lithology) and is currently used as an ecologically important water source (Mink and Lau, 1992). The upper aquifer has a low salinity with a chloride content between 250 milligrams per liter (mg/l) and 1,000 mg/l; however, the aquifer is not considered fresh or potable. This aquifer is considered irreplaceable and has a high vulnerability to contamination (Mink and Lau, 1992).

The lower aquifer is basal, unconfined, located in flank formations and has potential use as a drinking water source (Mink and Lau, 1992). The lower aquifer has a low salinity with a chloride content between 250 mg/l and 1,000 mg/l. This aquifer is considered irreplaceable and has a moderate vulnerability to contamination (Mink and Lau, 1992).

Brown and Caldwell also conducted a hydrogeological assessment of the landfill in 1992 to evaluate the extent of affected soil and groundwater from landfill leachate. Nine (9) wells were installed and sampled at the landfill. One of the nine wells installed is a leachate well used for comparison of landfill leachate and groundwater. Groundwater levels were evaluated in 1993 as part of the EIS. Contaminants were detected at low concentration in both soil and groundwater at the vicinity of the landfill. The levels were between one to two orders of magnitude below the EPA acute and chronic Marine Water Quality Criteria (MWQC) (Brown and Caldwell, 1993).

The post-closure plan for the landfill states that groundwater monitoring was to be conducted for a period of five years following landfill closure. The post-closure plan took into consideration the requirements of the AOC (Brown and Caldwell, 1993). Groundwater monitoring was conducted for a period of five years per the Wetland Monitoring Program (WMP) in wells KMW-1 (upgradient), KMW-2 (downgradient), KMW-3 (downgradient/crossgradient), KMW-4 (downgradient/crossgradient). The WMPs stated that there was no indication that the Kalamaula Landfill is adversely affecting downgradient groundwater or the wetlands (Brown and Caldwell, 2002).

Groundwater monitoring wells installed for the hydrogeological assessment except for MW-8 were located during site reconnaissance and are shown in Figure 2, Site Plan. Wells monitored for the wetlands monitoring plan were not encountered during the field investigation except for what we believe to be KMW-2; however the well was not labeled. One leachate well was located in the middle to the landfill. The coordinates, elevation, and conditions of the wells found during the field investigation are shown in Table 1.

Table 1: Monitoring Well Information

Monitoring Well	Easting UTM	Northing UTM	Elevation Feet msl	Well Condition
MW-1	1510447.106	278888.116	76.32	Vault good, no lock, well cap good.
MW-2	1510147.519	278572.6667	88.52	Vault good, no lock, cap decent condition, metal is rusted, rubber is old and cracking
MW-3	1509993.684	278344.4466	82.62	Vault has surficial rust, but adequate, cap decent condition, metal is rusted, rubber is old and cracking.
MW-4	1509711.356	278509.6152	96.37	Vault has surficial rust, but adequate, cap decent condition, metal is rusted, rubber is old and cracking, settlement has occurred around the well.
MW-5	1509552.097	278891.2969	98.72	Vault good, no lock, cap decent condition, metal is rusted, rubber is old and cracking.
MW-6	1509853.868	279341.5499	93.84	Vault damaged, missing lid, rusted, well cap damaged.
MW-7	1509884.23	279327.9036	94.50	Vault good, well cap good; however loose fit and will not tighten.
Leachate Well	1509894.9090	278817.2651'	100.37	Vault good, no lock, cap decent condition, metal is rusted, rubber is old and cracking.
KMW-2 (not confirmed)	1510299.250	278274.1576	82.07	Well vault locked and in good condition

Subsurface Landfill Fires

Subsurface fires reportedly occurred in 1985 for two months. As a result, a landfill subsurface fire investigation was conducted in 1992 to identify potential subsurface fires so they could be addressed prior to closure (Brown and Caldwell, 1992a). There were no indications of subsurface fire based on field observations and temperature measurements in 1992.

There were no indications of subsurface landfill fires during E2's site reconnaissance in October 2013. The site was visually inspected for signs of subsurface landfill fire such as smoke, odor, fissures, soil staining and/or stressed vegetation. The working supervisor said that he had not observed any indications of a landfill fire during his site inspections.

Landfill Gas

Brown and Caldwell conducted a perimeter landfill gas survey in 1992. Ten (10) perimeter boreholes were competed around the perimeter of the landfill. The boreholes were tested for methane and oxygen. Methane levels measured were below the allowable limits in the perimeter probes and the onsite structures (Brown and Caldwell, 1992b).

The study stated that the potential for landfill gas migration was low due to the shallow groundwater aquifer in the vicinity of the landfill (between one and three feet below surface grade). If landfill gas migration were to occur, it would be along the northern boundary adjacent to Hoawa Road (Brown and Caldwell, 1992b).

Post-closure landfill gas monitoring results were not encountered during site investigation activities. According to the Post-Closure Maintenance and Monitoring Plan, three (3) landfill gas probes installed were supposed to be monitored over the first year. If the results were below federal allowable limits, then the frequency would be reduced to semi-annual monitoring for a period of five years. Post closure landfill gas data was not encountered in either the HDOH files or the County's files; however two landfill gas probes were found along the northern edge of the site. Seven landfill gas vents were found around the landfill. Probes and vents are shown in Figure 2.

An analysis using a USEPA-approved land gas generation emissions model is discussed in the Recommendations section below. The results demonstrate that existing gas emissions are well below the threshold at which control would be feasible. It is also reasonable to conclude there is no danger of landfill gas migration. According to the model, the landfill does not present a threat to human health or the environment.

During site reconnaissance, gas probes and vents were identified in the field. Landfill gas features encountered during the survey are identified in Figure 2. The coordinates, elevation, and conditions of the vents and gas probes found during the field investigation are shown in Table 2.

Table 2: Landfill Gas Probe and Vent Information

Gas Probe/Vent ID	Easting UTM	Northing UTM	Elevation Feet msl	Gas Probe/Vent Condition
Vent-1	1510278.3610	278760.2529	89.26	Pipe is cracked
Vent-2	1509823.0580	278444.5252	97.35	Good condition
Vent-3	1509497.7350	278795.3256	94.75	Good condition
Vent-4	1509805.4420	279193.0087	110.07	Good condition
Vent-5	1509715.6240	279047.7940	110.12	Good condition
Vent-6	1509984.5670	278829.8599	109.33	Good condition
Vent-7	1510177.7090	279024.9714	113.43	Good condition
Gas Probe-2	1509989.9940	279319.3248	87.10	Good condition
Gas Probe-3	1510210.1470	279132.1973'	85.10	Good condition

Final Cover and Drainage

The closure and post-closure and maintenance plan, and the bid plans and specs describe the final cover system as a six inch foundation layer under an 18-inch clay, low permeable soil layer and six inch top soil layer capable of sustaining vegetation. The actual constructed cap/final cover system consists of two feet of final cover placed over a 30 mil PVC liner. The cap was designed by Parametrix, Inc. and constructed by Kiewit Construction. The as-built drawings were found in HDOH files; however a construction quality assurance report for the liner construction was not found.

The condition of the cover as of October 2013 is shown in Attachment B. At that time we observed areas that were bare of vegetation, significant erosion on side slopes, and sinkholes resulting in exposure of the underlying PVC geomembrane in some areas. Surface water has also been observed ponded on the top deck which has led to undermining the final cover. The vegetative soil layer showed cracks and water marks, and the vegetation was sparse in areas where water had collected in the past. The PVC liner did not appear to be damaged in areas where erosion had occurred.

The major cause of erosion is likely the result of the ponding of surface water on the top deck. Normal and expected settlement has caused ponding and is due to the landfill decomposition and consolidation of the refuse. The ponding promotes infiltration of surface water down to the PVC-soil interface and allows water to drain along the interface at the sideslopes. The cover system is not designed to accommodate this kind of drainage, and the result is excessive erosion and loss of the vegetative layer in areas where it occurs. There is also evidence of burrowing rodents creating paths for surface water to enter directly into the soil/liner interface at the top of slopes, resulting in subsurface erosion channels that emerge at the toe of sideslopes.

As of October 2013, erosion damage to the northwest slope had been repaired. There were still many sinkholes, cracks and erosion problems documented. Photos are shown in Attachment B. Many of the problematic areas were repaired in April 2014; however the storm water drainage/ponding problem has not been resolved. Erosion will continue to be a problem until the site's final cover and storm water drainage systems are evaluated and improved. It is notable that conditions similar to those observed in October 2013 have occurred repeatedly since closure of the landfill. Repairs have been conducted periodically for the last five to 10 years for similar conditions, including one instance in which the cover soil on a significant area of sideslope completely slid off the geomembrane.

Post-Closure Use

Post-closure use is not discussed in the Closure Plan or Post-Closure Maintenance and Monitoring Plan. The current use is open space. The site is secured by a locked gate and inspected quarterly.

3.0 RECOMMENDATIONS

The main goal of this study is to either demonstrate that the County has fulfilled their post-closure duties or to determine where post-closure duties need to be fulfilled to date. The elements of demonstration are as follows:

- Post-closure use: Current uses are compatible with the closure plan and uses meet all legal requirements.
- Final cover: Intact to an acceptable depth, has low permeability, adequate drainage, and vegetation.
- Landfill Gas: No subsurface migration and minimal surface emissions;
- Leachate: Little generation and/or no evidence of groundwater impacts;
- Groundwater: No evidence of contamination;

POST-CLOSURE PLAN/POST-CLOSURE USE

Post-closure use is not discussed in the Closure Plan or Post-Closure Maintenance and Monitoring Plan.

The EPA would not provide written approval of the County's certification that they had complied with the AOC's requirements because they had not created a "conservation easement or other binding mechanism" to preserve the adjacent Ohiapilo Wetlands. The EPA recommends the long-term and permeant protection of the wetland area (EPA, 2012).

Recommendations:

We recommend the following:

- Incorporate into the remedial closure plan a post-closure use plan that discusses appropriate uses for the site and site security measures.
- We recommend that the County pursue a long-term binding mechanism for preserving the wetlands to fulfill their compliance with the AOC. Though not required, it would show due diligence and the County's initiative to fulfill requirements. We recommend that the County work with DHHL toward a conservation easement for the wetland.

FINAL COVER

Storm water ponds on the surface of the landfill and infiltrates the vegetative cover. Storm water drains down to the interface of the liner and vegetative cover and causes erosion.

Recommendations:

We recommend the following:

- Acquire the services of a licensed surveyor to perform a topographic survey of the site. If the survey is done by aerial photography it would be advisable to cut any tall grass areas on the top deck to improve accuracy.

- Design a remedial closure plan that includes removal of geomembrane from sideslopes, adding soil and regrading the top deck to provide a minimum slope of 3%, an effective surface water management system, and vegetation. The top layer of soil should be suitable to sustain vegetation on the surface of the landfill and be underlain by a low-permeability soil (i.e. 10^{-6} centimeter/second).

- Obtain HDOH approval of the remedial closure plan.

- In the interim period before a comprehensive plan is implemented, continue to repair eroded areas as needed and take interim measures to manage surface water.

LANDFILL GAS

In order to provide an estimate of potential landfill gas emissions from the closed Kalamaula Landfill, A-Mehr, Inc. developed a conceptual model of landfill gas generation using the USEPA LandGem (Landfill Gas Emissions Model) computer program. Detailed results of the LandGem are provided in Attachment C. The model computes landfill gas emissions using a time record of site-specific waste disposal volumes combined with a series of assumed waste composition, moisture and climate characteristics developed for typical landfills.

LandGem output demonstrates a typical landfill gas curve with a methane generation rate that increases annually through the end of the landfill operational life, then decreases at an exponential rate. The projected average emission rate of landfill gas for 2014 is 21.4 standard cubic feet per minute (scfm) from the 19.2-acre landfill. By comparison, the landfill gas collection and control system at Central Maui Landfill typically handles 600 to 800 scfm.

If emitted uniformly from the surface of the landfill, the methane volume of 10.7 scfm projected by the model for 2014 would be equivalent to approximately 10.7 x 10^{-6} scfm per square foot of landfill surface, or to a concentration of approximately 11 ppmv of methane mixed in a one cubic foot volume of air above the surface. USEPA rules for gas collection and control systems in large landfills (40 CFR 60.755) require landfill surface emissions to be less than 500 ppmv methane.

Recommendations:

Based on the LandGem results, there are no further recommendations pertaining to landfill gas:

- Potential landfill gas emissions at the closed Kalamaula Landfill are well below the threshold at which control would be feasible.

- There is no danger of landfill gas migration.

- The landfill does not present a threat to human health or the environment.

LEACHATE

A well is located in the middle of the landfill to measure concentration of constituents in leachate; however, there is currently no leachate collection system in place at the landfill. There is no way to measure or monitor leachate collection or generation.

GROUNDWATER

Groundwater monitoring has been conducted for the site per the closure/post-closure plan and the AOC. Monitoring results did not indicate that the Kalamaula Landfill is adversely affecting downgradient groundwater or wetlands (Brown and Caldwell, 2002).

Recommendations:

We do not recommend further groundwater monitoring at the site due to the following conditions:

- Groundwater monitoring did not indicate impacts to downgradient groundwater or wetlands.
- Groundwater monitoring requirements have been met per the Closure Plan.
- Post-closure groundwater monitoring is not required because the landfill was closed prior to the Subtitle D operative date of October 9, 1993.

We recommend that the existing wells be evaluated, repaired and secured or closed in place. We recommend that the County obtain approval from HDOH prior to decommissioning the groundwater monitoring wells.

4.0 CONCEPTUAL CLOSURE COMPLIANCE COST ESTIMATES

The following cost analysis was established as a starting point to estimate future post-closure expenditures for the County. The actual cost of the recommendations will depend on the final remedial design plans and acceptance by the HDOH.

Task	Approximate Quantity	Unit	Unit Price	Amount
Remedial Design and Revised Closure/Post-Closure Plan				
Topographic Survey	1	allow	$15,000	$15,000
HDOH Approved Post-Closure Plan with Design	1	allow	$50,000	$50,000
Final Cover and Drainage				
Strip soil from sideslopes, remove geomembrane and place compacted soil to approved design	1	allow	$350,000	$350,000
Import and place soil to provide 3% grade on top deck	30,000	cubic yards	$50	$1,500,000
Improve Drainage Facilities	1	allow	$100,000	$100,000
Hydroseed and Maintain Nine Months	19	acres	$13,000	$247,000
Groundwater Monitoring Wells				
Repair or decommission monitoring wells	1	allow	$40,000	$40,000
Contingency		base cost	20%	$460,000
			Total Conceptual Cost	**$2,762,400**

Note: -Earthwork costs cannot be accurately calculated until current topography is available.
-Estimates are based on conservative assumptions.

We appreciate the opportunity to prepare this letter report for you. Please call me on my mobile phone at (231) 709-5033 or at the office at (808) 488-1200, if you have any questions.

Sincerely,

Lindsay Mason, P.E.
Environmental Engineer
Element Environmental, LLC

Figures: Figure 1-Site Location Map
Figure 2-Site Map

Attachments:
Attachment A: Bibliography and CD Containing Documents Reviewed
Attachment B: Site Photos
Attachment C: A-MEHR, Inc. Memorandum, Conceptual Landfill Gas Model and Emission Estimates

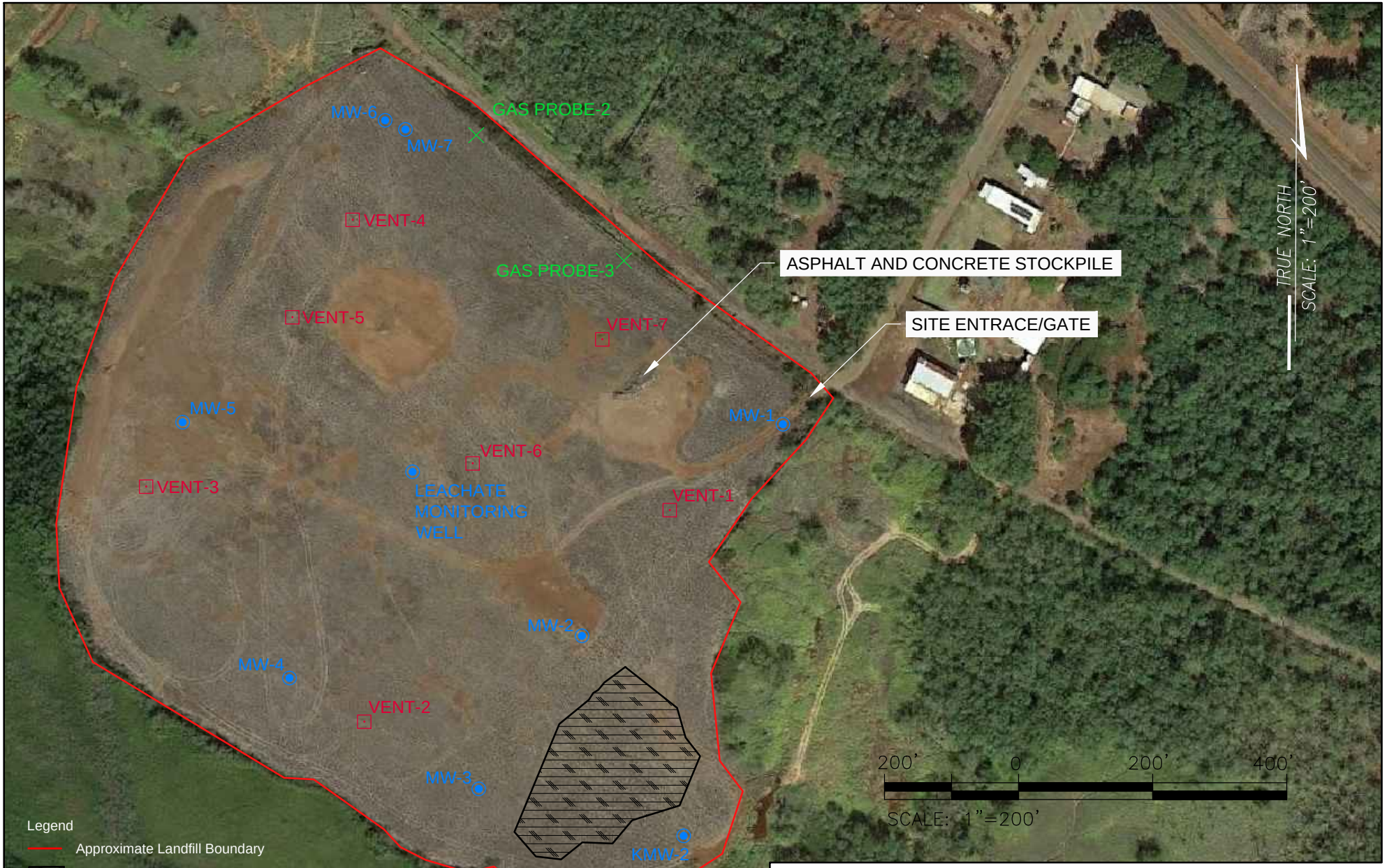
Figures
Figure 1: Site Vicinity Map
Figure 2: Site Map

Legend

- Approximate Project Location
- Kalamaula Landfill

References:
DeLorme, 2005; Google, 2014.

	DATE: OCT 2014	PROJECT TITLE: PHASE 1 OF POST CLOSURE SERVICES CLOSED KALAMAULA LANDFILL ISLAND OF MOLOKAI, HAWAII
	FIGURE TITLE: SITE VICINITY MAP	FIGURE NO.: 1



	DATE: OCT 2014	PROJECT TITLE: PHASE 1 OF POST CLOSURE SERVICES CLOSED KALAMAULA LANDFILL ISLAND OF MOLOKAI, HAWAII
	FIGURE TITLE: SITE MAP	FIGURE NO.: 2

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Attachment A: Bibliography and CD Containing Documents Reviewed

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ATTACHMENT A

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Attachment B: Site Photos

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ATTACHMENT B

Photo 1: Large Sinkhole

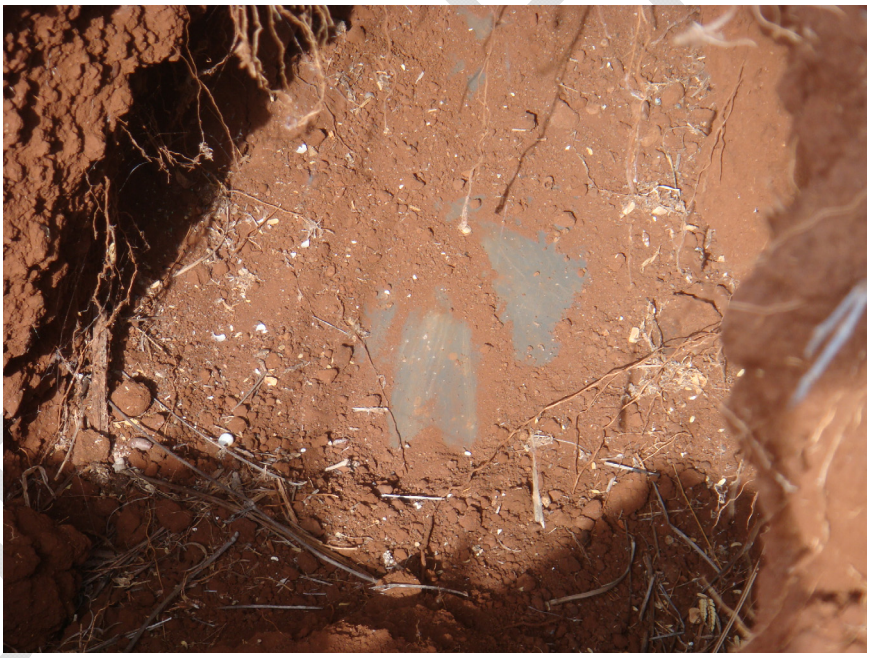

Photo 2: Exposed Liner in Sinkhole

ATTACHMENT B

Photo 3: Asphalt and Concrete Stockpile

Photo 4: Groundwater Monitoring Well

ATTACHMENT B

Photo 5: Damaged Landfill Gas Vent Pipe

Photo 6: Storm Water Drainage Structure

ATTACHMENT B

Photo 7: Storm Water Drainage Structure

Photo 8: Landfill Gas Probe

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Attachment C: A-MEHR, Inc. Memorandum, Conceptual Landfill Gas Model and Emission Estimates

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A-MEHR, INC.
Memorandum

July 28, 2014

TO: File, Kalamaula Closed Landfill

FROM: Glen Odell

RE: Conceptual Landfill Gas Model and Emission Estimates

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1. In order to provide an estimate of potential landfill gas emissions from the closed Kalamaula Landfill we developed a conceptual model of landfill gas generation using the USEPA LandGem (Landfill Gas Emissions Model) computer program. The model computes LFG emissions using a time record of site-specific waste disposal volumes combined with a series of assumed waste composition, moisture and climate characteristics developed for typical landfills.

2. In the absence of historical records of annual waste disposal volumes, we developed a synthetic disposal record based on:

   - Total volume of waste disposed - 326,500 cubic yards based information contained in the site's Closure Planb (Brown & Caldwell, 1993)
   - Average in-place density of waste - 1,000 lb/cubic yard, a conservatively high estimate for low to medium tonnage sites operating in the 1970's and 1980's. This results in an estimated total waste tonnage in place of approximately163,250 tons.
   - Active life from 1970 to 1993 (24 years)
   - Uniform annual tonnage intake of approximately 6,800 tons/year

3. Conventional LandGem default model parameters were used as follows:

   - Potential methane generation capacity (L_o) - 100 m^3/Mg
   - Methane generation rate (k) - 0.05 $year^{-1}$
   - Methane content - 50% by volume

4. The resulting model output demonstrates a typical LFG curve with a methane generation rate that increases annually through the end of the landfill operational life, and then decreases at an exponential rate. Results of the model analysis are summarized in Table 1 below. The projected average emission rate of LFG for 2014 is approximately 21 standard cubic feet per minute (scfm) from the 19.2-acre landfill. By comparison, the LFG collection and control system at Central Maui Landfill typically handles 600 to 800 scfm.

5. If emitted uniformly from the surface of the landfill, the projected methane volume of 10.7 scfm projected by the model for 2014 would be equivalent to approximately 13 x 10^{-6} scfm per square foot of landfill surface, or to a concentration of 13 ppmv of methane mixed in a one cubic foot volume of air above the surface. USEPA rules for gas collection and control systems in large landfills (40 CFR 60.755) require landfill surface emissions to be less than 500 ppmv methane.

TABLE 1
KALAMAULA LANDFILL
CONCEPTUAL LANDFILL GAS GENERATION
BY USEPA LANDGEM COMPUTER MODEL

YEAR	ANNUAL LFG (METRIC TONS / YEAR)	AVERAGE LFG (SCFM)	AVERAGE METHANE (SCFM)
1994	1,082	58	29
2000	725	43	22
2010	486	26	13
2014	398	21	11
2020	295	16	8
2030	179	10	5
2040	108	6	3
2050	66	4	2