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October 28, 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 Makani Landfill Makawao, Maui, Hawaii

Dear Mr. Kehano:

Element Environmental, LLC (E2) is pleased to submit this letter report documenting Phase 1 of post-closure services for Makani Landfill. E2, along with A-Mehr Inc., has 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 Makani Landfill on the Island of Maui, 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.** Elaine Baker and Tia Stupplebeen were interviewed on August 15, 2013, September 12, 2013 and again on January 14, 2014. They were able to locate site features such as landfill gas system features, perimeter gas monitoring wells and drainage structures, provide historical documents and verify site information.

- **Conduct site investigations to locate/map and inspect the status and conditions of gas wells, drainage systems, cover, roads, security, etc. Document existing post-closure uses.** Three site investigations were conducted on August 15, 2013, September 12, 2013 and again on January 14, 2014. Existing site features were documented with a GPS unit and are shown on Figure 2.

- **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of findings and recommendations based on completion of the above tasks.** Findings and recommendations were based on historical documents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 reconnaissance 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 Closed Makani Landfill is located on near Makawao on the Island of Maui, Hawaii (Figure°1). The property was transferred to the County from the Maui Land and Pineapple Company in July of 1992 (State of Hawaii Bureau of Conveyances, 1992). The landfill occupies approximately 14 acres and was in operation from 1966 to May 1, 1992 (County of Maui, 1992; Parametrix, Inc. 1992). Kailua Gulch is adjacent to the east and north of the landfill. The landfill is bound on all other sides by agricultural land.

Makani Landfill is situated within small steep-walled ravine that, prior to landfilling, was a tributary to the Kailua Gulch. The intermittent stream that flowed through where the current landfill is located was diverted to a manmade notch that flows to adjacent gulch. The landfill does not obstruct drainage through the Kailua Gulch (Parametrix Inc., 1992).

The landfill historically received an average 64 tons per day through 1988 and dropped down to 38 tons per day in 1991 just prior to closure (Parametrix Inc., 1992). Figure 2 shows the site map of the landfill. The site map is based on a survey conducted after closure in 1993 by Akamaki Land Surveying (Akamai Land Surveying, 1993). The approximate density of compacted refuse is 800 pounds per cubic yard (Parametrix Inc., 1992). The waste composition consists primarily of municipal solid waste with some demolition debris. The oldest section of the landfill contains some slaughterhouse waste. Hazardous and industrial waste disposal has always been prohibited (Parametrix Inc., 1992). Table 1 shows the results of a waste composition study conducted over four (4) days in 1988.

E2 used a Trimble® GPS unit to conduct a topographic survey during the January 2014 site visit. The topographic points E2 measured were compared to the historical 1954 United States Geological Survey (USGS) topographic map of the site area. According to the topographic survey, the current total volume of the landfill was calculated to be approximately 654,900 cubic yards. The accuracy of the calculated volume depends on the accuracy of the 1954 USGS topographic map used to evaluate the native land surface; however the calculated volume seems reasonable given the recorded waste volumes, settling and decomposition, and the

years in operation. The surveyed volume determined by E2 was used to evaluate landfill gas production and emissions.

Groundwater

According to Mink and Lau's hydrological study of the Hawaiian Islands, the site is located within the Makawao Aquifer System of the Central Aquifer Sector (Mink and Lau 1990). The upper aquifer is high level where fresh water is not in contact with sea water, unconfined, located in perched (aquifer on an impermeable layer) and is currently used as a drinking water source (Mink and Lau, 1990). The aquifer is located approximately 1,100 feet below the closed landfill. The upper aquifer has a salinity consistent with fresh water (chloride content of less than 250 milligrams per liter (mg/l)). This aquifer is considered replaceable and has a high vulnerability to contamination (Mink and Lau, 1990).

The lower aquifer is basal, unconfined, located in flank formations and has potential use as a drinking water source (Mink and Lau, 1990). The lower aquifer has salinity concentration consistent with fresh water (chloride content of less than 250 mg/l). This aquifer is considered irreplaceable and has a moderate vulnerability to contamination (Mink and Lau, 1990).

There is currently no groundwater monitoring well network at Makani Landfill. The results of the hydrologic assessment conducted for the Makani Landfill concluded the following information on the underlying groundwater and hydrogeology:

- The site is underlain with volcanic rocks of the Kula and Honomano Series;
- Soils surrounding the site are generally low permeability silty clays and retard infiltration of precipitation;
- The nearest groundwater beneath the site is basal aquifer and at a depth of more than 1,100 feet below the bottom of the landfill;
- Downgradient groundwater is primarily used for sugar can irrigation;
- There are no drinking water wells within three miles downgradient of the landfill;
- Downgradient water quality is poor due to impacts from irrigation practices;
- Communities surrounding the landfill do not receive their drinking water from the basal groundwater below the site.

No groundwater monitoring system was recommended for the following reasons:

- The great depth to groundwater; and
- No indication of perched groundwater aquifers were identified beneath the site.

Landfill Gas

The landfill gas venting system consists of a passive gas venting system, a flare facility, and perimeter monitoring probes. The gas venting system consists of in-refuse horizontal trenches that connect to above-ground PVC manifolds. The landfill gas is collected in the trenches and is

routed to the flare facility via the gas manifold. Condensate knock-outs are located at low points along the manifold (Parametrix, Inc., 1993). During the site survey, the landfill gas system appeared to have been appropriately shut down. All valves and the flare system were in closed position.

The trenches are connected to the above-ground manifolds with trench completions. The trench completions include a throttling valve and a monitoring port with a ¼-inch labcock valve (Parametrix, Inc., 1993). The landfill gas was measured at the monitoring ports using the GEM 2000 Plus landfill gas meter. Table 2 shows the results of landfill gas monitoring at the trench completion ports and also documents the condition of the trench completions encountered during the field survey.

Landfill gas was monitored in trench connection ports identified during the field survey as ES-01 through ES-17. Methane levels greater 5% by volume and 100% of the lower explosive limit (LEL) were measured in the ports throughout the landfill. Locations of the ports monitored and methane concentrations are shown in Figure 3. All valves in the gas system were in the off position, therefore landfill gas measurements collected in the field were representative of steady state landfill gas concentrations and not landfill gas flow concentrations.

Originally six (6) perimeter gas monitoring probes (GP-1 through GP-6) were installed at closure. Each well has three nested depths (shallow, middle, deep). Historical monitoring results of perimeter monitoring probes GP-1 through GP-6 do not indicate methane migration. Gas monitoring well locations are shown in Figure 2.

During the January 14, 2014 field survey, two perimeter gas wells (GP-5 and GP-6) were encountered and surveyed during site reconnaissance. E2, with the help of the County, searched for GP-1 through GP-4, but were unable to locate the wells. The perimeter gas probes were monitored using the GEM 2000 Plus landfill gas meter. Methane (CH_4) was detected in the shallow probe at GP-6 at 0.1% volume (2% of the LEL). CH_4 was not detected in GP-5 or the middle and deep probes at GP-6. Table 2 shows the monitoring results and the conditions of the probes. Figure 3 shows the monitoring results on the site map.

In order to provide an estimate of potential landfill gas emissions from the landfill, A-Mehr, developed a conceptual model of landfill gas generation using the USEPA LandGem (Landfill Gas Emissions Model) computer program. 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.

The resulting model output demonstrates 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 Attachment B. The projected average emission rate of landfill gas for 2014 is approximately 27 standard cubic feet per minute (scfm) from the 14-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 in the absence of a collection system, the projected methane volume of 13 scfm projected by the model for 2014 would be equivalent to approximately 21×10^{-6} scfm per square foot of the 14-acre landfill surface, or to a concentration

of 21 parts per million by volume (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. No such rules apply to small landfills or landfills established prior to 1993.

Landfill Fires

The landfill has had a history of subsurface landfill fires. During closure, a study was conducted that indicated that fires were present in the landfill along the east side of the landfill parallel to the Kailua Gulch and on the north side. A surface fire occurred in September 1995. Suspected subsurface landfill fires were also noted in September of 1998.

According to the County, the subsurface fire problems ceased when the highways department began stockpiling soil, sand and rock on the top of the landfill. The County believes the stored material may have helped to smother the fire.

During the site investigation, the GEM 2000 Plus landfill gas meter was used to monitor the perimeter gas probes (GP-5 and GP-6, shallow, middle and deep probes) and landfill gas system ports identified as ES-01 through 17. Gas measurements did not indicate that subsurface fire conditions were present because carbon monoxide (CO), a primary indicator of subsurface landfill fires, was not detected in any of the gas probes or the landfill gas system ports. Furthermore, there were no indications of active subsurface fire issues (i.e. sinkholes, fissures, smoke, stressed vegetation) at the landfill. Landfill fires were controlled during closure using water, cover material and installation of the flexible membrane liner (FML) (County of Maui, 1998). Table 2 shows the results of landfill gas monitoring.

Oxygen (O_2) was high in almost all probes indicating that sufficient oxygen is available for fires to ignite if high temperatures and fuel are available. The only areas where O_2 was low was at locations where CH_4 was elevated (ES-01, ES-04, ES-06 through 10, and ES-12 through ES-17). Explosive or ignitable conditions are present when the LEL is above five (5) percent by volume and (O_2) is above four (4) percent by volume. These conditions were not observed at any of the monitoring ports.

Landfill Final Cover and Drainage System

The final cover system at the landfill consists of the following components from the refuse to the surface of the landfill; FML on portions of the landfill, cover soil, top soil, and vegetative cover. The FML is made of 20 mil polyvinyl chloride (PVC) and was only placed in areas were landfill fires had been identified for the purpose of limiting oxygen infiltration. Eighteen (18) inches of cover material underlie 12 inches of topsoil. The landfill surface is vegetated with grasses specifically selected to function with the cover soils and the local climate.

The surface water drainage system at the landfill consists of landfill collector ditches, landfill perimeter ditches, culverts, perimeter channel, and a high velocity chute. The drainage system components were designed to accommodate a 50-year, 24-hour storm (Parametrix, 1993).

During the field investigation, the landfill cover and drainage system appeared to be well maintained and in good condition. The concrete drainage swale located on the east side of the landfill was relatively clear of sediments and soil during the site visit.

The final cover and drainage ways are regularly maintained on approximately a quarterly or as-needed basis. Just prior to E2's September 2014 site-walk the vegetation had been cleared and exposed the gas collection system and the area near the drainage swale discharge point to the adjacent gulch. In addition, the entire concrete drainage swale that runs along the eastern edge of the landfill had been cleared of vegetation along with the concrete vault and the steep concrete shoot into which all collected storm water runoff flows through to ultimately discharge to the deep gulch located to the west and northwest of the landfill.

Post-Closure Use

Post-closure use was not addressed in the Post-Closure Plan. The site is currently secured by two locked gates along the landfill's access road and a chain-link fence. During the field investigation the following was stored on site:

- Stockpiles of soil, sand, boulders for County DOT road construction projects;
- Dilapidated dump trucks;
- Piles of metal and other debris;
- Large metal vats;
- and tires.

Photos documenting stored materials are provided in Attachment C.

The property deed states that the County is to maintain a "steel pipe field gate" which block vehicular access to the property from the adjacent Ahualani Place. The gate must continue to be maintained and secured during post closure use of the landfill.

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:

- Landfill Gas: No subsurface migration and minimal surface emissions;
- Leachate: Little generation and/or no evidence of groundwater impacts;
- Groundwater: No evidence of contamination;

- Final cover: Intact to an acceptable depth, the permeability is $1X10E^{-6}$, adequate drainage, and vegetation.
- Post-closure use: Current uses are compatible with the closure plan and uses meet all legal requirements.

The recommendations provided in this section will require consultation with HDOH. The recommended elements of demonstration may require modification after consultation.

LANDFILL GAS AND POTENTIAL SUBUSURFACE LANDFILL FIRES

Existing on-site conditions are as follows:

The landfill gas system is intact and has been properly shut down for a number of years. Since the closure of the gas system, gas in the collection trenches has been escaping through the cover soil with no apparent environmental impact. Landfill gas measurements collected in the perimeter gas monitoring probes in January 2014 showed that no offsite migration is occurring. The cover vegetation shows no signs of distress due to gas venting from the cover.

The USEPA LandGem computer program output indicated that gas emissions form the landfill would be equivalent to a concentration of 21 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. No such rules apply to small landfills or landfills established prior to 1993.

Historical surface and subsurface landfill fires have been dealt with and do not appear to be an issue at Makani Landfill. Gas monitoring and observations during field investigations did not indicate the presents of surface or subsurface landfill fires.

Recommendations:

We recommend the following task be completed to prevent future subsurface landfill fires:

- The landfill gas system should be decommissioned because methane gas is no longer being produced in quantities that warrant a landfill gas system. If the system becomes dilapidated, it could be a conduit for oxygen which could fuel future subsurface fires. The landfill gas system should be decommissioned by capping off the risers below ground level at each connection to the manifold and removing the flare and above-ground piping.

LEACHATE

There is currently no leachate collection system in place at the landfill, therefore there is no way to measure or monitor leachate collection or generation.

GROUNDWATER

Existing on-site conditions are as follows:

Based on the Closure Plan, no groundwater monitoring wells were installed at the site. This was justified based on great depth to groundwater, complex geology and lack of any perched groundwater below the landfill.

Recommendations:

We do not recommend groundwater monitoring or further evaluation of groundwater under the site due to the following conditions:

- It is unlikely that the landfill would contaminate groundwater due to the high elevation of the landfill and the great depth to groundwater.
- Post-closure groundwater monitoring is not required because the landfill was closed prior to the Subtitle D operative date of October 9, 1993.

FINAL COVER

Existing on-site conditions are as follows:

Based on the recent site surveys, the site is heavily vegetated with lush grass, except in a few areas. The closed landfill is moderately used by the County's Solid Waste and Transportation departments for storage of old inoperable trash trucks, construction debris and road construction sand and gravel stockpiles. A reasonably well-maintained drainage system including concrete swales is present. All areas of the site appear to drain to the perimeter system.

Recommendations:

We do not have any recommendations pertaining to the final cover or landfill drainage system because they are both in good working condition.

POST-CLOSURE USE

Existing on-site conditions are as follows:

Post-closure uses weren't specified in the landfill's Post Closure Plan. The current post closure use of the site is open space with moderate use as storage of construction materials and dilapidated trash trucks.

Recommendations:

We recommend the following tasks be completed to resolve deficiencies in post-closure use:

- Prepare an HDOH-approved Post-Closure Plan that addresses post closure use as well as maintenance and monitoring requirements.
- Conduct a topographic survey of the property to meet requirements of the Post-Closure Plan.
- Create and implement a policy decision regarding use of site for storage of construction material and equipment by County agencies.
- Remove scrap trash trucks and other debris/solid waste.
- If decision is to use site for storage, initiate concurrent activities (1) permit the proposed use through HDOH; and (2) develop agreements with County agencies outlining acceptable operating guidelines for the site.
- Continue to maintain the gate which blocks vehicular access to the property from the adjacent Ahualani Place.

4.0 CONCEPTUAL COST ANALYSIS

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
Landfill Fire Mitigation				
Decomission/Remove Gas Collection System	1	allow	$90,000	$90,000
Post-Closure Use				
Remove metal scrap, abandoned vehicles and other waste materials	1	allow	$10,000	$10,000
Contingency		base cost	20%	$33,000
			Subtotal	**$198,000**

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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 B Mason

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

Attachments:

Figures: **Figure 1-Site Location Map**
Figure 2-Site Map
Figure 3-Measured Methane Concentrations

Tables: **Table 1-Results of 1988 Waste Composition Survey**
Table 2-Makani Landfill Gas Data

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

Figures

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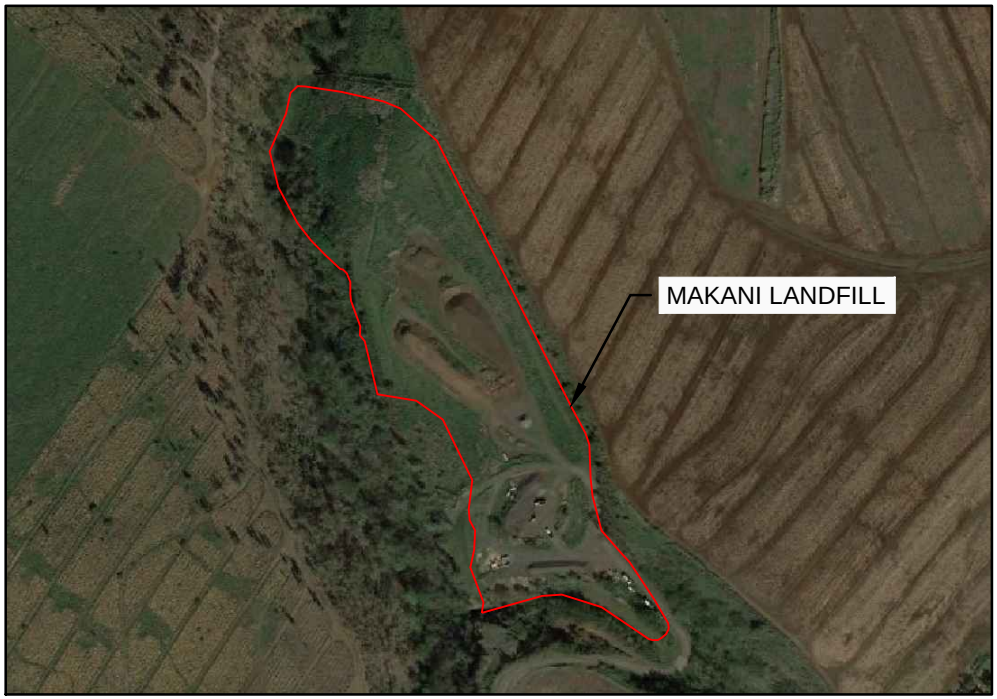
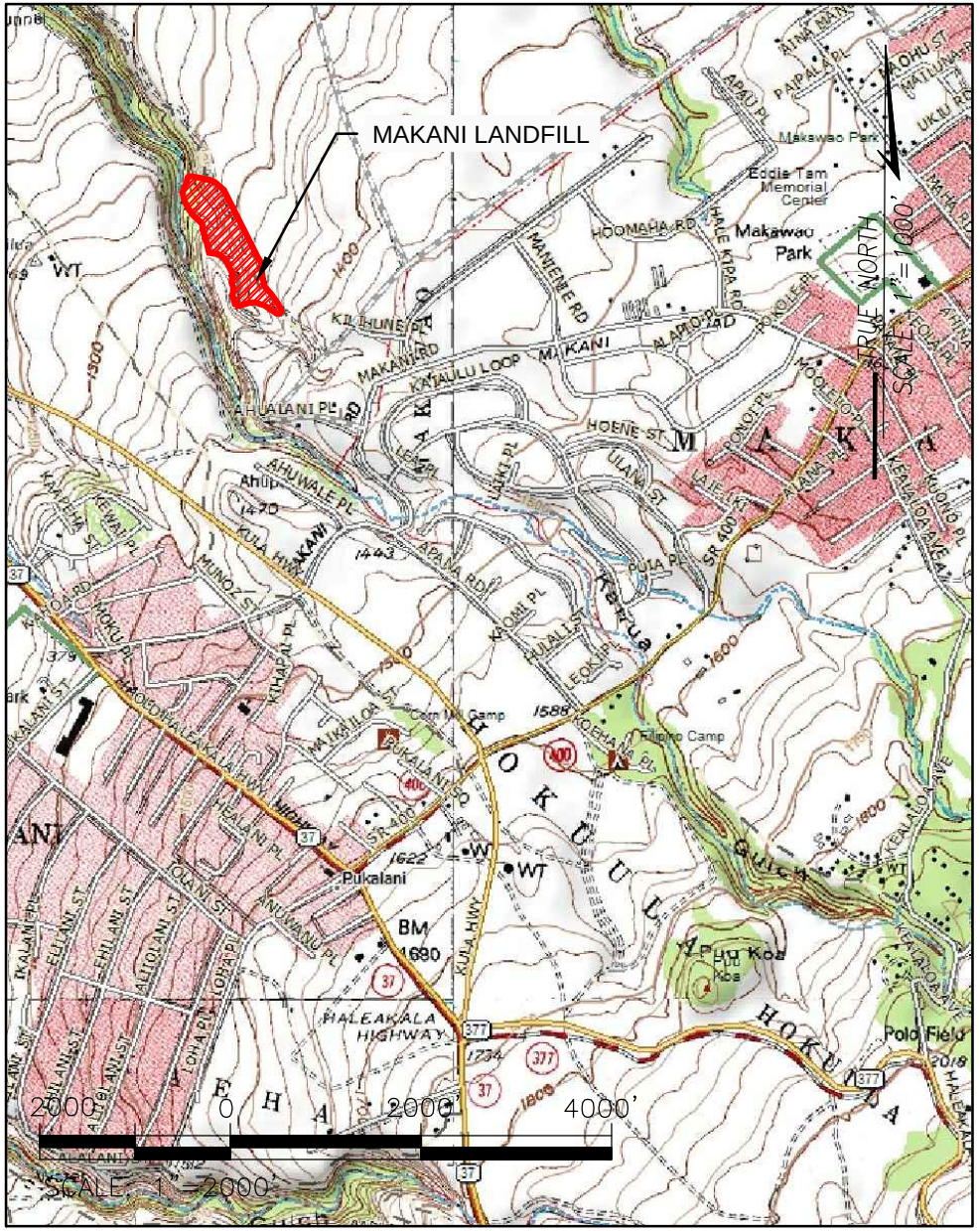




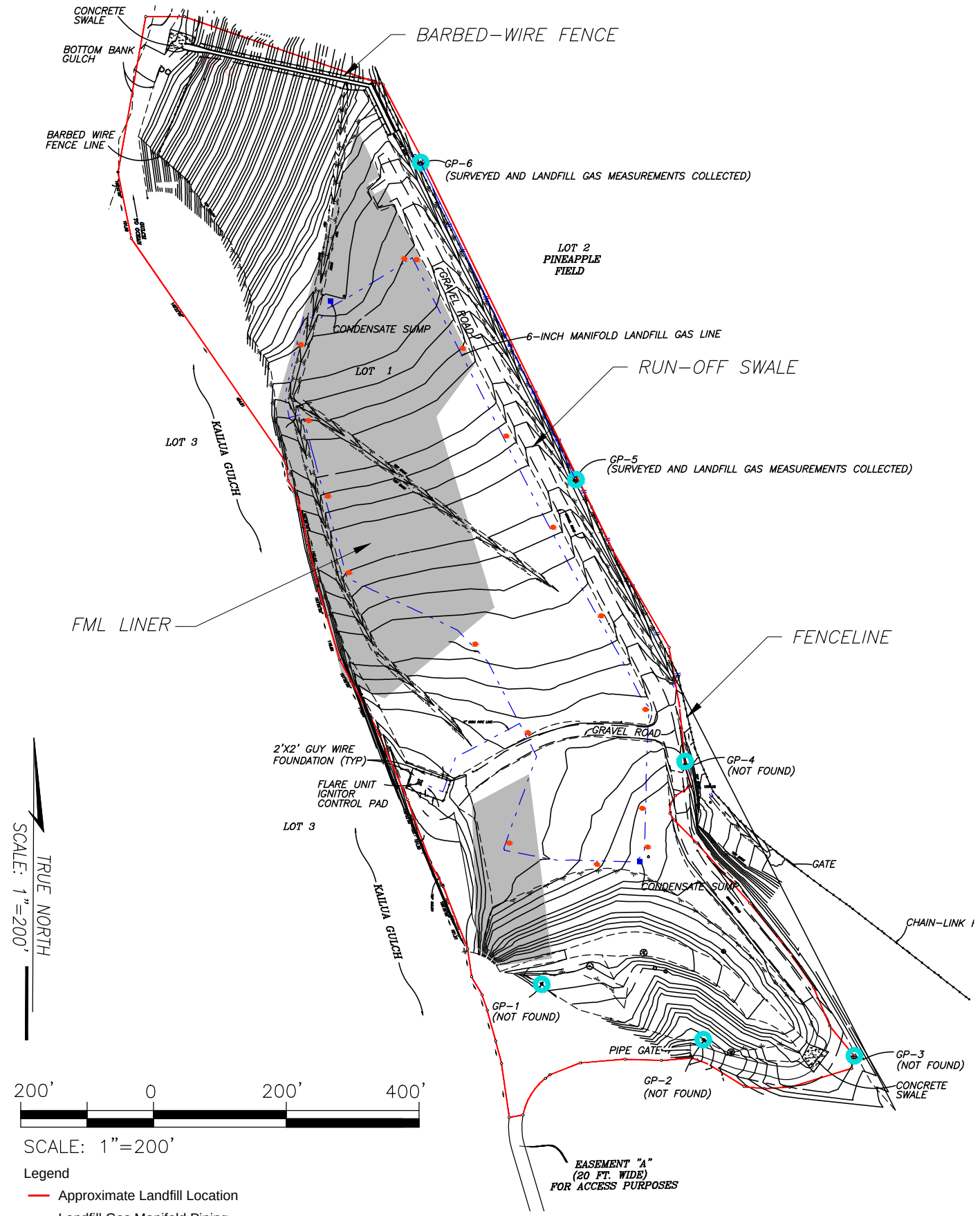
Legend

— Approximate Landfill Location

Makani Landfill

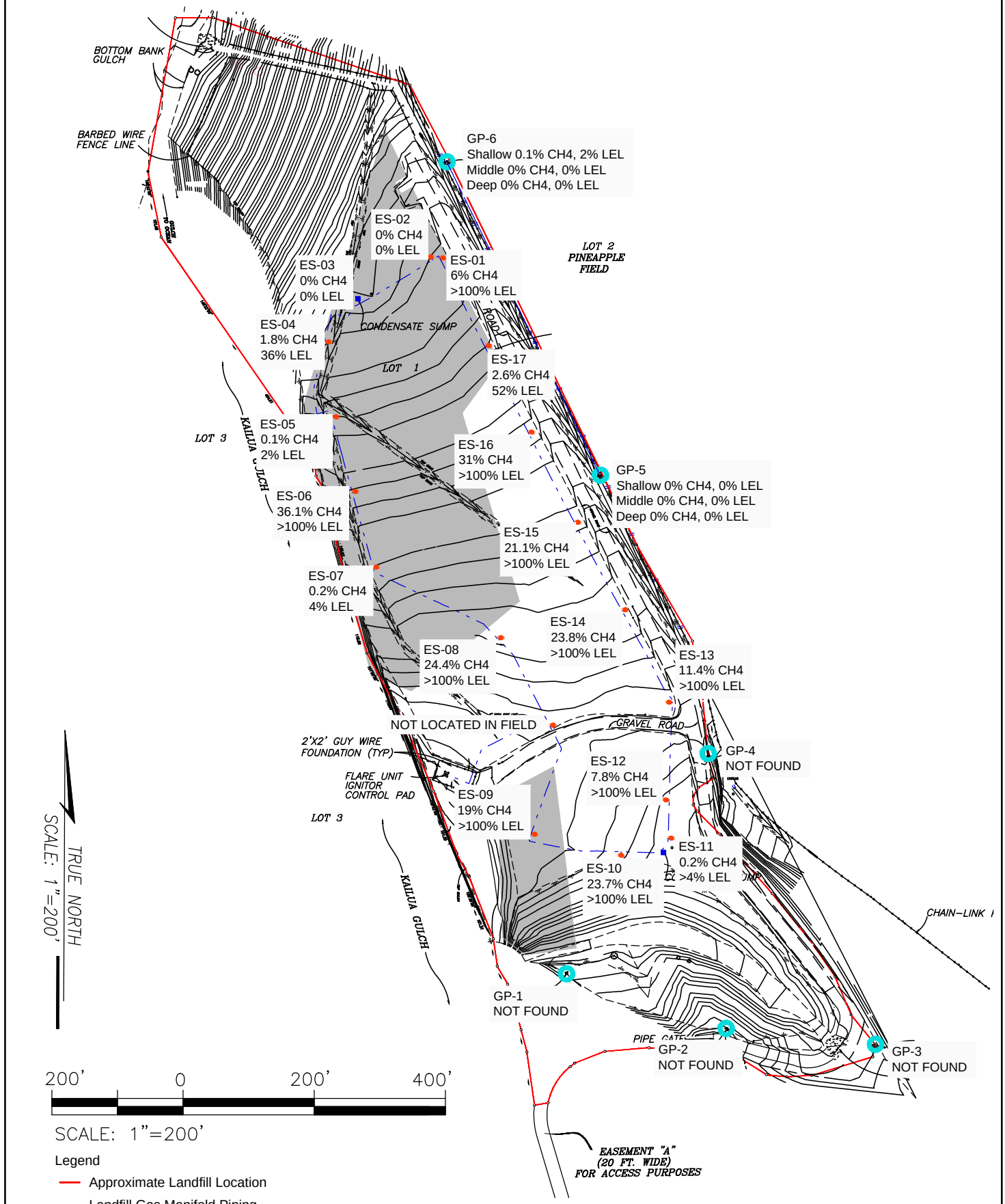
References:
DeLorme, 2005; Google, 2014.

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



Basemap: Akamai Land Surveying, 1993.

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



Basemap: Akamai Land Surveying, 1993.

	DATE: OCT 2014	PROJECT TITLE: PHASE 1 OF POST CLOSURE SERVICES CLOSED MAKANI LANDFILL MAKAWAO, ISLAND OF MAUI, HAWAII
	FIGURE TITLE: MEASURED METHANE CONCENTRATIONS IN LANDFILL GAS	FIGURE NO.: 3

Tables

Table 1: Results of 1988 Waste Composition Survey
Closed Makani Landfill
Makawao, Maui, Hawaii

Waste Category	Percentage of Total Waste Stream
Residential	41.5
Yard Waste	18.8
Dirt/Rock	32.8
Wood	4.4
Commercial	0.5
Construction and Demolition	0.2
Autos	0.4
Cardboard	0.6
Other	0.8

Table 2: Makani Landfill Gas Data
Closed Makani Landfill
Makawao, Maui, Hawaii

Gas Probe ID	Date/Time	CH4 %	CO2 %	O2 %	Balance %	LEL %	Teperature °F	CO ppm	H2S ppm	H2 ppm	Probe/Port Condition and Notes
GP-5 Shallow	1/14/2014 14:41	0	0.2	18.9	80.9	0	73	0	0	Low	Fair, vault cover has significant corrosion and a hole, gas probes are intact and good condition, vault hinge is broken, bollards are good with some rust.
GP-5 Middle	1/14/2014 14:43	0	0.1	19	80.9	0	74	0	0	Low	
GP-5 Deep	1/14/2014 14:46	0	0.3	22.8	76.9	0	72	0	0	Low	
GP-6 Shallow	1/14/2014 10:18	0.1	0.7	22.1	77.1	2	72	0	0	Low	Probe, vault and bollards are in good condition, some rust observed.
GP-6 Middle	1/14/2014 10:29	0	0.6	22.4	77	0	70	0	0	Low	
GP-6 Deep	1/14/2014 10:32	0	0.4	22.8	76.8	0	70	0	0	Low	
ES-01	1/14/2014 10:51	6	17.3	0.4	76.3	>100	81	0	1	Low	Good
ES-02	1/14/2014 10:45	0	2.9	19.9	77.2	0	79	0	0	Low	Good
ES-03	1/14/2014 11:07	0	6.5	14.1	79.4	0	79	0	0	Low	Good, intact
ES-04	1/14/2014 11:13	1.8	16.2	0	82	36	82	0	0	Low	Good, intact
ES-05	1/14/2014 11:19	0.1	5.7	14.5	79.7	2	85	0	0	Low	Good, intact
ES-06	1/14/2014 11:24	36.1	28.4	0	35.5	>100	86	0	0	Low	Good
ES-07	1/14/2014 11:29	0.2	14.1	2.3	83.4	4	83	0	0	Low	Good
ES-08	1/14/2014 11:36	24.4	22.3	0	53.3	>100	83	0	1	Low	Good
ES-09	1/14/2014 11:54	19	22.3	0.6	58.1	>100	81	0	2	Low	Good
ES-10	1/14/2014 11:59	23.7	27.7	0	48.6	>100	81	0	10	Low	Good
ES-11	1/14/2014 12:04	0.2	4.7	17.6	77.5	4	85	0	0	Low	Good
ES-12	1/14/2014 13:43	7.8	17.8	0.5	73.9	>100	77	0	0	Low	Good, filled with water
ES-13	1/14/2014 13:46	11.4	20.5	0	68.1	>100	83	0	2	Low	Damaged, pipe broken and emitting landfill gas.
ES-14	1/14/2014 14:28	23.8	22	0	54.2	>100	77	0	0	Low	Good
ES-15	1/14/2014 14:32	21.1	22.2	0	56.7	>100	72	0	0	Low	Good, cap missing.
ES-16	1/14/2014 14:50	31	19.6	0	49.4	>100	72	0	1	Low	Good
ES-17	1/14/2014 14:55	2.6	13.2	2.6	81.6	52	83	0	0	Low	Destroyed, standpipe missing, only hole in the ground.

Notes: Blue Highlight= Exceeded Lower Explosive Limit of CH4

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Attachment A: Bibliography and CD Containing Documents Reviewed

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BIBLIOGRAPHY

Akamai Land Surveying, 1992. AutoCAD file, Topographic Survey of Lot 1 of the Makani Sanitary Landfill Large-Lot Subdivision. November 6, 1992.

Akamai Land Surveying, 1993. AutoCAD file, Topographic Survey of Lot 1 of the Makani Sanitary Landfill Large-Lot Subdivision. June 7, 1993.

Browning-Ferris Industries, 1988. Makani Landfill Refuse Quantity and Composition Survey. Prepared for County of Maui Department of Public Works, 200 South High Street Wailuku, Maui, Hawaii 96793. November.

County Council, County of Maui, 1988. Letter to Mr. Alvin Fukunaga, Director Department of Public Works, County of Maui; Subject: Closure of Makani and Olowalu Landfills. From: Goro Hokama, Chairman Committee of the Whole, Maui County Council. July 20, 1988.

County of Maui Department of Public Works, 1992. Memo to David Wissmar, Acting Chief of Field Operations and Maintenance; Subject: Makani and Olowalu Sanitary Landfill Closures. From: Brian Hashiro, Solid Waste Division Chief. March 18, 1992.

County of Maui Department of Public Works and Waste Management, 1995. Letter to Mr. Gary Siu, State of Hawaii Department of Health, Office of Solid Waste Management; Subject: Fire Report at Closed Makani Landfill. From: Elaine Baker, P.E. September 18, 1995.

County of Maui Department of Public Works and Waste Management, 1995. Memo concerning Makani Post-Closure Fire Report. From Andy Hirose. December 31, 1995.

County of Maui Department of Public Works and Waste Management, 1997. Memo to: John Harder, Coordinator, Office of Solid Waste Management , HDOH; Subject: Care of Closed Landfills: Makani and Olowalu. From: Dave Goode, Deputy Director of Public Works, County of Maui. April 22, 1997.

County of Maui Department of Public Works and Waste Management, 1998. Letter to Mr. John Harder, Office of Solid Waste Management Hawaii Department of Health; Subject: Makani Closed Landfill Experiment of Grazing Cattle. From: Andy Hirose, Acting Chief of Solid Waste Division. July 8, 1998.

County of Maui Solid Waste Division, 1995. Memo to C. Jencks, Director, Department of Public Works and Waste Management; Subject: Emergency Repairs, Gas Monitoring and Recovery System, Makani Landfill, Makawao. From: D. Wissmar, Chief of Solid Waste Division. September 18, 1995.

Element Environmental, 2013. Makani Landfill Site Visit by Steve Spengler. Typed Notes with site photos. September 12, 2013.

Environmental Protection Agency (EPA) Office of Environmental Information (OEI), 2001. U.S. EPA Regulated Facilities Point Locations from Envirofacts for the United States and Territories: Makani Landfill. Retrieved from: http://www.epa.gov/envirofw/

Office of Solid Waste Management, 1992. Letter to Mr. George Kaya, Chief Engineer, County of Maui Department of Public Works; Subject: Draft Closure/Post-Closure Plans for Makani and Olowalu Landfills. From: John Harder, Coordinator, Office of Solid Waste Management. February 3, 1992.

Parametrix, Inc., and Environmental Communications, Inc., 1991. Environmental Assessment Makani Landfill Closure. Prepared for the Department of Public Works, County of Maui. August.

Parametrix, Inc., 1991. Drilling and Well Installation Specifications. Prepared for County of Maui, 280 South High Street, Wailuku, Maui, Hawaii 96793. February 1993.

Parametrix, Inc., 1991. Letter to Mr. Brian S. Hashiro, P.E., Solid Waste Division Chief, County of Maui Department of Public Works; Subject: Makani Landfill and Olowalu Landfill Closure/Post-Closure Plans. From: Dwight E. Miller, P.E., Assistant Project Manager. May 2, 1991.

Parametrix, Inc., 1992. Makani Landfill Closure/Post-Closure Plan. Prepared for the County of Maui Department of Public Works, Solid Waste Division. February.

Parametrix, 1993. Post Closure Maintenance Manual, Makani Landfill. Prepared for the County of Maui Department of Public Works, Solid Waste Division. July.

Parametrix, 1993. Letter to Mr. Andrew Hirose and Ms. Elaine Baker, Subject: Methane Gas Status and Monitoring Recommendations at the Olowalu and Makani Landfills. From: William F. Sullivan, Project Manager. October 15, 1993.

State of Hawaii Bureau of Conveyances, 1992. Makani Sanitary Landfill Deed transfer from Maui Land & Pineapple Company, Ltd, to County of Maui. August 4, 1992.

HDOH, 1991. Letter to Mr. George Kaya, Chief Engineer, Department of Public Works, County of Maui; Subject: Draft Closure/Post-Closure Plans for Makani and Olowalu Landfills. From John Harder, Coordinator, HDOH, Office of Solid Waste Management. February 3, 1992.

HDOH, 1999. Letter to Mr. Andrew Hirose, Acting Chief of Solid Waste Division, Department of Public Works and Waste Management; Subject: Makani Closed Landfill, Cattle Grazing. From: Steven Y. K. Chang, P.E., Chief Solid Waste and Hazardous Branch. Response to County of Maui Letter from July 8, 1998.

Unknown, 1995. Landfill Gas Monitoring Field Notes. 26 March 1993 through 29 June 1995.

Unknown, 2007. Makani Landfill Stormwater Check Field Notes. December 10, 2007.

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Attachment B: A-Mehr, Inc. Memorandum, Conceptual Landfill Gas Model and Emissions Estimates

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A-MEHR, INC.
Memorandum

September 23, 2014

TO: File, Makani 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 Makani 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:

   - Estimated total volume of waste and cover soil in place based on comparison of pre-landfill topography and existing grades - 654,900 cubic yards
   - Average in-place density of waste - 700 lb/cubic yards, based on statements in the Closure / Post-Closure Plan (Parametrix 1992).. This results in an estimated total waste tonnage in place of approximately 229,000 tons.
   - Active life from 1966 to 1992 (27 years)
   - Uniform annual tonnage intake of approximately 8,490 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 27 standard cubic feet per minute (scfm) from the 14-acre landfill. By comparison, the LFG collection and control system at Central Maui Landfill typically handles 600 to 800 scfm.

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

YEAR	ANNUAL LFG (METRIC TONS / YEAR)	AVERAGE LFG (SCFM)	AVERAGE METHANE (SCFM)
1994	1,359	73	37
2000	1,007	54	27
2010	611	33	16
2014	500	27	13
2020	371	20	10
2030	225	12	6
2040	136	7	4
2050	83	4	2

5. Closure construction at Makani Landfill included a passive gas collection system consisting of shallow horizontal collection trenches vented to an above-ground pipe loop leading to a passive flare. Six perimeter gas probes were installed outside the waste footprint to detect and measure any horizontal migration of landfill gas, although only two probes are currently operational. Element Environmental measured gas concentrations in these facilities in January 2014, with following results:

   - Detectible landfill gas was measured in 15 of 17 sample ports in the above-ground piping system;
   - Methane concentrations in ten (10) sample ports exceeded the lower explosive limit (5% by volume) for methane; and
   - Methane was detected at a concentration of 0.1% in one of the two perimeter gas probes that were located and sampled.

   Sample results are provided in Table 2. Gas emission rates were not measured during the sampling event.

6. Field investigations confirmed that all valves connecting the horizontal collection trenches to the above-ground gas headers are closed, and have been closed for a number of years. As a result gas collecting in the collection trenches has no way of venting except through the cover soil, unless there are leaks in the header pipes or pipes connecting with the trenches.

7. If emitted uniformly from the surface of the landfill in the absence of a collection system, the projected methane volume of 13 scfm projected by the model for 2014 would be equivalent to approximately 21×10^{-6} scfm per square foot of the 14-acre landfill surface, or to a concentration of 21 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. No such rules apply to small landfills or landfills established prior to 1993.

TABLE 2
LANDFILL GAS SAMPLING RESULTS, JANUARY 2014

Gas Probe ID/ Extr. System Outlet	CH4 %	CO2 %	O2 %	Balance %	%LEL %	Temperature °F	CO ppm	H2S ppm	H2 ppm	Probe/Port Condition and Notes
GP-5 Shallow	0	0.2	18.9	80.9	0	73	0	0	LOW	Fair, vault cover has significant corrosion and a hole, gas probes are intact and good condition, vault hinge is broken, bollards are good with some rust, see pg. 11 in field book for details.
GP-5 Middle	0	0.1	19	80.9	0	74	0	0	LOW	
GP-5 Deep	0	0.3	22.8	76.9	0	72	0	0	LOW	
GP-6 Shallow	0.1	0.7	22.1	77.1	2	72	0	0	LOW	Probe, vault and bollards are in good condition, some rust, see pg. 7 in fieldbook for details
GP-6 Middle	0	0.6	22.4	77	0	70	0	0	LOW	
GP-6 Deep	0	0.4	22.8	76.8	0	70	0	0	LOW	
ES-01	6	17.3	0.4	76.3	>100	81	0	1	LOW	Good
ES-02	0	2.9	19.9	77.2	0	79	0	0	LOW	Good
ES-03	0	6.5	14.1	79.4	0	79	0	0	LOW	Good, intact
ES-04	1.8	16.2	0	82	36	82	0	0	LOW	Good, intact
ES-05	0.1	5.7	14.5	79.7	2	85	0	0	LOW	Good, intact
ES-06	36.1	28.4	0	35.5	>100	86	0	0	LOW	Good
ES-07	0.2	14.1	2.3	83.4	4	83	0	0	LOW	Good
ES-08	24.4	22.3	0	53.3	>100	83	0	1	LOW	Good
ES-09	19	22.3	0.6	58.1	>100	81	0	2	LOW	Good
ES-10	23.7	27.7	0	48.6	>100	81	0	10	LOW	Good
ES-11	0.2	4.7	17.6	77.5	4	85	0	0	LOW	Good
ES-12	7.8	17.8	0.5	73.9	>100	77	0	0	LOW	Good, filled with water, see pg. 7 in fieldbook for details.
ES-13	11.4	20.5	0	68.1	>100	83	0	2	LOW	Damaged, pipe broken and emitting LF gas
ES-14	23.8	22	0	54.2	>100	77	0	0	LOW	Good
ES-15	21.1	22.2	0	56.7	>100	72	0	0	LOW	Good, cap missing
ES-16	31	19.6	0	49.4	>100	72	0	1	LOW	Good
ES-17	2.6	13.2	2.6	81.6	52	83	0	0	LOW	Destroyed, standpipe missing, only hole in ground

Notes:

Yellow highlights = exceeded lower explosive limit for methane

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Attachment C: Site Photographs

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ATTACHMENT C

Photo C-1: Scrap Metal Piles

Photo C-2: Large Metal Tanks

Photo C-3: Decommissioned Dump Truck

Photo C-4: Decommissioned Dump Truck and Scrap Metal Pile

Photo C-5: Landfill Gas Flare Facility

Photo C-6: Landfill Gas Trench Completions with Throttling Valve and Monitoring Port

Photo C-7: Material Stockpile

Photo C-8: Secured Entrance/Exit